Metallography of Celtic Iron Tools: Five Objects from a Hoard in Southern Bohemia

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The technology of ironworking in the European Celtic regions in the La Tène period deserves a special attention, since during the four centuries BC the Celtic blacksmith's craft saw an unusual rise of sophisticated techniques which influenced, in the first line, the manufacture of cutting tools. Therefore, all contributions pointing to this process should be considered as important.

In 1997 a late La Tène period hoard of 48 complete and 137 fragmentary iron objects was discovered in southern Bohemia, near the well known settlement site of Bezdědovice. There were selected five iron tools from this complex: 2 shears, 1 socketed axe-head, and 2 knives belonging to the category of the so-called *Ringgriffmesser,* with a circular ending of the handle. The goal was to evaluate the material and quality and to decipher the technology of manufacture.

The investigation method was the classical metallography present here the details.The purity of the metal as to the slag inclusions was estimated according to the Swedish Jernkontoret scale (1 to 5). The macroscopy involved the etching according to Oberhoffer and Heyn (distribution of the phosphorus and carbon contents), and with 5 % nital (distribution of the carbon content). The microscopic observation was carried out after the 2 % solution of nital. The grain size was estimated according to the ASTM norm (Czech norm 420563). The microhardness of the structures was measured by a Hanemann device, using the Vickers system under charge of 30g. Individual specimens are labelled by numbers 727 – 731 of the book of analyses at the Archaeological Institute, Prague (this numbering concerns other specimens, investigated in 1982 and 1996, being quoted in the conclusion); the Bezdědovice objects bear the relevant inventory Nos as well.

The shears (specimen 727, No B610), as to a transversal section of one of the blades, revealed a sandwich construction scheme with a central ferritic-pearlitic and pearlitic steel band with varying carbon content (ca. 0,2 – 0,7 % C, 220-270 mHV30g). Both side shells are ferritic with occasional traces of intercrystalline pearlite. Due to the abrasion, the steel band appeared excentrically in the cutting-line.

The other shears (specimen 728, B 611/770) are completely corroded so that a corrosion shell enveloped a hollow internal space. An isolated island of metal in the cutting-edge part is pearlitic-and-ferritic (Widmannstätten texture (241-268 mHV30g), and another one in the back is ferritic. This indicates that the cutting-edge was steeled but the technological scheme remains unknown.

The socketed axe-head (specimen 729, No B604) was a wood-working tool of considerable quality. In the cutting-edge alternate two steel and two wrought iron bands, welded together. The welds are marked with slag inclusion chains. One of the steel plates runs up to the cutting-line (pearlite and pearlite with ferritic cells, 300-350 mHV30g). The second, internal steel plate shows a similar structure but, due to the corrosion, there is no certain whether it reached up to cutting-line as well. The iron bands, one internal and one external, are ferritic (190-240 mHV30g). It is difficult to reconstruct the virtual construction scheme, because the possibilities of taking a sample were limited: either the whole blade corpus was conceived as a pile of steel and iron plates or the axe was a kind of a sandwich (with steel in the centre) and another steel plate was additionally welded-on in the cutting-edge. At any rate, the cutting-edge was quenched in water: the tips of the steel plates reveal martensite (800-890 mHV30g) which is gradually tempered to what used to be called martensite-and-troostite (above 700 mHV30) and sorbite in the direction to the socket. The result was a tool with excellent properties, showing a hard cutting-edge and enough tougness of the body. It should be mentioned that the late La Tène socketed axes of different schemes represent sophistically constructed and perfectly performed artefacts.

