RUDNA GLAVA AND THE BEGINNING OF METALLURGY IN THE CENTRAL BALKANS

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The existence of an independent metallurgy in the Balkans and the Danube Basin at the end of the Late Neolithic has been confirmed by the settlement finds of the younger Vinča group. According to the present relative chronology the whole Vinča group belongs to the Late Neolithic, but recent results favour the dating of its later phase to the Early Eneolithic (M. Garašanin, 1973, pp. 112-114; B. Jovanović, 1971, p. 11). In this connection, one should examine the objects made of copper discovered at a series of Vinča sites over the whole of the culture's distribution.

From the relative chronological and technological standpoints, the most important finds are the four hoards of copper implements from the site of Pločnik in South Serbia (M. Grbić, 1929, p. 9, fig. 98-102). Unfortunately, the hoards are chance finds, but on the other hand, it cannot be doubted that they belong to this site — a fact confirmed by the constituent pieces. The hoards consist mainly of very early forms of copper axe-adzes characteristic of the Early Eneolithic in the Balkans and the Carpathians. The same is true for the chisels and the copper ornaments, which are few in number, and for the double-headed(?) pin, which suggests the possibility of relations with the south Balkans (B. Stalio, 1964, pp. 35-40, fig. 9; 1973, pp. 157-160; A. Vulpe, 1973, p. 223).

The hoards from Pločnik represent the best example of the copper industry of the younger Vinča group, in this case its central Morava-Danube variant. As for the north-west zone of the Vinča group, a number of copper objects hawe been found on the site of Gornja Tuzla in East Bosnia, but this time only ornaments and small tools are in question. The stratigraphy of copper objects shows that a long history of copper processing had occurred on this late Vinča site (B. Čović, 1961, p. 98, pl. X).

Contemporaneous finds from other sites confirm the picture of the use of copper over the whole territory of the Vinča group. Examples are to be found in South-West Vojvodina, Gomolava at Hrtkovci (B. Brukner, 1974, p. 79), in Central Serbia, Grivac and Divostin near Kragujevac (B. Gavela, 1958, p. 265; A. Mcpherron & D. Srejović, 1961, p. 230). In all these cases the pattern is the same, the people of the younger Vinča group knew and used copper. Remains from the processing of copper ores have been found in a settlement of this group on the Kosovo plain at Fafos near Kosovska Mitrovica. This site shows that malachite, cuprite and azurite were the basic raw materials for this primary metallurgy. Since these minerals are all varieties of the copper-carbonate ore, it would seem that the oldest Vinča metallurgy followed the well-known technological sequence leading from the use of native copper to the smelting of sulphide ores via exploitation of carbonate ores (R. Tylecote, 1962, p. 22; T. Wertime, 1973, p. 880; B. Jovanović, 1971, p. 22).

If this short review has indicated the existence of the earliest forms of metallurgy in the Vinča group, with the emphasis on a faster development in the south Morava Valley, it has left unaswered the important question of the sources of the raw material used by this culture.

As the central Balkan area is rich in copper ores, it is justified to assume that local sources of raw material were used. Needless to say, this opinion carries with it the suggestion of local development of Early Eneolithic mining. Although reasonable, such conclusions were until recently, unsupported by any direct evidence, in comparison to the well-attested early copper metallurgy of the Vinča group, with its numerous metal objects from a whole range of sites. This situation has been partly rectified by the trial excavations of an Early

