THE CELTIC SWORD

RADOMIR PLEINER

with contributions by

B. G. SCOTT

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of
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R.P.

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Introduction

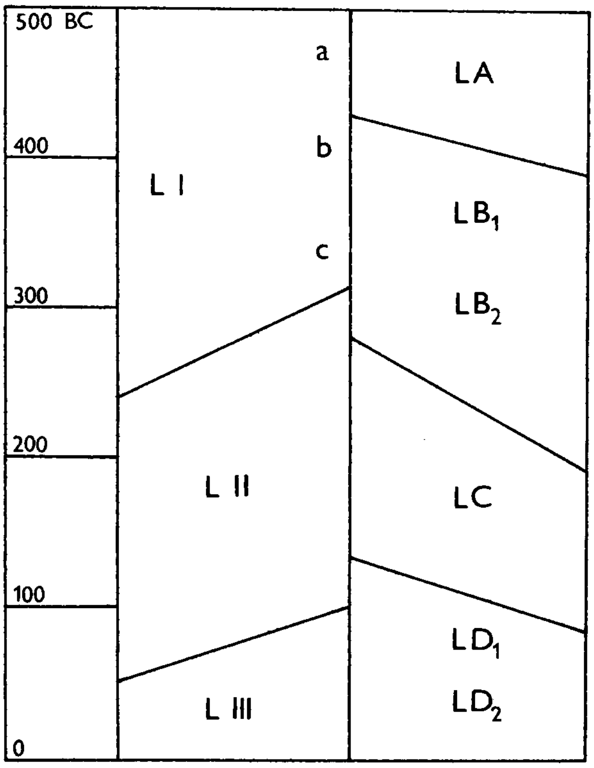
The image of the Celtic sword is a romantic one. The bravery of the Celtic warrior, his ancient culture with its barbarian customs and his life-and-death struggles on the Continent during the last centuries BC, so vividly recorded by ancient writers, have a strong emotional attraction. In the more prosaic historical context, the armoury of the early Celts is an eloquent source of information on a specific stage in the development of an important archaic European society. The destruction of its primeval system was accelerated by the fatal confrontations on the Continent and in Britain with the advanced world of Classical Antiquity. In this clash of civilizations, the long sword, the most important part of the barbarian panoply, symbolizes the contrast between Celtic warfare and the tactics of their adversaries. These swords moreover are witnesses to the craftsmanship of their makers, reflecting the technological achievements and economic circumstances of the Celts in the days of cultural prosperity and during their political rise and decline.

We have to emphasize the fact that we are using the term 'Celtic sword' as a code-name, denoting a weapon of a particular design, and appearing principally in areas known to have been occupied by the early Celts, but with outliers in adjacent regions. This style of weapon had a long currency overall, with its use in some regions outlasting by several centuries its *floruit* in what is now considered to be the Celtic heartland. In some regions where 'Celtic swords' have been found, it is not possible to state with certainty the dominant cultural and linguistic characteristics of their users. But provided that the code is read properly, the term avoids tedious circumlocution.

Until the end of the Hallstatt period and during the transition to the La Tène era, ironworking in Europe was still limited to, and primarily directed towards, the needs of the upper strata of society. The sudden appearance of thousands of iron swords, as well as spearheads and other martial equipment, indicates basic changes in the areas of smelting and production. Archaeological sources for the sixth and fifth centuries provide no information about the existence of contemporary iron-producing centres, bloomeries, and furnaces, though various finds of this period, scattered throughout Europe, indicate small-scale production of iron. Later, there are reliably dated bloomery sites and smelting areas from the second and first centuries BC. The intervening period, however, is a blank.

On the Continent, two types of archaeological evidence attest indirectly to a considerable increase in iron metallurgy among the Celts. One is the bipyrimidal bar, a heavy piece of malleable iron. Individual finds have been dated to the five centuries between 500 and 50 BC, but unfortunately the bulk, hidden in hoards and representing many tons of iron, remains undated. The other is the iron weapons found in the Celtic territories, and the relative abundance of swords, in comparison with any of the preceding periods, is significant. Production of the long blade of an iron sword involves great skill on the part of the maker, and metallographic examination of these weapons may be expected to yield interesting results, contributing to our general understanding of the development of the European blacksmith's craft.

Chronology of La Tène Period



Comparison of the two basic chronological systems used for the La Tène period in western and central Europe. In details, the chronological limits of phases and subphases vary according to individual authors and geographical areas.

In the 1970s, the Laboratory of the Archaeological Institute in Prague (Czechoslovak Academy of Sciences) investigated a set of La Tène period swords from cemeteries in Bohemia and Moravia. The results were compared with published analyses from other sites in Europe. Soon afterwards, a number of Celtic swords were examined in France and Britain, but much of the data was not published and only a few preliminary results were available (recently more detailed information from the British Isles has become available). However, the successful completion of the Prague programme encouraged us to build on the results to produce a broader historical sketch of the historical role of the sword, not only among the Celtic population of Europe but also in the early history of warfare, including those anonymous struggles in which early Europeans had been involved since the beginning of the Metal Ages.

This treatise however is not a typological study dealing with the morphology, adornment, and classification of Celtic swords. Although these topics will be discussed briefly, my primary concern will be with the historical and technological context.

1

The Origin of the Celtic Long Sword in Early Europe

The swords used by the Celts were described by several writers in Antiquity as weapons of considerable length. The fact that they were used predominantly as cutting and slashing weapons was considered unusual in comparison with the contemporary style of combat employed by the Mediterranean civilizations.[1] The length of the Celtic swords upon which the ancient authors remarked is, of course, only relative. An attempt to calculate the lengths of swords on iconographic representations of Celtic arms by relating them to the sizes of the associated human bodies produced a result of about 80 cm (Couissin 1927, 155). Absolute dimensions, naturally enough, can be obtained from archaeological finds of the swords themselves. Well-preserved weapons differ in their lengths not only individually, but also through time. Scholars of Celtic archaeology noted decades ago that Early La Tène swords were shorter than those of the Middle and Late La Tène periods.[2] In fact, in Europe, the Early La Tène sword (not counting daggers) measures roughly 40–50 cm, although substantially longer (60–90 cm) blades occur also. In the Middle La Tène period, weapons of 70–85 cm are common, while very long blades (over 90 cm) belong to the Late La Tène.[3] Since prehistoric bronze sword blades were also made in different lengths, they too merit our attention.[4]

We should note here the study by D. H. Gordon (1953) which has been commonly overlooked in recent years. As an aid to his discussion of the functions of blades, Gordon distinguished four categories: daggers (less than 35 cm), dirks (approximately 35–50 cm), short swords (approximately 50–71 cm), and long

[1] Greek writers use the term μάχαιρα *machaira* (*LS* 1940, 1084) for Celtic swords (Polybius 2. 30. 8, 30. 3, 30. 5, etc.). Later, other writers stressed their size by certain adjectives (Dionysius of Halicarnassus 14. 9.13: Strabo 4. 4. 3). Diodorus uses *spatha* instead of *machaira* (5. 30. 3) to distinguish them from the usual shorter sword (*xiphos*). Appian (4. 8) has *xiphos makros*, and ascribes the innovative introduction of long swords in Greek Antiquity to the lightly armed *peltastae* of the 4th cent. BC. Against this, Diodorus (15. 44. 3–4) attributes the idea to the genius of Iphicrates. *Peltastae* were recruited from the northern Greek and Thracian regions, but the origins of their long swords eludes us. For Latin authors, the standard word used for the Celtic sword was *gladius*, and Livy frequently refers to *gladii praelongi* (22. 46, 38. 17).

[2] Déchelette 1927, 612–6; Jahn 1916, 24–7. This observation is quoted also in general works dealing with the ancient Celts (e.g. Moreau 1958, 68; Schlette 1979, 166).

[3] Déchelette loc. cit.; Bretz-Mahler 1971, 99; Stead 1983. Irish swords of La Tène style are, on average, much smaller than their British and European counterparts (Mallory 1983; Scott 1990, 61).

[4] Schauer (1971, 1) classes all blades over 25 cm in length as 'swords'.

swords (over 71 cm).[5] Taking into account the fact that the majority of Classical Greek and Roman swords (the *xiphoi* and *gladii*) did not normally exceed 50 cm in length (Hazell 1981), it would be reasonable to consider as 'long swords' all blades longer than 70 cm (including the hilt).

The Birth of the Sword

The origins of the sword lie in the general development of warfare. Occasional violent conflicts between the earliest human groups, provoked by natural rivalries over settlement and hunting territories, must have been waged with the equipment used in the day-to-day struggle for existence, and, following the development of tool-use, mainly with manufactured hunting weapons. This would have continued through to the later Neolithic period. New techniques in the working of stone made possible the development of axe-type weapons for striking and cutting.

The next stage of social development comes in the Late Neolithic and Chalcolithic (Eneolithic) periods. It may be suggested that patriarchy and more integrated social systems were associated with more organized martial activity. The traditional weapons (bows and arrows, thrusting and throwing spears, tipped with shaped flint heads) were supplemented by the first specialized combat weapons, cast metal battle-axes. These stimulated, in central and northern Europe, the production of perfect skeuomorphs skilfully worked in polished stone. Further developments in metallurgy (in the smelting, casting, and hammer-hardening of non-ferrous metals, namely copper and copper alloys) made possible the production of categories of weapons which were effective in combat.

The long, thin, and sharply pointed blade of the dagger, probably together with a metal axe-hammer or a metal-tipped spear (Early Bronze Age), formed what may be described as the first group of weapons specially designed for single combat. The advantage provided by a weapon with longer reach was soon appreciated for close-quarters fighting, leading to the lengthening of dagger blades. With longer blades, mere stabbing could be superseded by a thrusting action. Dirks and thrusting swords (the latter frequently called 'rapiers' in archaeological literature) emerged in the material cultures of certain areas, rapiers being suitable for true fencing, a method of combat requiring considerable training and practice.

It should not be forgotten that weapons in these specialized categories, including many types of stone battle-axes, probably were often made purely for display. From the end of the Neolithic, such artefacts were reserved for the foremost warriors of the community, if not exclusively for leaders, that is, patriarchs. The question arises whether these artefacts, and particularly those of copper/bronze with rich ornamentation, should not be interpreted as the characteristic possessions

[5] He classes thrusting blades whose width is less than 2.5 cm as rapiers, designed solely for thrusting (Gordon 1953, 71). In the case of swords, the cutting role is definitive, even though in practice they might have been used mainly for thrusting.

of the leading personalities in a community, even as insignia of rank never actually used in combat. But H. Lorimer (1950, 262) surely exaggerated this possibility when he suggested that the long bronze sword was nothing more than an enlarged symbolic dagger. Some weapons were certainly attributes and symbols of status, but this role undoubtedly was secondary. That no fewer than 3,000 bronze swords have been found in central Europe alone (Middle Bronze Age to Early Iron Age, a period of around ten centuries) indicates with some exceptions their practical use in fighting. There are graves, dating to the Middle Bronze Age, in which swords, along with other goods and ornaments, are accompanied by other types of weapon—axes, spears, arrows, and daggers. In other instances, daggers and dirks are associated with long thrusting swords.[6]

The association of two swords, one short and one long, in grave 4 at Povegliana-Veronese, northern Italy, led Bianco Peroni (1970, 26) to suggest that the warrior fenced at a distance from his opponent with the rapier in his right hand, using the dirk in his left hand on coming to close quarters. Certainly, some of the earliest thrusting swords evoke the idea of warriors regularly fighting with enough space to wield them: their use in clashes between close-packed masses would have been quite impractical and ineffective.

It may have been that the leaders of minor, and later even of major communities were obliged not only to organize the acquisition and defence of arable land, pastures, and raw materials on behalf of their people, but also had to represent their communities personally in single combat. Such contests may well have been subject to regulation, ceremony, or ritual which initiated or concluded and decided at least some types of conflicts for the community as a whole. Allusions to such practices can be traced much later in the history of mankind, as will be recalled below. For this reason, much labour and skill must have been devoted to the manufacture of the weaponry of early chieftains.[7]

The Origin of the Long Sword

One of the earliest sword blades, 82.4 cm long and made of bronze, comes from the rich grave MA at Alaça Hüyük in Asia Minor, and is dated to the late third

[6] Combinations of long swords and short swords or daggers found together in the same grave are already known among Mycenaean finds. Some examples from European contexts include (after Schauer 1971) Sauerbrunn (p. 21) and Lisbjerg (p. 29); for Mägerkingen tumulus VII, grave 2 and Povegliana-Veronese grave 4, see Bianco Peroni 1970, 26 and 48.

[7] This is in complete accord with interpretations developed in quite different fields. Huizinga (1956, 90–100) considers the archaic struggles between individuals and groups as comparable to a sort of sacred 'game' with a strong ritual element. Single combat, as *pars pro toto*, played an important role in many ancient societies. Such an approach, however, is imaginable only between adversaries who considered themselves as equals. Should one side regard the other as their inferior, such 'rules' would be void. Our hypothesis does not entail the absence of armed masses (equipped with bows and spears and the like) from such conflict. Indeed, the existence of fortifications of various form known from Late Neolithic times, is a strong indication of such involvements. The suggestion basically is that the introductory or final stages of conflicts followed certain prescribed forms in which the personal intervention of the chief predominated.

millennium BC. But the lack of Near Eastern finds makes it hard to form a clear picture of the subsequent development of the long sword in South-West Asia.[8] This scarcity may reflect a different path of social evolution. As a more rapid increase of population heavily influenced and catalysed the organization of social life, leading to the early establishment of various forms of rudimentary state, modes of warfare underwent correspondingly deep changes. Masses of armed warriors engaged each other in true battles where short swords were of more use in close-quarter fighting than long ones. This gave rise to the common tradition of Classical Antiquity referred to at the beginning of the chapter.

In Eneolithic and Early-Bronze-Age Europe, incoming waves of Indo-European tribes who were still organized in various forms of kinship and clan systems, preserved more ancient methods of warfare despite the important technological innovations received from Near Eastern civilizations. Here, the transition from dagger to sword can be traced only sketchily. In the first half of the second millennium BC, in the Mycenaean shaft-grave period, the famous long thrusting swords of bronze, 60–110 cm long, appeared in the Mycenaean/Minoan area (Fig. 1.1). It is accepted that they inspired or accelerated the development of the European Early and Middle-Bronze-Age dagger.

Archaeological finds in Europe are sufficiently numerous to allow us to observe the transition from the dagger (about 25 cm) via the dirk and short sword to the long sword (over 70 cm). This is even reflected in one typological family of blades, Boiu–Keszthely–Sauerbrunn–Castions di Strada-Teòr (Middle Bronze Age BB_1–BB_2), which used to be interpreted by some scholars[9] as a link between the so-called Mycenaean rapiers and European swords proper (Fig. 1.2–3). In general terms, other types and variants of the Bronze-Age periods BA_2–BD exhibit a similar progression. In certain parts of Europe, swords 58–73 cm in length appear in the Lochham–Göggenhofen stages (BB_2–BC_1), for example at Bratislava, Saint Triphon, Adliswill, Mägerkingen, Beringen, Weizen, Rixheim, and elsewhere. These belong to the family of butt-plated blades (*Griffplattenschwerter*, Fig. 1.4–5).

The fastening of the hilt itself—the mounting of a (wooden) handle onto an ovate butt-plate by means of several rivets—shows that these weapons were not suited to the delivery of heavy blows. The unusually narrow and sharply pointed blades, moreover, suggest that they were intended primarily for thrusting. Two possibilities were open to metalworkers wishing to produce a weapon strong enough for use with a striking action: either the blade and hilt could be cast as one single piece, or a

[8] Childe (1948) believed that the cut-and-thrust sword originated in western Asia. However, according to the survey conducted by Maxwell-Hyslop (1946), the prevailing weapon in this region during the 3rd and 2nd millennia BC was the dagger (average length in the region of 20 cm), and later, in certain regions such as Assyria and Persia, the short sword (lengths centring on 30–40 cm). Those genuine long swords which do appear are exceptions: an unstratified example from Ashdod, Palestine, ascribed to the early 2nd millennium BC, is 115 cm long (Maxwell-Hyslop op. cit., 22), while another example from Bêt Dagîn, ascribed to the late 2nd millennium BC, is over 100 cm in length (ibid. 59). It is interesting that some of these long swords are seen as influences from the Mycenaean world.

[9] For the theory of an Aegean or Mycenaean origin, see Naue 1903; Reinecke 1931, 230; Catling 1956, 125; Müller-Karpe 1962, 259–60; Schauer 1971, 103; *et al.* Northern examples of Mycenaean rapiers occur in Bulgaria (see Velkov 1979, 111, figs. 1 and 3).

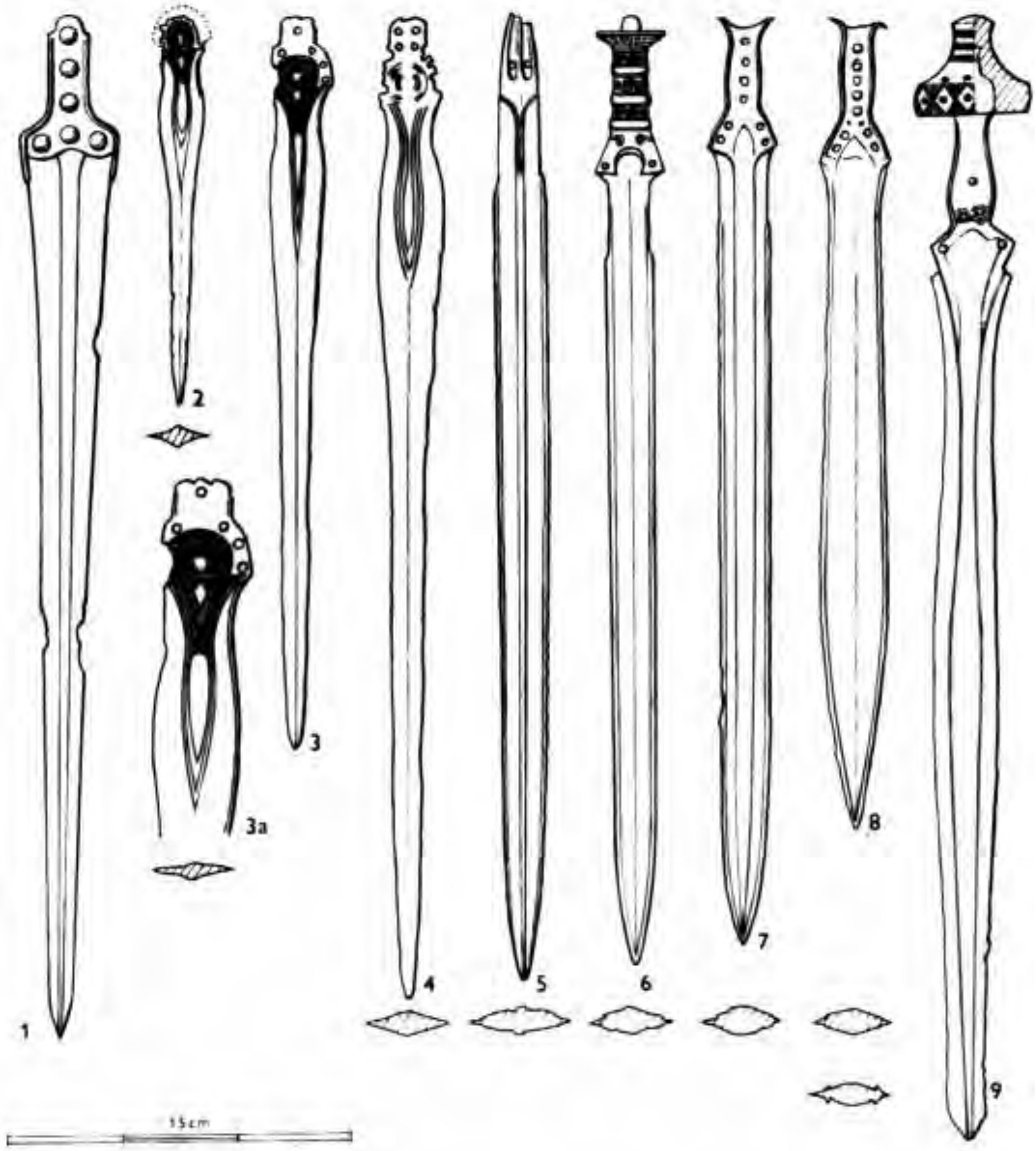


Fig. 1. The evolution of the European bronze sword

metal handle could be riveted firmly to the butt-plate. The first method was accomplished using rods or tangs as extensions of the blade (*Griffangelschwerter*). Tangs were used on Mycenaean/Minoan rapiers and on the predecessors of the genuine European flange-hilted swords (*Griffzungenschwerter*) which were, in their Classical form, a significant type in the period HA_2–HC. The second method gave rise to variants of the solid-hilted sword (*Vollgriffschwert*) which may be traced through to the BD period (Riegsee type), continuing into the Urnfield period. A cast hilt was riveted to the butt-plate of the blade as shown by X-ray examinations (Hundt 1965). The perforated hilt-pommels found on some examples were at one time explained as indicating the use of a wrist strap to prevent the sword being lost in use. Weapons made in this way could have been used for thrusting, but they could also withstand slashing blows. Their long edges also ensured that they delivered considerable force when used with a striking action. Very long examples are known—over 80 cm (e.g. Pfüten, Otterstadt, Mindelheim, etc.), and even as long as 100 cm (Port, near Nidau).

Broader and more robust blades developed in both categories: the maximum width and weight were shifted towards the point, making a leaf shape. Although a thrusting action was still possible, the main purpose of this modification was to enhance the cutting action. Among flange-hilted swords are the Reutlingen type (57–76 cm) with parallel-sided blades, which is considered to be the first true cutting sword, and the Hemigkofen type (54–69 cm) which is markedly leaf-shaped (Fig. 1.7–8). These date to HA_1–HA_2 (Schauer 1971, 134, 151). Among the solid-hilted swords, the Illertissen find is interpreted as an early cutting (and thrusting) sword with a leaf-shaped blade (HA_1: Müller-Karpe 1961).[10]

The introduction of slashing swords has been linked by many scholars with certain changes in warriors' equipment and tactics, such as the introduction of metal shields (e.g. of the *Herzsprung* type, as at Plzeň-Jíkalka),[11] and body-armour (e.g. Čaka) in the BD/HB periods, and the appearance in combat of the chariot or of cavalry.[12] In both cases, weapons would be required capable of

[10] I do not intend to deal with specific problems, or to discuss different views concerning the typological development, of the various derivative types of bronze swords known from European archaeology. The old problem of the origin of the true European flange-hilted sword is still unresolved, although the Romanian Boiu type has a prominent role in many hypotheses. Investigations of European bronze swords began at the end of the 19th cent., and its progress is marked in the works of Naue (1903), Sprockhoff (1931, 1934), Reinecke (1931), Savory (1948), Childe (1948), Holste (1953), Cowen (1951, 1952, 1956, 1966, 1967), Müller-Karpe (1961, 1962), Snodgrass (1964, 205–8), Bianco Peroni (1970), Schauer (1971), Novák (1975), Stary (1981, relevant paragraphs), Brown (1982), and by other contributions cited in the bibliographies of these works.

[11] Cf. Kimmig (1976, 386). The new dating of the *Herzsprung* shields is based on the example from Plzen-Jíkalka, the find-assemblage of which is not yet complete (for a new discussion, see Kytlicová 1986). The relationship of the sword to the shield in the Late Bronze Age is not well documented. For instance, in the *Iliad*, there are many passages describing the shield as a successful (or unsuccessful!) protection against spear-thrusts, but no use of the sword is mentioned in these contexts. The same is true of the helmet and of the corselet (cf. H. and J. Borchardt and Catling in Bucholz and Weisner 1977). The theory that the introduction of the cutting sword was a reaction to the protective qualities of the shield seems highly questionable.

[12] Cutting swords are often associated in archaeological literature with combat involving chariots (Müller-Karpe 1961, 91; Cowen 1967, 616–18; Schauer 1971, 2, 9, 196; Kimmig 1976, 310). But early written records describe chariots rather as platforms for the shooting and throwing of missiles, or as means of transport to the battlefield. Before this, horsemen usually dismounted before combat.

delivering heavy, long-reach, downwards strokes. However, account has to be taken of Gordon's view (1953) that cavalry clashes did not form a part of European warfare until the fourth century BC. Nor is there any evidence of sword-fighting from chariots.[13] A few solid-hilted swords (Mörigen, Auvernier types, HB_3) and the majority of the Halstatt flange-hilted swords (HC) have iron blades; the forging technology for iron, however, obliged smiths to produce less elegant blades, with parallel cutting-edges.

In spite of certain factors indicative of change, no warfare on a broadly conceived and organized scale in central Europe can be postulated from the limited archaeological sources.

The Sword and Combat in Homer

There is a unique source of evidence for the form of warfare practised in the Final Bronze Age, at least in the period of decline of the Aegean world, and that is to be found in Homer's *Iliad.* In spite of all of the critical discussions of the value of this epic as evidence, and bearing in mind the possible corruptions and contaminations implanted during the final phase of its arrangement in the eighth–seventh centuries BC (indeed, those also introduced by later redactors), it mirrors the transitional period from individual, principally heroic combat to clashes between massed armies. To paraphrase Snodgrass (1964, 179), the Bronze-Age element in the material culture described in the poems has been exaggerated, while the Iron-Age component has been understated. But Homer can be quoted to support, if not prove, almost any archaeological hypothesis involving the Later Bronze and Early Iron Ages in Greece. Nevertheless, it is highly instructive to isolate some key elements from the four famous days of battle so vividly described in the *Iliad.*

To begin with, the contest was decided on the battlefield in front of the well-fortified city whose capture was its objective. Bodies of men went into action under the leadership of heroes—noble leaders, heads of tribes, kings, chiefs, and prominent warriors. The inferior status of the rank-and-file is significant (1. 226, 4. 427–31, 12. 87, 13. 126 and 833, 15. 306, 17. 106 and 262, 17. 723–31 to give but a few characteristic examples). Although the Homeric Greek several times uses the term φάλανξ *phalanx*, its use should be taken here as referring to 'line of battle, battle array, the ranks of an army in battle' (*LS* 1940, 1913) as the various contexts show (cf. Snodgrass 1964, 177–8). Although there are cases in which

[13] Gordon argues that the effective use of the sword from horseback required the use of stirrups, but this did not come about until the Middle Ages. (The nomadic tribes of eastern Europe who used the sabre as a cutting weapon, are believed to have been responsible for the introduction of stirrups.) Earlier horsemen from the steppes were mounted archers who never used long swords, only short daggers (*akinakes*).

Against this, the bronze belt from Vace in the Subalpine Hallstatt region shows two men on foot and two horsemen fighting, not with swords but with axes and spears. Kimmig (1976) admits this is a *pars pro toto* scene, but a duel between two chiefs and their respective attendants is another possible interpretation. A rider with a sword in his right hand, exceptionally, is seen on the situla from Kuffern (Eibner 1980, 277, Abb. 10). Cavalry played a role of strictly minor importance in battle for many centuries.

clashes between considerable numbers of warriors are described, this does not imply the deployment of troops in regular battle formations. Heavily armed leaders used chariots, either to bring them to the battle (e.g. 4. 419, 11. 146, 14. 430–1, 16. 425–6), or to serve them as fighting-platforms (4. 306, 5. 13 and 585, 8. 88–90 and 115, 10. 144, 11. 109 and 273, 20. 487). Any encounter was usually resolved by hand-to-hand duels between individual chiefs and champions whose successes and failures decided the various phases of the conflict. These duels were subject to regulations, being preceded (as was common through to the Middle Ages) by challenges and taunts, often in front of the enemy's lines (e.g. 3. 52, 11. 92, 13. 455 and 809, 15. 689, 20. 159 and 178). But in crucial moments, retreat behind friendly lines was possible (e.g. 13. 457, 642, and 648, 14. 408, 16. 817, 17. 129).

Apart from the shooting of arrows, occasionally of stones, and the use of battle-axes, fighting was done primarily with spears, either throwing or thrusting. In duels, after an initial exchange of thrown spears, the sword was brought into play. The terms used for 'sword' are ξίφος *xiphos* (*LS* 1940, 1190) and ἄορ *aor* (p. 1191), or φασγάνον *phasganon* (p. 1918), without differentiation, and the weapon is usually described as large (*mega*) and sharp (cf. Snodgrass 1964, 174). It was employed predominantly as a slashing weapon (3. 361–2, 5. 80–1, 8. 88, 9. 109, 145–6, 210, and 261, 13. 203–4, 14. 26 and 496–7, 16. 332 and 337–8, 17. 126, 20. 481) with which limbs and heads were cut off. Besides his sword, Agamemnon carried a dagger or dirk at his belt (3. 271, 19. 252), but this was used for sacrificial purposes when the need arose. The duels between heroes almost always ended with the stripping of the corpse of its extremely valuable body-armour by the victor as booty: this seems almost to be a ritual aspect of the combat. The chance to take an enemy's body-armour might also have spurred on the common soldiers (e.g. 15. 616). Only occasionally did the heat of battle hinder the taking of armour from the fallen.

In my view, many of the elements described here are consistent with the archaeological evidence yielded by finds of the European Later Bronze Age. One characteristic theme in particular, the dominant role of the warrior representing his side in the conflict, may be seen to have a long history.

Changes in Warfare in Southern Europe

In the next section, the post-Homeric development of the long sword in the emergent civilizations of southern Europe will be discussed. Meanwhile, thanks to the work of Snodgrass (1964), we can review the situation in Greece down to the seventh century BC. From the eleventh century onwards, swords were mostly of iron, flange-hilted, and rather long. Those made before the last years of the Protogeometric period measure on average 74 cm (based on measurements of eleven firmly dated finds with a minimum of 55 cm, and a maximum of 90 cm for a sword from Athens-Kerameikos grave 28). We should also note the occurrence of three dagger-like weapons (22–44 cm) of the same flange-hilted type. Seven examples of swords, securely dated to the Geometric or (probably) Early Orientalizing periods (roughly ninth/eighth–seventh centuries BC) have lengths ranging from 54–91 cm (Halos, Thessaly, pyre VII), the average being 71 cm: four daggers or dirks from the same site range from 30–48 cm in length. The general type of warfare in the earlier phases still did not differ substantially from that reconstructed for central Europe and Mycenaean Greece. We should expect the final phases (eighth–seventh centuries BC) to be characterized by new elements. With the establishment of the Greek city states, the *poleis*, quite new principles of human organization emerged, producing new forms of conflict and new methods of warfare. Side by side with their leaders, the generals and their armed followers who were now much better organized groups of ordinary citizens, were obliged to take part. Historical events of the fifth century BC indicate strongly that substantial changes were already in train by the eighth–seventh centuries BC. Unfortunately, neither archaeological nor early written sources (quoted by Snodgrass 1964, 199–200) afford unambiguous evidence that new armament for the ordinary soldiers, the ὁπλῖται 'hoplites' (heavy shields, long spears, helmets, corselets, and greaves), with a diminution of the role of the sword as an auxiliary close-quarters weapon, was at that time an integral part of the introduction of the organized battle-unit. We may infer its existence by the seventh century BC, from such evidence as the important iconographic representations.[14]

Developments in Italy proceeded along similar lines, which we can follow from Stary's impressive account (Stary 1981). Here, the progressive element was the civilization of the Greek colonies of the South and the Etruscan cities of central Italy. Peripheral Italiote regions were less advanced in this respect. In those areas influenced by the Greeks and the Etruscans the tendency to shorten swords to somewhere in the region of 30–50 cm in length, and the reintroduction of daggers, are clearly attested by archaeological finds of the eighth–sixth centuries BC. There is an apparent increase in the role of cavalry, although horses served mainly for the transportation of warriors and not for mounted combat. Phalanx-like formations, though perhaps loosely knit, were in use in the sixth century BC in Etruria and Latium. With regard to iconographic representations the question arises as to whether the striking repetitions of warrior-figures on vases and toreutics (attested also on situlae of the south-east Alpine region) do, in fact, depict phalanxes. A group of hoplites, led by a trumpeter, on a black-figured Etruscan amphora from Tarquinii, certainly gives the strong impression of an organized attacking group (Stary 1981, ii, pl. 22.1). Thus, in the first half of the first millennium BC, Greece and parts of Italy entered a new stage in the organization of warfare. In contrast to these generally advanced civilizations, the peoples of central Europe were still in the final phases of development of their barbarian social systems. Amongst them, the long sword, of bronze or iron, continued to be the characteristic weapon.

[14] Lorimer 1950, 42, 83, 89, 107. For the late proto-Corinthian Chigi vase found near Veii in Italy, see Snodgrass 1964, fig. 36.

The Genesis of the Celtic Sword

We have noted that the bronze flange-hilted Hallstatt sword of the Mindleheim and Gündlingen types (Fig. 1.9) was the culmination of the development of the prehistoric long sword in Europe. Iron copies appear in significant numbers in Halstatt C (about seventh century BC). But iron flange-hilted sword-blades (Fig. 2.1) of Naue II type (Nenzingen and other variants) had been produced long before the Hallstatt period, in Greece and Thessaly (twelfth–eleventh centuries BC) and in Syria (Hama). Very early examples dating from about 1000 BC appeared in Macedonia (at Visoi in Pelagonia: Vasić 1973, 138—dimensions not reported; Rhomiopoulou and Kilian-Dirlmeier 1989), Bulgaria (at Topčii, Alexandrovo, Popovo, Omarčevo: Tončeva 1980, 50–1—dimensions not reported), Romania (at Banat: Lászl6 1977), and reached Istria which lies adjacent to the Hallstatt area (Škocjan-St Kanzian: Sombathy 1913, 198, fig. 92—surviving length 92 cm). It must be emphasized that these finds mark the end of the tradition of the long sword in the entire Balkan region. From Thrace and Illyria in the seventh and sixth centuries BC we have only the short, curved *machaira* or *akinakes.*[15] The inventories of Hallstatt cultural groups in Yugoslavia include no swords, though knives, axes, and spearheads have been found together with bronze helmets, corselets, and greaves in their chieftains' tumuli which are concentrated particularly in the south-east Subalpine area. The retreat of the fashion for the sword in this area is striking, and has drawn the attention of archaeologists.[16] A small island of survival is represented by the Glasinac group, with several swords occurring in chieftains' tumuli of the seventh–sixth centuries BC (Ilijak tumulus II, grave 1; Brezje tumulus 1, grave 6; Rusanoviče). All are badly preserved, or have even been broken intentionally, so that their lengths are difficult to determine. But they would appear to fall into the shorter range of 50–60 cm in length.[17]

In Northern Italy, long antenna-hilted bronze swords replaced short iron daggers during the later seventh–sixth centuries BC (Este). This situation makes the distribution of Hallstatt C type swords in central Europe a more or less isolated phenomenon. Of these, the bronze examples, although most numerous in south-central Europe, are found also in France, the British Isles, and north Germany with

[15] A hybrid sword from Dobolii de Jos in Romania (Berciu 1967, fig. 63) with an iron blade 133.5 cm in length is an exception. But the zoomorphic ornamentation of its hilt points clearly to the Scythian world.

[16] Hoernes (1915, 122) wrote: 'Schwerter sind merkwürdig selten oder fehlen ganz.' The survival of isolated antenna-hilted bronze swords at the end of the HB_3 period (or early HC_1), as at Klein-Klein and Podzemelj, and the absence of later examples, was ascribed by Gabrovec (1964, 44; 1966, 44) to the influence of the Thraco-Cimmerian tradition of dagger-bearing. The real explanation may be found in social changes occurring within the well-developed milieu of the Subalpine rulers who fought with axes and with spears. Their tombs contain corselets and helmets which are also to be seen on figure representations, and there are also the graves there of spear-bearers. It is possible that they came to allow their warriors (depicted on metal vessels with spears and shields) to fight more often in their places. Not dissimilar processes will be discussed below when the development of the Celts of some 100–150 years later is described.

[17] Benac and Čović (1957, ii. 98) claimed that the Glasinac sword had a close resemblance to the Hallstatt family, but this is dubious.

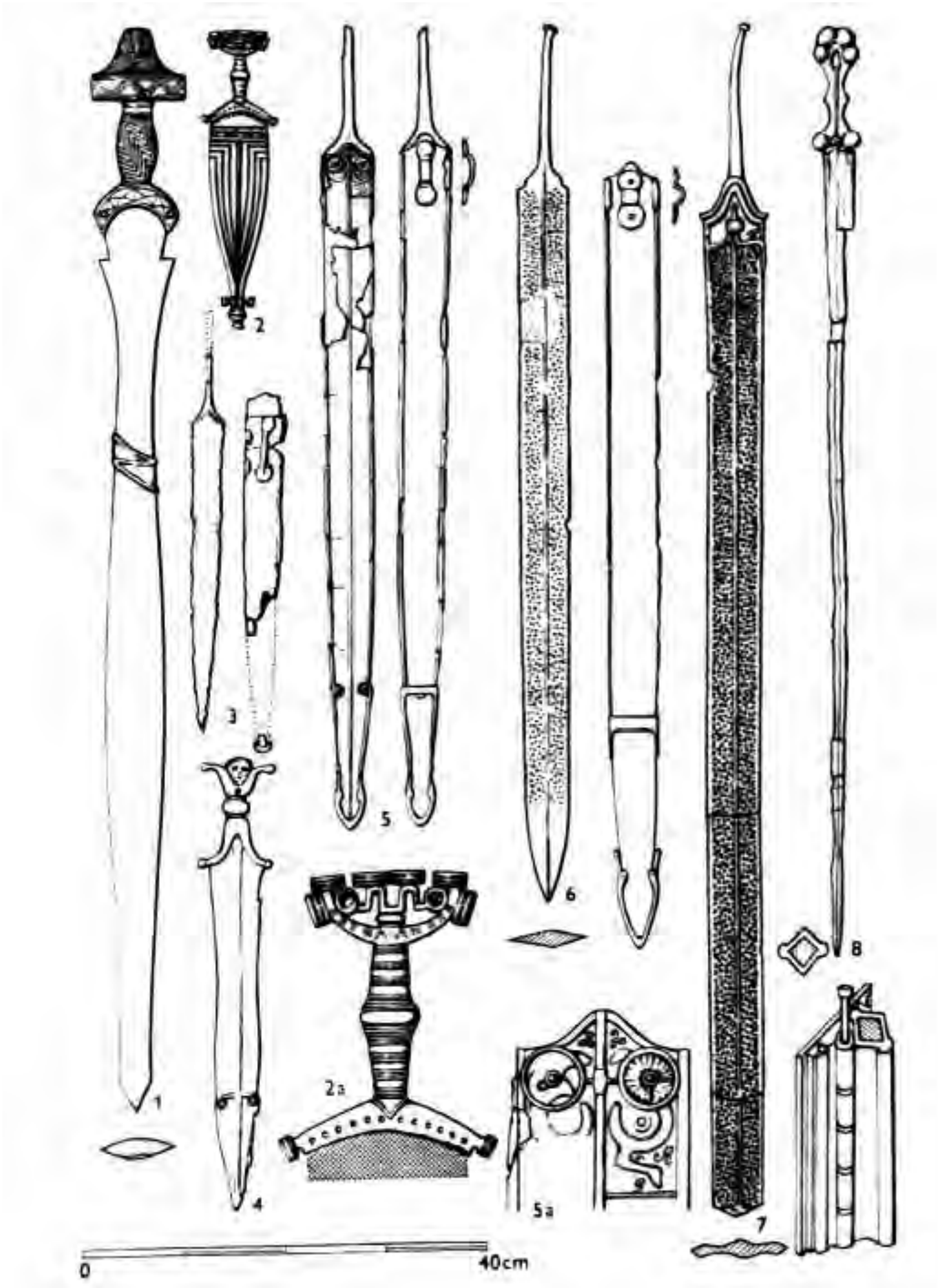


Fig. 2. Hallstatt and La Tène period iron swords and daggers

sporadic occurrences elsewhere. Their iron counterparts, on the other hand, are restricted to Bavaria, Bohemia, Upper Austria, Switzerland, Franche Comté, and southern France, with a few outliers in Belgium, Holland, Silesia, and Britain (Kimmig 1976, figs. 83 and 84), territory supposed to be the cradle of the Celts as the most westerly branch of the Indo-European family.

Hallstatt swords of iron, often found with splendidly ornamented hilts and pommels were obviously objects of exceptional significance. Kossack (1959, 125) wrote that no more than two swords could be registered for any cemetery in southern Bavaria. In many cases, and particularly on the periphery of the West Hallstatt province,[18] they were included with other rich goods in the graves of those people of prominence who were buried in chambered tombs and tumuli. On the other hand, in central areas such as Bavaria, the most lavishly equipped graves containing waggon mountings, spits and numerous bronze ornaments, had no swords, although they have been found in graves where the few other objects give an impression of comparative poverty.[19] This contrast may be indicative of important changes in the contemporary organization of armed conflict. The sword remained the weapon of the duel as is generally accepted, but, in certain of the proto-Celtic Hallstatt regions, it could appear in the hands of those who headed warrior bands—comparable to *strategoi* and *duces*—who fought on behalf of the chiefs proper who had now ceased to take personal part in combat. Further detailed sociological analysis is required to clarify this interpretation, although there is support from the trend of subsequent developments in the later Hallstatt period (Hallstatt D).

The development of the Hallstatt long sword, which was the legitimate predecessor of the later Celtic long swords of history and archaeology, was interrupted. It disappeared as it had in the Subalpine and Balkan regions, but only for a few generations. Around 600 BC, the spear became the main means of offence (spears are found in 91 per cent of the weapon-bearing graves in Bavaria: Kossack 1959, 9), and the standard side-arm of Hallstatt D became the iron dagger (Fig. 2.2).

To date, over 150 examples of daggers and short swords of many varieties are known, and many were obviously made as display objects. Their distribution differs somewhat from that of the Hallstatt C swords. Thus, no Hallstatt daggers are known from Bohemia. Southern France and Aquitaine have yielded somewhere in the region of 45 antenna-hilted short swords (Mohen 1980, 61–5), and similar weapons occur in Champagne (Joffroy 1958, 11). Genuine Hallstatt D iron dagger types (*Hufeisendolch*) are spread over Switzerland, Baden-Württemberg and South Bavaria, with scattered occurrences as far afield as the River Main and Alpine regions[20] and southern Britain (Jope 1961).

The replacement of the Hallstatt C sword by the Hallstatt D daggers (which

[18] Bohemia: Dvořák 1938, Hradenín grave XXIV; Pleiner 1959, Lovosice grave III. Austria: very conspicuously at Hallstatt cemetery, Kromer 1958, 45; 1959. eastern France: Les Jogasses, Joffroy 1958, 437 (tumulus de la motte d'Aprémont).

[19] e.g. at Beilngries, Bavaria, cemetery Im Ried-Ost, graves 1, 11, and 80 (Torbrügge 1965).

[20] Sievers 1980, fig. 1: see her slightly different map in Kimmig 1976, fig. 85.

range in length up to 30 cm), and by spearheads, has been taken to indicate the importation of the idea of the hoplite-and-phalanx from the European South (Kossack 1959, 96). This can hardly be proved, although influence from the south on the ancient Celtic milieu of the Hallstatt D period is certainly a possibility. But Hallstatt D daggers do not give the impression of suitability for intense or prolonged combat, and in HD_1 were most likely to have been symbols of status and rank (Sievers (1980), 405 speaks of a *breite Führungsschicht*). In the subsequent HD_2 period, such daggers are found only in the richest princely tombs, many of which in fact contain no weapons at all (ibid.).

The reason for the temporary demise of the sword might be sought among the social processes of the late patriarchal tribal kings. These individuals were wealthy because they could still use (or abuse) the resources given to them voluntarily in the ancient manner by their communities, though this was now in the form of goods gathered in from much wider territories than before. But this period of short-term prosperity and relative stability in our view must have influenced the approach to the resolution of conflicts, which most likely were now of local scale. This marked the decline which led to the eventual collapse of the entire ancient patriarchal system. No longer was it able to stimulate general production in societies which were bound into networks of kinship and of prestige heirarchies (Frankenstein and Rowlands 1978; Pleiner 1979). The indigenous rulers, based in residences such as Mont Lassois, Heuneburg, and Hohenasperg, delegated their personal, physical responsibilities for battle. Instead, groups of followers and subjects, spear-carriers and clients, protected them and fought if necessary on their behalf. As a result the chief's sword became redundant.

It is more difficult to explain the reintroduction of the sword by those same Celts after the passage of some four to five generations. In fact, the renaissance of the Celtic sword coincides roughly with the great expansion of the Celtic groups, *pagi* and tribes into southern regions where the developed civilizations of early antiquity flourished. A readoption of older weaponry by the foremost warriors in response to what, for them, would have been completely new techniques of fighting encountered during their savage raids is understandable. But at what point did this process start, and where? It is accepted that the late patriarchal organization of Hallstatt D/La Tène A was a 'blind alley' which permitted neither substantial growth of production, nor any significant opportunities for advancement to an increasing number of ambitious members of ruling clans and their clients. This must have resulted in tension and unrest, exacerbated it seems by local overpopulation (Filip 1976, 60).

The fact is that some time during the fifth century BC, the most prosperous proto-Celtic region of south-west Germany put out offshoots into other regions, where the erection of monumental tumuli bore witness through to modern times of the might of their tribal rulers. Among the areas involved in these events were Upper Austria with its reinvigorated salt-mining industry, south-west Bohemia, and the flourishing region around the Moselle and middle Rhine valleys. Imported toreutics and other goods from the South, now mainly from Etruria, are conspicuous in the preserved cultural assemblages of the upper classes, recovered by archaeology both from settlements and from grave deposits.

The same phenomenon may be observed in the rapidly developing centre of Champagne where, nevertheless, the milieu is slightly different. There, a series of tombs containing the remains of chiefs who were buried with their chariots, helmets, spearheads, and, most significantly, once again with swords of what is now typical La Tène design, is well known from archaeological discoveries made since the end of the nineteenth century. Sites like St Jean-sur-Tourbe, Écury-sur-Coole, Sept Saulx, La Gorge Meillet, La Bouvandau at Somme-Tourbe, together with other tombs and graves in the region (in this case without chariots, but containing swords, spearheads, and shields), represent the initial stage of the Early La Tène period in the Marne region. The presence of Italo-Celtic products points to highly active contacts with the Appenine Peninsula before the explosive Celtic invasions of the South which began around 400 BC. Could Champagne be seen as the starting point for these? Surviving historical traditions offer no unambiguous evidence. According to Appian (4. 2), Celtic groups first set out from Burgundy and the middle Rhine regions. The legend, preserved by Livy (5. 33–5), of the emigration of King Ambigatus and his grandsons with their people to the Hercynian Forest and to Italy, points to origins in southern France (although this may well be a second-hand explanation of events). Names of the historically attested Celtic tribes and *pagi*, or sections of them, known to have invaded Italy, include the Boii, Lingones, Senones, and Insubres, indicating that many parts of Transalpine Gaul (both in present-day southern Germany and eastern France) may all have contributed elements to these movements of peoples.

We must thus be satisfied with the general hypothesis that it was the disaffected sons and grandsons of former patriarchal or tribal rulers, along with other members of their families, minor chiefs of various ranks, their kin, as well as groups from economically depressed regions,[21] who led them, as military *duces*, to the South, to Etruria, Picenum, Umbria, and Latium in search of wealth, land, and to establish themselves in their own right.[22] At the same time, other groups occupied neighbouring territories, both of those occupied by aboriginal proto-Celtic peoples (Bohemia), or (later) in the possession of other ethnic persuasions (Illyrian, Dacian, Thracian) in eastern Europe. Subsequently, the Celtic thrust cut through

[21] Kruta and Szabó 1979, 40–1 on infiltrations of Celts into Italy before 400 BC. Legends which may reflect this include that of a certain master-smith who settled in Rome and invited his fellow countrymen to share the pleasures of Italy: *Helico ex Helvetiis civis earum, fabrilem ob artem Romae commoratus, ficum siccam et uvam oleique ac vini promissa remeans secum tulisset. Quapropter haec vel bello quaesisse venia sit,* Pliny, *H. N.* 12. 2. 5; cf. Livy 5. 33.

[22] Both Greek and Latin historical tradition throw light on the lust of the Celts for booty, and their longing for the advantages of countries with more benign climates than their own (cf. n. 21 above). The Gauls attacked neighbouring Italy because of their acquaintance with its beauty. In other instances their movements were attributed to the search by the inhabitants of over-populated territories for new lands: thus, Pompeius Trogus in Justin 20. 5. 8: *his autem Galli in Italiam veniendi sedesque novas quaerendi . . .* Plutarch in *Camillus* 15 makes a rare allusion to previous Celtic expansion to the 'North Sea' before entering vine-bearing Italy. Appian 4. 2. 1 explains the movements as the result of over-population forcing the Celts to seek new lands.

the Balkans to Greece and Asia Minor. A veritable avalanche of raids and more sustained military campaigns were followed by periods of partial settlement in the newly conquered territories. These not only destroyed many ancient cities, but also the ancestral system of kinship within Celtic society. New military and territorial ties gave rise to a new social structure. The former traditional social stratification became less pronounced, and the new breed of kings were not distinguished by the same degree of splendour as their predecessors. This much can be inferred by archaeology from their material culture.

2

Styles of Combat among the Celts

We must now examine the way in which the Celts fought in the light of the social developments outlined in Chapter 1. The period to be discussed includes both times of invasions undertaken by the Continental Celts in the earlier stages of their movements as well as times when they were forced onto the retreat, and the periods when Celtic societies survived in the Atlantic fringes. After the initial shock caused by encounters with savage Celtic warriors, the supremacy of the ancient Mediterranean civilizations began once again to reassert itself, especially in the field of general military organization. It is interesting that the Celts, who after four centuries had reached a relatively high level of civilization and social organization in the wilder parts of Europe (most particularly Gaul), were not able to adapt their warfare to counter that of the Romans and Greeks who had developed a higher level of military science. The decisive conflicts between Rome and Transalpine Gaul in the middle of the last century BC, and between Romans and Britons in the mid-first century AD, demonstrated this contrast very clearly. In Europe and southern Britain, the Celts succumbed to Roman might, and it was only in marginal regions such as Ireland which Rome failed to occupy and to dominate that Celtic society and polity survived in a recognizable form.

The Written Evidence and its Value

Our sources for the ways in which the Celts waged war are in two main categories, Classical and native. By and large, the Classical sources have some recognizable historical value, and the earliest are those of the Mediterranean world, but unfortunately these are fragmentary. The works of the earlier and later Roman annalists (second half of the third century BC, second half of the second century BC) which might have contained first-hand accounts of Celtic warfare in Italy survive only as minute extracts incorporated in the works of other ancient authors. But these writers were not much concerned with the presentation of authentic historical information, since their works had quite different purposes. Moreover, such information as they gave was not particularly objective, and they suppressed unpalatable circumstances and events. With few exceptions, Classical writers worked with the aid of earlier sources, often modifying certain observations, transferring episodes wholesale into other situations and contexts, sometimes inventing or copying quite fictitious speeches to be ascribed to historical personalities. Thus, what has survived presents considerable problems of interpretation and evaluation. Nevertheless, a general picture may be sketched from the data which it preserves.

The second source comprises a large body of vernacular texts the earliest of which, written in Old Irish, have come down to us from the middle of the first millennium AD onwards. Written in a Celtic dialect, this material contains embedded within its complicated stratigraphy a wealth of references to the practices and beliefs of insular Celts, but drawn ultimately from the common Indo-European ancestry which they shared with their British and European relatives. Although other later material can contribute to our understanding of warfare among Celtic peoples, it is to early Irish writings that we shall look in this study both for information and for comparison with the Classical sources. But we must emphasize that the texts must be treated with great caution since the material does not refer directly to historical events of the last centuries BC (except in politically motivated genealogies and in pseudo-histories), and was only beginning to be written down in the mid-first millennium AD after an indeterminately long period of oral transmission. Jackson (1964) has described the Irish material as providing a 'window' on the Iron Age, albeit one through which we receive a somewhat misty and distorted image. Nevertheless, we can find useful corroboration of at least some of the observations of the classical writers, and sometimes use our native material to expand on them.

(a) The Classical Sources. Among the classical sources, it is fortunate that one of the earliest authors to deal with Celtic affairs was Polybius (*c.*208–125 BC), a man who had himself received a military education and taken a personal part in military operations (he commanded the Achaean cavalry). His work shows him to be a critical historian with direct personal knowledge of the places he discusses. He travelled through Cisalpine Gaul, and his descriptions of the events that took place some three generations before him during the Roman offensive against the Celtic Insubres and Boii may be taken as relatively reliable. In his accounts of the battles fought near Telamon (225 BC) and Clastidium (222 BC), he apparently followed the account of Q. Fabius Pictor, an annalist of the older Roman group, who is believed to have participated in the operations.[1] Polybius has left us with a great deal of information concerning Celtic warfare in the third century BC.

Polybius served as an authoritative source for other important authors who have supplied us with records of the Celtic wars in Italy. Posidonius (157–137 BC) in his *History*, now preserved only fragmentarily in the work of Athanaeus, recorded some ethnographic data taken from reliable sources, although it is not really informative on military matters. Like Polybius and Posidonius, Diodorus Siculus

[1] Eutropius 3. 5; Orosius 4. 13. 6 (*Fabius historicus qui eidem bello interfuit scripsit*). For discussion of the nature of the main written sources dealing with Celtic military affairs, see Seyffert 1902; Dobiáš 1948; Walbank 1957; Drews 1962; Pédech 1964, 1969; Rambaud 1951; Duval 1971.

(80–36 BC) also made use of the work of Roman annalists, including possibly Q. Fabius Pictor, using his sources in a critical manner. Like those of Posidonius, Diodorus' observations are primarily ethnographic, and also seem to allude to situations current in the third century BC. An ethnographic approach was the natural one for Strabo (63 BC–AD 19) to adopt for his *Geography*, in which he described foreign peoples and their customs. In his historical excursions he used sources of varying reliability, of which Polybius is without doubt the best. Dionysius of Halicarnassus (second half of the last century BC) in his *Roman Antiquities*, followed the later Roman annalists. Excerpts from his book 14, dealing with the Celtic invasions of Rome in the fourth century BC are preserved in the work of Constantine Porphyrogenitus.

Julius Caesar (followed by Hirtius) deviated from the usual practices of ancient historians. Despite the overtly political nature of his *Commentarii de Bello Gallico*, which laid heavy emphasis on the success of Roman arms and in particular the importance of the author's role in all of the campaigns before the mid-first century BC, there is no doubt that his descriptions of Gallic activities are sober and accurate. Interestingly enough, he gives no detailed information on Celtic weaponry in his text. What is clear is that the style of Celtic warfare which he encountered differed from that which was remembered from the raids on Italy centuries before. Evidently it had been influenced by specific developments in Roman military organization, or at least bore some of the marks of Roman style, although it remained inferior.

Livy (59 BC–AD 17) in his monumental *Ab Urbe Condita* deals with earlier Celtic raids. But his books relating to an important period of Roman successes in Cisalpine Gaul (from 293 to 218 BC) unfortunately are now lost. In his reports of later events (the Punic Wars in Italy, Gauls in Asia Minor and Greece, and the wars against Attalus in the early second century BC) it is difficult to distinguish elements of general tradition concerning the Celts from what may be specific information about individual areas and definite periods. Livy used many sources which, except for Polybius, are now also lost. Valerius of Antium whom he frequently quotes was one of the least reliable of the group of Roman annalists. Descriptions of military events (not very exact in Livy) were derived from Coelius Antipater (*Bellum Punicum*, after 121 BC) who is renowned for his exaggerated style.

Among writers of the first and second centuries AD who relied on known as well as unknown or unconfirmable sources we should note the work of Silius Italicus (AD 25–101), whose *Punica* includes references to the Celts in Spain. Of greater interest is the writing of Plutarch (AD 50–120) who took an interest in the wars against the Celts in three of his biographies (of Romulus, Camillus, and Marcellus). He was not a historian in the proper sense, his main concern being to stress the moral rectitude of prominent public figures. If we may thus interpret his remarks, he recorded the general tradition on Celtic warfare, citing several hundred authors. Tacitus (AD 55–117) commented on the military struggles in Britain in his *Agricola* and *Histories*, and on post-Caesarian events in Gaul in his *Annals*. Appian (AD

90–169) wrote his history of Rome in several ethno-historical sections. In the fourth book, entitled *Celtica*, he gives some information relevant to our subject in tales about the Celtic siege of Rome in the fourth century BC. He also refers to one of the last victories of the Celts in northern Italy, the defeat of Roman troops under Piso Caesonius and L. Cassius by the Helvetian Tigurini in 107 BC (cf. Livy *Perioche* 473). He quotes Publius Claudius who used to be identified (wrongly, according to Duval)[2] with the Roman annalist Quintus Claudius Quadrigarius (second–first centuries BC), author of a history of Rome from the Gallic invasion down to his own times. There are, however, interesting excerpts from Claudius Quadrigarius in the ninth book of the *Noctes Atticae* of Aulus Gellius, a writer of the Antonine period. Pausanias the traveller and geographer of ancient Greece (second half of the second century AD) included in the tenth book of his *Periegesis* some interesting remarks on Celtic fighting in Greece (of the third century BC) based on earlier accounts whose reliability is open to doubt.

Florus' abridged history of Rome, the *Epitome*, quotes several passages dealing with the Gallic wars, both those in the early fourth and third centuries BC and those with the Allobrogi in southern Gaul in the second century BC. The inaccuracy of this author requires that his work be approached with great caution. Polyaenus (second century AD) was the author of a specific military treatise, the *Strategemata*, but with regard to the Celts he seems merely to have repeated Polybius' account of the battles with the Gaesatae but transposing it to the time of Camillus. Some information on Celtic warfare survived in the works of later writers such as Justin who preserved valuable sections of the work of the second-century author Pompeius Trogus. (Although he himself was a Gaul, Trogus was not very informative on the warfare of his people.) Aelian AD 175–239 wrote on interesting details of the history of the ancient world. All of these writers confirm the deep and lasting impression made on the Mediterranean civilizations by the impact of the Ancient Gauls.

On surveying the Classical sources described above, we find that the largest body of realistic and reliable data is concerned with the North Italian wars between the Romans and the Celtic Insubres, Boii, and Senones in the third century BC, and the battles at Sentinum, Telamon, and Clastidium. At Sentinum, close to the Appenine passes, the Romans achieved their first important victory over the allied strength of the Senones, Samnites, Umbri, and Etruscans in 295 BC (Polybius 2. 19; Livy books 27–30). Later, in 225 BC, at Telamon near the Etruscan coast, the Romans defeated the Insubres and Boii, despite losing their consul Atilius. The account of that battle includes a most instructive detail of Celtic fighting ritual, namely the actions of the Alpine Gaesatae in the front ranks (Polybius 2. 27). The operations of that time against these Celtic tribes were crowned by the victory of M. Claudius Marcellus over the king of the Gaesatae, Viridomarus, or Britomartus, at Clastidium, a Celtic *vicus* (γαλατικὴ κόμη) on the Via Postumia in 222 BC (Polybius 2. 34: Plutarch *Marcellus*, 6–7). It was in this period that the Roman

[2] Duval 1971, i. 229.

Republic began to take the initiative, following the shock of the Celtic invasion of Rome (390 or 386 BC) and the repeated raids which reached the Etruscan centres in the vicinity of Rome. The terrifying impression caused by the appearance of the barbarian hordes in the early fourth century BC, though deeply felt, was not described in detail in later literary works, even though it lived on in popular tradition for many centuries.

There are a relatively large number of passages in the historical works of Greek authors dealing with the Celtic invasions which passed through the Balkans and northern Greece into Asia Minor (third century BC), and the struggles with the Galatae (second century BC). A small amount of information, however, concerns the Celtic troops who were allies of the Carthaginians against the Romans in the wars with Hannibal and with the Celtiberians in Spain. In Caesar's commentary on the wars in Gaul proper (first century BC) we shall find, as we noted above, more general outlines of Celtic warfare, but few details of their armaments. Later reports of the campaigns in Britain (first century AD) record some traditional and archaic aspects of Celtic combat practices in the island.

(b) The Early Irish Sources. Early literature written in Old Irish and Latin, and dating from the second half of the first millennium AD includes heroic tales, law texts, poetry, annals, genealogies, the lives of saints, and origin legends, although here we shall restrict discussion to the heroic tales. It might seem that such texts should be excluded from our study, given an apparent gap of at least eight centuries between the Continental and British *floruit* of the Celts and the first recensions of the Irish texts. Nevertheless, Ireland was the home of a Celtic society which survived long after those elsewhere had lost their contests with the Roman world, and it is clear that many of the elements surviving in later written records had been transmitted orally over a substantial period. While extreme caution is required, Jackson's view (1964) that we can extrapolate back towards the start of the first millennium with some degree of confidence for some elements makes this literature a potential source of general information to be compared both with the evidence of Classical authors and the archaeological evidence.[3]

The early Irish tales must be treated for our purposes as having none of the historical value of the Classical sources. There is a reasonable concensus that there must have been bases in historical fact for many of the stories and the personalities involved, but any search for them is irrelevant here. It is also recognized that running through Irish heroic literature there are strong currents of Indo-European myth and legend, linking Ireland with the Celtic heartlands in Europe. Thus, in the same way that we can use Homer's *Iliad*, another product of oral transmission over several centuries, to throw light on the way in which warfare developed in the Classical world, we can use the Irish material to flesh out some of the detail on the skeleton built from the Classical writers on its later forms.

[3] A brief survey of the parallels between the Irish and Classical writers is given by C. O'Rahilly in the introduction to her edition of *Táin Bó Cúalnge* (O'Rahilly, c.1970, pp. x–xvi).

The problems of drawing out detail to check against archaeological evidence are insurmountable if we try to follow the nineteenth-century Celticists and try to take our texts literally.[4] For example, although the chariot is prominent in tales of warriors, Greene (1972) has shown just how unreliable is the impression which is given. Even when we have archaeological survivals, such as swords, we are unable really to match the swords ascribed to the major heroes with appropriate types from our collections (cf. Mallory 1983; Scott 1990, 171 ff.). Here at least one problem is the imposition of later models into earlier contexts. Furthermore, when we try to come to grips with finer detail, it usually eludes us, because the purpose of those who told and wrote down these stories was not to provide a handbook for archaeologists, but, ultimately, to glorify particular dynastic groups, and of course to entertain. If we look at descriptions of swords, for example, their ornamentation is portrayed in terms that leave the audience in no doubt that possession of such weapons marked down the owners as special. But it is only rarely that we are told what the swords were made of (Scott 1990, 172).

In fact, we may consider the artefacts which appear in the heroic tales as the props put, of necessity, on the stages on which the actors played their allotted roles, being there for verisimilitude. But it is this lack of interest in mundane detail that is, in fact, of value since we can often detect elements of the ordinary which have escaped the exaggeration and distortion frequently employed for dramatic effect.

The richest body of information comes from the tales which comprise the so-called *Ulster Cycle*, and which centre on a conflict between the northern and southern parts of the island. This is nowhere better seen than in the epic *Táin Bó Cúalnge* ('The Cattle Raid of Cooley'), whose first recension may well have been recorded from oral tradition as early as the mid-seventh century AD. The comparisons here with the heroic traditions of Gaul recorded by the Classical writers are striking, with the same elements of combat and battle appearing both in fiction and 'history', while each source is independent of the other.

The Nature of Continental Celtic Warfare during the Great Invasions

Of all the ancient civilizations that had achieved high levels of general production to supply the needs of everyday life, and of social organization, the first to experience the wild attacks of the Celts were in Italy, namely the Etruscans, the Italiote states, and the Romans. The ancient writers all ascribe the invasion by the Haeduan Insubres, Cenomani, Lingones, Boii, and Senones to two basic motives, first the overpopulation of the Celtic regions around the Alpine massif,[5] and second the lure of the pleasant and wealthy South.

[4] For a discussion of the value of the early Irish texts in elucidating archaeometallurgical problems in general, see Scott 1990, 170 ff.

[5] Above, Ch. 1, n. 22. For indirect references to the large numbers of the invaders as exceeding those of the Romans, cf. Polybius 2. 17. 3, 2. 23. 1; Livy 5. 35; Florus 1. 13; Justin 24. 4. 1. No doubt these are exaggerations, but it is significant that all of these descriptions refer to great numbers of Celts.

A number of parties drawn from among the Celtic tribes raided North Etruscan and Umbrian colonies even before the great avalanche of raids that descended on Rome in 390 BC (or, according to Polybius, in 387/386 BC). From then on, Celtic raids in the South, heavy enough to be considered a serious menace, were repeated at least once a generation throughout the fourth and third centuries BC.[6]

The citizens of the Cisalpine regions were horrified by the savage way in which the Celts prosecuted their campaigns. The hordes of men with their unusually large physiques and barbarian battle-customs filled them with *terrore Gallici nominis*. Celtic warriors provoked their enemies before battle (Diodorus 5. 29) with 'senseless bravado' (Dionysius of Halicarnassus 14. 9. 15), threatened them by shouting, singing, and by brandishing and clashing their arms. They immolated their captives and decapitated the enemy dead. The ritual basis of these practices is reflected in reports by Diodorus (5. 29. 4), by Strabo (4. 4. 5) and Silius Italicus (13. 382). The desperate aspect of the naked fighting men of the Gaesatae, equipped solely with their arms and golden ornaments created a horrific impression (Polybius 2. 29 and 30). The nudity of selected warrior groups was certainly based on symbolic and ritual approaches to lethal combats, and achieved a considerable psychological effect.[7] When Camillus captured some Celtic warriors, Appian (second century AD: 4. 8) records that:

> [Camillus] showed them [the Celts] naked to the Romans and said 'These are the creatures who assail you with such terrible shouts in battle, clash their arms and shake their long swords (ξίφη μακρά) and toss their hair.

Almost all accounts of the Celts and of the Celtic wars agree that the Gauls were cruel, wild, bellicose, and brave.[8] Dionysius of Halicarnassus (end of the first century BC) wrote (14. 10. 17):

> Thus at one moment they would raise their swords aloft and smite after the manner of wild boars, throwing the whole weight of their bodies into the blow like hewers of wood or men digging with mattocks, and again they would deliver crosswise blows aimed at no target, as if they intended to cut to pieces the entire bodies of their adversaries, protective armour and all . . .

The combination of their numbers and their audacity was particularly effective, especially in the first encounter, as their adversaries recognized. As soldiers, the temperamental Celts were impatient and with little endurance. After an unsuccessful attack, they soon lost heart and tired.[9] As a result, initial successes were often

[6] According to Polybius (2. 18–23), there were some 16 serious raids in the period 386–222 BC.

[7] Diodorus (5. 30) also reports that the Celts fought naked, but this evidently did not apply to all of their warriors since in the same passage, he described Celtic armour (which is often mentioned by other authors). Polybius makes a clear distinction between the Gaesatae and the rank-and-file Boii and Insubres who wore trousers and cloaks.

[8] *Gens natura ferox* (Florus 1. 13); *gens aspera, audax, bellicosa* (Justin 24. 4. 1). As early as the 4th cent. BC, Aristotle (*Politics* 7. 2. 5) had included the Celts among belligerent barbarian peoples like the Illyrians, Persians, and Scythians.

[9] Livy 7. 12; 10. 28, or in the fictional speech ascribed to Cn. Manlius Vulso before the battle with the Galatae to the effect that 'it was essential to withstand the first blind impact of the Galatae . . .'

turned into decisive defeats and routs. The absence of sophisticated military tactics and of control of operations, in certain instances at least (the earlier Italian campaigns, and those in Greece and Galatia in Asia Minor) was another striking characteristic noted by Greek and Roman observers.[10] Pausanias, however, expressed a different point of view, noting the effectiveness of the system of three-rider units (*trimarkisia*) in equestrian combats in Greece.[11] Caesar too in the first century BC spoke several times of organized and tactically handled units.[12]

The Romans countered the tactics of their opponents through co-ordinated and disciplined defence and offence. Dionysius of Halicarnassus described their counter-measures thus (14. 10. 17):

While their foes were still raising their swords aloft, [the Romans under Camillus] would duck under their arms holding up their shields, and then stooping and crouching low, they would render vain and useless the blows of the others, which were aimed too high, while for their own part, holding their swords (ξίφη) straight out, they would strike their opponents in the groin, pierce their sides, and drive their blows through their breast, into their vitals.

Similarly, in his second-century AD *Strategemata* (8. 7. 2), Polyaenus, probably quoting from Plutarch, wrote:

[Camillus] as protection against Celtic swords which slashed down and cut open heads, had helmets constructed entirely of iron so that the swords would either glance off or be broken; he had the shields sheathed with copper, as wood alone was no protection against the blows . . . For the iron of the Celts was badly wrought; it bent easily and their swords buckled and were no use for fighting.

At the end of the first century AD, Tacitus (*Agricola* 36) desribed the way in which the Agricola countered the tactics of the Britons:

. . . until Agricola exhorted four batallions of Batavi and two of Tungri to bring things to the point of the sword and to hand-to-hand fighting; a manœuvre familiar to them from long

primum impetum quem fervido ingenio et caeca ira effundunt) Cf. Florus 2. 4: *quippe sicut primus impetus eis maior quam virorum est, et sequens minmor quam faminarum* (paraphrasing Livy 10. 28). On the other hand, Polybius (2. 30. 7) records the gallantry of the decimated Gaesatae at the battle of Telamon.

[10] The Gauls were described as fighting like wild beasts (Livy 38. 21; Dionysius of Halicarnassus 14. 9. 15; Florus 2. 4; Pausanias 10. 21). They are also said to have attacked unintelligently, without any clear leadership and with no battle discipline: thus, Livy 7. 12: *in proelium ruunt primaque pugna coepit quam signum ab ducibus daretur*; ibid. 24: *inde barbari dissipati nec certa imperia nec duces essent*; Tacitus *Histories* 1. 67: *non ordines sequi non in unum consulere*. Polybius on the other hand admired the sophisticated circular defensive formation of the Gaesatae at Telamon in 225 BC. Livy (10. 29) refers to the closed ranks of the Celtic warriors and to their deployment of the *testudo* at the battle of Sentinum.

[11] Pausanias 10. 19. The leading horsemen were accompanied by two mounted attendants or slaves (οἰκέται, δοῦλοι) who took the places of their lords if they were killed. A similar use of substitutes (παραβάται) is referred to by Plutarch (*Aemilius Paulus* 12. 4) and ascribed to the Bastarnae who, according to some writers, were a tribe of Celtic origins. Livy too alludes to soldiers running behind horsemen and replacing them if necessary (44. 26. 3: *veniebant decem milia equitum, parnumerus peditum et ipsorum iungentium cursum equis et in vicem prolapsorum equitum vacuos capientum ad pugnam equos*).

[12] e.g. *BG* 1. 24: the Helvetii *confertissima acie reiecti nostro equitatu phalange facta sub primum nostram aciem successerunt* . . .; ibid. 25: *milites* . . . *pilis missis facile hostium phalangem perfregerunt*. Cf. 7. 28 (also 7. 62): *cuneatim constituerunt* . . . *acie instructa depugnarent*. The *testudo* of the ancient Gauls is mentioned at 2. 6 *Dumnorix instruit aciem* (*BG* 8. 29, by Hirtius).

service and embarrassing to the enemy whose shields were small and whose swords too long; for the British swords, without points, were of little use against locked lines and in fighting at close quarters.

Apart from these depictions of wildly energetic but ill-disciplined onslaughts by Celtic warriors on foot, we should note two other features in particular, namely the very effective use of cavalry, often co-operating with war chariots, and the unusual use and appearance of Celtic arms (Florus 1. 13: *ingentia arma*; Livy 5. 34: *invisitata gens armorum*). We have already referred to the fact that the earliest use of horses on the battlefield was either in harness to chariots or as the means of transporting warriors to the field. The Celts used war chariots long after this mode of fighting had become generally obsolete, even forgotten, elsewhere in the ancient world.[13] Horseman in Antiquity after riding to the battlefield, usually then fought on foot. This was reported of the Celts only as a curiousity in the peripheral area of Celtiberia, and then only in the final phase of an encounter.[14] As a rule, Celtic cavalry fought from horseback, and its superior quality was frequently noted.[15]

To sum up then the general picture of the style of fighting of the Celts, it seems that after contact with the enemy had been established, and after single-combats had taken place, a more general mêlée developed involving the clash of chariotry and cavalry (often on the flanks). The crucial stage of the action came with the first impact of forces, the initial phase of which was marked by a collective and co-ordinated discharge of missiles, a tactic common to both sides.[16] We should not forget that Celtic throwing and thrusting spears were so famous that in Greek and Roman terminology, four original Celtic terms have been taken as loan-words to denote these weapons: *lancea* (λαγκία), *mataris* (μάδαρις), *saunion* (σαύνιον), and *gaesum* (γαῖσον).[17] After the missiles had been discharged[18] and the charioteers (if any) had dismounted and joined the other fighters, the combat continued at

[13] In Italy, at least until the end of the 3rd cent. BC. At Telamon, chariots fought on the flanks (Polybius 2. 27; Diodorus 5. 29), while at Sentinum there were two-wheeled *essedae* and four-wheeled *carrae* (Livy 10. 28). Propertius (4. 10. 39) refers to king Viridomarus fighting from his chariot, while Plutarch explicitly refers to combat on horseback (*Marcellus* 7). Bituitus, the defeated king of the Allobrogi, was paraded in triumph on the silver-ornamented chariot from which he used to fight (*nil tam conspicuum in triumpho quam rex ipse Bituitus, discoloribus in armis, argenteoque carpento, qualis pugnaverat*: Florus 3. 2). Chariot fighting survived among Celts in Britain until at least the 1st cent. BC (*BG* 5. 15; Strabo 4. 5. 2). Latin *carpentum* in fact is a loan word from Celtic **karbanto-*. The later-recorded Irish sagas place much emphasis on chariotry, although there are great difficulties both with the Old Irish terminology and with precise analysis and interpretation of the texts (Greene 1972).