The last two specimens are knives. Both belong to a group called in German *Ringgriffmesser* i. e. knives the tip of their handle has been bent to a ring-shaped ending. The first one (specimen 730, No B606) reveals, according to a composed transversal section, three welded-together metal bands, clearly distinguished by slag inclusion chains: one of the outer strips is mild steel (ferritic- and pearlitic, 230-300 mHV30g, in the back of a sorbitic character (up to 430 mHV30g). The pearlitic structure penetrated to the adjacent ferritic band; the opposite outer strip is ferritic (180-220 mHV30g). The blade is a composite iron-and-steel artefact. Possibly it was hardened by subsequent tempering but the cutting-edge part might have been secondarily annealed so that the hardening effect was wiped out. The effect of a plasma conservation may be taken into account.

It is not out of interest that the second *Ringgriffmesser* (specimen 731) was conceived identically, having been welded-together from three bands; one of the outher bands was steel (pearlit-and-ferrite, heterogeneously

distributed, 0,2-0,8 % C, with phosphorus-enriched strips, 240-338 mHV30g). This steel band does not protrude to the cutting-edge proper (probably, the steel part was removed by abrasion or it was secondarily decarburized by final heating). Both knives were of a medium quality and it is not out of question that they were made by hands of the same master smith. The absence of hardening or a heavy tempering may be the result of plasma conservation treatment when the thin blade is taken into account.

In sum, the five investigated tools from the Bezdědovice late La Tène hoard shows that the blacksmiths used combinations of metal enriched in carbon (in historical terminology hard or medium steel) and carbon-poor wrought iron which were realized by fire welding. No one piece was manufactured from a single piece of metal. The five examples cannot be considered in terms of statistical reflection but they can be compared with other investigated representants of relevant categories: shears, socketed axes, and *Ringgriffmesser*.