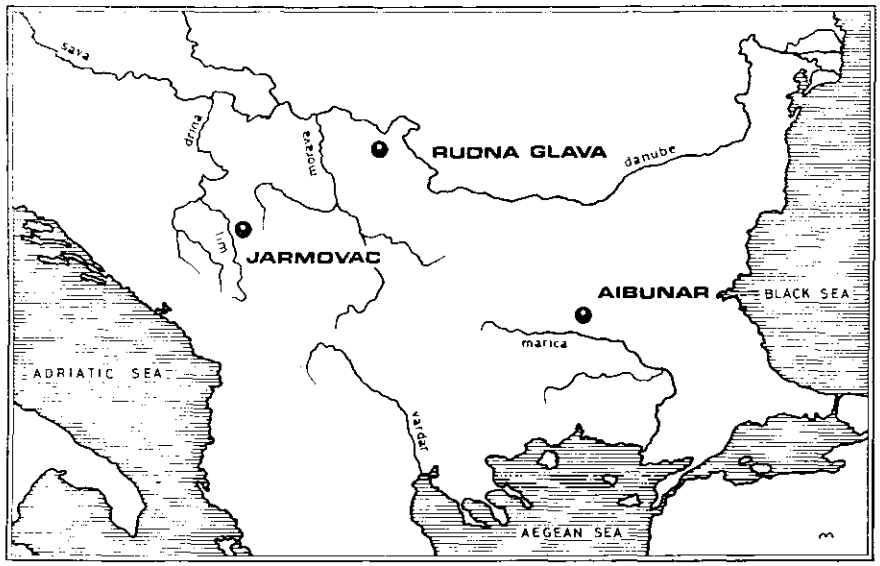


Fig. 16
Geographical position of the investigated prehistoric copper mines in the Balkans.

Eneolithic and Antique mine at Rudna Glava near Majdanpek, in North-East Serbia.
The existence of ancient mine shafts at this site was discovered during modern exploitation carried out by a large open-cast iron mine, which had cut and partially destroyed the shafts and galleries of the Early Eneolithic and Antique period.

Fig. 17
Open-cast of the modern Rudna Glava iron mine. The dotted area shows zone of ancient workings.

The excavations were carried out by the Museum of Mining and Metallurgy at Bor and the Archaeological Institute of Beograd. They began in 1968 but it was only in the 1974 season that decisive results were obtained (B. Jovanović, 1974, pp. 4-7, pl. I-III). The limited size of the trenches, the very novelty of the site and the search for a suitable method of archaeological investigation, all caused difficulties or have led to incomplete conclusions. But by the excavation of 1974 the stage of preliminery investigation into the Rudna Glava mine has been completed and the data acquired have been sufficient for the basic chronological and cultural determination of the mine. What is more, a new picture on the technology of the earliest known mining in the central Balkans has been furnished.

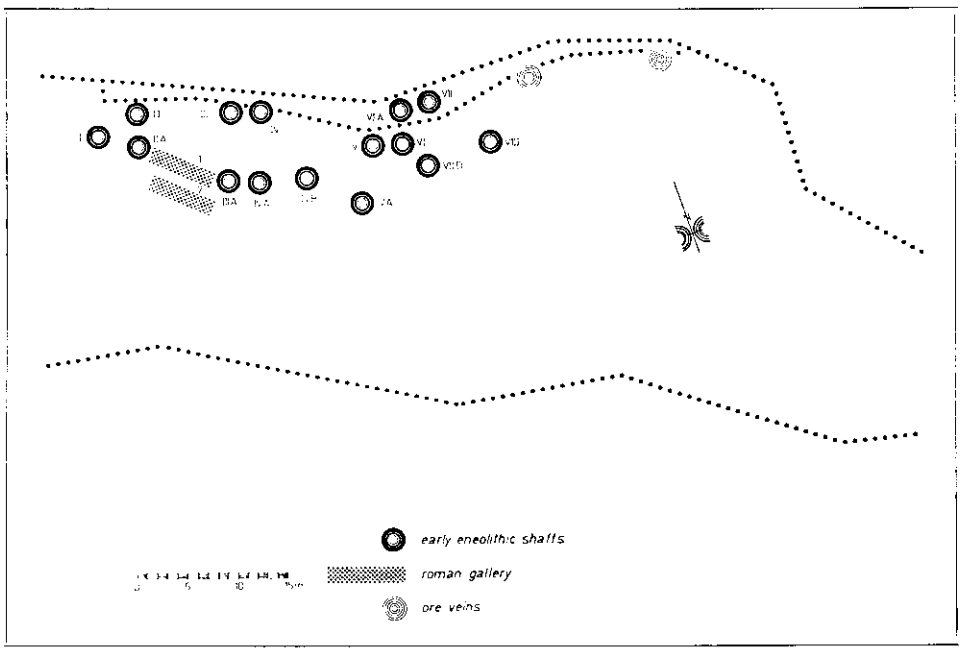


Fig. 18
Sketch of the disposition of the early eneolithic shafts and antique galleries on the north-east side of the open-cast iron mine at Rudna Glava.

