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Book XXI

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НОВА МУЛТИДИСЦИПЛИНАРНА ИСТРАЖИВАЊА ИСТОЧНЕ СРБИЈЕ, ОКОЛНИХ ОБЛАСТИ И СРПСКОГ ЕТНИЧКОГ ПРОСТОРА

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за проучавање културе источне Србије и суседних области

НОВА МУЛТИДИСЦИПЛИНАРНА ИСТРАЖИВАЊА ИСТОЧНЕ СРБИЈЕ, ОКОЛНИХ ОБЛАСТИ И СРПСКОГ ЕТНИЧКОГ ПРОСТОРА

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SOME REMARKS ON TIN ORE DEPOSITS IN THE BALKANS

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Abstract: *This paper will present several tin ore deposits on the territory of Balkans and adjacent areas, which could possibly be connected to prehistoric exploitation. Tin represented rare and relatively inaccessible resource, necessary for tin-bronze production, so the question of tin origin and distribution more and more comes to the focus of present day prehistoric archaeology.*

Key words: *tin, cassiterite, tin deposits, Balkans.*

Апстракт: *У раду ће бити приказана лежишта руда калаја која се налазе на територији Балкана, а која би се уједно могла довести у везу са праисторијском експлоатацијом. Како је калај представљао ретку и релативно неприступачну сировину, а неопходан је за добијање калајне бронзе, питање његовог порекла и даље дистрибуције данас је све више у фокусу истраживања праисторијске археологије.*

Кључне речи: *калај, каситерит, лежишта, Балкан.*

Based on the quantity of tin ores in Earth's crust, it represents a relatively rare element, being in the 50th place.¹ On the other hand, tin is necessary for tin-bronze production, and without a doubt it represented a luxurious and not so accessible resource. The problem of available deposits, exploitation and distribution of tin becomes especially conspicuous if we look towards Balkans and Eastern Mediterranean, as on these territories, during the Bronze Age, we record a great amount of bronze artifacts.

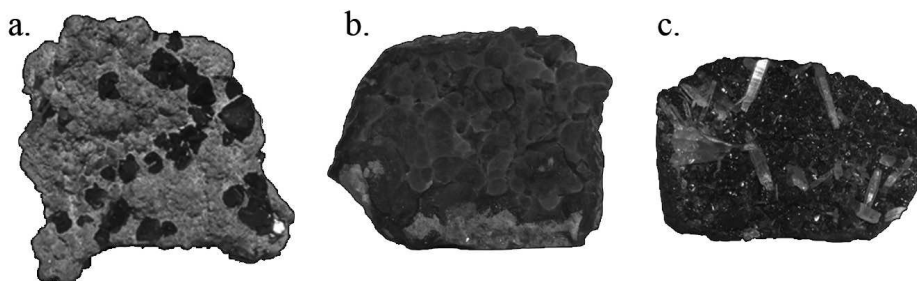


Fig. 1 - Different forms of cassiterite mineralisation from Museum of Natural History in Berlin: a. Erzgebirge/Ore mountains, Germany; b. Cornwall, England; c. Siberia, Russia.
Сл. 1 - Различити облици минерализације каситерита из Природњачког музеја у Берлину: а. Erzgebirge/Рудне горе, Немачка; б. Корнвол, Енглеска; с. Сибир, Русија.

In the early 20th century, an interest for origin of tin in prehistoric bronzes increases, while at the same time the idea of the Balkans as a possible source of tin in bronze artifact from the territories of present day Greece (with islands) and Balkans appears for the first time.² In his extensive paper dealing with tin in antiquity from 1986, Roger D. Penhallurick once again discusses about possible tin deposits in Balkans,³ and decade later Aleksandar Durman pays more attention to this problem.⁴ Despite this, certain authors tend to overlook the territory of Balkans when discussing potential trade and exchange routes of tin, copper and bronze between Central and Southeastern Europe, particularly in various phases of The Bronze Age.⁵

Present day tin ore deposits are globally well familiar,⁶ therefore we can say that the largest ones are located in Mali, Burma (Myanmar), Eastern parts of Siberia, Nigeria, England and Australia.⁷ Speaking of Europe, largest tin ore deposits are located

¹ Stwertka 2002: 133–134.