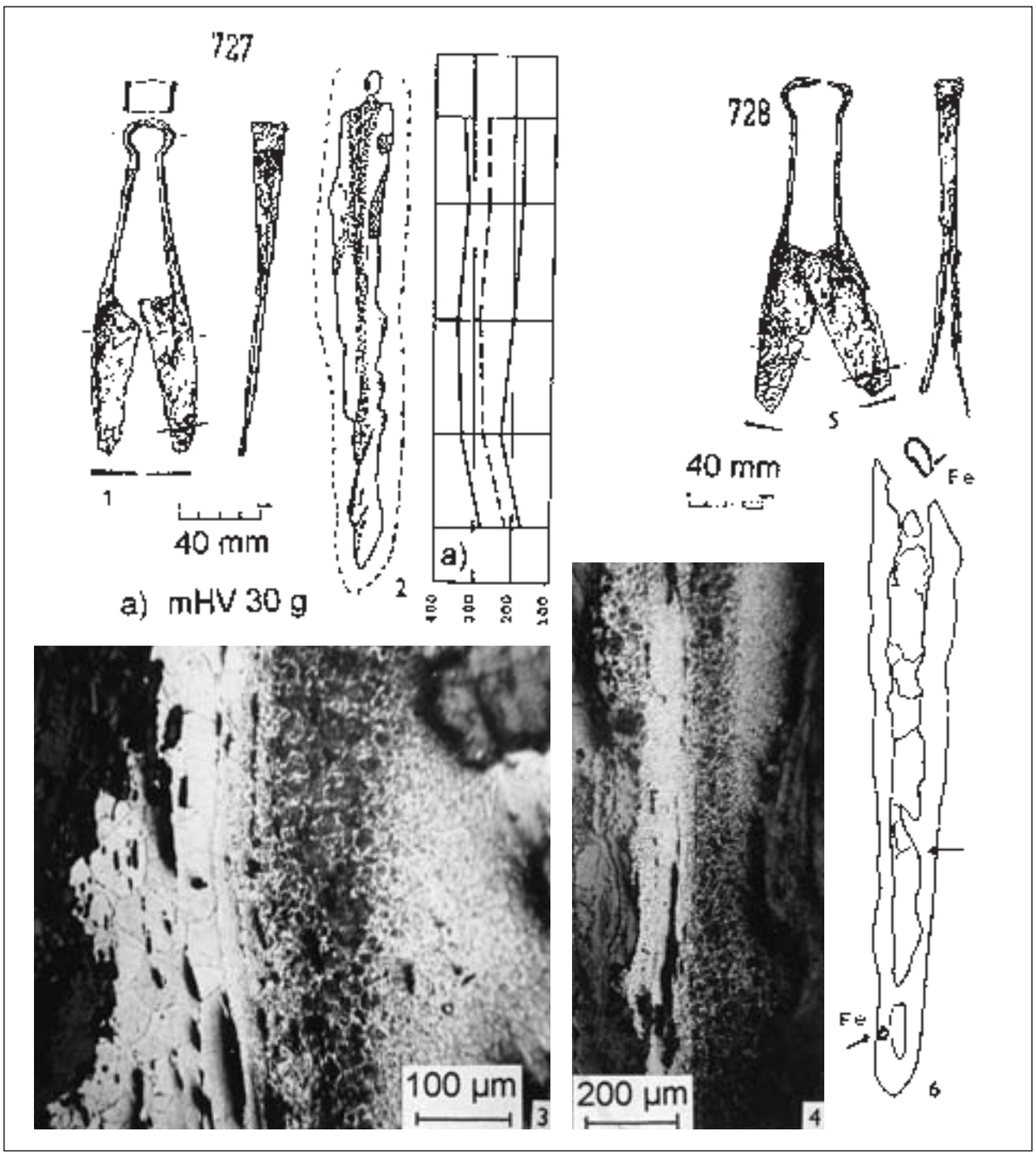

Fig. 1. Hoard of Bezdědovice. Shears, specimen 727 (1 – 4) and 728 (5 – 6). 1, 5 Sample positions; 2 Specimen 727, scheme of transversal section of one blade (grey: carbon steel) and microhardness (mHV30g); 3 – 4 microphotographs dark pearlitic strip (etching 2 % Nital); 6 transversal section of a completely corroded blade, with position of isolated metal spots (Fe).

Up to now more than 130 La Tène period iron artefacts were analysed by metallography (and published in an evaluable form) from the Celtic territories of Central Europe. About one half comes from Bohemia, Moravia, and Slovakia. Only five shears were examined and all of them were made by using different construction schemes as the three examples 477, 478, and 479 from the oppidum of Závist, Bohemia show: Specimen 479 is a pile of laterally carburized bands, 487 is an all-steel blade; No 477 consists of wrought iron back and steel cutting-edge but the construction is not legible due to the corroded part between. The same situation appears in the case of the Bezdědovice specimen 728. Thus, Bezdědovice 727 represents a perfect shear blade constructed as a three-layer sandwich with steel in the centre.

Socketed axes belong, to a great deal, to tops of the contemporary blacksmith's work. However, among eleven investigated specimens different techniques appear as well. A sandwich with steel central inlay was observed in Manching, an oppidum in Bavaria (716), and in Liptovská Mara, an oppidum in northern Slovakia (497). Two central plates of axe 407 from the oppidum of Hostýn (Moravia) were carburized only in the cutting-edge region, backed by wrought iron shells. On the other hand the axe-head 715 from Manching has a welded-on