It has been ascertained that the access platforms to the shafts were one of the most important constructional features of this mine. Of special interest was the fact that a layer of forest humus and accumulated material covered the shafts and their access platforms, in this way protecting them from major damage. Thus, the most important finds should be expected not only at the bottom of the shafts but also, in fact in the first place, on the access platforms themselves. These areas were used by the ancient miners as sort of workshop or as small stores for mining equipment. The discoveries made during the last year's excavation gave complete confirmation of the function of the access platforms.
The discovery that the Rudna Glava ore deposit was capable of yielding copper ores was made by the ancient miners on the base of clearly visible signs recognisable even today in the immediate vicinity. This noticeable difference in the

soil was caused by the process of oxidation of the magnetite ore, whose veins came directly to the surface. As the magnetite ore was impregnated by veins of chalcopyrite during the process of oxidation, the carbonate ores were produced at varying depths. Previous analyses have shown that malachite was most strongly represented, but that azurite was also included (B. Ottaway, 1974, in print). Other analyses were made by the Faculty of Mining and Metallurgy laboratories in Bor. These are the very minerals whose early utilisation in the oldest copper metallurgy of Europe and Asia Minor has already been clearly demonstrated.

The zones of oxidation of the iron and copper ores on the Rudna Glava hill are coloured by dark yellow, brown and greenish stains which are reliable indicators of the places where the ore veins came to the surface. In areas such as these, the Vinca miners began digging their access platforms. They were oval or elliptical in form, with sloping sides and were dug until the limestone was reached, the massive layers of which had been penetrated by ore veins coming from below.

When the humus layer and the accumulated material had been removed in in this case magnetite impregnated with copper-carbonate minerals. The was systematically emptied of its contents. Such ore veins were channels of irregular shape and size filled with the ore whos depth, from the surface to the junction of the ore bed, seldom reached more than 20 metres. The miners did not change the shape of the channels; they simply extracted their contents, in this case magnetite impregnated with copper — carbonate minerals. The compactness and hardness of the ore in the oxidation zone was not pronounced,

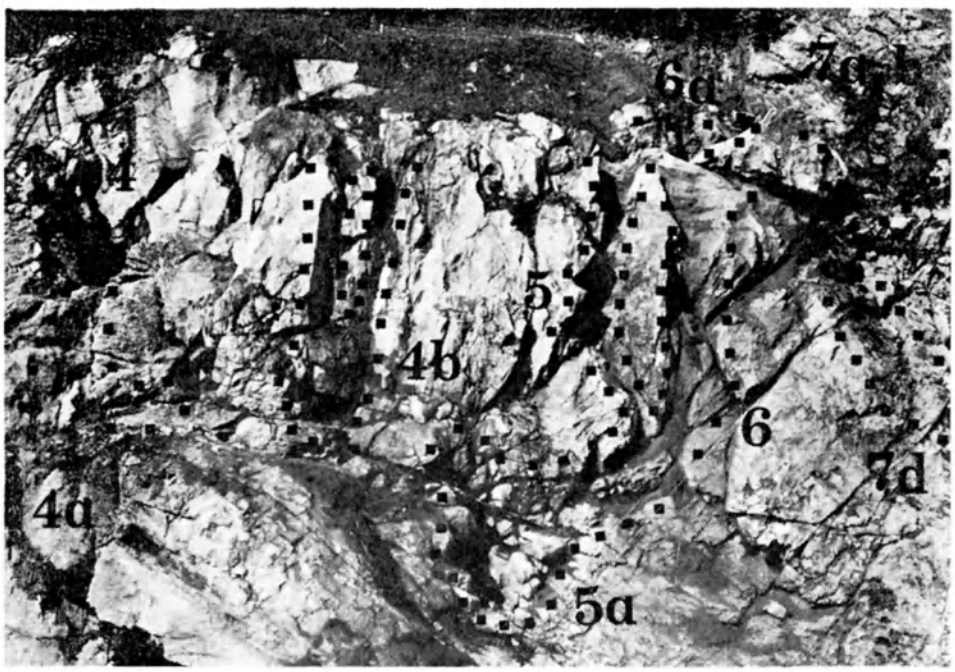


Fig. 19

North-east side of the open-cast iron mine at Rudna Glava with the damaged early eneolithic shafts.