[14] Diodorus 5. 33. 5: 'when they have defeated the cavalry they dismount, and assuming the role of foot-soldiers they stage marvellous battles . . .' (tr. Oldfather). The dismounting of Celtic horsemen to fight (Tectosagi and Trogmi in Asia Minor) is mentioned by Livy (38. 26, although this was due to the unsuitability of the battlefield (*equitatum, quis equorum nullus erat inter inequales rupes usus, deductum*).

[15] See above, n. 11. For further evidence of Celtic troops in cavalry battles, cf. Polybius 2. 27. 9 etc.; Caesar *BG* frequently; Silius Italicus 4. 147 f. Strabo (4. 4. 2) writes that although the Celts were all fighters by nature, they were better as cavalry than as infantry (κρείττους δ' ἱππόται ἢ πεζοί), and that the best cavalry which the Romans had at that time came from among them. According to Plutarch (*Marcellus* 6), the Gauls at Clastidium ignored Roman horsemen because their own were superb (κράτιστοι γὰρ ὄντες ἱππομαχεῖν).

[16] Polybius 2. 30; Diodorus 5. 21. 1; Caesar *BG* 1. 25; Livy 10. 28.

[17] Holder 1896, i. 1517–20, ii. 131–9, 458 (*mataris* might also be a form of Celtic throwing-axe), and 1382.

[18] The use of other missiles (arrows, sling-stones, throwing-axes) was of minor importance in Celtic warfare. For references, see Dottin 1915, 277–81.

close quarters either with another thrusting spear[19] or with the sword. Swords were used to slash and to cut, and presumably the denser the mass of fighters the less effective could this be.

Single Combat and the Survival of Archaic Customs in Fighting

In the full-scale operations of Antiquity, where masses of Celts were engaged, it would seem that little place could have been left for such an archaic mode of fighting as single combat. Nevertheless in the works of the Classical writers, there are striking allusions to it in relation to the Gauls, while in the Irish sources single combat is a common motif. As the sword had a role in duels, although not as the sole weapon of offence but along with the thrusting and throwing spear, it will be useful to look at this practice in some more detail.

Both Posidonius and Diodorus mention duels between warriors in the course of their ethnographic accounts of the Celts. Posidonius describes famous duels off the battlefield, in the course of feasts, where the prize was the prestigious haunch of meat.[20] Diodorus, on the other hand, writes that when approaching the enemy, renowned warriors at the front of the band would challenge their adversaries to single combat. He wrote (5. 29; trans. Oldfather 1961):

> It is also their custom when they are formed for battle, to step out of the line and to challenge the most valiant men from among their opponents to single combat, brandishing their weapons in front of them to terrify their adversaries. And when any man accepts the challenge, then they break forth into song in praise of the valiant deeds of their ancestors and to boast of their own high achievements.

Beneath the superficial appearance of almost casual violence at barbarian feasts and on the battlefield, there runs a clear theme of ceremony, if not rite, as the overture to the general battle and, in some cases, a decisive influence on its result.

Among duels that are reported in historical contexts, the earliest is the success of Q. Fabius Ambustus in an equestrian duel with a Gallic chief in a skirmish near Clusium (387 BC). Unfortunately, Fabius was one of a group of ambassadors, and this event had an unfavourable influence on the development of the first war between the Gauls and Rome.[21] Before the battle of Anienum (*c.*360 BC) an

[19] A pair of Celtic spears is referred to e.g. by Livy (9. 36. 6) and Virgil *Aen.* 8. 661 f. As will be evident from the discussion, the comparative frequency of use of sword and spear by Celtic warriors in different regions and at different times is difficult to assess. We may note, for example, the tribal name *Gaesatae* whose first element is cognate with Old Irish *gae* 'spear'. It is also instructive to note that the Old Irish term for a warrior, and champion is *gaiscedach*, while the expression *gaibid gaiscedach* means 'assumes arms'. For a discussion of the role of the sword and spear in earlier Iron Age Ireland see Scott 1990, 95.

[20] Posidonius reported that during feasts the Celts often fought duels, more or less for form's sake, despite suffering injuries. But a hero who was awarded by the host with a haunch of boar was ready to defend it against all-comers in armed hand-to-hand combat which could be to the death unless the intervention of others put an end to the combat (fr. 16, at Athenaeus 4. 40: cf. Jacoby *FGrHist* iiA, 230).

[21] Livy 5. 36: the inevitable taking of the enemy's armour is mentioned also.

anonymous, well-built Gallic warrior in his brightly coloured garments and gold-ornamented and painted arms (*versicolore veste pictisque et auro caelatis refulgens armis*: Livy 7. 10) provoked the Roman forces until Titus Manlius accepted his challenge to the duel. With the permission of his commander,[22] Manlius killed him and took his necklace (*torquis*) as a trophy, thus winning himself the honourable cognomen Torquatus. Livy (7. 10) describes the events thus:

The Gaul, whose huge bulk towered above the other, advanced his shield with the left arm, to parry the attack of his oncoming enemy, and delivered a slashing stroke with his sword that made a mighty clatter, but did no harm (. . . *inminens proiecto laeva scuto in adventis arma hosti caesim cum ingenti sonitu ensem deiecit*). The Roman, with the point of his weapon raised, struck up his adversary's shield with a blow from his own against its lower edge; and slipping in between the man's sword and his body, so close that no part of his own person was exposed, he gave one thrust and then immediately another, and gashing the groin and belly of his enemy brought him headlong to the ground (*Romanus mucrone subrecto . . . ventrem atque inguina hasta . . .*).

A version of the same incident appears in the second century AD work of Aulus Gellius (9. 13) who quotes verbatim from Q. Claudius Quadrigarius (writing about 100 BC):

Manlius, armed with an infantry shield and Hispanic sword, advanced against the Gaul . . . according to his customs, the Gaul held up his shield singing. Manlius, relying more on his courage than his skill, dealt him a blow shield-to-shield and upset the Gaul's stance. While the Gaul tried to regain his balance, Manlius once more struck his shield against that of his opponent again knocking the man from his position. In this way he got under the Gaul's guard and stabbed his Hispanic sword into his breast (*Manlius scuto pedestri et gladio hispanico cinctus contra Gallum constitit . . . Gallus sua disciplina scuto proiecto cantabundus: Manlius animo magis quam arte confisus, scutum scuto percussit, atque statum Galli conturbavit. Dum se Gallus iterem eodem pacto constituere studet, Manlius iterem scutum scuto percutit atque de loco hominem iterem deiecit. Eo pacto ei sub Gallicum gladium successit atque Hispanico pectus hausit*).

According to tradition, the outcome of Manlius' victory was that the Gauls retired from the field the next night.[23] This tale displays the quintessential contrast between Mediterranean fighting with short swords and Celtic (or Iron Age and preceding Late Bronze Age) fighting with long cutting swords. Both types of sword, the pointed Hispanic and unpointed Celtic, appear again in Livy's account of the battle of Cannae (22. 46).[24]

[22] Roman troops were not allowed to start fighting spontaneously, and were punished for infringing this rule.

[23] Livy 7. 9–10. Presumably, this tale has its origins in the lost annals of Q. Claudius Quadrigarius, which should date to the 1st cent. BC, and which are referred to by Aulus Gellius in his *Noctes Atticae* (9. 13). There is described a gigantic naked Gaul, adorned with a necklace and bracelets, and carrying a shield and two swords (*Gallus quidam nudus praeter scutum et gladios duos torque atque armillis decoratus processit*). However, of his two swords, he used only one, with the outcome of the duel being as reported by Livy. For problems concerning authenticity see below, n. 19. Dottin (1915, 271) adds that Polybius (2. 18. 6–7), while recording the nocturnal escape of the Gallic troops, fails to mention the duel.

[24] The Hispani and Gauls were allies of Hannibal. Of them, Livy writes (22. 46); 'The Gauls had extremely long swords (*praelongi gladii*) but without

A famous duel, in a very similar setting, took place sometime around 349 BC during one of the Celtic campaigns. A huge Gaul challenged the Romans, and Marcus Valerius, a young military tribune, was allowed to defend the Roman honour. The purpose of the tale was to underline the symbolic significance and moral support of the happy omen when a raven (*corvus*) perched on the Roman's helmet, facing the enemy and pecking at him. Valerius, who killed the Gallic warrior, stripped the body of its armour as spoil and named himself Corvinus. This single combat was the signal for a general battle which was won by the Romans (Livy 7. 26: Florus 1. 8). These tales are legendary, and their purpose was to celebrate the foremost Roman families, such as the Fabii, Manlii, and Valerii.[25] However there must here be some historical core, since ancient Rome had also many famous *gentes* who were not glorified in legends of their prowess in single combat.

Another single combat took place during the battle of Clastidium (222 BC), where the Consul, M. Claudius Marcellus attacked the cavalry of the Gaesatae under their king Viridomarus (or Britomartus in corrupted form). Both commanders, Viridomarus with his insignia (σύμβολα), rode out in front of their squadrons and the Gaul challenged Marcellus by brandishing his spear. As other prominent Celtic warriors, Viridomarus is described as a man overtowering his followers and distinguished by his brightly coloured armour which glittered with gold and silver.[26] Naturally he lost the contest, pierced through by his adversary's spear. The point to note is that Marcellus declared himself to be the third Roman commander-in-chief to have killed his opposite number in single combat, and therefore he decided to consecrate the despoiled armour (*spolia opima*) in the temple of Jupiter Feretrius at Rome, following the examples of Romulus and Cornelius Cossus.[27]

There are two other duels to be noted in which leading personalities participated. In one, an equestrian contest fought with spears, P. Cornelius Scipio (later Africanus Major) killed Crixus the King of the Boii and Senones who was an ally of Hannibal. Crixus had slain many renowned warriors on the Roman side before Scipio put an end to his bravery in the no-man's land between the two armies.[28]

points (*sine mucronibus*); the Hispani on the other hand had appropriately short and pointed swords, more suitable for thrusting than cutting at the enemy.' Strabo (4. 4. 3: trans. Jones 1960) writes: 'The Gallic armour is commensurate with the large size of their bodies: a long *machaira* (μάχαιρα μακρά) hangs along the right side.'

[25] So *RE* vii A 2, 2414 (s.v. Valerius Corvus). There has been much discussion as to which of these stories served as the model for the other, and as to the identity of the original author. The article cited discusses the various opinions and analyses all of the passages in which traces of these legends are found. It should also be remembered that the great Celticist Hubert noted the unique nature of the Corvus story in Roman pseudo-history, drawing attention to the very similar motif in *Táin Bó Cúalnge*, and suggesting in fact that this story was borrowed through Gaulish contacts (Hubert 1934, 31).

[26] Polybius 2. 34. 5; Plutarch *Marcellus* 7; Propertius 4. 10. 39. According to the poet, the king wore striped trousers and protected himself with a Belgic shield while fighting from a chariot. Cf. Cicero *Tusc.* 4. 49; Florus 2. 4.

[27] Roman legends stated that Romulus overpowered the Caecinian king Acro in single combat, and consecrated his armour to Jupiter. Cornelius Cossus defeated the Etruscan king Tolumnius of Veii (Propertius 4. 10; Plutarch *Romulus* 16. 5–6, *Marcellus* 8. 6).

[28] Silius Italicus (*Punica* 4. 155–291) describes the golden *torquis* and gold-ornamented armour of Crixus. His defeat in this duel led to the flight of the Celtic forces.

Much later, P. Cornelius Scipio Aemilianus when taking part in Spain around 150 BC with the rank of military tribune, displayed outstanding courage in accepting the challenge of a powerfully built Celtiberian warrior who wore, as usual, his golden jewellery and display-weapons. Despite his small stature, Scipio gained the victory. Unfortunately we have no details of the tactics and weapons of the protagonists.[29]

In our view, these picturesque tales reflect the fact that the ancient institution of single combat between leading warriors or even leaders prevailed in the distant past among the Romans, but had been nearly forgotten by them at a time when the Celts kept this archaic tradition alive until at least the second century BC in Europe. It was conducted ceremonially, beginning with the boasting of personal prowess, provocation of the enemy, and brandishing of weapons, followed by the issuing of a formal challenge. Ostentatious dress and arms were also customary, at least in some of the more important contests. All of these details fit together perfectly with the rules of archaic combat that can be seen in the Irish and Norse sagas of the first millennium AD, and which survived through to the Middle Ages (cf. Huizinga 1956, 90–102). These combats had considerable psychological and moral effects and on their outcomes often turned the results of entire military operations.

Single combat between famous warriors is a constantly recurring motif in the early Irish sources. As with the combats described by Livy and others, the Irish contests are preceded by the ritual parading and display of weapons. Thus, in *Táin Bó Cúalnge* (1383 f), the hero Cú Chúlainn confronts the army of Queen Medb at Drum Én (O' Rahilly, *c.*1970, 38):

> That night the men of the four great provinces of Ireland came and encamped at Drum Én . . . that night Cú Chúlainn waved and brandished and shook his weapons [at them] so that one hundred warriors died of fright . . .

Following such displays came the verbal exchanges. Single-combats were such a common motif of the early story-tellers that unless the duellists were of particular importance, description of the ritual was often reduced to a cursory note prefacing the hero's despatch of his opponent. Single combat was sometimes avoided, with subsequent loss of face. In *Cath Maige Mucrama* (O Daly 1975, 41 ff.), it is told how Mac Con, fearing defeat, sought to avoid single combat with Eogan by substituting a look-alike in the person of his jester. The discovery of this deception did not enhance Mac Con's reputation! When the contest was between two warriors of high reputation and worthy opponents one for the other, accounts of proceedings are more detailed. Of all single combats described in the heroic literature, none has the poignancy and detail of the fatal clash between Cú Chúllainn and Fer Diad, friends in earlier years, who fought an epic duel over several days with throwing spears, thrusting spears, swords and shields (*TBC* 2607 ff.), which ended with the death of Fer Diad (by spear thrust). Both heroes dressed with special care for this combat (*TBC* 3230 ff.), with Fer Diad being arrayed in 'his

[29] Appian 6 (*Iberica*), 53.

filmy satin apron with its border of variegated gold . . . his crested helmet of battle which was adorned with forty carbuncle-gems, studded with red enamel . . .' While this description, like most of the others, is stylized and formulaic, nevertheless the compliers of the tales always dressed their warrior heroes splendidly, preserving the tradition recorded earlier by the Classical writers. The description of the use of swords (*TBC* 3229 ff.) by the two heroes is of interest also:

> Then they took up two great, long shields . . . They wielded their heavy, hard-smiting swords. Each of them began to smite and hew, to slaughter and slay each other, and every portion and piece that each hacked from the shoulders and thighs and shoulder-blades of the other was as big as the head of a month-old child.

Allowing for the hyperbole, it is nevertheless clear that the story-tellers viewed fighting with the sword as consisting of hacking and cutting, with strokes aimed at the head and shoulders and the lower torso, not fencing and thrusting. This accords well with the portrayal by the Classical writers.

In many cases, the final act of the victor (though not in the case of Cú Chúllainn and Fer Diad) was to decapitate his fallen opponent. Once the preliminaries were over, battle was joined and it is noticeable that, as in the Iliad, the rank-and-file fighters are mentioned only as victims of the various heroes who ploughed through their ranks.

Two motifs which recur are those of the hero's portion and head-taking. Perhaps the two best versions of disputes over the prestigious portion of meat occur in *Fled Bricrenn* ('Bricriu's Feast') and *Scela Mucce Maic Dá Thó* ('The Tale of Mac Datho's Pig'). In the latter, the dispute between Cét of Connacht and Conall of Ulster (Murphy 1961, 46. f) which begins with their boasts of prowess has a grisly twist:

> '. . . move away from the pig,' said Conall. 'And what would bring you to it?' said Cét. 'Truly,' said Conall, '. . . I swear by that by which my people swear, since I took spear in hand I have never been without slaying a Connachtman every day and plundering by fire by night, and I have never slept without a Connachtman's head beneath my knee.' 'It is true', said Cét, 'that you are a better warrior than I. But if it were Ánluan who were here, he would match you victory for victory.' . . . 'But he is,' said Connall, drawing Ánluan's head from his belt; and he hurled it on to Cét's chest so that the blood flowed over his lips. Then Cét left the pig and Conall sat down by it.

This passage encapsulates features that so fascinated Posidonius, and in the casual and contemptuous brutality of Conall's assault on Cét we may gain a glimpse of what it was about the Celts which so horrified the Classical world. As Murphy (1961, 49) remarks, Conall's behaviour is even more barbaric than that of Achilles' when he dragged the body of Hector behind his chariot (*Iliad* 22).

The sword also attracted its share of magical attributes, as recorded in both Irish and Welsh tales. In Ireland, besides supernatural spears, the sword of Nuadu, irresistable when unsheathed and from which none escaped, has been equated with the lightning of the gods (O'Rahilly, T. F. 1946, 67). In the tales of the Ulster

Cycle, composed and recorded in the Middle Ages (seventh–fifteenth centuries), the use of the sword is frequently described in combats between heroes like Cú Chúlainn, Fergus Mac Cécht and others. The mighty sword of Fergus to which was ascribed the power to smash mountains, had the name *Caladcholg* (literally 'hard *colg*', *colg* being another word used alongside *claideb*, for a sword), and it appears specifically in the epic *Táin Bó Cúalnge* and in the voyage-tale *Echtra Fergus maic Léite* (Mallory 1983, 106). Mallory suggests that the name derives from *Caladbolc*.[30] Irish *Caladbolc* or *Caladbolg* in turn has been equated with the sword of the British king Arthur, called *Kaladvwlch* (popularly *Excalibur*) which appears in the Welsh tale of *Culhwych and Olwen*, compiled after AD 1100.[31]

The Celtic Long Sword as Seen by the Classical World

The only mention by Classical writers of swords in single combat between prominent warriors—if we discount the legendary sword of Brennus (Livy 5. 48)—comes in the account of the duel fought by Manlius Torquatus. According to Quadrigarius, his opponent even seems to have had two swords (Aulus Gellius 9. 13). Other important duels were fought with spears. Most ancient accounts generally describe swords as the weapons of the rank-and-file, often accompanied by a spear. Two authors say explicitly that the sword was the main weapon of the Celts. Plutarch (*Camillus* 40) tells us that Camillus realized that the strength of the Gauls depended on their swords, although this passage may be a paraphrase from Polybius (2. 30). Livy (38. 21) states that the Galatae in Asia Minor in 189 BC had no other offensive weapons than swords. On the other hand, Dionysius of Halicarnassus (end of the first century BC) wrote: 'As weapons of offence they [the Celts] have spears and very long slashing blades (μάχαιραι κοπί δες ὑπερμήκεις) (14. 9, 13), while Diodorus Siculus (first century BC contents himself with a brief statement (5. 30, 3–4: trans. Oldfather 1961) 'In place of the short sword (ξίφος) they carry long broadswords (σπάθαι).'

What is seemingly beyond dispute is the primary use of the long Celtic iron sword for cutting and slashing. Indeed, ancient writers do not ascribe any use of such weapons for thrusting, even though the majority of them (with the exception of some late La Tène examples), with their long parallel cutting edges and prominent points, should have been effective in this mode of fighting. However, Classical writers criticized Celtic swords both on the grounds of their poor quality (discussed

[30] For etymology see Lewis 1940 and O'Rahilly, T. F. 1946, 62–72. O'Rahilly equates *bolg* with lightning.

[31] The story of Culhwch and Olwen, which has strong Irish connections, where Arthur appears as a cousin of the central hero, is the seventh part of the *Red Book of Hergest* and is dated to the twelfth century. It follows the older tales of the *Mabinogion*. Other parts of Arthur's armoury are given personal names: thus, the spear *Rhongomyant* (*Ron* in the *Historia* of Geoffrey of Monmouth), the knife *Karnwehan* and the shield *Wyneb Gwrthucher*. In the same tale, there three swords *Bebyn Byn* and three spears *Gowan Gwn* belong to the three heroes Bwlch, Kyvwlch, and Syvwlch (Czech tr. J. Velikovsky (Prague 1965) of Guest's English translation of the *Mabinogion:* see also O'Rahilly, T. F. 1946, 60–70).

in Chapter 9 below), and their lack of effectiveness against Roman weaponry and tactics.

Writing at the end of the second century BC and probably using the text of Q. Fabius Pictor (presumably an eye-witness of the event), Polybius has left what may be described as a detailed report of the battle of Telamon. This is in contrast to the paucity of the information which he gives on other Celtic campaigns of the years before 220 BC. The swords of the Gaesatae, he writes (2. 30. 8) were inferior for fighting, since the Gallic sword only cuts:

> On the other hand, their [the Gauls] shields were worse [than those of the Romans] in terms of protection, and their swords (*machairai*) were worse for attack because the Gallic sword has only the cutting-edge.[32]

Later, in skirmishes on the Clusium river the observation of this led Roman military tribunes to change the tactical behaviour of their *triarii.* They were ordered to stop the first Celtic sword attack with spears and, having blunted their opponents swords, then to operate with short thrusting swords held horizontally. The Celts were unable to cope with this unfamiliar mode of fighting. Then follows the famous passage in which the bending and blunting of Celtic swords is described (see below, p. 157). Polybius returns to the theme once more in his account of the Second Punic War in Italy (3. 11. 43), where he comments that the Gaulish sword was useful only for cutting, and then only at a certain distance from the opponent:

> their [the Celts'] swords were of a different kind [to those of the Romans]: the Iberian was suitable for wounding with the point as well as by the cutting edge, while the Celtic sword could only be used with the cutting edge and then only from a distance.[33]

Polybius' account of the handling of the Roman and Celtic swords seems to have greatly impressed later authors, and to have provided material for otiose treatises and detailed descriptions. Some of these accounts are worthy of examination since they characterize the general differences between the *gladius* and *spatha* (or *machaira*).

We may compare the contents of some other passages relevant to our discussion. Plutarch transposed the theme of the contrast of styles back to the fourth century BC (*Camillus* 40):

> [Camillus] knew that the strength of the barbarians [Celts] is based upon their swords which they use for brandishing, that being the custom among barbarians, so that they usually cut the chests and heads.

In the fourth century AD, although not mentioning the Celts by name, F. Vegetius Renatus wrote:

[32] The reproduction of the text is based on the French translation by Pédech (1970, ii. 73–4). The term καταφορά would refer, in this phrase, to the cutting-edge rather than to the cut itself (Walbank 1957, i. 445). Paton (1922, 317) translates the passage as: 'The Roman shields, it should be added, were much more serviceable for defence and their swords for attack, the Gaulish sword being good only for a cut and not for a thrust.'

[33] Walbank 1957, i. 445.

They [the ancient Romans] were likewise taught not to cut but to thrust with their swords. For Romans not only made a jest of those who fought with the edge of that weapon, but always found them an easy conquest. A stroke with the edge, though made with ever such force, seldom kills, as the vital parts of the body are defended both by the arms and armour. On the contrary, a stab, although it penetrates but two inches, is invariably fatal.

It is clear therefore that although the Celtic sword and the warriors who wielded it was feared and respected by the Romans, they developed effective tactics to counter it.

The Later Role of the Sword in Society

In the Early and High Middle Ages, we can see clearly that the sword became established as the prominent weapon, whose possession was the privilege of the upper strata of society, the symbol of war and of might, superseding all other weapons.[34] Among the Germanic peoples in that period characterized by the military raids which they mounted in the first millennium AD, as their old tribal system was dissolving, the sword enjoyed high esteem and also magical, even divine, properties which came to be expressed in their epic sagas.[35] In pre-Christian Continental Celtic history there is no indication of this, either in the reports of ancient writers[36] or in archaelogical finds, at least during the historical period of Celtic and the subsequent period of consolidation. Swords buried in graves were always treated as part of the panoply of the warrior, often accompanied by spears and shields, as well as other goods. Nevertheless, among the insular Celts, a much later-recorded tradition provides evidence of the fabulous significance of the sword.

[34] In early societies, the object of veneration tended to be arms in general, or the spear as the general weapon of offence. Survivals of this symbolism can be traced into the Middle Ages. See Wenskus *Bewaffnung* 460, and also the legends of holy spears in Poland and Bohemia. In Ireland too, spears were prominent in mythology (O'Rahilly, T. F. 1946).

[35] This was a long and apparently uneven process, since swords were at first not equally available to all Germanic groups—see e.g. passages in Tacitus' *Germania: rari gladiis aut maioribus lanceis utuntur* (6. 11); *munera non ad delicias muliebres quaesita nec quibus nova nupte comatur, sed boves et frenatum equum et scutum cum framea gladioque* (18. 2); *nudi iuvenes . . . inter gladios se atque infestas frameas saltu iaciunt* (24. 1). As archaeology shows, swords had a place in the panoply of Germanic warriors from the decades after the birth of Christ. The existence of a dance among swords and vertical spears indicates a symbolic role for these weapons. However, accounts of similar exercises by Irish warriors with spears and swords were a form of training for agility (cf. Scott 1990, 193). There is an explicit report by Ammianus Marcellinus (17. 12. 21) of sword worship among the 4th-cent. AD Quadi, and of the role of swords in the swearing of oaths by chieftains: *eductisque mucronibus, quos pro numinibus colunt, iuravere se permansuros in fide* ('then, drawing their swords which they venerate as gods, they swore that they would remain loyal': trans. Rolfe 1956, 3. 380–1). Later, in the post-Carolingian period, Louis the Debonair was given his sword in a ceremony marking the day of his coming of age (*Vita Hludowici* 6: see Wenskus in *Bewaffnung* 460–2). The swords of legendary heroes, both in Carolingian and Nordic cycles, bore proper names, such as *Joyeuse* which belonged to Charlemagne, Roland's *Durendal*, Wieland's *Mimung*, and Siegfried's *Balmung*. Falk enumerates 177 swords with personal names, some of which were endowed with magical powers (see Buchholz in *Bewaffnung* 476, who also cites Keller, *The Anglo-Saxon Names Treated Archaeologically and Etymologically*, 1906).

[36] Only in Tacitus' *Agricola* 29, although Calgacus, chief of the Caledones, who was *virtute et genere praestans*, seems to have derived his name from a Celtic term for sword (*calg*, *colg*, *Calgacus* 'sworded': Holder 1896, i. 698).

It has been suggested that the legendary sword *Caliburnus* (later *Excalibur*) attributed to King Arthur is one of the important Celtic elements in the Arthurian epic (Bruce 1923, i. 87, with references). In Geoffrey of Monmouth's *Historia Regum Britanniae* (9. 4) Arthur was helped to victory by this sword at the battle of Badon (*Mons Badonicus*) fought against the Saxons, probably in the early years of the sixth century AD, and in his supposed campaigns in Gaul. As the Arthurian legend developed, the king's sword took on an increasingly magical role,[37] and gradually came to be accepted as a magical guarantee of victory for Arthur. In the *Historia*, *Caliburnus* was treated as exceptional not just on account of its personal name (other items belonging to Arthur also had personal names), but also because it was supposed to have been made on the mythical Island of Avalon.

In *Mort Artu*, after the last apocalyptic battle, before Arthur was carried over to Avalon, he commanded the sword to be taken by the knight Gifflet[38] and cast into a lake. There it was caught in a huge, mysterious hand which brandished it three times before taking it below the waves. This motif was developed in the story of Merlin by pseudo-Robert-de-Boron (*c.*1240–50), in which the sword was originally given to Arthur by the same hand emerging from the lake. The act of returning it to water might be regarded as a symbol of burying the weapon—an idea widespread many centuries before among Celtic and Teutonic peoples. Here, the miraculous sword is to be reserved for the king until, as it is believed, he will return and once again take the defence of his country into his hands.[39]

In the Welsh *Red Book of Hergest*, the story *The Dream of Rhonabwy* (compiled in the twelfth century), Kadwor (Cador), the Duke of Cornwall, who had been in attendance when Arthur was forming his army to fight the Saxons at Mount Badon, unsheathed the king's sword (here unnamed). On the blade was the image of two snakes spitting flames, a sight too horrible for anyone to behold. Bulard (1980, 49) is inclined to see in these inlaid ornaments apotropaic powers, similar in function to the punchmarks and other symbols on ancient Celtic swords.

The magical function of swords, or perhaps of greater significance, the reservation of special swords for kings, is evident from a late section concerning Merlin in the pseudo-Boron. Here there is an anvil into which Excalibur is fixed, and from which only he who is fit to be king may draw it. The young Arthur is the only one who can succeed and he, of course, is hailed as king (Bruce 1923, ii. 318; Chambers 1927, 158).[40]

[37] See Bruce 1923, i. 21, 42, 87–8, 434–5, 466, ii. 320, 363–80; Chambers 1927, 36, 39, 88, 124, 163, 219, 274. Later in the 13th century it was made the subject of even more preternatural events. In the Arthurian vulgate cycle (*Mort Artu*, composed in the period 1200–30), the sword is called *Excalibur* (or *Escalibour*, *Escalibor*, etc.).

[38] According to the 14th-cent. English metrical *Morte Arthur*, it is Sir Bedevere (Bedwyr) who throws Excalibur into the lake (Chambers 1927, 164).

[39] Chambers 1927, 264. A 13th-cent. vulgate continuation called *Livre d'Artus* describes Excalibur as Arthur's gift to his favourite Sir Gawain. In a 12th-cent. text by Benedict of Peterborough, Caliburn was given by Richard the Lionheart to Tancred of Sicily (*gladium optimum Arcturi, nobilis quondam regis Britannorum, quem Britoni vocaverunt Caliburnum*).

[40] Other hints of miraculous swords or of sword symbols are to be found in the Arthurian romances. Thus, in *Perceval* by Chrétien de Troyes (*c.*1175) there appears the 'Sword of Strange Hangings' (*espee as estranges renges*) which can only be broken once, and

From the sources quoted above one may conclude that in the archaic society of the Celts, the cult of the sword was nowhere nearly as prominent as in that of the early Germanic peoples.

Direct comparison of the Celtic mode of fighting with the more developed tactics and armament of the Mediterranean civilizations leads us to the belief that on the Continent, Celtic combat remained until at least the fourth–third centuries BC on the level depicted in the Homeric poems. In Britain, it survived until the Roman conquest of the first century AD, while in Ireland, archaic combat styles probably survived until at least the second half of the first millennium AD. In fact, it reflected traditions and rules of combat prevailing among late tribal societies, although modified in most regions by rapid detribalization during the period of expansion and by contact with the tactics of the adversaries which they encountered. It did not survive the zenith of independent Celtic power and, during the first century AD (*Histories* 1. 68), Tacitus described the Helvetii as *Gallica gens olim armis virisque mox memoria nomine clara* 'a Gallic tribe which used to be famous for its arms and men, and now only for the memory of its name'.

then at a time known only to its maker, Trebuchet (Bruce 1923, ii. 296–7). The idea of the 'Way to the Overworld', bridged by a sword, also included by Chrétien, must also be interpreted as of Celtic origin (for discussion see Bruce 1923, i. 201–4).

3

Notes on the Archaeology of the Celtic Sword

To compare the evidence of written sources with that of archaeology we need to discuss the main categories of finds from cemeteries of the LB–LC periods. Here again we encounter various difficulties, since the archaeological sources are fragmentary, and at most cemeteries only a sample of the total number of graves has been excavated. In each case, we must ask if these samples are truly representative, and provide sufficient evidence from which to extrapolate general conclusions from the numbers of graves, hence from the type of equipment which they contain. The complete sociological or demographic analysis of many Celtic cemeteries is made impossible by the absence of anthropological data. But attempts have been made recently to distinguish the principal social categories among the populations which these cemeteries represent,[1] by analysis of the metal components of costume, ornaments, and other sets of equipment such as armaments.

In general, Celtic cemeteries in Europe are famous for the abundance of finds of swords, usually accompanied by spears, shields (whose presence can be confirmed only when metal fittings survive), masculine belts, and *ceintures.* A strongly armed warrior class is seen represented in flat inhumation or bi-ritual burial grounds of the LB–LC periods, and this is in perfect accord with the ancient written sources (Filip 1976, 101–7). This thesis can be checked by taking into account the total number of graves in individual cemeteries and their relations to the lengths of their use. Some recent analyses of Celtic cemeteries such as Münsingen-Rain in Switzerland (Martin-Kilcher 1973) or Jenišův Újezd in Bohemia (Waldhauser (ed.) 1978), have shown that earlier estimates of the military component of the population, at least in central Europe, should be substantially reduced. Those cemeteries lasted for two or three centuries and in fact were used by only two to four households (farms, families), perhaps not exceeding a dozen individuals living at any one time. The number of sword-bearers indicates a larger proportion in earlier periods (LB: fourth–third centuries BC), but even then, the use of this weapon was reserved to one, or at most two, men from each community. One would expect lesser warriors to have been armed with a spear, and this is indeed the case in some localities. In the very early cemeteries of the Marne region, for example, swords appear only exceptionally in graves in comparison with those containing spearheads (Sankot

[1] See Schaaf 1966; Martin-Kilcher 1973; Sankot 1977; Neustupný 1978; the statistical analyses in Waldhauser (ed.) 1978; Kruta 1980, 1981; Bujna 1982.

1977). In the north of the Carpathian basin, in Slovakia, or the Middle Danube region, burials equipped solely with one or more spearheads are well attested (Bujna 1982). These graves date from a relatively late period (LB_{2b} onwards). In the classical area of Celtic flat inhumation or bi-ritual cemeteries, spearheads are frequently found along with swords in graves, and graves containing swords unaccompanied by spearheads are in the minority.

Sword Graves in Cemeteries

The limitations of the archaeological evidence make it difficult to give here a thoroughly detailed demographic study among the Celts of the armed population who were buried in hundreds of grave-fields all over Europe. We shall try instead to illustrate the situation by reference to selected sites from different regions of the Celtic *oekumena*. Table 1 summarizes the relevant information on sword-graves in well-known cemeteries dating roughly from the fourth to second centuries BC. We must add some comments to supplement the information presented in the individual columns.

With regard to the total number of graves in cemeteries we should note that most of the sites have been severely damaged by later industrial and agricultural operations, so that only a fraction of the original burials are now available for excavation. For this reason, sites with fewer than twenty surviving graves have been excluded to avoid distorting the picture. Thus, we cannot be sure if the four sword-burials recovered from the sixteen surviving graves at Bologna-Benacci (Kruta 1980) did not come from an area reserved specifically for the burial of warriors. Estimated original numbers of graves (or the minimum possible) are given, followed by the number of those which have been used for archaeological evaluation. This is followed by the numbers of graves with the typical combination of sword and spearhead. Occurrences of shields (though these were part of the usual panoply) are not noted, since not all shields were fitted with metal bosses and rims and thus the number of recorded traces would be misleading. Graves with swords, but without spearheads, are noted to complete the information. Among those graves containing spearheads (of various forms) only, it should be noted that in both of the main areas of their occurrence, i.e. eastern France and the middle Danube Basin, finds of more than one spearhead per grave are quite common.[2] The next column gives the numbers of remaining graves which contain no weapons. We have not reproduced the more detailed demographic data which have begun to appear in publications recently (above, n. 1).

[2] Note grave 97 with sword at Beograd-Karaburma (Todorović 1972, 52, pl. xxx) and the curious occurrence of miniature spearheads in female graves 29 and 57 at the cemetery of Jászberény-Cseröhalom (Kaposvári 1969). Bujna (1982, 396–7) discusses the possibility that these were not true spearheads but rather spearhead-shaped components of a belt or girdle. If they are in fact miniature spearheads, they may have symbolic significance (but cf. Scott 1990, 43 for the practical role of miniaturization of spearheads in the Irish Late Bronze Age).

TABLE 1. *Examples of the La Tène period flat cemeteries with sword and spear graves*

Area	Site	Number of graves estimated	Number of graves treated	Sword and spearhead	Sword	Spearhead	Male graves, no weapon	Other graves	Swords %	Swords per generation	Dating (as given)	Phases suggested	Reference
Marne	Villeneuve-Rennville	nd	47	2	2	12	nd	5	6	nd	L Ia	3	Brisson *et al.* 1971/72, Sankot 1976/77
Seine-Marne	Gravon	nd	40	3	–	–	3	34	10	nd	L Ic/L II	3	Sankot 1976/77
Ardennes	Liry	nd	23	3	2	–	nd	17	23.6	nd	L Ic–IIa	3	Sankot 1980
Switzerland	Münsingen-Rain	~ 300	225	10	8	–	8	207	8	1	L Ia–IIb	9	Hodson 1968, Martin-Kilcher 1973, Sankot 1980
	Vevey	nd	31	1	1	–	6	23	6.5	1	LB_1–LC	3	Schaaf 1966, Sankot 1980
	Bellinzona-Giubiasco	nd	67	8	3	11	nd	45	16.6	nd	L II	3	Ulrych 1914
		nd	97	9	2	10	nd	76	11	nd	L III	nd	Ulrych 1914
N. Italy	Montefortino	47	47	10	4	3	nd	30	30	3.5	320–270	3	Kruta 1981
	Camerano	103	103	7	2	15	nd	45	16.5	nd	300	nd	Lollini 1979
Bavaria	Nebringen	> 27	27	4	3	–	3	17	26	nd	LB	nd	Krämer 1964
Bohemia	Jenišův Újezd	138	123	14	2	–	37	70	13	1.2	LB_1–LC_1	5	Waldhauser ed. 1978
	Letky n. Vltavou	> 38	38	4	6	–	nd	28	26	nd	nd	nd	Filip 1956
	Makotřasy	> 25	25	2	1	–	6	16	12	nd	LB_1–LC_1	nd	Čižmář 1978
Moravia	Brno-Maloměřice	> 76	76	14	6	–	nd	56	26	nd	LB	nd	Poulík 1942, Čižmář 1972

	Holubice	> 77	77	12	12	–	nd	52	31	2	LB–LC_1	2	Procházka 1937
	Křenovice	nd	38	5	2	–	3	28	18	nd	LC_2–LC	nd	Procházka 1937
Slovakia	Maňa	> 109	109	10	2	8	nd	89	11	nd	LB_2–LC	2	Benadík 1978, 1983
	Horný Jatov-Trnovec/V.	> 40	40	3	–	2	4	31	7.5	0.5	LB_{2b}–LC_1	2	Benadík *et al.* 1957
	Palárikovo	> 94	94	7	–	1	nd	86	7.5	nd	LB–LC	nd	Benadík 1975
	Bajč-Vlkanovo	> 67	65	3	–	2	nd	60	5	nd	LC	nd	Benadík 1960
	Dubník	38	38	8	–	–	4	27	24	nd	LB–LC	nd	Bujna 1989
Hungary	Jászberény-Cseröhalom	> 52	52	1	–	2?	nd	49	2	0.5	LB_{2b}–LC_1	nd	Kaposvári 1969
Yugoslavia	Beograd-Karaburma	nd	96	11	2	17	nd	66	13.5	nd	LB_2–LD	5	Todorović 1972, Božić 1981
Romania	Ciumeşti	> 38	38	1	1	1	nd	34	5	nd	LC	nd	Zirra 1967

nd = not determined

The number of well-armed but otherwise poorly equipped male burials (provided only with a few fibulae or armlets of iron or bronze) is found to be roughly the same as that of women buried with rich assemblages including torques, armlets, anklets, and often with expensive *ceintures*. Children's graves, which occur regularly, seldom contain much in the way of grave-goods. Graves containing no goods at all are in a minority (10–12 per cent of the total), an exception being the cemetery at Gravon in France where some 56 per cent of burials were without deposits (Sankot 1977).

The proportion of graves containing swords in the cemeteries selected for study varies from 5 to 31 per cent of the total number. In the case of sites with 40–80 or more burials, this tells us something about the social structure of the communities which they served. Taking the time factor into account, a median value for burials with swords of 5–15 per cent suggests that it was the head of the family or farm who owned a sword (and spearhead) or full war equipment. More than 25 per cent (e.g. 26 per cent at Letky in Bohemia, 26 per cent at Brno-Maloměřice in Moravia, 31 per cent at Montefortino in Italy) would indicate that another sword-bearer, presumably the elder son, or brother, had joined the head of the family. If this is the case, then those groups headed by family chiefs (*patres familias*) would have formed the basis of the hordes of warriors that began the raids on Italy and Greece, from their homelands in the hinterland of Europe.

A different social structure may have been developed in frontier areas where the most frequent fighting occurred. In addition, there is the probability that other sword-bearers will be represented in cemeteries, namely clients of the local ruler and members of chieftains' retinues (followers, *hetairoi*). We cannot hope to reconstruct anything resembling a complete picture from the archaeological evidence alone.

The Problem of Chieftains' Graves

From the evidence outlined above, we may conclude that sword-bearers were usually the heads of small social units, and that they constituted the heavy formidable military levies so often referred to by ancient writers, only when martialled for raiding and for other warlike operations. But who were their leaders in the field, and how may their graves be recognized in the course of archaeological excavations? There is little hope of finding the brightly coloured garments and gilded and painted armour that, according to written traditions, were their hallmark.[3] Is there any possibility of distinguishing those sword-bearers who were

[3] Interestingly enough, torques do not generally appear in male grave complexes (about 6 unspecified examples are given by Kruta and Szabó 1979, 54–7), contrary to ancient written records and to notes in the older archaeological literature. The same applies to gold which is extremely rare in warrior graves (Kruta and Szabó loc. cit.; our Tables 2–7). Some exceptions include Montefortino graves 18 and 33 (finger-rings: Brizio 1901), Dubnik in Slovakia grave 19 (finger-ring: Bujna 1989), a gold-plated iron helmet from Apahida (Crişan 1971, pl. xii–xiii), minute gold inlays on swords (inlaid into punchmarks as on the weapons from

the chiefs of the larger communities or *pagi*, or even of identifying the graves of tribal kings in wide areas of the Celtic transalpine hinterland? The graves of sword-bearers are typified, as a rule, by their general uniformity. They comprise extended inhumations, and swords, if present, are usually found on the right side of the body where they would have been worn, hanging from a (chain) belt: sometimes they are found higher on the body, at the shoulder (Fig. 3). Swords are found on the left side of the body, but much less frequently. The positions of spearheads in graves reflects that of the swords, with the tip of the spearhead by the head, although some examples where this position is reversed have been observed. Apart from their weapons and belts, the men wore simple personal ornaments of bronze or iron, one or two fibulae, very occasionally a ring. Within this general uniformity, a closer analysis may reveal certain distinctive features of the assemblages or arrangements of the graves.

Middle and Late La Tène graves can also contain helmets of bronze or iron (Table 2). In the Late Bronze and Early Iron Ages, helmets were a typical part of the chieftain's armour. For later periods, however, the picture is rather confusing. In the Celtic cemeteries of northern Italy, there are helmet graves of the fourth century BC, such as the chambered tombs at Canosa and graves 10 and 12 at Filottranto. With their rich furnishings and finely wrought bronze vessels, included in addition to swords and spears, these correspond to the usual perception of a chieftain's burial. But in the Montefortino cemetery near the east coast (47 burials), we see that in all ten warrior graves of the (*a*) and (*b*) phases, swords, spearheads (of different types, including examples of the *pilum*), and helmets of either bronze or iron, were deposited with the bodies. Only grave 25 (phase (*c*)) yielded a small bronze vessel, while grave 18 (phase (*a*)) contained a gold ring. Bronze or iron strigils were quite common.[4] Thus, to distinguish a military chieftain amongst those buried there would be very difficult.

At Bellinzona-Giubiasco (Ulrych 1914), only one helmet grave (no. 222), which also contained a knife, was found among 67 Middle La Tène graves (comprising 11 including swords, and 11 with spearheads), and this suggests that it is the burial of someone of prominence. The subsequent Late La Tène phase at this cemetery comprised 97 graves, of which 23 contained weapons—nine contained a helmet, sword, and spearhead(s), one a helmet and sword, one with a helmet only (no. 423), one with a sword and spearhead, and eleven with a spearhead or spearheads. The majority of the helmet graves also contained bronze vessels and knives. Since it

Böttstein and Mainz-Kastell) and scabbards (Weiss-kirchen: see Jacobstahl 1944, no. 100, earlier tumulus complex). Kruta considered that burials misrepresent the actual extent of the warrior's equipment, because funeral rites did not allow for the provision of gold torques and other luxuries in the graves of warriors. It is possible also that in some cases, elements of warrior equipment were passed down from one generation to another, rather than following their bearers automatically into the grave.

[4] Brizio 1901, 660 f; Kruta 1980; see above, n. 3. Greek painted vases were the norm. The richest graves are those of females, such as no. 8 which contained gold-leaved diadems, bronze vessels, and no. 23 in which a torque was found. Frey (1986) refers to two iron helmets and swords in LB_I graves from Monte Bibele in Northern Italy, but gives no detailed descriptions.

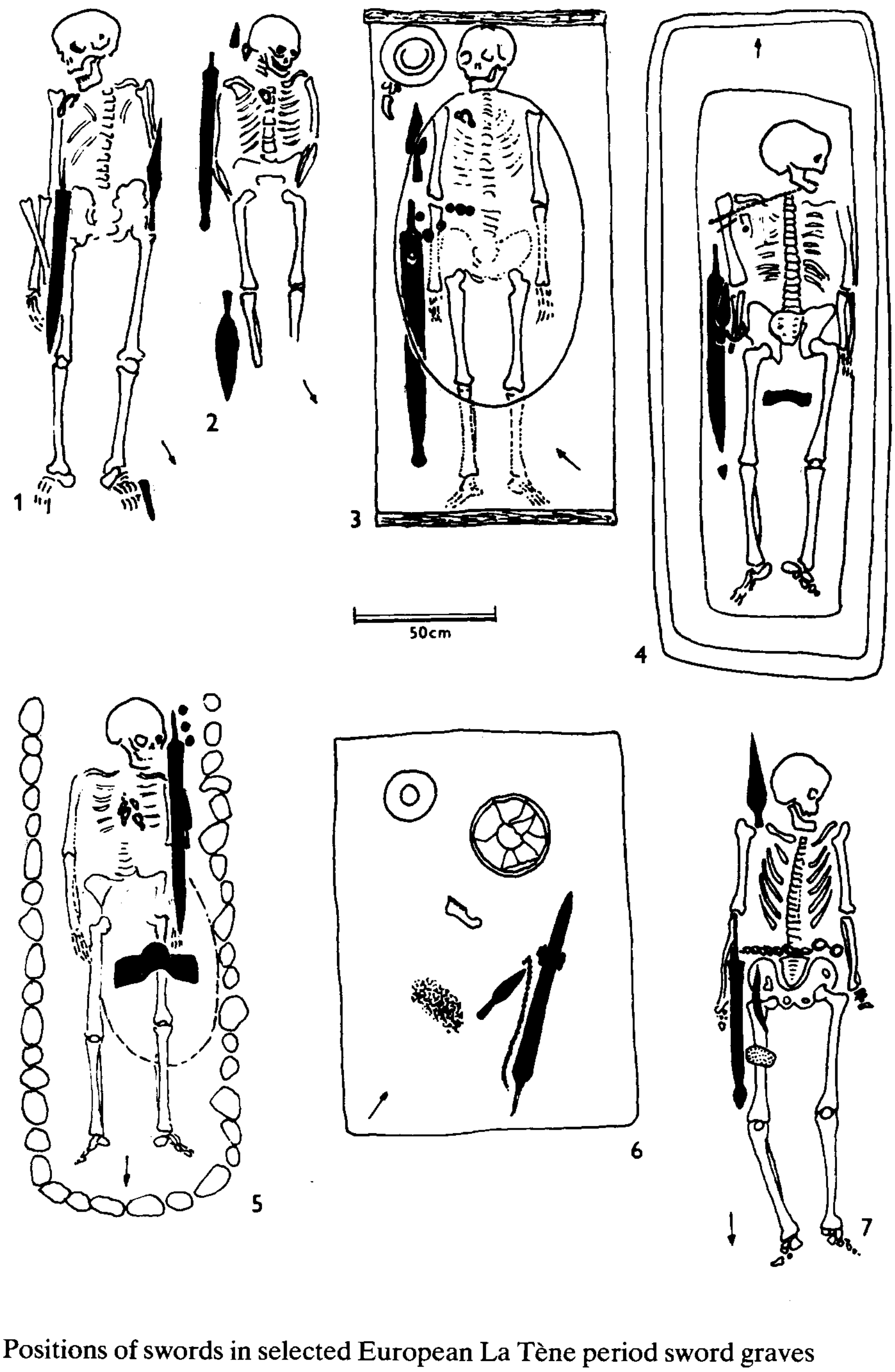


Fig. 3. Positions of swords in selected European La Tène period sword graves

was provided with four bronze vessels, two silver objects, and an axe, grave 32 might well be classified as the most important. Bronze vessels and helmets, as well as Greek painted pottery (as at Montefortino) were more commonly placed in graves in Cisalpine Italy where economic conditions made it possible to provide luxury grave-goods not only for chiefs of high rank, but also for prominent warriors. The situation of the richly furnished cemeteries of Hallein, near Salzburg in Austria is unclear in this regard. There are iron helmets in warrior graves, but evaluation of their roles in the grave assemblages is not really possible because of the incomplete publication of the finds and the fact that excavation work is still in progress.

North of the Alps, circumstances are different, and thus bronze vessels are almost entirely absent from Middle La Tène graves, while helmets are rare. The central position of the single grave containing a sword and helmet within the cemetery of Nebringen in Bavaria, indicates the leading role in the small community which it served of the man who was buried there. This cemetery included a total of seven graves containing swords (amongst them four with both sword and spearhead), but no ornaments or other precious objects were found (Krämer 1964). The helmet grave from St-Laurent-des-Arbres near Nîmes in southern Gaul contained in addition to the usual assemblage, a ladle (*stipulum*). The same combination, plus an oenochoe and Italic amphorae, may be observed also in the warrior grave at Beaucaire in France. Among 62 graves discovered in the neighbourhood of Nîmes, 20 were warrior graves, but of these, only one, from St-Laurent, contained a helmet. The St-Laurent burial has been interpreted as that of a prominent warrior from the territory of the Volcae Arecomici (Barruol-Sauzade 1969). The Late La Tène period helmet grave at Novo Mesto, Yugoslavia, contained only a fibula, belt attachments and three vessels along with a sword, spearhead, knife, and shield (Schaaf 1980). In the east, the pit of a grave(?) at Ciumeşti, Romanian Transylvania, contained a splendid iron helmet with bird ornament, bronze greaves, and an obviously valuable chain cuirasse, presumably the possessions of a chief of significant rank, higher than merely the leader of the community represented by the 38 graves excavated to date. Strangely enough, no sword was found in that assemblage, but its absence, like that of human remains, may well be due to later disturbance (Rusu 1969; Zirra 1967). In the west, at Trier-Olewig (Schindler 1971), a Late La Tène helmet grave contained no precious metal objects other than two iron scissors and two knives. Other helmet graves, and the significant parts of their inventories, are listed in Table 2. It may well be that in the barbarian hinterland, the presence of a helmet is indicative that we are dealing with a local chief (Armant-Caillat 1965, 265).

It has been thought that punched marks on certain La Tène period sword blades (see pp. 64–5) designated those weapons which excelled in quality and were the property of prominent customers (Vouga, cited by Drack 1955, 198; 1967; Filip 1976, 105). The actual quality of some of these blades will be discussed later (below, pp. 99–133). Most of them come from the deposits at La Tène and Port in

TABLE 2. *Contents of some helmet graves*

Site	Area	Sword	Ornamented scabbard	Short anthropoid sword	Spearhead	Chariot	Bronze vessels	Gold	Varia	Dating BC (as given)	Reference
Hallstatt grave 994	Austria	1	1	–	2	–	1	–	Knife	LB	Kromer 1959
Moscano di Fabriano	Italy	1	1	–	1	–	1	–	Greek vases, tripod, horse gear	LB	Frey 1971
Filottrano grave 12		1	–	–	2	–	1	–	strigil	350–330	Baumgärtel 1937
10		1	–	–	–	–	6	–	strigil, razor		
Casa Selvatica		1	–	–	1	–	–	–	knife	300–280	Kruta-Poppi 1981
Montefortino graves 4–5		2	–	–	2	–	–	–	Greek pottery	350–300	Brizio 1901
grave 2		1	–	–	2	–	–	–	Greek pottery, strigil		
18		1	–	–	2	–	–	1	Greek pottery		
3		1	–	–	1	–	–	–	Greek pottery, strigil		
1		1	–	–	1	–	–	–	strigil		
17		1	–	–	1	–	–	–	strigil		
22		1	–	–	2	–	–	–	strigil		
11		1	–	–	2	–	–	–	strigil		
Bologna-Benacci 1881		1	–	–	1	–	?	–	–	*c*.300	Kruta 1980

Bellinzona-Giubiasco	Switzerland										
grave 222		1	–	–	1	–	–	–	knife	*c*.200	Ulrych 1914
32		1	–	–	1	–	4	–	2 × Ag axe	100–50	
69		1	–	–	1	–	–	–	–		
71		1	–	–	1	–	1	–	knife		
96		1	–	–	2	–	3	–	–		
119		1	–	–	1	–	1	–	–		
262		1	–	–	–	–	–	–	–		
263		1	–	–	1	–	–	–	–		
423		–	–	–	–	–	–	–	–		
425		1	–	–	1	–	2	–			
266		1	–	–	2	–	–	–	5 bracelets, 6–7 fibulae		
330		1	–	–	?	–	–	–	knife, mortarium		
St-Laurent-des-Arbres	S. France	1	–	–	1	–	1+	–	knife and ladle	L III	Barruol–Sauzade 1969
Beaucaire grave 64		1	–	–	2	–	2+	–	strigil, Ital. amphorae, and ladles	L III	Barruol–Sauzade 1969
Nebringen grave 11	Bavaria	1	–	–	1	–	–	–	–	LB	Krämer 1964
Trier-Olewig	W. Germany	1	–	–	2	–	–	–	2 scissors, 2 knives	LD	Schindler 1971
Novo Mesto	Yugoslavia	1	–	–	1	–	–	–	knife	LD	Schaaf 1980
Ciumeşti	Romania	–	–	–	1	–	–	–	cuirass, greaves, no human remains	LB	Rusu 1969
Silivaş		1	–	–	2	–	–	–	knife, scimitar	nd	Roska 1925
Apahida		1	–	–	3	–	–	1+	knife, and gold-plated	LB_2	Crişan 1971

nd = not determined

Switzerland, and no assemblage has provided us with an example that could be attributed to an owner. A group of marked swords from graves in Switzerland and eastern France were unaccompanied by any goods of particular value or note (the Courgenay grave contained one knife: see Table 3). The question of who carried, or was allowed to carry a punched mark on his sword remains unresolved.[5]

Some La Tène period swords have decorated metal scabbards which sometimes are themselves artistic masterpieces, whose production, or at least ornamentation, must have been the work of specialist craftsmen (Megaw 1979). This in turn implies that the customer who specially ordered such work must have been a wealthy warrior, if not a leader. Those swords with the best ornamented scabbards, are unfortunately for the most part without context, having passed through the antiquities market,[6] thus telling us nothing about grave complexes. For some other examples (Table 4) we see that decorated scabbards, engraved and/or fitted with ornamental elements on their suspension gear and chapes (and, in earlier periods, with a bronze sheet and iron back), may have belonged both to rich and to ordinary warriors, as is evident by comparing assemblages in the LB–LC periods. If we omit from consideration the fine sword scabbards from the burial mound at Liebau, Saxony (Coblenz 1956), and that from Weisskirchen (Jacobstahl 1944 no. 100), both of which belong in the context of the princely barrow-graves which occur during the decline of the LA phase, we find again in Italy and the Alpine region important grave assemblages which include decorated scabbards. At Moscano di Fabriano, a possible chieftain's burial contained a tendril-ornamented scabbard of Waldalgesheim style, accompanied by several bronze vessels and Greek painted vases, a tripod, an Italiote helmet, and elements of horse-harness (Frey 1971). At Halstatt cemetery, inhumation grave 994, containing a skeleton laid out on a clay platform, included in its assemblage an iron helmet, a copper-alloy sieve, a knife, two spearheads, a long iron sword with bird-shaped tips to the pommel, and also the famous bronze plate on which is engraved a depiction of a horseman (Fig. 4). Other transalpine warrior graves from central Europe which contain decorated scabbards are found among other, less well-furnished burials. Curiously enough, in some of these there are no traces of spearheads or shields. Thus, an ornamented

[5] This problem has been much discussed in the case of a sword punchmarked with a personal name *KORISIOS*, in Greek letters. Wyss (1954) believed that the name might have been that of the master-smith who made it, while on the basis of historical and linguistic analysis, Livens (1972) argued for its being the name of the owner, added later after his return from Italy. Cf. in the almost illegible fragment of a stamped inscription in Latin letters on the blade of the Zemplin sword (our specimen 510, pp. 97–8), which seems to read _V_TILICL_O_ (Fig. 11). For further discussion of the significance of punchmarks, see pp. 64–5 below.

[6] It is not possible to include here discussion of these splendid pieces which were described by Filip (1956, 103–4) as prestige pieces distinguishing pre-eminent warriors. They have been discussed frequently in treatises on Celtic art, and we will merely note some of the most famous: Vert-la-Gravelle, Cernon-sur-Coole, Marson, all in France; Obermenzing and Ameis in Germany; Dražičky in Bohemia; the Hungarian scabbards which give the name to the so-called Hungarian Sword Style including Bölcske, Kosd, Kisköszeg, Halmajugra, Velemszentvid; in neighbouring Yugoslavia Simunovec and Batina; Drna in Slovakia; Sutton, Kingston-upon-Hull, Bugthorpe, Mortonhall in England; Lisnacrogher and Toome in Ireland. In general, decorated scabbards are dated 4th–2nd cent. BC. For stylistic classifications and discussions, see Jacobstahl 1944; Piggott 1950; Filip 1956, 57, 76, 149; Jope 1954; de Navarro 1972; Szabó 1977 and 1979; Duval 1977; Megaw 1979, etc. See also pp. 65–6.

TABLE 3. *Contents of French and Swiss graves with punchmarked swords*

Site	Area	Sword	Ornamented scabbard	Short anthropoid sword	Lance	Helmet	Chariot	Bronze vessels	Gold	Varia	Reference
Courgenay	France	1	–	–	–	–	–	–	–	knife, 3 bracelets	Drack 1954/55
Wangen	Switzerland	1	–	–	1	–	–	–	–	–	
Basadingen		1	1	–	1	–	–	–	–	reverse scabbard sheet of bronze	
Mandach		1	–	–	1	–	–	–	–	bronze scabbard	

scabbard on its own is not necessarily a reliable indicator of the importance in the society of Celtic warriors of its owner. In fact, there exist many decorated spearheads which might have played a similar role.

There is another type of weapon which is claimed to be the emblem of rank among warriors, commanders, or chiefs, and this is the anthropoid-hilted short sword or dirk (see p. 69: for interpretation, see Filip 1956, 158; Petres 1979; Bulard 1980). Only a small number of the total number known (about 40) can be assigned to grave assemblages (Table 5). As this table shows, here are some burials where this kind of weapon merely replaces the long sword. In grave 20 at Křenovice in Moravia, one was found with two bronze-mounted boar tusks by the right arm of the skeleton (Procházka 1937, 85), while at Les Gobillons in France, inhumation grave 4 contained another, again accompanied by two boar tusks adapted for wear as ornament, and placed in the same position (Bontillot *et al.* 1975). At North Grimston in England (Clarke and Hawkes 1955, 226) and at Bern-Spitalacker in Switzerland (op. cit. 222) similar weapons were found. In other graves, anthropoid-hilted swords have been found together with normal swords, as at Nemilany in Moravia (Skutil 1941) and Györszemere (Hunyady 1957, 8) in Hungary, and at Salon in France (Clarke and Hawkes 1955, 224). Since punchmarked short swords containing gold or gold-coloured metal in the form of solar and lunar symbols exist also (unfortunately none come from closed contexts: Bulard 1980), it may well be the case that these weapons too were the symbols of rank of prominent figures. Two assemblages in addition deserve particular attention, namely those at Chatenay-Machéron (Chaumont) which contained an anthropoid-hilted dagger together with a long sword, and also a boat made from a single piece of wood, and at Châtillon-sur-Indre where an anthropoid-hilted dagger was found along with a

TABLE 4. *Examples of the contents of sword graves with ornamented metal scabbards*

Site	Area	Sword	Short anthropoid sword	Lance	Helmet	Chariot	Bronze vessels	Gold	Varia	Moat	Dating (as given)	Reference
Moscano di Fabriano	Italy	1	–	–	1	–	>1	–	Greek vases, tripod, horse gear	–	LB_1	Frey 1971
Hallstatt grave 994	Austria	1	–	2	1	–	1	–	knife	–	LB	Kromer 1956
Dürrnberg-Hochbichl		1	–	–	–	–	–	–	amber, knife, arrows	–	LB	Hell 1929
Jenišův Újezd grave 115	Bohemia	1	–	–	–	–	–	–	inventory incomplete	–	$LB_{1/2}$	Waldhauser ed. 1978
Willeperrot grave W 25	France	1	–	–	–	– –	–	–	–	–	L II	Bulard 1979
WC 2		1	–	–	–	–	–	–	–	7 × 7 m	L I/II	
WD 1		1	–	1	–	–	–	–	–	5 × 5 m	L I/II	
Kruft	Germany	1	–	–	–	–	–	–	–	–	4th cent. BC	Hörker 1918
Simunovec	Hungary	1	–	1	–	–	–	–	–	–	L	Hampel 1902
Dubník grave 15	Slovakia	1	–	1	–	–	–	–	–	–	LB–LC	Bujna 1989
grave 16		1	–	1	–	–	–	–	razor	–		
grave 30		1	–	1	–	–	–	–	shears, knife	–		
grave 31		1	–	1	–	–	–	–	shears, knife	–		

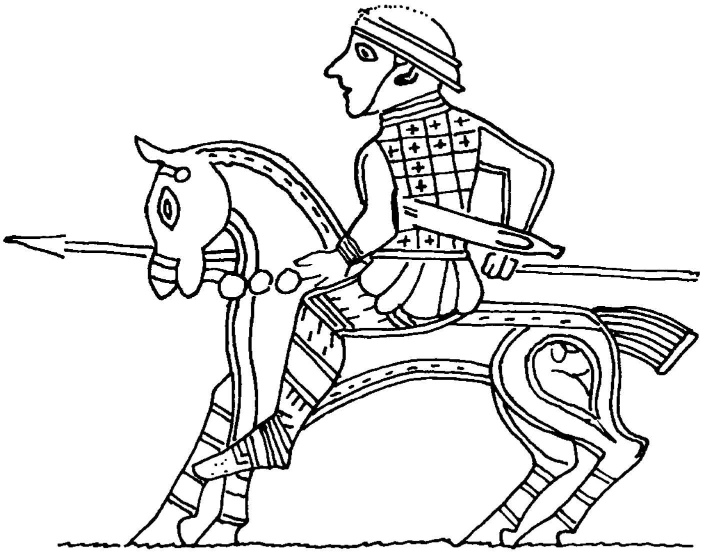


Fig. 4. Hallstatt, Austria. Celtic horseman armed with sword and spear from an ornamented scabbard (grave 994)

bronze plaque, three bronze vessels, seven Italic amphorae, and boar tusks[7] (Coussin 1926, 46–7; Clarke and Hawkes 1955, 223–5). In accordance with present views, the anthropoid-hilted sword may denote warriors of special, possibly rather high rank, although their actual status and function remains obscure.

The wagon and rich chariot graves which begin to appear in the European Late Bronze Age, typical for the Hallstatt and Earliest La Tène, are traditionally explained as the last resting-places of princes and chiefs of renown. The splendour of their contents must indeed be indicative of, and intimately linked to their social rank and power. The custom for all practical purposes came to an end during the fourth century BC, at any rate in the central regions of the Celtic territories and the frontier lands in Italy and the Balkans.[8] None the less, there are some notable chariot graves dating from the Middle and Late La Tène periods in Gaul, mostly in the northern parts, and, characteristically, in peripheral areas of the Celtic world as in Yorkshire, England, the middle Rhine area (formerly one of the richest early Celtic domains), and sporadically to the east in Yugoslavia, Hungary, and Transylvania (Table 6).[9] They are distinguished from ordinary burials within the

[7] Boar tusks occur in different positions in graves. At Křenovice and Les Gobillons tusks were placed by the right arm, while in one of the standard sword-graves at Prague-Bubeneč a pair of tusks lying by the skull may originally have adorned a leather helmet (Bouzek 1974). At Châtillon-sur-Indre there were a number of tusks whose positions are not given in the report. That the boar had a special significance to the Celts seems to be confirmed by its role in cult and ritual.

[8] The pigs buried along with two horses in a grave from Adria (Fogolari 1940, 440–1) present problems since no human remains are associated with them, as they were in other similar burials (see also Frey 1968, 318 n. 13).

[9] We will not include here the rich, stone-walled *tholos* tomb of Mezek, Bulgaria (Filov 1937), as the few objects of Celtic style are intrusions among the luxurious property of a Thracian ruler. The Middle and Late La Tène chariot graves are discussed in papers by

same cemetery or region by the presence of chariot-remains. Sometimes, burial mounds, following older tradition, mark the graves. As Joachim (1969, 97–8) accepts, in some cases, destroyed vehicles, or even substitutes for vehicles (e.g. lynch-pins, mounts, etc.) were employed in the funerary rite. It is difficult, therefore, to say what types of chariots are represented in these cases, although two-wheeled vehicles of the Celtic *esseda* type would be the most likely candidates. Some chariot-burials contain no weapons, as at Boé in southern Gaul which contained bronze ornaments and stamped Italian amphorae, a lamp and other articles (Coupry 1961, 382–4), and Rüsselsheim, Bad Nauheim, and Neuwied Heimsbach-Weis grave 2, none of which are conspicuously luxurious.[10] On other sites, the only weapons found were spearheads, as at Urmitz or Gransdorf in Germany.

Grave assemblages which include in addition to the chariot, the normal combination of sword and spearhead, have been found at Nanterre and Plaidt (both, apparently, double burials), and Rocroi-les Pothées, all in France, and in the east at Brežice, Odžaci, Balsa, Arnót, and Cristurul Săcuiesc in Romania. As in other important graves, various other goods are found, such as toilet utensils (scissors and razors), along with knives, bronze buttons or attachments (e.g. Neuwied), spurs (Neuwied), glass beads, and other small items (for other sites and references see Table 6). It is likely that in the northern crescent of the Celtic zone, an ancient tradition survived in which leading figures were buried with their chariots or with artefacts symbolic of the chariot.[11] Concentrations of such burials in certain regions (e.g. Yorkshire, England, and the middle Rhineland) complicate the picture, since apart from these examples, the presence of the Celtic chariot, so renowned in ancient written records, is not clearly in evidence in Middle La Tène graves in general.

The same lack of evidence is true also for the celebrated Celtic cavalry of which we discern only a faint reflection in warrior graves. There are a few horsemen's graves with simple horse-bits, but without weapons (e.g. Bad Nauheim, Niederholm).[12] Several horse burials are known from Montefortino (graves 24, 30, and 41: Brizio 1901; Kruta 1981), and an exceptional example at Beograd-Karaburma (grave 16: Todorović 1972, pl. vi) which included a simple bronze torque, while a spur was found in grave 30 at Beograd-Rospi Ćuprija (Todorović 1963). In the east,

Stead, Végh, Guštin and others in the volume *Keltski voz* (Guštin and Pauli 1984), and also in papers by Harbison (1969), Joachim (1969, 1973), A. Duval (1975), A. Duval and Blanchet (1974). Apart from those sites referred to in the text and included in Table 6, there has not been time to follow through on all of the relevant references.

[10] Joachim (1969) considers the assemblages to be extensive, as they contain distinctive and specialized objects such as toilet gear, and significant amounts of pottery. We have not considered ceramics in our discussion, since their roles in Celtic flat inhumation (and cremation) cemeteries depends strongly on the local cultural milieu. The amount of pottery in graves increases towards the northern and eastern peripheries of the Celtic zone, while it is minimal in the centre. The fine imported ceramics found in the south have quite different significance.

[11] Harbison (1969, 44) emphasizes the point. There are few graves of this type outside the Celtic realms (see Joachim 1969, 95 no. 5, and map, Abb. 7).

[12] Schönberger 1952, 89, Fund 60; Behrens 1918, 50. For other references see Joachim 1969, especially for the cavalry graves with imported Roman ware at Goeblingen-Nospelt (op. cit. 95 n. 5, 111 n. 103).

TABLE 5. *Contents of graves with anthropoid short swords*

Site	Area	Long sword	Lance	Helmet	Chariot	Bronze vessels	Gold	Varia	Moat/ Barrow	Dating (as given)	Reference
Györszemere	Hungary	1	1	–	–	–	–	whetstone	–	L I	Hunyady 1957
Szendrö		–	–	–	–	–	–	carving knife	–	L	Reinecke 1898
Nemilany	Moravia	1	1	–	–	–	–	–	–	L	Skutil 1941
Křenovice grave 20		–	–	–	–	–	–	2 boar tusks	–	LB	Procházka 1937
Châtillon-sur-Indre	France	1	1	–	–	3	–	Boar tusks, bronze plaque	–	L III	Couissin 1926
Les Gobillons		–	–	–	–	–	–	Boar tusks, bracelet	–	L	Bontillot *et al.* 1975
Chatenay-Machéron (Chaumont)		1	1	–	–	–	–	monoxyle boat	–	L II	Couissin 1926
Mouriès		–	–	–	–	–	–	knife		L III	Couissin 1926
Salon		1	–	–	–	–	–	–	–	L	
Fleinheim	Germany	–	–	–	–	–	–	glass bead	barrow	L	
Berne-Spitalacker	Switzerland	–	–	–	–	–	–	–	–	L	Clarke–Hawkes 1955
North Grimston	England	1	1?	–	–	–	–	Pig bones	–	L	Clarke–Hawkes 1955
Ham Hill		–	–	–	–	1	–	bronze nails	–	L	
Malnate	Italy	–	–	–	–	–	–	stone stele	–	L	

TABLE 6. *Contents of some Middle and Late La Tène period chariot graves*

Site	Area	Sword	Ornamented scabbard	Anthropoid short sword	Lance	Helmet	Bronze vessels	Gold	Varia	Moat/ Barrow	Dating (as given)	Reference
Garton Slack	England	–	–	–	–	–	–	–	bronze fragment, horse-bits	barrow	L III	Stead 1984
Arras King's Barrow		–	–	–	–	–	–	–	horse-bits	barrow		
Charioteer's Barrow		–	–	–	–	–	–	–	horse-bits, phalerae	barrow		
Lady's Barrow		–	–	–	–	–	–	–	horse-bits, iron mirror	barrow		
Beverley		–	–	–	–	–	–	–	horse-bits	–		
Cawthorn Camps		–	–	–	–	–	–	–	horse-bits	barrow?		
Hunmanby		–	–	–	–	–	–	–	horse-bits, sheet bronze	–		
Danes Graves		–	–	–	–	–	–	–	horse-bits, bronze disc and button	–		
Pexton Moor		–	–	–	–	–	–	–	horse-bits	barrow		
Nanterre	France	2	–	–	2	–	–	–	horse-bits, phalera	–	3rd century BC	Hubert 1902
Attichy		–	–	–	–	–	–	–	–	–	L IIa–b	Duval–Blanchet 1974
Rocroi-les-Potheés		1	–	1+	1	–	–	–	horse-bits	–	L II	Harbison 1969

Inglemare		2?	–	–	–	–	–	–	horse-bits	–	L III	Duval, A. 1975
Armentières		–	–	–	–	–	–	–	horse-bits, iron spur	–	L III	Van Endert in *Keltski voz*
Boé	S. France	–	–	–	–	–	–	–	fire-dog, amphorae, lamp	–	L I	Coupry 1961
Plaidt	W. Germany	2	–	–	4	–	?	–	bronze attachments, buttons	–	LC/LD_{I}	Joachim 1969
Urmitz		–	–	–	2	–	–	–	glass bead	barrow?	LD_{I}	Joachim 1969
Neuwied Heimsbach-Weis		1	–	–	2	–	–	?	spurs, razor, kettle-hook	–	LD	Joachim 1973
Gransdorf grave 16		–	–	–	1	–	–	–	knife, flask	barrow	L	Schindler 1970
Bad Nauheim		–	–	–	–	–	–	–	–	–	LD	Schönberger 1952
Cristurul Săcuisec	Romania	1	–	–	1	–	–	–	knife, bronze button	–	L II	Roska 1927–32
Balsa	Hungary	1	–	–	1	–	–	–	scissors, knife, boar tusks	–	LC–LD	Végh in *Keltski voz*
Arnót		1	–	–	–	–	–	–	horse-bits	–	L	Végh in *Keltski voz*
Brežice grave 6	Yugoslavia	1	1	–	–	–	–	–	knife	–	LC	Guštin in *Keltski voz*
Odžaci		2	2	–	5	–	–	–	knife, horse-bits, 2 burials	–	LC	Guštin in *Keltski voz*
Tarinci		1	–	–	> 1	–	> 1	> 1+	amphorae, glass vessels, and gold leaves	–	LD/Rom.	Guštin in *Keltski voz*

a few Celtic graves, such as those at Jászberény-Cseröhalom (grave 49: Kaposvári 1969), Dezmir, Curtuişeni, Dobrosloveni and Aiud (Zirra 1971; Crişan 1964, 19 pl. 2), contain bridle-bits, and these probably are connected to the Thraco-Getian cavalry tradition. With the possible exception of grave 49 at Jászberény-Cseröhalom, a warrior's grave containing sword and spearhead, none of the Celtic graves containing elements of equestrian equipment can be shown, either by excavation of the cemetery at Dubník in southern Slovakia (Bujna 1989). Among 46 graves so far excavated there are three large inhumation graves containing swords (graves 17, 18, and 19), which are marked out by enclosures formed by cemetery has not yet been fully excavated.