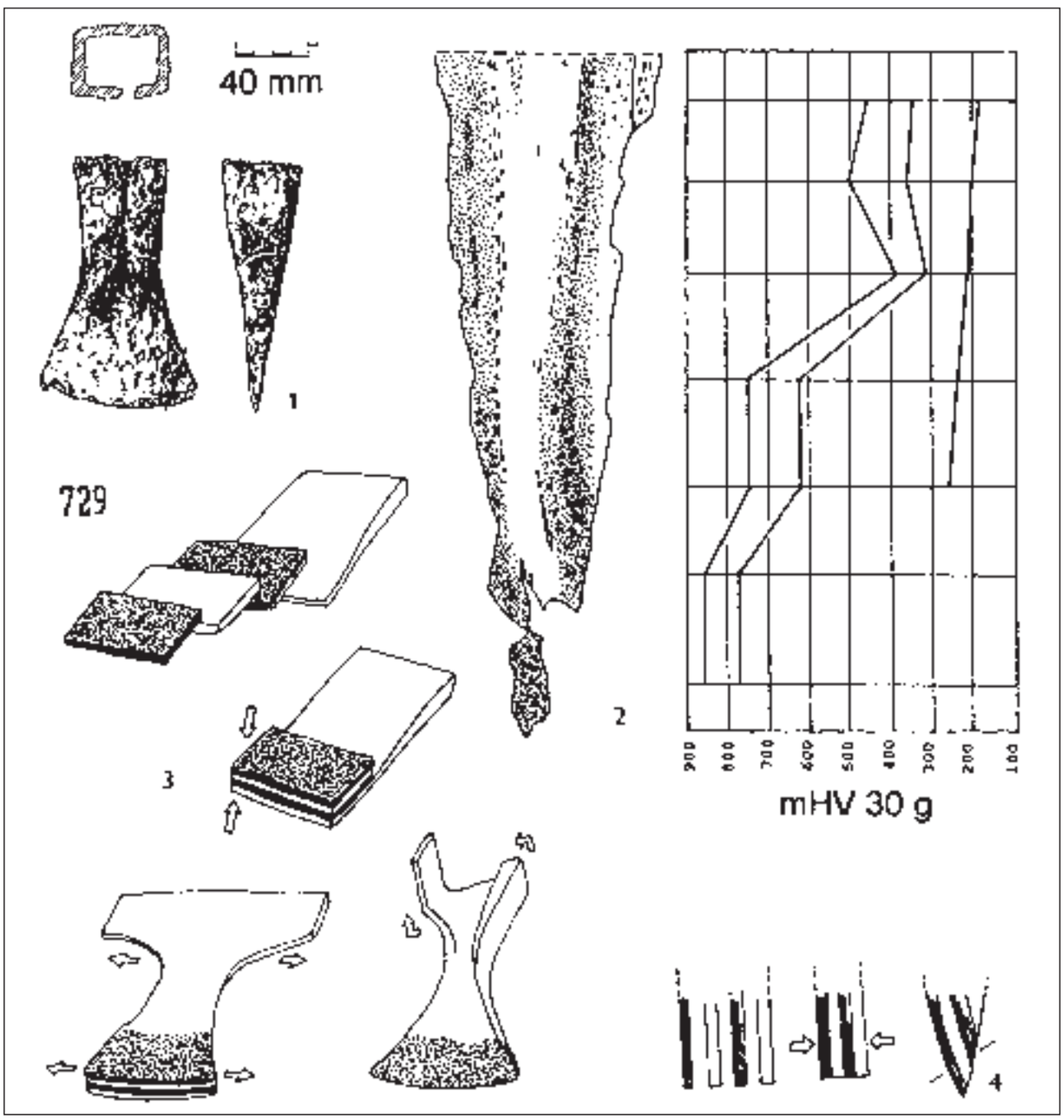

Fig. 2. Hoard of Bezdědovice. Socketed axe-head specimen 729. 1 sample position; 2 scheme of the polished block (iron: white; carbon steel: grey) and microhardness (mHV30g); 3 – 4 reconstruction of the manufacture technology.

hard steel cutting-edge on one side. This scheme was a standard for high medieval cutlery and tool making. Other axes (Hostýn 505 and 506, 44 from the oppidum of Stradonice in Bohemia, Widderstett in Thuringia) were of minor quality. They were piled from iron plates, sometimes laterally carburized, sometimes with slight carbon content. There is a question how to classify, in the light of presented counterparts, axe 729 from Bezdědovice which shows a bundle of four alternating steel and iron plates: a sandwich improved by welding-on an additional steel cutting-edge? A certain analogy may offer the socketed axe-head from Widderstett (2435), an open site near the oppidum of Steinsburg in Thuringia.