² Davies 1939: 89 and further; *Idem* 1932: 145 and further; Gaul 1942: 400 and further.

³ Penhallurick 1986.

⁴ Durman 1997: 7 and further.

⁵ E.g. Kristiansen, Larsson 2005: 110 and further.

⁶ We must count on the fact that some deposits could to this day remain undiscovered, and that some deposits could be completely exploited in past, which would make it impossible for us to detect them.

⁷ Janjić, Ristić 1995: 124–125.

in Cornwall (England),⁸ Central-Iberian Zone (Spain),⁹ Massif Central and Brittany (France),¹⁰ and Erzgebirge/ Ore mountains (Germany/ Czech Republic).¹¹ Besides those, some smaller tin ore deposits are known from Mourne mountains (Northern Ireland),¹² Carmarthen (Wales),¹³ Isles of Scilly (England),¹⁴ Portugal,¹⁵ Northern Corsica (France), Tuscany, Calabria, Sardinia, Sicily, Elba island (Italy),¹⁶ and Jizerské hory/Izera mountains (Czech Republic/Poland).¹⁷ Several of these deposits provided data that could indicate prehistoric exploitation.

Tin naturally occurs in two mineral forms i.e. ores – cassiterite (SnO_2) and stannite ($\text{Cu}_2\text{FeSnS}_4$) (Fig. 1). Although stannite is relatively widespread, there are no data that would confirm its prehistoric exploitation, and even today it does not represent a resource of major economic significance. As for tin, it occurs in granites, pegmatite dikes, and quartz veins, but also in high-temperature hydrothermal veins in or near granite.¹⁸ As cassiterite is very resistant in surface conditions, it is very suitable for the formation of secondary alluvial deposits.¹⁹ Tin also possesses 10 stable isotopes (^{112}Sn , ^{114}Sn , ^{115}Sn , ^{116}Sn , ^{117}Sn , ^{118}Sn , ^{119}Sn , ^{120}Sn , ^{122}Sn , ^{124}Sn),²⁰ which is more than any other element and makes tin very favorable element for provenance analysis. Tin provenance analysis are becoming a more common method in archaeology for the past 20 years, thus helping determine the origin of tin in greater amount of bronze artifacts. Several problems and issues still occur, as tin provenance analysis methods are still being perfected.²¹ This paper will present those deposits located on the territory of Balkans, but also in some adjacent areas that stand in direct geographical connection with Balkans. Some remarks will also be made on present data on potentials of prehistoric exploitation of Balkan tin ore deposits. The deposits will be presented in geographical order, starting from Northwest towards Southeast.

⁸ Penhallurick 1986: 173–224; Tylecote et al. 1989: 435; Gerrard 1998; Pearce 2004: 8.

⁹ Merideth 1998: 64–67; Gumiel, Arribas 1990: 216–271; Rovira, Montero 2003: 15 and further.

¹⁰ Penhallurick 1986: 84, Map 15; McGeehan-Liritzis, Taylor 1987: 287–288.

¹¹ Bouzek et al. 1989: 203 and further; Beran, Sejkora 2006; Ulrich 2013: 135–140.

¹² Warner et al. 2010: 29 and further.

¹³ Penhallurick 1986: 110.

¹⁴ *Idem.*: 119–122.

¹⁵ Neiva 2008.

¹⁶ Venerandi-Pirri, Zufardi 1981: 525 and further; Penhallurick 1986: 79; Dolfini 2013: 23–24, with complete earlier literature; Benvenuti *et al.* 2014: 261 and further.

¹⁷ Penhallurick 1986:71; Pieczka et al. 2007: 219 and further, with complete literature.

¹⁸ Rapp 2009: 171.

¹⁹ Fletcher, Loch 1996.

²⁰ Laeter, Jeffery 1965: 2899–2902.

²¹ E.g. Hausteine et al. 2010: 816 and further; Balliana et al. 2014: 2973 and further; Yamazaki et al. 2014: 458 and further.