Eminence in social position among the arms-bearing members of a community might not only be marked by special grave-goods, but by the special layout and form, such as an enlarged grave-pit, of the grave itself (Čižmář 1972), or by a stone setting or timbering or the like. On the eastern periphery of the Celtic world, we find the graves of warriors surrounded by square (from 7 × 7 m to 9 × 9 m) or circular (some over 7 m in diameter), moated enclosures. A specific instance which also throws light on the stratification of sword-graves, has been revealed by excavation of the cemetery at Dubník in southern Slovakia (Bujna 1989). Among 46 graves so far excavated there are three large inhumation graves containing swords (graves 17, 18, and 19), which are marked out by enclosures formed by shallow ditches of length of side from 13 to 17 m. Graves 18 and 19 were conjoined on one side, and grave 19 exceptionally contained a gold ring. Another three graves, without swords, were contained inside similar enclosures. Apart from these, there were five graves with smaller grave-pits containing swords accompanied by modest grave-goods, one an inhumation, the others cremations. It seems that among the graves from that part of the cemetery excavated so far we can identify those of leading members of the community, of whom the occupants of graves 18 and 19 are clearly pre-eminent. These, and other graves, are easily distinguished from less conspicuous sword-graves, and usually find counterparts with female burials which are accompanied by more splendid sets of ornaments. Men's graves usually contain no special luxury goods, although sometimes, a half or whole pig served as a grave offering, one apparently of considerable value (e.g. at Horný Jatov-Trnovec, grave 362 and Palárikovo grave 44). There are other enclosed graves in Slovakia and in the adjacent regions of Hungary and Moravia (Holiare, Bajč Vlkanovo, Györ-Menföcsanak, Domamyslice: for references see Table 7).[13] Although containing the usual equipment of warriors, they may be interpreted specifically as the tombs of prominent personalities charged with the leadership of groups of communities or more extensive territories.

[13] Pairs of male and female moated graves (also those of children) can be found in Slovakian cemeteries, apparently containing the remains of leaders of communities, or even of groups of communities. Such pairs include Trnovec graves 362 and 233, Holiare graves 29 and 136, Palárikovo graves 46 (containing only a spearhead accompanying a cremation), 84 and 86 (a child's burial). For references see Benadík *et al.* 1957; Benadík 1978. At Bajč-Vlkanovo, two moated graves (nos. 60 and 22) should be noted, although unfortunately they had been robbed in antiquity (Benadík 1960).

TABLE 7. *Contents of some La Tène period moat and enclosure graves*

Site	Area	Long sword	Ornamented sword	Short sword	Lance	Helmet	Bronze vessels	Gold	Varia	Enclosure (moat)	Dating (as given)	Reference
Domamyslice	Moravia	1	–	–	1	–	–	–	–	9 × 9 m	LB_1	Čižmář 1973
Horný Jatov-Trnovec grave 362	Slovakia	1	–	–	1	–	–	–	scissors, 1 pig	10 × 10 m	LB_{2b}/LC_1	Benadík *et al.* 1957
Holiare, now Bodza grave 29		1	–	–	–	–	–	–	–	∅ 10 m	LC_1	Benadík *et al.* 1957
Palárikovo grave 44		1	–	–	1	–	–	–	½ pig	∅ 6.5 m	LB–LC	Benadík 1975
46		–	–	–	1	–	–	–	–	∅ 6.5 m	LB–LC	
84		1	–	–	1	–	–	–	–	7 × 7 m	LB–LC	
Dubník grave 17		1	–	–	1	–	–	–	razor, animal bones	14 × 14 m	LB–LC	Bujna 1989
18		1	–	–	1	–	–	–	shears, razor, knife, animal bones	15 × 15 m		
27		1	–	–	1	–	–	–	razor			
19		1	–	–	1	–	–	1	shears, razor, animal bones	15 × 20 m		
Ménföcsanak grave 14	Hungary	1	–	–	1	–	–	–	–	9.5 × 9 m	LB–LC	Uszóki 1970
18		1	–	–	1	–	–	–	knife, animal bones	7 × 7 m	LB–LC	
Wallertheim grave 3	W. Germany	1	–	–	2	–	–	–	scissors, axe, 6 fibulae	28 × 28 m	LD	Kessler 1929/30
5		1	–	–	1	–	–	–	–	20 × 20 m	LD	
Villeperrot grave WC 2	France	1	–	–	–	–	–	–	–	7 × 7 m	L I/II	Bulard 1979
WD 1		1	–	–	1	–	–	–	–	5 × 5 m	L I/II	

Little evidence in regard to this problem is provided by the west European square-enclosure graves (Stead 1961),[14] but two are of some relevance to our discussion. At Villeperrot in France, two graves of the period LC_2–LD_1 draw attention, but only on account of the decorated scabbards which they contain (Bulard 1979). They were surrounded by moated enclosures, in the case of one a square formation measuring 7 × 7 m, the other also a square of side 5 m. At Wallertheim in Germany (Kessler 1930; Behrens 1930), several enclosures were superimposed one on another. One which contained a centrally placed cremation burial along with a sword, spearhead and five fibulae in an oblong, rectangular-sectioned pit, measured 20 × 20 m. The sides of an enclosure which it overlay, and which contained graves 3 and 4 (grave 3 containing a sword with bronze scabbard, two spearheads, an axe, scissors, and six fibulae, while grave 4 was a female burial accompanied by two bronze vessels) measured some 28 × 28 m. In the area of a third enclosure, adjacent to the northern area of the site, two simple cremation graves (no. 1 and 2) were uncovered.

We may draw some tentative conclusions from this survey of selected features of cemeteries. The heads of small units of population, and probably also their closest male relatives, wore long swords. In large-scale military operations, accompanied by their retainers, they joined their chiefs who were the organizers of raids and war campaigns. Such warriors comprised the bulk of Celtic war-bands and armies. The chiefs, whose hierarchical organization is hidden from us, were also armed, possibly in the same style as their *hetairoi* with long swords. With a few exceptions, it is difficult to recognize the military leaders (and in the Celtic hinterland, the regional rulers) from the evidence of excavated graves, for the simple reason that not every sword-bearer can have been a leader. Nevertheless, the general uniformity of grave assemblages from Middle La Tène Celtic burials allows us to pick out those which, besides the usual sword and spearhead (and shield), contain exceptional goods—the main categories of which are helmets (and cuirasses), 'commanders' ' anthropoid-hilted swords, and chariots. Such graves also contain luxury items such as bronze vessels, Greek or Italiote vases, toilet gear (strigils, razors, scissors) and specific emblems such as boar tusks. There are, moreover, graves which attract our attention by their unusual arrangements or positions within a cemetery or region (burial mounds, moated enclosures, *stelae*, and the like). The significance of these categories in distinguishing the rank of those buried varies according to their geographical distribution and degrees of exposure of cultural influence from the south. The moated enclosure of a warrior grave in Slovakia which contains a pig as grave goods, or a chariot in a northern France grave, are both more indicative of high rank or position than a helmet or a richly

[14] In Yorkshire, in England, such graves have been severely damaged by subsequent activity so that a proper evaluation and listing of grave assemblages is not possible. An object resembling a dagger was reported from the Seamer Moor barrow (Stead 1961). In France, at Normée and Écury-le-Repos, the enclosures, ranging from 9 × 9 m to 16 × 16 m, contained several burials and it is possible (particularly in the latter case) that these were ritual sites.

decorated sword, Greek vases and southern imports in graves in northern Italy or the subalpine regions.

To distinguish between different classes of leader among the Celts (kings, princes, chieftains, military commanders) on the basis of archaeological evidence is almost impossible in the Middle La Tène period, when there was a tendency not to surround the dead, however honourable, with ostentatious luxuries. The sword at that time was no longer reserved for the top men in society, but had become spread throughout the bulk of the population, represented by their 'ironsides'—the heads of families, households, and farms (*oikoi, vici, aedificia privata*)—in a broader social context.

Mass Deposits

In addition to finds of swords in graves, and occasionally on settlement sites, a number of Celtic swords have been found in several important mass deposits. One of these is obviously the famous eponymous site of La Tène in Switzerland, where two moles or bridge-like structures were discovered in the ancient Zihl river after the Jurassic water-level correction between 1861 and 1881, La Tène itself having been known since 1858. Many hundreds of artefacts have been collected there in the neighbourhood of the 'Pont Vouga', and among these, arms predominate, with the assemblage including 166 swords many of which are still in their scabbards, 270 spearheads, 22 shield bosses and 5 complete shields, together with chariot parts, saddles, tools, ornaments, iron bars and fittings, and many other types. The assemblage dates from the Early through to Late La Tène, with new dendrochronological determinations for indicating a range of at least the third to first centuries BC (timber from Pont Vouga 287 ± 6 BC, wooden shield 256 BC, wood from Pont Desor 65 BC). Interpretations of the site vary, and it has been at one time or another described as an *oppidum*, a fort, a fortified trading post and a customs post. More recently, Raddatz (1952) introduced the idea that it was a place of sacrifice, analogous to a number of other contemporary sites. Among these is Port at Nidau, upstream on the Zihl river, which was discovered and worked in the period 1868–71 and 1874, where among the oak piles of an ancient bridge were discovered more than 60 swords, 38 spearheads, 14 daggers, and other objects including tools and animal bones. Another site for comparison is Chalon-sur-Sâone (ancient Cabillonum) where from the river were dredged 20 swords, spearheads, and other artefacts. It is interesting to note here that the majority (77 per cent) of the punchmarked swords known come from La Tène and Port (for listing, see Drack 1955), supporting the idea that the motive for depositing weapons in waters and marshes, like that for the application of punchmarks, was religious in inspiration.

Finds from another site would appear to support this interpretation. In the moat of a square sanctuary at Gournay-sur-Aronde in northern France, in its frontal wings on both sides of the entrance, were recently found between 80 and 90 swords (represented by 102 items, some of which were fragments), 73 spearheads, between 179 and 190 shield-bosses, the elements of more than 102 belt-chains or girdles, and a mass of animal bones which provide evidence of sacrifices. Lejars (1989) has published two old deposits of Celtic weapons in sites excavated in the nineteenth century and explained as sanctuaries, at Faye l'Abbesse (9 swords) and Nalliers (4 swords) in Poitou, western France. The site at Llyn Cerrig Bach, Anglesey in Wales, which is estimated to date from *c.*150 BC to AD 50, seems to have had a similar purpose, and 11 swords, 6 spearheads, one shield-boss, and many other objects including chariot components, sickles, and cauldrons were found there.[15] The situation is somewhat different with the find of a deposit in the central part of the *oppidum* of Manching in Bavaria, where weapons, including swords with notches in their blades, and belts, have been excavated from pits (Sievers 1989). The interpretation of these finds is ambiguous, and they might be either the remnants of a votive deposit or, as originally suggested by Krämer, traces of a localized clash.

Many of the swords from La Tène, Port, and Gournay bear series of cuts on their edges. It is not clear whether these are the result of combat or were inflicted deliberately before the swords were deposited as sacrifices (see pp. 159–61).[16]

[15] La Tène: Déchelette 1914, II-3, 935–41; Vouga 1923. Châlons-sur-Sâone: Raddatz 1952, 27 n. 13; Kruta and Szabo 1979, 248, fig. 34. Port: Fellenberg 1891; cf. Tschumi 1940, 1953, 328. Gournay-sur-Aronde: Brunaux *et al.* 1978; Caudron *et al.* 1978; Rapin 1982; Uran 1983, 72–6, fig. iii.2.13. Nalliers and Faye l'Abbesse: Lejars 1989. Llyn Cerrig Bach: Fox 1946, esp. 5–6. There was a long pan-European tradition of making ritual deposits in water, as evidenced by finds from rivers, springs, lakes and bogs (Torbrügge 1973; Lavrsen 1982), supporting Raddatz' interpretations of the site of La Tène.

[16] There has been controversy surrounding similar cuts on weapons from Danish bog deposits of the Roman period (see Gebühr 1977, 1980; Biborski 1981).

4

The Characteristics of the Celtic Sword

Among archaeological finds made in Europe, the Celtic sword is distinguished by characteristic features of its constructional system (guard, scabbard, suspension gear), and in some cases by decoration. The principal typological elements of shape are, for all practical purposes, uniform over wide areas of the Celtic world, revealing a Celtic weapon as intrusive if found far outside the Celtic lands. While local spatial and chronological variants exist, they do not invalidate the definition of the general design. In fact, little attention has been paid to the possibility that foreign master-smiths may have imitated true Celtic long swords in all their details, but again, this possibility does not alter the definition. The decoration which appears on the sheet-metal scabbards of some weapons, has been inspirational in the study of Celtic art, and has given rise to investigations of the influences of individual artists and workshops through contacts between different regions of the Celtic world and beyond.

The Long Sword

The blade of the typical La Tène period long sword (Fig. 2.5–6) is relatively wide, the proportion of length to breadth being in the region of 18 : 1, or, in the case of the late and very long blades 23 : 1.[1] The blade basically is a two-edged bar, shaped to give a flat or lenticular cross-section, or provided with a central rib which makes the cross-section lozenge-shaped. There are blades with prominent midribs, but grooved blades, or those with grooves on either side of a central midrib, are the exception. In other cases, midribs are less prominent, merely being the centre of a blade surface whose topography is like that of a roof. At each side of the top of the blade, there are shoulders which have curved, bowed, or sloping lines. Rectangular shoulders to the blade, indicating a straight guard, are exceptional, appearing only on some late La Tène examples. The shouldering allows the protrusion of the long hilt-tang which is rectangular or round in cross-section, narrowing towards its tip. The tang formed the skeleton of the hilt, the shape of which has been lost in the

[1] Based on late examples from La Tène and Port (Wyss 1968; see also Stead 1983).

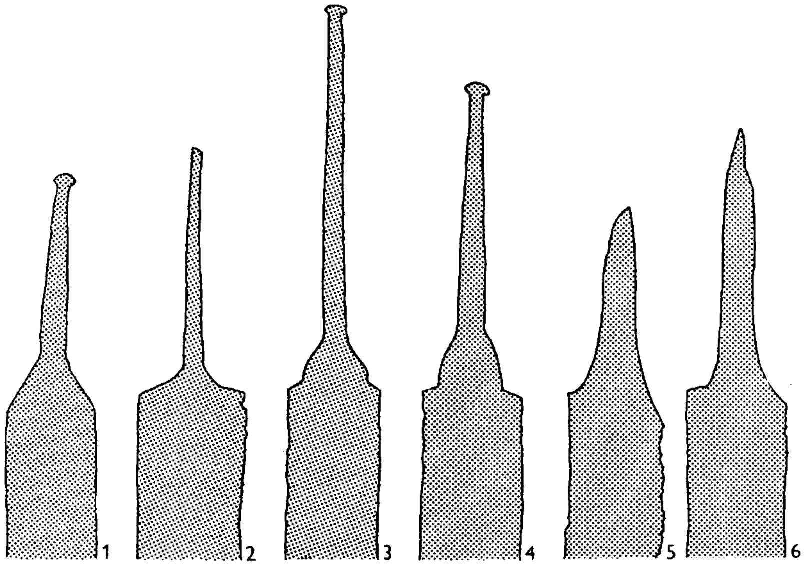


Fig. 5. Examples of types of blade-shouldering which contributed to the form of the hilt.

great majority of cases[2] (Fig. 6). It is particularly difficult to visualize the form of the original hilts in the case of blades with assymetrically-sloping shoulders (Fig. 5.5–6). In place of a pommel at the tip of the tang, there is an oval or disc-shaped button, mounted as a separate component or upset from the metal of the tang itself, or a rivetted disc-formed plate, all of which variants served in fixing the body of the hilt in place (e.g. the sword from Dalj, Yugoslavia: von Jenny 1932; Emmerling 1975). The hilt is divided from the blade by a thin, short and rather rudimentary guard which follows exactly the campanulate curves of the blade shoulders. This is one of the most striking characteristics of La Tène period swords.

The general design concept is that of a typical cutting sword, a fact that accords with the written sources. However, it is better to think of most of these swords as being cut-and-thrust weapons, because, contrary to the written tradition, there are very few Celtic swords without points (*sine mucronibus*),[3] and these are all late in date. The writers of the first century BC were probably familiar with this type, and had not had the opportunity to see swords of the fourth and third centuries BC. The bulk of these earlier weapons have a relatively sharp point which is the tip of the parallel-sided blade gradually narrowed over the last third of its length. This shape, developed in the Early La Tène period (Fig. 2.3) tends to shift the centre of

[2] The domed or campanulate forms of the scabbard mouths evoke the image of a four-armed hilt in a stylized X-form, one which is well exemplified by the Liebau sword (Coblenz 1956, 322, abb. 47–8). Rapin (1982) and Uran (1983, fig. i.13) also reconstruct hilts of Celtic swords in this way (Fig. 6): there is also an unpublished example, in iron, from Hallein, near Salzburg in Austria. This four-armed form of hilt would, after all, correspond to the general design of the anthropoid sword-hilt.

[3] Rounded or squared points are found on some of the latest La Tène swords (Déchelette 1927, 615; Jahn 1916, 27; Wyss 1968, Taf. L.8, 2.3–6, 4.2–3).

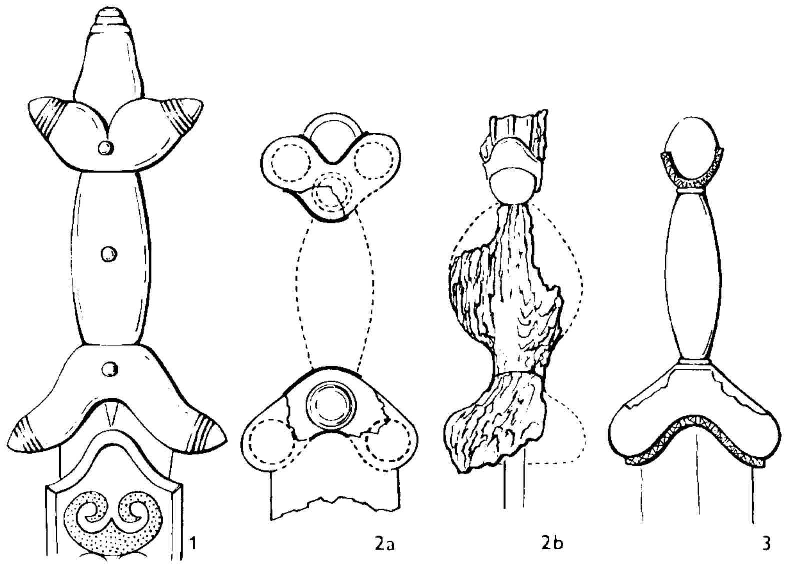


Fig. 6. La Tène period sword-hilts

gravity towards the point, creating a rather Gothic silhouette. While we do not need to set out the classification of La Tène blade forms, we may note that the average length of the European and British swords is 72 cm (including hilt) within a range of 55 up to 95 cm. Late swords, such as examples from La Tène itself, and Port, often reach lengths in the range of 105–130 cm. Stead (1983) has offered a basic chronology of Celtic swords from Champagne in France, based on the ratios of length to width of the blades.

The surfaces of the blades of Celtic swords are generally badly damaged by corrosion exactly like other iron artefacts from archaeological contexts. Nevertheless, there are well-preserved examples, especially those excavated from wet, anaerobic conditions, which permit more detailed observations to be made. On such weapons, strips run in relief along the main axis of the blade, sometimes perfectly straight, sometimes sinuous. In some instances, they mark out the cutting-edges like weld-seams, while in others they form oblong, worm-like features. Recent research has shown that such features result from etching by natural acids (a form of preferential surface oxidation), since their internal crystal structures show no traces of weld-seams (France-Lanord 1964; Wyss 1968).

Apart from these naturally produced features, we also have artificial features for blades, usually the later ones, where large areas of the surfaces are covered with punched or incised dots which give them the appearance of worked leather, hence the use of the term *chagrinage* (or *shagreening*) in archaeological literature (after de Navarro 1972). Besides fields shagreened by simple tooling, there also appear fields stamped with compound punches with rows of round, squarish or even figure-of-eight head cross-section. Sometimes this form of decoration resembles that observed on warriors' girdle chains (*Panzerketten*, *gepanzerte*, *gedellte Ketten*). If this was not purely ornamental, then the purpose of the technique is not quite clear, although it could be suggested that this densely packed, shallow punching must have hardened the surface to a certain extent. This form of treatment is not a common feature, and is seen on a limited number of weapons only.

Punchmarks

One very distinctive feature is the punched mark which is found on a group of La Tène swords discussed above (see pp. 45, 48). They were normally placed singly, or in twos and threes, on the surface of the blade, several centimetres below the guard. When two occur, they are situated either on one side of the blade one below the other (Mandach, Wangen, and SW Lothringen in Germany; 'Italy' provenance unknown), or side by side one in each half of the blade (St Michael in Kranj-Slovenia, La Tène: on anthropoid swords such as examples from Mainz-Kastell, Untermenzig and Munich-Allach in Germany; Musée de Lyon; Lysice). A sword from Böttstein, Switzerland is exceptional in bearing three marks, two placed one below the other on one side of the blade, and a third on the other face. In other instances traces of gilding of these marks has been noted (Böttstein: cf. Drack 1955). Others were inlaid with gold or brass, including those astral symbols on anthropoid-hilted swords (Bulard 1980). Among the motifs represented by punchmarks, Drack (1955) distinguished the following groups: (i) zoomorphic representations of boars, horses, bulls, and birds; (ii) anthropomorphic marks usually in the form of a human bust *en face* with a frilled gown and the head inclined so as to be observed from the perspective of the sword-bearer: two exceptional motifs are known from France, one on a blade from Chaussin in the French Jura which shows a crouching human figure with what can be described as a hammer, the other on a sword from Courgenay which shows a human head in profile (Parruzot 1955); (iii) astral or planetary symbols, comprising solar discs, crescents, or a crescent side by side with a solar symbol and often divided by an inlaid bar on the rib of the blade. Combined motifs are comparatively rare, but include groups comprising horsemen, or the tree of life with two goats on either side as on the famous *Korisios* sword from Port at Nidau, Switzerland.[4] Footprint-shaped marks appear also at La Tène.

The distribution of punchmarked swords of which there are more than 50 examples, is at the time of writing restricted to the Senonian or Helvetian sphere of northern Switzerland, with sporadic occurrences in eastern France, northern Italy and southern Germany. All of these swords come from just eight sites, with 34 of them coming from La Tène itself, and a further 5 from the Port deposit. Punchmarks occur also on swords in northern Italy and south-eastern Europe, but are not discussed here because of the paucity of information.

[4] Wyss 1954; Lieb (in Wyss 1954); Livens 1972.

The marks have been interpreted in a variety of ways. Thus, Keller (1866, 295), followed by Wyss (1954) and Parruzot (1955), interpreted them as makers' or workshop marks, put on by master-smiths as emblems of their highest-quality workmanship and hence of their workshops. Against this, Vouga (1923, 36) ascribed them to the customers. In his detailed study, Drack (1955) gathered much evidence which suggested that these marks were of symbolic, magic, and apotropaic significance, and concluded that they were symbols of deities and of supernatural forces. One aspect requires consideration, and that is the fact that these punchmarks required special steel tools which are likely to have been found in only a few workshops. Despite the variety of forms, and slight differences which occur among types (e.g. boars and busts), it is hard to imagine that there were punches made specifically for individual blades. A certain number must have been struck with the same tool, and this eliminates the theory that the marks were those of the owners of swords. On the other hand, the theory that they were the marks of individual masters does not sit well with the facts that only a limited number of swords were marked and that we find different motives occurring on the same blade (e.g. the Mandach sword which is marked both with a human bust and a boar).

As Bulard (1980) correctly recognized, astral symbols, solar discs, and crescents on the blades of anthropoid-hilted swords are definitely not makers' marks. It seems evident that the significance of these symbols which were widespread throughout the Celtic world, some even appearing on Celtic coins (Drack 1955, 223–6; Wyss 1954) was magico-religious. In our view, set out in an earlier work (Pleiner 1962, 96–8), their significance is to be sought in the sphere of belief. Selected warriors or chiefs were able to draw upon the powers attributed to certain symbols as protection against evil, or to stimulate them to heroic deeds. These swords of course must have been manufactured in a workshop which may or may not subsequently have used special punches to mark them. It is thus crucial to note that there is no correlation between the appearance of punched marks and the quality of the blades. Four punchmarked swords which have been subjected to metallographic examination were of only average properties (Heiligenstein, Tuttlingen, Augsburg, and one unprovenanced example: see Chapter 7, examinations 67, 69, 70, and 119). Against this, a Late La Tène sword from Zemplín in Slovakia, stamped in Latin letters with a word which may be a personal name (Fig. 11), proved to be a good quality steel weapon (Chapter 6, examination 27). A blade from an unknown site in Champagne bears an incised animal figure (Stead 1983, no. 83) which should not be confused with the punchmarks which occur regularly on La Tène swords.

Scabbards

Scabbards were normally made of metal sheets, and consist of two copper, bronze, or iron shells clamped together by the technique discussed by Emmerling (1977).

Earlier display-scabbards, however, have a decorated front-piece of bronze and a plain iron back-piece (Osterhaus 1969). Traces of wooden linings to a number of scabbards have been observed. The scabbard-sheets were fastened by mountings, themselves often decorated artistically. At its mouth, the scabbard followed the shape of the shoulders of the blade in a campanulate profile, and were often reinforced at this point. The suspension gear too was important, consisting of a metallic suspension-loop with circular, oval or other shapes of plate rivetted to the reverse scabbard-sheet (Fig. 2.5–6) and sometimes connected to the front plate by metal bridges. The suspension-loop allowed a leather strap or belt chain to be passed through it. The end of the scabbard was reinforced by special openwork mountings called chapes which may be decorated. The variety of chape-form provides a useful basis for archaeological classification. The very early chapes are of open ring and chordate forms, and this latter form may have from two to five insert discs or medallions in twin, trefoil, or bunch-of-grapes arrangements. These discs could also be inlaid with coral. Filip (1956, 159–60) believes that the scabbards bearing medallions had a role in distinguishing a warrior hierarchy. Some chordate chapes have finials (themselves often decorated) which point or curve inwards. There are also openwork chapes, and chapes with so-called 'bridges' which are transverse joints attached by clamps to the scabbard-sheets.

It is clear that the decoration of Celtic scabbards was an integral part of their construction. Indeed, in the more elaborate cases, this decoration might cover the whole surface or significant parts of it with incised, engraved, or chased motifs. These scabbards developed in several chronological stages and in different cultural areas. They are characterized by the styles of the motifs with which they were covered. The Celts adopted and transformed some Greek, Etruscan, Italiote, and even Oriental motifs, apparently in two main waves (Hatt 1982), but to a great extent moulded and enriched the originals with their own typical ornamental elements.

The first immature figure depictions, such as that on the scabbard from grave 994 at Hallstatt cemetery, believed to be of non-Celtic, probably subalpine origins (Filip 1956, 160), are found among the earliest decoration of scabbards in the fourth century BC. To this horizon also belongs geometric decoration in which a complete surface is covered by swastika- or meander-motifs (e.g. Vert-la-Gravelle: Jacobstahl 1934, no. 90), or where the margins are filled by bands of S-lyres, U-elements, dots-in-circles, or tremolo-and-meander decoration (Jenišův Újezd grave 115: Fig. 7.1; St Germainmont in the Ardennes and Bavilliers near Belfort, in France: Osterhaus 1969, Abb. 2.1),[5] or tendrils (Moscano di Fabriano: Frey 1971). The use of the typical Celt curvilinear motifs developed slightly later. Most of the best-known scabbards belong to the third century BC. The repertoire of the artists who decorated the majority of scabbards included stylized zoomorphic elements, S-lines, spirals, triangles with curved sides, triskeles or triquetras, peltas, and

[5] These elements find their counterparts on stamped decoration of Early La Tène pottery.

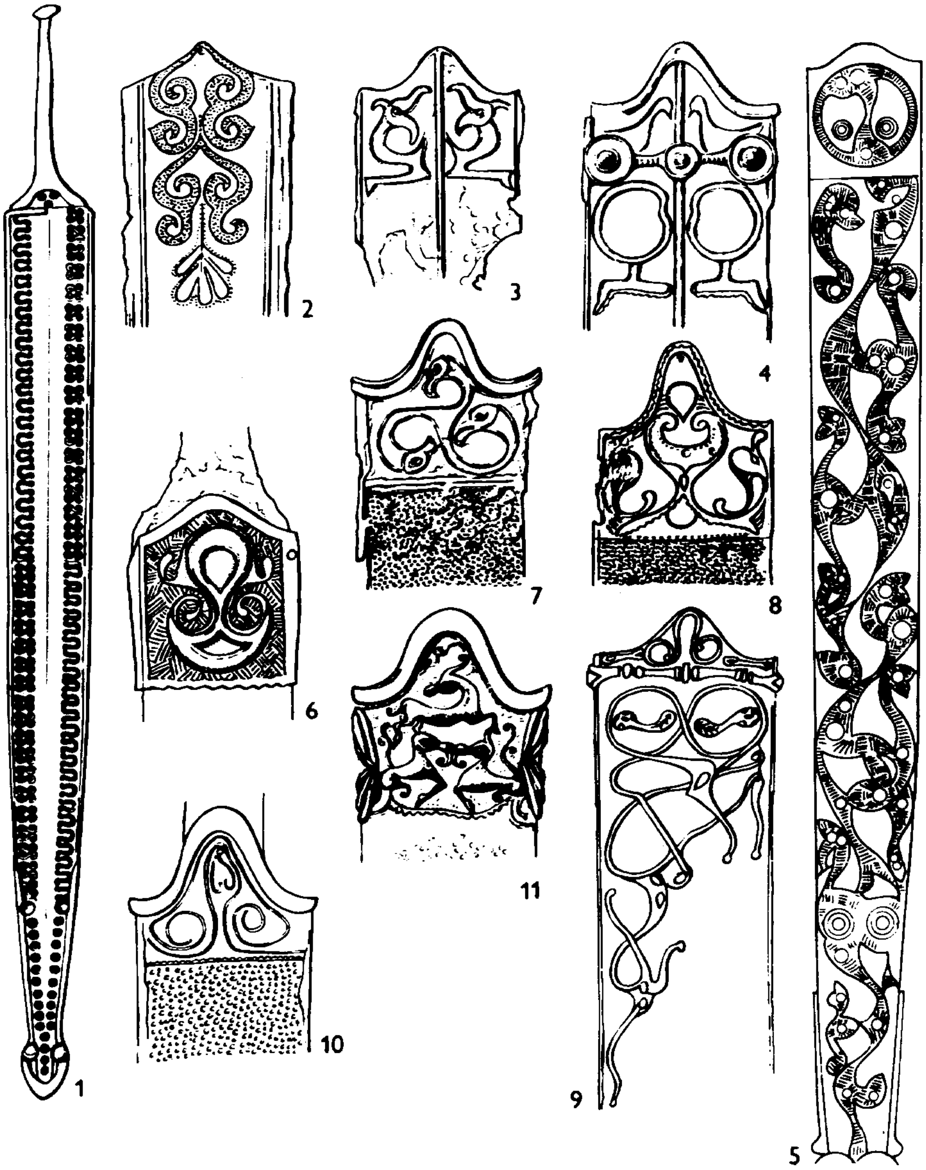


Fig. 7. Selected examples of Celtic ornamented sword-scabbards

arabesques (Fig. 7). On the basis of their careful comparative analyses, De Navarro (1972) and P.–M. Duval (1977) suggest that hippocamp motifs and stylized bird-pairs arranged facing one another were gradually replaced by analogous dragon-pairs which adorned the upper part of the front-plates of scabbards, just below the guard. Later in the developmental series, more floral elements (palmettes, peltas, virgules, and mistletoe leaves) in a wide variety of arrangements, are found concentrated in the upper or upper and lower regions, spread along the central axis, or running in assymetrical, diagonal/oblique fields. This last type of composition, very elaborate and complex, is identified by Jacobstahl (1934, 95–7; cf. Szabó 1977, 1979) as his famous Hungarian Sword Style of the third century BC.

Recent studies tend to offer reconstructions of complex interchanges between different Celtic regions in which master-craftsmen accepted from, or transmitted influence to other areas. The Hungarian style, spread by contacts between Celtic groups (Megaw 1979), is thus supposed to have inspired a revival of artistic expression in a very ancient region, that of the Senones, Helvetii, and related tribes, thus giving rise a little later to the Swiss Sword Style (de Navarro 1972, i. 239f.). This, in turn, is seen as transmitting its component motifs (triskeles, cursive lyres and scrolls, animal representations, etc.) to other distant areas in Gaul and Britain (P.-M. Duval 1977, 120). Very late English and Scottish scabbard ornamentation depended upon axial systems of plastic mountings, placing the suspension-loop in the middle of the front-plate (Piggott 1950, 1–2, and Figs. 9 and 10).

Late Continental sheet-iron scabbards also bear punched *chagrinage* or laddering, sometimes carefully, sometimes not so carefully executed by overlapping the marks. Compound punchmarks with lozenge-shaped, crescentic, squarish and triangular teeth appear on scabbards (Fig. 7.7–8 and 10–11). There are examples of laddering with space reserved for chiselled or chased decoration. Despite the general chronological sequences and stylistic developments, one must always be prepared to admit the long survival of motifs and the overlapping of stylistic representations.

The decoration applied to those scabbards selected for this treatment indicate the work of master-smiths not only endowed with admirable artistic feeling, but also capable of complicated workmanship. The mastering of complex geometric designs and their application by incising, engraving, embossing, and punching required not only skill and dexterity, but also specialized tools. This leads to the speculation that the manufacturers of decorated scabbards might have formed a separate caste of craftsmen.

It is highly probable that the significance of decorated scabbards lay not only in their aesthetic appeal, but as with the punchmarks, also in some form of ideological function. Many motifs can be regarded in terms of possible beliefs in their prophylactic or apotropaic potential.[6] If this was the case, then the question arises as to the selectivity of ownership of swords with decorated scabbards among warrior groups. Possession of such a weapon may not have depended solely on position in the leadership hierarchy, but could have been connected also to factors such as those personal qualities (warriorship, personal merit, potential) which we cannot recognize from the archaeological record.

[6] The motifs on scabbards, which are often preserved only in fragments, have in many cases, as P.-M. Duval (1982) points out, been wrongly reproduced in publications and thus misinterpreted.

The Anthropoid Short Sword

As mentioned above (pp. 49, 50), there is a group of La Tène short swords or daggers labelled as anthropoid or pseudo-anthropoid, the name deriving from the stylized anthropoid form of the bronze or iron hilt (Fig. 2.4) mounted on the tang of the blade. The whole configuration resembles the letter X, with the elongated middle forming the torso, the lower branches being the legs, the upper the arms, these limbs generally ending in disc-buttons. The tip of the tang which protrudes between the arms is usually topped by a knob (sometimes lost) or a human head.[7] There are hilts on which the head is either missing or else merely vestigial. Anthropoid hilts have been subdivided into seven classes (not discussed here) by Clarke and Hawkes (1955).

The blades of these swords usually have lozenge-shaped cross-sections and well-developed points, and range in length from 29 to 55 cm.[8] Some bear punched marks in the shapes of crescents and solar discs (dots-and-circles), sometimes separated by a perpendicular bar in the central rib, perhaps representing the contrast between night and day (Bulard 1980, 47; Čižmář 1989); these punchmarks were occasionally inlaid with gold or brass. No metallographic examinations of this type of sword have been carried out. Some specimens are still held by corrosion in their scabbards which were made of iron or bronze. The scabbards are equipped with suspension gear similar to that of the scabbards of long swords, and can bear similar decoration. Some 40 examples are known from Europe, spread from the central Gallic territories to the west coast of Ireland and to parts of the Carpathian basin (Petres 1979, 575). According to recent studies, they date to all phases of the La Tène period. While this type of sword might have been suitable as a personal weapon, possibly distinguishing warriors or commanders of certain rank (cf. pp. 49, 50), it could hardly have been used for fighting on the field of battle.

Rapiers

We should note finally a curious type of sword, the long rapier known in German archaeological literature as the *Knollenknaufschwert* (Fig. 2.8). Fewer than 20 examples from some 15 localities in central Gaul and southern Germany have been recorded. They come in the main from wet sites, so that for a long time their dating was in doubt, until Krämer (1962) in his analysis of the Chiemsee find, brought out a consensus opinion that this type was a Celtic weapon of the Late Hallstatt or Early La Tène periods.[9] What is striking about these weapons is that they are

[7] The British example from Witham, now lost, had instead a crouched human figure.

[8] The pseudo-anthropoid Early La Tène sword from Kyšice in Bohemia is, in fact, a long sword (74 cm: for illustration see Pleiner and Rybová 416, fig. 20.1).

[9] The rapier from a river at Montereau in France was found with a Late La Tène sword, while the example from the river Loire at Nantes, also in France, was found with some La Tène period *potin* coins (Krämer 1962, 120).

exclusively thrusting weapons, a fact completely at variance with the concept of the Celtic cutting sword. It is also most noticeable that these weapons are totally unknown from the usual cemeteries and hoards.

Their technical characteristics are of interest also. The type has a square-shaped section, and is narrow (tapering from 18–25 mm at the guard to about 12 mm at the point) and extremely long (in the range 73–83 cm). If we include the hilt-tang, then the range of length rises to 86–105 cm. From X-radiography carried out by Driehaus (in Krämer 1962, 121–4, pl. 11), the blade (at least in the case of the Chiemsee specimen) was welded together from two triangular-sectioned iron bars. The hilt-tang was not formed by drawing down the metal of the upper part of the blade, but by welding on short bars of lozenge-shaped section to the campaniform arch at the top of the blade which formed the guard and on the long swords marked the transition from blade to tang. The top of the hilt where the pommel sat was perforated centrally. The most characteristic feature is the iron beads or globules attached to the welded-on hilt-tang, with four located at the pommel and two on the tips of the guard, crowning the hilt.

The scabbards found with these rapiers are constructed from two overlapping iron strips, and they fit closely to the blade surface. It was mounted by a hinged joint to an iron plate locked by a removable iron pin. These look very like very good examples of the work of the locksmith (Fig. 2.8*a*). It is hard to see how the plate was ever suspended to a normal belt, or even how it could have been hung immobile on pillars, walls, or trees, and further discussion would merely be highly speculative. We may hazard the guess that this weapon, which was clearly suitable for fencing only, was used in duels of exceptional, even ceremonial or ritual importance, and was never worn to battle. Thus it did not form a part of the normal equipment of a warrior.

5

How the Long Sword Was Made

It has already been pointed out that the shaping of a relatively thin and long sword-blade must have been a difficult task for early smiths who had only the basic tools—hammers and tongs—at their disposal.[1] To appreciate the techniques of these workers, who understood well how to shape the long blades with their varierty of cross-sections, without access to rolled bar material, we decided to organize a series of forging experiments aimed at reproducing swords modelled on those of the La Tène period (Plate I).[2] It should be stressed that the object of the work was not to imitate the techniques of blade construction as reconstructed through metallographic examination (see below, pp. 78–155). Rather, we aimed to retrieve that data not obtainable from metallography, namely the stages and approximate number of heats required by the manufacturing process, the techniques of hammer-and-anvil work required to produce the various cross-sections, the consumption of materials and the duration of the process.

In terms of raw materials, our task was easier than that of the ancient smiths, since we had no iron blooms and were thus forced to use modern commercial construction steel (0.1–0.2 per cent C with a structure of fine ferrite and pearlite). The process was carried out in an ordinary blacksmith's forge, the hearth being fed with brown mineral coal. The project involved the forging of the two main types of Celtic sword, a flat blade of lenticular cross-section and a blade with a central midrib and a rhomboidal cross-section. One question which we addressed was that of whether Celtic smiths had any suitable semi-products available which they could forge out into blades.

The Starting Point

Small bloomery furnaces produce a sintered iron sponge which then has to be reheated and forged both to expel slag resulting from the smelting process and to

[1] It is questionable whether all smiths had iron anvils. The dimensions of examples preserved from the La Tène period are too small for use in heavy hammerwork. It is conceivable that stone anvils were used instead (Pleiner 1982, 125–8).

[2] The Archaeological Institute in Prague, represented by the author, co-operated with the Regional Museum in Blansko, Moravia, which employs a master blacksmith, Mr F. Brodecký. The experiments were carried out in a smithy at Štechov, near Lysice in the area of Boskovice, in November 1982. Mr Brodecký carried out the work with great understanding of its requirements and was very helpful in recording the data presented here.

consolidate it into a more compact loaf-shaped bloom. A number of blooms, weighing 2–2.5 kg, are known from the Hallstatt period, in one case even from a Final Bronze Age context,[3] while a set of similar blooms dated to the Late La Tène period was found at Nový Smokovec in northern Slovakia.[4] These blooms originate in a neighbouring region, close to the eastern frontier of the Celtic world, and which was later occupied by Celts. From the central parts of the Celtic heartland we have some blooms from the *oppidum* at Manching in Bavaria.[5]

Such loaf-shaped blooms could have been used as the starting points in the manufacture of a variety of artefacts, but then longer bars were required, they would have had to undergo several operations to transform them into rod shapes. In the Continental Celtic domains (including Britain), there are scores of finds of various types of iron bar, one of the best-known being heavy bi-pyramidal ingots.[6] Given their weight, averaging 6–7 kg, these would have required to be divided and reforged to provide stock suitable for the manufacture of long blades. Metallographic examinations, in fact, have shown that these ingots were themselves formed by the welding together of three or four individual blooms.

In addition to bi-pyramidal ingots, there are also bar-shaped semi-products, usually interpreted as a form of pre-monetary exchange, the so-called 'currency bars' (supposedly the *talleae ferreae* referred to by Caesar *BG* 5. 12. 4), but which could equally have been treated as the stock from which various elongated artefacts were forged. These would have been ideal for conversion into long sword-blades, and in European archaeological literature they are frequently referred to as *saumons d'épée* and *Schwertbarren.* They occur in three main forms, each with its own variants. The first comprises the so-called *Schwurschwerter* which are found distributed among a few hoards on the northern periphery of the Celtic domain in Germany. They are long, ranging from 54–60 cm right up to 84–109 cm, the longer ones weighing around 4–5.5 kg. They are typified by a 'neck' which reduces the width at one end,[7] and is reminiscent of the transition between the blade and tang

[3] Šafárikovo in Slovakia (Final Bronze Age, HB_3, excavated by V. Furmánek, at present under study); Jasov and Krasna Hôrka (both presumably of HC date: references in Pleiner 1962, 61 nn. 82–3). Several blooms from the hillfort of Smolenice-Molpír (excavated by M. Dušek) have been investigated metallographically (Pleiner unpubl.: Archaeol. Inst. Prague report 2356–7/70).

[4] Pleiner 1962, 68, pl. i.

[5] Jacobi 1974, 253, no. 1498. It is possible that this brick-shaped piece represents not a bloom, but a worked bi-pyramidal bar the tips of which have been cut off.

[6] They are mostly undated, but some recent finds indicate the time-span of the currency of bi-pyramidal bars as being from Hallstatt D (Heuneburg, Germany: Kimmig and Gersbach 1971, 54–6 and 168–71), through the Early La Tène (Mont Lassois, France: France-Lanord 1963, 168–71), to the age of the *oppida* (Manching, Germany: Jacobi 1974, 248–50). Bi-pyramidal bars have two main variants, one short and thick, the other with prolonged points. Several Late Hallstatt period beak-shaped (and sometimes perforated) bars from central and eastern Europe might have been the early models on which they were based (Býčí Skála, Leipzig-Wahren, Maszkowice, Biskupin, Witów: for references see Pleiner 1980, 410 n. 25; Peschel 1980). Their relationship to Assyrian bi-pyramidal bars of the 8th cent. BC is not clear (Pleiner and Bjorkman 1974, 307). Kleeman (1961) believed wrongly in a late date for the European bars, and it is now clear that they were the products of the time when Celtic smiths were applying their technology to make swords for their warriors. The distribution map of bi-pyramidal bars corresponds almost exactly to that of the Celtic heartland and the first zone of expansion (Pleiner 1980, 393, 395, fig. 11.7). Several specimens have been submitted to metallographic examination by Hanemann, Rädeker, Naumann, Zwicker, and France-Lanord (for references see Pleiner 1980, 411 n. 28).

[7] Weiershausen (1942) some time ago interpreted them as ploughshares. If they were indeed units of

of a sword. The second type is that represented by the British 'currency bars' which are widely distributed over southern England. Their three main variants, categorized by Allen (1967),[8] have rolled-over or socketed 'hilt'-ends, and range from 51 to 89 cm in length (Allen's 'sword-shaped' type being 77–89 cm in length), with weights in the range 0.59–0.99 kg. The third type includes bars some 35–40 cm in length and has a long tang protruding from one end. The comparison with a rudimentary sword is obvious, and thus the term *saumon d'épée* ('salmon-shaped sword') was introduced to French archaeological literature. Their geographical distribution covers Switzerland, Bavaria, and eastern France. Two variants have been distinguished, one a broader trapezoidal bar (as at La Tène: Vouga 1923, 119, pl. xlix.1–2), and a longer, more rectangular bar (e.g. from Port and from Seurre near Chalon-sur-Saône).[9]

Because of the problem of obtaining an original bloom to be reforged into a long blade, we chose the third type of Celtic sword-shaped bar, using an example from Port-Nidau (in the Landesmuseum, Zürich) as a model to be made up as the rough-out for our experiments. This stock originally was 400 mm in length, of which the tang was 135 mm long, 35 mm broad and 8 mm thick (Plate I, left; Fig. 8.1).

So that we could make several replicas, we used pieces of rolled bar made from low-carbon steel, and these were hot-forged into shape using 8–9 heats. The smith worked with a 1 kg hammer, using only the pane, and four blanks (weighing 634–654 g) were made, each requiring around 20 minutes work. We wanted to find out how many such pieces would be required in the production of a sword-blade 72 cm long.

Forging Trials

As the smith was not familiar with the making of sword-blades, he chose first to try forging shorter pieces paying particular attention to the forming of the cross-section. Parts of a piece of low-carbon steel 205 mm long, 25 mm wide and 4.5 mm thick (*c.*0.2 per cent C, structure fine ferrite and pearlite, with mHV of 250–300 for the pearlite) were used in order to test volumetric changes and to work out the technique of holding the heated metal on the anvil.

After widening the band up to 40 mm, the shape of a flat blade, lenticular in shape, was obtained, with a subsequent reduction in thickness to 4 mm. Subsequent metallographic examination revealed a slightly overheated structure

currency, then their form derived presumably from those of implements or tools (spits, spades, axes, sickles, etc.). They were suitable for forging long artefacts, sword-blades included.

[8] Allen 1967: sword-shaped and spit-shaped bars, each with shouldered and coiled tangs, and ploughshare-shaped bars with socketed ends. For currency bars, see Tylecote 1962, 206–11 (metallography on p. 210 and pl. xxi).

[9] Seurre: Kruta and Szabó 1979, 252, pl. 76. For a short survey of the *saumon d'épée*, see Jacobi 1974, 251–3. He discusses all of the variants (pp. 248–54); see also Pleiner 1962, 66–70 and 1980, 391–4.

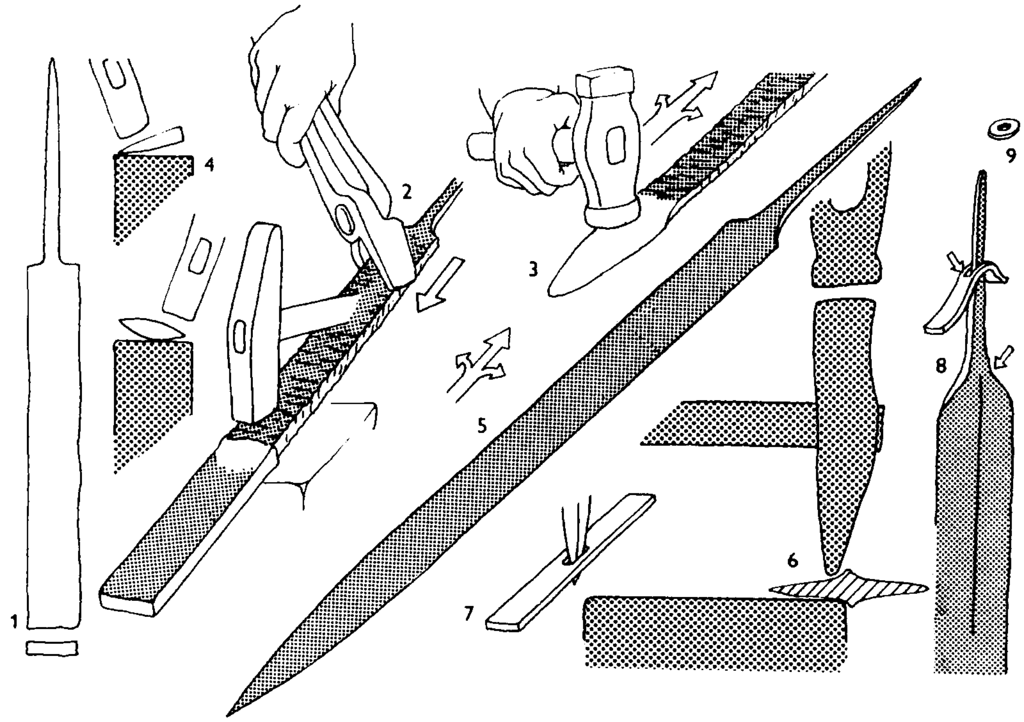


Fig. 8. Experimental forging of La Tène type sword-blades (1982)

with Widmanstätten ferrite, as well as traces of deformation of ferrite due to working on a falling heat (around 500 °C) in the final stages of forging: the final mHV for ferrite (20 g load) was 180, and for pearlite 220–30.

It was found that to produce a blade with a midrib was more laborious, although forging of the rib allowed more metal to be spread out to widen the blade, and a width of 45 mm was achieved. Moreover, the rib, which was 4 mm thick, provided good resistance to bending. The heated piece was placed on the edge of the anvil while the smith struck on the opposite surface with the edge of the hammer-face, working longitudinally, and parallel to the rib being formed on the other side. Metallographic examination revealed no deformation of grains, but there had been slight overheating of both cutting edges to produce Widmanstätten ferrite: the final mHV for ferrite (20 g load) was 160–70, and for pearlite 250–300.

These tests showed that the modern steel which we used was not suitable for fire- or forge-welding, and also that modern blacksmiths have forgotten this art. From the tests, however, it was also clear that the *saumon d'épée* could be shaped to any original blade cross-section. The next question to be answered was to what length they could be stretched out?

As a model for the making of a replica of a La Tène period sword, we chose an original from grave 21 at Holubice near Brno (from the Moravian Museum at Brno, register no. Pa 2627/38), which had been examined metallographically as part of our programme (see below, pp. 91–2). It was 720 mm long (including a hilt-tang of 100 mm), 47 mm broad, 4–5 mm thick, and with a slightly assymetrical slope to the shoulders. These dimensions and shape were followed exactly in our work. To reproduce a blade with a midrib, we reduced the length to 715 mm (with 100 mm left for the hilt-tang), reduced in width to 42 mm, and given a rib thickness of 5 mm.

Making Flat Blade A (Pl. I centre)

The plastic hot-forming of a sword-shaped bar (weight 654 g) was carried out in two principal stages which showed that the initial ingot of Port-type contained enough metal for the lengthening and widening of the entire blade to the specified dimensions, without the need to weld two bars together, or add on any other pieces. In our view, this result is of crucial significance since it supports the hypothesis that these sword-shaped bars were originally conceived as the blanks from which individual swords were made.

The forging process involved the heating of the blade to orange-heat (900–1000 °C), followed by longitudinal lengthening away from the tang (Fig. 8.2). After some 14 or 15 heats, taking about three hours, the length of the blade had reached 50 cm from an original length of 26 cm. After a further 4 heats, the desired blade length of 61 cm was achieved, this operation taking 100 minutes. The second phase, carried out on the next day, included the widening of the blade (Fig. 8.3) which required a further 13 heats and took 40 minutes. The heated portion of the blade was each time about 10 cm long. The lenticular cross-section was produced by hammering while the blade was held with its face against the anvil, and rocked backwards and forwards so that the point of impact of the blows passed in turn from one edge to the other (Fig. 8.4). Since the formation of the point required a certain reduction in mass, forging resulted in a lengthening of the blade to 633 mm. The last four heats were devoted to straightening the blade, to ensure that the cutting edges were exactly parallel, and it should be noted that this was found to be one of the most difficult phases of the whole process. The final length of the blade, from the point to the tip of the hilt-tang, was 740 mm (Fig. 8.5). The continuous reheating produced hammer-scale through oxidation, and the loss of metal brought the weight of the finished blade down to 510 g, representing a loss of 21 per cent. Both cutting edges were sharpened roughly under the hammer at dark red and under a falling heat down to around 500 °C. Evening-out of the surface was kept to a minimum, with the blade left with its 'blue' surface without any grinding or polishing.

To complete the second stage, the rough forging of the blade, took a total of 22 heats over 140 minutes or 2.5 hours in total. When the time for all preparation is taken into account, this represents roughly half a day's work. This is to be added to the three hours required to complete the first stage, bringing the total time (including preparation) to around 6–7 hours.

Unfortunately it is not possible to estimate the length of time that would have been required in Antiquity to produce the sword-shaped bar either from the spongy bloom with its entrapped slag, or by the welding together of two or more smaller bars. We might offer the opinion that it would probably have taken longer to have worked up a bloom into usable condition than the time required to forge up a blade from a prepared sword-shaped ingot.

Making Blade B, with Midrib

The initial weight of the bar was 643 g. As with the production of Blade A, the forging proceeded in two stages, the lengthening of the bar from the hilt-tang towards the point, followed by the widening of the blade from the point towards the hilt-tang. The difference between the two processes was in the length of time required by the substantially more laborious forging of the midrib, and loss of metal through oxidation was higher than for Blade A. On the other hand, forging of the midrib made the widening of the blade easier to achieve. Shaping of the blade took some 4 hours and 36 heats.

The midrib was formed by hammering with the heated section of the blade placed lengthwise and slightly off-centre against the edge of the anvil. The edge of the hammer was used on the upper face to widen the base of the rib, so that both surfaces were shaped at the same time (Fig. 8.6). It is interesting to note that a certain degree of assymetry can be observed in the cross-sections of original La Tène swords, and this can be ascribed to a similar mode of working. A substantial improvement in the effectiveness of the process was achieved by the introduction of an assistant who struck the butt of the smith's hammer as it was pressed against the hot metal surface, allowing him to control its position very easily. This does not imply that a master-smith could not have been able to work perfectly well on his own.

It proved advantageous also to finish off the rib by forging almost cold, as this helped to keep the edge sharp. The brittleness which this induced was eased by subsequent reheats. This cold work took some 70 minutes. Three heats were necessary during the forging of the sharp corners of the shouldered hilt-tang, and this work was not easy. A further 14 heats over 40 minutes were required for the finishing off of the point and straightening of the cutting edges.

In all, the forging and rough surface-finishing of this blade took a total of 350 minutes which, with preparations, represents a day's work. Losses through oxidation reduced the final weight of the blade to 470 g, a decrease of 27 per cent from the original weight of the bar. From a bar of proportions virtually identical to that used for the production of Blade A (1.1 g difference in weight), the blade with midrib which we made measured 670 mm in length, overall length 777 mm, and was 45 mm wide with the midrib being 4–4.5 mm in thickness.

Fitting a Hilt

To complete the project as originally conceived, it was decided to furnish both swords with simple wooden hilts and with typical campanulate guards. There was no intention to attempt a precise reconstruction of a Celtic sword hilt on the lines of the replica by Pietzsch (1956), finds from Münsingen-Rain (Emmerling 1977), or the illustrative reconstructions of Irish sword hilts by Rynne (1983). A metal strip measuring 50 × 7 × 3 was hot-pierced using a square-sectioned drift (Fig. 8.7) and progressively bent to fit the contours of the shoulders of the blade. This took 5 heats over about 30 minutes. It was necessary to do some filing of the cold metal to obtain a precise fit of the guard against the shoulders.[10] A wooden bar was bored initially at both ends and then pushed down on to the hilt-tang while it was red-hot. A circular plate was put over the hilt, and the protruding tip of the tang was then splayed out slightly to hold the whole assemblage in place (Fig. 8.9), in the manner to be observed on a sword from Dalj.[11]

The final weights of the swords with their hilts and guards were 600 g for Blade A (lenticular cross-section) and 560 g for Blade B (with midrib). While the sword with midrib was the more difficult to make, nevertheless it was possible to make it to the same dimensions as Blade A, but lighter in weight.

Both experimental swords were left with their 'blue' metal surfaces, no attempts having been made to grind or polish them. The cutting edges were sharpened and the blade faces evened out only by hammer work at the final temperature. We assume that final finishing by whetstone or similar medium would take much more time than forging.

[10] Files and filework are attested from the Hallstatt period onwards. La Tène period sites have yielded numbers of files. Metallographic examinations of files show that they were made of very hard steels (Pleiner 1982, 92, Taf. 9.1–6, 94, Abb. 3, 95, Taf. 22.1–5).

[11] von Jenny 1932.

6

Metallographic Examinations of Swords from Czechoslovakia

The Finds

A number of years ago, a sword and its scabbard from destroyed cremation graves at Maňa in Slovakia, dated to the LC period (Benadík 1976; 1983, Taf. LIX. 9–10), were investigated (Pleiner 1962, 75–7, Taf. XI, analyses 5–6).

Two swords (analyses 178 and 179), together with a spearhead and fragments of scissors from destroyed La Tène period graves at Třebohostice, South Bohemia, were also examined (Pleiner 1974). These weapons clearly belong within the La Tène period, but more precise chronological determination has not been possible.

The well-known Celtic inhumation cemetery at Jenišův Újezd, North-West Bohemia, is represented in the analytical programme by swords from two graves, nos. 30 and 110. The first is dated to the LB_1 period, the other to $LB_{1/2}$ (Waldhauser 1978, 46–7, Taf. 10.88–9, Taf. 33). The inventory of grave goods consisted solely of a few personal ornaments and belt fittings, spearheads, and, in grave 110, traces of a shield fitting. The results of this metallographic study were published by Pleiner (in Waldhauser 1978 nos. 584 and 586).

During study of an assemblage of Late La Tène (LD) period iron tools from *oppida* in Czechoslovakia a sword fragment from the *oppidum* of Staré Hradisko, West Moravia, was examined (Pleiner 1982, 93, Taf. 10.1–4, analysis 464).

In 1977, as part of a systematic research project on the development of La Tène period blacksmith's work, a further twenty-one swords were submitted to metallographic examination. Among these were five blades from Bohemia: two from the inhumation cemetery at Makotřasy, Central Bohemia, grave 13 (Čižmář 1978: dated to LC_1—our number 587), and grave 22/75 (Pleslová *et al.* 1978: dated by Waldhauser to LB_1—our number 588); and three from similar graves at Tuchomyšl, North-West Bohemia (numbers 190, 187 and 244: analyses 613–15, dated by Waldhauser to LB_1). In all of these graves, the objects found with the swords are typical of the average equipment found in central European warrior burials—spearheads, belt and shield fittings, and bronze or iron fibulae. The bulk of this material belongs to the fourth century BC.

Sixteen swords were selected from Moravian cemeteries. From Brno-Maloměřice swords from inhumation graves 3, 50, and 76 (Poulík 1942, 51, 70,

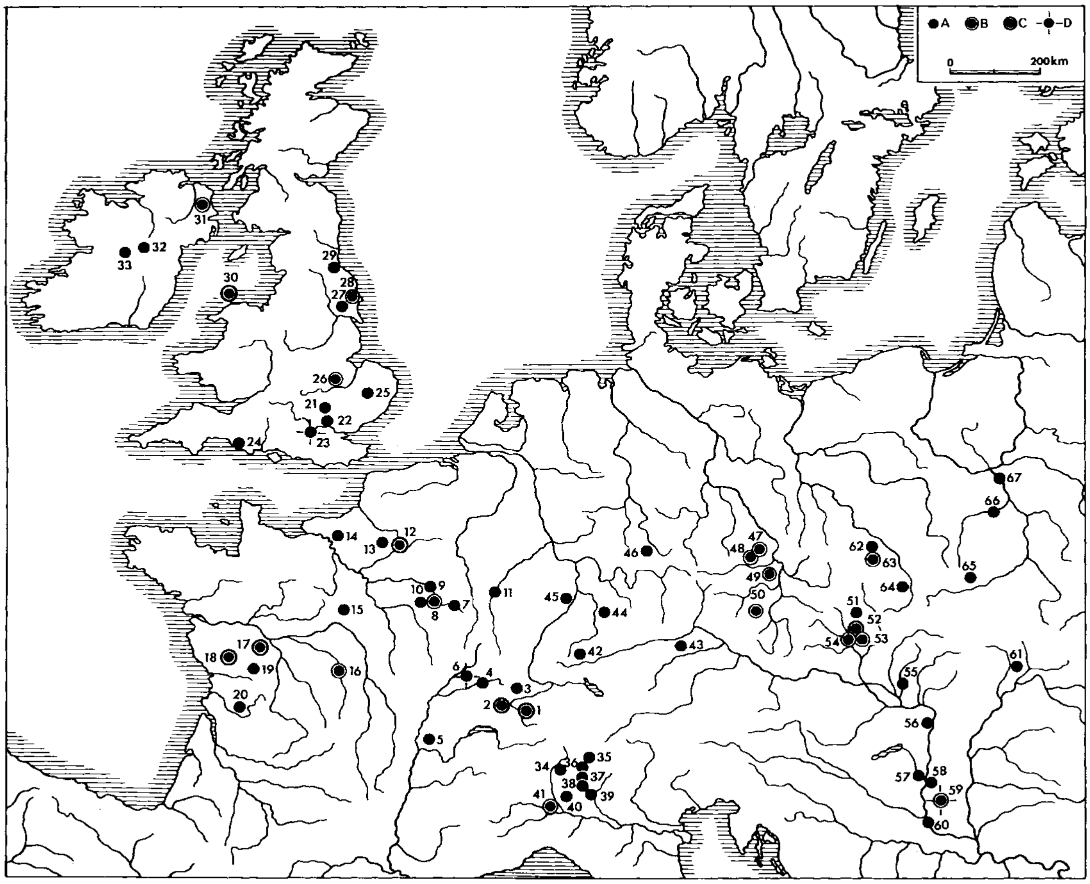


Fig. 9. Geographical distribution of investigated Celtic swords described in this study

A one specimen, B 2–3 specimens, C more than 3 specimens, D approx. position.
For key to sites see p. xiii.

79–80) were examined (analyses 592–4). In addition to shield fittings, spearheads, and a rather ordinary set of personal ornaments, these graves also contained pottery vessels, a common find in Moravia. Poulík (1942, 86) suggested a date in the LC_1 phase for the cemetery complex (late third century BC).

The Holubice inhumation cemetery in west Moravia (Procházka 1937) provided a further eleven swords for the research programme. According to preliminary dating by M. Čižmář (Archaeological Institute at Brno), graves 35, 46, and 63 would belong to LB_1 (analyses 602, 604, 606), and graves 47 and 56 (analyses 603 and 605) to LB_2 Grave 21 (analysis 598) is assigned to the transition period between the LB_2 and LC_1 phases (finds include three bronze and three iron fibulae, and shield and belt fittings). Graves 26, 32, and 34 are generally to be dated to LB, with no possibility of dating them more precisely (analyses 599 and 601). Apart from grave 21 (which included more fibulae than the others), none of the grave assemblages is exceptional: pottery vessels occur, while grave 32 also contained boar tusks and bones.

Křenovice, near Brno, is another important cemetery dating from LB through until LC_1. Those graves which yielded swords included in the present research programme belong, according to Čižmář, to the LB phase. Graves 22 (analysis 596) and 6 (analysis 595: assigned to LB_2) contained assemblages including a shield, a spearhead, and bracelets of iron and sapropelite.

From the east Slovakian site at Zemplín (excavated many years ago by Professor Budinský-Krička) came a bent sword with a punched inscription, along with fragments of an openwork bronze scabbard of a Noricum type (Werner 1977). The sword was found in a depression (no. 1—a grave?) covered by a burial mound (no. 8), together with a shield-boss of a Romano-Barbarian type. Sherds of late La Tène pottery were found in the make-up of the mound, but a relatively late date (last decades BC–first decade AD) is not out of the question (information courtesy of M. Lámyová, Košice).

In total, twenty-seven swords and one scabbard from Czechoslovakia were investigated during the course of this research.

Methods of Investigation

Standard metallographic techniques, supplemented by microhardness tests, were used in the study of the properties and manufacturing technology of the swords under investigation.

Sampling technique. Samples were cut from blades, either from both edges, or else in a manner which provided a representative sample of the entire cross-section of the blade. In a few cases, additional control specimens were taken from one cutting-edge. Specimens weighing 2.1 g were taken for chemical analysis from the areas examined metallographically. After sampling, all objects were restored.

Macroscopy. The distribution of carbon-rich and carbon-poor zones was recorded by drawing and photography, after etching with different reagents, Heyn and 5 per cent Nital. Phosphorus-enriched zones were revealed using Oberhoffer's reagent. Coupled with a map of the distribution of slag inclusions, this information provided the basis for determining the construction of the blades.

Microscopy. Microstructures were observed at magnifications between × 30 and 80 × after the specimen surfaces had been polished and etched with 2 per cent Nital (HNO_3 solution in ethanol). A standard magnification of × 100 was used for estimating grain-size (ASTM: Czechoslovak Standard number 42 0463), and the number of non-metallic impurities was recorded using the Swedish Jernkontoret scale (1–5). The type of slag inclusion (glass, light phases, wüstite dendrites, etc.) was briefly described.

Microhardness. A Hanemann measuring device was used, with a standard 30 g load. The hardness measurements (Vickers units) are to be treated only as relative values. Average hardness values in individual specimens are recorded in the form of simplified curves.

Chemical analyses. Apart from carbon, the only elements to be determined were phosphorus, manganese, copper, and nickel; P and Mn were determined gravimetrically, Cu and Ni by polarography (0–1.4 V). Due to the heterogeneity of carbon distribution, this element was estimated by determining the proportion of pearlite to ferrite. The silica content, being for all practical purposes restricted to slag inclusions, was not determined. In view of the purpose of the research programme, no qualitative analyses were carried out.

Interpretation of weld-seams. The identification of joints between components is difficult and depends largely on the conditions under which the object was forged (Pleiner 1973). Identification of weld-seams is, in each individual case, based on the general structure, taking all factors into account; uncertainties of identification are noted.

The analyses are numbered according to the analytical logbook of the Metallographic Laboratory of the Archaeological Institute, Prague. This archive contains more details of the investigations of the specimens examined.

Results of Investigations

1. JENIŠŮV ÚJEZD 584, Bohemia. Iron sword from inhumation grave 30. Museum of Teplice, inv. no. 8497. Preserved length 650 mm, blade with central rib (visible in section), completely covered by a rusted scabbard with textile imprints. The point is completely covered by a corroded chape. A transverse section was taken from the middle portion of the blade. *Non-metallic inclusions.* Glassy slag inclusions appear in several longitudinal stripes slightly inclined to the specimen axis. The number of inclusions varies between 3–4 and 1–2. Light-coloured crystal phases are visible in only a few inclusions. *Macrostructure.* Phosphorus segregations follow the main chains of inclusions, apparently marking welding-seams. Three layers of metal are indicated, and this is suggested also by the results of etching with Heyn and 5%-Nital: although differences in the carbon content of three layers can not clearly be distinguished, they do exist. *Microstructure.* Fine ferritic-pearlitic stripes (0.1–0.2% C), corresponding to the phosphorus segregations, divide the surface of the specimen into three zones. Approaching both edges the amount of pearlite increases in these bands (0.2–0.4% C: stripes with a ferrite network surrounding the metal core contain lamellae or globules of cementite,

TABLE 8. *Chemical analyses of the La Tène period iron swords investigated in Czechoslovakia*

Site and specimen number	% Mn	% Cu	% P	% Ni
Jenišův Újezd 584	0.023	0.079	0.083	0.069
586	0.014	0	0.76	0.051
Makotřasy 587	trace	0	0.16	0.031
589	trace	0	0.15	0.032
Maloměřice 592	0.016	0.069	0.094	0.171
593	0.017	trace	0.453	0.015
594	trace	trace	0.101	0.028
Tuchomyšl 613	0.012	0.131	0.276	0.018
614	trace	0.734	0.111	trace
615	trace	0.352	0.239	0.032
Třebohostice 178	0	trace	0.012	trace
179	0	0.029	0.094	0.036
Křenovice 595	0.030	trace	0.029	0.065
596	0.017	0.051	0.074	0.034
Holubice 597	trace	trace	0.011	0.040
598	0.013	0.082	0.044	0.097
599	0.019	trace	0.342	0.011
600	trace	0.065	0.148	0.065
601	0.016	trace	0.058	0.051
602	0.008	0.038	0.107	0.024
603	0.017	0.029	0.105	0.078
604	0.031	0.053	0.091	0.048
605	0.023	0.105	0.042	0.191
606	0.016	trace	0.018	0.090
Staré Hradisko 464	0.056	0	0.061	0.111
Zemplín 510	0.055	0.055	0.040	0.012
La Tène 199	trace	0	0.209	0.055

showing that the carbon content must originally have been considerable). *Microhardness.* Very fine lamellar pearlite in one edge, 450–536, at the other edge *c.*250, in the centre of the section 200–250 mHV (30 g load). *Chemical analysis.* Mn 0.023%, Cu 0.079% (high), P 0.083% (moderate), Ni 0.069% (high). *Interpretation.* The swordsmith welded together three flat, heterogeneously-carburized bars to form the blade. The weld-seams run slightly obliquely to the transverse axis of the blade. The metal at the edges of the sword is harder than the rest of the blade. One edge was more rapidly cooled than the other (accidental or intentional?), leading to an elevated hardness. The smith has produced a weapon of higher than average quality.

Pl. II, Fig. 17.10. Pleiner 1987.

2. JENIŠŮV ÚJEZD 586. Iron sword from inhumation grave 110. Museum of Teplice, inv. no. 9047. Preserved length 490 mm. Blade with midrib; the scabbard is corroded onto the blade which is broken into two pieces. A transverse section of

the blade was taken from the area of one of the breaks. *Non-metallic inclusions.* Of the three longitudinal zones of slag inclusions observed in the polished section, the central one shows the most impurities (4–5). It contains many chains of entrapped slag inclusions, which are glassy or show light crystal phases, even wüstite(?) dendrites in a glassy matrix. Both side-shells are substantially purer (2–3). Globular oxides were also observed. *Macrostructure.* Use of various etching reagents showed clearly that the blade was constructed in sandwich form. Both outer shells are rich in phosphorus in comparison to the central bar. Etching with Heyn and 5%-Nital reveals variations in grain size rather than heterogeneity of carbon content. *Microstructure.* The structure of all three components is almost entirely ferritic (traces of pearlite were discovered at the grain boundaries of one bar). The side-shells are notable for their coarse ferrite grain size (1–2, 1–3, as compared with the fine grains of the central bar, 6–7). Neumann bands were observed in one area of one of the side-shells. *Microhardness.* The ferrite in the central zone gave a microhardness in the region of 150 mHV, while that in the side shells was around 200 mHV (30g load). This is attributable to the high phosphorus content. *Chemical analysis.* Mn 0.014%, Cu 0.00%, P 0.76% (very high), Ni 0.051%. *Interpretation.* It is evident that this sword has been forged from three bars of wrought iron piled together. It is not impossible that the material was intentionally selected on the basis of its elevated phosphorus content whose effect could be observed empirically. The overall result is an inferior quality weapon. Pl. III; Fig. 14.6. Pleiner 1978.

3. TUCHOMYŠL 613, Bohemia. Iron sword from inhumation grave 190/74, Archaeological Institute Prague, dep. Most, no 314/74. Preserved length 710 mm, blade almost flat with adhering iron scabbard. Specimens a_1 and a_2 were taken from opposite edges, 40 and 55 cm below the shoulders at the hilt-tang junction, so that the entire transverse section was observed (a_1 = 20 mm; a_2 = 25 mm). *Non-metallic inclusions.* An oblique strip of inclusions crossed the blade at its core (visible in specimen a_2). There, values of 3–4, or 2–3 on the Jernkontoret scale were observed; at the cutting-edges, 2–3, or 1–2. Globular oxides are present. *Macro-structure.* Heterogeneity in the phosphorus content, which seems to be high, is not particularly significant. Etching with Oberhoffer shows a low-P area in the centre of the body of the blade. Its oblique shape, bordering the strip of inclusions, also showed up with Heyn and 5%-Nital solutions. A feature resembling a weld-seam occurs in specimen a_1 at the cutting-edge, marking a C-rich area. In specimen a_2, a seam runs through the centre, also marking a steel zone. *Microstructure.* Specimen a_1 shows fine ferrite (10–11), which occurs at the core. At the cutting-edge, along the seam, there are stripes of pure pearlite, pearlite with ferritic cells, and a pearlitic-and-ferritic mixed structure. In specimen a_2 ferrite also occurs in the core, but it is gradually replaced by pearlite with a ferritic network. This is the predominant structure at the opposite cutting-edge. *Microhardness.* Ferrite about 170 mHV 30g; pearlite-and-ferrite in specimen a_1 250–300, and in a_2 about 300 mHV. *Chemical analysis.* Mn 0.012%, Cu 0.131% (elevated), P 0.276%

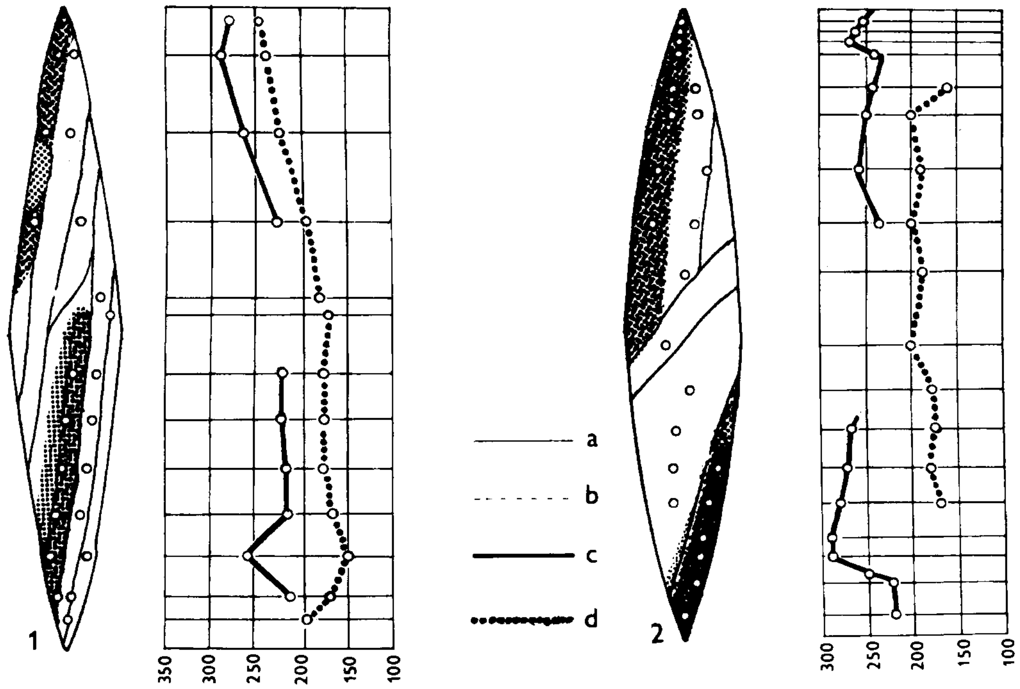


Fig. 10. Schematic representation of cross-sections of the blades from Tuchomyšl, Bohemia

(elevated), Ni 0.018%. *Interpretation.* The two halves of the blade were more or less obliquely piled, the harder steel zones having been positioned on the outside. Both halves were almost butt-welded and joined to the blade with steel cutting-edges on both sides. Not hardened. Perfect result.
Pl. VII; Fig. 10.2.