Among La Tène period knives, the category of the *Ringgriffmesser* represents, in terms of the manufacture technology and quality, an intersting group of ware for everyday use. Sixteen blades from European

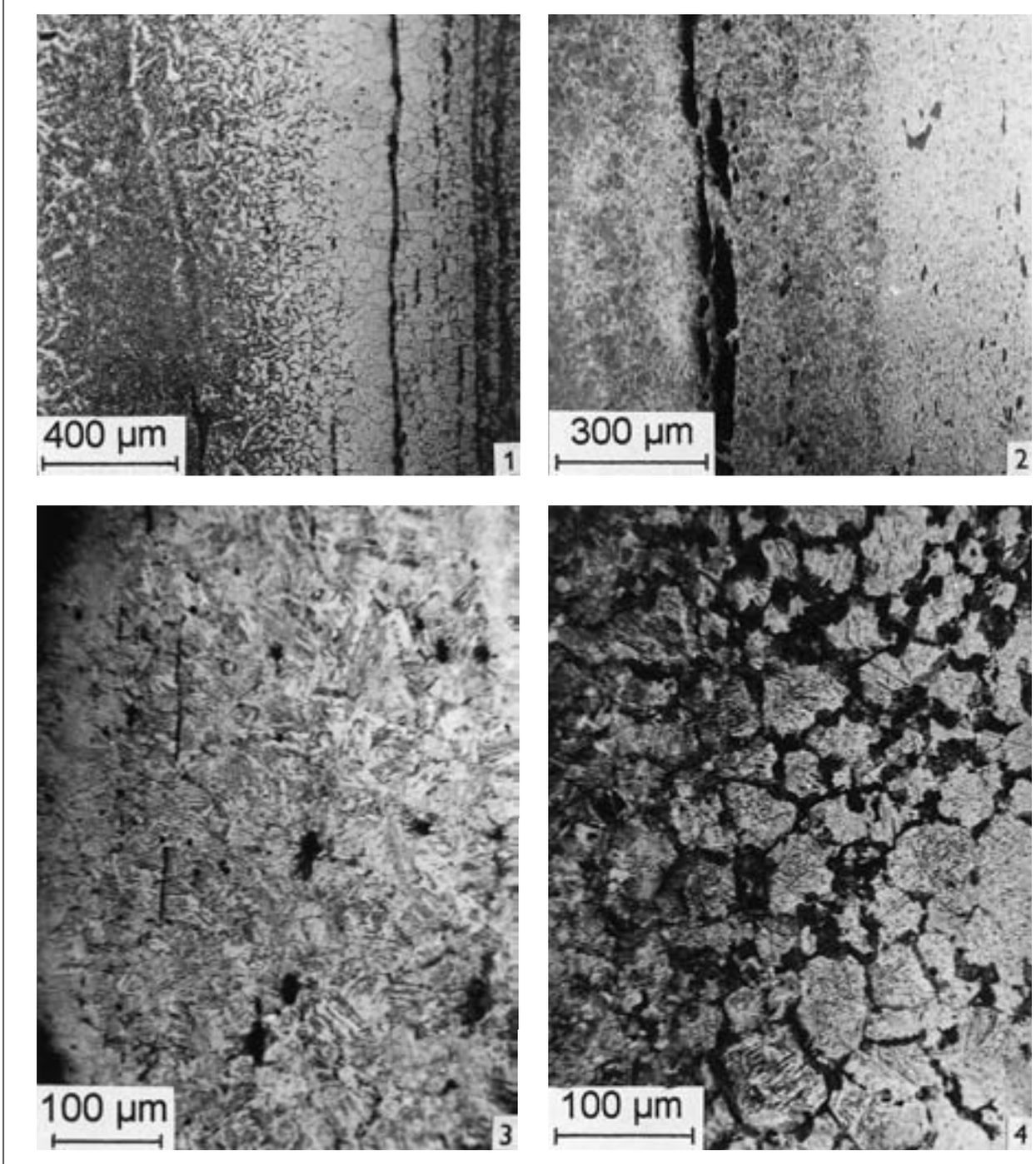

Fig. 3. Hoard of Bezdědovice. Socketed axe-head specimen 729, microphotographs: 1 – 2 Central part above the cutting-edge (grey martensite, light ferrite, black inclusions accompanying the welds; 3 cutting-edge: martensite, 4 martensite and dark troostite. Etching: 2 % Nital.

sites were examined. Nine of them may be classified as composite artefacts, using, in their blades, steel of very different quality, mostly poor in carbon. Those from the Bezdědovice hoard (730 and 731) are three-layer blades with a steel band on one side. Their construction resembles knife 660 from Berching-Pollanten, an open site near the Manching oppidum in Bavaria. The latter site, Manching, yielded four examined *Ringgriffmesser*: 718 was a three-layer piece with two hard steel bands and one iron band on one of the sides, 713 revealed two low carbon steel strips on both sides, not reaching cutting-edge, and 714 of the same scheme (side steel bands up to 4 % C, but the middle and cutting-edge heavily corroded). Specimens 718 and 719 from the same site are three- or four-layer bundles of iron, the side shells of the latter being enriched in phosphorus. In addition, R. Schwab examined two further knives of this type from Manching, one being a