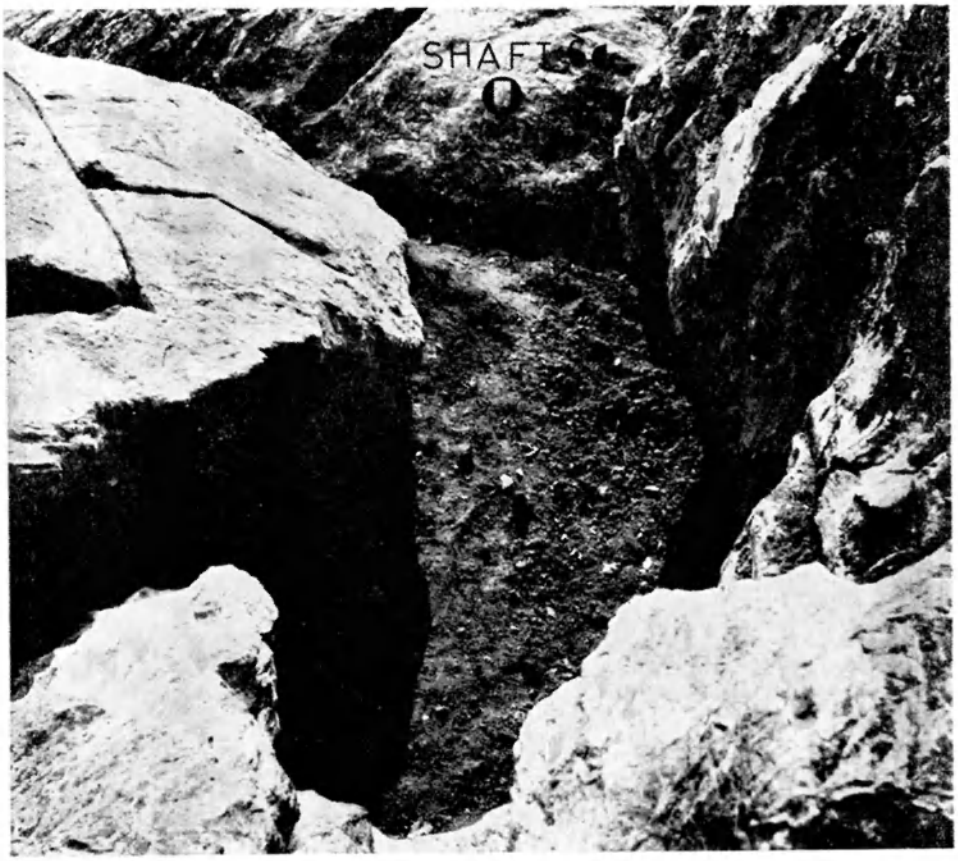


Fig. 20
Access platform of the shaft 6a.

a fact that is visible nowadays in those ore veins that have not been exploited. The state of the ore made its mining relatively simple, this despite the fact that the Early Eneolithic miners had a very basic technology at their disposal.
The depth reached by the old miners was never greater than 15 to 20 metres; they never went beyond the border of the zone of oxidation: this was probably the limit of natural surface ventilation. The dimensions of the shafts, depending on the shape of the ore veins, were between 0.50 and 1.50 metres in width, and some widening was often attempted at the base of the shaft, marking the zone of contact with the ore bed. According to the natural configurations of the ore veins, shafts ran into each other fairly often, thus aiding the circulation of fresh air. The organization of the Early Eneolithic mine was completely dictated by the disposition and frequency of the ore veins, which restricted even surface preparation. Since the ore veins had no regular disposition, it may be supposed that a separate zone of exploitation existed consisting of more groups of shafts. This affords a good opportunity for future investigation of the ancient mining complexes on Rudna Glava, especially in the zone of the open-cast iron mine.
The finds from the ancient mine of Rudna Glava have been recovered from

Fig. 21
Bottom of the damaged shaft 7d.

three main levels: the first consists of the access platforms, which contain the highest concentration of objects (shafts 6a and 7); the second group belongs to the channels of the shafts, where some implements were found in the fill (shafts 4,7d and 6); the third corresponds to the bottom of the shafts or to lateral cracks in the bottom of the shafts. Here single tools or groups were located. As a rule these tools were fragmentary or damaged by use (Shafts 2a, 3a, 4a and 7d).
Platform 6a, discovered during the last season of excavation, is a typical example of the finds of the first level. The platform was located very close to the platform of shaft 7, above the destroyed shafts 5 and 6. These locations, incidentally, provide a good example of the concentration of shafts in a restricted area. The ore vein of shaft 6a came out on the surface between massive blocks

Fig. 22
Bottom of the shaft 7d with the stone hammer in situ.

of limestone, so the lateral cracks and hollows were used for the storage of two small ceramic hoards. On the same platform, finds of stone, bone and wooden implements were frequent.
The fact that both ceramic hoards were found *in situ* is significant. They were protected by the limestone slabs which formed a kind of cover, indicating that the mine was not exploited after the oldest miners, the Vinča population, had departed. The later mining works at Rudna Glava belong to the Antique period (C. 4th. century A.D.) and quite different technical methods were employed for the very different means of recovering the magnetite ore.
Finds from the second level were discovered from almost all the shafts whose channels were even partially preserved, for example shafts 4 and 4b. But one should note that no complete channel of any shaft was examined in the former excavations. For the present, only the complete shafts 6a and 7, as well as shafts 3 and 4, whose channels were damaged in the upper part only can be taken into consideration in this discussion.