4. TUCHOMYŠL 614. Iron sword from inhumation grave 187/74, Archaeological Institute Prague, dep. of Most, no. 312/74. Preserved length 635 mm. Part of the hilt-tang is broken, and there are traces of an adhering iron scabbard. The blade is rather flat. Specimens *a* (13 mm) and *b* (18 mm) representing a transverse section were taken from opposite sides close to the hilt. Another specimen, b_1, was taken from a site 130 mm from the point, and extending 25 mm deep into side *b*. Specimen *b* is heavily corroded, and includes isolated splinters of the cutting-edge. *Non-metallic inclusions.* Slag occurs in chains which run parallel or inclined to the main axis. A long fissure, sealed with corrosion products, runs through the centre of specimen *b*. The slag is glassy, and light phases are rare. Globular oxides are present. The degree of impurity is 2–3, or 3–4, locally 1–2. Cutting-edge b_1 contains fewer impurities. *Macrostructure.* Etching with Oberhoffer shows that side *b* of the blade, divided by a cracked weld-seam, has an elevated phosphorus content. There are also phosphorus-enriched areas in section *a*. In both specimens from side *b* one side is lower in phosphorus, being sharply

divided from the P-rich metal behind the crack. Etching with Heyn and 5%-Nital reveals definite welds, although the distribution of carbon content is not clear. *Microstructures.* Specimen *a* has a mainly ferritic structure showing traces of welds, one of which runs towards the surface. There is an area of pearlite with ferritic cells. The opposite cutting-edge, seen in specimen *b*, shows one side ferritic, while the other is pearlitic with a C-content reaching the eutectoid value (only the crack—a bad weld—is decarburized). The same picture is seen in specimen b_1. The C-rich zone ends before the cutting-edge is reached, although there is a strong suspicion that it was destroyed by corrosion, which forms a layer continuing out to the edge. Pearlite shows traces of spheroidization. *Microhardness.* Ferritic areas about 150 mHV 30g, pearlite 250–260 mHV; in the cutting-edge of side *b* hardness goes up to slightly over 130 mHV. *Chemical analysis.* Mn trace, Cu 0.734% (high), P 0.111% (high), Ni trace. *Interpretation.* The welds are not easy to trace. It seems likely that three main bands were welded together obliquely. The central band has been heavily carburized on the side forming one of the cutting-edges. The opposite cutting-edge remained as wrought iron. Locally, the welding was of very poor quality, in spite of the fact that the design of the sword was well conceived, with one of its cutting-edges made of a good quality material.
Pl. VIII.

5. TUCHOMYŠL 615. Iron sword from inhumation grave 244/74, Archaeological Institute Prague, dep. of Most, not numbered. Preserved length 720 mm, flat blade. Specimens a_1 and a_2 were cut out of opposite sides close to the shoulders. Both (20 and 27 mm) cover the entire transverse section. *Non-metallic inclusions.* Chains of slag, glassy, with light phases, run obliquely to the surfaces. There are a large number of impurities, reaching 4–5 on the Jernkontoret scale. Globular oxides are present. *Macrostructure.* Etching with Oberhoffer reveals sharply delineated heterogeneities (in specimen a_1 a phosphorus-enriched stripe runs out to the surface; specimen a_2 is more complicated, with more enriched stripes occurring). Etching with Heyn indicates that those bands are poor in carbon. *Microstructure.* Specimen a_1 contains a pearlitic zone with a ferritic network (grain-size 4–6 ASTM which continues up to the cutting-edge). A weld-seam separates this from a ferritic zone. Similar ferritic bands are also visible in specimen a_2 (locally, also with traces of pearlite in a Widmannstätten structure), but in the middle of these is a steel stripe and also traces of additional carburized zones (pearlite and ferrite-network). The steel stripes run out at the surface away from the cutting-edge. Estimated carbon content 0.4–0.5% in specimen a_1, and about 0.3% in specimen a_2. *Microhardness.* The steel cutting-edge in specimen a_1 gives 250–300 mHV 30g; in the pearlitic areas of specimen a_2 about 270 mHV, but at the ferritic cutting-edge only about 200 mHV. *Chemical analysis.* Mn trace, Cu 0.352% (high), P 0.239% (high), Ni 0.032%. *Interpretation.* A rather irregular faggoting of iron and steel bands. One of the steel plates covers one of the cutting-edges, which was therefore of better quality than the other.
Pls. IX and X; Fig. 10.1.

6. MAKOTŘASY 587, Bohemia. Iron sword from inhumation grave 13, Archaeologial Institute Prague, no. 3a/61–13–1. Preserved length 720 mm, flat blade with adhering fragments of a sheet scabbard, hilt-tang in two pieces. A specimen representing more than half of the transverse section of the blade was removed from its lower part. *Non-metallic inclusions.* Spheroidized oxides are present. Two continuous chains of glassy slag inclusions run parallel to the axis of the specimen, pointing toward the cutting-edge. The degree of impurity in the core is 2–3, at the cutting-edge 1–2. *Macrostructure.* The inner core of the blade marked by the slag lines referred to above is rich in phosphorus. Etching with Heyn and 5%-Nital shows that the carbon content is insignificant. *Microstructure.* The central wedge-shaped areas has a primarily ferritic structure (grain-size 8–9) with some intercrystalline pearlite of lamellar or globular structure. Ferrite also occurs in the side-shells (grain-size 8–7), with only tertiary cementite particles at the grain boundaries. At the cutting-edge deformed cold-hammered ferrite grains occur. *Microhardness.* Average 200 mHV; 210–230 mHV 30g in the area of deformed ferrite. *Chemical analysis.* Mn trace, Cu 0.00%, P 0.16% (elevated), Ni 0.031%. *Interpretation.* The blade has been formed from three layers joined by welding. An iron bar of elevated P-content was positioned at the centre. The cutting-edges turned out to be soft, so that the smith tried to harden them by cold hammering, with only limited success. The weapon is of somewhat inferior make. Pl. IV.

7. MAKOTŘASY 588. Iron sword from inhumation grave 22/75. Archaeological Institute Prague. Length 700 m, flat blade, with the remains of a sheet scabbard. Two specimens, *a* and *b*, were taken from opposite edges below the middle of the blade. A supplementary specimen, b_1, was removed from the same edge as specimen *b*, near the point, and reaching the central axis of the blade. *Non-metallic inclusions.* Essentially, impurities increase towards the cutting-edges (from about 2–3 to 3–4). In specimen *b* there are two main slaggy stripes visible. Inclusions are grey and glassy and in specimen *b* also show light crystalline phases, while in specimen b_1 dendrites are visible. *Macroscopy.* Examination of phosphorus distribution shows that the entire area of the cutting-edge in specimen *a* is P-rich. The cutting-edge of specimen *b* shows enrichment in the form of striped segregations; a P-rich area, wedge- or arrow-shaped also occurs. Etching with Heyn shows this to consist of coarse grains, and at the same time shows that the cutting-edge in specimens *b* and b_1 has an elevated carbon content. *Microstructures.* In specimen *a*, the cutting-edge shows a ferritic structure with intercrystalline pearlite. There is an area of fine crystals (grain-size 9–10) distinguished from the coarse grain-size of the wedge- or arrow-shaped area (grain-size 1–3). In the core of the blade a pearlitic zone with a ferrite network begins (grain-size 5–7, *c.* 0.3–0.4 up to 0.6–0.7% C), running out towards the opposite cutting-edge (specimens *b* and b_1). In the cutting-edge area of specimen b_1 even small areas of eutectoid structure may be observed (0.7–0.8% C). A small area of surface decarburization does not

diminish the good quality of this cutting-edge. The pearlite is lamellar or partly spheroidized. *Microhardness.* Pearlite zones 300 and 400 mHV, ferrite-pearlite areas about 200 mHV, ferrite in specimen *a* 186–250 mHV 30g. *Chemical analysis.* Mn trace, Cu 0.00%, P 0.15% (elevated), Ni 0.032%. *Palaeomagnetic measurement.* According to F. Marek, a thermoremanent magnetism orientated from the hilt to the point could be detected. This was presumably caused by air-cooling from high temperatures (after forging), the blade having been held point-down while under the influence of the earth's magnetic field (inclination +66°). *Interpretation.* The blade seems to have been forged from a single, heterogeneously carburized bar. It is difficult to say whether this was a primary steel obtained from the bloomery furnace, or if one of the cutting-edges has been secondarily carburized. In any case, only one of the cutting-edges was of a sufficiently good quality for the purpose of the weapon.

Pls. V and VI; Fig. 18.2. Pleslová *et al.* 1978.

8. TŘEBOHOSTICE 178, Bohemia. Iron sword, presumably from a destroyed cremation tumulus grave. Museum of Strakonice. Preserved length 583 mm, blade bent flat, point broken. On one edge are adhering the remains of an ornamented sheet scabbard. One specimen representing half of the blade cross-section was cut out 193 mm from the shoulders of the hilt. *Non-metallic inclusions.* Inclusions range from 1–2 in the core of the blade to 2–3 at the cutting-edge. *Microstructure.* The structure is principally ferritic (grain-size 6–7), with some lamellar or partly spheroidized pearlite at the ferrite grain boundaries. The pearlite content increases towards the cutting-edge, but the carbon content does not exceed 0.2% C. At one of the cutting-edges a thin copper or bronze layer appears, adhering to the blade; possibly a scabbard splinter (?). *Microhardness.* Ferrite 160–210 mHV, isolated pearlite grains 280–339 mHV 30g. *Chemical analysis.* Mn 0.00%, Cu trace, P 0.012%, Ni trace. *Interpretation.* It is possible that the blade has been constructed by welding together three bars of wrought iron or very mild steel, very low in chemical impurities. The slightly elevated pearlite content towards the edge does not seem sufficient to warrant interpretation as intentional carburization. Overall, the weapon is of poor quality.

Pl. XI. Pleiner 1974.

9. TŘEBOHOSTICE 179. Fragment of an iron blade, presumably from a destroyed tumulus grave. Museum of Strakonice. The preserved length of the flat, broken blade is 270 mm. The asymmetric shoulders of the blade originally led to its description as a carving knife; the blade, however, is clearly two-edged, and it should rather be considered as a sword-blade. Two specimens, *a* and *b*, were taken from across the fractured end, covering the complete transverse section. *Non-metallic inclusions.* Slag inclusions run prominently in distinct transverse lines, perpendicular to the major axes of the specimens. The degree of impurity in the body of the blade is 3–4, at the cutting-edges 2–3 or 1. Light-coloured crystalline phases show in the glassy matrix of these entrapped silicates; granulated oxides also

occur. *Microstructure.* The individual transverse bands consist, particularly at the cutting-edges, of ferrite (grain-size 5–6, locally 7). In the body of the blade ferrite-and-pearlite structures (not exceeding 0.2% C) are to be observed. In one area there is a Widmannstätten structure. *Microhardness.* Ferrite over 200 mHV, isolated pearlite grains 300–400 mHV 30g. *Chemical analysis.* Mn 0.00%, Cu 0.029%, P 0.094% (slightly elevated), Ni 0.036%. *Interpretation.* The blade was butt-welded from several wrought iron or very mild steel bars. With regard to the properties of the materials used, the weapon must, however, be classified as of poor quality.
Pl. XII. Pleiner 1974.

10. BRNO-MALOMĚŘICE 592, Moravia. Iron sword from inhumation grave 3. Moravian Museum, Brno, inv. no. 14029. Preserved length 755 mm, blade with central rib. Specimens a_1 and a_2 were cut out from opposite edges of the blade at distances 280 and 330 mm from the tip of the hilt-tang, and cover the entire transverse section of the blade. *Non-metallic inclusions.* Wavy lines consisting of numerous elongated slag inclusions (degree of impurity 4–5) run parallel to the axes of the polished sections. Inclusions are mostly grey and glassy, showing, to a small degree, light-coloured crystalline phases. Granulated oxides are also visible. *Macrostructure.* Etching with Oberhoffer's reagent reveals segregations of phosphorus, producing dark and light stripes parallel to the section axes over all of the section areas. Slight colour differences occur after etching with Heyn, revealing what appear to be weld-seams or joints between two areas in specimen a_1, and three longitudinal areas in specimen a_2. In the latter case, the central stripe is lighter in colour. The most instructive etch is that with 5%-Nital: the central stripe in specimen a_2 and a side area in a_1 are light, which in reversed light means C-rich. The two side shells in a_2 and the larger area in a_1 are dark, i.e. of wrought iron. *Microstructure.* The C-rich areas consist of pearlite with a ferritic network, the original austenitic grain-size being about 4, and containing 0.4–0.6% C. The pearlite is lamellar, showing signs of the onset of coalescence. The wrought iron areas have a fine-grained ferritic or ferrite-pearlite structure (grain-size 7–9). *Microhardness.* Wrought iron 180 mHV 30g average, the steel strip 250–280 mHV at the edge and 310–314 mHV towards the centre. *Chemical analysis.* Mn 0.016%, Cu 0.069% (elevated), P 0.094% (elevated), Ni 0.171% (high). *Interpretation.* The blade has been constructed by welding together three or four main bands of metal. The central bar of medium steel was protected by two wrought iron shells which flank it at one cutting-edge. But it outcrops at the opposite side leaving the other cutting-edge merely of iron. The blade has not been hardened. The swordsmith's work resulted in the production of a double-edged weapon, only one of whose cutting-edges was of good quality.
Pl. XIII; Fig. 18.4.

11. BRNO-MALOMĚŘICE 593. Iron sword from inhumation grave 50. Moravian Museum, Brno, inv. no. 14 423. Preserved length 570 mm (the hilt is missing),

blade with midrib. Specimens a_1 and a_2 were cut from opposite edges at distances of 300 and 290 mm from the point, representing the complete transverse section. *Non-metallic inclusions.* Elongated slag inclusions are dispersed over the polished surfaces of both specimens, the level of impurity reaching 4–5. Both glassy and crystalline inclusions with light phases (dendrites in specimen a_1) occur. Oxides in specimen a_2. *Macrostructure.* Minimal changes in colouring occur on both polished surfaces after etching with Oberhoffer, Heyn, and 5%-Nital. All etching, however, indicated a piled structure. *Microstructure.* The structure is mainly ferritic, varying only in grain-size—coarse in the central areas (4–5) and fine (8–9) elsewhere. Traces of intercrystalline pearlite and some nitride needles stand out in one of the marginal strips. *Microhardness.* Ferrite grains 182 mHV 30 g. *Chemical analysis.* Mn 0.017%, Cu trace, P 0.453% (high), Ni 0.015%. *Interpretation.* The blade has apparently been fire-welded from four bars of P-rich wrought iron, and is of inferior quality.
Pls. XIV. 1–2 and XV. 1–3.

12. BRNO-MALOMĚŘICE 594. Iron sword from inhumation grave 76. Moravian Museum, Brno, inv. no. Pa 14 551. Preserved length 652 mm, blade with central rib. Specimens a and a_2 were cut out from opposite edges at distances 355 and 390 mm from the point, representing the entire transverse section. *Non-metallic inclusions.* Distorted chains of slag inclusions, which are glassy, or with crystallized or dendritic (a_2) phases, or oxides, occur. The average degree of impurity is 2–3 in the central area 4–5, while the edge of a_1 is relatively slag-free (1–2). *Macrostructure.* Etching with Oberhoffer shows strongly curved segregations, the lines of which correspond with those revealed by etching with Heyn and 5%-Nital. *Microstructure.* The lines and curves mentioned above outline ferritic areas of differing grain-size—coarse (2–4) and fine (9–10). In the area of the cutting-edge in specimen a_1 only, there are some stripes of ferrite and pearlite, tending to a Widmannstätten structure, although even there the carbon content is minimal. *Microhardness.* The average microhardness of ferrite is 172–176 mHV 30g, of the ferrite-and-pearlite mixture 212 mHV. Microhardness of isolated pearlitic grains reaches 240–268 mHV. *Chemical analysis.* Mn trace, Cu trace, P 0.101% (elevated), Ni 0.028%. *Interpretation.* The blade has been made from three or four bars of wrought iron with slightly enriched contents of P and Ni, which were welded together, having first been folded or slightly upset longitudinally. The slightly higher hardness of one of the edges is not sufficient to mark the weapon as being of a good quality.
Pls. XIV. 3–5 and XV. 4–5.

13. KŘENOVICE 595, Moravia. Iron sword from inhumation grave 6. Moravian Museum, Brno, inv. no. Pa 1269/39. Length 652 mm, blade with midrib. Specimens a_1 and a_2 were taken from opposite edges at distances of 295 and 340 mm from the point, representing a complete transverse section of the blade; specimen b was cut from the point. *Non-metallic inclusions.* Glassy slag inclusions occur in irregular

chains on the surfaces of the specimens, and follow the axes of the sections. The degree of impurity is moderate (2–3; specimen *b* 1–2). *Macrostructure.* Etching with Oberhoffer reveals a dark phosphorus segregation which runs from the edge down to the central rib on the left side of specimen a_2. Etching with Heyn and 5%-Nital reveals the same picture in terms of the distribution of carbon, the relevant area being P-rich and C-free. *Microstructure.* The C-free strip is formed of very fine ferrite (grain-size 10–11), which grades into a fine structure of globular pearlite with isolated grains of ferrite (grain-size 5–6 and 10–11). The pearlite at the point (specimen *b*) has a structure resembling what used to be called sorbite. *Microhardness.* Pearlitic steel 270–300 mHV, at the point reaching 400 mHV 30 g; ferritic side strip *c.*183 mHV. *Chemical analysis.* Mn 0.030%, Cu trace, P 0.029%, Ni 0.065% (slightly elevated). *Interpretation.* The sword was forged from a medium carbon steel of slightly fluctuating carbon content. It is possible that there has been secondary decarburization of some spots on the surface. The steel at the point seems to have been cooled somewhat more quickly, although it is uncertain whether there was an intentional partial tempering. The blade as a whole is of good quality and would have been an effective cutting weapon.
Pl. XVI.

14. KŘENOVICE 596. Iron sword from inhumation grave 22. Moravian Museum at Brno, inv. no. Pa 1334/38. Preserved length 765 mm, blade with central rib disappearing near the point. Specimens were cut out of both edges: a_1 and a_2 were taken 310 and 275 mm from the point, representing a complete transversal section; *b* was a control of edge a_1 and was taken 460 mm from the point. *Non-metallic inclusions.* Elongated slag inclusions occur in almost continuous chains over all of the areas examined: the degree of impurity varies between 3 and 4, indicating that there is a considerable amount of entrapped slag in the metal. *Macrostructure.* A striped texture is visible after etching with all three reagents, but without showing substantial differences in P or C contents in specimens a_1 and a_2. Only the surface of specimen *b*, after etching with 5%-Nital, shows a lighter central zone bordered with darker areas. *Microstructure.* There is a central zone running throughout the blade, characterized by a very fine ferrite-pearlite structure (grain-size 10–11: 0.2–0.3% C), and delimited by weld-seams from fine ferritic side shells in specimens a_1 and *b*. In specimen a_2 the side shells show more pearlite than the central bar, but the presence here of the Widmannstätten structure prevents estimation of the carbon content. *Microhardness.* Central bar just above 200 mHV 30 g, ferritic areas 172–195 mHV, average in the C-rich edge 231 mHV, maximum 268 mHV 30 g. *Chemical analysis.* Mn 0.017%, Cu 0.051% (slightly elevated), P 0.074% (slightly elevated), Ni 0.034%. *Interpretation.* The swordsmith attempted to use a sandwich construction for the blade, but chose (or only had at his disposal) a very mild steel for the central bar. It happened (but we do not know whether or not intentionally) that the bars composing the outer shell were carburized in one cutting-edge which became harder and of a good quality.
Pls. XVII. and XVIII. 1–3; Fig. 14. 7.

15. HOLUBICE 597, Moravia. Iron sword from destroyed inhumation graves. Moravian Museum, Brno, inv. no. 64 865. Preserved length 705 mm, blade with central rib. Specimens a_1 and a_2 were taken 270 and 240 mm from the point and represent a complete transverse section; a control specimen b, was cut out from the same side as a_1 400 mm from the point. *Non-metallic inclusions.* Slag inclusions and oxides are irregularly dispersed on the polished surfaces of the specimens; only in specimen b is a longitudinal line or chain of coarse entrapped slag visible. The majority of inclusions are glassy, but a small number also contain light crystallites and, in b, dendrites (wüstite). *Macrostructure.* Vague evidence of heterogeneity in the phosphorus content was revealed by Oberhoffer's reagent (showing in specimen b as stripes). Etching with both Heyn and 5%-Nital indicates irregular areas of fine and coarse grain size. Coarse grains occupy the right side of a_2 up to the central rib, and the entire cutting-edge of a_1. *Microstructures.* The coarse-grained areas consist of ferrite (grain-size 3–4). The structure of the fine-grained areas is also ferritic, but with intercrystalline globular pearlite (grain-size 7–8 and 10–11: carbon content 0.1–0.15% C, but in the inner part of the section, near the midrib, up to 0.35% occurs—specimen b). In the edge of a_2 there is a thin zone possibly containing 0.1–0.3% C. *Microhardness.* Coarse ferrite 140–160 mHV 30 g, pearlite in the edge of specimen a_2 up to 280 mHV 30 g. *Chemical analysis.* Mn traces, Cu traces, P 0.011% (slightly elevated), Ni 0.040% *Interpretation.* The sword-blade was manufactured by forging a heterogeneously carburized material, although it is possible that the structures observed represent the welding together of at least two metal bars. One edge has a higher carbon content and better hardness, but it is not possible to say if this result was produced intentionally. Pls. XVIII. 4–5 and XIX; Fig. 18.1.

16. HOLUBICE 598. Iron sword from inhumation grave 21. Moravian Museum, Brno, inv. no. Pa 2627/38 Chl. Preserved length 700 mm, flat blade. Specimens a_1 and a_2, representing the complete transverse section at the midpoint of the blade, were taken (340 and 385 mm measured from the point). Specimen b was taken from the point. *Non-metallic inclusions.* Impurities are unevenly distributed, reaching 4–5 in a_1, 2–3 in a_2, 1–2 in b. Chains of slag inclusions occur in specimens a_1 and a_2, while specimen b shows dispersed inclusions. All of the slag inclusions are glassy, some containing light crystalline phases and, in specimen b, dendrites. *Macrostructure.* Etching with Oberhoffer reveals elongated phosphorus segregations which bordering welding-seams: there is an arrow-shaped feature in the area of the central rib. Etching with Heyn and with 5%-Nital does not reveal any significant variations in the carbon content, but, as with the Oberhoffer etch, does reveal welding-seams. *Microstructure.* Etching with 2%-Nital reveals areas with different distribution of carbon content. The point of the sword (specimen b) is ferritic (grain-size 7–8 and 10–11); at the edge of specimen a_2 a ferritic band (grain-size 8–10) contrasts sharply with the ferrite-pearlite body (0.3–0.35% C). In the body of specimen a_1 the ferrite strip gives way to other heterogeneously carburized zones and bands (ferrite with traces of pearlite, pearlite with ferrite network): one

of these runs up to the line of the cutting-edge and contains about 0.2% C. *Microhardness.* Ferrite areas *c.*170 mHV, pearlitic stripes 250–350 mHV (e.g. at the edge of specimen a_2), ferrite at the point 150–200 mHV 30 g. *Chemical analysis.* Mn 0.013%, Cu 0.082% (elevated), P 0.044%, Ni 0.097% (elevated). *Interpretation.* It is very difficult to reconstruct the process of manufacture. The blade was apparently welded together from various bars with differing properties, but not to any fixed pattern. A piece of metal of comparatively good quality was incorporated into one of the edges, but the improvement in quality seems to be rather accidental.
Pl. xx; Fig 18.5.

17. HOLUBICE 599. Iron sword from inhumation grave 26. Moravian Museum, Brno, inv. no. Pa 16/35–31. Preserved length 685 mm, blade with midrib. Specimens a_1 and a_2 were taken 385 and 360 mm from the point and represent a transverse section of the blade. *Non-metallic inclusions.* Numerous slag inclusions, reaching 4–5, form distinct chains which divide the polished surfaces into five or six stripes. Inclusions are glassy and elongated, but granular inclusions (oxides) are also present. *Macrostructure.* The phosphorus content is concentrated in the stripes delineated by the chains of slag inclusions: similar bands are revealed by etching with Heyn and 5%-Nital, the darker bands containing more carbon. *Microstructure.* These stripes of ferrite (grain-size 6–7 and 10–11) alternate with zones of ferrite and intercrystalline pearlite (grain-size 10–12). Their carbon content does not exceed 0.15–0.2% C. *Microhardness.* Thin ferritic stripes under 200 mHV, ferrite-and-pearlite zones 210–225 mHV, at the edge of specimen a_1 up to 250 mHV 30 g. *Chemical analysis.* Mn 0.019%, Cu trace, P 0.342% (high), Ni 0.011%. *Interpretation.* A bundle of very mild steel bars of high phosphorus content was welded together and forged for a time just above the critical temperature. The resultant properties of the weapon are rather poor.
Pl. xxi; Fig. 14.3.

18. HOLUBICE 600. Iron sword from inhumation grave 32. Moravian Museum, Brno, inv. no. 2665/38 Chl. Length 729 mm, blade with central rib and adhering iron-sheet scabbard fragments. Specimens a_1 and a_2, taken 265 and 235 mm from the point, represent the transverse section. *Non-metallic inclusions.* Moderate numbers of elongated slag inclusions (2–3 or 3–4) are dispersed over both polished surfaces. Three types of inclusions occur—glassy, those with irregular light crystallites, and those with light dendrites. Granular oxides also occur sporadically. *Macrostructure.* Etching with Oberhoffer indicates the presence of phosphorus segregations between a number of metal bands. These weld-seams run somewhat obliquely to the axes of the sections. The same picture is revealed by etching with Heyn and 5%-Nital, although they do not show up any significant difference in carbon content. Some enriched areas occur in the inner part of the central rib. *Microstructure.* The individual bands consist of fine ferrite (grain-size 5–6 and 7–8; at the edge of specimen a_1 9–10). It is only in the inner central region that

the grain-size reaches 4–5. Some ferrite-pearlite areas occur in specimen a_2, where in addition an overheated Widmannstätten structure is visible at the cutting-edge. Small areas of lamellar pearlite with a ferrite network can be seen in the body of the blade. *Microhardness.* About 150 mHV, at the edge of specimen a_1 slightly over 200 mHV 30 g. *Chemical analysis.* Mn trace, Cu 0.065% (slightly elevated), P 0.148% (elevated), Ni 0.065% (slightly elevated). *Interpretation.* The blade was presumably constructed by welding together three heterogeneously carburized flat bars, and is of inferior quality.

Pl. XXII; Fig. 14.5.

19. HOLUBICE 601. Iron sword from inhumation grave 34. Moravian Museum at Brno, inv. no. Pa 16–35/48. Length 724 mm, blade with central rib. Two specimens a_1 and a_2 were cut from opposite edges at distances of 385 and 330 mm from the point, and represent the complete transverse section. *Non-metallic inclusions.* Distinct chains of slag inclusions run parallel to the axes of each section (level of impurity 3–4). The slag is glassy in form, and very fine globular inclusions may be of sulphide type. *Macrostructure.* Etching with Oberhoffer reveals phosphorus segregated in stripes which correspond to the chains of slag inclusions. Etching with Heyn does not clearly show the carbon distribution, but after etching with 5%-Nital, dark and light stripes blending one into the other are revealed, especially in specimen a_1. *Microstructure.* The darker zones have a ferritic-pearlitic structure of fine grain-size (10–11). In the lighter zones traces of pearlite can be detected. In the middle of specimen a_1 a pearlite stripe with ferrite network (original austenitic grain-size 6–7) occurs. The pearlite lamellae show signs of the onset of coalescence. Two similar C-rich stripes occur at the edge of specimen a_2 (grain-size 8–9), where patches of Widmannstätten structure also occur locally. The carbon content of the enriched zones is in the region of 0.2–0.4% C. *Microhardness.* Pearlite-and-ferrite 250–275 mHV; ferrite-and-pearlite in specimen a_2 100-120 mHV, and 150–200 mHV 30 g in a_1. *Chemical analysis.* Mn 0.016%, Cu trace, P 0.058% (slightly elevated), Ni 0.051% (slightly elevated). *Interpretation.* The sword-blade must have been forged by welding together several bars whose edges had been carburized, either accidentally or intentionally: the positioning of the harder zones militates against accidental carburization. The welding-seams are perfect and clean, and are hard to distinguish. The blacksmith's work resulted in a weapon of at least medium quality.

Pl. XXIII; Fig. 17.1.

20. HOLUBICE 602. Iron sword from inhumation grave 46. Moravian Museum, Brno, inv. no. 2694/38 Chl. Length 636 mm, flat blade, the hilt-tang twisted. Complete transverse section is represented by two overlapping specimens, a_1 and a_1, cut out from the edges at distances of 200 and 215 mm from the point. Specimen b was taken at a distance of 375 mm from the point and from the same cutting-edge as a_1. *Non-metallic inclusions.* Dispersed slag inclusions occur at the level of 1–2 of the Jernkontoret scale, with a slight concentration (2–3) occurring only in a_1.

Light crystalline phases and dendrites (the latter in specimen a_2) occur in the glassy matrix of the silicate inclusions. Oxides are also present. The uneven distribution of entrapped silicate slag is shown by specimen *b*, where quantities reaching 4–5 occur. *Macrostructure.* Phosphorus is distributed irregularly, not in stripes but in angular patches. Etching with Heyn and 5%-Nital did not reveal any significant variations in the distribution of carbon content, although these are present and may be seen under the microscope after etching with 2%-Nital solution. *Microstructure.* The structure is basically ferritic, but with areas of differing grain-size (coarse 1–3, fine 7–8 in the centre); there is grain-deformation at the edge of specimen a_2. There are also thin areas with ferrite-and-pearlite at the edge of specimen a_1. The carbon content is estimated there at about 0.3% C, with a local occurrence of Widmannstätten structure. Some carbon has diffused from those lamellae into the ferritic body across the weld-seam. *Microhardness.* Ferrite 150 mHV, deformed ferrite 170–180, ferrite-and-pearlite areas in specimen a_1 about 200 mHV. *Chemical analysis.* Mn 0.008%, Cu 0.038%, P 0.107% (elevated), Ni 0.024%. *Interpretation.* It is not easy to determine the method of manufacture. Presumably a wrought-iron blade was equipped on one side with a welded-on mild steel edge, while the opposite edge appears to have been cold-hammered. Neither of these operations could provide the cutting-edges with sufficient hardness, and despite these attempts, the weapon remained of an inferior quality.
Pl. XXIV.

21. HOLUBICE 603. Iron sword from inhumation grave 47. Moravian Museum, Brno, inv. no. 2706/38 Chl. Length 685 mm, blade with midrib, to which the remains of iron scabbard fragments adhere. Specimens a_1 and a_2 were taken 380 and 355 mm from the point and represent the complete transverse section of the blade. *Non-metallic inclusions.* Inclusions are dispersed irregularly. In specimen a_2 two longitudinal cracks occur near the centre of the specimen. The level of impurities is between 2–3 and 3–4. Inclusions are mainly glassy in form, and in some of them light coloured phases have crystallized out. Oxide and sulphide(?) inclusions may also be observed. *Macrostructure.* Variations in the distribution of phosphorus are minimal, although the presence of stripes may be distinguished. After etching with Heyn the carbon content appears homogeneously distributed, although a striped texture appears. *Microstructure.* The principal structure is lamellar pearlite with a ferrite network and needles in both specimens. The carbon content is estimated in the region of 0.7% C. The striped appearance result from fine pearlite, or from the Widmannstätten structure, which developed along the weld-seams. *Microhardness.* Pearlite in the body about 275 mHV, at the cutting-edges 300 mHV or greater; intercrystalline ferrite about 174 mHV 30 g. *Chemical analysis.* Mn 0.017%, Cu 0.029%, P 0.105% (slightly elevated), Ni 0.078% (elevated). *Interpretation.* The swordsmith used several hard steel bars and welded them together perfectly to form a blade. There is no evidence of any intentional hardening, although the weapon is of a good quality.
Pl. XXV; Fig. 17.2.

22. HOLUBICE 604. Iron sword from inhumation grave 35. Moravian Museum, Brno, inv. no. Pa 16/35–98. Preserved length 735 mm, blade with central midrib, adhering traces of an ironsheet scabbard (remains of rims, and the chape). Two specimens a_1 and a_2, were cut out 385 and 305 mm from the tip of the blade, and represent the complete transverse section. *Non-metallic inclusions.* Much entrapped slag (3–4 and 4–5) in the form of elongated inclusions showing light crystallites in a glassy matrix. Inclusions are arranged in slightly S-shaped lines parallel to section axes. Occasional inclusions of oxide type occur. *Macro-structure.* Etching with Oberhoffer reveals four or five bands of material enriched in phosphorus. Etching with Heyn and 5%-Nital reveals only minimal variation in distribution of carbon content. *Microstructure.* The primary structure is ferrite with traces of intercrystalline pearlite, in slightly enriched zones, and some Widmannstätten needles occur. The grain-size alternates between the stripes (grain-sizes 6–7 or 7–9 or 10–11). *Microhardness.* 150–200 mHV 30 g in a very flat curve. *Chemical analysis.* Mn 0.031%, Cu 0.053% (elevated), P 0.091%, Ni 0.048% (elevated). *Interpretation.* This is a blade of inferior quality, which has been piled from four or five main bars of wrought iron.
Pl. XXVI; Fig. 14.4.

23. HOLUBICE 605. Iron sword from inhumation grave 56. Moravian Museum, Brno, inv. no. Pa 16/33–105. Length 702 mm, blade with central rib disappearing at the point, traces of a sheet-scabbard rim on one edge. Specimens a_1 and a_2, taken 415 and 370 mm from the point, represent a complete transverse section of the blade. *Non-metallic inclusions.* Discontinuous chains of slag inclusions occur, sometimes accumulating in certain areas (4–5 in specimen a_1; 2–3 in a_2). The majority are glassy in form, but there are also crystalline inclusions in specimen a_2, and some oxides. *Macrostructure.* Irregular areas of phosphorus enrichment occur at the edge of specimen a_2; etching with 5%-Nital reveals darker spots towards the centre and at the edge of a_1. *Microstructure.* The basic structure is lamellar pearlitè, with local areas of ferrite network (0.7–0.8% C). The lighter edge in specimen a_1 is sorbitic in structure, while in the body there is an area of pearlite-ferrite (grain-size 7). *Microhardness.* About 350 mHV; near the edges 400 mHV and above; at the edges proper 300 mHV 30 g. *Chemical analysis.* Mn 0.023%, Cu 0.105% (elevated), P 0.042%, Ni 0.191% (elevated). *Interpretation.* The weapon was made of a good-quality hard steel, its cutting-edges getting their hardness presumably by a more rapid air cooling.
Pl. XXVII; Fig. 17.3.

24. HOLUBICE 606. Iron sword from inhumation grave 63. Moravian Museum, Brno, inv. no. Pa 728/38 Chl. Preserved length 607 mm, blade with central rib. Specimens a_1 and a_2 were taken 345 and 305 mm from the point, and represent a complete transverse section of the blade. *Non-metallic inclusions.* Discontinuous and slightly wavy chains of glassy slag inclusions, with lighter crystallites, occur in specimen a_1. Impurities reach 2–3 to 3–4 in the body, 1–2 at the cutting-edges. *Macrostructure.* Poorly defined phosphorus segregations follow the

curved lines of inclusions. Etching with Heyn indicates the presence of welding-seams there, while etching with 5%-Nital reveals darker areas in the body near the rib in specimen a_1, and similar areas at the margins of a_2. *Microstructure.* The dark areas in specimen a_2 are ferrite with traces of intercrystalline pearlite (grain-size 9–10), and a tendency towards the formation of Widmannstätten needles in the body can be observed. A broader central stripe in specimen a_2, and covering the entire right half of a_1, consists of lamellar pearlite (original austenitic grain-size 6), with thin ferrite network locally (overall 0.7–0.8% C). *Microhardness.* Pearlitic zones about 250–300 mHV; at the edge of a_1 187 mHV average; ferritic areas 150–200 mHV 30 g. *Chemical analysis.* Mn 0.016%, Cu trace, P 0.018%, Ni 0.09% (elevated). *Interpretation.* Determining the method of manufacture is not easy. The most likely explanation is that two partly carburized bars, one side of each having undergone partial secondary decarburization, were welded together with the steeled surfaces facing each other (one of the bars has a higher carbon content). The result of this work was a weapon with at least one edge of relatively good quality.

Pls. XXVIII and XXIX.

25. STARÉ HRADISKO 464, near Okluky, Moravia. Iron sword fragment found in superficial layers of a Celtic *oppidum*. Archaeological Institute Brno, No. 602–1386/64. Preserved length of blade 229 mm, width 46 mm: thin blade, much corroded, with slight central rib flanked by two flat channels, leaving more mass for both cutting-edges. A complete transverse section was cut from one end. *Non-metallic inclusions.* Chains of slag inclusions form several lines, containing oxides in a glassy matrix; globular oxides in the metal occur irregularly. The level of impurity reaches 2–3 on the Jernkontoret scale. *Macrostructure.* Etching with Oberhoffer reveals two high- and two low-P stripes. Etching with Heyn and 5%-Nital reveals three bands. *Microstructure.* The central bar has a very fine ferritic structure (grain-size 9–10). Etching with 2%-Nital reveals coarser ferrite grains in both side-shells (grain-size 5–7), and weld-seams between the components are visible. One of the cutting-edges shows a small V-shaped area of carburization with some globular pearlite within ferrite grains. *Microhardness.* Ferrite 204–226 mHV, pearlite 265–350 mHV 30g. *Chemical analysis.* Mn 0.056%, Cu nil, P 0.061% (elevated), Ni 0.111% (elevated). *Interpretation.* Three bars were welded together, the central one being low in phosphorus, although its carbon content does not influence the hardness of the material: both side shells are practically carbon-free. But there is the possibility of an additional slight carburization of one of the cutting edges, although overall the sword is of rather poor mechanical properties.

Fig. 18.6. Pleiner 1982: 93, pl. 10.1–4.

26. VEĽKÁ MAŇA (now MAŇA) 5, Slovakia. Fragment of an iron sword and remaining iron-sheet scabbard from destroyed cremation graves. Archaeological Institute Nitra. Preserved length 300 mm, blade with central rib and thin guard. Specimen *a* was cut from the hilt-tang, while specimen *b* covers nearly half the

transverse section of the blade. *Non-metallic inclusions.* The level of impurity in the hilt-tang is low, while that of the blade is somewhat higher; there is a crack above the central axis of the body of the blade. *Microstructure.* The structure of the blade is entirely ferritic, grain-size 4–5. Nitride needles occur within the ferrite grains, presumably due to the slow rate of cooling after the cremation rite. The structure of the hilt is also ferritic (grain-size 3) but with some intercrystalline pearlite grains. There is an area of heavily deformed ferrite grains near the surface. The scabbard (specimen no. 6) was of a very pure ferritic wrought-iron sheet, which was reinforced by welding twin strips of steel wire on both inner and outer surfaces. The structure of the wires is predominantly fine pearlite, with some carbon having diffused into the sheet across the weld-seams, which are marked by globular inclusions. *Microhardness.* Blade edge 133 mHV, body 119–125 mHV, deformed ferrite of hilt 180–185 mHV, pearlite 270 mHV; ferrite of scabbard 147–175 mHV 50 g. *Chemical analysis.* Mn and P approaching 0.01%, Cr, Al, Ag traces. *Interpretation.* The blade was made of soft wrought iron is of extremely low quality; cold hammering was used in finishing the hilt-tang. The sophisticated construction of the scabbard with its welded-on steel wire reinforcements is in marked contrast to that of the sword it contained.

Pleiner 1962, 75–7, pl. xi.

27. ZEMPLÍN 510, Slovakia. Iron sword, bent before deposition, from grave 1 of destroyed tumulus no. 8. Košice branch of the Archaeological Institute Nitra, no. 340/614–40. Straight length 950 mm, blade with three central grooves, marked with several legible Latin letters /V/TILICI/O?/ stamped 55 mm below the hilt shoulders: fragments of a copper/bronze scabbard, ornamented in an openwork style of Late La Tène Noric type. The surface of the iron blade is covered with a black patina. Two specimens, *a* and *b* were taken from the right cutting-edge at

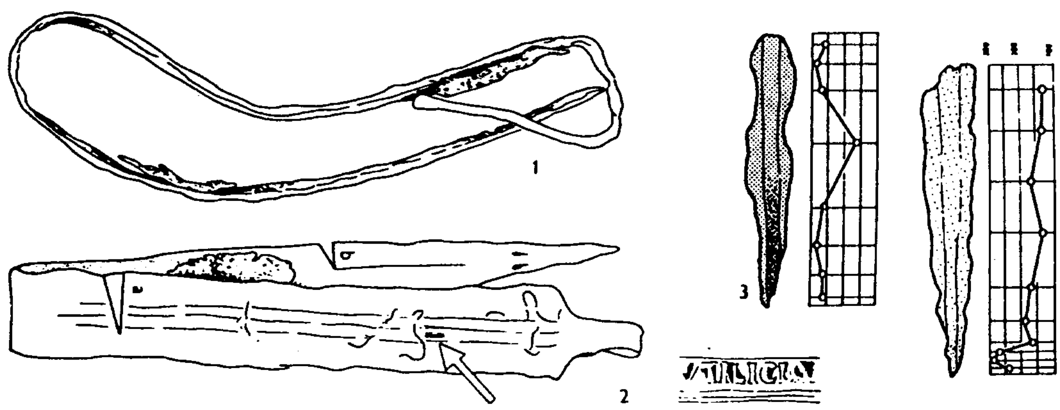


Fig. 11. Zemplín, E. Slovakia, sword specimen 510

distances 505 and 165 mm from the point, and represent more than one half of the transverse section of the two-edged blade. *Non-metallic inclusions.* Inclusions are scattered across the sections, with some also occurring in chains which run parallel to the specimen axes. The level of impurities is between 2–3 and 3–4. Inclusions are glassy in form, and in addition to silicates, there are also oxides present. *Macrostructure.* Etching with Oberhoffer, Heyn and 5%-Nital reveals no variations in the distribution of carbon and phosphorus, although traces of parallel bands can be seen. *Microstructure.* In specimen *a*, towards the middle of the blade, a fine low-carbon ferrite-pearlite structure (grain-size 8–9: carbon content 0.05–0.1%) with spheroidized pearlite occurs in stripes which are marked by welding-seams. The area of the cutting-edge contains more pearlite, but the carbon content does not exceed 0.15% C. Specimen *b*, which was taken closer to the point, contains more carbon (0.3–0.4% C). Ferrite-pearlite or pearlite structures are prominent, also in bands. The grain-size is fine (7–8, 8–9; locally 5). In the area of the cutting-edge the carbon content rises to about 0.5–0.6% and here, the lamellar pearlite (grain-size 4–5) is surrounded by a ferrite network and needles. *Microhardness.* Specimen *a*, ferrite 110–150 mHV, pearlite 240–290 mHV, average near cutting-edge about 250 mHV; specimen *b*, ferrite 120–150 mHV, pearlite 250–280 mHV 30 g. *Chemical analysis.* Mn 0.055% (elevated), Cu 0.055% (slightly elevated), P 0.040%, Ni 0.012%. *Interpretation.* The blade was apparently constructed by the welding together of three or four steel bars, whose carbon contents varied along their lengths. Apparently the middle of the blade was enriched in carbon. In cross-section also, the carbon content increases towards the cutting-edge. It is possible that the blade had been additionally carburized to steel and subsequently homogenized by intensive forging. After the cremation, the sword was left in an annealed state. Owing to the fact that the sword was in its scabbard, no decarburization or formation of coarse grains occurred. Any final hardening, if applied at all, was completely obliterated. In its present state, the weapon is not of the high quality that might have been expected from the display-scabbard and maker's mark.
Pl. XXX–XXXII; Fig. 11.

7

Metallographic Examinations of Other La Tène Period Swords from Europe and the British Isles

When our metallographic investigations were complete, we thought it necessary to compare the results with those from an additional 177 metallographic examinations of La Tène swords, the analyses of which appear in the literature. The individual results are reproduced below in paraphrased form. Twenty-eight of them were found in territories believed to be the scene of the ethnogenesis of the Celts, namely Switzerland, south Germany and eastern France, while 126 come from countries later settled by the Celts or situated on the periphery of the ancient Celtic world; northern and western France, Britain, Ireland, central Germany (Thuringia), and Silesia. Eighteen pieces originate in parts of Europe temporarily occupied by Celts during their historical expansion (northern Italy, the present Hungarian–Yugoslavian border region and Hungary). Four swords (of typical La Tène shape) are from an area far from the Celtic milieu (modern central Poland). One blade is of unknown European origin.

This total of 177 blades seems to be a considerable sample. However, the numbers have to be substantially reduced in terms of the quality of presentation of results. For instance, from the 76 analyses from Gournay in northern France, the system of preliminary publication, not giving the results of examination of individual specimens, enables us to get only a rough idea of the technology for about three items. The same applies to the set of seventeen swords from western France of which only about four items can really be seen in their complexity from the published evidence.

Moreover, the examinations, in general, differ in value. Overall, they represent work carried out in various stages of the development of archaeology and archaeometallurgy, and therefore attempt to answer different questions. The subjects of examination too are of unequal value from the archaeological point of view. Some are from well-documented complexes (e.g. graves); others are isolated finds in various collections and estimation of their relevance to the La Tène culture is based solely on their shape.

The Finds and Methods of Investigation

We must first summarize the primary data concerning the find circumstances of the individual artefacts and also the analytical methods applied.

There are nine swords from the well-known La Tène cemetery in Münsingen, south-east of Berne, Switzerland. Apart from two isolated blades from destroyed burials, they were found in inhumation graves (grave 10 from the early period L Ia or LA, about fifth century BC); graves 45, 56, 80, 86*b*, 98 from the period L Ib or LB_1, covering approximately the fourth century BC; grave 146 L Ic or LB_2, third century BC. The dating is based on analyses of the Münsingen cemetery and on juxtapositions of chronological systems of the La Tène period (Wiedmer-Stern 1908; Giesser and Kraft 1950; Hodson 1968; Martin-Kilcher 1973; Sankot 1980). The swords were investigated by J. Emmerling (1968). The analyses are detailed and well documented, including macro- and micro-observations and microhardness tests. The chemical composition is unknown. All specimens represent semi-transverse sections whose locations on the blades are documented.

Six swords from the eponymous site of La Tène at Neuchâtel, Switzerland have been examined. Unfortunately, their precise dating within the La Tène period is unknown. The shore waters of the lake were used over more than two centuries; recent dendrochronological data indicate at least the period from 278 to 60 BC (de Navarro 1972, i. 353; Haffner 1979). Isolated blade fragments have been examined. Of one of those swords (M 549, housed in the museum at Geneva, Switzerland, which may be from the middle La Tène period), a polished semi-transverse section has been published and depicted, though not described. It serves only to demonstrate that the plastic surface veining had its origin in surface-etching, not in the welding-on of bars or wires (Wyss 1968). The blade from Port (ibid.), which dates from the Late La Tène period, was similarly treated. A second blade from La Tène was examined by Professor Muegli and published by E. Salin (quoted by France-Lanord 1964, 317), without any mention of its whereabouts. The analysis consists of comments on its metallographic structure and microhardness. A third fragment comes from the stores of the Neuchâtel Museum. It was offered to the Archaeological Institute, Prague, for analysis of the type adopted as standard data for the objects from Czechoslovakia (described above, pp. 78–98). Three sword blades, two of them kept in the British Museum were investigated in detail by J. Lang (1987) but the data presented in the published paper, which includes examinations of a further eight Celtic swords from England, Germany, and Hungary, are too abridged to provide a true picture of their technology.

Two La Tène type swords from unknown sites in Switzerland, housed at the museum at Basle, were investigated metallographically by Messrs Stewart and Lloyd for the Pitt Rivers Museum, Oxford (Coghlan 1957, 144). The location of specimens is given only approximately. Partial chemical analyses and Vickers hardness tests were carried out.

Five sword-blades from France were investigated by A. France-Lanord (1964): one from Châlons-sur-Marne (La Tène I), one from near Metz (La Tène II in Déchelette's chronology), another from the river Saône (Musée Lorrain, collection Millon, imprecisely dated); and one from the river Seine (museum at Rouen, no data given). The analytical information includes general remarks on metallographical structure and Vickers hardness, partial chemical analysis, and in some cases the macroscopy of transverse sections. The location of specimens is not given. An examination of the sword found at Saint-Dizier (dated as La Tène II) was published by L. Lepage and F. Claisse (1967). We are given the macroscopical picture of a semi-transverse section (from an undesignated position), microstructures, partial chemical analyses, and Vickers hardness tests. Another sword-blade (La Tène III) was submitted to metallographic examination by G. Chapotat (1970, i, 48, 90; ii pls. 1–2. xxix). The site is the *oppidum* of Sainte-Blandine near Vienne, eastern France. His general description of the metallographical structures, observed somewhere on the transverse section, can be used. The punchmarked sword from Chaussin near Dôle was investigated by Vuaillat (1987, 112–15) whose comments accompany some microphotographs of a demi-transverse section from a known location.

In 1983 L. Uran from the Université de Technologie at Compiègne in France, presented a mimeographed thesis on the structures of Celtic swords. He discusses 85 examples (76 from Gournay; nine from other sites in France) which were submitted to complex metallographic analyses (250 sections were investigated). As he treats the material from the point of view of the physics of metals, he does not discuss individual blades, and therefore only selected specimens are identified in his text. However it has been possible to reconstruct the properties and technology of manufacture of one sword, no. 1667 from Gournay (which appears here on p. 114); three other swords are included here in our Table 9, on the basis of data derived from Uran's work. He also gives some information on other swords (here p. 115), from Bromeille, grave 13 (Earlier La Tène), and from Cire-les-Mello (Late La Tène). Undoubtedly, future evaluation of the imposing number of analyses made by Uran will contribute substantially to our knowledge of Celtic sword technology. Two swords from Écury-le-Repos (Crayon), and Morains, also treated by Uran, were published separately (Roualet *et al.* 1982; 1983), and these are discussed on p. 115.

Twelve swords from the sanctuaries at Faye l'Abbesse et Nalliers, and other blades from Mazerolles, Juac, Germond, and Valdivienne in western France were submitted to metallographic investigation (microscopy, hardness on demi-transverse or even longitudinal sections) but, again, only some brief references to results, accompanied by unidentified micrographs appeared in the publication by Lejars (1989).

Work on three sword-blades from the central territory of Celtic settlement in south and south-west Germany should be mentioned also. An early La Tène grave find, the sword from Cleebronn, near Heilbronn, was investigated by E. Schulz *et* *al.* (1983); three specimens including a surface-polished area were examined metallographically. The other two blades, from Heiligenstein (quoted by de Navarro 1972, 169–70, a rather early La Tène sword) and Tuttlingen, are housed in the Römisch-Germanisches Zentralmuseum at Mainz. They were investigated by the late E. H. Schulz, together with four other swords, also at Mainz (Baracska, Hungary; two specimens from the territory of western Vojvodina, now Yugoslavia), and a La Tène type sword of unknown provenance. The analyses may be described as full, containing well-documented macro- and micro-observations, partial chemical analyses, and Vickers hardness measurements (for publication see Schulz and Pleiner 1965). The punchmarked sword fragment from the area around Augsburg (Bavaria) in the British Museum has been studied by J. Lang (1987). Two specimens taken out of the blade offer a survey of the transverse section and chemical analysis was made on three specimens.

Examinations of sixteen fragments of La Tène period sword-blades in Britain have been published to date. Five are from the deposit at Llyn Cerrig Bach, Anglesey (McGrath 1968*a*; 1968*b*), and date to the period 150 BC to 50–75 AD. The report comprises macroscopic observations of transverse sections, very brief descriptions of microstructures and Vickers hardness tests, but no chemical analyses. The sword from Waltham Abbey, described as late pre-Roman or Roman (Lang and Williams 1975; Lang 1987) was chemically analysed; a semi-transverse section (position not indicated) is described and illustrated by microphotographs. From England, swords from the river Thames, Orton Meadows (two blades, one early La Tène, the other Late La Tène), Lockwood Reservoir at Walthamstow, late La Tène swords from Grimthorpe, Isleham, Whitcombe, Sadberge, and two blades from Stanwick have been examined also (Lang 1987). Some of these finds were chemically analysed, while the metallographic examinations were carried out on transverse or demi-transverse sections (only depicted in some cases). As the author (Lang, op. cit. 61) writes, the analyses were more detailed than the report specifies and, for some of the specimens, involved scanning electron microscopy, X-ray spectrometry, atomic absorbtion and colorimetric analyses, and X-radiography. The results are not fully presented in the report.

It is possible to use six examinations of Irish Early Iron-Age swords (not stratified but stylistically comparable with La Tène weapons), dating to the period from about 300 BC to AD 500 (Lisnacrogher, Co. Antrim—three specimens; Kildrinagh, Co. Laois—2 specimens; Banagher, Co. Offaly—Scott 1990). Full data are presented: specimen positions, inclusions, macrostructure, microstructures, HV hardness and microhardness, and quantitative chemical analyses, accompanied by interpretations of observations.

Metallographic studies of twelve La Tène period swords found in northern Italy have been carried out by various workers. The finds are housed in museum collections at Lecco, Milan, Novara, and elsewhere. Unfortunately, very little information concerning the find circumstances is available (only the swords from Sforzesca and Esino Lario come from graves, the Sforzesca one presumably from a cremation burial). The metallographic data are incomplete, depending in the main on the evidence of cylindrical specimens bored out by a tubular device from blade cores. There are two exceptions, however: blade 3 from Borgovercelli (Leoni 1975), where the cutting-edge has been examined in addition to cylindrical borings, and the blade from Cuvio from which many semi-transverse and longitudinal sections were taken, and where chemical analyses were conducted (Reggiori and Carino 1955, 48–51). It should be noted that this blade, like the Cleebronn find, shows a well-developed pattern-welding scheme, comparable with artefacts of the third to fourth centuries AD. Vickers hardness was measured for this blade and also for the swords from Sforzesca, Magenta, Novate, Acquate, and Varenna 1 and 2. Analyses of swords from Esino Lario and the Bergamo province (private collection) were published by Storti and Mariani (quoted by Coghlan 1956, 143). Metallographic structures and hardness are described, but the precise positions of sections are not given. Partial chemical analytical information is included in the report.

Emmerling, who investigated the Münsingen swords, brilliantly later published (1975) two additional examinations of Celtic swords, including a blade from Dalj, Yugoslavia, housed in Berlin (Staatliche Museen) and dated to the LC period (second century BC; see von Jenny 1932). From the fact that this blade was bent, probably at the time of a cremation burial, von Jenny assumed the presence of non-Celtic groups equipped with weapons of Celtic origin. The second blade was found at Báta (southern Hungary), but no other details of the find-circumstance are known. The investigation involved macroscopic observation, identification of microstructures, and detailed Vickers hardness tests. Semi-transverse sections were examined at located positions, but no chemical analyses were made. Mrs J. Lang investigated another sword from Hungary (now in the British Museum), from Tinnye near Budapest (unpublished). The style of presentation of results is as described above.

From the opposite end of the ancient Celtic world there is a metallographic analysis of a La Tène sword from the Steinsburg *oppidum* in Thuringia, central Germany, by Hanemann, the pioneer in the application of metallography to archaeological iron-work (1922). Unfortunately, the information published is fragmentary and consists solely of a description of the microstructure. Moreover, the position of the sample taken from the artefact is not indicated.

Four La Tène swords from Silesia and three from more distant parts of modern Poland have been analysed by J. Piaskowski. His investigations are methodologically uniform and include the macroscopic characterization of polished specimens, most of which represent parts of transverse blade sections exactly located by sketches, slag inclusion and microstructure description, microhardness measurements, qualitative and partial quantitative chemical analyses. The Sobocisko and Głownin 1 and 2 finds (Piaskowski 1961), as well as those at Iwanowice (1960) are unstratified. The Kietrz (1979) and Brzeźce swords were found in La Tène period graves (the latter from a cremation burial; Piaskowski and

Hensel 1979). The sword and scabbard from Warszawa-Żerań were found in a La Tène period cemetery (Piaskowski 1960/70); de Navarro (1972: I, 47) classifies it tentatively as a Middle La Tène example.

To sum up, in chronological terms we shall be dealing with one very early sword (fifth century BC, Münsingen grave 10) and five swords from the fourth century BC (graves, 45, 56, 80, 86*b*, 98 in the same cemetery). The finds from Bromeille and Cleebronn also date from the Early La Tène, as do those from Orton Meadows and Walthamstowe. Swords 2 and 5 from Faye l'Abbesse have been estimated as dating from the end of the La Tène I period. The sword from Münsingen grave 146 is dated to the third century. A group of eighteen blades may be ascribed generally to the Middle La Tène period: La Tène, Metz, Gournay, Heiligenstein, Augsburg, Saint-Dizier, river Saône, Museum of Rouen, Mazerolles (2), Faye l'Abbesse 7 and 8, Sforzesca, Dalj, Tinnye, Iwanowice, and Warszawa-Żerań. The following sword-blades are certainly from the Late La Tène period: Port, Cire-les-Mello, Vienne-Ste Blandine, Faye l'Abbesse 1 and 4, Nalliers 1 and 2, Esino Lario, Bergamo, Borgovercelli (3), Llyn Cerrig Bach (5), Isleham, Whitcombe, Waltham Abbey, Stanwick (2), Grimthorpe, Sadberge, Orton Meadows 2, the Irish finds (6), and Steinsburg.

The remaining specimens are not specifically dated closer than to the La Tène period as a whole, although the majority of them are likely to belong to the Middle La Tène period.

Investigation Results

28. MÜNSINGEN 24286, near Bern, Switzerland. Iron sword from inhumation grave 146. Bernisches Historisches Museum, inv. no. 24286. Length 668 mm, width 35 mm, flat blade. A specimen was cut out in transversal direction, reaching 19.5 mm from the cutting-edge. *Non-metallic inclusions*. One side, occupying about a third of the specimen surface, is relatively slag-free; the remaining area is divided into two by a chain of oxides. *Macrostructure* (etched with Nital). The slag-free zone is darker in colour than the rest. *Microstructure*. The dark zone reveals a mixed ferritic–pearlitic structure with 0.4–0.5% C, and varying grain-size distributed in stripes, delineated by small elongated silicate inclusions. This steel is corroded at the cutting-edge. The other two bands are ferritic, showing different grain-size, fine and super-coarse. In the area of the cutting-edge, there are deformed ferritic grains. Within these two bands minute layers are distinguished. The investigator does not mention any occurrence of pearlite, though he speaks of spots with carbon content reaching 0.15% C. *Microhardness*. Steel band: ferrite 201–248 mHV, pearlite 260–263 mHV. Adjacent bars: coarse ferrite 195–260 mHV, medium size 239 mHV, fine size 284 mHV. The curve jumps heavily, leaving the inner part a little softer. *Interpretation* (by J. Emmerling). The blade consists of three welded-

together and precisely refined bars. They are not arranged in any sandwich system since the medium steel bar forms one of the side shells. The central bar and the opposite shell are of wrought iron. Cold hammering of the cutting-edge raised the hardness to some extent.
Emmerling 1968, 166–8.

29. MÜNSINGEN 24447. Iron sword from inhumation grave 86. Bernisches Historisches Museum, inv. no. 24447. Length 704 mm, blade with central rib, sheet scabbard with rims and chape. Badly corroded, but a major part of the cross-section was taken (24 mm) at a distance of 315 mm from the point. *Non-metallic inclusions*. A longitudinal oxide line runs through the edge. Slag inclusions occur in the centre; their orientation is distorted. *Macrostructure* (etched with Nital). Marginal zones are light in colour, the core is dark. *Microstructure*. The core is ferritic (less than 0.01% C), and traces of bad weld-seams were noted. There is a small zone of ferrite–pearlite material (0.2–0.3% C) at the side near the cutting-edge, presumably the remains of an outer shell. *Microhardness*. Cutting-edge 245, centre 228, ferrite in the shell 194 mHV. *Interpretation* (by J. Emmerling). The heavy corrosion of the surface allows only conjecture of the original blade construction. A soft wrought-iron core might have been placed between two mild steel side shells in a sandwich position, but while the design was probably good, workmanship was bad. A weapon of inferior quality.
Emmerling 1968, 164–6.

30. MÜNSINGEN 24484. Iron sword from inhumation grave 98. Bernisches Historisches Museum, inv. no. 24484. Length 712 mm, width 44 mm, blade with central rib. The sheet scabbard, now with a badly corroded surface, has clasped rims and originally had a disc-shaped chape. A specimen covering the greater part (24 mm) of the cross-section was taken 330 mm from the hilt-tang junction. In addition, a rivet and a part of the loop-plate were investigated. *Non-metallic inclusions*. The metal contains a small number of irregularly dispersed inclusions. *Macrostructure*. (Etched with Nital). A dark central zone and traces of lighter side zones suggest a sandwich scheme which was in fact confirmed by microscopy. *Microstructure*. The central band consists of pearlite and ferrite with a heterogeneously distributed carbon content (0.1–0.5% C, rarely below 0.3% C), and a striped texture. Remains of side shells were observed (ferrite and traces of pearlite 0.01–0.03% C as given by the investigator, locally up to 0.1% C). *Microhardness*. 234 mHV in the centre, 234 mHV in the cutting-edge; side shells 177–178 mHV, near the cutting-edge 167 (fine ferrite). *Interpretation* (by J. Emmerling). A steel core between two wrought-iron shells was refined by forging and the welding together of the components, although workmanship was poor. The two operations, i.e. the refining and the construction, might be the work of different master-smiths. The buried rivet showed fine, as well as coarse, ferrite–pearlite structures of 183–230 mHV, and traces of welds, and might be manufactured from different wires. The clip-plate must have been piled together from five ferritic wrought-iron sheets,

showing alternating microhardness (200, 215, 208, and 210 mHV) which was probably influenced by an elevated phosphorus content.
Fig. 17.6. Emmerling 1968, 158–61.

31. MÜNSINGEN 24527. Iron sword from inhumation grave 80. Bernisches Historisches Museum, inv. no. 24527. Length 720 mm, width 48 mm. Blade with central rib; sheet scabbard. Two specimens *A* and *B* represent the transverse section 248 mm from the hilt-tang tip. *Non-metallic inclusions*. Slag and oxide inclusions occur in parallel lines. *Macrostructure* (etched with Nital). A light-coloured piled texture appeared. *Microstructure*. Ferrite occurs in fine lines between silicate and oxide inclusions. *Microhardness*. 128–205 mHV (average 165). *Interpretation* (by J. Emmerling). The blade was made of soft wrought iron refined without complete expulsion of slag.
Emmerling 1968, 156–7.

32. MÜNSINGEN 24663. Iron sword from inhumation grave 10. Bernisches Historisches Museum, inv. no. 24663. Length 748 mm, width 44 mm, blade with central rib, corroded sheet scabbard with rims and chape. Two specimens were taken from the same cutting-edge: *A* at 288 mm from the hilt-tang tip, and *B* at a distance of 103 mm from the blade point. Both specimens represent parts of transverse sections; *A* reaches 21.5 mm, *B* 10 mm from the cutting-edge. *Non-metallic inclusions*. There are oxide lines visible on the surfaces of the polished specimens. *Macrostructure* (etched with Nital). *A*—three zones run along the major axis, and one of the side-shells is of dark colour. *B*—The surface is dark in colour except for two stripes, one of which runs through the centre near the cutting-edge. *Microstructure*. *A*—The dark side shell consists of a very fine lamellar pearlite or sorbite (eutectoid, 0.86% C) or, locally, of pearlite with ferrite network. A decarburized stripe (0.35% C and below) runs along the seam in the body of the blade (overheated Widmannstätten structure). The central bar seems to be divided into three (or four) butt-joined bars. These are of ferritic wrought iron, except for the third, taken from the cutting-edge, which is, again, of steel (fine ferrite–pearlite, about 0.5% C). The other outer flank is described as ferritic, but the carbon content is given as 0.1–0.3% C. In the seam a line of Widmannstätten structure occurs. *B*—The major part of the specimen shows a very fine martensite described as 'hardenite'. In lighter zones indicated by macro-etching pearlitic-and-ferritic structures occur. *Microhardness*. *A*—pearlite (or sorbite) in the steel shell up to 349 mHV, Widmannstätten zones 239 mHV (average), ferrite in wrought-iron bars about 168, ferrite and pearlite in the inner steel rod 237 mHV (average). *B*—the structure called "hardenite" 321 mHV (average), locally up to 419 mHV; decarburized areas 251 mHV (average). *Interpretation* (by J. Emmerling). The main structural part of the blade represents a hard steel bar, reinforced by a faggoted butt-joined wrought-iron and steel bundle, covered with another wrought-iron (or mild steel) shell. This reinforcement did not reach the

blade point. The blade was carefully hardened but only along the cutting-edges. An excellent artefact.

Fig. 17.9. Emmerling 1968, 168–71.

33. MÜNSINGEN 24709. Iron sword from inhumation grave 56. Bernisches Historisches Museum, inv. no. 24709. Length 704 mm, width 40 mm (i.e. with the scabbard). Blade with slightly marked midrib, inserted into a clasped-sheet scabbard with chape. A transverse specimen (18.5 mm) was cut out 233 mm above the chape tip. *Non-metallic inclusions*. Discontinuous oxide inclusions mark two seams and three main bands of material. *Macrostructure* (etched with Nital). One of the outer shells, which is heavily corroded, comes out dark. *Microstructure*. The dark outer zone consists of pearlite-and-ferrite, with the carbon content distributed slightly heterogeneously, but containing 0.4–0.5% in average. It is suspected that the original cutting-edge might have had about 0.6% C. A strip of Widmannstätten structure runs along the weld. There is fine ferrite in the central bar. The opposite outer shell is also ferritic, but its grain is coarser. *Microhardness*. Steel shell at its cutting-edge 249–357 mHV, in the body 258 mHV; the wrought-iron core 183 mHV (average), the wrought-iron shell 199–218 mHV. *Interpretation* (by J. Emmerling). The blade was welded together from three metal bars, the core being of wrought iron. Of the side shells, one was of medium steel, the other of wrought iron.

Fig. 17.8. Emmerling 1968, 163–4.

34. MÜNSINGEN 24745. Iron sword from inhumation grave 45. Bernisches Historisches Museum, inv. no. 24745. Length 712 mm, blade with central rib; sheet scabbard. A specimen representing more than half of the cross-section (26.3 mm) was cut out 340 mm from the point. *Non-metallic inclusions*. Slag lines run along the major specimen axis. *Macrostructure*. The lighter-coloured inner part does not reach the edges, being embedded in darker shells. *Microstructure*. Slightly overheated ferrite with pearlite in the grain boundaries occurs. The outer shells are pearlitic/sorbitic containing about 0.6–0.86% C, in the cutting-edge 0.6% C. In the latter a structure described as 'hardenite' has been identified by the investigator. *Microhardness*. From the core (180 mHV) the microhardness increases towards the cutting-edge up to 430 mHV. *Interpretation* (by J. Emmerling). The mild steel or wrought-iron core was surrounded by hard steel shells and these components were welded together to form a blade. Only the cutting-edge proper could be hardened, but corrosion has caused the disappearance of the original martquenched parts. Perfect work and good quality.

Fig. 17.4. Emmerling 1968, 161–3.

35. MÜNSINGEN 26177. Iron sword, isolated find from inhumation graves. Bernisches Historisches Museum, inv. no. 26177. Length 644 mm, blade with central rib. A specimen representing half of the cross-section (220 mm from the recent tip of the hilt-tang) was cut out and polished. Surface heavily corroded.

Non-metallic inclusions. Elongated slag inclusions run along the major axis, but their forms are not described. *Macrostructure* (etched with Nital). The section surface is dark, with more light spots in the centre and near the cutting-edge. Bad welding-seams run parallel to the major axis of the specimen, but interpretation is very difficult on account of heavy surface corrosion. *Microstructure*. The central part and the cutting-edge consist of eutectoid pearlite. These areas are surrounded by hypereutectoid sorbitic or pearlitic areas with more than 0.86% C. Near the weld-seams there are traces of a Widmannstätten texture. *Microhardness*. Pearlite average 304 mHV, pearlite in the centre average 254 mHV. *Interpretation* (by J. Emmerling). Presumably faggoted from several hard steel bars; alternatively the steel core was surrounded by very hard steel shells.
Emmerling 1967, 171–8.

36. MÜNSINGEN 31194. Iron sword, isolated find from destroyed inhumation graves. Bernisches Historisches Museum, inv. no. 31194. Flat blade. A specimen showing half of the cross-section was taken 216 mm from the point. *Macrostructure* (etched with Nital). The cutting-edge is lighter in colour. There are traces of weld-seams visible in the central part, which is possibly divided into three stripes. *Microstructure*. Fine ferritic-and-pearlitic or pearlitic-and-ferritic mixed structures occur, with the carbon content ranging from about 0.35% up to 0.5% C, in some areas even up to about 0.6% C. Widmannstätten structure is visible along what are identified as seams. *Microhardness*. Centre 262, edge 256, softer spots 252 mHV. *Interpretation* (by J. Emmerling). The bar was faggoted and perfectly welded together from 6 bars of steel, 3 in each half. Wavy internal seams developed in the centre during the working. The steel has apparently been homogenized by overlapping and refining. Excellent blade.
Emmerling 1968, 157–8.

37. LA TÈNE 199, near Neuchâtel, Switzerland. Iron sword fragment from the Zihl deposit. Museum at Neuchâtel, not numbered. Preserved length 316 mm, width 40 mm, cutting-edge lines heavily attacked by corrosion; blade with a very slightly marked midrib, with adhering traces of the guard. A transverse specimen was taken at the broken end (30 mm). *Non-metallic inclusions*. Numerous inclusions run in more or less parallel chains along the major axis of the specimen, impurity degree low, about 2 on the Jernkontoret scale. Slag inclusions are glassy, many of them containing light coloured crystallites and dendrites. *Macroscopy*. There is phosphorus enrichment of the thinner flank of the blade; another irregular area may be seen at the side in the centre, after etching, with Oberhoffer, Heyn and 5%-Nital etchings revealed a lighter area in the better-preserved flank. The carbon content there is elevated. *Microstructure*. The area just mentioned contains ferritic-and-pearlitic in a fine-grained structure (grain-size 9–10; carbon content 0.2–0.3% C) in which prolonged stripes of pearlite ferrite network occur (6–7; about 0.3–0.4% C). The pearlite is lamellar, tending towards decomposition into spheroids. Most of this type of structure is concentrated near the core and is gradually replaced by ferrite (grain-size 7–8), with isolated pearlite at the grain

boundaries. *Microhardness*. Structures with prevailing pearlite 220–310 mHV, fine ferrite–pearlite areas 182–220, the ferritic cutting-edge 150–170 mHV 30 g. The curve shows that the core is the hardest part. *Chemical analysis*. Mn traces, Cu 0.00%; P O. 209% (elevated), Ni 0.055%. *Interpretation* (by R. Pleiner). The blade has been apparently made of one heterogeneously carburized bar in such a way that one of the two cutting-edges obtained the properties of wrought iron, the other those of steel. From the point of view of technology it was a rather simple artefact. As regards the quality, one cutting-edge was somewhat better than the other, but not substantially.
Pls. XXXIII and XXXIV. Unpublished; investigated in the Laboratory of the Archaeological Institute Prague.

38. LA TÈNE. Iron sword from the La Tène deposit. Very little is known about this weapon. According to the published data it is a flat blade of 50 mm width which was cut transversally and investigated by metallography. The structure is ferritic with alternating areas of fine and course grain-size, which are oriented perpendicular to the major specimen axis. A. France-Lanord writes on grain cracks caused by cold hammering. The microhardness of ferrite is given as 155–185 mHV. Apparently a blade of inferior quality.
France-Lanord 1964, 317–18, pl. i.1, quoting E. Salin (1952) and the author of the investigation, Professor Muegli.

39. LA TÈNE M 549. Iron sword from the La Tène deposit. Musée d'Art et d'Histoire, Geneva. Well-preserved blade with a thin guard and with many wavy plastic ribs or veins resembling welded-on wires. A partial transverse section revealed (after two unspecified kinds of etch) that no welding was applied. The veins were developed by deep (acid?) etching of the blade surface of the ready-made artefacts covered with protective (wax?) stripes. V-shaped lines are visible on the surface of the section, but no structures are identified.
Wyss 1968, figs. 1.4; 3; 5; 8.7*a–b*.