*

Smaller ore deposits, in which amongst others tin ore cassiterite occurs are located in Bosnia and Herzegovina. These are deposits on Vranica mountain (Fig 2/1), as well as possible alluvial deposits on Motajica and Prosara Mountains (Fig 2/2).²² Ore deposits on Vranica mountain were extensively exploited primarily for gold during the The Roman Period (from 1st century AD), while its prehistoric exploitation can be connected to the period following the mid II millennia BC.²³ The results of recent analysis

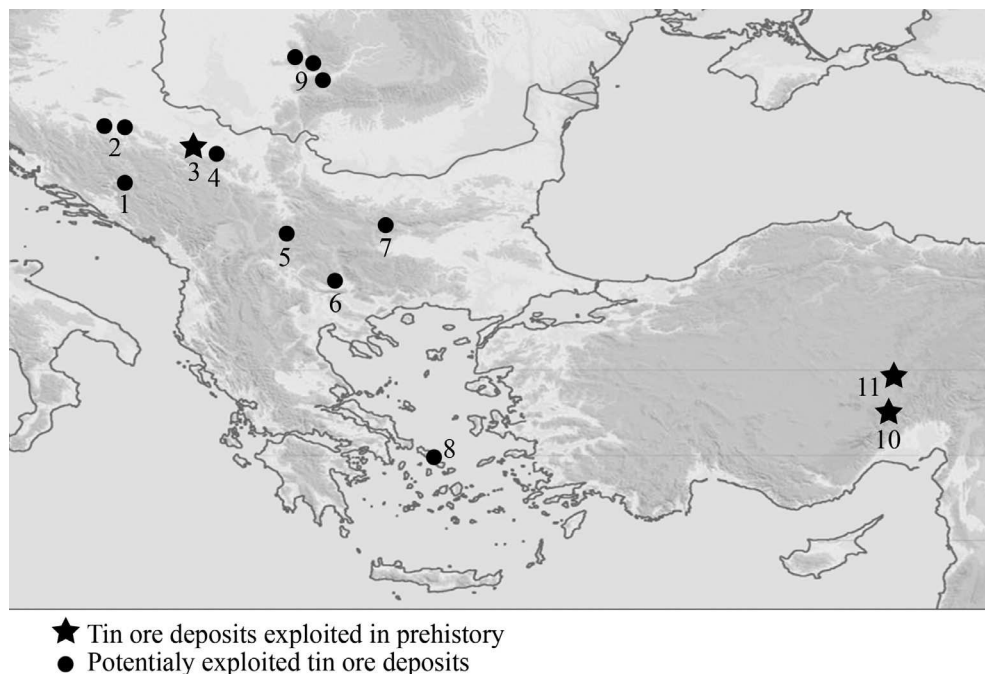


Fig. 2 - Tin ore deposits in the Balkans and surrounding areas.
Сл. 2 - Лежишта калаја на територији Балкана и суседним територијама.

conducted on bronze artifacts dated to the Transitional Period and Early Iron Age (Ha A1 – B3) of Central Bosnia and Herzegovina pointed to extensive exploitation of copper ore in mentioned and adjacent areas in that period. This data could also to a certain extent point out the potential tin ore exploitation. Future analysis of tin ore from Bosnia and Herzegovina could provide us with some final data on this topic.²⁴

On the territory of present day Serbia, several fluvial deposits in which tin ore cassiterite occurs are known. In aforementioned paper on tin deposits in Southeastern

²² Durman 1997: 9, ref. 3.

²³ Gavranović 2012: 103–104.

²⁴ Gavranović, Mehofer 2016: 87 and further.