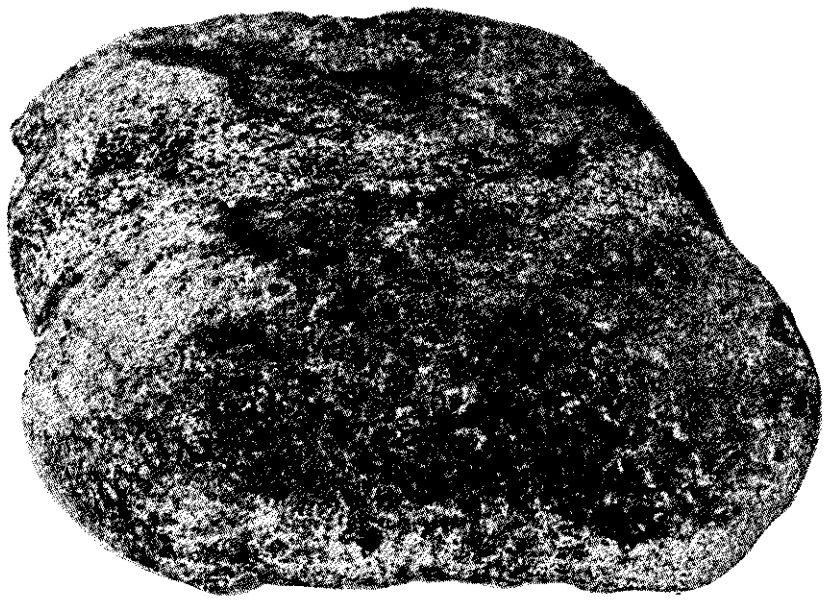


Fig. 23
Rectangular stone mining hammer (Shaft 7d; Dimensions: 13,5 x 12,5).

The third level is at the bottom of the shafts where stone or bone mining tools and sometimes fragmentary pots could be found. So, for instance, at the bottom of shaft 4a, eleven massive stone hammers were collected, together with some antler tools (B. Jovanović, 1974, pp. 7-8, pl. V-VI). Fragments of large coarse pottery were found at the bottom of shaft 7d as well.
The bases of the shafts have been the most thoroughly explored parts of the Rudna Glava mine, mainly because they were visible in the sloping sides of the open-cast iron mine whilst the access platforms and their channels have been destroyed mainly by modern working. That is the reason for finding preserved shafts on the edge of the open-cast mine or for searching for them in the surrounding areas.

The archaeological finds from Rudna Glava represent a series of closed finds from a single period but, according to the problem to be investigated, they can be viewed in two ways: first, as objects of importance for the relative chronological determination of the ancient mine and, secondly, as objects which contribute to the knowledge of primary mining technology.

The cultural and chronological determination of the ancient mine at Rudna Glava (i.e. vertical shafts) can be reliably defined by the pottery. The clearest evidence comes from the small ceramic hoards from the access platform of shaft 6a, including the fragments of an amphora and a bowl from the supporting wall of shaft 7a (B. Jovanović, 1974, pp. 6-7, fig. 3). Coarse ware sherds from the base of other shafts supplement these basic ceramic finds from the Rudna Glava mine.

Leaving aside the detailed typological analysis of these ceramics, it will be sufficient to examine the amphorae of hoards 1 and 2 from the platform of shaft 6a. The black burnished amphora-jug is of special importance; it has a ribbon handle and a row of shallow channelled spirals. The closest parallels are to be found in the Vinča settlements of the Morava and Danube basin, where such decoration is typical of the younger Vinča phase. A more precise analysis of this type of pottery suggests a date at the beginning of the late Vinča period. This would correspond to the date of both amphorae from hoard 2 (M. Garašanin, 1973, p. 102 pl. 21,1; M. Vasić, 1936, p. 89, fig. 135).