40. LA TÈNE 380. Iron sword from the La Tène deposit. Musée Cantonal, Neuchâtel. Investigated in the British Museum by J. Lang (1987). The investigator describes the technology of manufacture as surface-to-surface piling (butt-welding) from lamellae of varying carbon content. Hardness at the surface and edges is 280–300 HV (ferritic areas 150 HV). The phosphorus content is described as low, as is the hardness.
J. Lang 1987, 71.

41. LA TÈNE. Iron sword from the La Tène deposit, now in the British Museum (67.7–1). Examined by J. Lang 225 mm below the blade top. Length 650 mm, width 41.7 cm. It is stated that this blade shows no signs of any welds (although the structures appear as bands), the structure being mainly fine-grained ferrite and pearlite with the carbon content increasing towards the cutting-edge (Hardness there 426 HV), although carburization is not suggested. The rest of the structures average 270 HV. Functionally it seems to be a good weapon.
Lang 1987, 71.

42. LA TÈNE. Iron sword from the La Tène deposit, now in the British Museum (80.12–14.2). Examined by J. Lang 182 mm from the blade top. Length 633 mm, width 427 mm. The surface of the blade is covered by punched dots and depressions. The investigator interprets the technology as edge-to-edge piling with bands enriched in phosphorus. The structure consisted principally of coarse ferrite (up to 1.2 mm grain diameter), with some pearlite at grain boundaries. Neumann bands indicate the cold working or final forging at low temperature. *Hardness.* 318 HV near the cutting-edge, 279–287 HV at the surfaces, interior 220–250 HV.

43. PORT, near Nidau, Switzerland. Iron sword from the Late La Tène period deposit. Bernisches Historisches Museum (13598). A blade with central rib and *plastic veining* on the surface. In the published illustration of a partial transverse section, there are V-shaped, dark and light zones running across it (not described). The light areas apparently represent coarse ferritic grains. There are three light bands with two dark stripes in between on a longitudinal section.
Wyss 1968, figs 2.8; 8.8*a–b*.
Comment. The illustration seems to show a soft ferritic material, giving a blade of inferior quality.

44. SWITZERLAND (no. 1), unknown site. La Tène type iron sword. Historisches Museum, Basle, inv. no. 1947.640. Blade with central rib. Two guard. Two specimens were prepared for examination: one from the middle part of the blade, and the other from near the point, exact positions are not given. *Non-metallic inclusions.* The metal is free from large inclusions of entrapped slag. *Microstructure.* Ferrite of coarse grain-size (ASTM 2), with Neumann bands indicate the cold working or final forging at low temperature. *Hardness.* distorted ferrite grains with traces of intercrystalline pearlite indicate that the final forging continued below about 450 °C. There are also fine grains containing nitride needles near the central rib. Close-by there is a small area with pearlite (0.6% C) occurs. *Hardness.* In the core 196 HV, in the cutting-edge 190 HV. *Chemical analysis.* Cu traces, Ni 0.05%. *Interpretation* (by H. H. Coghlan). Cold hammered wrought-iron blade.
Coghlan 1957, 135, pls. i. 1 and 3.

45. SWITZERLAND (no. 2), unknown site. La Tène type iron sword. Historisches Museum, Basle, inv. no. 1947.640. Blade with central rib. Two specimens were taken: near the point, and in the middle part of the blade (exact positions not given). *Non-metallic inclusions.* The junctions of layers are free from large particles of slag. *Microstructure.* Near the central rib a fine-grained ferritic structure with intercrystalline pearlite was noted (grain-size 7; about 0.15% C). Towards the cutting-edge the carbon content increases up to about 0.5% C. Lamellar pearlite with a ferrite network and needles show coarse grains of size 2, indicating a final forging at about 1000 °C. The structure of the weapon is typical of piling. *Hardness.* Low-carbon core 161 HV, carburized cutting-edge 286 HV. *Chemical analysis.* Mn 0.00%, Cu traces, Si 0.02%. *Interpretation* (by H. H.

Coghlan). The cutting-edge was carburized, or else the edge had a higher carbon content in the original faggot used for making the blade.
Coghlan 1957, 135–6, pl. i. 4 and 7.
Comment. The blade seems to be of adequate quality.

46. SAÔNE river, unknown site, France. Iron sword. Musée Lorrain, Collection Millon (G–2416). Blade with longitudinal plastic surface veining. A stamped punchmark is barely visible. Two transverse specimens were cut, one below the slopes at the hilt-tang, and the other across the blade (exact position not indicated). An illustration composed from microphotographs shows wavy transversal welds in V-shape. *Microstructure.* The report mentions coarse ferrite grains which are deformed at the cutting-edge. *Interpretation* (by A. France-Lanord). Several wrought-iron bars or rods were faggoted in butt-position and bent to a U-shape to make the length of the blade, and were welded together and forged in order to form the cutting-edges. Both were covered with resinous material, protecting them against the artificial deep etching with organic acids and soils which produced the veining of the central surface of the blade.
France-Lanord 1964, 320–4, pls. iii and iv.

47. SEINE river, France, unknown site. La Tène type iron sword. Rouen Museum (1882, not numbered). Length 720 mm, width 450 mm, flat blade. Transverse section polished. *Microstructure.* The core of the blade contains pearlite–ferrite on both sides of a line of slag inclusions. The report refers to the occurrence of a eutectoid carbon content there. The outer flanks are low in carbon, having an overheated ferrite–pearlite structure. On one side, a very coarse ferrite is observed. *Interpretation* (by A. France-Lanord). The blade is classified as a simple one.
France-Lanord 1964, 318–19, pl. i. 5.
Comment. An iron bar, carburized on one of its surfaces, might have been bent to a U-shape and welded together to a blade, so that carbon free parts were situated at the surfaces, thus keeping the steel in the core. Complete decarburization of the surface by overheating is also possible.

48. METZ, France. Iron sword of La Tène II type, without any data concerning the find circumstances and deposition. Flat blade, 45 mm wide. Transverse section examined. *Macrostructure.* Piled structure throughout the body of the blade. *Microstructure.* Stripes of ferritic structure alternate with others showing ferrite–pearlite (maximum carbon content about 0.2% C). One of the outer flanks contains more intercrystalline pearlite. *Chemical analysis.* Mn 0.03%, P 0.080% (slightly elevated). *Interpretation* (by A. France-Lanord). Heterogeneously carburized metal was heated, folded and hammered in order to remove slag.
France-Lanord 1964, 318, pl. i. 2.
Comment. The published macrophotograph indicates the welding of a mild steel side shell on to one of the blade surfaces, as in the case of certain examples from Switzerland (Münsingen, see Fig. 17.8).

49. VIENNE, SAINTE BLANDINE, near Lyon, France. Iron sword fragment

from the oppidum. Musée de Vienne (2Sb 55). Preserved length 450 mm, width 48 mm, blade with a slightly marked central rib. The specimen, the position of which is not specified, covers a good deal of the transverse section. *Microstructure.* Ferrite and intercrystalline pearlite (Widmannstätten texture) occur between chains of slag inclusions. The carbon content is very low. *Interpretation* (by Mrs J. Condamin and M. Picon). The blade was made by bending, refining, hot forging, and homogenizing a low carbon material.
Chapotat 1970. i, 48, 90; ii, pls i.2. and xxix.
Comment. The sword was of inferior quality.

50. CHAUSSIN, near Dôle, Jura, eastern France. No information of find-circumstances and deposition are given. A long sword-blade with an incomplete hilt-tang, showing on the surface parallel stripes of metal. There is a punchmark in the shape of a human figure with a hammer (a smith) on the blade near the hilt. Length 904 mm, width 41 mm. A demi-transverse section was cut out of the cutting-edge some 20 cm from the hilt end. A piled structure with ferrite and interstitial pearlite and V-shaped welds was observed, indicating butt-joining. In the cutting-edge, deformed ferritic grains appear, as a result of cold working. Despite the presence of the punchmark the sword is of poor quality.
Vuaillat 1987, 113–15, figs. 55–6.

51. CHÂLONS-SUR-MARNE, France. Iron sword, classified as a La Tène I type, with a developed central rib. No information on find-circumstances and deposition. Transversal section was made. *Macrostructure.* The light surface of the polished and etched specimen makes several dark areas visible. *Microstructure.* The report mentions a heterogeneously carburized metal. *Interpretation* (by A. France-Lanord). An iron bar weighing originally about 1.5 kg was refined by heating and multiple folding so that the resulting weight was reduced by about 50%. Final plastic formation of the cutting-edges and the rib took place after the bar had been prepared.
France-Lanord 1964, 319, pl. i.3.

52. ÉCURY-LE-REPOS, site of Crayon (Marne, northern France). Iron sword and scabbard from inhumation grave 1, Musée Epernay, not numbered. Total length 790 mm, width 42 mm. Blade with central rib, without preserved guard, parts of adhering iron-sheet scabbard with belt loop and chape. Four semi-transversal specimens were cut out: E 1 at the foot of the tang, E 2 about 45 mm below the guard (covering more than a half of transverse section and including the midrib), E 3 90 mm and E 4 25 mm from the point. *Non-metallic inclusions.* Very numerous, arranged in chains following the presumed welds. *Macroscopy* (etched with 5%-Nital). Piled structure with four zones, apparently joined by welding was revealed. The zones run along the long axis of the section. *Microstructure.* The structure is made up of alternating zones of coarse and very fine ferrite, the latter with traces of intergranular pearlite. Near the area of the cutting-edge, large ferrite grains with Neumann bands occur. *Interpretation* (by G.

Béranger and C. Coddet). The blade was manufactured by welding together wrought-iron rods, which are carbon-free or contain a minimal amount of carbon, along with much entrapped slag. Mechanical properties were rather inferior. The cutting-edges were forged while the temperature was falling rapidly.
Roualet *et al.* 1982.

53. ÉCURY-LE-REPOS. Iron sword from inhumation grave 3, Musée Epernay, not numbered. Total length 830 mm, width 52 mm. Blade with central rib, iron-sheet scabbard with riveted belt-loop and chape. Four transverse specimens up to and including the midrib were cut out: E 1 about 50 mm below the guard, E 2 about 270 mm, E 3 about 120 mm, and E 4 about 65 mm from the point (all on the same cutting-edge). *Non-metallic inclusions.* Numerous silicate inclusions arranged principally in chains run along the specimen axis. *Macrostructure* (etched with 5%-Nital). The structure shows a piled texture, but transitions between carburized and carbon-free parts are not sharp and their localization varies among the different specimens. *Microstructure.* Ferritic areas merge into those of ferrite and pearlite. Pearlite with a ferritic network and needles (similar to a Widmannstätten structure) also occurs, just reaching medium steel values. *Interpretation* (by G. Béranger and C. Coddet). The fortuitous situation of carburized zones does not reflect the intentional application of any technique.
Roualet *et al.* 1982.
Comment. Several possibilities may be considered—either the use of a bar with its carbon content heterogeneously distributed, or local surface carburization, or the welding together of heterogeneously carburized rods or plates, or the placing of harder material inside shells.

54. SAINT-DIZIER, Haute Marne, France. La Tène II type iron sword, isolated find. Length 930 mm, width including the scabbard 50 mm, almost flat blade. A specimen covering the semi-transverse section was taken near the point. *Non-metallic inclusions.* There are elongated glassy slag inclusions embedded in the metal, some of them containing light-coloured crystalline phases. *Macrostructure.* There are bent transverse weld-seams visible after etching with Oberhoffer's reagent; they are typical for the central part of the blade. *Microstructure.* Ferrite occurs in the cutting-edge area with some pearlite (carbon content below 0.3% C), while deformed ferritic grains are observed in the edge area. Coarse ferrite grains stand out between the centre and the cutting-edge. *Microhardness.* The centre below 200, towards the cutting-edge 200–255 mHV. *Chemical analysis.* Mn 0.00%, P 0.106%. *Interpretation* (by L. Lepage and F. Claisse). The blade was welded together from several wrought-iron bars. A slightly carburized metal was chosen for the cutting-edge.
Lepage and Claisse 1967.
Comment. Do the transverse weld-seams in the blade core indicate a sort of pattern-welding? This idea could be verified by surface polishing and etching. Traces of cold hammering in the cutting-edge appear to be present.

55. MORAINS, site of Les Terres Rouges (Marne, northern France). Iron sword with scabbard fragment from a warrior inhumation grave. Musée Epernay, not numbered. Length 730 mm, width 53 mm. Flat blade. Three semi-transverse sections were cut out from the blade. E 1 and E 2 on one side (at the blade shoulders and at the point of percussion), and E 3 (near the point, in the opposite cutting-edge). *Slag inclusions.* Elongated, glassy. *Macrostructure* (etched with 5%-Nital). Dark carburized areas appear in different parts of sections. *Microstructure.* Ferritic areas merge into pearlitic parts with an acicular ferrite network. Locally, ferrite lines and unintentionally developed welds appear (E 1). There are deformed ferrite grains in the cutting edge (E 2), and Neumann bands close to it. The carbon content of the very fine pearlitic-and-ferritic structure reaches values of about 0.4% C. *Interpretation* (by L. Uran). The blade was shaped from a solid bar of heterogeneously carburized steel which had been reforged several times. Date: third century BC.
Roualet *et al.* 1983.

56. GOURNAY-SUR-ARONDE, near Compiègne (Oise, northern France). A fragment, no. 1667, of the upper blade of an iron sword from the sanctuary deposit found in the northern flank of the moat, near the gate. Two specimens were taken, one of them being a transverse section covering the greater part of the blade width. *Slag inclusions.* Continuous chains across the blade section were accompanied by granular inclusions. *Macrostructure.* Ferrite in coarse and fine grain stripes bordering the inclusion chains. *Microhardness.* About 150 mHV 30 g.
Uran 1983, 80, 87, 125, figs. iv.1.11. and 3.3.
Comment. The work from which these data are compiled deals with physical aspects and gives no detailed description or interpretation of the technology used. The blade was apparently butt-welded from several rods of pure wrought iron and is to be considered as an artefact of low quality.
Note. Uran's thesis is based on 250 metallographic analyses of specimens taken from 76 swords from Gournay-sur-Aronde (35 complete, 5 medial, 15 distal, and 21 proximal blade fragments). In the course of his physico-chemical studies, he refers to some individual specimens. Swords 1458, 1482, and 1865 are mentioned as being completely ferritic. Cold-working deformation of ferritic structures was observed several times in cutting-edges as well (e.g. no. 142). It is striking that approximately 50% of the cases show Neumann bands within the ferritic grains, especially in coarse areas of bent parts (4683). Sometimes these bands occur in the centre of the blade, sometimes only in one of the two cutting-edges (1143, 3113). No. 1490 is remarkable for the nearly eutectoid pearlite in the core and decreasing carbon content towards the cutting-edges and surfaces. In one case (1484) a local ferritic-and-bainitic area implies certain conditions of rapid cooling. Some blades were laminated or their structures were arranged laterally (ferrite and ferrite–pearlite zones, ferrite microhardness varying between 100 and 180 mHV, pearlite between 200 and 230 mHV 30 g). The blade on fig. iii.2.6, not numbered, seems to have been only just welded together from two bars of different carbon content. On the

other hand, nos. 1528, 2149, and 3757 were butt-welded like 1667, as the transverse seams in ferritic structure on cross-sections show.

57. CIRE-LES-MELLO (Oise, northern France). Iron sword from the Thérain river, apparently Late La Tène. Fragmentary investigation results quoted in another context. *Slag inclusions*. Limited to local groupings, otherwise a very poor metal. *Microstructure*. Ferrite. *Microhardness*. 120–200 mHV 30 g. A cross-section involving more than a half of the blade width was taken.
Uran 1983, 77, 127.

58. BROMEILLE, near Mainville (Loiret, France). Iron sword from inhumation grave 13 (third century BC), blade length 530 mm. Fragmentary investigation results quoted. The steel structure is said to be pearlitic of a eutectoid value.
Uran 1983, 77, 127.

59. FAYE L'ABBESSE, Les Crânieres, Deux Sèvres, Poitou, western France. Sword 1 found in the Late La Tène strata of a Celtic sanctuary. Length 809 mm. From the notes published by Lejars (1989, 17–22) one can deduce that the blade has been manufactured from a high carbon steel (nearly 0.8% C, HV hardness 250), with some decarburized areas revealing Neumann bands which testify to the low temperature of the final forging. The sword would probably have been of good quality.
Lejars 1989, 18–19, fig. 3.1.

60. FAYE L'ABBESSE, Les Crânieres. Sword 2, earlier layer of the sanctuary deposit, length 730 mm, flat blade, an allusion to a slight midrib near the hilt. Said to be of a nearly eutectoid structure with some pearlitic-and-ferritic areas (about 0.6–0.7% C) of Widmannstätten structure. Some accidentally decarburized spots were observed. Good blade.
Lejars 1989, 18–19, fig. 3.2.

61. FAYE L'ABESSE, Les Crânières, Sword 4 from the later part of a sanctuary votive deposit. Flat blade, upset campanulate slopes at the hilt-tang, length 810 mm. Bent in the upper section. In the comments by Lejars it is explicitly stated that this blade was made of pure ferritic wrought iron of varying grain size. No welds were visible. Neumann bands occur especially in the areas exposed to torsion. Inferior quality.
Lejars 1989, 18–19, fig. 3.4.

62. NALLIERS, L'Îlot-les-Vases, Les Serres, Vendée, western France. In fact, four La Tène swords from this site were examined (numbers 1 and 2 are described as late). However, the reader of the archeometallurgical comments has no possibility of deciphering the technique of making individual blades. Scattered notes reveal that while the material used was rather poor in carbon (ferrite-and-pearlite, Widmannstätten structure, Neuman bands), blades 1 and 2 should nevertheless have been of good quality.
Lejars 1989, 18–19, fig. 7.
Note. Swords 1 and 2 have midribs, while the rest of the blades are flat (not included in Tables 9–11).

63. MAZEROLLES, Lusac-les-Châteaux, Vienne, western France. Sword 1 (from graves) is claimed to be made of nearly eutectoid, hard carbon steel of fine grain, with traces of piling (?) and local areas of decarburization. Seemingly good quality blade, unfortunately no details available.
Lejars 1989, 18–19.

64. MAZEROLLES, Lusac-les-Châteaux. Sword 2 (from a grave) is said to be composed of three layers of metal welded together, the central one being ferritic with interstitial pearlite, while the outer shells contained more fine-grained pearlite. No other details. The weapon is classified as good.
Lejars 1989, 18, 21.

65. VALDIVIENNE, Vienne, western France. Lejars (1989, 18–19) quotes a La Tène period blade made of a slowly cooled, nearly eutectoid carbon steel with locally decarburized areas.
Note. This paper mentions also metallographically investigated swords of the La Tène period from Le Pont de Juac (Saint-Simon, Charente) and Germond-Rouvre (Deux Sèvres) in western France. They could be made of low carbon ferritic-and-pearlitic steels, but no reconstruction of the techniques of manufacture is possible from the data published so far.

66. FRANCE, unknown site. Iron sword of the La Tène II type, Rouen Museum (not numbered). Parallel stripes are visible in the central zone of the surface of the blade. *Microstructure.* Ferrite-and-pearlite with about 0.2–0.3% C alternates with bands of pure ferrite corresponding with a piled and welded-together construction. Cutting-edges were carburized, as stated in the report. *Interpretation* (by A. France-Lanord). These iron and steel bars which were welded together, were bent into a U-shape, so that the last weld was, in fact, along the longitudinal axis of the weapon. Artificial etching of central surface produced veining.
France-Lanord 1964, 324–5, pl. v.

67. HEILIGENSTEIN, near Speyer, Rheinpfalz, Germany. Iron sword, isolated find. Römisch-Germanisches Zentralmuseum, Mainz, inv. no. 0.29262. Length 931 mm, width 35 mm, with traces of longitudinal surface veining and a punched mark at the campanulate, ornamented guard. Remains of a bronze-sheet scabbard. A specimen covering more than a half of transverse section was cut out 110 mm from the guard slopes. *Macrostructure.* Etching with Oberhoffer's reagent revealed distinct transverse stripes in the blade body, some of which were considerably enriched in phosphorus. Similar dark areas, of V-shape, alternating with lighter stripes, occur in the cutting-edge. Similarly arranged zones were revealed by Nital etching, but differences in colour are not very significant. Sharp boundaries between individual zones are, in fact, the welds. *Microstructure.* In all zones ferritic structure prevails. The pearlite concentrates somewhere near the welds or occurs as a component of a low (0.1% C) ferrite-and-pearlite mixture, in fine grains, locally of Widmannstätten structure. *Hardness* (1 kg). Zones rich in

phosphorus 140–180 HV, zones poor in phosphorus 105–140 HV, in one case 170 HV. *Chemical analysis* P 0.127% (average), 0.093% (light zones), 0.179% (elevated, dark zones), Cu 0.02%, As 0.011%. *Interpretation* (by E. H. Schulz). Welded-together wrought-iron bars with elevated and poor phosphorus contents might perhaps have been twisted, then reforged and equipped with a welded-on cutting-edge, consisting of similar materials. The section resembles a sort of pattern-welded work. The phosphorus, not the carbon, provided the metal with a certain hardness.

Schulz and Pleiner 1965, 38, 44–5, pls. 11.2, 12.2, 16.3, 17, 18.6.

68. CLEEBRONN, near Heilbronn, south-west Germany. Iron sword with adhering scabbard fragments, from an Early La Tène inhumation grave. Museum Heilbronn, no. BW 224. Length 710 mm, width 410 mm, broken into three pieces. In the excavation report by W. Mattes (1957) the blade is depicted with a clear and sharp midrib, but this seems to be flatter on the sections investigated. Two specimens were cut out from the middle fragment, representing the complete cross-section with both cutting-edges (*A*, *B*). Close by, surface area *C* has been polished and etched. *Non-metallic inclusions.* Not described, but visible in welds and in metal matrix as oblong glassy features. *Macrostructure.* Both cutting-edges

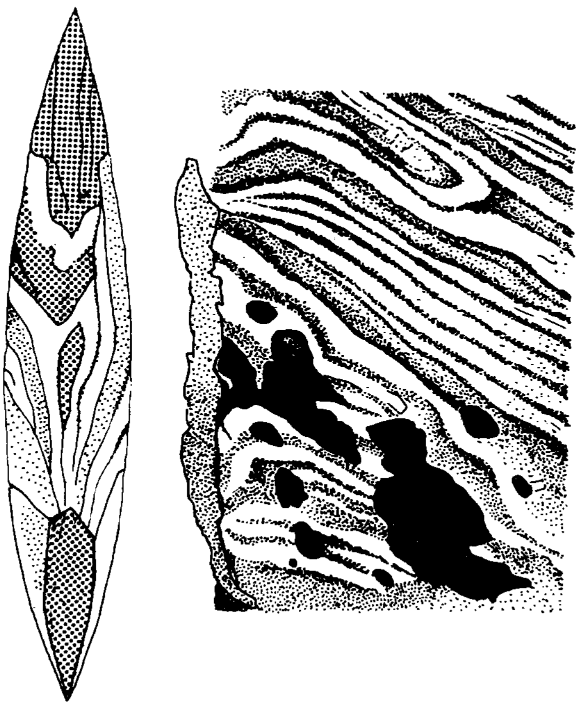


Fig. 12. Cleebronn, near Heilbronn, western Germany. Sword from an Early La Tène grave

(specimens *A* and *B*) are of steel and welded on to the core, which consists of transverse, wedge-shaped and longitudinal dark steel and light iron bands. The steel of the edge *A* is covered by thin iron shells, that of *B* is laminated. The surface etching of the area *C* (core) reveals a clear wavy pattern of dark and white transverse and oblique stripes. *Microstructure*. The structures consist of ferrite, ferrite-and-pearlite mixtures, and pearlite. In the edge *A* the carbon content reaches about 0.6% C, in *B* 0.4% C, in the dark stripes of the core 0.15% C, and in ferritic zones 0.03% C. No hardness measurements or chemical analyses were carried out. *Interpretation* (by Mr E. Schulz *et al.*). A pattern-welded blade core was equipped on both sides with medium and hard steel cutting-edges. The result was an excellent weapon. Specimens *A* and *B* were mar-quenched in the laboratory, so that martensitic structures appeared; on the evidence of limited carbon diffusion across the weld from pearlitic into ferritic parts the authors assume that the originally hardened blade was secondarily annealed for a short time at about 910 °C (this was also tested and pearlitic structures again produced) before being buried in the grave. The purpose is assumed to have been to destroy the sword's hardness. Fig 12.
E. Schulz *et al.* 1983, 8. 187–94.
Comment. A genuine S-twisted damask comes to mind. This is a surprise in the case of an Early La Tène period weapon. There is no direct evidence that the sword was actually hardened by quenching by the sword-smith.

69. TUTTLINGEN 4, WÜRTTEMBERG, SW Germany. Iron sword, isolated find. Römisch-Germanisches Zentralmuseum, Mainz, inv. no. 0.29934 (ex-1913.354 of the Prähistorische Staatssammlung at Munich). Length 615 mm, width 42 mm, flat blade with broken point and punched square-shaped mark close to the guard slopes. A specimen covers about a half of the transverse section 141 mm from the slopes. *Non-metallic inclusions*. Piling is indicated by numerous slag inclusion lines. *Macrostructure*. Irregular dark stripes, visible after the Oberhoffer etching, running roughly along the major axis, reflect phosphorus enrichments. With regard to carbon distribution, Nital etching reveals one darker longitudinal strip which is situated near the axis. It ends before it reaches the core of the blade. *Microstructure*. Darker stripes represent pearlitic structure (grain-size 4–5) with a fine ferrite network. These alternate with purely ferritic stripes and with stripes of Widmannstätten structure. *Hardness* (1 kg). Carbon-rich zones about 200 HV, phosphorus-rich zones near 180 HV, the rest 150–160 HV. *Chemical analysis*. P 0.045%, Cu 0.01%, As 0.006%. *Interpretation* (by R. Pleiner). The blade was piled from bands with differing phosphorus and carbon contents.
Schulz and Pleiner 1965, 38–9, 43–4, pls. 11.4, 12.4, 16.1–2, 18.5.
Comment. One of the bars seems to be carburized and its position in the centre of the cutting-edge makes good sense.

70. AUGSBURG, environment of, Bavaria. British Museum 67.7–5. A Middle La Tène period sword fragment (22 cm long according to Drack 1955, 129), including

the hilt-tang, campanulate guard and distal part of the blade punched with a crescent-and-human-bust mark. Investigated by J. Lang of the British Museum. Specimens were cut from both cutting-edges of the blade in two positions (142 mm from the blade top). Both were similar in macrostructure but varied in carbon content. Etching revealed a surface-to-surface butt-welding of heterogeneously carburized iron bands of 150–200 and 200–250 HV at the edges. At one side a strip of pearlitic-and-ferritic structure (*c*.0.7% C) appeared, showing secondary decarburization at the surface. Although punchmarked, the sword is not of particularly good quality.
Lang 1987, 71, pl. i.

71. STEINSBURG, near Römhild, central Germany. Iron sword of La Tène type from an *oppidum*. Formerly in the Museum für Völkerkunde, Berlin, no number indicated. Flat blade with campanulate guard. Position of the specimen not indicated; a surface polishing is mentioned. Information is scarce: ferrite structure with partly coarse, partly fine grains. *Interpretation* (by H. Hanemann). The weapon was classified as an artefact belonging to the category of simple construction objects.
Hanemann 1922, 98, no. 12.

72. THAMES river, iron sword in the British Museum (64–9.3–6). Investigated by J. Lang 401 mm from the top of the blade. Length 595 mm, width at the blade top 499 mm. The investigator suggests the welding together of two metal strips, one ferritic with some cementite at the grain boundaries, the other with larger proportions of pearlite and some small ferritic, phosphorus-rich areas. Hardness was almost uniform (150–300 HV for the central rib, 250–480 for the cutting-edge). The positions of the specimens are not located.
Lang 1987, 70–1.

73. WALTHAM ABBEY, Essex, Great Britain. Iron sword fragment from a hoard of late pre-Roman or Roman date. Waltham Abbey, no number indicated. The blade has a central rib with a channel on either side. The position of semi-transverse section is not specified. *Microstructure*. Banded structure containing 24–25 bands of metal varying from mild steel (0.25% C) to ferrite of differing grain sizes. *Microhardness*. Cutting-edge 250 mHV (average), central rib 170 mHV 30 g (average). *Chemical analysis*. Mn 0.0035%, P 0.075%, Ni 0.125% (elevated), Co 0.030 %. *Interpretation* (by Mrs J. Lang and A. R. Williams). Piled sword-blade, neither hardened, nor carburized; some hardening at the cutting-edge has been achieved by working.
Lang and Williams 1975, 202–4, fig. 4; Lang 1987, 71; Manning 1977, 89, fig. i.2. (showing notches on both cutting-edges).

74. WALTHAMSTOW, Higham Hill, Lockwood Reservoir. Iron sword in the British Museum (1905.1–14.1), examined by J. Lang. Not described, length 564 mm, width 44,7 mm. Specimen position 312 mm from the top of the block. Said to be piled edge-to-edge from at least ten lamellae of varying carbon content (as a

demi-transverse section shows). The carbon content of some of the carbon-rich layers reached about 0.4% C. Some of the ferritic layers were enriched in phosphorus. Pearlite was spheroidized and coarse-grained. *Hardness*. 150–280 HV, with the maximum at the cutting-edge and central rib.
Lang 1987, 71, pl. 3.

75. ORTON MEADOWS (no. 1), Orton Longueville, Nene Valley, Cambridgeshire. Iron sword in the British Museum P 1981 12.2.1. Sword in the scabbard, not described. J. Lang suggests an edge-to-edge system of piling, including a carburized band enclosed by ferritic bands (one of them with intergranular cementite). Microanalyses of slag inclusions led the investigator to the view that the ores used may have come from nearby Northamptonshire.
Lang 1987, 70.

76. ORTON MEADOWS (no. 2). Sword 16 discovered in September 1982, Late La Tène (first century BC). Not described. No location of the specimens, nor micrographs or drawings. The results of metallographic investigation suggest that the blade was composed of about twelve butt-welded strips (surface-to-surface welding). Their carbon content varied but in no case exceeded 0.3% C. A ferritic structure with some pearlitic regions were observed. The grains near the surface and at the cutting-edges were finer and also contained Neumann bands, indicating cold work. *Hardness*. Cutting-edge 232 HV, central rib 242 HV, ferritic areas 190 HV. Some slag inclusions contained vanadium which is said to be exceptional.
Lang 1987, 71.

77. ISLEHAM, Cambridgeshire. Iron sword with richly ornamented bronze scabbard, found in 1976, now in the British Museum 1976 7–3.1, dated first century BC. The blade is poorly preserved, length 720 mm, width 39.2 cm. An unusual punchmark in shape of two circles in an oval appear near the hilt-tang which is broken off. A semi-transverse section was removed from the blade at a distance of 90 mm from the hilt. Metallographic examination suggested that the edge-to-edge piled construction consisted of three principal components welded together, all having different but fairly high carbon content, with some areas being completely pearlitic. Slight decarburization is visible near the surface. *Hardness*. Cutting-edge 415 HV, central area 378–450 HV, surface 320 HV. *Chemical analysis*. 0.01% P, 0.03% Ni, 0.01% Co, and 0.01% Cr. This must have been an excellent weapon although no quench-hardening was detected.
Stead *et al*. 1982, 71; Lang 1987, 71–2.

78. WHITCOMBE, Dorset. Sword in the Dorchester Museum, grave-find, dated to the first century BC. Examination indicated that the blade consists of about twelve layers welded together in an edge-to-edge system. Individual bands differ in carbon content: some are purely ferritic (coarse grains), others also contain pearlite (up to 0.6% C near the surface). The investigator is inclined to see a carburization of the outer shells. No hardness is given.
Lang 1987, 72.

79. STANWICK (no. 1), North Yorkshire. Iron sword in the British Museum (47 2.8–8.7, dated to La Tène III, first century BC). Sword in bronze scabbard with ornamented chape, the blade has a midrib and is about 52 cm long. Investigated in complete cross-section (125 and 238 mm from the blade top) from two specimens. A butt-welded surface-to-surface construction is identified. At least one cutting-edge shows welds pointing to the edge, and carburization of one cutting-edge and decarburization of the other is mentioned. *Chemical analysis.* 0.02% P, 0.02% Co, 0.01% Cr. No hardness is given.
Lang 1987, 72.

80. STANWICK (no. 2). Iron sword 1950 2–2.1 in the British Museum, dating to the first century AD. Length 696 cm, width 47 mm. The specimen is located 378 mm from the top of the blade. Edge-to-edge piling observed, with different strips of ferritic and ferrite–pearlite structures. One outer shell was nearly eutectoid (0.8% C), the opposite one reaching about 0.3% C. Phosphorus segregations in bands can be seen, as well as inclusion chains. Some grains of the carbon-rich surface are elongated at right angles to it. This particular arrangement is said to be the result of carburization.
Lang 1987, 72.

81. GRIMTHORPE, North Humberside. Sword 76.2–8.10 in the British Museum, from a grave dating to the first century BC. Blade with midrib and campanulate guard of bronze, length 599 mm, width 41.8 mm. The heterogeneous structure of the section and some large inclusions nearer to the midrib area are suggested as indicating either an inhomogeneously carburized bloom or the making of the blade from two or three pieces. Highly carburized surface areas reveal what is called bainite or tempered martensite, appearing together with the ferrite in pearlitic zones (Hardness 450–520 HV). The inner structures reach some 250–350 HV. Insufficient quenching or even tempering is suggested. Quite a good weapon.
Lang 1987, 71.

82. SADBERGE, Durham. Sword 96.1–20.1 in the British Museum, dated to the first century AD. Bronze guard with campanulate upper part, blade with midrib. An edge-to-edge piled construction with few layers of varying carbon content is referred to. One cutting edge and one surface are enriched in carbon; the low carbon bands are enriched in phosphorus. The presence of some welds is suggested, also of chlorine (flux) and iron oxides. The possibility of carburization is admitted but considered as uncertain. *Chemical analysis.* 0.14% P, 0.01% Ni, 0.02% Co, 0.01% Cr. *Hardness.* 314 HV for the cutting-edge, 364 HV at one surface.
Lang 1987, 72.

83. LLYN CERRIG BACH (no. 1), Anglesey, Great Britain. Fragment of an iron sword-blade from the La Tène period deposit. Archaeology Department of the National Museum of Wales, not numbered. Flat blade, preserved length 236 mm, both ends broken. Transverse section of one of the fractured ends examined. *Non-metallic inclusions.* Considerable quantity of entrapped slag and longitudinal

cracks were observed. *Macrostructure* (etched with Nital). Laminated (faggoted) texture with low-carbon core (up to 0.25% C) and carbon-enriched skin (0.3–0.7% C). *Microstructure*. Not discussed. *Hardness*. Low-carbon core 157–185 HV, medium-carbon outer zones 200–219 HV. *Interpretation* (by J. N. McGrath). Faggoted blade with poor weldings, showing low carbon and more carburized flank zones.

Fig. 17.5. McGrath 1968*a*; 1968*b*.

84. LLYN CERRIG BACH (no. 2). Fragment of an iron sword from the La Tène period deposit. Archaeology Department of the National Museum of Wales, not numbered. A fragment of a flat thin blade, 380 mm long, includes the point, which is rounded. Transverse section as for blade 1. *Microstructure*. Not described. *Hardness*. Inner core 157–164, outer layer and the area near cutting-edge 195–199 HV. *Interpretation* (by J. N. McGrath). The same as for blade 1.

McGrath 1968*a*; 1968*b*.

Comment. In two microphotographs published by McGrath (1968*b*, pls. iv.2 and v.1) the body of the blade shows ferritic structure with small amounts of pearlite at grain boundaries. The proportion of pearlite increases very slightly towards one surface, and significantly towards the other, in which pearlite and pearlite–ferrite are seen behind the welding seam. The scheme corresponds to some blades from Münsingen and especially to that from Metz (see p. iii).

85. LLYN CERRIG BACH (no. 3). Iron sword fragment from the La Tène period deposit. Archaeology Department of the National Museum of Wales, inv. no. 44.32/6. Preserved length 152 mm, very thin and flat upper part of the blade. Transverse section examined. Description as for blade 1, low-carbon core, carburized or piled medium-steel skin or shells. *Microstructure*. Not discussed. *Hardness*. Low-carbon zones 175–197 HV, medium-carbon zone near the cutting-edge 265 HV. *Interpretation* (by J. N. McGrath). As for blade 1.

McGrath 1968*a*; 1968*b*.

86. LLYN CERRIG BACH (no. 4). Fragment of an iron sword (foible or point part of the blade) from the La Tène period deposit. Archaeology Department of the National Museum of Wales, inv. no. 44.32/4. Preserved length 240 mm includes the point. The surface corrosion of the blade indicates a sinuous pattern running longitudinally down its faces. Transverse section showing a flat bi-convex profile investigated. *Non-metallic inclusions*. Slag inclusions cross the section approximately at right or slightly inclined angles to the major axis. *Macrostructure* (etched with Nital). Corresponding to the slag distribution, alternating transverse layers with low carbon and carbon-rich contents were recorded. The large cracks running across the blade section are the result of more rapid corrosion along the lines of folds. Both cutting-edges are composed of the high-carbon material. *Microstrucure*. Not discussed. *Hardness*. Low-carbon areas 140–171 HV, carbon-rich areas 190–210 HV. *Interpretation* (by J. N. McGrath). A heterogeneously carburized iron sheet was folded several times along its

longitudinal axis and welded to a bar, the short sides of which have been removed and the rest shaped to a double-edged blade and trimmed. Hard steel occurs in the cutting-edges but it is debatable whether this was the result of a deliberate operation. The striped pattern of the surface faces of the blade was brought out by etching, enabling us to consider this sword as representing a step in the development of pattern-welded blades.
Fig. 17.11. McGrath 1968*a*; 1968*b*.

87. LLYN CERRIG BACH (no. 5). Hilt-tang part of an iron sword from the La Tène period deposit. Archaeology Department of the National Museum of Wales, inv. no. 44.32/2. The blade shows a so-called sword-smith's mark. Description of the section is the same as for blade 1, but carburized zones under the blade surfaces are preserved only as very thin traces. They may be corroded away. *Hardness*. Measured values 140–151 HV in four positions on the transverse section.
McGrath 1968*a*; 1968*b*.
Note. McGrath (1968*b*: 423) mentions 27 unspecificed La Tène swords as being under examination in the British Museum.

88. LISNACROGHER (no. 1), Co. Antrim, Northern Ireland. Iron sword in the Ulster Museum, Belfast (UM B2), dating from the Irish Earlier Iron Age (third century BC–fifth century AD). Badly corroded blade, campanulate guard, hilt-tang ended with a globular knob, length about 58 cm. Specimen *a* taken from the central region below the guard, specimen *b* from the middle fragment of the upper blade.
Section *a*. *Non-metallic inclusions*. Numerous one- and two-phase inclusions. *Macrostructure*. Slight variation in the carbon distribution (etched by Nital) and minor phosphorus segregations (Oberhoffer). *Microstructure*. Fine ferrite (GS 6–8) with interstitial pearlite, areas with coarser ferrite grain. It seems that the proportion of pearlite increase towards the section centre but, as to the remanent structures in corrosion capsulae, the differences in the carbon distribution indicate the heterogeneity of the primary bar. *Microhardness*. 269 mHV for ferrite.
Section *b*. *Non-metallic inclusions*. One-, two-, and three-phase inclusions are numerous. *Macrostructure*. Low carbon metal, indicated by Nital, no significant phosphorus segregations (Oberhoffer). *Microstructure*. Almost entirely ferrite (Gs 2–7) with interstitial pearlite or intergranular cementite, with patches of excessive ferrite grain growth (GS > 1). Acicular precipitates in some larger ferrite grains. *Interpretation* (by B. G. Scott). The blade was forged from a piece of heterogeneous bloomery iron with much entrapped slag. Slowly air-cooled. Simple technology.
Scott 1990, 66–8, no. 6, pl. 4.2.1.

89. LISNACROGHER (no. 2). Iron sword in the Ulster Museum, Belfast (UM B5), dating from the Irish Earlier Iron Age (third century BC–fifth century AD). The blade survived merely in three fragments, the widest of which has been transverse-sectioned (approx. length of the three fragments 180 mm). *Non-*

metallic inclusions. Few simple-phase inclusions, several of them quite coarse. *Macrostructure*. Variable carbon distribution with banding. A visible weld-seam at one side (after Nital etch); no significant phosphorus segregations (Oberhoffer). *Microstructure*. The banding comes out more clearly revealing high differences in the carbon content. Fine ferrite (GS 7–8), a high carbon metal band with ferrite and pearlite Widmannstätten structure with coarse ferrite is seen in the central area. Some pearlite grains show spheroidization of carbides. As well as the main weld-seam, which is penetrated by corrosion, other weld-seams are visible. *Hardness*. Ferrite 315 mHV, pearlite 448. HV: 182–234. *Interpretation* (by B. G. Scott). The blade was forged from an unevenly carburized bloomery iron. The welds seem to be traces of folding during the consolidation and reforging of the bloom piece. The quality is better than in the case of UM B2.
Scott 1990, 67–8, no. 7, pl. 4.2.2.

90. LISNACROGHER (no. 3). Iron sword in the British Museum (80.8–2.116). A well-preserved weapon with oval-sectioned hilt-tang with three fittings the upper of which bears incised dots, as well as the campanulate guard. Length 580 mm, width 36 mm. A semi-transverse section cut out from the middle part of the blade. *Non-metallic inclusions*. One-, two-, and three-phase slag inclusions (some of them containing Mn, Al, and Ti with conjunction with Fe and Si, according to SEM analysis) run in chains in an edge-to-edge arrangement. *Macrostructure*. No significant segregations revealed, either by Nital or Oberhoffer etching. *Microstructure*. Primarily ferrite (GS 6–7) with some interstitial pearlite and grain-boundary cementite. Pearlite tends to spheroidization. Some elongation of ferrite may be locally observed. *Hardness*. 129–140 HV, microhardness of ferrite 100–183 mHV. *Interpretation* (by B. G. Scott). Forged from bloomery iron with virtually no carbon content. Forging has been apparently prolonged at around A_1, resulting in spheroidization of the pearlite, and cooled on falling temperature.
Pl. XXXV Scott 1991, 68–9, no. 8, pl. 4.2.3.
Comment. Folding or edge-to-edge piling may come into question. Quite inferior blade.

91. KILDRINAGH (no. 1), Co. Laois, Ireland. Iron sword in the National Museum of Ireland, Dublin (NMI WK10: W135: F468), dated to the Irish Earlier Iron Age (third century BC–fifth century AD). Length about 430 mm. Demi-transverse section examined. *Non-metallic inclusions*. Numerous one- and two-phase inclusions arranged parallel to the long axis of the section. *Macrostructure*. Highly unhomogeneous carbon distribution and bloom welds revealed by Nital. No phosphorus or other segregations (Oberhoffer). *Microstructure*. Fine ferrite and ferrite with coarse pearlite dominate in the midrib area. Towards the cutting-edge, pearlite shows spheroidization of carbides. Several parallel as well as oblique weld-seams appear, presumably caused by bloom working. Increase of carbon may be observed toward the cutting-edge. *Hardness*. HV 115–162; microhardness of

ferrite 183 mHV, pearlite 263–369 mHV. *Interpretation* (by B. G. Scott). Quite serviceable weapon whose blade has been made by refining and subsequent folding of a stock of heterogeneously carburized iron. Secondary carburization of the edge is indicated by carbon distribution. The spheroidization of pearlite, might have been caused by prolonged forging at A_1, or by strong tempering of quenched martensite.
Pl. XXXVI Scott 1990, 70–1, no. 9, pl. 4.3.4.
Comment: The arrangement of welds within the macrostructure may result from piling, if not the insertion of a steel edge as the V-shaped weld-seam indicates. At any rate, it differs from the other Irish specimens examined.

92. KILDRINAGH (no. 2). Iron sword fragment in the National Museum of Ireland, Dublin (NMI WK24: W157: P470). Upper part of the blade and tang preserved (length 180 mm). Full cross-section investigated. *Non-metallic inclusions*. Few one-phase slag inclusions occur. *Macrostructure*. No real heterogeneity could be revealed by Nital and Oberhoffer etchings. *Microstructure*. The structure is almost entirely ferritic, with some interstitial pearlite. The grain size is homogeneous (GS 4–6), except for a patch of fine ferrite (8) at one edge. *Hardness*. 99–113 HV; microhardness of ferrite 135–178 mHV. *Interpretation* (by B. G. Scott). The blade was forged from a piece of carbon-free iron and could not have been a particularly effective weapon.
Scott 1991, 72, no. 10.

93. BANAGHER, Co. Offaly, Ireland. Short iron sword in the National Museum of Ireland, Dublin (NMI WK18: A130), dating from the Irish Earlier Iron Age (third century BC–fifth century AD). Kidney-shaped organic guard and two-pointed hilt fitting, blade with midrib, length 270 mm. The blade is badly corroded and in the demi-transverse section surviving metal was found in the centre near the midrib. All of the cutting-edge region has been converted to corrosion products. *Non-metallic inclusions*. Few large light grey inclusions occur. *Macrostructure*. Uneven distribution of carbon (Nital), no significant segregations of other kind like phosphorus (Oberhoffer). *Microstructure*. Ranging from fine ferrite (GS 7–8) through ferrite and interstitial pearlite (GS 3–4) to the eutectoid pearlite. Locally, the coarse pearlite shows a Widmannstätten arrangement. Several 'ghost' lines occur. Metal islands may be observed in the corrosion layer, showing the overall heterogeneity. *Microhardness*. Ferrite 255 HV, pearlite 404 mHV. *Interpretation* (by B. G. Scott). The blade was made of a highly heterogeneous bar, cooled in the air after the forging. No heat treatment.
Scott 1991, 72–3, no. 11.

94. CUVIO, near Varese, northern Italy. Iron sword. Musei Civici di Varese, no number indicated. The sections show that the blade has a central groove. Four specimens were cut out, three of them representing a semi-transverse section from one of the cutting-edges, the fourth the hilt-tang. Longitudinal sections were also cut. *Non-metallic inclusions*. Slag inclusions and oxides are oriented along

welding-seams. *Macrostructure* (after etching). White lines (welds) divide the specimens into dark cutting-edges with three panels in the centre: two outer flanks with sinuous dark-and-light pattern, and the dark core. *Microstructure.* In the dark areas pearlite prevails with varying carbon content (up to about 0.5% C), in the light zones ferrite or ferrite and pearlite. *Hardness* (1 kg). Pearlite or pearlite–ferrite in the cutting-edge 154–224 HV, the central bar 190–210 HV, softer parts about 115 HV. *Chemical analysis.* Mn about 0.30% (high), P less than 0.005%. *Interpretation* (by A. Reggiori and E. Garino). The blade was composed and welded together from several bars of differing carbon content. The technology may be considered sophisticated. The properties of the artefact make it suitable for use as a weapon. There is no indication, however, of more rapid cooling of certain parts for regular hardening.
Fig 17.12 Reggiori and Garino 1955, 48–51, figs 5–7.
Comment. In spite of the absence of polishing of the faces, all sections reveal a composition typical of developed pattern-welding, i.e. a blade with a central steel bar and pattern-welded display flanks and welded-on steel cutting-edges. The profiles of the sections indicate the existence of a flat central channel which is, in itself, unusual for a La Tène sword. But the entire scheme corresponds perfectly with Roman-made *spathae*, which gives rise to a suspicion that the weapon may not be correctly classified among La Tène blades. Fig. 17.12

95. NOVATE, near Lago di Como, northern Italy. Iron sword fragment with typical La Tène sheet scabbard. Castello Sforzesco at Milan, no number indicated. Specimen positions not stated. The microstructure is specified as ferrite. *Interpretation* (by A. Reggiori and E. Garino). A very simple wrought-iron blade typical of the second class of La Tène swords: those made of ferritic iron, which were of inferior quality as weapons.
Reggiori and Garino 1955, 45.
Comment. The lack of any information on cutting-edges makes it difficult to estimate the efficiency of the blade.

96. VARENNA (no. 1), near Lago di Como, northern Italy. Iron sword. Musei Civici di Como, no number indicated. A blade broken near the point. Seven borings carried out: three in the central axis of the fragment, and four (two on either side) near cutting-edges. No complete section, but small cylindrical columns of material from a tubular boring head were investigated. In all specimens, apart from numerous slag inclusions, ferritic structures occur (coarse grain 2–5). *Hardness* (1 kg). About 115 HV. *Interpretation* (by A. Reggiori and E. Garino). The blade was forged from a bar of soft wrought iron.
Reggiori and Garino 1955, 44–5, figs 2 and 3.

97. VARENNA (no. 2). Iron sword fragment. Musei Civici di Como, no number indicated. The long hilt-tang with a knob and a part of a narrow blade preserved. Four specimens bored out: two from the major axis of the fragment (one in the hilt-tang, another in the blade close to the shoulders), and two from the sides in

positions towards the cutting-edges. *Non-metallic inclusions.* In specimen cylinders 1, 2, and 4 long slag inclusions are attested between zones of metal. *Microstructure.* In more or less clearly visible layers structures with differing carbon content occur: they are ferritic, or ferritic-and-pearlitic, or revealing a Widmannstätten texture, or acicular network-and-needles of pearlite–ferrite structures (0.1–0.5% C). It is in the hilt-tang that all bands are perfectly distinguished; further down, in the blade, the material was more intensively forged (about 1000 °C) and the diffusion of carbon made transitions between original bars indistinct. *Hardness* (1 kg). In carburized parts 140–150 HV. *Interpretation* (by A. Reggiori and E. Garino). The blade was welded together with differing and heterogeneously distributed carbon content (medium steel as a material relatively rich in carbon). Air-cooled.
Reggiori and Garino 1955, 45–8, fig. 4.

98. ACQUATE, near Lecco, Lago di Como, northern Italy. Iron sword kept in the Musei Civici di Lecco. Analytical information as for the Novate blade.
Reggiori–Garino 1955, 45.

99. MAGENTA, northern Italy. Iron sword fragment with scabbard of typical La Tène design. Castello Sforzesco at Milan. Analytical information as for the Novate blade.
Reggiori and Garino 1955, 45.

100. ESINO LARIO, northern Italy. Iron sword from a La Tène period tomb. According to the second-hand information available, the core of the sword-blade was considerably carburized and consisted mainly of pearlite (0.5–0.6% or even 0.8–0.9% C), but in the outer regions ferrite was the major structural component. *Interpretation* (by C. Storti and E. Mariani). The steel blade must have been definitely decarburized in its surfaces. Cold hammering mentioned. No hardening.
Storti and Mariani 1953, followed by Coghlan 1956, 143.

101. BERGAMO, province of; unknown site, northern Italy. Iron sword in a private collection. According to the information available the metallographical picture shows that the sword was made of pure wrought iron and contained very few slag inclusions. Inferior quality weapon.
Storti and Mariani 1953, quoted by Coghlan 1956, 143.

102. BORGOVERCELLI (no. 2), near Novara, northern Italy. Iron sword of La Tène III type. Museo Civico di Novara, inv. no. 699. Length 770 mm, width 50 mm, flat blade. Two cylindrical specimens bored out from the major axis of the blade: *a* and *b*, the first in the upper part, the latter in the lower part of the blade. No general picture of the blade section is available. *Microstructure.* In the core, ferrite and slag inclusions or ferrite–pearlite as Widmannstätten structure (low carbon content, up to 0.2% C) in *a*; in *b*, there is ferrite with some intercrystalline pearlite in certain areas. Very elongated slag inclusions. *Hardness* (1 kg) a 163–

172 HV, *b* 161–175 HV. *Interpretation* (by M. Leoni). Low-carbon steel artefact.
Leoni 1975, 116, 118, fig. 10.
Comment. Unfortunately, all the crucial data, i.e. those concerning the cutting-edges, are absent from the report.

103. BORGOVERCELLI (no. 3). Iron sword of La Tène III type. Museo Civico di Novara, inv. no. 701. Length 880 mm, width 48 mm; flat blade. Two cylindrical specimens, *a* and *b*, were bored out from the major axis of the blade, so that no information on the complete transverse section or on the cutting-edges could be obtained. *Non-metallic inclusions.* Numerous slag inclusions are mentioned. *Microstructure.* Specimen *a*, from the upper part of the blade, indicates a fine ferrite and pearlite structure with a relatively small amount of globular pearlite. This is the result of longer heating above 738 °C. Specimen *b*, from the centre of the lower part of the blade, shows a fine pearlitic structure with thin ferrite network in some areas. This indicates a more rapid air-cooling. *Hardness* (1 kg). 116–146 HV in *a*, and 338 HV in *b*.
Leoni 197, 116, 119, 121, fig. 11.
Comment. The technology of manufacture is difficult to reconstruct. A heterogeneously carburized metal is attested.

104. BORGOVERCELLI (no. 4). Iron sword of a La Tène III type. Museo Civico di Novara, inv. no. 700. Length 900 mm, width 51 mm, flat blade, asymmetrical slopes. Four specimens were taken: three from the centre by boring out cylindrical columns (*a–c*), and *d* a transversal section of the cutting-edge in the vicinity of the position of *c*. *Microstructure.* In *a* and *b* bands of ferrite-and-pearlite (0.2–0.3% C) and, vice versa, pearlite-and-ferrite (0.5–0.6% C) alternate betweeen slag and oxide inclusion lines. There is pearlite with a fine ferrite network in the core (specimen *c*). In *d*, from the edge area, martensite with troostite rosettes occurs. Some light bands, with slag and oxide inclusions, are visible on microphotographs of specimens *c* and *d*. *Hardness* (1 kg) a 146–191 HV, *b* 225–283 HV, *c* 253–346 HV, *d* 388–577 HV. *Interpretation* (by M. Leoni). Hard and mild steel bars may have been welded together. At the point the ready-made blade must have been briefly quenched along its cutting-edge.
Leoni 1975.

105. SFORZESCA (no. 1), near Novara, northern Italy. Iron sword of a La Tène II type. Museo Civico di Novara, inv. no. 435. Length 720 mm, width 50 mm, blade with central rib. Three specimens provide information on the metal properties of the blade: *a* and *b* are cylindrical borings in the upper and lower part of the central axis; *c* is a transverse section in one of the cutting-edges, below the position of *b*. *Microstructure.* According to the description and microphotographs there are bands of coarse ferritic structure (2–5) with nitride needles, alternating with pearlite-and-ferrite (4–5); the latter structure contains about 0.1–0.2% C, not exceeding 0.3% C. *Hardness* (1 kg) 110–158 HV. *Interpretation* (by M.

Leoni). A weapon of inferior quality, not adequate for the mechanical stress at the cutting-edge expected during use.
Leoni 1975, 114–17, figs. 8 and 9.

106. VOJVODINA 5, former Bacsbodrog province, now northern Yugoslavia, unknown site. Iron sword, possibly having been accompanied by three iron spearheads (from a grave?). Römisch-Germanisches Zentralmuseum, Mainz, inv. no. 0.1824. Length 725 mm, width 40 mm, flat blade with remains of an iron-sheet scabbard and chape; the hilt-tang with a globular knob. *Macrostructure.* Etching with Oberhoffer's reagent shows two joined bars, low in phosphorus. No difference in carbon content were visible after a Nital etch. *Microstructure.* None the less, a certain heterogeneity in the carbon distribution appears under microscopic observation. There is a pearlitic structure with a rich ferrite network near the cutting-edge. In another area, towards the core, coarser ferrite grains (3–4) alternate with islands of scattered pearlite-and-ferrite. Carbon content estimated as 0.3% (average). *Hardness* (1 kg) 110–160 HV. *Chemical analysis.* Cu 0.05%, P 0.007%, As 0.010%. *Interpretation* (by E. H. Schulz). The blade was forged from heterogeneously carburized steel.
Schulz and Pleiner 1965, 39, 42–3, pls. 11.5, 12.5, 15, 18.4.
Comment. Secondary carburization of the edge and subsequent homogenization by forging is possible.

107. WEST VOJVODINA 6, former Bacsbodrog province, now northern Yugoslavia, unknown site. Iron sword, isolated find. Römisch-Germanisches Zentralmusuem, Mainz, inv. no. 0.1668. Length 698 mm, width 60 mm. Flat blade. A semi-transverse section was cut out 60 mm below the guard slopes. *Non-metallic inclusions.* Numerous slag inclusion chains embedded in the metal. *Macrostructure.* In spite of a local phosphorus concentration in one of the surface flanks both phosphorus and carbon contents (as revealed by etching with Oberhoffer and Nital) show minimal differences. Piled texture visible. *Microstructure.* Relatively coarse ferritic grains (size 2–4). *Hardness* (1 kg). 100–120 HV, the stripe with elevated phosphorus content 180 HV. *Chemical analysis.* Cu 0.03%, P 0.008%, As 0.006%. *Interpretation* (by E. H. Schulz). A piled blade made of soft and pure wrought iron.
Schulz and Pleiner 1965, 39, 40–1, pls. 11.6, 12.6, 13.1, 18.1.

108. DALJ, near Osijek, northern Yugoslavia. Bent sword from a cremation burial. Museum für Ur- und Frühgeschichte an den Staatlichen Museen zu Berlin, inv. no. IV d 2461 d. Blade with central rib, bent in S-shape, with a guard; the entire upper part of the blade, with the hilt-tang and iron discs, and the ornamented iron-sheet scabbard are now missing. The length of the preserved fragment of the lower part of the blade measures 270 mm, width at the fractured end 30 mm. A semi-transverse section, 24 mm long, was taken from the cutting-edge 80 mm from the fracture. *Non-metallic inclusions.* Nearly pure metal. *Macrostructure.*

There is a small bar of different material at the side, and the cutting-edge is welded on in a V-shape. *Microstructure*. The body and the cutting-edge consist of ferrite, the grain-size of which increases towards the core. The weld-seam of the cutting-edge is marked by a line of lamellar pearlite. The welded-on side-bar shows mild steel in the form of an overheated ferrite-and-pearlite mixture (0.2–0.35% C). Its presence is perhaps, the matter of accident. *Vickers microhardness* (converted into kg/mm²). Body 124 (average), cutting-edge 151, flank ferrite 129 (average). *Interpretation* (by J. Emmerling). The wrought-iron blade has a welded-on cutting-edge. This too is now ferritic. Decarburization during the incineration rite is not out of the question.
Fig. 14.8. Emmerling 1975, 211–13, pls. lvii–lviii.

109. BÁTA, near Tolna, southern Hungary. Iron sword of the La Tène type, isolated find. Museum für Ur- und Frühgeschichte an den Staatlichen Museen zu Berlin, inv. no. IV d 1118. Preserved length 584 mm, width 42 mm, nearly flat blade with a campanulate slope at the guard (which is missing); point broken. A specimen covering more than half the transverse section (22 mm) was taken 460 mm from the present hilt-tang tip. *Non-metallic inclusions*. Two inclusion chains divide the blade into three bars, the central one being the thickest. *Macro-structure*. The photograph shows the right side of the specimen as dark. *Micro-structure*. The central zone is rich in carbon and consists of pearlite and ferrite in various proportions: ferrite-and-pearlite in the body (0.3–0.5% C), pearlite/sorbite-and-ferrite towards the cutting-edge (0.7–0.8% C), reaching locally eutectoid values of 0.86% C. The cutting-edge is decarburized (about 0.4% C). Along the seams bordering the flanks or shells an overheated Widmannstätten structure appears. Ferrite-and-pearlite mixture (about 0.35% C) in the flanks, towards the cutting-edge about 0.1% C. *Vickers microhardness* (converted into kg/mm²). Central bar: ferrite 188 mHV (average), pearlite 220 (average), pearlite/sorbite 308 (average, maximum 365). Cutting-edge area 258 (average). Flanks: ferrite 196 (average), pearlite 222 (average). *Interpretation* (by J. Emmerling). Three refined and folded bars welded together occur: the central one consists of hard steel, both outer shells of mild steel. The cutting-edge region decarburized.
Emmerling 1975, 207–11, pls. lv and lvi.

110. BARACS, near Baja, southern Hungary. Iron sword, isolated find. Römisch-Germanisches Zentralmuseum, Mainz, inv. no. 0.2811. Length 622 mm, width 36 mm, flat blade with a pair of sharp grooves in the axis, campanulate shouldering at the guard. Heavy corrosion losses in one cutting-edge. A specimen representing a semi-transverse section was cut out 47 mm from the guard. *Macrostructure*. Oberhoffer etching reveals thin phosphorus segregations dividing the specimen surface into three principal zones. The left zone shows, in general, an elevated phosphorus content. No differences in carbon distribution are visible. *Micro-structure*. The material is ferritic (coarse grains 3, fine grains 6 in size). In one of the side shells some pearlite scattered among coarse and very fine ferrite grains

appears. Estimated carbon content 0.15% C. *Hardness* (1 kg). Low phosphorus bands 95–125 HV, phosphorus-enriched bands 140–170 HV, ferrite–pearlite structure 91–105, maximum 135 HV. *Chemical analysis*. Cu 0.02%, P 0.04%, As 0.018%. *Interpretation* (by E. H. Schulz). A soft blade, piled, of pure wrought iron.
Schulz and Pleiner 1965, 38, 41–2, 45, pls. 11.1, 12.1, 13.2–3, 18.2.

111. TINNYE near Budapest, Hungary. Sword in the British Museum (1930.10–24.3, ascribed to the third–fourth centuries BC. J. Lang took two samples but the publication does not indicate their position. The blade revealed an edge-to-edge piled construction with differences in the carbon content in individual layers. The metal was ferritic with little pearlite or tertiary cementite. Coarse and fine grains alter from 0.015 to 0.3 mm of dia. There were two bands of almost continuous pearlite running parallel to the surface, associated with slag inclusions. Some ferrite grains were distorted, apparently due to cold working. *Chemical analysis*. Light etching area 0.08% P, 0.03% NI, 0.009% Cu; dark etching area 0.065% P, 0.025% Ni, 0.005% Cu. *Hardness*. Central rib 200–250 HV, carbon-rich area close to the surface 300–350 HV. No other documentation published.
Lang 1987, 71.

112. SOBOCISKO, near Olawa, Silesia, Poland. Iron sword fragment, no find circumstances defined. Museum Śląskie, Wrocław, 147:09. No dimensions given. Blade with central rib; transverse section examined. *Non-metallic inclusions*. A few glassy slag inclusions. *Microstructure*. Pearlite, showing tendency to spheroidization; locally a ferrite network penetrates. Estimated carbon content 0.75% C. *Microhardness*. 274 mHV 50 g. *Chemical analysis*. Mn traces, Cu n.d., P 0.003%, Ni 0.00%. *Interpretation* (by J. Piaskowski). The blade was made of homogeneous hard steel.
Piaskowski 1961, 97, figs. 4 *h* and 5 *a–b*.

113. GŁOWNIN (no. 1), near Strzelin, Silesia, Poland. La Tène period iron sword, find circumstances not defined. Museum Śląskie, Wrocław, inv. no. 1610: 31.1. Blade with central rib, both hilt-tang and point broken. Semi-transverse section investigated in the upper part of the blade. *Non-metallic inclusions*. Sporadic coarse slag inclusions. *Macrostructure*. Heterogeneous distribution of carbon. (One side of the specimen is more carburized). *Microstructure*. Fine ferrite (size 8) with intercrystalline pearlite in more carburized portions. Carbon content not exceeding 0.2% C. *Microhardness*. Ferrite 137 mHV, pearlite 213 mHV (50 g). *Chemical analysis*. Mn 0.00%, P 0.10%. *Interpretation* (by J. Piaskowski). The blade was made of a heterogeneously carburized bar.
Piaskowski 1961, 97, figs. 5*g–h* and 2*g*.
Comment. The slight carburization is limited to the entire right side of the polished specimen.

114. GŁOWNIN (no. 2). Iron sword fragment, no data given. Museum Śląskie, Wrocław, inv. no. 329:27. Transverse section at one of the fractioned ends

examined. *Non-metallic inclusions*. Slag inclusions are black and glassy. *Macrostructure* (etched with Nital). One side is dark, but in one of the cutting-edges this dark area disappears. *Microstructure*. Ferrite–pearlite merges through a Widmannstätten zone into pearlite–ferrite (grain-size 3, locally islands of very fine ferrite-and-pearlite). Estimated carbon content 0.4–0.8%. *Microhardness*. Ferrite 172, pearlite 288 mHV 50 g. *Interpretation* (by J. Piaskowski). The blade is made of heterogeneously carburized metal.
Piaskowski 1961, 97–8, fig. 6 *a–c*.
Comment. The narrow side-strip, rich in carbon, suggests an intentional flag carburization. The blade was very good in one cutting-edge.

115. KIETRZ, near Opole, Silesia, Poland. Iron sword fragment from grave 1701. Instytut Archeologii Universitetu Jagiellońskiego, Kraków, no number indicated. A transverse section in one of the fractured ends allows one to observe the distribution of structures. *Non-metallic inclusions*. Black glassy inclusions. *Macrostructure*. Heterogeneously carburized metal. *Microstructure*. Pearlite and ferrite network (grain size 5), estimated carbon content 0.7% C. A small decarburized area occurs near the surface of the blade. *Microhardness*. Ferrite 210 mHV 50 g, pearlite not indicated. *Chemical analysis*. Cu 0.00%, P 0.025%, Ni 0.21% (high). *Interpretation* (by J. Piaskowski). Hard steel blade, slightly decarburized during the forging.
Piaskowski 1979, 72–3, figs. 2*a* and 3*a–b*.

116. IWANOWICE, near Miechów, southern Poland. Bent iron sword of the La Tène B type. Muzeum Archeologiczne, Kraków, no number indicated. Flat blade, secondarily bent. A transverse section cut out from the blade and tip of the hilt-tang. *Non-metallic inclusions*. Not defined. *Macrostructure*. A schematic sketch suggests that the structures are homogeneously distributed. *Microstructure*. In the blade ferrite–pearlite (or ferrite with traces of intercrystalline pearlite), grain-size 2–4 for ferrite, 3–5 for pearlite; estimated carbon content up to 0.2%. In the hilt-tang the proportion of pearlite is a little higher than in the blade; estimated carbon content up to 0.35% C. *Microhardness*. Blade: ferrite 177, pearlite 258 mHV 50 g. Hilt: ferrite 196, pearlite 303 mHV 50 g. *Chemical analysis*. Mn 0.00%, Cu 0.00%, P 0.026%, Ni traces. *Interpretation* (by J. Piaskowski). The sword was made of mild steel, the carbon content of which was not fully homogenized.
Fig. 14.2. Piaskowski 1960, 206, figs. 1.23, 2.23, 79, 80.

117. BRZEŻCE, near Białobrzegy, Radom, Poland. Bent iron sword from a La Tène period incinerary grave, site 1. Instytut Historii Kultury Materiałnej, Warsaw, no. 4162. Flat blade, no dimensions given. A semi-transverse specimen cut out from the middle part of the blade. *Non-metallic inclusions*. Glassy slag inclusions. *Macrostructure* (etching with Nital). Darker spots in the core. *Microstructure*. Ferrite-and-pearlite 0.1% C. The dark spots consist of pearlite with ferrite network (up to about 0.8% C). Coarse grains. *Chemical analysis*. Cu

traces, P 0.025–0.04%, Ni 0.105% (elevated). *Interpretation* (by J. Piaskowski). The blade was made of a heterogeneously carburized metal.
Piaskowski and Hensel 1979, 145–6.

118. WARSZAWA-ŻERAŃ, Poland. Bent iron sword from a La Tène period cemetery. Państwowe Muzeum Archeologiczne, Warsaw, no number indicated. Flat blade with remains of ornamented iron-sheet scabbard and strap-loop. A specimen representing more than half the transverse section cut out from the blade; another specimen taken from the scabbard. *Microstructure*. Blade: ferrite and traces of pearlite, grain-size 3 and 7, about 0.1% C. Scabbard: ferrite, size 4. *Microhardness*. Ferrite 142 mHV (in both specimens), pearlite 279 mHV (blade). *Chemical analysis*. Mn 0.00%, P 0.005% (in the scabbard 0.014%), Ni 0.00%. *Interpretation* (by J. Piaskowski). The blade was made of very mild steel, practically of wrought iron, extremely low in phosphorus. Similarities in the ferritic structure suggest the same provenance of the blade and the scabbard.
Piaskowski 1960, 278, pls. lxxi.8 and lxxiv.6–7.

119. EUROPE, unknown site. Iron sword of characteristic La Tène type. Römisch-Germanisches Zentralmuseum, Mainz, not numbered. Length 800 mm, width 41 mm, flat blade with an asymmetrically situated punchmark near the shoulders. Campanulate guard. A specimen covering a semi-transverse section originates in a place 73 mm far from the guard. *Macrostructure*. Oberhoffer's reagent revealed numerous stripes enriched in phosphorus, especially in the cutting-edge area. Some differences in colour appearing after the etching with Nital are to be ascribed to varying grain-size. *Microstructure*. Stripes of nearly pure pearlite (about 0.75% C) alternate with zones of low-carbon metal. Towards the core a ferrite-and-pearlite mixture with about 0.25% C occurs. *Hardness* (1 kg). 120–180 HV, average 150–160 HV.
Schulz and Pleiner 1965, 38, 42, pls, 11.3, 12.3, 14, and 18.3.

8

Techniques of Sword Manufacture

It is an interesting fact that the technology of Celtic sword manufacture was discussed long before attempts were made at typological classification. As early as 1864, Colonel Verchère de Reffye in a paper on the arms found at Alesia, devoted a very short but often-quoted paragraph to long swords in which he correctly identified the Gallic examples and described their technology. We can paraphrase his conclusions (1864, 364):

> It is apparent that the cutting-edges of these weapons are not of the same iron as the core. Having forged the body and extended it to the required length, the maker welded on to both sides angled bands of soft iron which were subsequently hammer-hardened. Thus, after battle, the warrior himself was able to repair the notches on the blade by hammering, in the same manner as harvesters do, beating their scythes when they became notched.

This is clear enough even if he gives no indication of how he reached his conclusions, some of which were absolutely correct. Other, far more complicated techniques, however, were also employed in the making of swords as the metallographic studies presented in Chapters 6 and 7 show. In this Chapter, we shall try to give a summary survey of the techniques observed, with the main focus of attention being the construction of the blades themselves.

The Manufacture of Sword Blades

To reconstruct the working technologies and the histories of manufacture of individual blades from metallographic data is a difficult task. In many instances, the picture is somewhat confusing, since weld-seams may have been obliterated by long working, or there may be seemingly inexplicable positioning of carbon-free and carbon-rich zones. Even the individual microstructures themselves, in particular the subtle variations in those developed through different cooling regimes, may be hard to explain. This is not unexpected in archaeometallurgical investigations, but there are further problems involved in examining long swords.

The Celtic sword is a two-edged weapon. To gain at least a basic understanding of its manufacture and properties requires identification of structures, determination of hardness and composition, and observation of other features across the entire cross-section to include both cutting-edges. But if we survey our sample of 122 examinations,[1] we find that only 62 (i.e. 51 per cent) meet these requirements. In 49 cases, (i.e. 40 per cent) the data are based on examination of one edge only. Within this last category, however, there are some cases where the sample taken covered more than half the cross-section, thus permitting a reasonable interpretation of blade construction, particularly where there is an obvious bilateral symmetry of structure. In other cases, however, the structure of the unsampled area is quite unknown. There is also, unfortunately, a third category of 10 examinations (8 per cent) based solely on small specimens drilled out, or removed by electro-erosion, from the core of the blade. These do not permit any reconstruction at all of the techniques of manufacture.

Another problem centres on the original stock from which the blade was made. We must ask if it was made from one piece of stock (whether or not this had itself been made up from two or more pieces) or lengthened by the welding on of one or more additional sections, each of which might have been made up in a different way, or have had a different composition, from the main stock. Thus we must ask the crucial question—is any one of our metallographic specimens fully representative of the whole piece? In our view, we have to distinguish between construction and composition. The structural scheme, if it is clearly determinable, usually remains the same for the whole length of the cutting-edge (as is the case with the swords from Křenovice 595 and 596—examinations 13 and 14, Tuchomyšl 614—examination 4, Makotřasy 588—examination 7, Zemplín 510—examination 27, Stanwick 1—examination 79, Cuvio—examination 94, and Écury-les-Repos 1 and 2—examination 52 and 53, where, in each case, two sections were cut from the blade). An exception to this is the sword from Holubice 597, where the section taken at *b* on the diagram has a large central crack which does not appear in the section taken at position *a*, some centimetres nearer to the point. Otherwise, it seems that each of these blades must have been forged from a single piece of stock.[2] The situation is different when we come to consider composition. Microstructures, the distributions and levels of the contents of carbon and phosphorus, grain-size, and hardness may vary (as Uran 1983, 91–2, 126, points out) either because of the heterogeneity of the original stock, or because of changes induced during the manufacturing processes by differences in the intensity and duration of forging, and in heating and cooling. Thus, the blade from Zemplín 510 was laminated from four bands of metal, and yet the centre of the section is mild steel of about 0.15 per cent carbon content, while the surface region showed ferrite-and-pearlite grading into pearlite at the cutting edge (less than 0.4 per cent carbon). In practice, however, archaeometallurgists are not usually permitted to cut up valuable blades to

[1] The total number of Celtic swords which have been submitted to metallographic examination in fact is much higher. Thus, as already mentioned, Uran (1983) in his thesis conducted some 85 examinations including those incorporated into this survey. However, it was only possible to make use of two of them here, since the rest are not published in sufficient detail to allow for meaningful discussion, even though in his discussion of the physico-chemical features of the Gournay swords he does quote salient facts about selected specimens.

[2] Forging experiments (see Ch. 5) demonstrated that it was possible, indeed advantageous, to draw down the entire blade from one single block, rather than to lengthen it by welding on additional components.

retrieve the fullest information: nevertheless, it would be most useful if we always had investigations of both cutting-edges.

The degree of understanding of the basic quality and structure of a sword which we can achieve is determined by the site of a sample.[3] Among the swords in this sample where sections cover the whole of the cross-section, we find that 59.7 per cent had at least one medium or hard steel edge, a surprisingly large proportion. However, among those swords where the section covered only one cutting-edge, the proportion falls to 40.7 per cent. Steel components in the core occur in 27.3 per cent of cases examined in full cross-section. This means that a number of Celtic swords have an asymmetric constructional scheme, with only one cutting-edge being of steel. Furthermore, if steel is present at least in one edge, it extends to the core. We should not expect to find a large number of welded-on or surface-carburized steel cutting-edges.