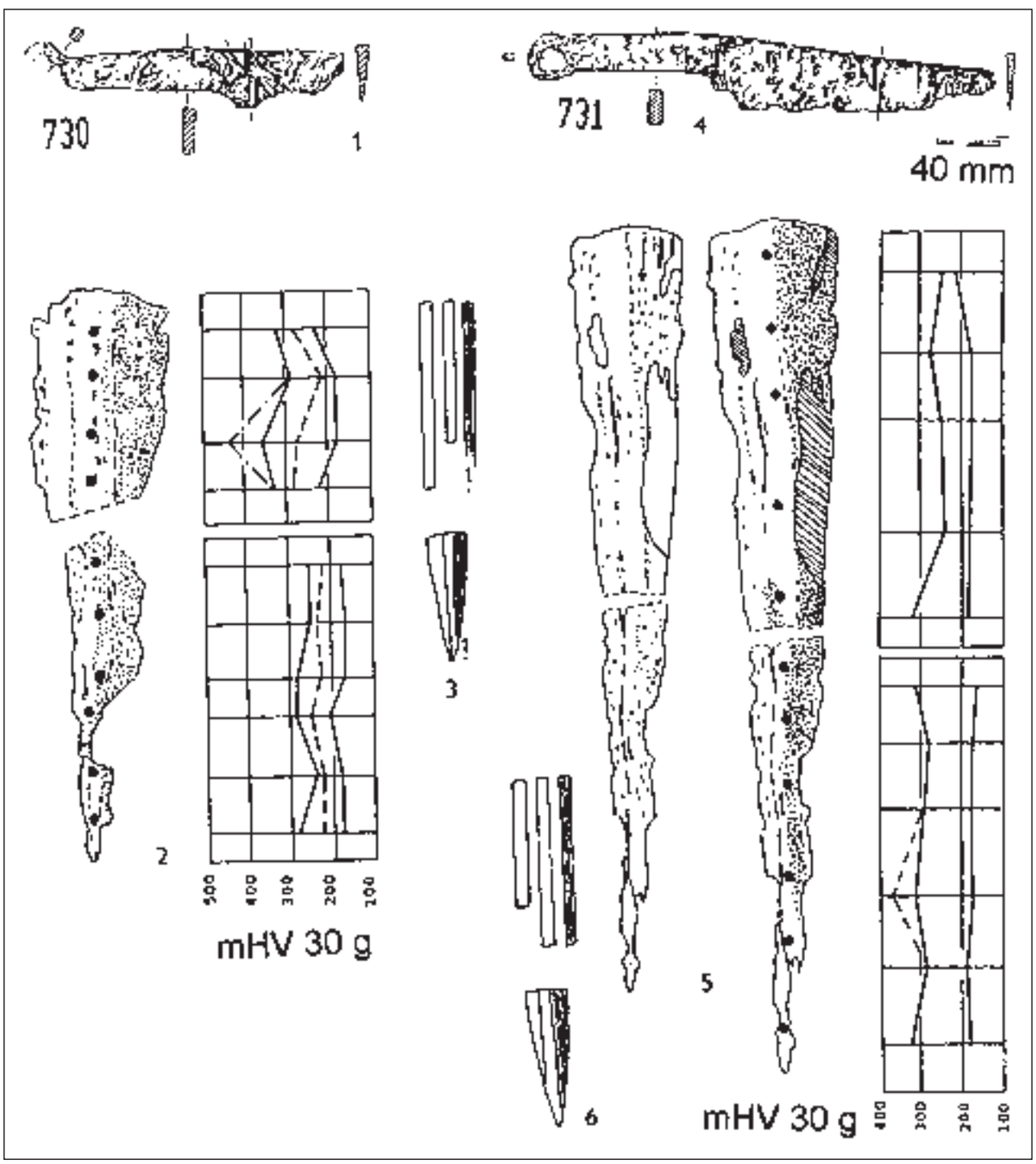

Fig. 4. Hoard of Bezdědovice. Ringgriff knives specimen 730 (1 – 3) and 731 (4 – 6). 1, 4 Sample positions; 2 – 5 Schemes of transversal blade sections (white: iron; grey: mild and medium steel) and microhardness (mHV30g); 3, 6 Reconstructions of manufacture technology.

wrought iron blade (specimen 7) an the other a pile with central phosphoric iron lamella (specimen 12). Knife 503 from Hostýn is a folded bundle with a steel cutting-edge and a steel wire, welded to the back; this specimen was quenched. There are two examined examples from the Závist oppidum: 474 is a pile, the central plates of which are carburized in the cutting-edge, and specimen 487 is a small *Ringgriff* razor welded from two steel bands with a decarburized cutting-line. The last three knives were forged from a single piece of metal, 502 from Hostýn and 496 from Liptovská Mara reveal heterogeneously distributed carbon content, 454 from Staré Hradisko is a ferritic wrought iron knife.

In the light of data being at disposal until now, the *Ringgriffmesser* represent a cutlery ware of medium or even minor quality.

Thus, the late La Tène period tools of discussed kinds show that a type of identical or very similar shape includes another, internal typology: that of technological construction. Such a variability of construction schemes may be observed in the case of other tools as well: chisels, planes, razors, scythes, weapons etc. In the future, when large numbers of investigated specimens will be compared, the different schemes could be plotted on a map. Might be, certain regional working trends or `blacksmith's schools' could be traced. No doubt that