A similar chronological determination applies to the altar with deer's head

Fig. 24
Two amphorae in situ. *Access platform of the shaft 6a*

terminals found in one of the destroyed shafts at a depth of 12 metres, before systematic work began (B. Jovanović, 1971, p. 21, pl. III, 3-4). The characteristic shape of the deer's head, as well as the decorative system of incised meanders, are typical for the transition period between Early and Late Vinča, and the same relative chronological position is filled by the sherds found in shaft 7d. A relatively lengthy exploitation of the Rudna Glava mine is therefore suggested, beginning at the end of the early Vinča phase and continuing throughout the early part of the late Vinča period.

The stronger the evidence was for the oldest copper objects belonging to the Early Eneolithic of the Central Balkans, the more apparent became the lack of any knowledge of the technology of mining in that same area. The series of mining implements from Rudna Glava, made of wood, stone and bone, present an opportunity for a more detailed knowledge of the tecniques and methods used at the very beginning of mining in the Central Balkans and South-East Europe.

The most significant kind of tools, found in the shafts or on the access platforms, are a series of massive stone hammers or mauls. These are pebbles of volcanic origin (mainly gabbro) with a shallow groove round the middle, dimensions of 10 to 25 centimetres and weighing up to 4 kgs.

Although there was considerable variation in shape, between examples of the rocks but three main types could be defined according to their naturali shapes: 1. massive and cylindrical; 2. flat and rectangular; 3. small and triangular. The variety of shape suggests that they may repressent the beginnings of specialisation. This seems to be confirmed by the fact that this type of stone tool is unknown in settlements of the late Vinča group investigated to date.

The nature of the damage to their working edges and the existence of the shallow groove suggest that the basic purpose of these tools was to smash the ore. The hammers were not perforated; apparetly, they were held suspended on a rope or strap, which made it possible to use them in shafts of minimal dimensions with no reduction in efficiency. Their weight, good balance and variation in form or size enabled the miners to deliver hard swinging strokes, even though the space in the shafts was restricted.

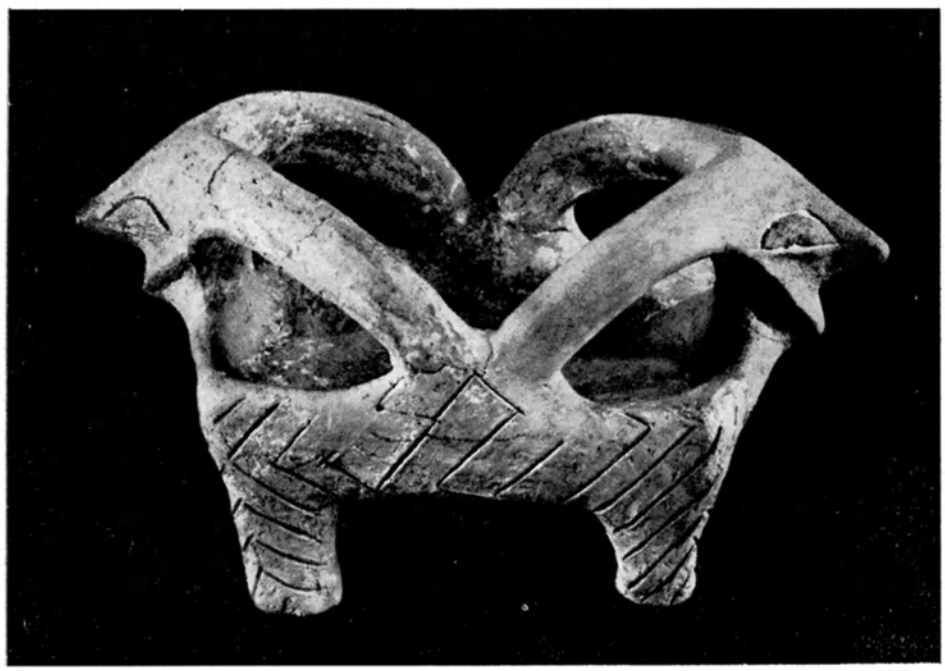
Judging by the data obtained so far from Rudna Glava, the earliest mining technology comprised the following operations: alternate heating and cooling of the ore (the remains of a hearth were found on the floor of shaft 4a), widening the cracks in the ore with wooden or bone wedges smashing the ore with massive stone hammers and lifting the ore to the surface of the shaft, where the separation of the carbonate materials from the magnetite probably took place. Apparently early types of copper implements, such as axe-adzes, chisels, etc. were not used in contemporary mining.