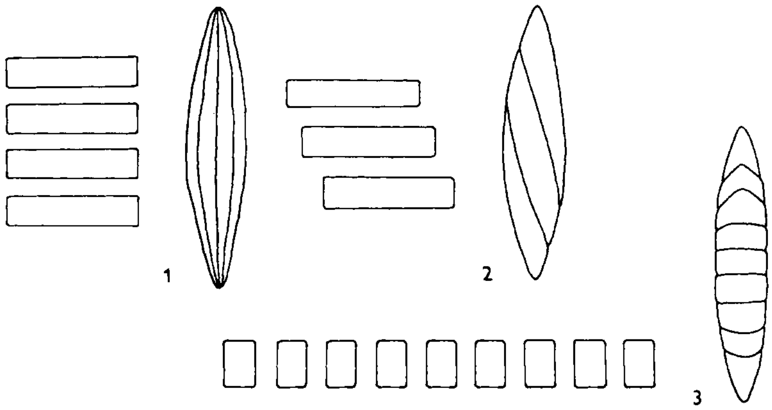


Fig. 13. Principal schemes of building up Celtic sword-blades

The sample included in this survey is not to be considered as of sufficient statistical reliability to act as the basis for a general scheme of classification of the construction techniques of Celtic swords. However, each set of investigations conducted by researchers can suggest some groupings (e.g. Reggiori and Carino 1955, 53–4; Schulz and Pleiner 1965, 45–9; Emmerling 1968, 180–2; McGrath 1968*b*, 422, fig. 6). In drawing up a classification of the swords included in our sample, we decided to concentrate on three characteristics: first, the presence or absence of steel in cutting-edges; second, the ways in which steel cutting-edges were made (by simple carburization, by welding together carburized strips, by welding together alternating strips of steel and wrought iron, by welding steel shells around an iron core, etc.); and third, the ways in which the bodies of the blades were constructed.

[3] In spite of Verchère de Reffye's view of the advantage of the soft sword edge, we regard hard-edged swords as being much more effective as weapons.

From study of the metallographic data on the swords included in our survey, it seems that there were three basic schemes followed by Celtic smiths in building up the rough bar or stock from which the blade would be forged (Fig. 13): it could be formed (1) from a single piece of metal which was then drawn down to form the blade, (2) by welding two or more flat bars together, arranging these either broad-face horizontal, so that the weld seams between them run from cutting-edge to cutting-edge in the final blade section ('edge-to-edge', to use Lang's 1987 term), or with some lateral displacement so that all of the edges did not line up exactly before forging, or (3) by butt-welding two or more flat components together, with the broad faces in the vertical so that the weld-seams between them run transversely across the section ('surface-to-surface' in Lang's terminology).

Whichever scheme was followed, this stock could then be subjected to further treatment, in particular reheating followed by folding it over and welding the two inner faces together, and repeating this operation several times (termed 'fold-welding' in Scott 1990, 21). This process, a form of refining, dispersed entrapped slag more evenly, and also helped homogenize the distribution of carbon both by physical displacement and by diffusion during heating. Such 'refining', termed *Gärben* in German, will always be difficult to recognize if the forging has been prolonged at high temperature. Moreover, it will also be difficult to distinguish between fold-welding and the welding together of a number of components of different provenances, chemical compositions, and carbon contents. Working at heat will lead to enrichment at the surface of elements such as phosphorus and arsenic,[4] as well as copper, nickel and cobalt (if one or more of these elements are present), through preferential oxidation of the iron. These enriched internal surfaces may delineate weld-seams, as do continuous chains of slag inclusions. But in some cases such traces cannot be detected, making interpretation of the macrostructure very difficult, particularly if the components which form a composite piece were very similar in quality and composition. When materials of varying composition were intentionally welded together as part of the process, reconstruction of the technology is much simpler.[5]

The results of the metallographic examinations presented in detail in Chapters 6 and 7 are summarized below in Tables 9–11. Table 9 offers a classification of those swords which were examined in full cross-section and which thus present the most complete data. Tables 10 and 11 deal with those swords examined in half

[4] Tylecote and Thomsen 1973: white lines delineating welds with components enriched in arsenic and phosphorus seldom occur among La Tène swords (some examples being Cuvio—examination 94, Borgovercelli 700—examination 104, and Holubice 599—examination 17, all of which show enrichment of phosphorus at weld-seams). In general, the welds observed in this survey are of differing quality, although usually visible and very fine. Indeed, the welds found in Münsingen swords 24745 and 31194 (examinations 34 and 36) can be taken as perfect examples of good technique. On the other hand, swords 24447 and 24527 (examinations 29 and 31) from the same site, exhibit examples of very poor technique. Where welds were poorly made, they allowed for the rapid ingress of corrosion into the interior, a feature noted, for example, on Tuchomyšl 614 (examination 4).

[5] Pleiner 1973. Experimental forge-work showed that intensive working for prolonged periods at high temperature will eradicate traces of welds almost completely.

TABLE 9. *Swords examined in full transverse section*

Item no.	Subdivision	Site, identification	Hard components, mHV	Notes
	A. WROUGHT-IRON OR VERY MILD STEEL SWORDS BELOW ABOUT 0.3% C (35.6% of total 59)			
	A1. Blades with no visible welds (5.1%)			
1		Chalons/Marne 59/60K4		
2		Cire-les-Mello	f 200	
3		Iwanowice		
	A2. Laminated blades (15.2%)			
4	A2*a*. Simple piling	Holubice 599	fp, 197–215	~0.15% C
5		604		
6		Maloměřice 593	f 180–200	n
7		594	f 170–212	
8		Münsingen 24527		
9		Écury/Crayon grave 1		N
10	A2*b*. Oblique piling	Holubice 600	ppf centre, 229	
11	A2*c*. Three-layered sandwich	Jenišův Újezd 586	f 200, shells	0.76% P; N
12	(?)	Münsingen 24447		
	A3. Butt- or pattern-welded blades (13.6%)			
13		La Tène (France-Lanord)		
14		Saône G 2416		bad welds
15		Heiligenstein 029262	bands f 180	0.179% P
16		Třebohostice 179	fpW	< 0.2% C
17		Gournay/Aronde 1667		
18		1528		
19		3757		
20		2149		N
	A4. Welded-on lamellae (1.7%)			
21		Holubice 602	fpw lamellae f 176	not in edge

	B. SWORDS WITH MEDIUM OR HARD STEEL EDGES 0.3–0.8% C (64.4% of total)			
	B1. Bilateral steel edges (44.2%)			
	B1*a*. All-steel blades (13.6%)			
22	B1*a*.1. Presumed single piece	Holubice 605	p,ppf,pf 336–362	0.190% Ni
23		Kietrz grave 1701	ppf, 210–243	~ 0.7% C

24		Sobocisko 147.09	p, ppf 274	~ 0.75% C
25		Bromeille grave 13	p, ppf	~ 0.8% C
26	B 1*a*.2. Presumed piled core	Holubice 603	p, ppf 322	~ 0.7% C
27		Zemplín 510	fp 265/ppf 263	0.15/0.5% C
28		Münsingen 26177	ps 254–304	0.86% C
29		31193	pf 252–262	0.35–0.6% C
	B1*b*. Carburized laminating (1.7%)			
30		Holubice 601	ppf 256–262	thin layers
	B1*c*. Steel shells (8.5%)			
31	B1*c*.1. Single piece core	Münsingen 24745	m /h/ 430	0.6–0.86% C
32	B1*c*.2. laminated core	Llyn Cerrig Bach 1	208–219	
33		2	265	
34		3	299	
35		5	206	
	B1*d*. Three-layered sandwich (3.3%)			
36		Münsingen 24484	fp–pf 249	0.1–0.5% C
37		Báta IV d 1118	pfs 365	0.4–0.7% C
	B1*e*. Other types of laminating (12%)			
38	B1*e*.1. Outer steel side	Holubice 606	pf, ppf 187–243	~ 0.6% C
39		Münsingen 24709	pf	~ 0.6% C
40		24286	fp 201–263	0.4–0.5% C
41	(ditto, with butt-jointed core)	24663	ppf 282	< 0.86% C
42		Metz	fp 182	~ 0.3% C
43	Bl*e*.2. Oblique carburized piling	Jenišův Újezd 584	ppf,s 500/265	
44		Tuchomyšl 613	ppf 250–300	
	Bl*f*. Butt-joint /pattern-welded blades (5.1%)			
45		Llyn Cerrig Bach 4	p	
46	(pattern-welded core)	Cleebronn BW 224	pf	0.4–0.6% C
47	(pattern-welded panels)	Cuvio	p 162/224	0.46% C
		B2. Unilateral steel edge (20.2%)		
	B2*a*. Carburized, single-piece (10.2%)			
48		Křenovice 595	p,s 408	
49		Makotřasy 588	p 363	0.8% C
50		Holubice 597	fp, p 285	thin layer
51		La Tène	fp, ppf centre	
52		Morains	pf, heterogeneous	0.4% C; N
53		Głównin 2	ppf 288	0.4–0.8% C

	B2*b*. Oblique carburized piling (6.7%)			
54		Maloměřice 592	ppf 250–270	0.4–0.6% C
55		Holubice 598	fp, ppf 164–232	0.35–0.4% C
56		Tuchomyšl 614	ppf 320	bad welds
57		Tuchomyšl 615	ppf 200–270	
	B2*c*. Three-layered carburized sandwich (3.3%)			
58		Křenovice 595	fpw	0.3% C
59		Staré Hradisko 464	fp 230–350	thin layer

Key to symbols in the column on hard components (the data refer to the higher limits in the parameters concerned): p = pearlite; ppf = pearlite enclosed in ferrite cells; pf = pearlite–ferrite mixture; fp = ferrite–pearlite mixture less than 50% p; m = martensite; h =hardenite; s = sorbite-like pearlite.

mHV numbers: specimens from Czechoslovakia charged by 30 g load.

Notes column: estimated carbon content, based on metallographical analysis, is usually that found in the cutting-edges.

n = nitride needles; N = Neumann bands; W = Widmannstätten.

cross-section or core. We can now go on to make some comments on the individual groups within the proposed classification.

Group A: Swords Made of Wrought Iron (Fig. 14)

Of the swords examined in full cross-section, 40.3 per cent were made from true wrought iron with no pearlite in the microstructure (0.02–0.05 per cent C) and from very mild steel in which the carbon content stays below 0.3 per cent. These blades would not have been suitable for quench-hardening. Using the proportion of ferrite to pearlite as the measure, carbon content concentrated in the range 0.1–0.2 per cent (ferrite 75–85 per cent with pearlite between grain boundaries).

Group A1: Swords with No Welds Visible in Section. Some of these appear to have been made up from single pieces of stock, or from stock from which any evidence of composite construction is absent. Such blades would have been produced by the simple plastic forging used in the experimental reconstructions described in Chapter 5. The sword from Châlons-sur-Marne (examination 51) has a zone of slight carburization in the inner part of its body (Fig. 14.1). The blade from Cire-les-Mello (examination 57) is of very pure, but hard ferrite. Irish swords from Lisnacrogher (UM–B2: examination 88, and UM–B5: examination 89) and Kildrinagh (NMI–WK24: examination 92), while showing a degree of heterogeneity in the distribution of their carbon contents, and traces of welds left over from the consolidation of the original blooms, may be included within this group. A deformed sword from Iwanowice (examination 116) was made of very mild

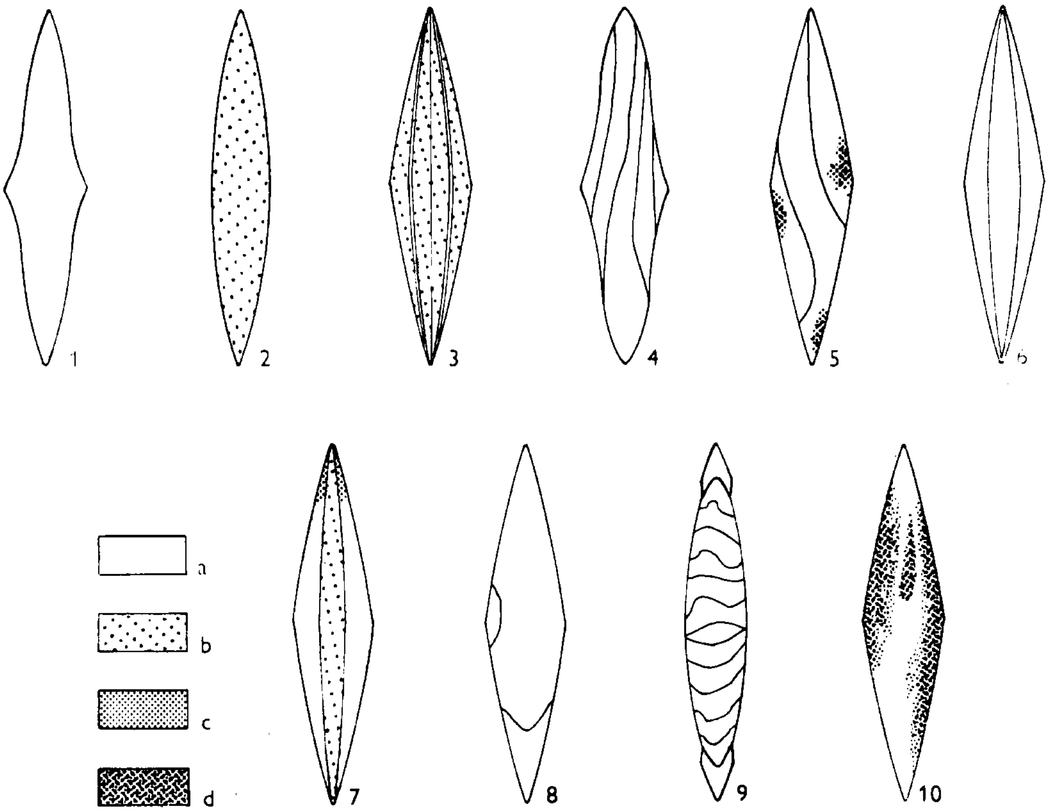


Fig. 14. Selected examples of wrought-iron or mild steel blade-constructions.

steel (0.2% C), with an area of enrichment (up to 0.35 per cent C) in the hilt-tang (Fig. 14.2).

A2: Wrought-Iron Blades with Laminar Structures. These make up 16.1 per cent of the swords examined in full cross-section, and 40 per cent of Group A. All exhibit traces of weld-seams in their sections, mostly in the form of thin zones of enrichment or chains of slag inclusions, indicating that the original stock had been made by welding together two or more pieces of metal.

A2*a*: simple piling is the easiest way to form a bar, and this can be detected from traces of welding running along and parallel to the main axis of the section. Blades of this type have microstructures that are almost entirely ferritic, although localized areas of pearlite-and-ferrite can occur in the cores (e.g. Malomĕřice 594 and Holubice 604: examinations 12 and 22). Münsingen 24527 (examination 36) is interpreted as having had its structure homogenized by the fold-welding of a wrought iron bar. Neumann bands were observed near the cutting-edge of the sword from Écury-le-Repos grave 1 (examination 52), indicating cold-working. The Holubice 599 (examination 17: Fig. 14.3) and Malomĕřice 593 and 594 swords (examinations 11 and 12) contained ferrite of a relatively high hardness which presumably results from their elevated phosphorus contents.

A2*b*: oblique piling resulted in weld-seams which run at a steep angle to the main axis of the section. Examples are found in Group A, including Holubice 600 (examination 18: Fig. 14.5), where the elevated phosphorus content (0.148 per cent P) induced relatively hard ferrite (mHV around 176: 30 g load). Localized areas of carburization can appear on surfaces near the central rib, but cutting-edges are ferritic.

A2*c*: these swords show a three-layered scheme of construction reminiscent of the technique of welding hard steel shells over an iron core (see below p. 145), but in these instances, the outer shells are of very mild steel only. On Münsingen 24447 (examination 29) only a small splinter from the outer shells is preserved, so that this interpretation is conjectural. The scheme can be seen well, however, in the case of Jenišův Újezd 586 (examination 2: Pl. III.2 and Fig. 14.6), but in this case, the outer shells are entirely ferritic, although made quite intentionally of high-phosphorus metal (more than 0.76 per cent P) giving a relatively high hardness (mHV 170–203: 30 g load).

A3: Butt-Welded Blades with Pattern-Welded Cores. These make up 12.9 per cent of the blades examined in full cross-section, and 32 per cent of Group A blades. They are distinguished by having weld seams running transversely, perpendicular or steeply inclined to the main axis of the section, sometimes forming wedge-shapes. Very clear welds with this alignment are seen in the section of the sword from the river Sâone G2416 (examination 46). Misinterpretation of the welding-on of edges is avoided, according to France-Lanord (1964) by a drastic etching of the core while isolating and protecting the edges from the etchant: this technique is discussed also by Wyss (1968, 670–2). Some of the bands in the core of Třebohostice 179 (examination 9: Pl. XII) are of mild steel (0.2 per cent C). A group of swords from Gournay-sur-Aronde have ferritic microstructures, with transverse welds bordered by inclusions and finer grains, particularly conspicuous in example 1667 (examination 56, where these swords are discussed as a group). As will be shown on p. 149, other butt-welded swords occur amongst the group examined by taking sections from one cutting-edge only. Although we do not include them here, it seems most likely that in these cases butt-welding occurs throughout the entire cross-section.

The manufacture of stock of butt-welded construction has not been studied in sufficient detail, although it is clear that swords made in this way would have had surfaces showing patterning due to their composite nature and the alignment of the components. France-Lanord (1964) assumes that the starting point for the Sâone sword was made up from seven pieces of metal and subsequently fold-welded. But heavy grinding both to remove excess metal and to smoothe the surface would have been needed to reveal any patterning, and we must ask why such effort was expanded on the production of swords that would always have been of inferior quality. These blades lack any evidence whatsoever for the use of twisted bars in their cores, a feature typical of classic pattern-welding (see below p. 147) which lent real resistance to bending, and thus the lack of any technical advantage of these over other blades, leads to the suggestion that they were made for display purposes (and some of them bear punchmarks). It may be that this particular category of Celtic sword is the forerunner of genuine pattern-welding.

A4: Blades with Welded-on Lamellae. Holubice 602 (examination 20) is remarkable for the remains of mild steel (0.3 per cent C) lamellae welded on to one face. They do not continue up to the cutting edges, and we do not know if the smith intended to add another component to the cutting-edges, or whether the two surviving fragments originally formed part of a complete cover to this face. Münsingen 24447 (examination 29: see above p. 105), explained by the investigator as a three-layered piece, might in a sense fit better into this category.

The twenty-five swords making up Group A might well be described as of inferior quality, since the materials used in the making of the majority of them were relatively soft and there is little evidence of serious attempts having been made to harden them by cold-working. Although deformed ferrite grains were observed in the edges of Holubice 602 and Makotřasy 587 (examination 6), and in several of the blades examined in half-section only, and Neumann bands were observed in many of the weapons from Écury-le-Repos and Gournay, these features need not necessarily have been caused by cold-working, but could have resulted from shocks suffered in combat, or caused by the 'killing' of the blades in ritual (Uran 1983, 91–8). However, around one third of the wrought iron blades were not particularly soft at their cutting-edges, and in these cases values of 170–215 mHV resulted from the use of high-phosphorus metal. The upper part of this hardness range would have produced swords whose edges matched in hardness those made from medium steels with ferritic–pearlitic structures, making them quite effective weapons (Figs. 15 and 16).

Group B: Swords with Medium or Hard Steel Edges

One would expect to find steel cutting-edges in those swords destined for use in battle, since steels which contain 0.3–0.4 per cent carbon (the minimum for quench-hardening) or above, ideally 0.6 per cent (medium steels) or 0.7–0.8 per cent (hard steels), would have made much more effective cutting weapons than softer materials. Wrought iron with an elevated phosphorus content can compete with unquenched medium carbon steel, but the steel has the advantage of being much less brittle. Of the swords examined from full cross-sections, 61.7 per cent are steel edged.

B1: Swords with Two Steel Edges (Fig. 17). These make up 40.3 per cent of swords examined in full cross-section, and 67.7 per cent of Group B swords, and are

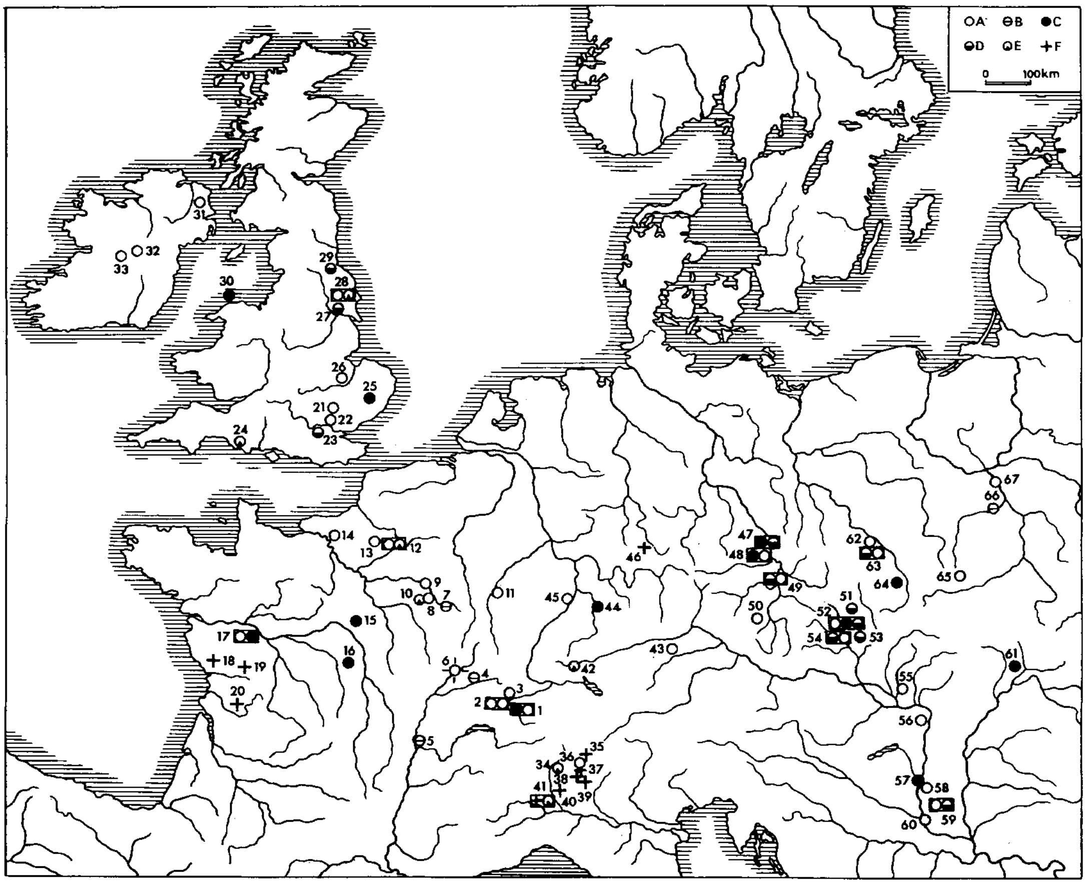


Fig. 15. The use of steel (more than 0.3 per cent C) in blade-constructions of Celtic swords For key to sites, see p. xiii.

characterized by having both cutting-edges made of steel. The group can be further subdivided as:

B1*a*: all-steel blades (12.9 per cent of those examined in full cross-section, 21.6 per cent of Group B) were usually made of hard carbon steels (*c*.0.7–0.8 per cent C), either as single-piece of composite stock. Where there are areas of microstructure with dark-etching pearlitic structure, any piling is difficult to detect. For example, Zemplin 510 (examination 27) has a laminar structure, but in the central area of the blade where there is an elevated carbon content, the weld-seams are less easy to recognize. A heterogeneous distribution of carbon was noted in the core of Münsingen 31194 (examination 36) where islands of *c*.0.35 per cent carbon steel occurred within a matrix of 0.5–0.6 per cent steel.

B1*b*: carburized laminae were noted only in the case of Holubice 601 (Fig. 17.1), where pearlite-and-ferrite stripes (*c*.0.4% C) are found in the cutting-edges, two on one side (average mHV 262: 30 g load), one on the other (mHV 202–230: 30 g

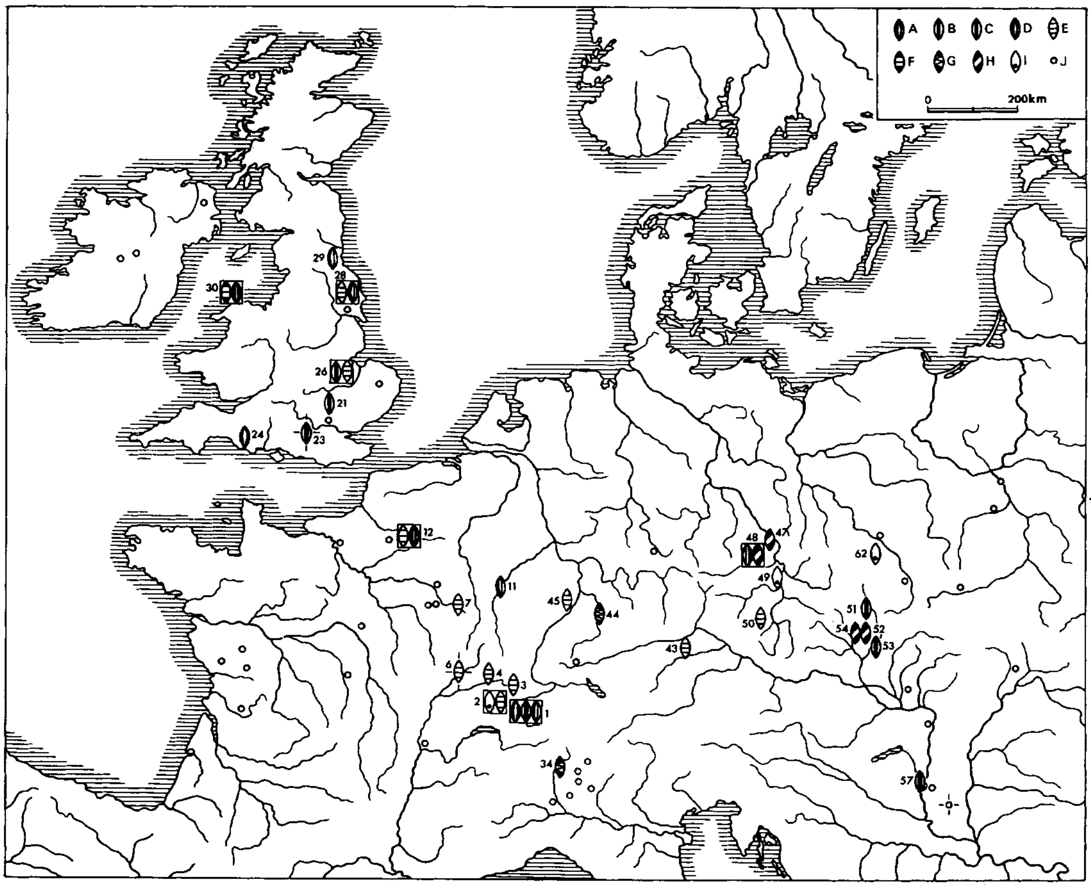


Fig. 16. Geographical distribution of some specific types of blade-construction
For key to sites, see p. xiii.

load). These laminae appear to have been produced by welding together strips which had received a slight degree of surface carburization.

B1*c*: the welding of hard steel shells around a mild steel core (8 per cent of swords examined in full cross-section, 13.5 per cent of Group B) was a sophisticated scheme of construction which gave increased hardness to the blade surfaces. Münsingen 24745 (examination 34) was made by welding a hard steel (0.6–0.7 per cent C) coat around a mild steel (*c*.0.3 per cent C) core. The cutting-edges showed an extremely fine microstructure described as martensite of hardenite form (mHV 430). Blades 1–3 and 5 from Llyn Cerrig Bach (examinations 83–5 and 87), dating to the Late La Tène, are claimed to belong to this type. However, the outer surface regions of these blades had ferrite-and-pearlite microstructures of lower carbon content and with HV values of 200–270 as compared with 150–200 HV for their piled cores. Similar schemes of construction can be suggested for some other British swords which were examined in half-section only (Whitcombe—examination

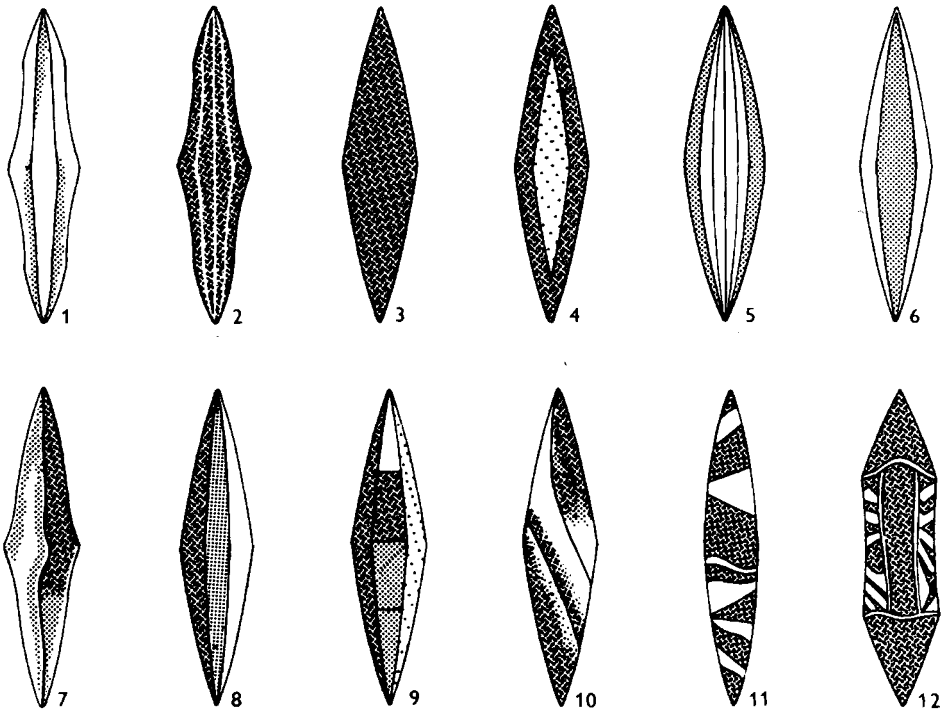


Fig. 17. Reconstructions of important blade-constructions (hardenable steel over 0.3 per cent C)

78, Stanwick 2—examination 80, and Grimthorpe—examination 81), although Lang (1987) who conducted these examinations considered them to have been surface carburized—a difficult process when we consider the length of the blades.

B1*d*: a three-layered 'sandwich' scheme (2 specimens, 5.4 per cent of Group B) represents the opposite principle to the previous group, with a hard steel core being contained between two wrought-iron or mild steel shells. Münsingen 24484 (examination 30) had a steel core of heterogeneous carbon distribution (0.1–0.85 per cent C) between two wrought-iron shells (0.01–0.1 per cent C). The Báta sword (examination 109) showed a hard steel core (0.4–0.85 per cent C) between two mild steel shells (0.35 per cent C) where the pearlite has a sorbitic form.

B1*e*: a somewhat heterogeneous group includes blades with laminated structures composed of two or three iron and steel components. According to the investigator (Emmerling 1968), three of the Münsingen swords (nos. 24286, 24663, and 24709—examinations 28, 32, and 33) were made by welding together three components of differing carbon contents. One surface is formed from a hard steel piece, and the core is of mild steel, while the other face is of iron/mild steel. We may also include two other blades in this group, one from Metz (examination 48) which has a lamella or rather low carbon steel on one side. The structure of the blade of Holubice 606 (examination 24) is not easy to interpret, having one iron face which is partially carburized along one edge (a strip of ferrite-and-pearlite with Widmannstätten structure), and a steel face which is decarburized along one edge (Fig. 17.7). We may at least suggest that the original intention was to provide the blade with two steel cutting-edges.

B1*f*: butt-welded blades with steel edges and 'patterning' (4.8 per cent of swords examined in full cross-section, 8.1 per cent of Group B) are particularly noteworthy (Fig. 17.11–12). Sword 4 from Llyn Cerrig Bach (examination 86) has cutting-edges with pearlitic microstructures, while the core shows bands of ferrite-and-pearlitic running from surface to surface. The author claims that the surfaces of the blade show a slightly sinuous pattern, although this is not really visible in the published photographs, and use of twisted components in the core is not attested. However, the Early La Tène sword from Cleebronn (examination 68) has two welded-on steel edges, while the core between them shows twisted iron and steel components layered so that a wavy pattern can be seen on the surfaces. It is clear that this must be pattern-welding. Furthermore, the sword from Cuvio (examination 94), although examined in half-section only, has a developed pattern-welded structure with the steel core flanked by two pattern-welded iron and steel panels, and outside them, two hard steel cutting-edges welded on. If we can rely on the dating ascribed to these swords, then the use of pattern-welding by Celtic smiths is clearly established (Figs 12; 17.12)

B2: Swords with a single steel cutting-edge. The swords which make up this group, discovered only in the course of recent research, provide us with a surprise. Why was only one cutting-edge made of steel? It might be suggested that a warrior using such a sword attacked with the steel edge and parried his adversary's strokes with the iron edge, but this is surely too far-fetched.[6] It is more likely either that some of the makers were not well versed in the differences between iron and steel, or that their control over the piled bundle during forging was weak.

B2*a*: carburized examples (representing 12.9 per cent of swords examined in full cross-section) forged from a single block, and which seem to have been deliberately made in this way, are known. Thus, Makotřasy 588 (examination 7: Fig. 18.2) has one of its cutting-edges carburized to give up to the eutectoid composition with a purely pearlitic microstructure. The microhardness of this region is 363 mHV (30 g load), suggesting some form of heat-treatment, possibly a rapid air-cooling. On the other hand, Holubice 597 (examination 13) shows only slight carburization of the surface of one of the cutting-edges (ferrite-and-pearlite in section *a1*: Fig. 18.1). Moderate carburization was observed in the core of sword 199 from La Tène (examination 37). The carbon content was highest there, decreasing to that of a medium steel in the direction of one of the cutting-edges, while the other remained

[6] The term used by Greek writers for the Gallic sword was μάχαιρα (cf. Ch. 2, n. 1), which originally denoted a single-edged knife or dagger, or a single-edged sword (*LS* 1085). However, nowhere in early written sources is there any evidence of its use with one preferred edge only.

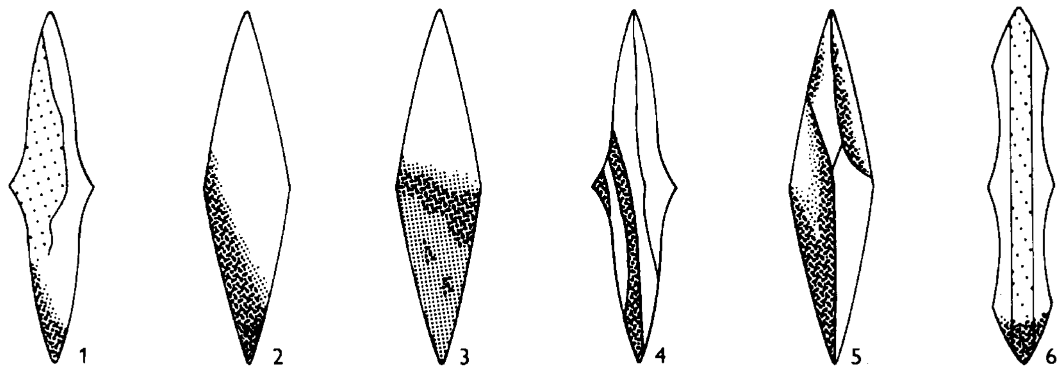


Fig. 18. Intrepretation of some one-sided blade-constructions (with steel in one cutting-edge only)

purely ferritic in microstructure (Fig. 18.3). One surface of Głownin 2 (examination 114) has been unevenly carburized (0.4–0.8 per cent C), although the carburization exends to only one of the cutting-edges, making its occurrence look accidental. Accident may also be invoked to explain the structure of Krenovice 595 (examination 13) which looks like an all-steel weapon but with one edge decarburized leaving only traces of pearlite in the microstructure.

It should be stressed again here that although we interpret some microstructures as indicating that the blades were carburized, we have little idea how this difficult and time-consuming operation was carried out in the case of long swords. We do know, however, that in recent times, some sabre-smiths in Iran, working to traditional techniques, used special hearths with long grooves in which carburization was carried out.

B2*b*: blades with obliquely-piled components of steel or partially carburized iron, such as Tuchomyšl 614 and 615 (examinations 4 and 5: Fig. 10.2), Holubice 598 (examination 16: Fig. 18.5), and Maloměřice 592 (examination 10) are a speciality of Bohemian or Moravian workshops. In these blades the carbon contents of the steel components is in the range 0.4–0.6 per cent.

B2*c*: three-layered blades, resembling the 'sandwich' scheme of construction, have been identified in blades of Křenovice 596 (examination 14) and Staré Hradisko 464 (examination 25). The Late La Tène Staré Hradisko blade is very thin and was constructed from a core whose microstructure is ferrite with traces of pearlite. The core was covered by ferritic shells. In one of the cutting-edges is a thin arrow-shaped zone with a pearlite-and-ferrite microstructure, and this seems to have been produced by secondary carburization (Fig. 18.6). The same construction scheme may be seen in the much earlier Křenovice 596 blade, but in this example, carburization had been carried out before the components had been welded together, despite the inherent difficulties involved. The central layer was made of mild steel (0.2–0.3 per cent C) while both shells were made of ferritic iron. Both of the shells were carburized in the region of one of the cutting-edges, thus providing it

TABLE 10. *Swords examined in only one cutting-edge*

Item No.	Subdivision	Site, identification	hard components, mHV	Notes
		A. WROUGHT-IRON OR MILD STEEL EDGE (78.8% of total 23)		
		A1. Metal poor in carbon (13.1%)		
60		Maňa 5		steel-reinforced scabbard
61		La Tène M 549		etched blade surface
62		Warszawa-Żerań		~ 0.1% C
		A2. Steel zones, heterogeneously distributed in the core (26.1%)		
63		Mus. Basel 1947.639	fp 190, core up to 0.6% C	–n, N
64		Écury/Crayon, grave 3	midrib ppf	
65		Tuttlingen	ppf 200, core	
66		Brzezce 4162	ppf, core	0.1–0.8% C 0.105% Ni
67		Głownin 1	ppf 293	0.2% C
68		Sforzesca 435	ffp, fp	0.3% C, n
		A3. Laminated blades (30.4%)		
69	A 3.1. Two layers	Seine 1882	p 0.85, core	
70	A 3.2. Three layers	Makotřasy 587	wrought iron	
71		Třebohostice 178	fp	~ 0.2% C
72		Baracs 0.2811		
73	A 3.c. Piled/folded	Vojvodina 2 0.1668		
74		Vienne-Ste Blandine	fpw	0.2% C
75	A 3.d. Welded-on lamellae	Dalj	fp 231, core	0.35% C
		A4. Butt-welded blades (8.7%)		
76		Saint-Dizier	fp def., 255 edge	< 0.3% C
77		Port 13598		
		B. MEDIUM OR HARD STEEL CUTTING-EDGE (21.7%)		
		B 1. Presumably carburized (13%)		
78		RGZM Mainz	ppf 180–205	~ 0.75% C
79		Mus. Basel 1947.640	ppf	0.5% C
80		Vojvodina 1 0.1824	ppf	0.4% C
		B2. Welds visible or reported (8.7%)		
81		Mus. Rouen	fp	< 0.3% C
82		Borgovercelli 700	ppf, m 388–577	0.6% C

For explanation of symbols see Table 9.

with an effective cutting-edge whose microhardness reaches 231 mHV for the ferrite-and-pearlite aggregate.

In general, the steels used for making the blades or cutting-edges of these Group B Celtic swords were seldom homogeneous. However, more than one third may be classed as hard steels (0.7–0.8% per cent C), with two-thirds falling into the medium steel group (0.35–0.6 per cent).

If we turn now to the second largest group of examinations, those examined in half-section only (Table 10), we have already noted that the proportion of blades with steel components was only 40.7 per cent. The majority (59.3 per cent) of microstructures among these are ferritic, more than in the group examined in full-section. About 49 per cent show piling or fold-welding of the edge-to-edge type, while in about 21 per cent weld-seams run surface-to-surface implying butt-welding. In the cases of the blades from Port (examination 43) and Saint-Dizier (examination 54) mild steel cutting-edges had been welded on and hardened by cold-working as indicated by deformed ferrite grains. Sword 380 from La Tène (examination 40), and the Chaussin sword (examination 50) both show transverse weld-seams running at an angle to the main axes of the section. Heiligenstein 029262 (examination 67) is exceptional in having alternating bands of high- and low-phosphorus iron (0.179 and 0.093 per cent P) welded together obliquely.

Secondary carburization is claimed as having been commonly used to improve the quality of cutting-edges. Six specimens (12.2 per cent of the sample total)

TABLE 11. *Swords examined only in the core*

Item No.	Site, identification	Hard components, mHV	Notes
	A. WROUGHT IRON OR VERY MILD STEEL (72.7% of total 11)		
	A 1. No welds indicated (63.6%)		
83	Steinsburg		
84	Magenta		
85	Acquate		
86	Novate		
87	Varenna		
88	Bergamo		
89	Borgovercelli 699	fpw 177	0.2% C
	A 2. Lamination indicated (9.1%)		
90	Waltham Abbey	fp 250	0.25% C
	B. MEDIUM OR HARD STEEL STATED, LAMINATION INDICATED (27.3%)		
91	Borgovercelli 701	pf 338	
92	Varenna 2	ppf	0.5% C
93	Esino	ppf	0.7–0.8% C

For explanation of symbols see Table 9.

provide evidence of this technique whose occurrence seems to decrease in frequency from earlier to later periods.

For the third category of examinations on specimens drilled from the core of blades, see Table 11.

To sum up, it seems clear that Celtic smiths did not find the making of long sword blades an easy task, especially when it came to the use of different types of metal. These smiths had just begun to appreciate the differing qualities of the materials at their disposal, although some were unable to differentiate between wrought iron and mild and hard steels, or between hard high-P and soft low-P irons. It is because of these uncertainties that we find such a variety of construction schemes represented in the blades examined. The reason why the majority of all examinations (40 per cent) show structures based on the edge-to-edge system of piling, or on fold-welding, may be that the homogenization of composition of different components which this brought about made the shaping of the blades easier. It seems, however, that a significant number of sword-smiths already had an appreciation of the qualities of hard carbon steels and knew how to use them in making their blades. More than 50 per cent of Celtic swords have medium or hard steels in at least one cutting-edge, and in this respect were not of such poor quality as suggested by Polybius. And when damaged by notches resulting from combat, they would have been capable of inflicting quite horrific wounds.

Hardening

From the available metallographic data on Celtic swords, it is fairly clear that their makers generally did not practise quench-hardening. Some pearlitic structures are so fine as to be sorbitic in character (e.g. Makotřasy 588—examination 7, Jenišův Újezd 584—examination 1, Holubice 605—examination 23, and some of the Münsingen blades), with microhardness in the range 350–400 mHV. Such structures may have arisen from rapid air-cooling, but there is no real evidence that this would have been intentional. In one specimen from Gournay-sur-Aronde (examination 56) a small region of acicular ferrite–bainite structure[7] was reported, but this was the only example found among a large number of examinations (Uran 1983, 144–5). The structure of the Grimthorpe sword (examination 81) is not published in detail, but is described as being quenched and even possibly tempered, with hardness in the region 410–520 HV.

Three other swords seem to have been rapidly cooled by immersion in liquid. Münsingen 24575 and 24663 (examinations 34 and 32) are reported as having very fine microstructures identified as martensite or 'hardenite' in their cutting-edges,[8]

[7] Bainite is an isothermal transformation product whose appearance in plain carbon steels (i.e. those with no significant alloying elements other than carbon) is supressed by that of pearlite. Ancient iron alloys where bainite could form are known, but the data offered here is such as to make this identification doubtful.

[8] 'Hardenite' has been described as a very fine martensite whose acicular structure cannot normally be resolved under the light microscope, resulting from the cooling of hard steel from the critical point at 721 °C. The term, however, is obsolete, and this structure is now commonly referred to as 'plate martensite'.

while Borgovercelli 700 (examination 104) is reported to have a cutting-edge of martensitic microstructure. The investigators of the pattern-welded Cleebronn sword (examination 68) are inclined to believe that it was quenched originally to a martensitic structure, but subsequently annealed before its deposition in the grave, although the evidence is ambiguous. Given the very small number of blades involved (only about 5 per cent of the hardenable steel used), it is possible that very rapid cooling or quenching were chance occurrences.

We must consider also the question of cold-working, since out of the total number of 122 examinations discussed here, 12 specimens (i.e. 8.2 per cent) showed deformed ferrite grains (Makotřasy 587—examination 6, Holubice 606—examination 24, Maňa 5, only in the hilt-tang—examination 26, Münsingen 24286—examination 28, River Sâone—examination 46, Morains—examination 55, Switzerland 2—examination 45, Waltham Abbey—examination 73, Saint Dizier—examination 54, Faye l'Abbesse 4—examination 61, Chaussin—examination 50, Tinnye—examination 111). The Saint Dizier blade had one ferritic cutting-edge which showed slight carburization and cold-working. Uran (1983, 80–2) mentions two other (unspecified) weapons with evidence of cold-working, a technique which he considers to be of importance despite the limited number of cases reported.

Further evidence of cold-working is provided by so-called Neumann bands, which are parallel deformation twins found in ferrite grains. They have been reported occasionally among the microstructures discussed above, but Uran (1983, 91–8) claims to have found *fer maclé* in as many of the swords investigated from Gournay. He suggests that this feature arose independently of the manufacturing process, by the cold shocks of combat or, more likely, during the ritual 'killing' of the blades in the course of sacrifice. In this latter context, we should remember that both Gournay-sur-Aronde and Faye l'Abbesse were sanctuaries. Indeed, the Neumann bands observed in Faye l'Abbesse no. 4 (examination 61) occurred in the bent part of the blade.

Surface Finishing

The heavy corrosion of most of the surviving La Tène period swords does not allow us much information on the final finishes (planishing, draw-filing, and polishing) applied to them. In the majority of cases it also makes it impossible to recognize the application of any special surface finishes, even though we know from exceptional survivals that they do occur. In those cases where blades are well preserved, as at the eponymous La Tène site, we can only but admire the laborious work required to produce display finishes by punches or deep-etching (see above, pp. 110–1). Wyss (1968) writes that these features began to appear in the Middle La Tène period, becoming the vogue in the Late La Tène.

Punchwork could cover the entire surface of the blade, apart from the cutting-edges, with fields of dots. The use of compound punches having multiple teeth is also in evidence (Jahn 1916, 116–21; Wyss 1968, 668, pl. 5.1–3; de Navarro 1972, 38). To date, no experimental work has been carried out to elucidate the technical aspects of this type of decoration, and we do not know if working was hot or cold. We may assume that the punches, especially the compound ones, were of the finest quality with steel working-surfaces. The making of such tools itself represents a very high degree of skill, and they may only have been found in a few workshops.

The other technique of forming plastic decoration on the surfaces of swords, pellets, tendrils, etc., gives the appearance of having involved the use of wires or bundles of wires (both loose and welded together) welded into the surface (p. 109: for details see Wyss 1968, 670, 680, pl. 3.4–6 and 4). However, by comparing surface detail with cross-section, Wyss proved in specific cases that no welds observed in the section could be shown to correspond to grooves in the surface. In the case of the wrought-iron sword no. M 549 from La Tène (examination 39), long etching with natural acids would have been necessary after the areas designed to be free of decoration had been protected by an application of wax, tar, or grease. Wyss himself made some successful experiments in which he used fruit vinegar to etch depressions into a metal surface (1968, pl. 8.5).

The purpose of such long and involved treatments being applied to blades of widely varying quality is not obvious. Were such weapons merely for display, or was there some deeper underlying significance?

Hilts

The original forms of La Tène period sword hilts are not well known, although a few finds hint at rather complex forms carved in wood. These examples were in two halves joined by rivets. Four protrusions, one on each side of the guard and on each side of the pommel produced an X-form reminiscent of those on the pseudo-anthropoid and anthropoid-hilted daggers (Fig. 6). In addition to the Early La Tène find from Liebau in Saxony (Coblenz 1956, 322, figs. 47–8; Pietzsch 1956, 343–7), reconstructions of wooden hilts can be offered for swords from Münsingen (nos. 31513 and 24484) where oak-wood components were riveted together (Emmerling 1977, 186–90, figs. 1–2). Unlike other examples, the Münsingen examples have no metal guards. Sufficient survives of the copper-alloy hilt-furniture of two swords from Lisnacrogher in Ireland to allow Rynne (1983, 95, Fig. 3) to offer a reconstruction of the original appearance (cf. Raftery 1984, 64, fig. 43.4–5 for the surviving form).

Some swords are distinguished by a degree of asymmetry in the slope of the shoulders from the hilt-tang to the blade (Fig. 5). In such cases, the hilt itself may also have been of asymmetrical form, and this gives rise to the speculation whether this would favour the use of either the hard or soft cutting-edge in the cases of blades with one steel edge only. However, this seems quite improbable. Some swords with single steel edges (such as Holubice 597 and 598—examinations 15 and 16) do have asymmetrical shoulders, but this feature is encountered also among those blades which have two steel edges (e.g. Holubice 601—examination 19), as well as among those where the edges are of soft iron (Holubice 604—examination 22, Maloměřice 593 and 594—examinations 11 and 12).

Very rarely, globular knobs or circular riveted plates are preserved at the top of hilt-tangs. These would have ensured that the hilt was firmly secured and could not slip off the tang (Fig. 8.9). We may assume that the manufacture of the hilt with its various components, including the minute campanulate guard, required additional precise cold-work including the use of files.

The Manufacture of Scabbards

Celtic sword scabbards are artefacts which demand our appreciation. Not only does their splendid decoration make them famous, but it also provides the basis for detailed stylistic and chronological studies. But it is not only their artistry which is worth detailed investigation: they are also masterpieces of craftsmanship and this is an area which, in our opinion, has been largely neglected in the past.

Despite some indications in the archaeological assemblage of the existence of leather scabbards with metal frames and fittings, the typical scabbard for the long sword was made of metal. Two sheets of metal were used, both of iron in later periods, but earlier examples have one the front plate made of bronze. These parts were prefabricated and required chasing, traces of which technique were revealed by taking moulds from the insides of two scabbards from Port in Switzerland.[9] On these scabbards, the marks of the hammer pein run along the long axes, the plates seeming to have been made by drawing down suitable blocks of metal. The front plate of a scabbard was made perfectly smooth, and was either left plain, or had applied to it engraved, incised, chiselled, or punched decorative patterns, or (like some of the sword-blades) was covered with punched or stamped fields, shagreening or *chagrinage* as de Navarro calls it, (de Navarro 1972: see also above p. 63), a specialized technique requiring specialized tools. When we come to look at stamped scabbards, more complex shapes appear, and the teeth—which must have been made of steel or carburized iron—obviously had quite elaborate shapes, being chiselled by cold-work into rhombuses, S-shapes, lunulae, squares, and so on. The iron sheets used in scabbard construction were obviously of good enough quality to take chasing, and those few examples which have been examined metallographically were made of soft ferritic iron.

The metal of a scabbard fragment adhering to Münsingen 24527 (examination 36) proved to be ferrite with large magnetite inclusions (possibly including hammer-scale) which showed deep penetration of intergranular corrosion (Emmerling 1968, 156–7, figs. 7–9). A thin layer of copper or bronze adhering to

[9] Historisches Museum, Berne nos. 13598 and 13600—see Wyss 1968, 680, pl. 8.2–3. The inner wooden lining of a sheet scabbard is attested for the Early La Tène sword from Liebau (Coblenz 1956, 325, fig. 52). Rare leather scabbards are referred to by de Navarro (1972, 104–5).

the blade of Třebohostice 178 (examination 8) may be a minute surviving fragment of its scabbard (Pl. XI.7). The decorated scabbard fragment from the disturbed grave at Maňa, Slovakia, belonged to sword no. 5 (examination 26) from that site (see above pp. 96–7). The back plate was ferritic in microstructure (average grain size 5, 147–175 mHV: 30 g load). A hitherto unique feature is the reinforcement of this back plate by two steel wires running for about a quarter of the width of the scabbard. These were welded on to both internal faces, front and back. The welding resulted in a massive diffusion of carbon into the iron sheet as very large pearlite colonies among ferrite grains show. The structure of these wires is most striking. In their lenticular sections, they have microstructures of fine pearlite or sorbite (see Pleiner 1962, 77, pl. XI). We know that at least some Celtic master-smiths were acquainted with heat-treatments, but why did the maker of this sword apply them to two reinforcements, obscured by black patina and invisible on the scabbard surfaces,[10] and not to the sword itself? Could it be that in this case at least, we have evidence that scabbards were made not by sword-smiths but by a separate group of craftsmen?

Once the initial sheet of stock, had been prepared, the maker of the scabbard had to cut out to shape and size, remembering that one plate had to be slightly larger than the other to allow its edges to be bent round over those of the other sheet, thus fastening them together. Before the two sheets were joined in this way, the suspension loop was prepared and riveted to the upper part of the back sheet.

Emmerling (1968, 160–1, Abb. 18) studied a fragment of the loop-plate of the scabbard of Münsingen 24484 (examination 30), and found it to have been forged from a piece of composite stock made up of five layers of relatively hard (mHV 200–215) ferritic iron. On the same specimen he found also a neatly made countersunk rivet which had joined the now-corroded scabbard to this suspension loop. This rivet was formed from a bundle of three wires of low and medium carbon steel welded together. Both the shaping of the loop and the forming of the rivet must be acknowledged as fine-quality metalworking.

The quality of workmanship is also evident when we examine the formation of the scabbard itself by clasping the two sheets together. Three ways of achieving this have been recognized so far, and these are represented by the scabbards associated with Münsingen swords 24709, 24447, 24286, and 26177 (Emmerling 1977, 190–3). The first technique involved the turning-out of the edges of both plates, placing them together, and then folding them over so that the edges of the back plate covered those of the front. The second way of joining the panels together was that the margins of the front plate were turned over to form a tubular band with a slit into which the edge of the back plate was inserted. The third, and simplest method was to fold the margins of the back panel over those of the front. Whichever

[10] Scabbard-ribbing is rarely found. The sheath from Charvaty in Moravia (Pleiner 1962, pl. ii) has two visible side-ribs in the same positions as on the Maňa example. The ribs on the bronze front plate of the scabbard from Dürrenberg are chased (Hell 1929, fig. 10). Ribbed scabbards are also mentioned by de Navarro (with references) as coming from Vert-la-Gravelle and Weisskirchen (1972, i. 47)

method was employed, the scabbard-maker always tried to create an aesthetically pleasing effect on the side to be viewed.

Another distinct task to be performed in the final stages of the assembly of the scabbard was the fitting of the chape over the point. To date, no technological investigation of an iron chape has been carried out.

It may well not be any exaggeration to suggest that the complex construction of the scabbards for Celtic swords—decorated or undecorated—took more time and required a higher level of skill than the simple forging out to shape of the blades they contained. Each scabbard had to fit its own blade, but we do not know anything of the division of labour in the various stages of production of a sword and its scabbard. Certainly, the splendid decoration of some scabbards leads one to doubt that the smiths who forged their blades were responsible for this too (cf. Megaw 1979, 51). An additional complication to be considered is that the originator of the decorative pattern need not have been the man who applied it, or indeed the man who forged and constructed the scabbard which it adorned. There are certainly some grounds for believing that at least some Celtic swords and their decorated scabbards were the products of workshops in which smiths, braziers and artists worked on each production stage in turn.

The majority of the swords discussed here belong, insofar as they are amenable to dating from their contexts, to the Early and Middle La Tène periods fourth–second centuries BC). Thirty-five weapons, however, date to the Late la Tène (first century BC through to the first decades AD). These include the swords from Port, Cire-les-Mello, Nalliers 1 and 2, Faye l'Abbesse 1 and 4, Esino, Bergamo, Borgovercelli (3 words), Zemplín, Orton Meadows 2, Waltham Abbey, Isleham, Grimthorpe. Whitcombe, Llyn Cerrig Bach (5 swords), Vienne Ste-Blandine, Staré Hradisko and Steinsburg (these last three being finds from *oppida*). Some British examples of La Tène type are said to date to the first century AD. The Irish Lisnacrogher swords are dated to the Middle La Tène on the basis of the decorated scabbards associated with them (end of the third century BC: Raftery 1984, 88 ff.), but the dating of the Kildrinagh and Banagher swords is much less certain, although the form of the Kildrinagh blades suggests close affinities with the better-dated Lisnacrogher weapons. Rynne (1983) and Raftery (1984, 70 f.) date the Banagher sword and similar weapons to the first centuries AD while still describing them, in Irish terms, as of La Tène style.

When we examine the materials and technology employed to fabricate these Late La Tène swords, we see no technological innovation to set them apart from those of earlier periods. From twenty-seven examples whose technology can be reconstructed, eleven (41 per cent) were of inferior quality (Port, Vienne, Cire-les-Mello, Faye l'Abbesse 4, all of the Irish examples). The remaining sixteen blades (59 per cent) show constructional schemes known from earlier weapons, using medium carbon steels in their surface regions. Thus, the proportion of good and less-good quality weapons is the same throughout each La Tène period.

9

Battleworthiness

Having considered the construction and qualities of Celtic swords through metallographic examinations, we must now compare the results with the evidence which survives for their performance in battle.

Criticisms in Ancient Sources

The Celtic cutting sword was greatly feared by the Romano-Greek world for more than a hundred years, and remembered for more than four centuries as a frightful aspect of the wild Celtic raids. It was however heavily criticized by Classical writers on two grounds. One was that the sword was designed solely for cutting and thus lent itself to tactics on the part of Gallic troops rendered obsolete by Roman military innovation (this aspect has been discussed in Chapter 2). The other was the weapon itself which was deemed to be of inferior quality both in material and manufacture. These criticisms, especially that of quality, seem to have originated in the events (perhaps even one event) in northern Italy in the third century BC wars when the Celts were being pushed northwards by the Romans. This was recorded by Polybius in the second century BC, and he mentions Gallic swords in three different contexts (the battle of Telamon in 225 BC, the skirmishes at the river Clusium, the Punic Wars (see above pp. 33–4)), with his comments on their softness being of relevance here:

> from the way their [the Gauls'] swords are made,[1] as has been already explained [30. 8], only the first cut takes effect; after this they at once assume the shape of a strigil, being so much bent length-wise and side-wise that unless the men are given leisure to rest them on the ground and set them straight with the foot, the second blow is quite ineffectual.

This passage (2. 33. 3, tr. Paton 1922, 321–2) is the source for all of the later versions in which Polybius' comments and criticisms were taken up by other authors over many centuries and were applied very freely in time and space. Usually the criticism of quality was put into the context of the first Celtic raids against Rome in the early fourth century BC and the battles against Camillus. The more interesting of the other versions have been quoted in Chapter 2, and there is

[1] Καταφορά could mean in this context 'arrangement, system, construction' rather than 'manufacture' as it is usually translated. This fits better in the context of 2.30. 8 where Polybius quotes himself.

no need to repeat them here, as they are all ultimately based on Polybius. The blunting of Celtic swords is described in the subsequent lines:

Having put their [the Gauls'] swords out of action by parrying their first strokes with spears, the Roman proceeded to come to close-quarters, not allowing the Gauls to strike with the cutting edges of their swords as is the custom of their fighting, since their swords have no points.

More than a century later, in his *Parallel Lives*, Plurtarch wrote (*Camillus* 41. 4):

[the Gauls] raised their swords and rushed in quickly to join combat, but they [the Romans] thrust out their javelins and deflected off their iron plated armour the strokes of the [Gallic] swords, the iron of which was soft and badly forged (εληλασμένον: *LS* 1940, 529) so that they rapidly bent double.

There is, in fact, no reference to 'weak tempering' as is given in Perrin's translation[2] of this passage. Plutarch obviously took it from Polybius, although transposing it back to the fourth century BC, and placing his emphasis not on the concept of the Celtic slashing sword which had obviously interested Polybius, but on the supposedly poor materials and manufacture which is exaggerated in the use of the term διπλόος (folded double: *LS* 436). In the second century AD, Plutarch in turn inspired the rhetorician Polyaenus who, in a chapter devoted to Camillus in his *Strategemata* (8. 7. 2), incorporated the comments on the quality of Gaulish swords, 'the iron of the Celts was soft and badly forged and bent quickly so that the swords folded double and were useless for fighting.' He added (see above p. 26) that Camillus ordered iron helmets and copper-sheathed shields in order to deflect and break the swords of the attacking Celts.

The source of Polybius' information is not known exactly. Indeed Salomon Reinach (1906), in a defence of Celtic iron metallurgy, refused to lend credence to his statements on the quality of swords. He envisaged the Greek historian as having had what might be described as an 'archaeological experience' during his travels through the countries whose histories he recorded. Reinach suggested that Polybius saw, or was told of by local peasants, ritually bent swords from destroyed Celtic cemeteries which he mistook for old battlefields, and then generalized his impression, this account being taken up and paraphrased by much later writers. However, in our view, Polybius, as an experienced soldier and former cavalry commander of the Achaean confederation, and later an experienced and critical historian, would scarcely have failed to differentiate between a battlefield and the remains of disturbed graves. He used either some information from his earlier sources (e.g. Q. Fabius Pictor who was apparently a witness of, or participant in these campaigns), or as Pédech (1970, ii. 72 n. 2) believes, drew on a relatively contemporary incident involving the Gauls in Asia Minor.

We may note that in the Old Irish tale *Cath Maige Tuired* (Grey 1982, 54–5), the warriors of the Tuatha Dé Danaan were assisted after each day's fighting by the

[2] Walbank 1957.

smith-god *Gobniu* who effected repairs to their weapons: 'Although their weapons were blunted one day, they were restored the next, because Gobniu was in the forge making swords and spears and javelins.' One notes that although Gobniu pledged to equip warriors with weapons that were infallibly lethal, he made no such promises for their quality. This is interesting in view of the emphasis placed on the splendour of hero's weapons generally in early Irish tales, and may reflect a tradition of poor quality iron adorned with high-quality non-ferrous metalwork and organics (Scott 1990, 172). This would accord both with the opinions of Classical writers such as Polybius and with at least some of the metallographic evidence presented in Chapters 6 and 7.

Whatever the grounds for his comment, the metallographic evidence shows that Polybius was right up to a point. To judge from the swords examined in this survey, only one third could be described as conforming to the quality which he ascribed generally to Celtic swords.[3] Even so, it is quite possible that some of the better-quality blades would have failed in battle, possibly more than once. Despite these reservations, however, the fact remains that warriors wielding these swords spread terror throughout Italy, Spain, the Balkans, and Asia Minor.[4]

Notches on Blades

Some swords have been found which show what appear to be actual traces of combat in the form of notches and indentations on their cutting-edges, although such features are rare due to the effects of corrosion. Nevertheless, there are some important finds among specimens well preserved in the anaerobic conditions obtaining in lake and bog deposits, or by the scale formed during cremation rites. Good examples include blades from La Tène and Port where swords show damage in the form of deep cuts or notches and also by long stretches of blunting of their edges,[5] these features having been interpreted as resulting from combat (Vouga 1923, 32; Wyss 1968, 674 and 680). The assemblages of weapons from Gournay, Faye l'Abbesse, and Nalliers also yielded several swords with notched cutting-edges, and in the case of sword 3113, these are concentrated along the edges, close to the point, and distributed symmetrically over both edges.

The problems associated with interpreting this evidence have been discussed frequently. Notching of blades is most commonly observed on the well-preserved assemblages of Middle and Late Romano-Barbarian times in the Germanic world, the majority of them from large Danish bog deposits of Nydam, Vimose, Illerup,

[3] This figure is based on the 122 swords included in our survey, and could well be altered by future research. Thus, in 1974 when data from some 50 examinations were available, the opposite was observed, with the proportion of good to inferior swords being 1:2!

[4] Celtic arms must have been of good quality for them to have replaced those worn by Punic warriors during Hannibal's campaign (Polybius 3. 49). In Spain, Celtiberian warriors were explicitly admired for the quality of their swords (Diodorus 5. 33. 3–4). They had to pass the test of being bent over the head from shoulder to shoulder and recovering their straightness (Philo *Mechaniké*, 4. 71).

[5] Bernisches Historisches Museum, e.g. nos. 13700 and 13687 (see Wyss 1968, pl. 5.2–3).

and Eisbøl,[6] each of which has produced examples. Similar features may also be observed in more easterly regions, as in the assemblage of the Przeworsk Culture in Poland where the assemblage of grave finds from sites at Gostomia, Kapalica, Gacz and Babice[7] are of particular note. Both in Denmark and in Poland, not only swords, but also scabbard suspension fittings, spearheads, shield-bosses, and shield-handles show this kind of mutilation.

Two views of the notching of swords and other weapons are current. On the one hand, this feature is regarded as evidence for the ritual 'killing' of weapons whose function was ended as, for example, the weapons of defeated enemies thrown into bogs as sacrifice (*spolia opima*), or those of a renowned warrior whose weapons 'died' with him as a part of the funerary rite.[8] On the other hand, such cuts and indentations have been interpreted as evidence not only of use in battle but also of a warrior's fighting qualities.[9]

In reviewing the evidence of Germanic finds from the Romano-Barbarian period, the supposition that this was intentional destruction of artefacts is strengthened by the fact that similar damage is observed on objects other than weapons, such as ornaments and bronze vessels (Biborski 1981, 58 f.). Damage is also observed on parts of weapons that would not normally have been exposed to the blows of an opponent's sword—the pommels of swords and handles of shields. And, in the case of some spearheads, there are notches which are aligned from the sockets of the weapons. Sometimes also, notches seem to be too deep to be the result of battle (up to 12 mm deep, even in the cases of some steel-edged swords). One of the Nydam swords bore 23 indentations in one cutting-edge and 11 in the other (Englehardt 1865, 65 n. 1). At Eisbøl, the notching resulted from cuts received after the arms had been annealed in a (ritual?) fire (Ørsnes 1963, 235).

To date, similar damage to La Tène period weapons has not been submitted to detailed analysis. It would seem that the annihilation of the fatal power of a sword by bending its blade (Fig. 19), attested both in deposit (Gournay) and grave assemblages (in the north Italian Alpine valleys, Pannonia and the north-eastern Celtic territories), was inspired by particular rites. The explanation of the notched cutting-edges of the swords from La Tène, Port, and Gournay may be ambiguous. The strict symmetry of the arrangement of notches in restricted zones of both cutting-edges on Gournay 3113 (Uran 1983, 101, fig. iv.1–24 and 25) militates against its having been caused in the course of battle.

[6] Nydam: Englehardt 1865, Pl. vi.10 and vii.16. Vimose: Englehardt 1865; Ilkjaer 1975, 137, 160, and fig. 20. Illerup: Andersen 1956, 9; Ilkjaer and Lønstrup 1975, fig. 13. Eisbøl: Ørsnes 1963, 265.

[7] Biborski 1981, 55 ff.

[8] Englehardt 1865, 65. Some doubt was later thrown on the idea of a collective offering, such as might be made after a victory in battle, because of the chronological spread represented within the assemblage, and the idea of smaller, periodic offerings was offered as an alternative explanation. Analysing the Eisbøl find, Ørsnes (1963, 239–46) concluded that while periodic small offerings might have been made at the site, there were at least two larger groups of weapons and other artefacts (parts of the spoils of war) thrown into the bog. Before deposition, both (the southern and the heap of finds in the northern agglomeration) had been subjected to fire and to mechanical damage.

[9] Gebühr (1977, 1980) draws the distinction between smaller dents in the central margins of blades produced by offensive strokes, and deep and oblique notches in the upper margins, closer to the guard, which represent defensive parrying.

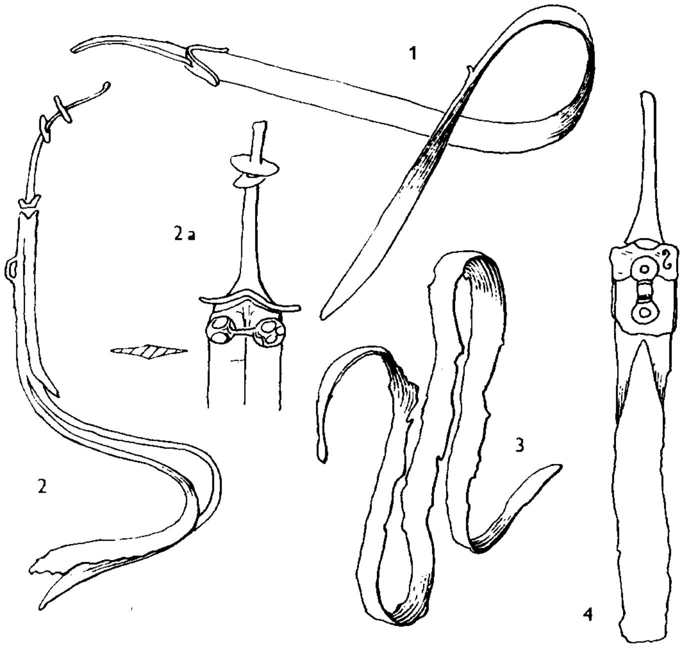


Fig. 19. Ritual bending of Celtic swords

From the historical records we know that the weapons of defeated enemies were sacrificed in temples and sacred areas,[10] and among these might well be included weapons damaged in combat. On the other hand, it is also conceivable that weapons destined for deposition as part of ritual might be damaged deliberately (or damaged further) by bending the blade, or by destroying the cutting-edges by various means, to demonstrate that their function was now at an end.[11] We must also ask why only certain weapons received this treatment before they were buried in places of worship or interred in graves. In fact, the problem admits of no solution, since we are faced with an impenetrable jungle of unknown and irretrievable possibilities concerning details of ceremony and ritual. In the face of this, further discussion and speculation is really meaningless.

[10] In Ancient Greece, votive offerings are mentioned in texts, and some of these sacrifices have been recovered in the course of archaeological excavation from the treasuries of temples, such as those at Perachora, Olympia, Delphi, and Dodona. For a similar tradition in Republican Rome, see Propertius *Elegiae* 4. 10 (*spolia opima*); Plutarch *Marcellus* 4, *Romulus* 16. 5–6. Celtic votive deposits are specifically referred to by Caesar in *BG* 6. 17. 3–5 (Edwards 1970, 342–3): 'To Mars, when they [the Gauls] have determined on a decisive battle, they dedicate as a rule whatever spoil they may take. After the victory they sacrifice such living things as they have taken, and all the other effects they gather into one place. In many states heaps of such objects are to be seen piled up in hallowed spots, and it has not often happened that a man, in defiance of religious scruple, has dared to conceal such spoils in his house or remove them from their place, and the most grievious punishment, with torture, is ordained for such an offence.'

[11] We may recall the almost romantic symbolism of the breaking of the sword at the moment of surrender. It might also be noted, however, that in more recent times, the ceremonial breaking of a sword has formed a part of the disgracing of an officer.

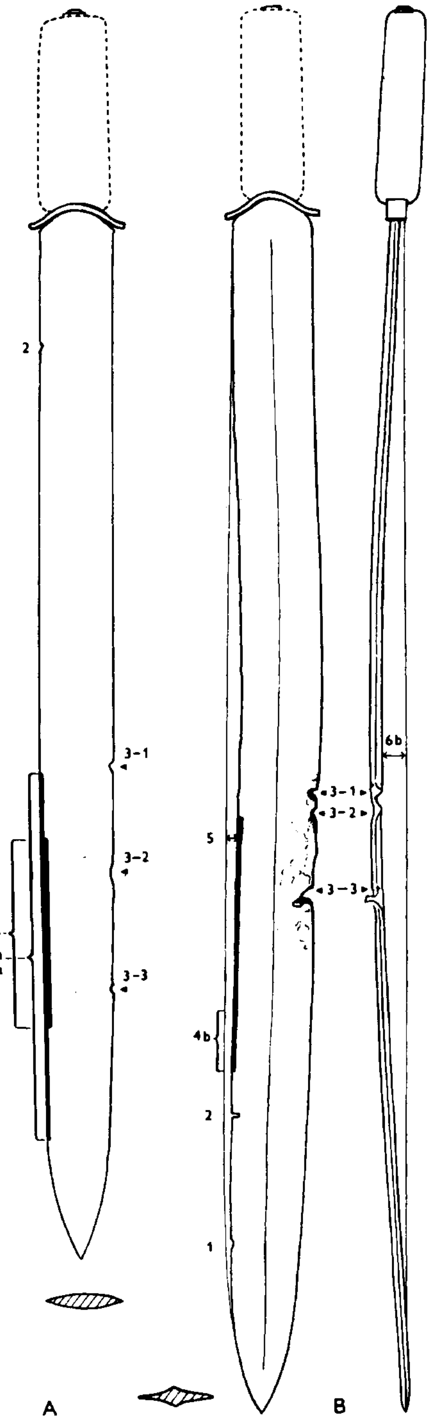


Fig. 20. Deformation of the test blades caused by experimental strokes

Practical testing

To get a preliminary idea of the effects of various strokes and cuts on swords, we subjected the roughly-forged low-carbon steel (*c*.0.2% C) swords from our experiments to some improvised trials.[12] The types of blows simulated and their effects are summarized in Table 12 and illustrated in Fig. 20. Although it would be premature to draw definite conclusions from our limited trials, some comments are worth making.