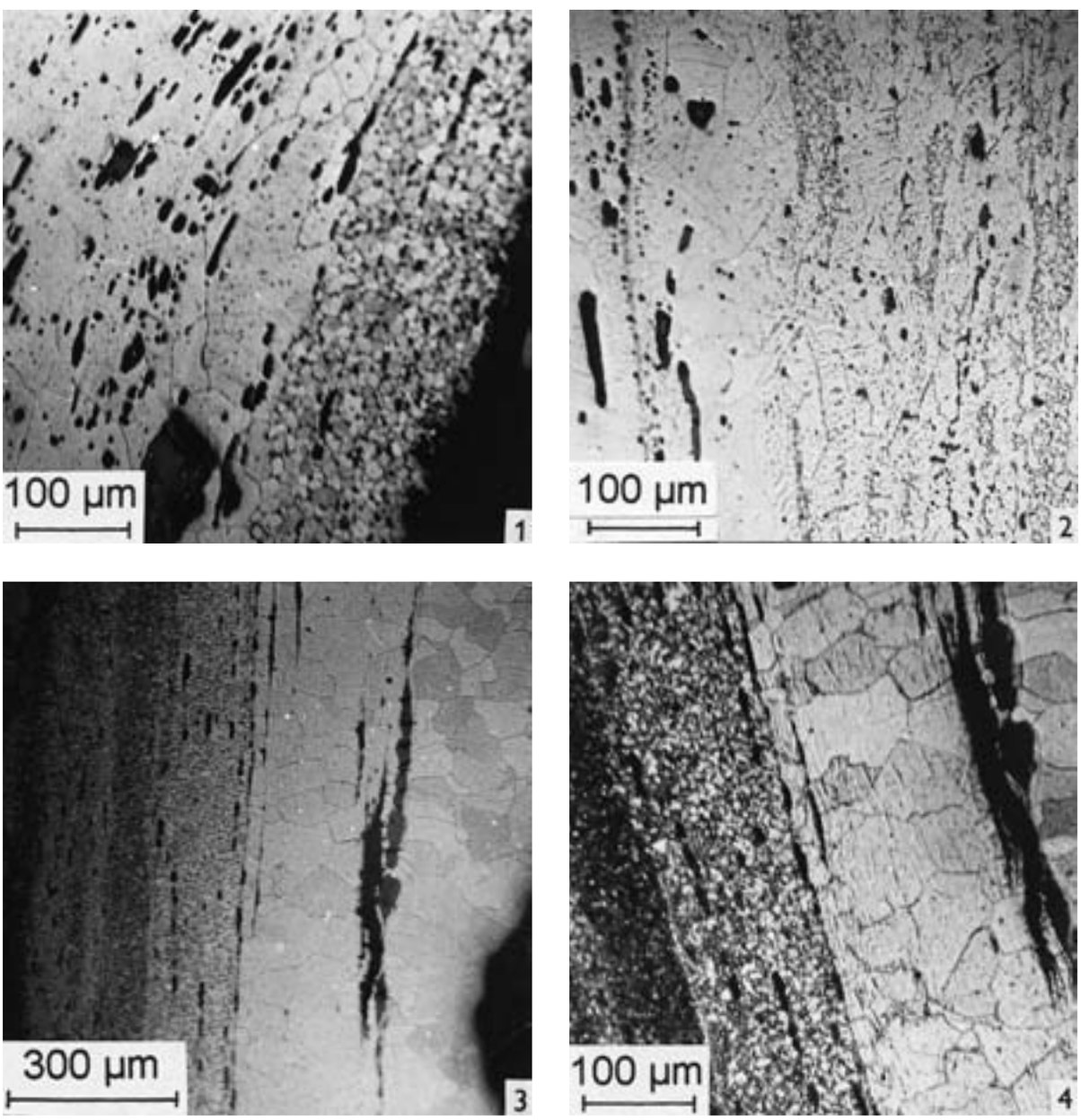

Fig. 5. Hoard of Bezdědovice. Microphotographs of Ringgriff knives specimens 730 (1 – 2) and 731 (3 – 4). Light: ferrite, grey: ferrite-and-pearlite and pearlite, black: slag inclusions accompanying the welds. Etching: 2 % Nital.

the Celtic ironworking craft was passing through an experimental stage and did not yet achieved a level of standardization of techniques. It should be added that the masters smiths on the periphery of the Celtic world, in Thuringia, Silesia, Brittany applied the trends to use high grade materials and sophisticated techniques in much more modest way.

The spread of advanced technologies during the last centuries BC remains a problem, because practically no metallographically investigated iron artefacts are known from Republican Rome, Etruria, or post-classical Greece up to the present days. Research programmes would be needed.

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