These massive hammer-rocks found at Rudna Glava are not only characteristic of the early mining in the central Balkans (compare the old mining works at Jarmovac, west Serbia). (O. Davies, 1937, p. 2). On the contrary, their distribution is very wide, stretching from the Negev desert at Timma (B. Rothenberg, 1972, pp. 26-27, fig. 6), to south-east Siberia, in the region of ancient Tuve (Y. Suntschugashev, 1969, p. 67, fig. 6,14), and from the north-west coast of Ireland, Mount Gabriel (S. Jackson, 1968, p. 96, pl. III,IVb), and Middle Italy at Cornacchino, Provincia di Grosseto (R. Grifoni, 1964, p. 19, fig. 4), to the central part of Asia Minor and North-west Iran, at Kuhestan-E-Oom (F. Holzer, M. Momenzadeh & Groop, 1971, p. 5).

This type of early mining tool, represented over such a wide area, shows certain typological and chronological differences, but the manner of utilisation

Fig. 25
Black burnished amphora-jug from the access platform of the shaft 6a. The beginning of the younger Vinca group (Height: 34.5 cm).

Fig. 26
Altar with deer's head terminals. The beginning of the younger Vinca group (Dimensions: 14 x 10 cm).



was probably the same. Its almost universal use in early mines, dating from the fourth millennium B.C. at Timna and at Kuhestan-E-Qom, to the first millennium B.C. at Mount Gabriel or even later, in 8th. century B.C. at Tuve (B. Rothenberg, 1972, p. 24; F. Holzer, M. Momenzadeh & G. Groop, 1971, p. 10; S. Jackson, 1968, p. 101; Y. Suntchugashev, 1969, p. 102), does not seem to be a result of diffusion. Parallel results may have been reached by similar technical processes.

Until full-scale investigation of Rudna Glava is accomplished the conclusions relating to the origins and technology of early mining are limited by the scope of the results. A similar situation is discernible in other parts of the Balkans. Old copper mines dating to the Late Eneolithic are known from the vicinity of Stara Zagora in South Bulgaria. These mines in their general technical characteristics correspond to Rudna Glava (E. Tchernih, A. Raduntcheva, 1972, p. 62).

It is further suggested that primary exploitation of copper mines has a technological predecessor in the typical Late Neolithic activity of flint mining, found

Fig. 27
Cylindrical and triangular stone mining hammers. (Shafts 6 and 6a: Dimensions: 23,5 x 12,5 cm and 19 x 8 cm).

all over Europe. A whole range of sites exhibit large-scale exploitation of flint: Krasnoe in White Russia, Grimes' Graves in Eastern England, or Spiennes in Belgium (N. Gurina & G. Kovnurko, 1964, p. 6; G. Sieveking and others, 1973, p. 182; F. Hubert, 1969, p. 43, pl. I). The miners of the well-investigated flint mine at Mauer near Vienna probably belonged to the Lengyel culture painted pottery phase (E. Rutkay, 1970, p. 74, pl. II-IV). It seems that the primary mining of copper was based on the experience gained in mining flint and that native copper was first regarded as a kind of stone.
According to these and other technological features, one can distinguish the

following phases of prehistoric mining : a) the mining of the Late Neolithic (mainly flint); b) the mining of the Eneolithic period, which took advantage of the experience gained in exploiting flint during the Late Neolithic but created its own technology, exemplified by massive stone implements; c) the mining of the Bronze and Iron Ages, with their well-developed mining techniques and the use of metal tools, for example the Mitterberg mine, near Salzburg (R. Pittioni, 1951, p. 24).

The relative chronological position of the phase of primary mining in the central Balkans and the broader region of South-East Europe has been determined, as noted above, by the dating of the Rudna Glava mine to the Early Eneolithic. As this mine belongs to the early part of the late Vinča period, the following groups are contemporaneus, at least in a general sense: the younger Vinča group/Vinča-Pločnik I/-central Balkans; Karanovo V/Marica group/-Thrace; Late Neolithic of Macedonia; Boian group-lower Danube basin; Herpaly-Csöszhalom group-north-eastern part of the Pannonian plain; Petresti group-Transylvania; Lengyel group-middle Danube basin; Sopot group-North-West Yugoslavia; Butmir group-Central Bosnia; Lisičići-Hvar group-Adriatic coast; late phase of Square-mouthed Pottery group-North Italy (B. Jovanović, 1971, p. 41; A. Benac, 1964, p. 29; E. Neustupný, 1969, p. 286, pl. III; L. Barfield, 1973, p. 395, fig. 1).