The strokes were made with some vigour, but without exerting the maximum force possible. The so-called offensive blow (after Gebühr), made with the middle-section of the blade may cause a deeper and more visible trace on the attacking than on the parrying blade (see Table 12, no. 2). Forceful blows easily produced notches on the parrying blade up to 5 mm in depth (and, if more strength were exerted by the attacker, these notches would correspondingly be deeper). Blade A (with lenticular cross-section) resisted damage better than Blade B (with midrib), taking notches about 1 mm in depth. Blade B, which was thinner at the cutting-edges, suffered considerably. With both blades, bending only occurred when

[12] To have obtained results that might be considered definitive would have required the organization of tests involving the different techniques of using arms, and of simulating battle conditions.

TABLE 12. *Damage on the experimental swords after simulated cuts*

Simulated action	Effect on sword A (flat blade, 0.2% C)	Effect on sword B (midrib, 0.2% C)	Effect on other objects attacked
1. Blow against the edge of a steel chest	–	round notch, 1.4 mm	rounded edge slightly scratched, not measurable
2. Offensive blow with the proximal part of B against A	round notch 0.4 mm	narrow rectangular notch, 3.1 mm deep, 1 mm wide	–
3. Triple set of blows of A against B in an immediate sequence:			
blow 1	round notch 1.5 mm	triangular notch, 2.2 mm	–
blow 2	round notch 1.3 mm	round notch, 0.9 mm	–
blow 3	round notch 0.6 mm	triangular notch, 5 mm deep, turned out fissure	–

4. Blows into a simulated helmet (iron sheet, 1 mm thick, 0.05% C):			
a. intensive stroke	no notch, slight trace on the cutting-edge 115 mm long	–	groove-shaped depression in the iron sheet, 18 mm deep
b. less intensive stroke	–	no notch, slight trace on the cutting-edge, 35 mm long	the same, 3 mm deep
5. Blow into an iron-fitted shield (iron band, 1mm thick, 0.05% C)	–	no notch but sabre-curved deformation of the blade, an arch 6.4 mm high, slight mark on cutting-edge, length 142 mm	depression in the iron band, cut in the wood, 3 mm deep
6. Blows into an iron sheet with a bulged midrib (1.7 mm thick 0.05% C):			
a. intensive stroke	no notch	–	groove-shaped depression 320 mm long, 9 mm deep (in the midrib), 5.2 mm close to the midrib
b (slid off blow)	–	no notch, blade flat-arched (10 mm)	No trace

See also Fig. 20.

surfaces (such as those of a shield) were struck, and no notches were produced. The sort of doubling-over which Plutarch claimed was not observed, and indeed from our tests seems quite unimaginable. We used a 1 mm thick iron sheet for this test, and found that while the swords did not penetrate it, the blows made deep depressions which, had it been the metal of an opponent's helmet, would presumably have caused him injury (cf. Dent 1983).

Longer and more energetic combat could well have resulted in the destruction of the cutting-edges, similar to that attested in the positions to be expected on swords from bog deposits. This, however, still leaves unresolved the questions surrounding the ritual destruction of weapons. Despite Polybius' assertions, it is probably that a warrior armed with a simple mild steel sword of La Tène type would have been able to deliver more than one good cutting stroke, and that he would have been able to continue to fight even though the edges of his sword would have become indented and after a time seriously damaged.

Summary and Conclusions

The origins of the European long sword lie in the Bronze Age, apparently developing as a thrusting weapon, under Mycenaean influence, from the dagger. Its employment was limited then to men of high status within communities who used daggers, swords, and other kinds of display weapons both as symbols of their leadership, and in fulfilling their personal responsibilities in armed conflicts, particularly in introductory or final combat. It may be assumed that the use of weapons of this kind was bound up with ceremony and ritual that were a feature of encounters between adversaries of equal standing. By the very end of the Bronze Age, the sword began to be adapted as a cutting weapon. The reasons for this are not clear, but improvements in the protection of warriors in the form of the first metal armour might have lended some impetus to this development. Certainly, it seems doubtful that the shift to cutting swords came about through combat from chariot or on horseback.

The *Iliad* appears to encapsulate the decline of the era of close-quarters fighting between leaders. Although bodies of rank-and-file warriors are portrayed as engaged in battles, their role is played down, and the decisive encounters still take the form of single combat between chiefs. But the trend towards the importance of the rank-and-file was brought to its logical conclusion by the Classical civilizations of the Mediterranean who began to fight battles using troops manœuvring under their generals' commands in closed phalanx-like formations. Long swords, ineffective (even a handicap) in clashes of this kind were replaced in these civilizations by shorter thrusting weapons, since short swords and daggers could be used effectively in confined spaces.

Among the Celts, however, the archaic mode of fighting survived until their dominance by the Romans in Europe and Britain, and even later in Ireland. Battles continued to commence or be concluded by single combat between the foremost warriors, chiefs, or kings, using long swords, almost as a ceremonial. Initial mass attacks were in essence wild assaults of disorganized mobs armed with long swords and spears. The swords of the Celts are to be interpreted as a characteristic element in the confrontation between their ancient world which was in the process of dissolution, and those of the Romans and Greeks.

The thousands of swords which have been found in European La Tène period cemeteries and votive deposits provide archaeological evidence for their history and development. The plans of graves show that swords were long, about 70 cm in length and 4–5 cm wide (although some Late La Tène examples exceed 100 cm in length), and almost invariably were worn on the right side. In Continental cemeteries, sword-graves account for 5–30 per cent of the total number of burials, and some scholars have interpreted this as indicating a strong military ruling class among Celtic communities. This is in accordance with the image portrayed by the written records of the campaigns of the Gauls in Italy, Spain, and Greece. When analysing the compositions of cemeteries, however, we must take into account the lengths of time in which they were in use. Sword-bearers seem, in fact, to have been recruited from among the heads of smaller social units, communities, and extended families, that is from land-owners and sometimes their brothers and elder sons. These men united for raids, forming the terrifying bands described by ancient authors. The high casualty rate suffered by the Celts in those areas of northern Italy, Greece, and elsewhere which were most raided, might have led to the social range included in raiding parties being widened to include the armed retinues of kings and chiefs. This situation might be reflected by the higher proportion of sword-graves to be found in cemeteries in these regions.

It is difficult to distinguish the tombs of chiefs who controlled large, well-populated territories solely on the data so far available from the swords they contain. Neither the richly decorated sword scabbards, whose motifs may have been charged with symbolism, nor the punchmarks on individual blades, have a direct relationship to the level of social standing of their owners. The same applies also to the quality of the weapons, since punchmarked blades contained in decorated scabbards vary greatly in the level of technology employed in their manufacture.

The functions of two other types of Celtic sword—short anthropoid-hilted daggers and the long thrusting rapiers known as *Knollenknaufschwerter*—are also unclear. If the former can be ascribed to prominent warriors (if not to chiefs), the status of the latter remains quite obscure. The fact that this weapon, equipped with unusual suspension gear, and quite unsuitable for use in close battle, comes exclusively from lakes and rivers, has given rise to the hypothesis that it might have been used in ceremonial combat only, such as in ordeal by combat or similar (now unknown) rituals.

The manufacturing technology displayed by Celtic swords provides valuable information on the level of skill attained by blacksmiths. The experimental forging to the same size of the two types of La Tène blades described in Chapter 5 demonstrates that it is possible to shape a sword by hot forging from a bar about 40 cm long, 4 cm wide and 8 mm thick. The form of the initial stock was copied from an original found at Port in Switzerland, of the type known as *Schwertbarren* or *saumon d'épée*. The type with central midrib was derived in design from ancient thrusting swords of bronze and demanded more skill and time than the simple blade. A total of 36 heats (some 6 hours net) were required to produce the basic blade shape, without any surface-finishing. The flat blade which had a lenticular cross-section required only 16 heats and less than 2 hours net of hot forging. When the time taken to make and fit the guard, hilt, and pommel is taken into consideration, then one day's work seems to be a reasonable estimate of the time taken to produce the basic La Tène style sword, although we assume that final finishing to produce a smooth, polished blade would have consumed more time than the forging process.

In our view, each roughed out bar of stock already carried the internal scheme of construction of the finished sword. The type of stock used ranged from single pieces of iron or carbon steel, to bars made by welding together several bands of different composition, including contents of phosphorus and carbon, and properties. The preparation of the stock obviously required additional time to that expended on the shaping of the sword, and itself was a task reflecting the skill of the smith. The constructional scheme of a sword-blade can be recognized, sometimes clearly, sometimes only in outline, through metallographic examination of sections which cover the whole of the blade cross-section. From a sample of 122 swords, a minority of about 36 per cent consisted of softer metal and are considered of inferior quality. Some of the group were piled by the welding together of strips of metal, either to produce surface-to-surface laminae in section, or, much less commonly, butt-welded to produce edge-to-edge laminae.

More than 60 per cent of blades contain mild (0.3–0.5 per cent C) or hard (0.5–0.8 per cent C) carbon steels in their cutting-edges, and this usually would have imparted greater hardness over edges made of metal with lower carbon contents. With the exception of some blades made entirely from steel, wrought iron and steel strips alternated. Forge-welding together of different types of metal requires considerable skill on the part of the smith, and this is a point worthy of note when considering the various constructional schemes observed. In addition to one-piece construction, swords were also made by welding a steel core between two iron shells, or an iron core between two steel shells, or by welding together a pile of strips each offset slightly one from the other, so that in each case the weld-seams run through the body of the blade. Interestingly, a group of swords whose main provenances lie in Czechoslovakia (19 per cent of the sample), and which conform outwardly to the normal design of La Tène swords, show the use of steel in only one of the two cutting-edges. The best swords found in this survey come from Cleebronn in Germany and Cuvio in Italy, and are pattern-welded in the classic sense of the term. The cross-section of the Cuvio sword, unfortunately unstratified, shows steel cutting-edges welded on to a three-piece core, the outer surfaces of which were made by welding together panels of twisted iron and steel wires. The butt-welded blades of Celtic swords incorporate technology that was the predecessor of pattern-welding, which became fully developed in Roman times, and survived in swords up to the Middle Ages, and in the construction of gun barrels up to the nineteenth century.

Whatever the scheme used, the stock from which the swords were made in the La Tène period was of heterogeneous carburization, a feature which tends to obscure the pattern of construction so that in some cases, no specific design can be discerned. In these cases, the smith probably used whatever material was to hand, without any regard for its physical properties.

We may conclude that while some sword-blades made in the Celtic territories were beginning to be made using sophisticated designs and construction, the majority of sword-smiths had only just started to gain an empirical understanding, through practical working, of the various materials. Thus, for example, we find well-made welds alongside badly made ones, and quench-hardening had not been mastered. A very small number of blades (about 5–6 per cent of our sample) show fine pearlite with above-average hardness which must have resulted from a fairly rapid cooling in air. However, we do not know whether or not this was intentional.

There are still many questions remaining to be answered. For example, how do we explain the fact that in many cemeteries, swords made by different techniques appear? How many smiths supplied a community or group of communities with swords within a micro-region? Were individual smiths wedded to set practices, or did they vary them? Did there exist anywhere in the Celtic regions rudimentary schools of sword-smithing? What percentage of the swords found in any cemetery came from outside the locality which it served? We will not be able to provide anything approaching satisfactory answers to such questions until much more research has been carried out.

We are also ill-informed about the manufacturing technologies employed in making sheet scabbards. A few examinations suggest that soft iron (possibly differing in source for that used for blades) was normally hammered out to form the front and back plates. These plates were then clasped together at the edges in three different ways. In the case of the scabbard from Maňa in Slovakia, a sophisticated design of reinforcement was identified in which the soft iron sheet was strengthened by welding steel wires to the insides of the plates. Despite this, the blade which this scabbard held was made of soft wrought iron.

In summary, then, we have identified ten constructional schemes among the 122 blades surveyed, and a wide variety in their quality. But in general, were they really so inferior as Polybius' account (2. 33. 5), exaggerated by later writers, would lead us to believe? The majority of swords in our sample had at least one steel cutting-edge, and would have been effective in combat. Some 40 per cent of them were of poor quality, having been made of soft iron. But again, used skilfully, these too could have fulfilled the basic aim of despatching an enemy. Even when their cutting-edges were marked by the notches resulting from clashes with other weapons, La Tène swords would have been capable of inflicting devastating injury. As our improvised experiments showed, the more solid blades of lenticular cross-section resisted damage far better than the thinner-edged swords with midribs. In addition, the swords with midribs were inclined to bend slightly, but certainly not to bend double as Plutarch stated. We have the impression that swords with midribs followed the tradition of the ancient bronze thrusting rapiers, while the blade with lenticular cross-section was an out-and-out cutting and slashing weapon. And we must still come back to the fact that whatever the criticisms made, Roman writers continued to stress the fear and terror which warriors wielding such swords instilled for many centuries in the Classical world.

The cause of the Celtic decline on the Continent was not their swords, but rather the structure of their society which was not fully mature at the critical time when they clashed with the more advanced civilizations of the Mediterranean world. Indeed, the manufacture of the Celtic sword must be recognized as an important stage in the development of European ironworking in general.

It is noteworthy that the Celtic sword, however archaic the system of fighting it embodied might have seemed to the Romans, survived through subsequent ages and formed, in a modified guise, the principal weapon of European feudalism.

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Glossary of Technical Terms

Annealing. The slow heating of iron and steel at temperatures between 500–720 °C, mainly 600–650 °C, for more than one hour. This eases the distortion of the crystal lattice, leading to recrystallization of ferrite grains that were deformed by cold-hammering, and to spheroidization of the cementite lamellae in pearlite (globular pearlite). Annealing, followed by slow cooling, makes the metal softer and more ductile.

Austenite. A solid solution of carbon (or other elements) in face-centred γ -iron. In carbon steels, austenite appears only above the critical temperature (more than 721 °C). Cooling of austenitic structure below the critical temperature leads to the crystallization of ferrite and pearlite, while very rapid cooling (quenching) leads to martensite.

Bainite. An acicular aggregate of ferrite and cementite formed when austenite is isothermally transformed at intermediate temperatures (below the pearlite range and above the martensite range). Developed by more moderate heat treatment than in quenching.

Bloom. A rough piece of iron or steel of pasty consistency, produced by the direct (bloomery) process of iron smelting in bloomery furnaces, at temperatures of 1200–1300 °C. Blooms contained much entrapped slag and have to be refined by reheating and re-forging. Their carbon content varies.

Carbon in iron. As an alloying component, carbon increases the hardness of iron (carbon steel) and simultaneously its brittleness. Carbon is absorbed by iron during the reduction of ore in the furnace and during secondary carburization.

Carburization. The introduction of carbon into iron by prolonged heating (above 900 °C) in contact with carbon-containing substances, essentially with charcoal. Nitrogenous materials accelerate carburization, phosphorus tends to block it. Carburization is used for steeling surfaces of iron artefacts, especially their cutting-edges.

Cementite. The hard and brittle iron carbide Fe_3C, which occurs in steel (and cast iron) either as a component of pearlite, or as the white cementite network surrounding pearlitic grains in hypereutectoid steel. In extremly low-carbon materials, cementite films appear at the ferrite grain boundaries.

Cold-hammering (forging, working) of iron. This deforms the ferrite grains, causing brittleness but to a certain extent increasing hardness. Forging at low temperatures (below 500 °C) develops fissures in grains (Neumann bands). The effects of cold hammering may be removed by annealing. Small objects may be shaped by cold-working (iron rivets, wires, sheets).

Drawing out. A forging operation performed by the hammer edge (usually the pane) in transversal strokes. The rod or bar becomes longer and thinner.

Eutectoid steel. Hard steel, containing about 0.86% C. The structure is pearlitic. Steel with lower carbon content is called hypoeutectoid steel (with varying proportions of ferrite), that with higher carbon content is hypereutectoid steel (with a white cementite network around pearlitic grains).

Ferrite. Ductile crystals of almost pure body-centred α -iron, containing no carbon or a minimal amount (0.02–0.03% C). Ferritic iron is easily malleable and relatively soft. It appears as a white structure in the optical field of the microscope.

Grain-size. There are coarse-grained and fine-grained crystalline structures in iron and steel (ferrite, pearlite) which have been classified according to the size of individual grains by the American Society for Testing Materials (ASTM). The classes (1–8, with additional classes 9–12) were derived from the number of grains per unit area of cross-section. Well-performed hot-forging produces fine grains; slow cooling of unworked iron produces coarse grains. Acicular structures (bainite, martensite) may be fine or coarse.

Hammerscale. The oxidized surface skin developed by the heating of iron, consisting of wüstite and magnetite crystals. Hammerscale should be removed especially before welding, either mechanically by shocks (hammerscale flakes of typical bluish-grey colour) or by adding fluxes (quartz sand, etc.) to produce liquid slag.

Hardenite. A now obsolete term for martensite, sometimes denoting a very fine martensitic structure.

Heyn's reagent. A solution of ammonium cupric dichloride in water, used for macroetching polished iron and steel specimens, revealing the phosphorus and carbon distribution.

Hypereutectoid steel. *See* Eutectoid steel.

Hypoeutectoid steel. *See* Eutectoid steel.

Inclusions. Non-metallic impurities in the crystalline metal matrix. In wrought iron and steel, they appear as elongated silicate (slag) inclusions, often following the lines of welds. They may be glassy or contain light oxide phases (fayalite, wüstite, the latter also in dendritic form). Globular oxides of various types may also occur. The quantity of inclusions may be expressed by the numbers 1–5 on the Swedish Jernkontoret scale, with the number 1 denoting the lowest (purest) degree.

Martensite. A solid solution of carbon in iron, cooled rapidly from the austenitic stage. It appears as a grey acicular structure, typical of quench-hardened carbon steels. It is very hard and brittle. When heated it changes into pearlite.

Microhardness. The hardness of individual grains in metals, determined by low loads of the measuring device, applying e.g. a diamond pyramid for impression (D.P.N. or Vickers method). Numbered units are derived from the diagonal lengths of impressions. There are other methods, too.

Neumann bands. Parallel twin lines occurring in ferrite grains of iron, worked heavily at temperatures below 500 °C.

Nital. The basic etching reagent used for distinguishing microstructures of iron and steel. It attacks different constituents of the structure, thus giving good optical contrasts. Nital is a solution of nitric acid in ethanol. A 5%-solution is used for macro-observation and a 2%-solution for microscopic observation.

Nitrides. Compounds of iron and nitrogen, appearing as short or longer needles within the ferrite grains ($Fe_{16}N_2$ or Fe_4N), usually in slow-cooled wrought iron. They originate primarily in the reducing furnace atmosphere.

Oberhoffer's reagent. A solution of cupric and ferric oxides, and tin dichloride in ethanol, hydrochloric acid, and distilled water. It reveals phosphorus enrichments and segregations in polished specimens of iron and steel.

Pattern-welding. A blacksmithing technique based on twisting and welding steel and wrought-iron wires and shaping these bundles into bars. Etching with acid reveals various wavy dark and light patterns on the polished surfaces of the bars, which usually form the core of excellent blades. The alternation of soft and hard materials in a twisted texture provides good resistance to bending, but since Roman times, pattern-welding has been primarily developed into a display technique and used also for inlays.

Pearlite. A lamellar conglomerate of ferrite and cementite in carbon steel. Its pearly lustre is due to the fine and regular alternations of the two constituents. Cementite, being harder than ferrite, is left in relief after etching, and the minute shadows cause pearlite to appear darker, when observed by the microscope. When annealed, the lamellae of cementite coagulate into globulae (globular pearlite). Pearlite is the basic microstructure of carbon steel.

Phosphorus in iron. Partly dissolved in ferrite as iron phosphide (Fe_3P), mostly forming segregations, particularly near inclusion chains and welds. Phosphorus, when present in amounts higher than 0.03%, increases the hardness and brittleness of iron significantly. To a certain extent it hinders carbon penetration into iron and improves its resistance to atmospheric corrosion.

Quench-hardening. Heating of carbon steel above the critical temperature range and its subsequent rapid cooling, e.g. in water (or oil, etc.). Not pearlite, but very hard martensite, is formed. Quenching in acids produces a more drastic effect.

Slag. A waste product of ore smelting, consisting of molten gangue constituents (glass and crystalline phases containing oxides) and varying residual metal contents which are high in the case of bloomery iron slags (about and over 50%), appearing as ferrous orthosilicate ($2FeO.SiO_2$, fayalite) and ferrous oxide (FeO, wüstite) or even metallic fibrous and crystalline particles. Slag, entrapped in pasty bloomery iron, occurs regularly as inclusions in forged objects. Removal of slag requires repeated heating and re-forging, which leads, naturally, to considerable metal loss by oxidation. Long forging disperses slag particles in the metal, especially from the welds.

Sorbite. A now obsolete term for the microstructure of steel, consisting of uniformly distributed globular or slightly acicular cementite particles, enclosed in a ferrite matrix, produced by tempering at about 550–650 °C from the quench-hardened martensitic state. The hardness remains considerable; the brittleness is reduced.

Steel. A malleable alloy of iron and carbon. In the case of carbon steel the carbon decisively determines hardness and other properties. Formerly, steel was denoted as hardenable material containing more than about 0.3% C (i.e. medium and hard steels). The microstructures of steel are pearlite (or pearlite-and-ferrite mixtures in varying proportions) or metastable quenched or tempered structures (martensite and its transformed products). Steel is harder than iron, but less malleable. It can be decarburized by drastic heating under oxidizing conditions.

Tempering. The process of re-heating of quench-hardened steel to temperatures below the transformation range (200–650 °C) and holding it for the appropriate time at that temperature, followed by rapid cooling. The hardness and brittleness decrease, the latter considerably. Smiths traditionally estimated temperature according to the temper colours (purple, violet, blue, etc.) of oxide layers on heated steel.

Troostite. A term used formerly for a microstructure of steel consisting of very fine carbides (cementite particles), obtained either by tempering martensitic steel at 240–450 °C, or by mild quenching (in oil, boiling water, etc.). It etches rapidly and appears as dark rosettes, e.g. in the martensitic matrix.

Upsetting. A forging operation during which the stock is shortened and its cross-section increased.

Welding. The uniting of two pieces of metal (here iron or steel) by raising their temperature to a plastic condition (720–1200 °C, austenitic state) and then hammering. Until recently the basic process was fire-welding in which the pieces of metal were joined after being heated in the blacksmith's hearth. Welding iron with iron is easier (and performed at higher temperatures, estimated according to light heat colours) than welding iron with steel, because steel is less malleable than iron and suffers, when rapidly heated, from decarburization. It is important to remove the hammerscale and slag before joining the surfaces.

Widmannstätten structure. A structure resulting when low-carbon steel is cooled at fast rates from very high temperatures. It consists of pearlite and ferrite of acicular, cross-hatched appearance arranged in certain crystallographical planes in each grain. The Widmannstätten structure is also formed in many non-ferrous alloys.

Wrought iron. A malleable and relatively soft iron, low in carbon, produced at low temperatures in a pasty consistency, and containing much entrapped slag. Bloomery iron belongs to this category.

Wüstite. Ferrous oxide FeO, often appearing as light grey phases (grains or dendritic formations) in bloomery slags, and also in slag inclusions of forged artefacts.

TOPOGRAPHICAL INDEX

Roman numerals refer to the list of figure captions at the beginning of the book.
Numbers in italic indicate references to figures.

SUBJECT INDEX

PLATES

I. Experimental forging of La Tène type sword-blades. *Left*: Bar of the 'saumon d'épée' type (after an original in Landesmuseum Zürich, found at Port, Switzerland), *Centre*: Sword *A* with flat blade (lenticular cross-section). *Right*: Sword *B* with central rib (lozenge-shaped cross-section). The hilts shown are not intended as reconstructions

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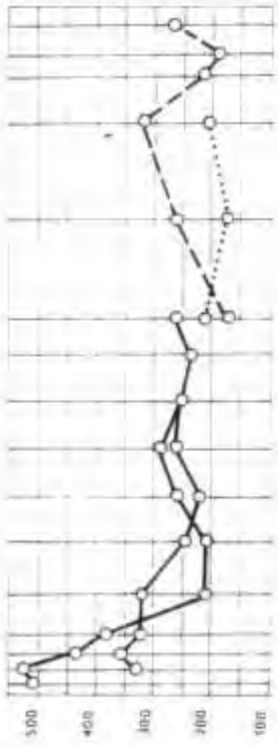

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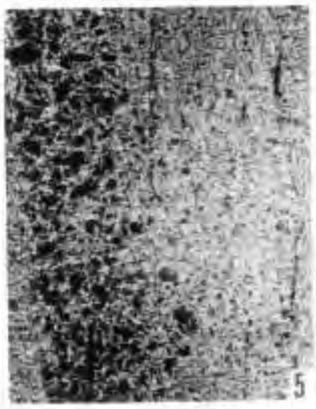

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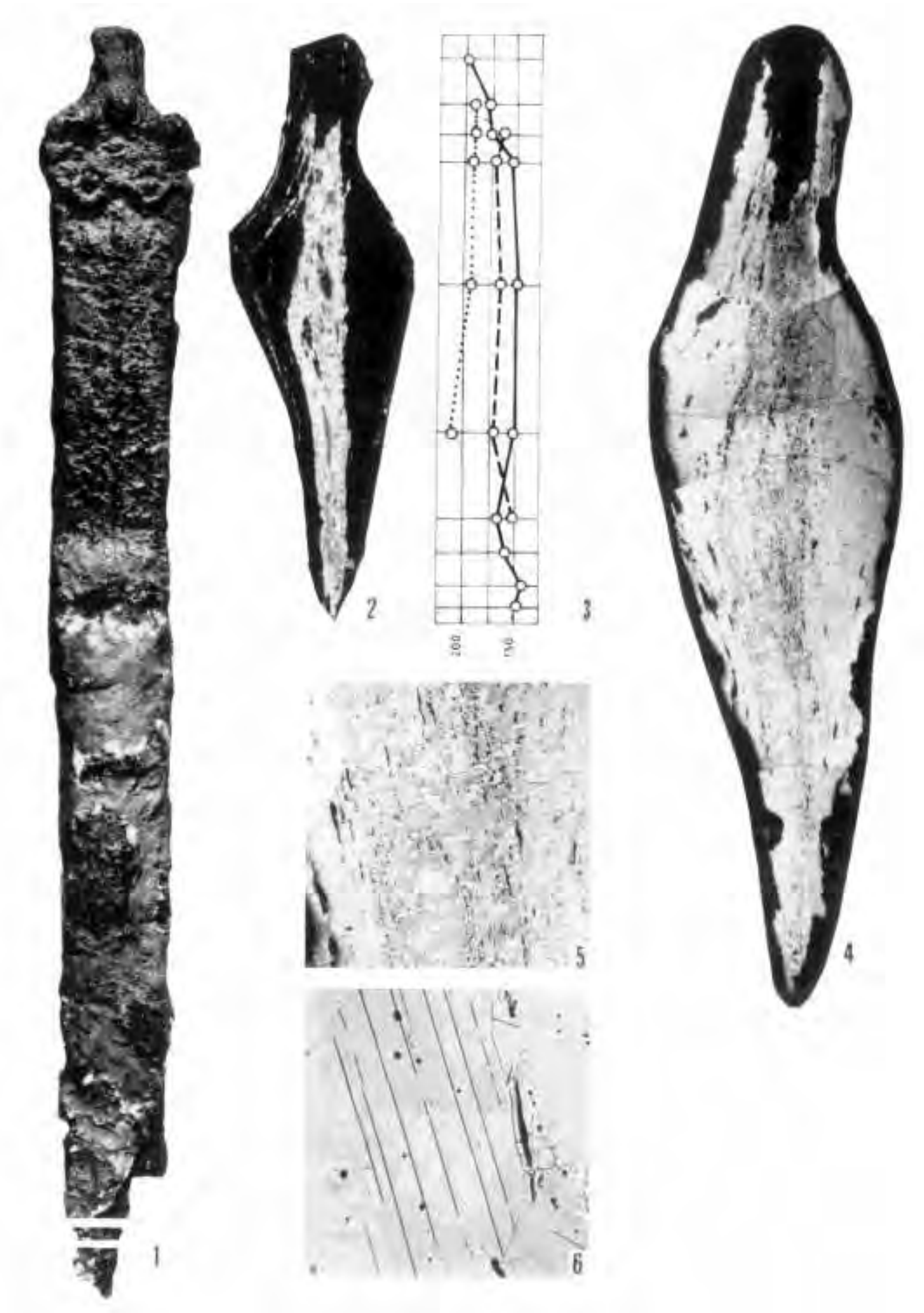
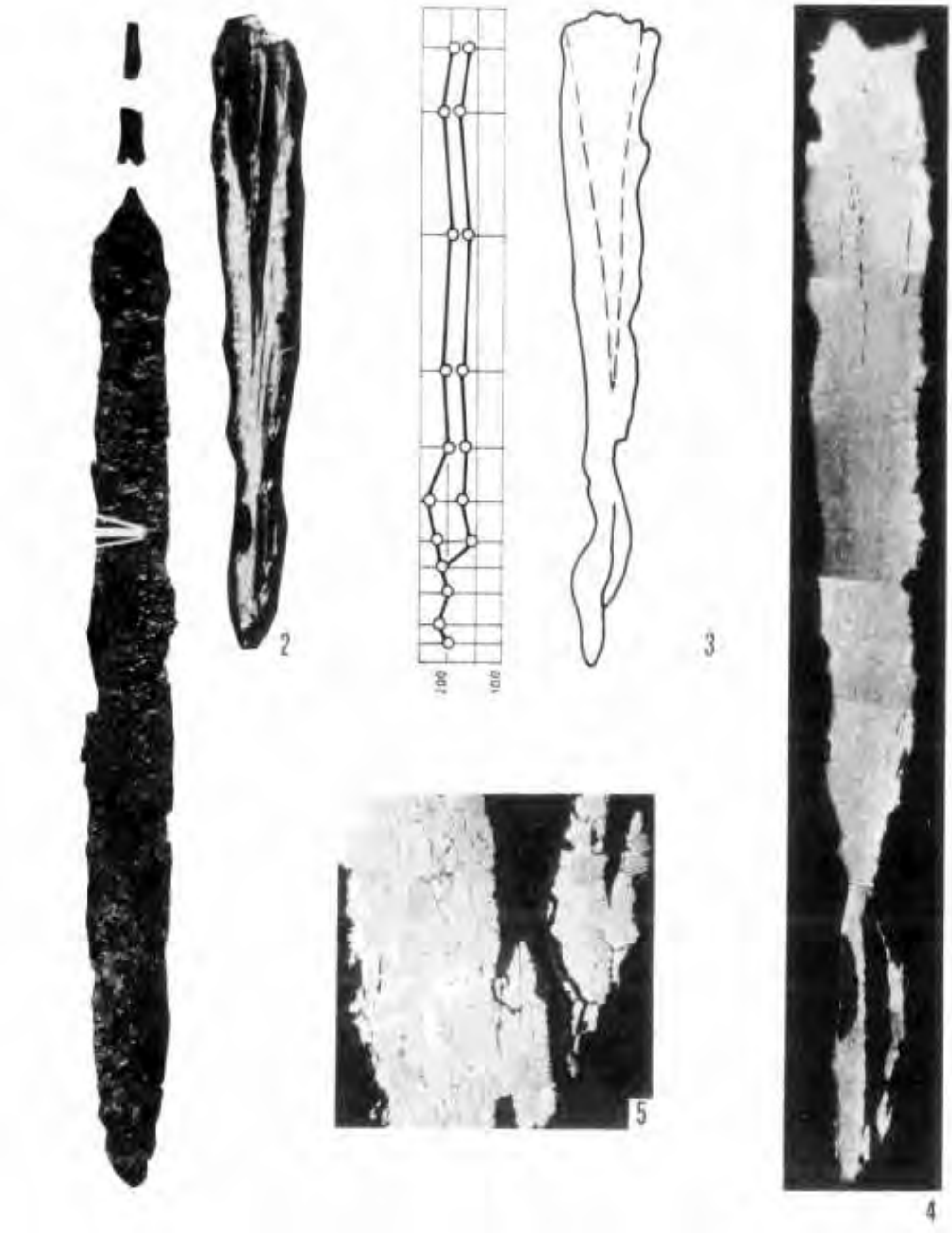
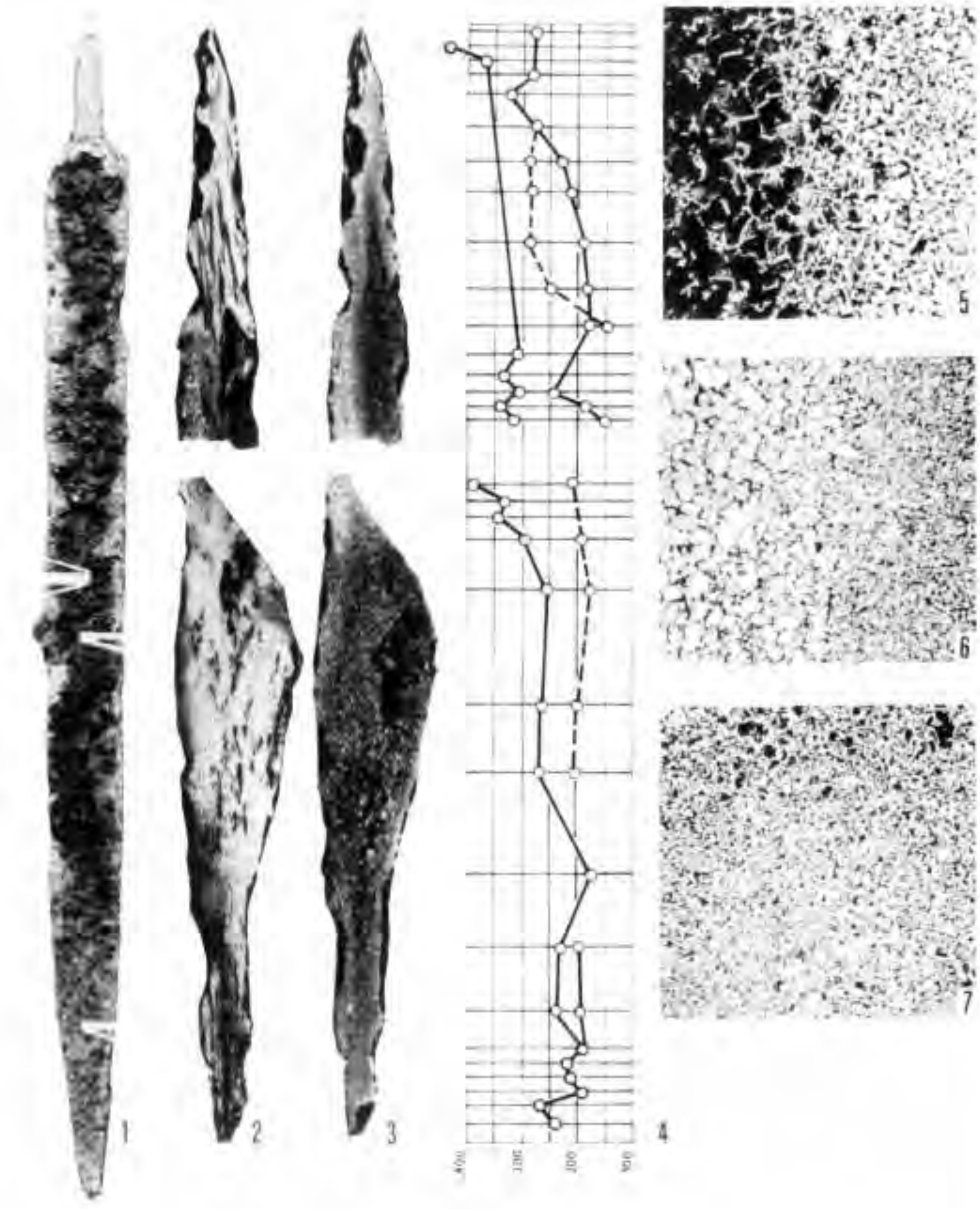
II. Jenišův Újezd 584, NW Bohemia, examination 1. 1 Blade in its scabbard, with specimen position marked; 2 Cross-section composed of microphotographs (2%-Nital): carburized zones in cutting edges, welding seam (×15) 3 Microhardness 30 g; 4 Cross-section, etched with Oberhoffer (×10): dark phosporus segregations follow the welds; 4 Pearlite with white ferritic network and fine pearlite-and-ferrite in the lower cutting edge, etched with 2%-Nital (×100)



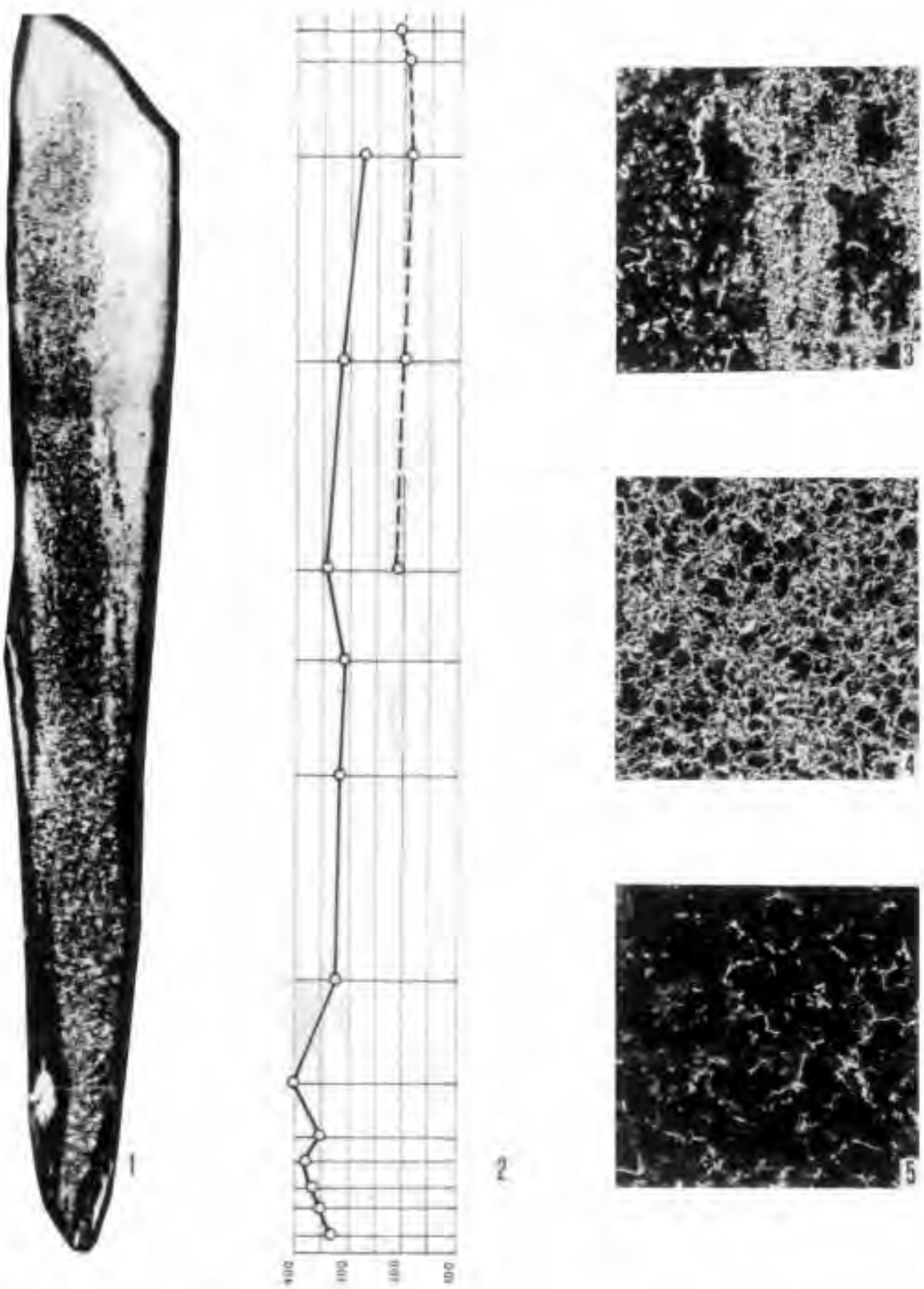
III. Jenišův Újezd 586, examination 2. 1 Blade in its scabbard, frontal side, with specimen position marked; 2 Cross-section, etched with Oberhoffer: both dark side-shells are rich in phosporus (×10); 3 Microhardness 30 g: central bar in solid line, side-shells hatched and dotted; 4 Cross-section composed from microphotographs (×19): the fine ferritic central zone is distinguished from both coarse ferritic shells; 5 Detail of microstructure, as in 4, (×100); 6 Neumann bands in the right shell, etched with 2%-Nital (×200)



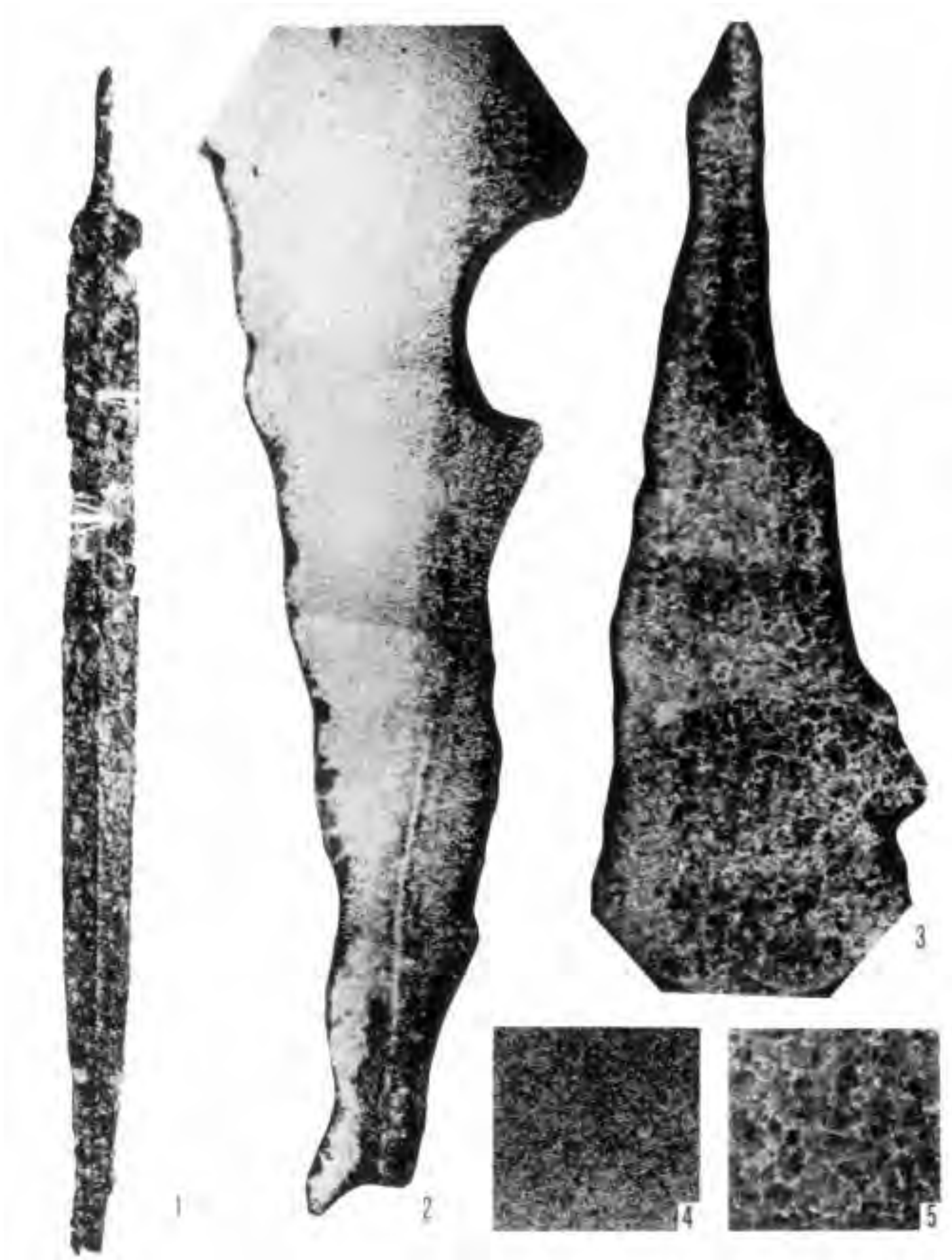
IV. Makotřasy 587, central Bohemia, examination 6. 1 Blade, with specimen position marked; 2 Cross-section, etched with Oberhoffer: a wedged shaped core with elevated phosphorus content (×7); 3 Microhardness 30 g, and a cross-section sketch, showing principal inclusion chains; 4 Cross-section composed from microphotographs, ferrite, etched with 2%-Nital (×15); 5 Cutting-edge: deformed ferrite grains (×100), etched with 2%-Nital



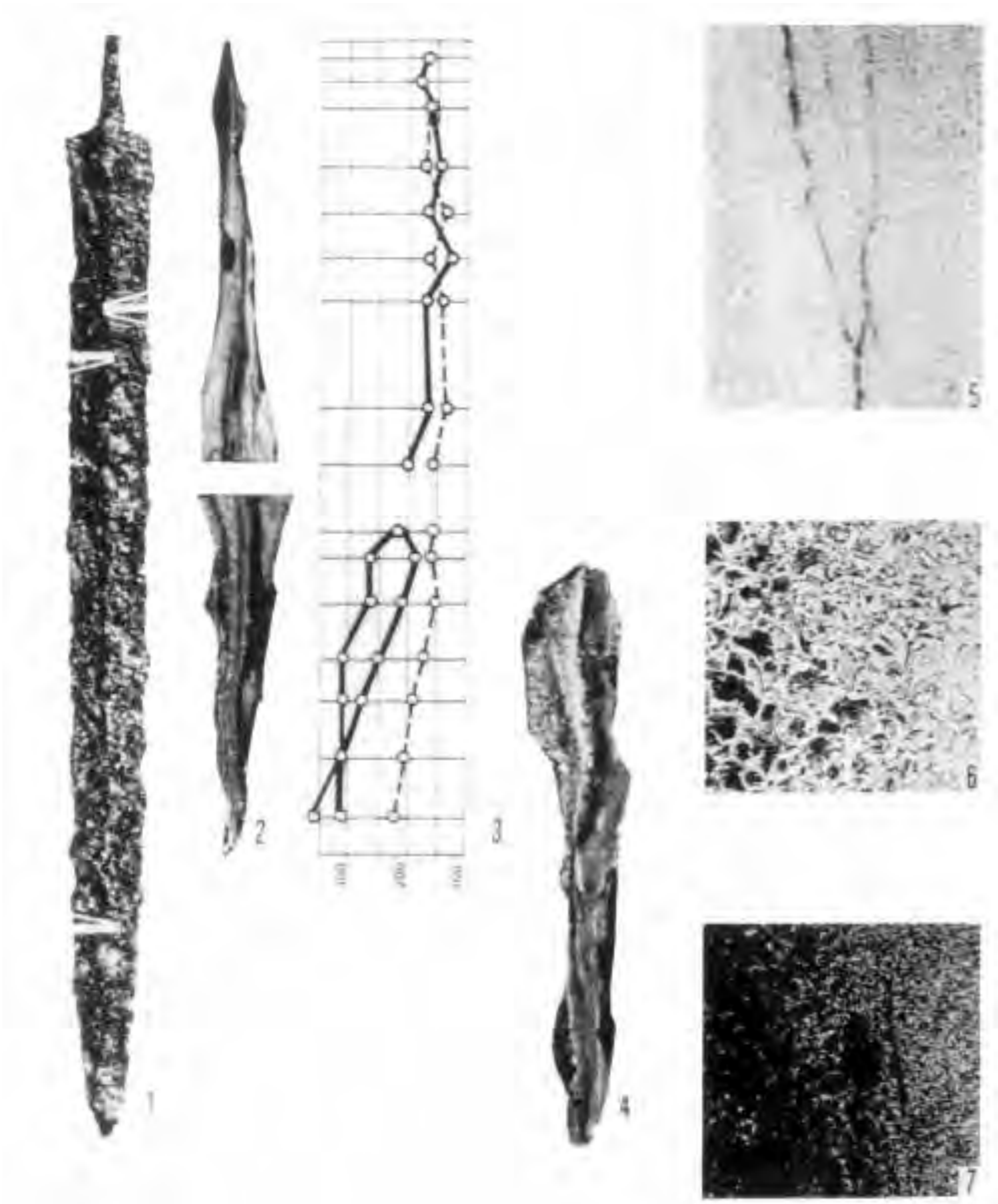
V. Makotřasy 588, examination 7. 1 Blade, with specimen positions marked; 2 Cross-section, etched with Oberhoffer; phosporus segregations appear dark (×6); 3 Cross-section, etched with 5%-Nital: carbon enriched areas are lighter; 4 Microhardness 30 g: solid line = pearlitic areas, hatched line = those with ferrite as major component; 5 Specimen *b*: dark pearlitic area left at the surface of the cutting-edge (×100); 6 Specimen *b*: light ferrite and transition to a fine ferrite-and-pearlite structure (×100); 7 Specimen *a*: fine ferrite-and-pearlite grains. 5–7 etched with 2%-Nital



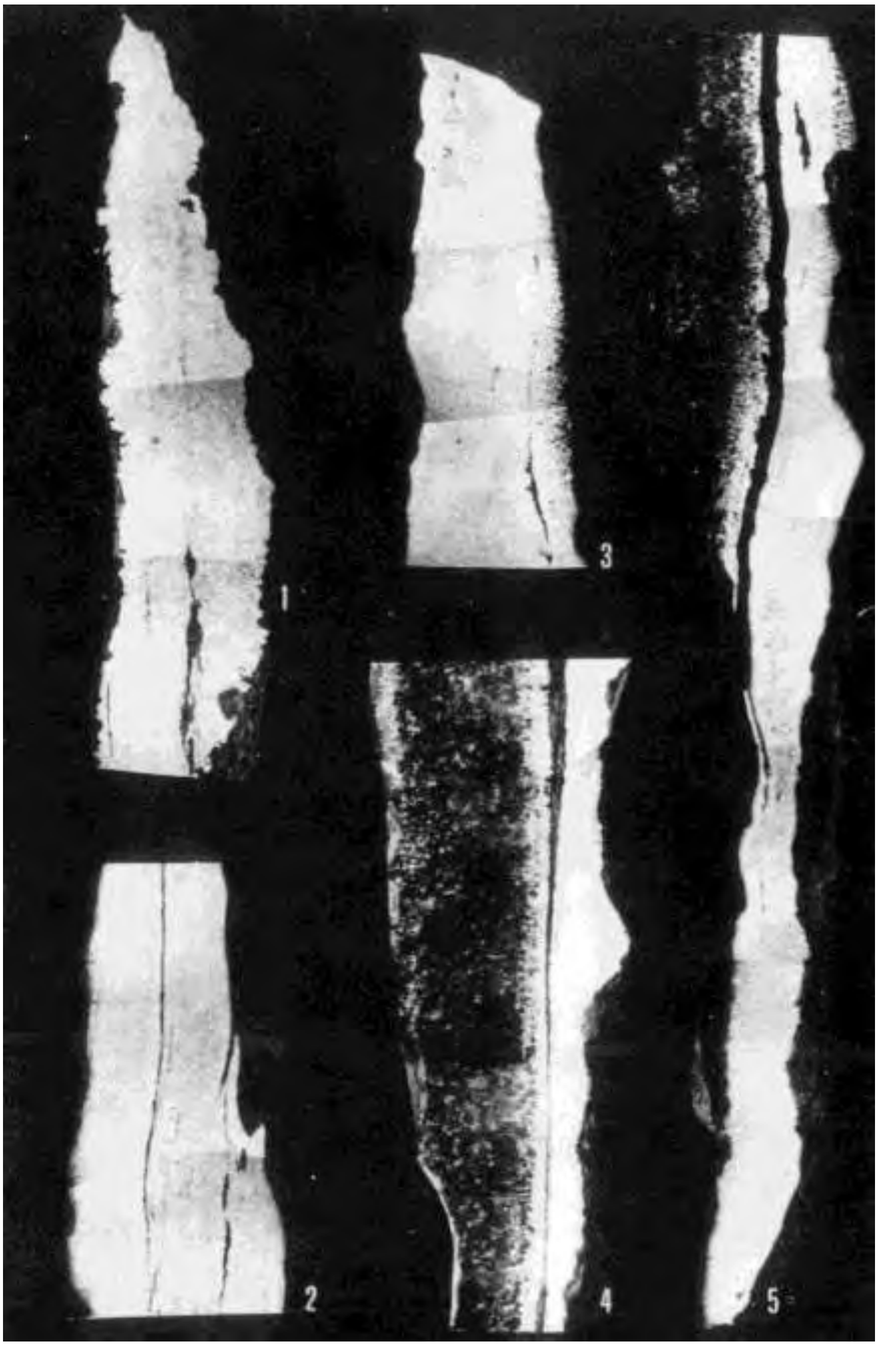
VI. Makotřasy 588, cutting-edge b_1, examination 7. 1 The specimen as composed from microphotographs (etched with 2%-Nital): dark pearlitic area and transition to ferritic-and-pearlitic and ferritic structures in the core (×13); 2 Microhardness 30 g: solid line = pearlite, hatched line = softer structures with prevailing ferrite; 3–5 Structures with varying grain size and different proportion of pearlite (dark) and ferrite (white) (3 and 5 ×150, 4 × 100). Etched with 2%-Nital



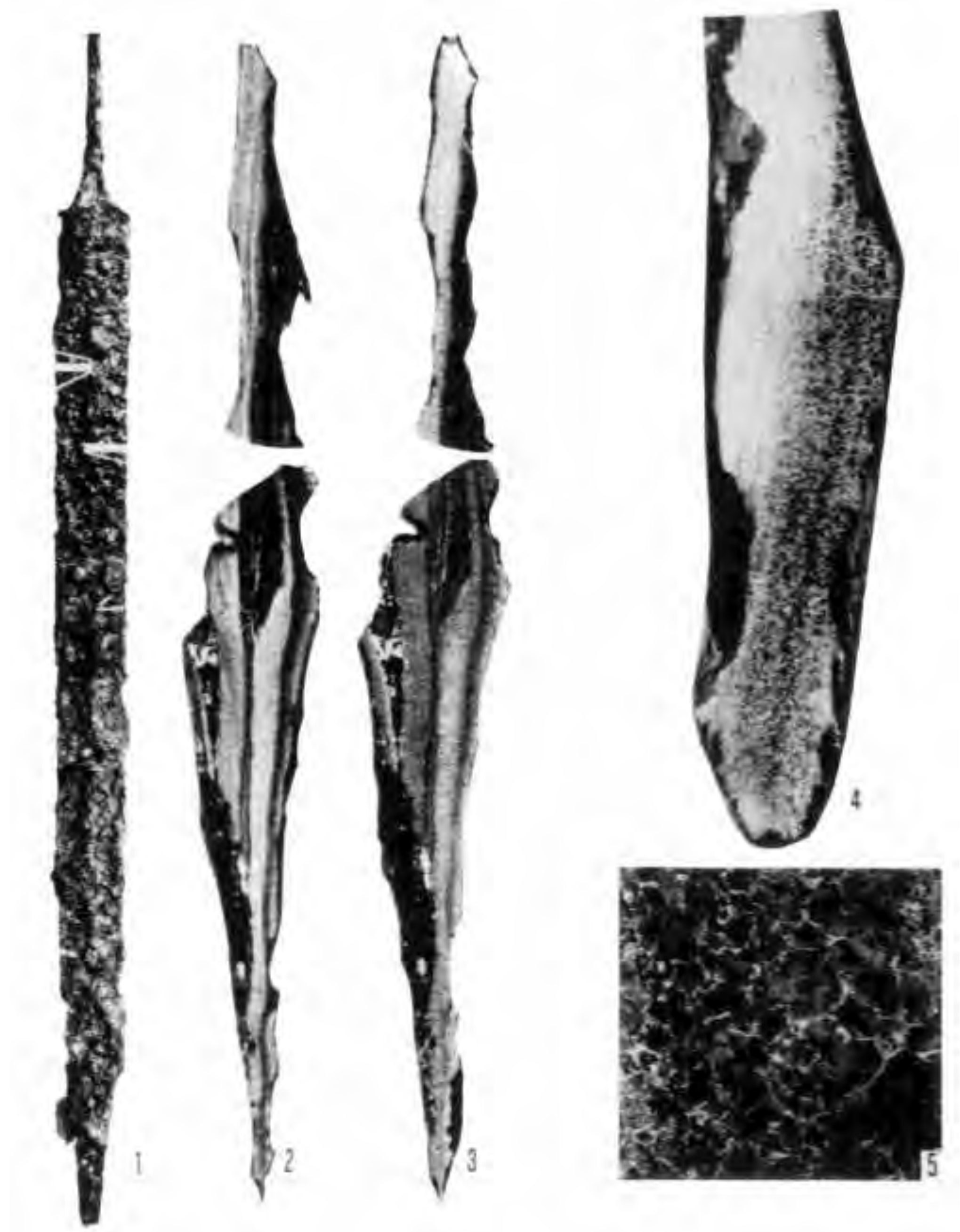
VII. Tuchomyšl 613, NW Bohemia, examination 3. 1 Blade, with adhering scabbard fragments in the upper part, specimen positions marked; 2 Specimen a_2, composed from microphotographs: welded-on steel cutting-edge, dark: fine pearlite (×16); 3 Specimen a_1, composed from microphotographs: steel cutting-edge consisting of pearlite and white ferrite cells (×25); 4 Fine pearlite, detail of **2** (×75); 5 Detail of **3** (×100). Etched with 2%-Nital. See also Fig 10.1



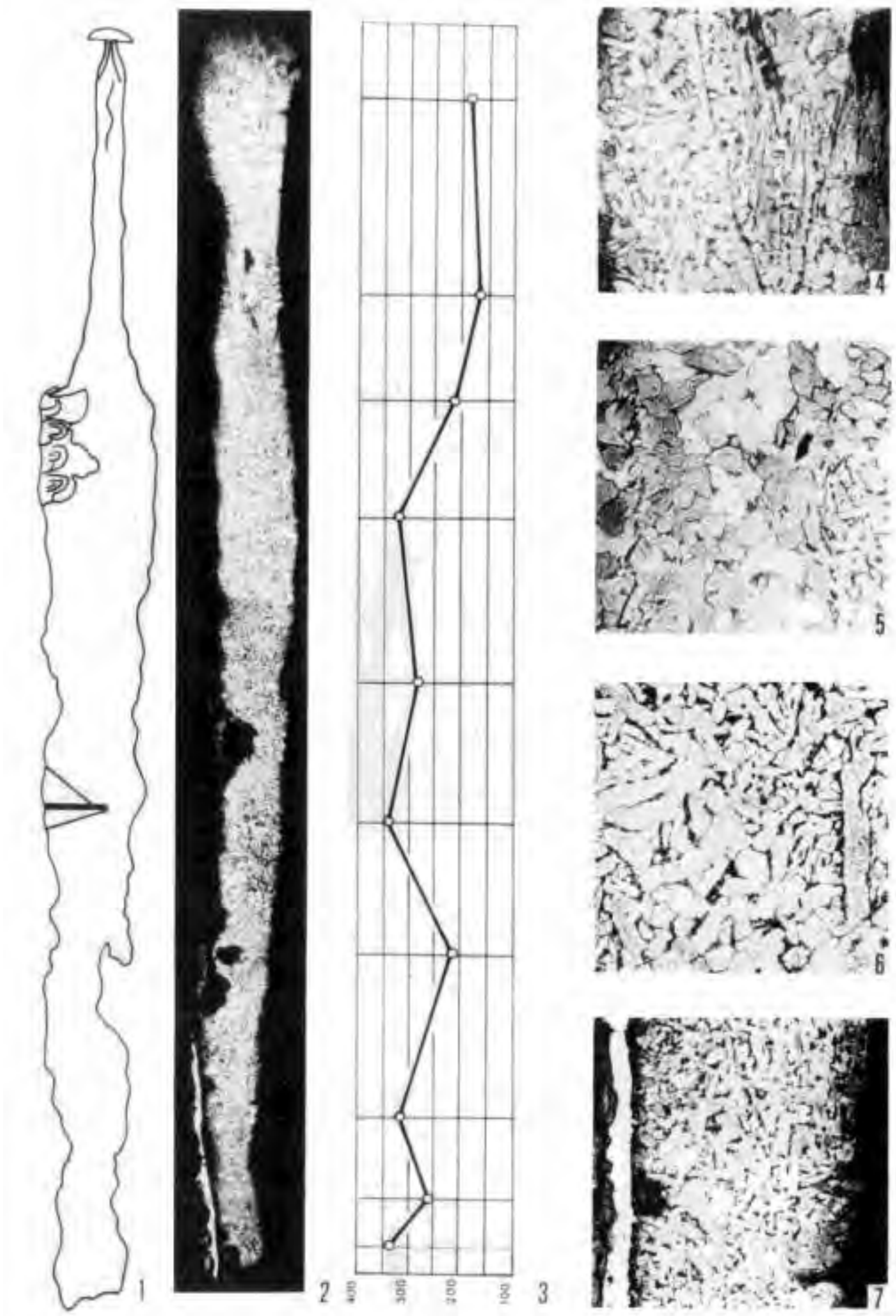
VIII. Tuchomyšl 614, examination 4. 1 Blade, with specimen position marked; 2 Transverse section composed from specimens *a* (above), and *b* (below), etched with Oberhoffer: darker stripes are enriched with phosphorus (×3); 3 The same, specimen b_1; 4 Microhardness 30 g: solid line = pearlitic area, hatched and dotted lines = ferritic areas; 5 Specimen *a*, core: welding-seam in a ferritic structure (×100); 6 Specimen *b*: transition from ferrite into pearlite (dark, ×150); 7 Specimen b_1: transition of fine ferritic-pearlitic structure into pearlite with coarser grain. 5–7 etched with 2%-Nital



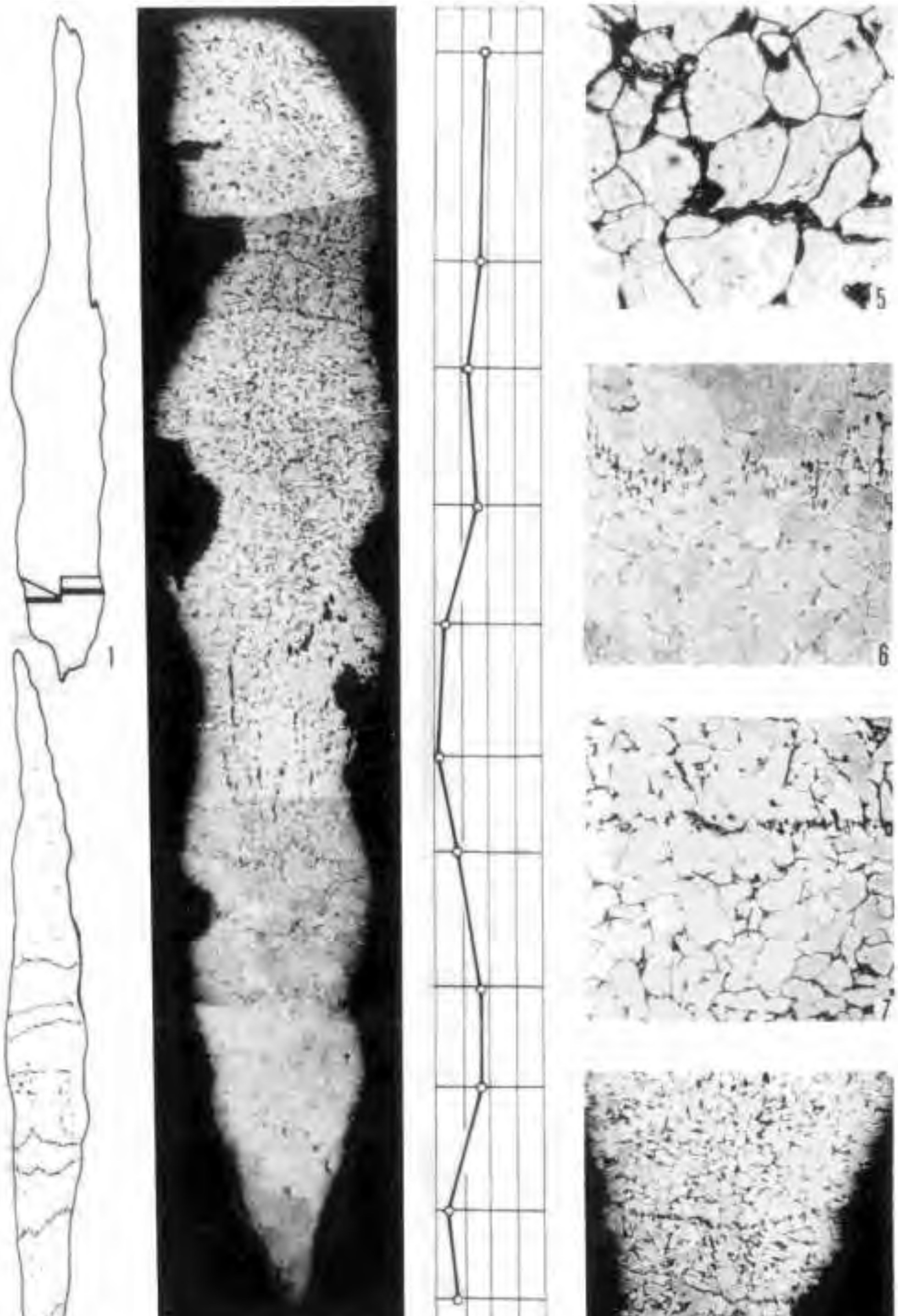
IX. Tuchomyšl 615, examination 5, parts of cross-sections, composed from microphotographs. 1 Specimen *a*1: cutting-edge, ferritic; 2–3 the same, far from the edge; 4 Specimen *a* 2: a steel (dark) and wrought-iron band welded together near the cutting-edge; 5 Specimen *a* 2, edge: an iron and steel band joint by welding (a poor weld), leaving the cutting-edge ferritic. Enlargements: 1, 4 ×50; 2–3, 5 ×20. Etched with 2%-Nital



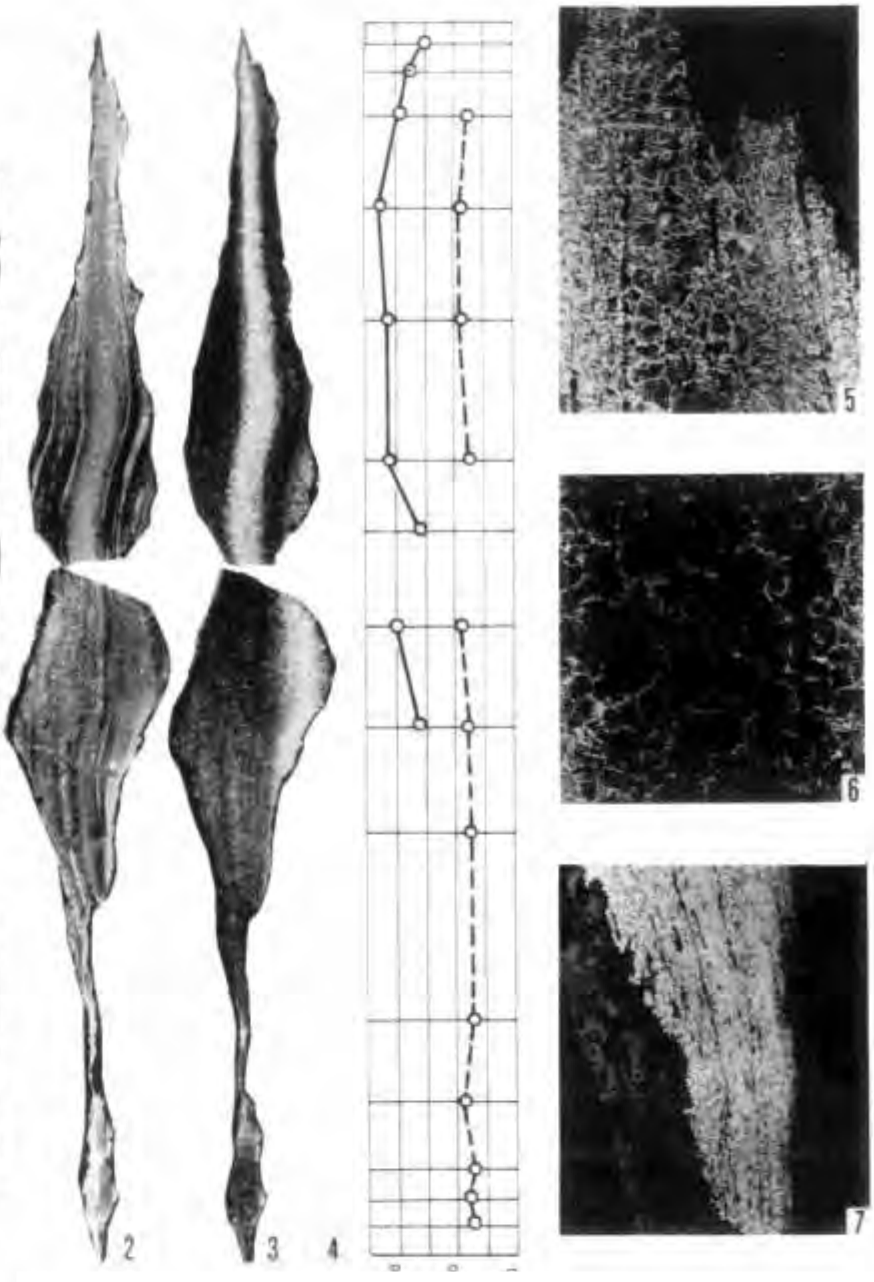
X. Tuchomyšl 615, examination 5. 1 Blade, with specimen positions marked; 2 Cross-section consisting of specimens a_1 (above), and a_2 (below), etched with Oberhoffer: dark bands are enriched with phosphorus (×6); 3 The same, etched with 5%-Nital: light zones are carburized; 4 Cutting-edge a_1, composed from microphotographs (etched with 2%-Nital; ×24): pearlitic steel (dark), welded on to wrought-iron ferritic body; 5 Specimen a_1: pearlite (dark) with thin ferritic cells (etched with 2%-Nital; ×150). See also Fig. 10.2



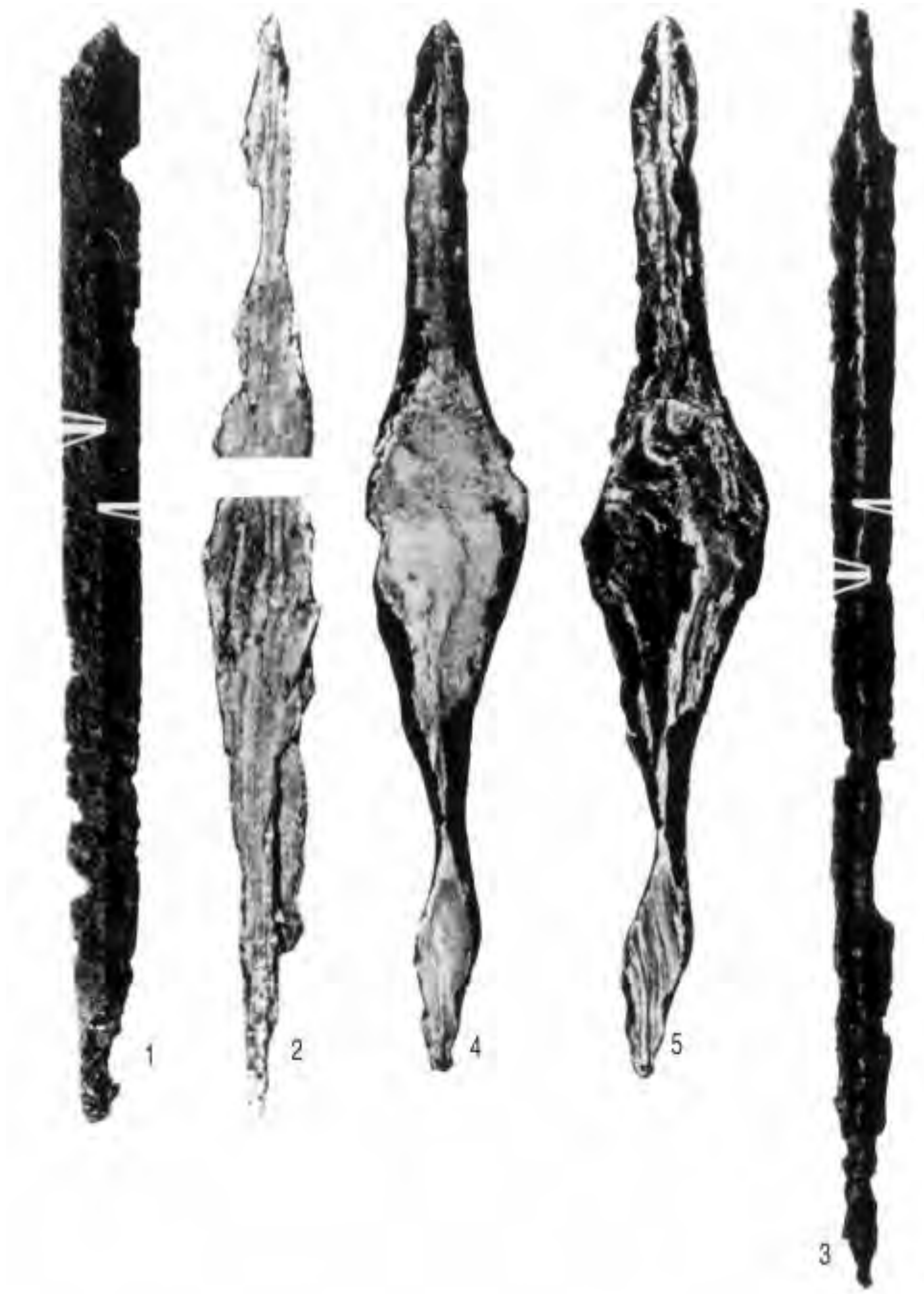
XI. Třebohostice 178, S. Bohemia, examination 8. 1 Blade with specimen position marked; 2 Transversal section, composed from microphotographs, ×23; 3 Microhardness 30 g; 4–5 Ferritic structures with intergranular pearlite in various parts of the section; 6 a wedge-shaped weld; 7 Adherent thin layer of a copper-based metal (on left). Etched with 2%-Nital. Magnifications: 4 and 7 (×100); 5 and 6 (×150)