Following the high chronology supported by absolute C-14 dating, and the relative chronological sequence of the above mentioned cultural groups, the Early Eneolithic period belongs to the middle or second half of the 4th. millennium B.C. This is at least two millennia later than the date of the earliest use of metal in Anatolia, at Catal Hüyük in the second half of the 7th. millennium B.C. (J. Mellaart, 1967, p. 217). The cultural groups of the Early Eneolithic of the Balkans and the Danube basin were formed by long-lasting but gradual migration involving the populations who used black burnished pottery. These groups derived their origin from the Thracian-Aegean region and were the first groups to use copper in this area.

It should be stressed that the population of the Late Neolithic and Early Eneolithic belonged to the same evolutionary line, which includes also the autochthonous inhabitants of the Early Neolithic. It seems therefore possible to regard the oldest copper mining and metallurgy of the central Balkans as a local phenomenon synchronous with a phase of economic development which itself is almost contemporaneous across Central and South-East Europe. This is indeed the area where the cultural groups mentioned above, who are related in a demographic and productional sense, were formed and developed during the Late Neolithic.

Riassunto: Lo scavo di una miniera di rame dell'Eneolitico antico a Rudna Glava (Nord-Est della Serbia), ha rivelato nuovi fatti circa l'origine dell'estrazione del rame nei Balcani Centrali e nel Sud-Est Europeo.

Utensili di pietra, osso e legno hanno suggerito una sequenza di quattro operazioni di scavo: 1) alternazione di riscaldamento e raffreddamento del minerale per allargarne le crepe con cunei di legno o osso; 2) frantumazione del minerale con grandi martelli di pietra; 3) sollevazione del minerale alla superficie del pozzo; 4) separazione dei carbonati dalla magnetite. La miniera viene datata dal contesto di ritrovamenti, per la maggior parte ceramiche, dalla fine di Vinča antico persistendo nel tardo Vinča (seconda metà del 4° millennio A.C.). Un'immagine generale dell'evoluzione delle attività minerarie ci mostra: a) nel tardo Neolitico prevalentemente selce; b) nell'Eneolitico usando la precedente esperienza, si aggiungono grandi strumenti di pietra quali nuovo elemento tecnologico; c) nell'età del Bronzo e del Ferro

si aggiungono nuove sviluppate tecniche di estrazione e l'uso di strumenti metallici. L'Autore afferma che le popolazioni del tardo Neolitico e del primo Eneolitico sono discendenti degli autoctoni del Neolitico antico. Pertanto le più antiche operazioni minerarie e metallurgiche dei Balcani Centrali sono viste come fenomeno locale concomitante alla fase di sviluppo economico che si espanse attraverso l'Europa Centrale e del Sud nello stesso periodo.

Résumé: Les fouilles effectuées dans une mine de cuivre de l'Enéolithique ancien à Rudna-Glava (Serbie nord-orientale) ont donné de nouveaux aperçus sur les premières techniques d'extraction au centre des Balcans et dans l'Europe sud-orientale. Des outils en pierre, en os et en bois ont suggéré que l'on puisse établir une série de quatre opérations pour l'extraction du mineral: à une succession préalable de chauffage et de refroidissement, aurait suivi l'élargissement des fentes au moyen de cales en bois ou en os et le broyage du mineral par des marteaux très massifs en pierre. Ce procédé se serait terminé par le transport du mineral jusqu'à l'embouchure du puits d'extraction, où avait lieu la séparation entre le carbonate et le magnétite. La mine est datée par des découvertes in situ, surtout de la poterie. Le début de l'exploitation date de la fin de la période Vinca ancien, en se poursuivant pendant le Vinca tardif (vers le milieu et la deuxième moitié du 4ème millénaire av. J.-C.). Il a été possible d'atteindre une vision générale sur l'évolution des techniques minéraires de la préhistoire: a) celle du Néolithique tardif, concernant surtout l'extraction du silex; b) celle de l'Enéolithique qui, utilisant l'expérience précedente de l'extraction du silex, créa quand-même sa propre technologie, i.e. celle des outils massifs en pierre; c) celle des âges du Bronze et du Fer, avec leurs techniques d'extraction bien développées et l'usage d'outils en métal.
L'Auteur affirme que les populations du Néolithique tardif et de l'Enéolithique ancien se situaient dans la même ligne d'évolution, qui n'a pas d'interruptions dépuis les premiers habitants du Néolithique ancien. Les techniques les plus anciennes de l'extraction du cuivre et de la métallurgie, au centre des Balcans, peuvent être considérées un phénomène local, en concert avec une phase de développement économique répandu dans l'Europe centrale et sud-orientale.

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