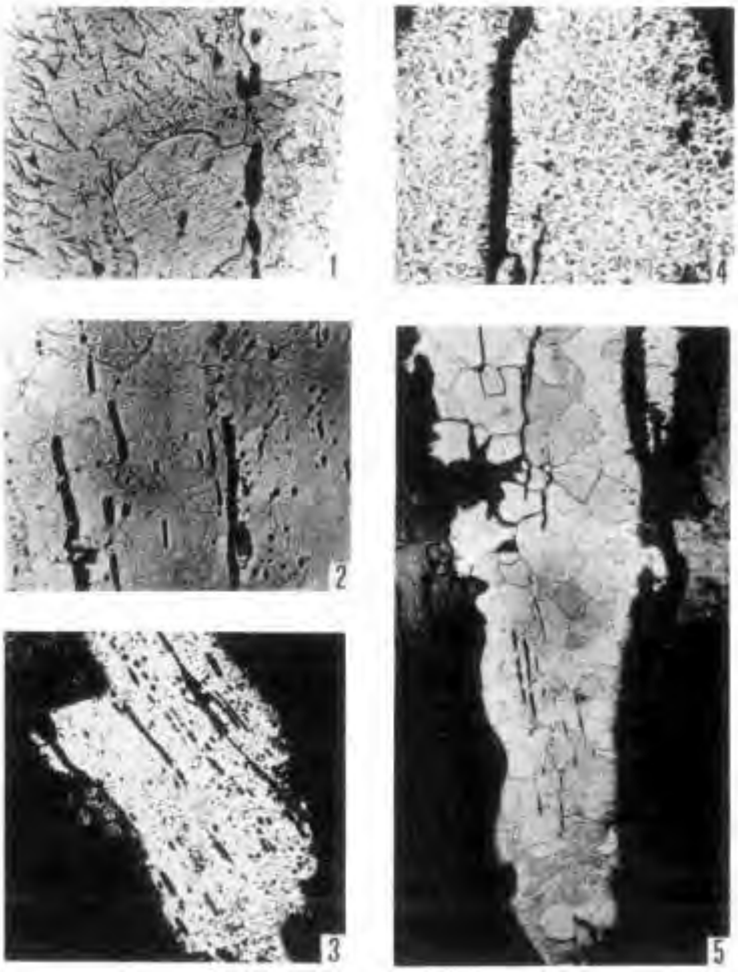
XII. Třebohostice, 179, examination 9. 1 Blade with cross-section marked; 2 Schematic sketch of the cross-section, composed from parts *a* and *b*: transverse welds; 3 Cross-section part *a*, composed from microphotographs, (×4); 4 Microhardness 30g; 5 Ferrite with intergranular pearlite (×250); 6–8 Simliar structures with transversal welding-seams, (6–7 ×100; 8 ×75) Etched with 2%-Nital



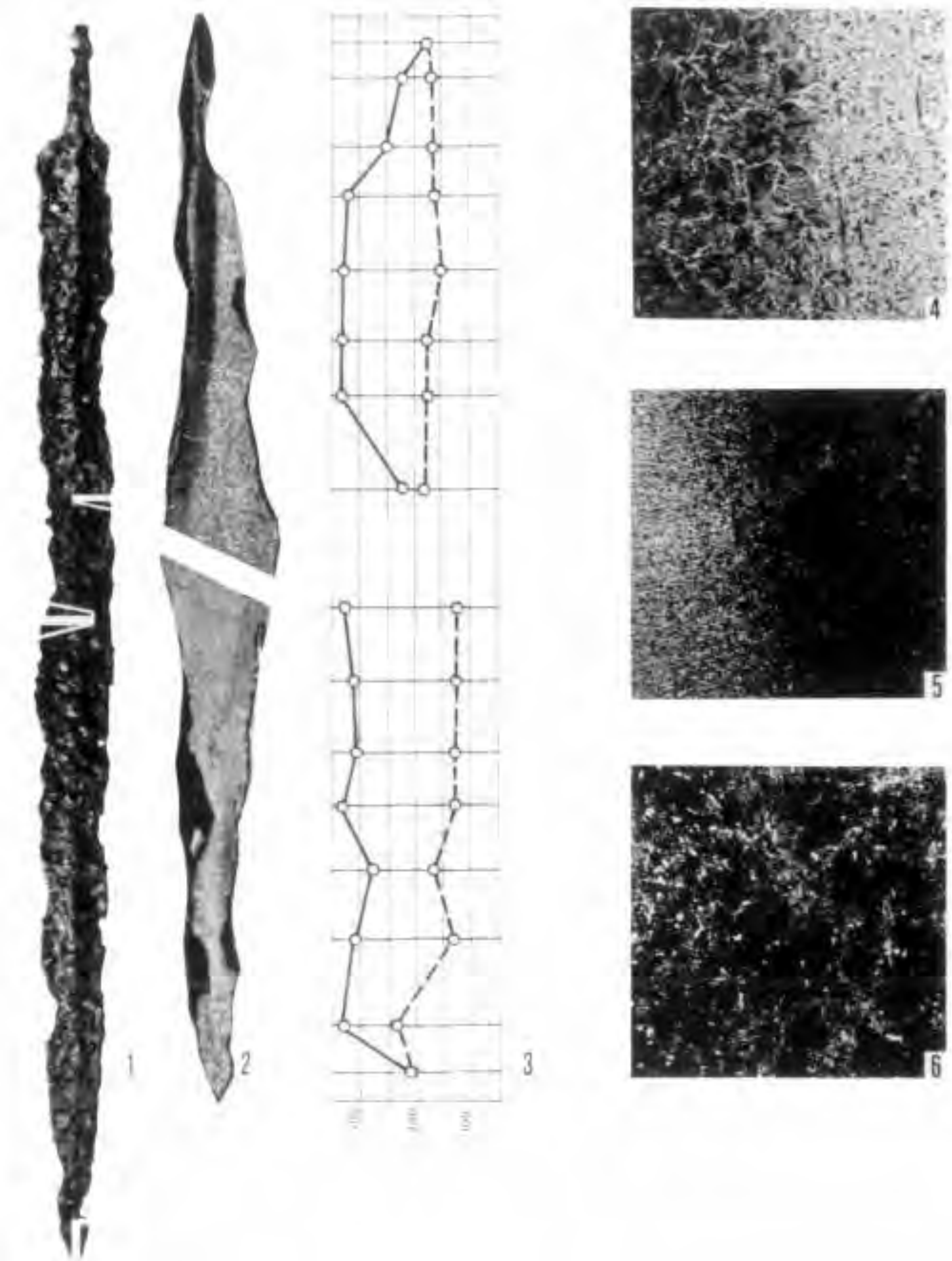
XIII. Brno-Maloměřice 592, Moravia, examination 10. 1 Blade, with specimen positions marked; 2 Two parts of cross-section (a_2 lower, a_1 upper), etched with Heyn: the light grey central band, pointing to the side in a_1, is steel (×5); 3 The same, etched with 4%-Nital: the light strip is steel; 4 Microhardness 30 g: solid line = pearlitic steel, hatched line = ferritic wrought-iron zones; 5 Cutting edge a_2: pearlitic-and-ferritic central plate between two ferritic shells, divided by slag inclusion chains (×100); 6 Detail taken far from the edge: pearlite and white ferritic cells (×100); 7 The ferritic a_1 cutting-edge (×75). 5–7 etched with 2%-Nital



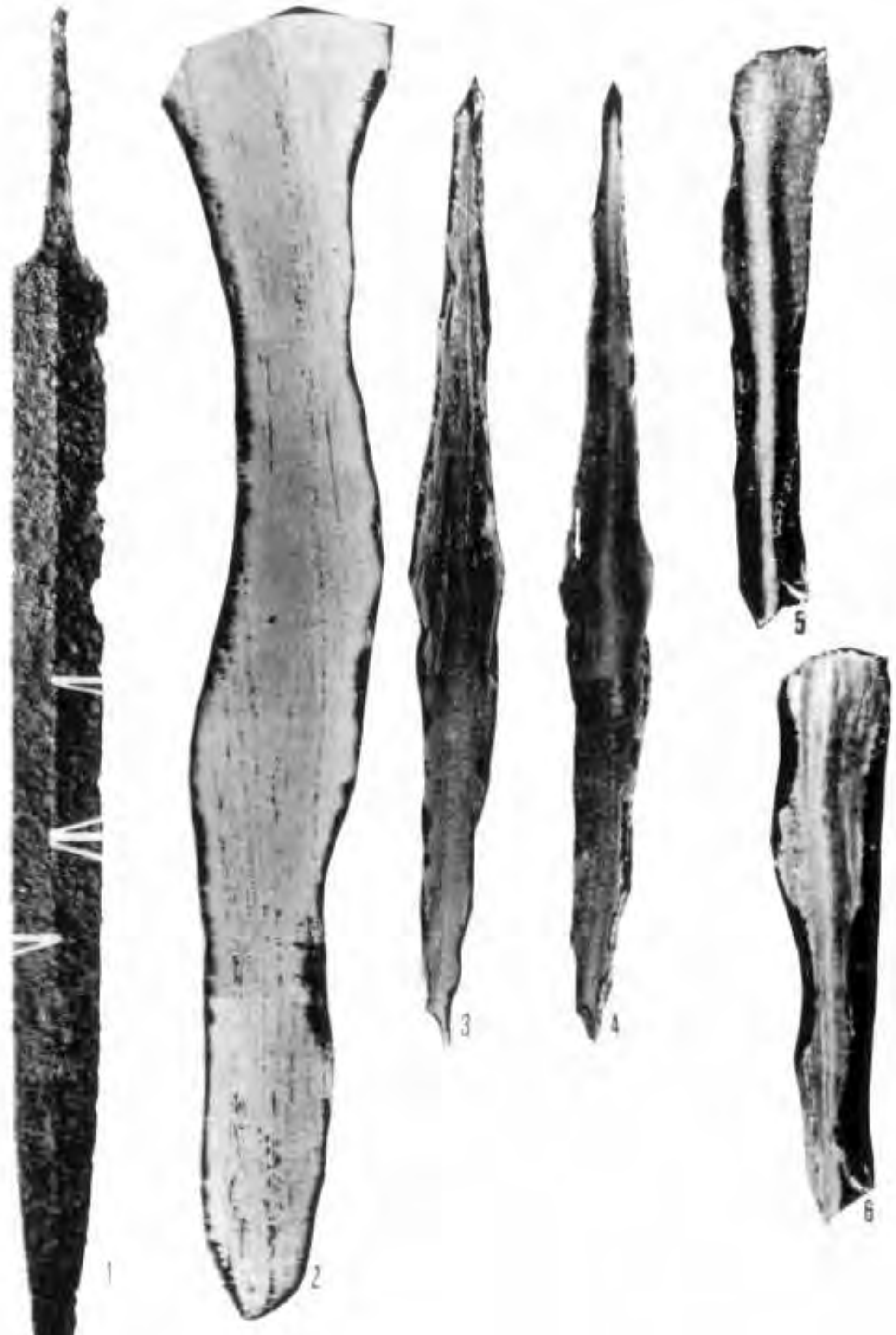
XIV. Brno-Maloměřice 593 and 594, examinations 11 and 12. 1 593 with specimens positions marked (a_1 left, a_2 right); 2 593; composite cross-section, showing lamination, etched with Heyn (a_1 above, ×8); 3 594: cross-section composed from a_1 (lower cutting-edge) and a_2, and etched with Heyn (×6); 4 The same, etched with Oberhoffer: distorted bands with varying phosphorus content; 5 594: with specimen positions marked (a_1 left, a_2 right)



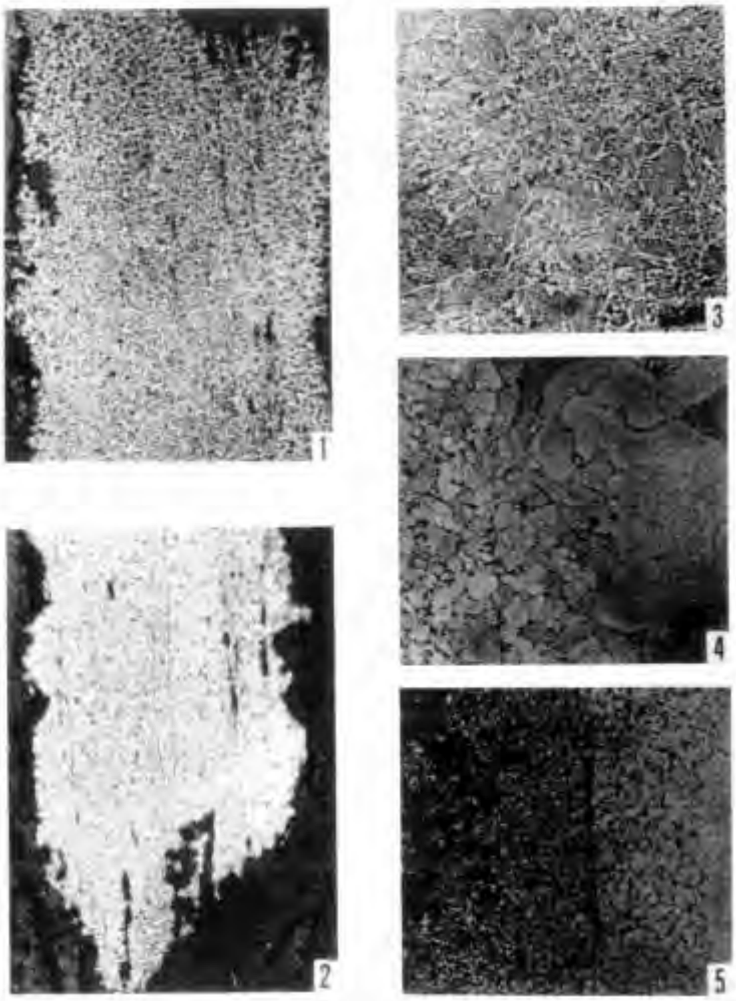
XV. Brno-Maloměřice 593 and 594, microstructures. 1 593; ferrite and nitride needles, (×200); 2 593: ferrite, phosphorus eutectic mixture (intercrystalline grey shades) (×50); 3 593: ferrite and slag inclusions in the a_2 edge, (×75); 4 594: edge a_1, ferrite and pearlite (×75); 5 594 edge a_2; ferrite, inclusions and cracks, (×150). Etched with 2%-Nital



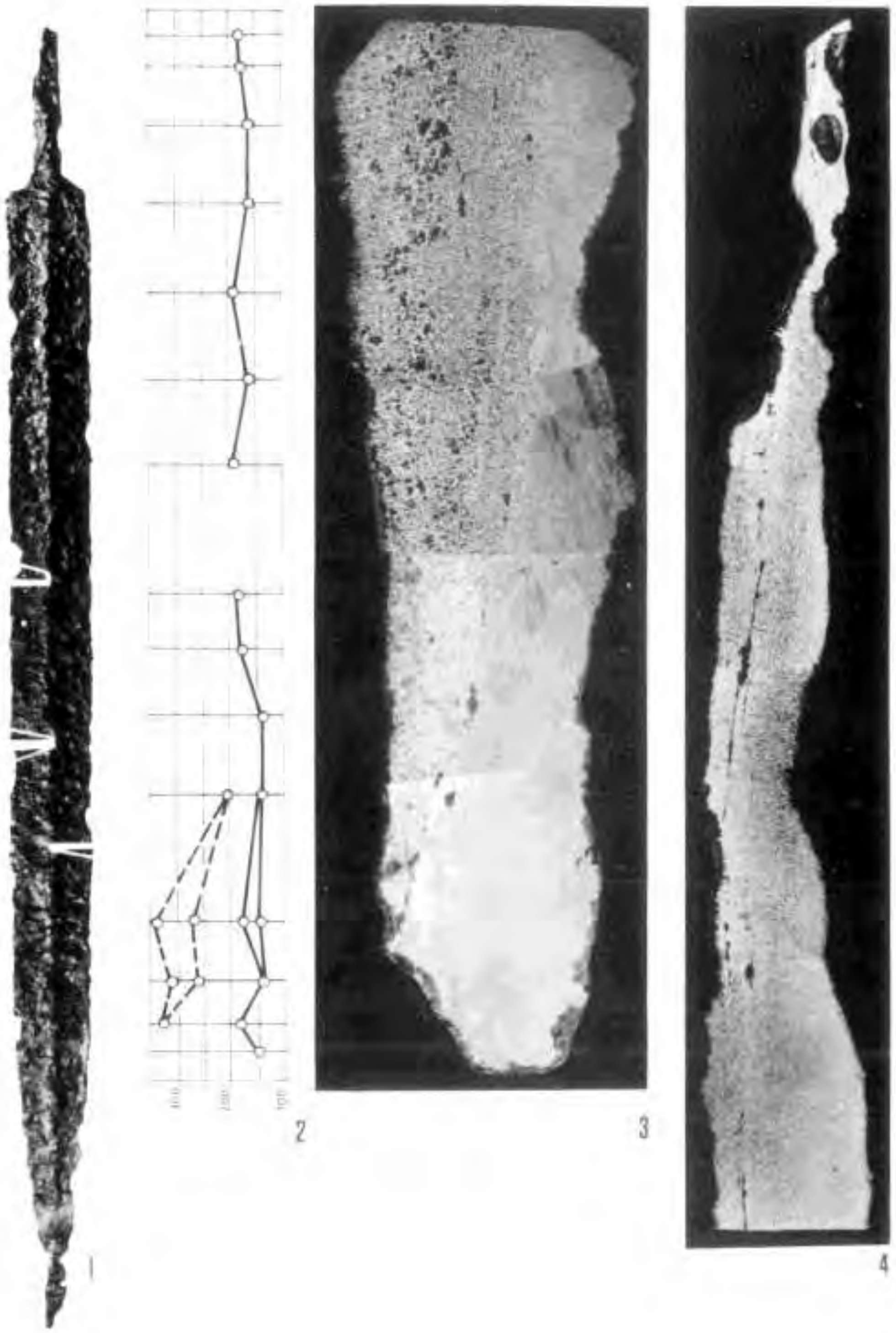
XVI. Křenovice 595, Moravia, examination 13. 1 Blade, with specimen positions marked (a_1 left, a_2 right b at the point); 2 Cross-section composed from a_1 and a_2, etched with 5%-Nital; darker stripe is ferritic, presumably a decarburized zone (×6); 3 Microhardness 30 g: solid line = pearlitic areas, hatched line = ferritic areas; 4 Specimen a_1: pearlite (dark) and ferritic cells, at right fine ferritic grains (×100); 5 Specimen a_2 dark pearlitic area and the transition to very fine ferritic structure (×75); 6 Specimen b: sorbite or fine pearlite (×100). 4–6 etched with 2%-Nital



XVII. Křenovice 596, examination 14. 1 Blade, with specimen positions marked (*b* above right, a_1 below, a_2 left); 2 Edge *b*, composed from photomicrographs, etched with 2%-Nital: a central band with low carbon ferritic-and-pearlitic structure runs between two ferritic side shells (×18); 3 Cross-section composed from a_1 and a_2, etched with Heyn; 4 The same, etched with 5%-Nital, the central band visible in both representations (×6.5); 5 Edge *b*, etched with 5%-Nital; 6 The same, etched with Oberhoffer: the right side shell is enriched in phosphorus, (×5)



XVIII. Křenovice 596 and Holubice 597, Moravia, examinations 14 and 15. 1 596: edge a_2, ferrite-and-pearlite (×75); 2 596: cutting edge a_1, ferrite, in the centre a band with some intergranular pearlite (×100); 3 596: core of the blade, pearlite (grey) with ferritic network (×100) 4 597: cutting-edge a_2, transition of ferrite with some intergranular pearlite into and area with coarse ferritic grains (left, ×200); 5 The same, the boundary of a carbon-poor area with pearlitic steel (left beyond the slag inclusion, ×150). Etched with 2%-Nital. For 597 see also Pl. XIX.



XIX. Holubice 597, examination 15. 1 Blade, with specimen positions marked: (a_2 right, a_1 left, *b* top left); 2 Microhardness 30 g through the centre of the cross-section: hatched lines = areas with more pearlite, solid lines = ferritic parts; 3 Cutting-edge as in a_2, composed from microphotographs: the ferritic-and-pearlitic part left, and coarse grains of ferrite at the right side (×15); 4 Cutting-edge as in *b*: ferritic areas replace in various spots the ferritic-and-pearlitic mixed structures, leaving the edge soft (×15). Etched with 2%-Nital. For microphotographs see Pl. XVIII. 4–5.

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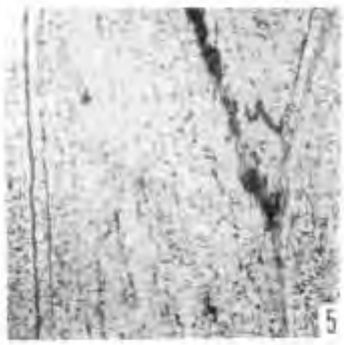

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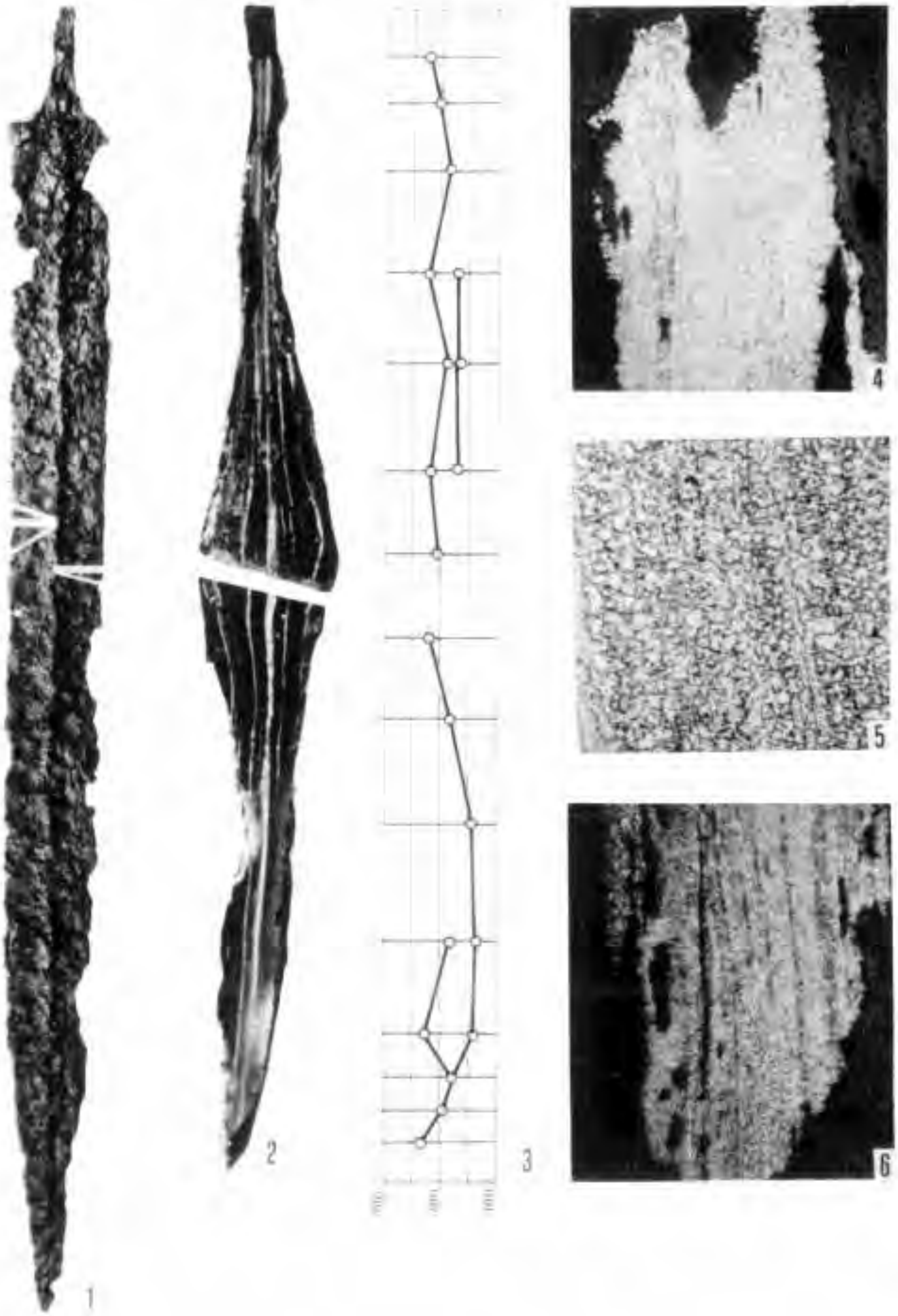
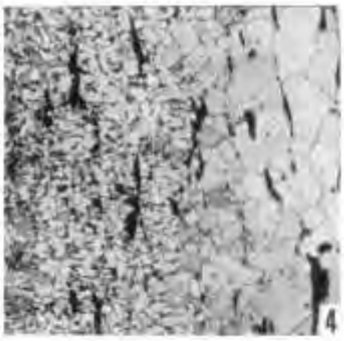
XX. Holubice 598, examination 16. 1 Blade, with specimen positions marked (a_1 right, a_2 left, b at the point); 2 Composite cross-section, etched with Heyn: the weld-seams appear as lines (×1); 3 The same, etched with 5%-Nital: in the inversed light the zones enriched with carbon appear as light; 4 Cutting edge a_2 composed from microphotographs: a pearlitic-and-ferritic band with varying grain size, etched with 2%-Nital (×50); 5 One of the wedge-shaped joints in the blade core: ferrite, some intercrystalline pearlite (×100). Etched with 2%-Nital

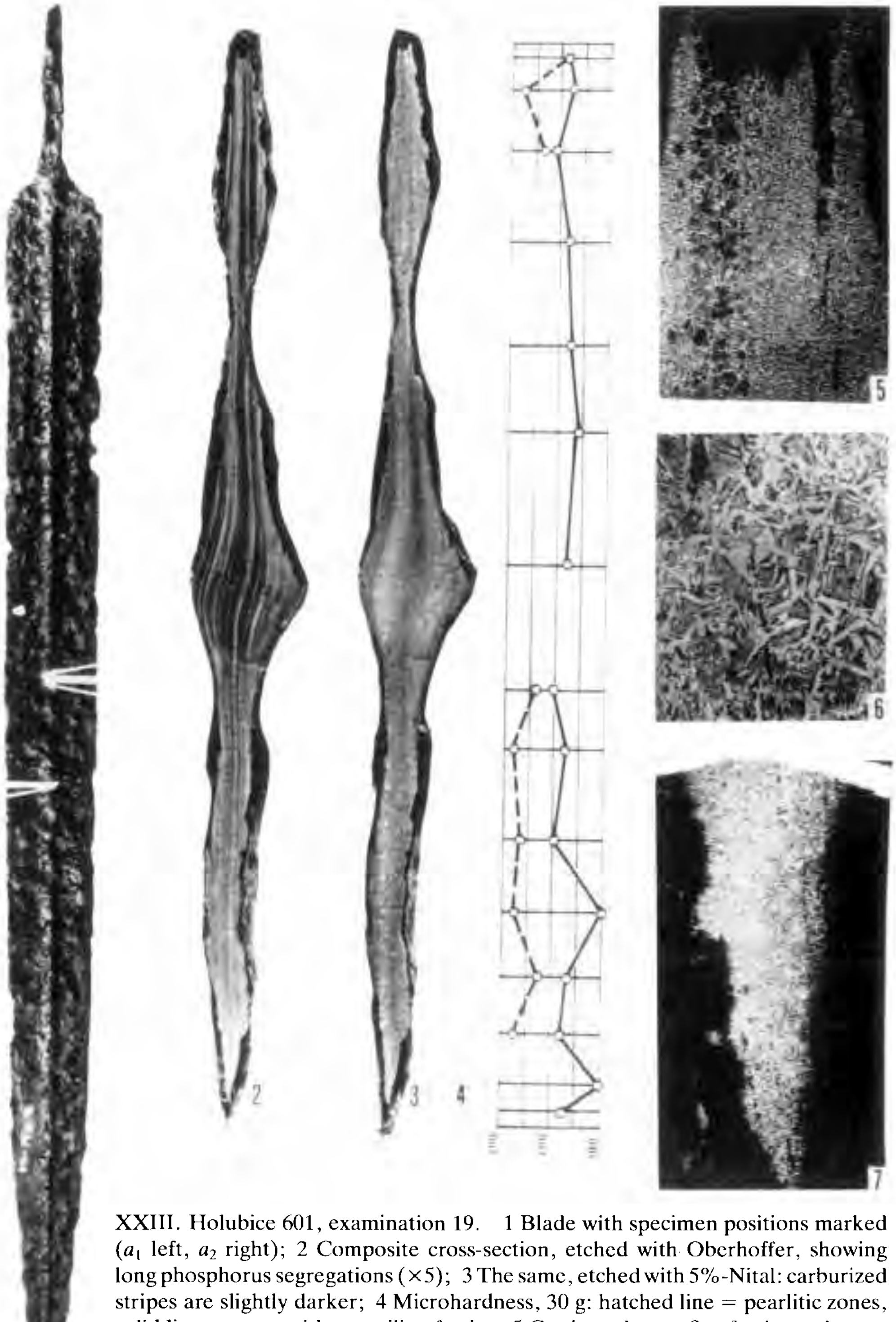


XXI. Holubice 599, examination 17. 1 Blade, with specimen positions marked (a_1 left, a_2 right); 2 Composite cross-section, etched with Oberhoffer (laminated texture, ×5); 3 Microhardness 30 g; 4 Cutting-edge a_2 (×100); 5 The same specimen, far from edge, ferrite (×150); 6 Cutting-edge a_1: ferrite with traces of pearlite (×75). 4–6 etched with 2%-Nital

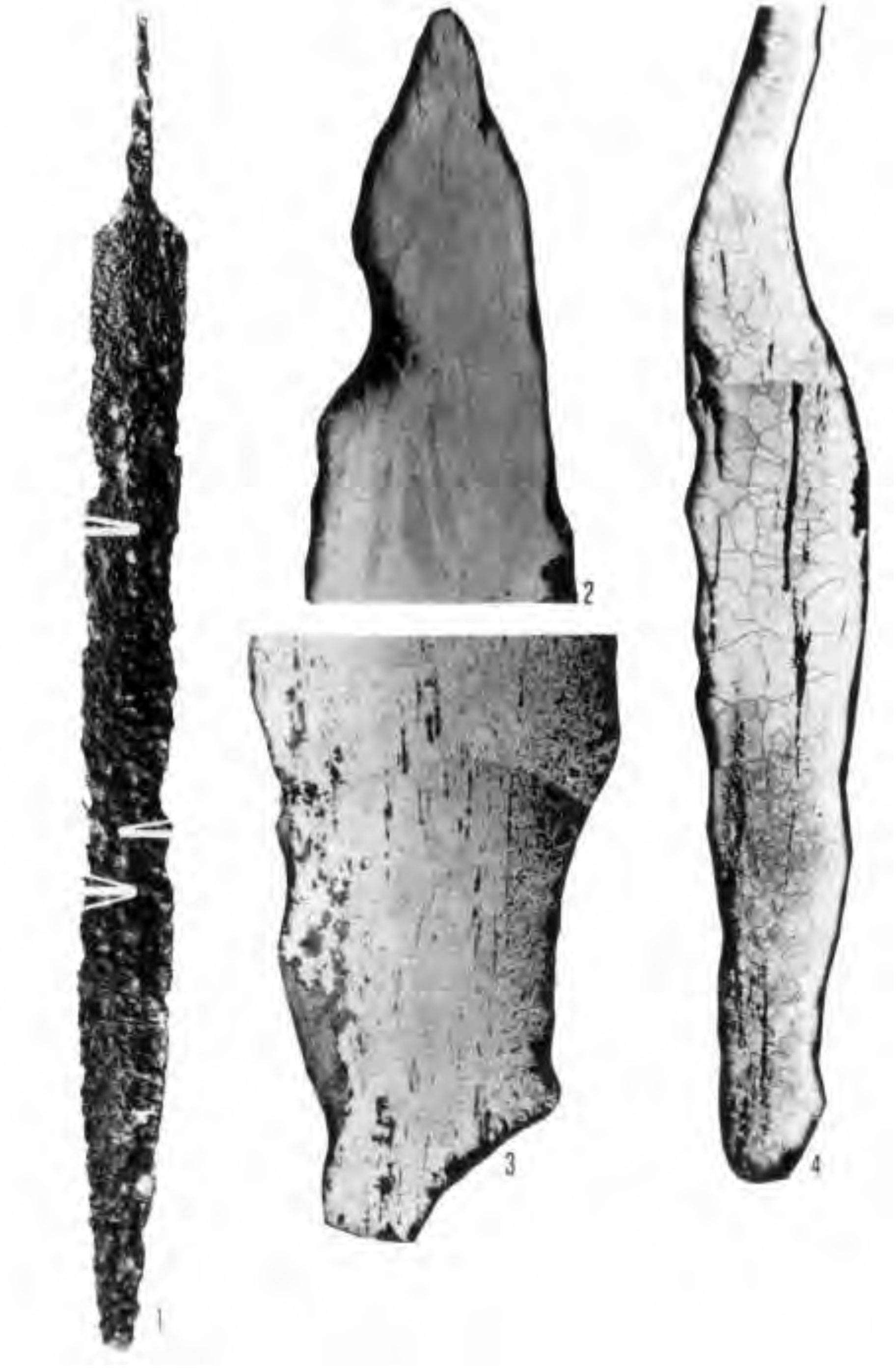


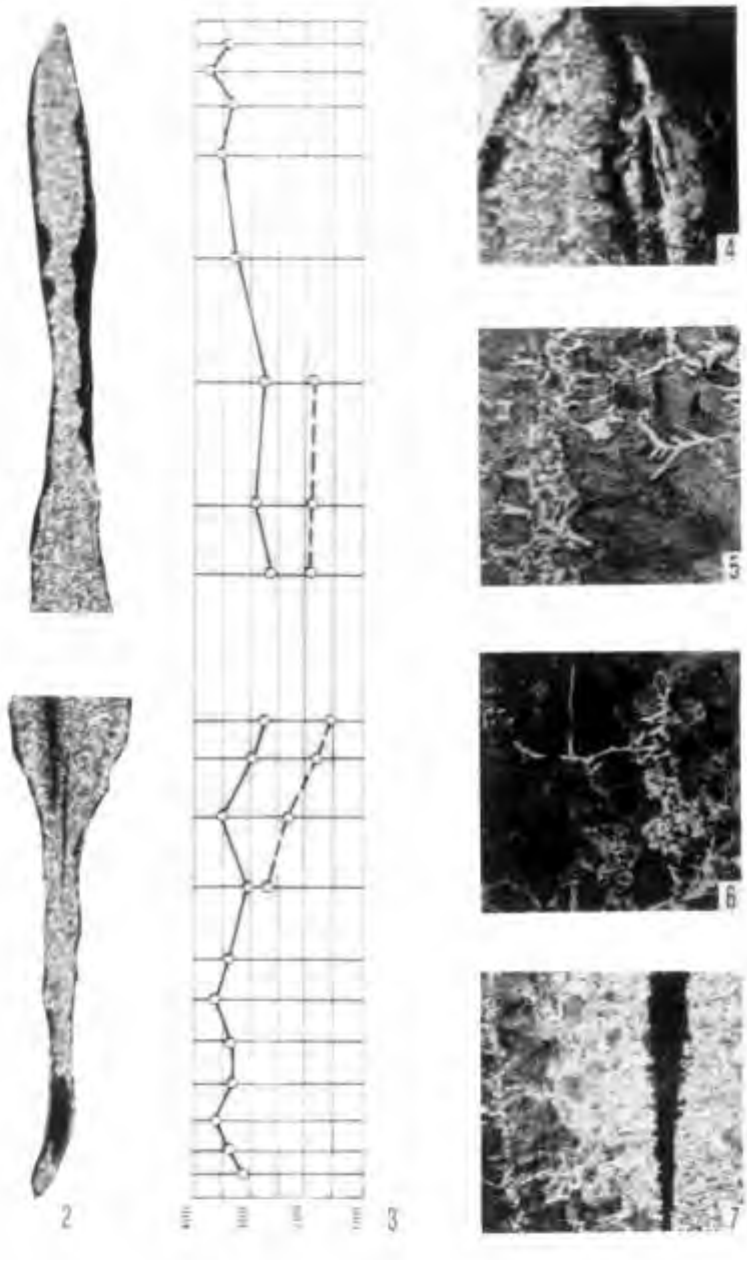

XXII. Holubice 600, examination 18. 1 The sword in a metal scabbard, frontal piece (left) and reverse (right), with specimen positions marked (a_2 left, a_1 right): 2 Composite cross-section, etched with Heyn: oblique welds (×5.5); Cutting-edge a_1: ferrite (×100); 4 Core: ferrite merging into an area with pearlite (dark grey), numerous oblong slag inclusions (×150); 5 Cutting-edge a_2: ferrite, at the left side some pearlite appears (×100). Etched with 2%-Nital



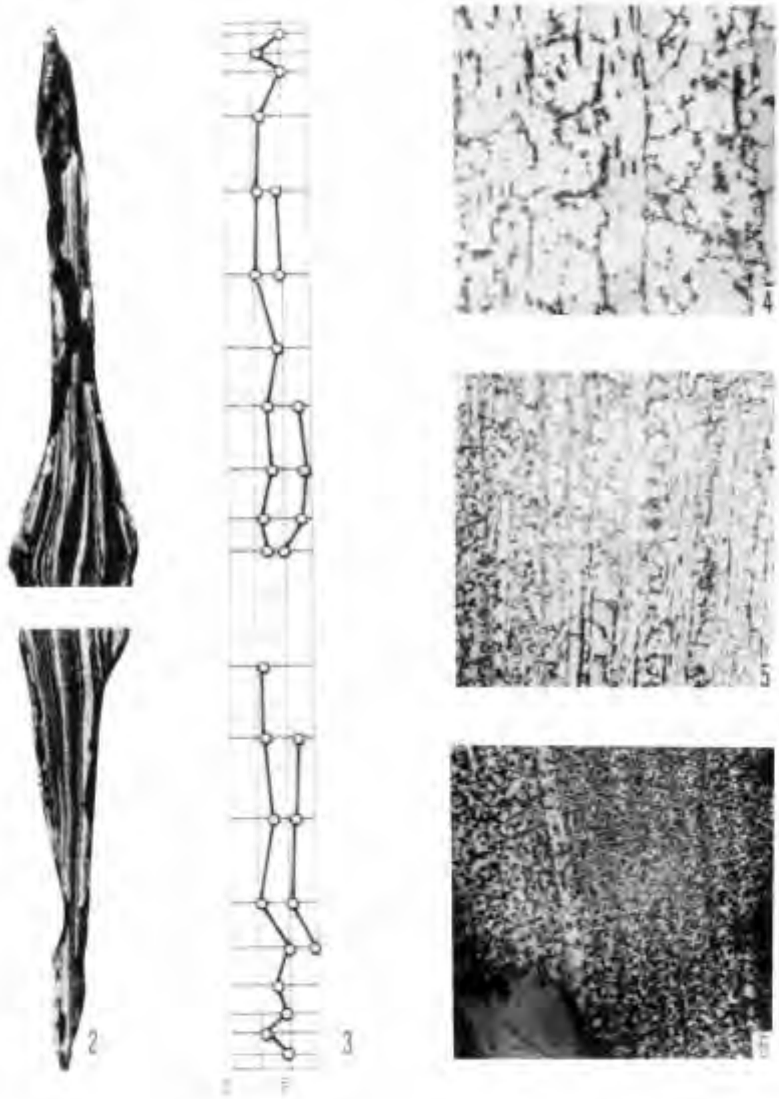
XXIII. Holubice 601, examination 19. 1 Blade with specimen positions marked (a_1 left, a_2 right); 2 Composite cross-section, etched with Oberhoffer, showing long phosphorus segregations (×5); 3 The same, etched with 5%-Nital: carburized stripes are slightly darker; 4 Microhardness, 30 g: hatched line = pearlitic zones, solid line = areas with prevailing ferrite; 5 Cutting-edge a_1: fine ferrite-and-pearlite with and dark coarse-grained pearlitic stripe (×75); 6 Detail of a lamellar pearlitic stripe far from the edge, acicular ferritic network (×100); 7 Cutting-edge a_2: fine ferritic-and-pearlitic structure (×75). 5–7 etched with 2%-Nital



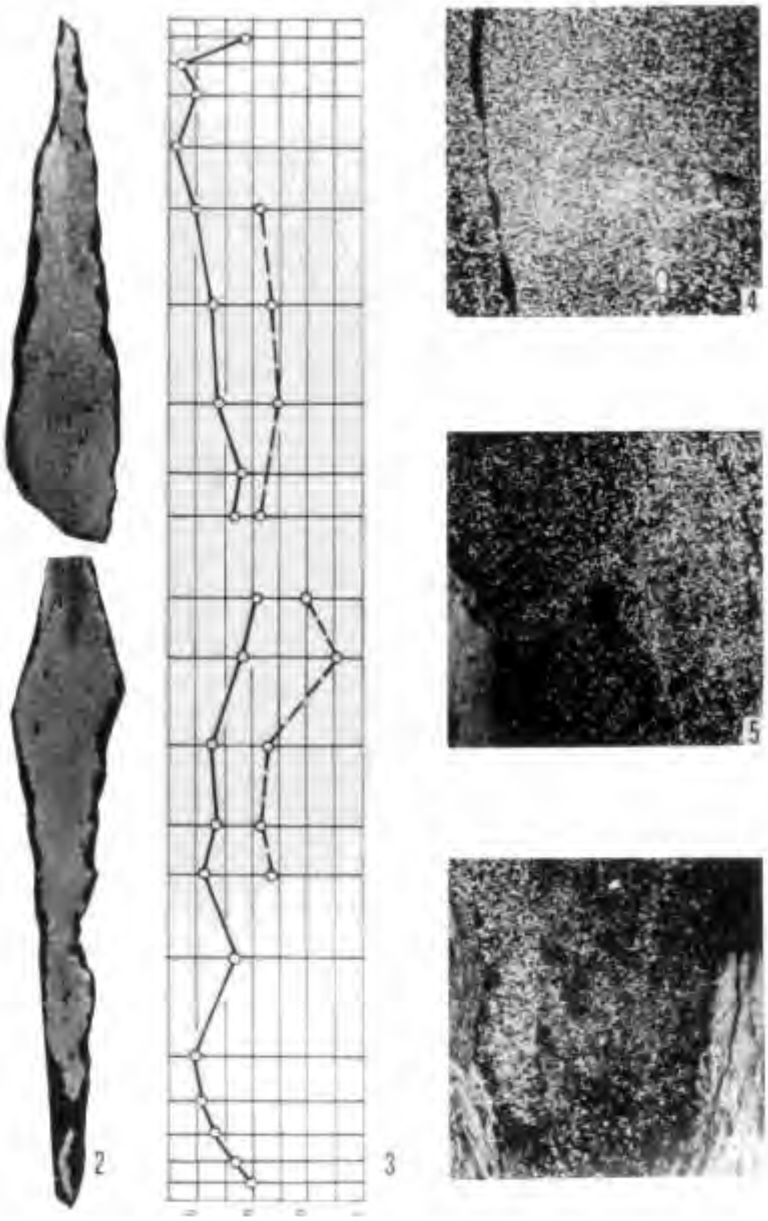
XXIV. Holubice 602, examination 20. 1 Blade, with specimen positions marked (a_2 right, a_1 left, and b above it); 2 Cutting-edge a_2: coarse ferrite, deformed (×100); 3 Cutting-edge a_1: ferrite, at right a surface layer of pearlitic-and-ferritic network and needles, numerous dark slag inclusions, (×100); 4 Cutting-edge at b: ferrite with varying grain size (×100). Etched with 2%-Nital



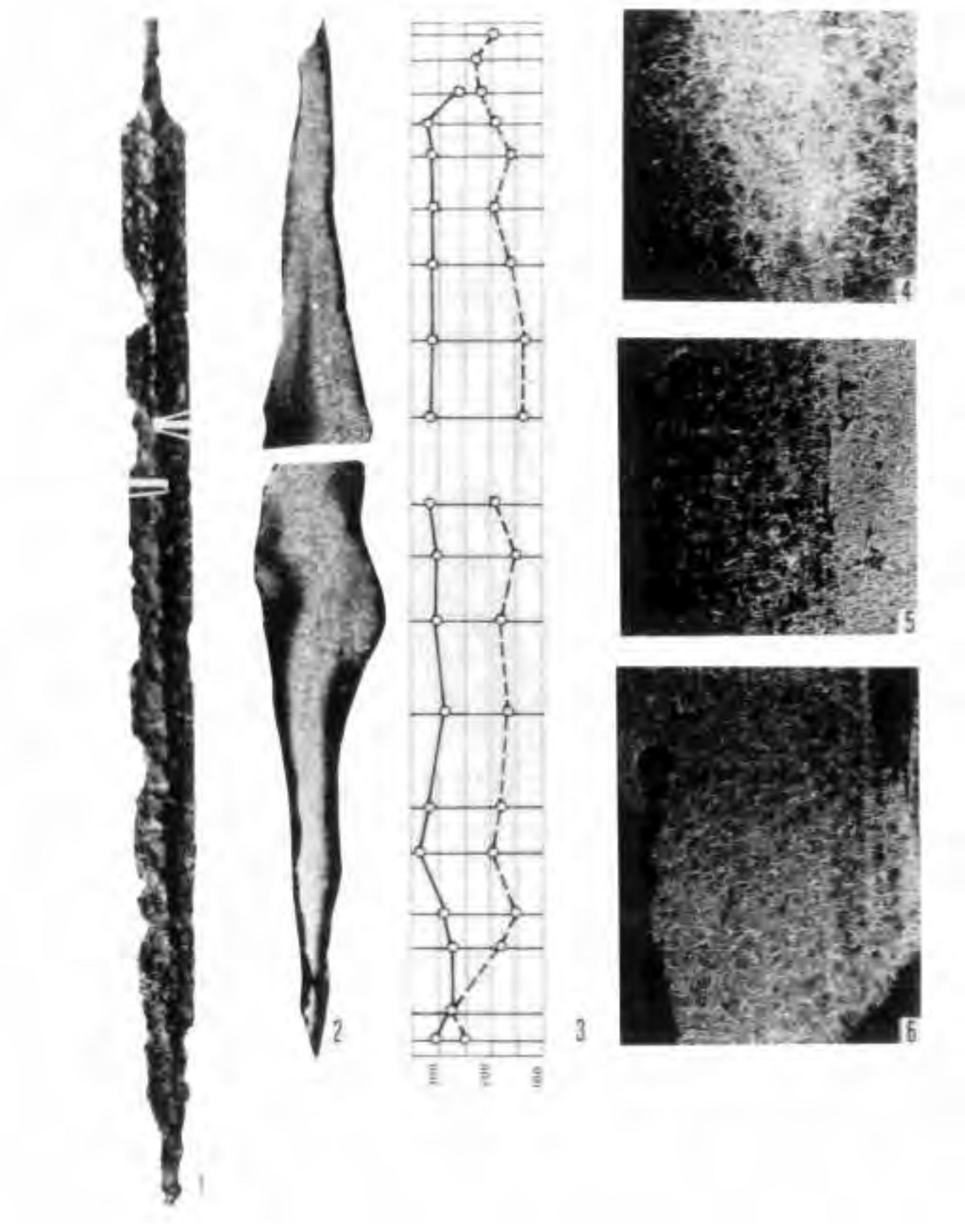
XXV. Holubice 603, examination 21. 1 Blade with specimen positions marked (a_1 left, a_2 right); 2 Composite cross-section, etched with 5%-Nital: homogeneous carbon distribution. (×5); 3 Microhardness 30 g: solid line = steel, hatched line = ferrite in the core; 4 Cutting-edge a_1: darker pearlitic structure with some ferrite (×10); 5–6 Core: lamellar pearlite with ferritic network (×100); 7 Decarburization at a crack in the core: ferritic structure, merging into dark pearlitic areas (×100). 4–7 etched with 2%-Nital



XXVI. Holubice 604, examination 22. 1 The sword with adhering scabbard fragments and chape, specimen positions marked (a_1 right, a_2 left); 2 Composite cross-section, etched with Oberhoffer (×5): banded texture with phosphorus segregations; 3 Microhardness 30 g; 4–5 Specimen a_1: ferritic grains with traces of intercrystalline pearlite (dark) (×250 and ×150); 6 Cutting-edge a_2: fine ferritic-and-pearlitic structure (×100). Etched with 2%-Nital

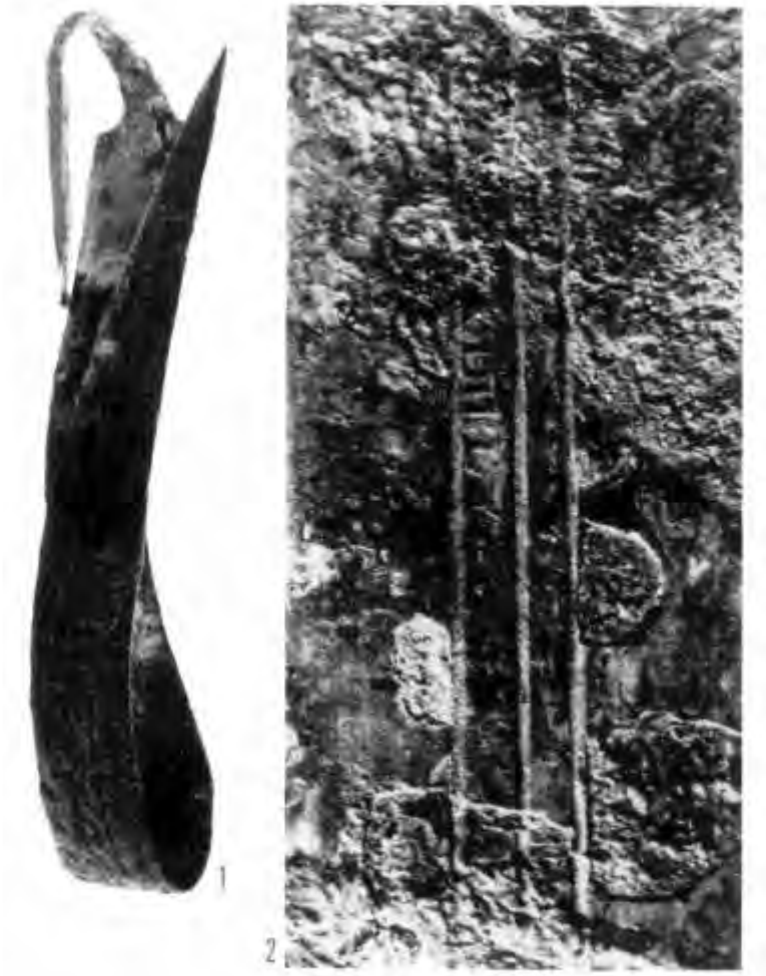


XXVII. Holubice 605, examination 23. 1 Blade, with specimen positions marked (a_1 above, a_2 below); 2 The same specimens. Etched with Heyn: slight decarburization in the core (×4); 3 Microhardness 30 g: solid line = pearlitic areas, hatched line = slightly decarburized core area; 4 Core: ferritic-and-pearlitic spot (×100); 5–6 Structures at edge a_1: dark grey pearlite or sorbite, at the left side a pearlitic-and-ferritic mixture (×100). 4–6 etched with 2%-Nital

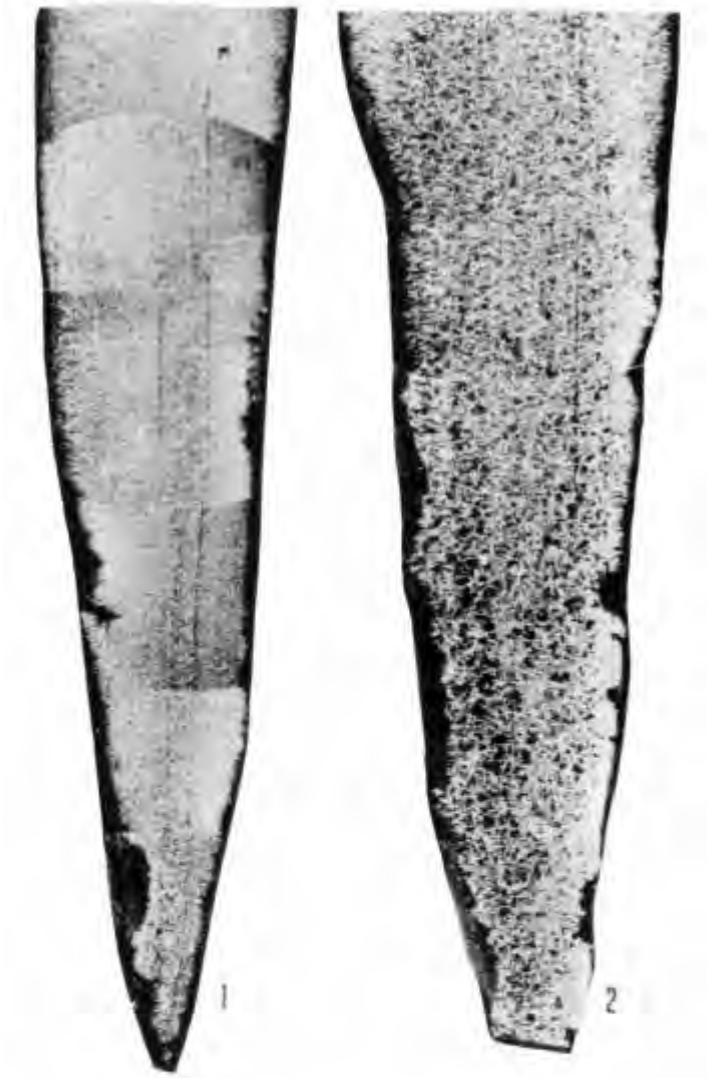


XXVIII. Holubice 606, examination 24. 1. Blade, with specimen positions marked (a_1 right, a_2 left); 2 Both specimens (a_2 above), etched with 5%-Nital, (inversed views, ×5); 3 Microhardness, 30 g: solid line = pearlitic areas, hatched line = zones with prevailing ferrite; 4–5 Specimen a_2: transitions from pearlitic areas (dark) into ferritic-and-pearlitic structures (×100); 6 The cutting-edge in the same specimen: pearlite with ferritic cells (×100). 4–6 etched with 2%-Nital

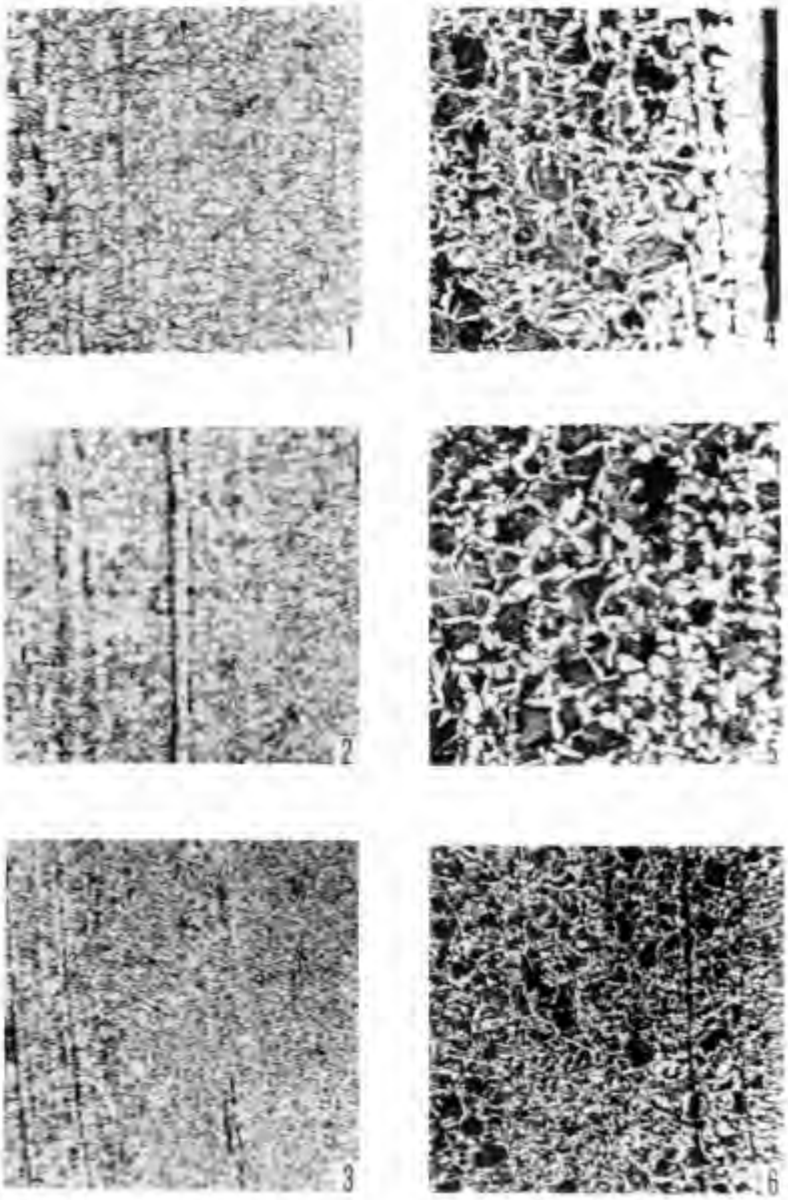
XXIX. Holubice 606, cutting-edge a_2, composed from microphotographs: a pearlitic steel band (dark), joint with wrought iron by welding (×26). Etched with 2%-Nital



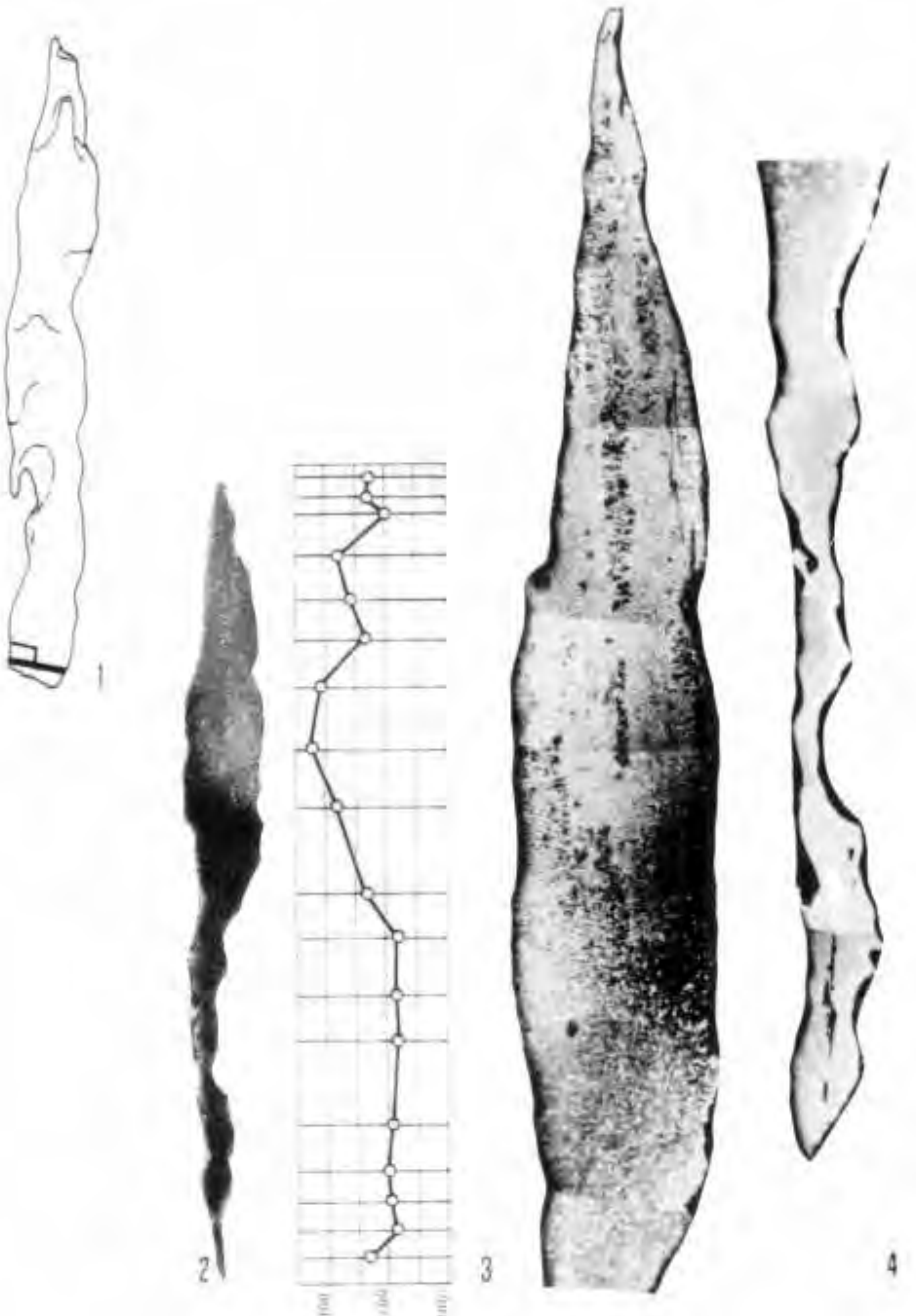
XXX. Zemplín 510, Slovakia, examination 27. 1 Ritually bent blade (parts of openwork bronze scabbard removed); 2 Detail of the blade with traces of stamped letters (V)TILICI (×2.5)



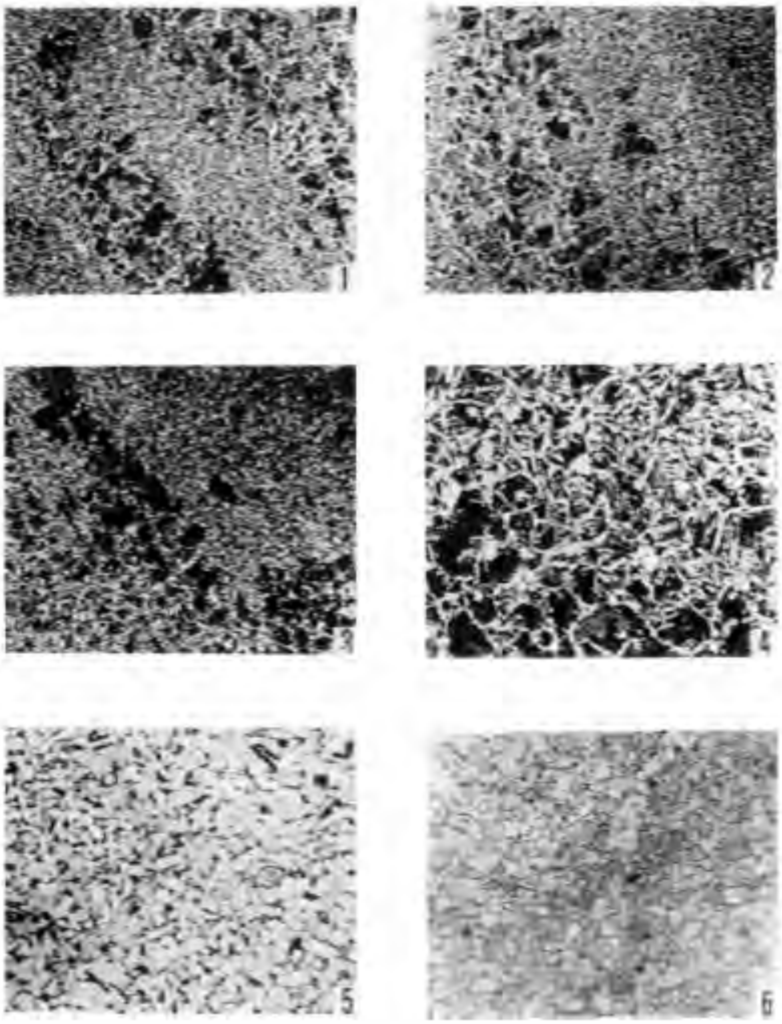
XXXI. Zemplín 510. 1 Specimen *a*, composed from microphotographs (×20): ferritic-and-pearlitic steel, weld-seams; 2 Specimen *b*: pearlitic structure (dark) with ferritic cells and needles (×30). Etched with 2%-Nital



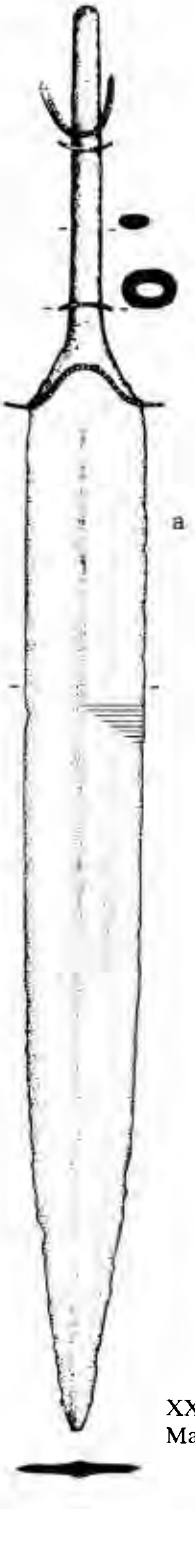
XXXII. Zemplín 510. 1–3 Specimen *a*: ferrite and ferrite with intergranular pearlite (**1, 2** ×100, **3** ×75); 4–6 Specimen *b*: 4 pearlite with ferritic cells and needles, at right a decarburized ferritic surface layer (×150); 5–6 lamellar pearlite (dark) with ferrite grains and cells (**5** ×150, **6** ×100). Etched with 2%-Nital

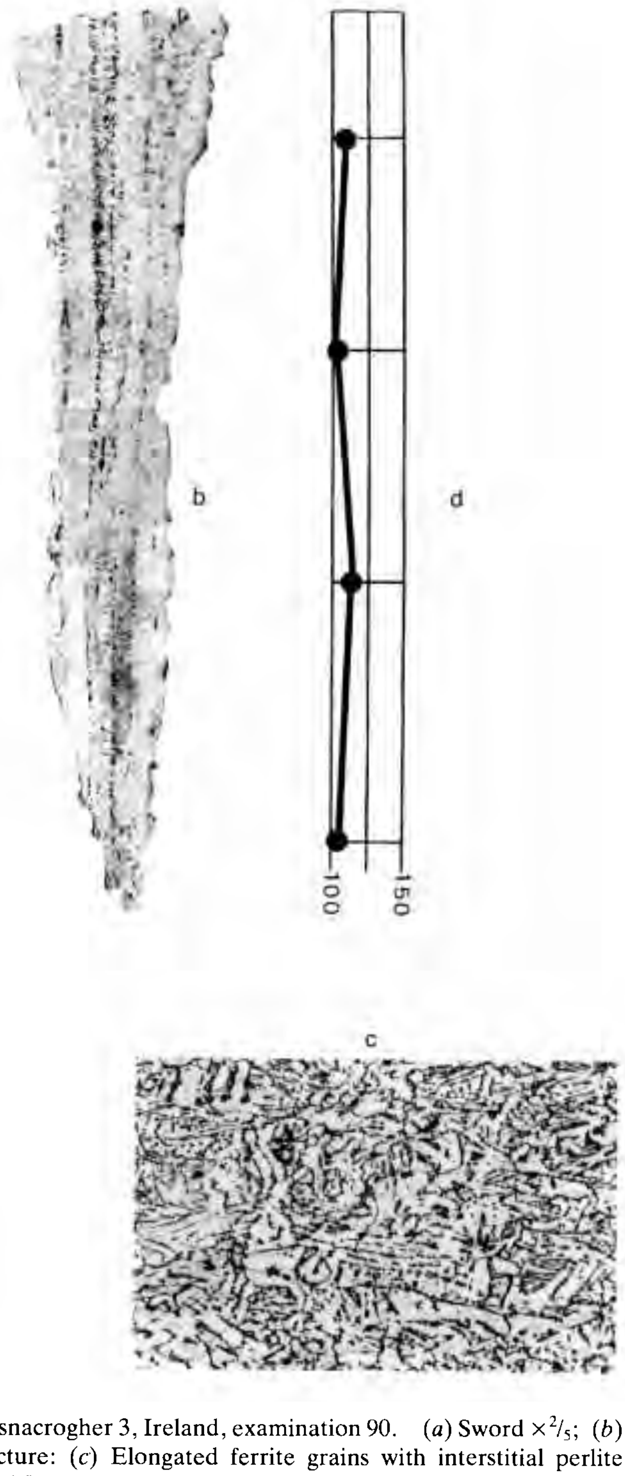


XXXIII. La Tène 199, Switzerland, examination 37. 1 Blade fragment, with the specimen position; 2 Transverse section eched with Heyn: the grey area is carbon-rich, the darker zone carbon-poor (×4); 3 Microhardness 30 g; 4 Two halves of the transversal section, composed from microphotographs: the thick end is pearlitic-and-ferritic with differing pearlite grain size, carbon-rich structure being cumulated in the core; the thin edge is ferritic (×13). Etched with 2%-Nital. For microstructures see Pl. XXXIV.

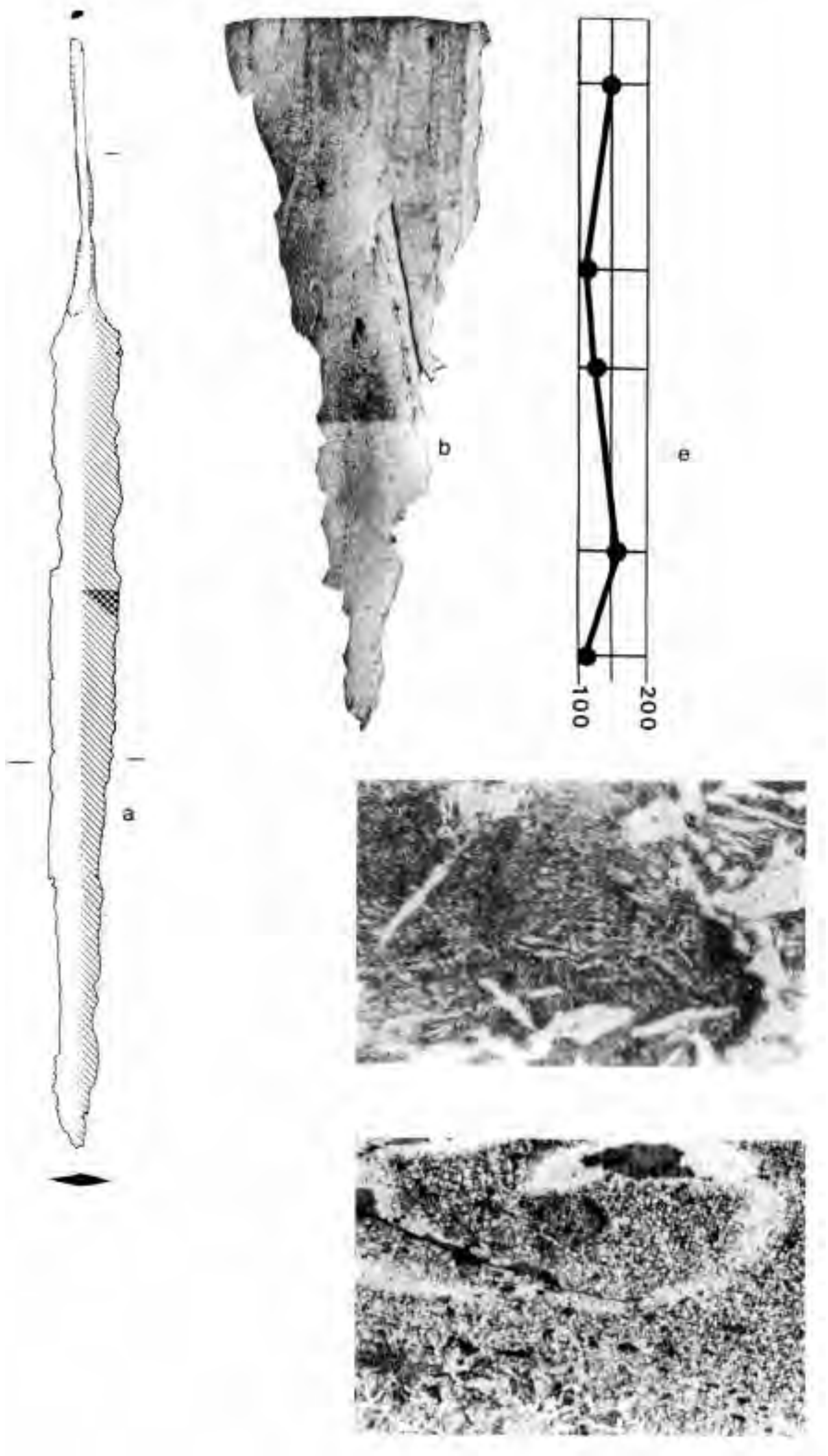


XXXIV. La Tène 199, microstructures. 1–2 Cutting-edge: fine pearlitic-and-ferritic mixture with areas of coarse pearlitic grains (dark); 3 Core: similar structure to the edge: 4 The same in detail: dark pearlitic grains with ferritic cells and needles, merging into the acicular Widmannstätten texture; 5 Transition to the opposite cutting-edge: ferrite with some dark intercrystalline pearlite; 6 Nearer to the edge-line: ferrite. Etched with 2%-Nital. Magnifications: 1–2, 5–6 ×100; 3 ×75; 4 ×150





XXXV. Lisnacrogher 3, Ireland, examination 90. (*a*) Sword $\times^{2}/_{5}$; (*b*) Macrostructure: (*c*) Elongated ferrite grains with interstitial perlite $\times 100$; (*d*) HV profile. Etched 4%-Nital. (After Scott 1990.)



XXXVI. Kildrinagh 1, Ireland, examination, 91. (*a*) Sword $\times^{2}/_{5}$; (*b*) Macrostructure; (*c*) Pearlite showing spheroidization of carbides ×500; (*d*) Remains of bloom welds ×50; (*e*) HV profile. Etched 4%-Nital. (After Scott 1990.)