Europe by Aleksandar Durman, certain alluvial cassiterite deposits are mentioned in correlation with Lešnica and Cernica Rivers²⁵ which are descending from Cer Mountain in western Serbia.²⁶ As an increasing interest in prospecting the potential tin ore deposits in Western Serbia appeared, a detailed geological survey, sampling and PXRf analysis were conducted, thus proving that alluvial deposits do exist in banks of more than several rivers and streams descending from mountain Cer. The highest yield of tin ore cassiterite was provided by Milinska and Cernica Rivers (0.5 and 0.4% of cassiterite in samples) (Fig. 2/3).²⁷ Prehistoric

exploitation of these deposits could be confirmed by recently conducted isotopic analysis on more than 90 bronze artefacts from the territories of Serbia and Romania.²⁸ All analysed artefacts are dated to Late Bronze Age and Transitional Period (Br C-Ha A₂). Namely, by cross-referencing these results with the geographical distribution of sampled artefacts, three distinct isotopic groups (signatures) were proposed: *Serbian Group*, *Vojvodina Group* and *Banat-Transylvanian Group* (Figs. 3 and 4).²⁹

Further cross-referencing these isotopic groups with the results of isotopic analysis from cassiterite ore originating from Cer Mountain could provide precise data on prehistoric exploitation. One sample, originating from

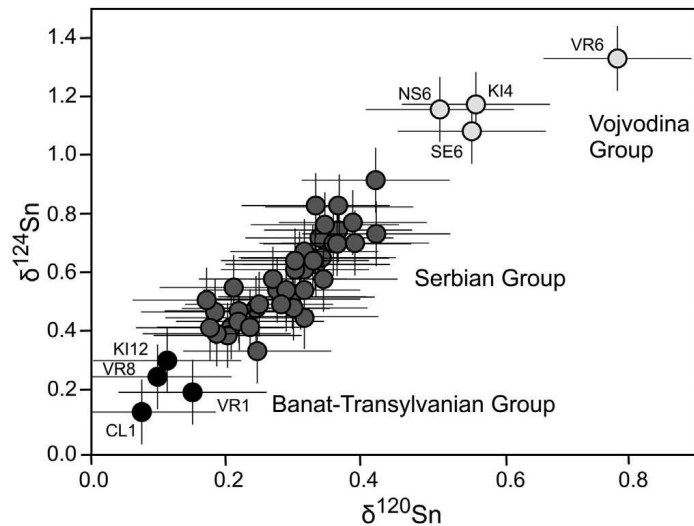


Fig. 3. Results of tin isotope analysis in reference to geographical distribution of sampled artifacts (after: Mason *et al.* 2016: fig. 4).
Сл. 3. Резултати изотопских анализа калаја у односу на географско порекло узоркованих предмета (према Mason *et al.* 2016: fig. 4).

²⁵ Durman 1997: 10.

²⁶ On page 10 of his paper (Durman 1997), speaking of quantitative relationship of tin ores between Bukulja and Cer mountains, Aleksandar Durman refers to paper: *U prilog mogućnosti bronzanodopskog rudarstva u području planine Cera i Podrinju* (Panić 1991). At that point mentioned paper existed only as unpublished manuscript. It remains uncertain if that paper was ever published, bearing in mind that I was not able to recover it.

²⁷ Huska *et al.* 2014: 482–489.

²⁸ Some analyzed artifact originate from sites in present day Croatia (e.g. Vinkovci), although they are in collections of Serbian museums.

²⁹ Mason *et al.* 2016: 110 and further.

Gologlava site, could not be fitted into proposed groups, as its isotopic signature remains unique for now. Since Cer Mountain is located in western Serbia, we have to mention a pottery fragment from Spasovine site, located on the right side of Milinska river in Western Serbia, which was covered with glass-like slag traces, probably from vitrification. The pottery fragment is preliminary dated to Middle/Late Bronze Age.³⁰ Later PXRf analysis determined that surface slag contains copper and tin, possibly pointing out to prehistoric copper/tin/bronze metallurgy at this site.³¹ On the other hand, it is known that certain alluvial cassiterite deposits exist in Bukulja Mountain fluvial deposits (Fig. 2/4).³² Possible alluvial cassiterite deposits are also connected to Bujanovac granite massive in Southern Serbia (Fig. 2/5). At this point, we have no data on Bukulja or Bujanovac prehistoric tin exploitation.

The problem of tin ore deposits on the territories of present day Macedonia and Bulgaria is to a great extent noticeable. Namely, no extensive research of tin deposits was conducted so far on these territories. One of potential alluvial tin ore deposits is located eastern from Strumica River, with the tin ore allegedly originating from Ogražden

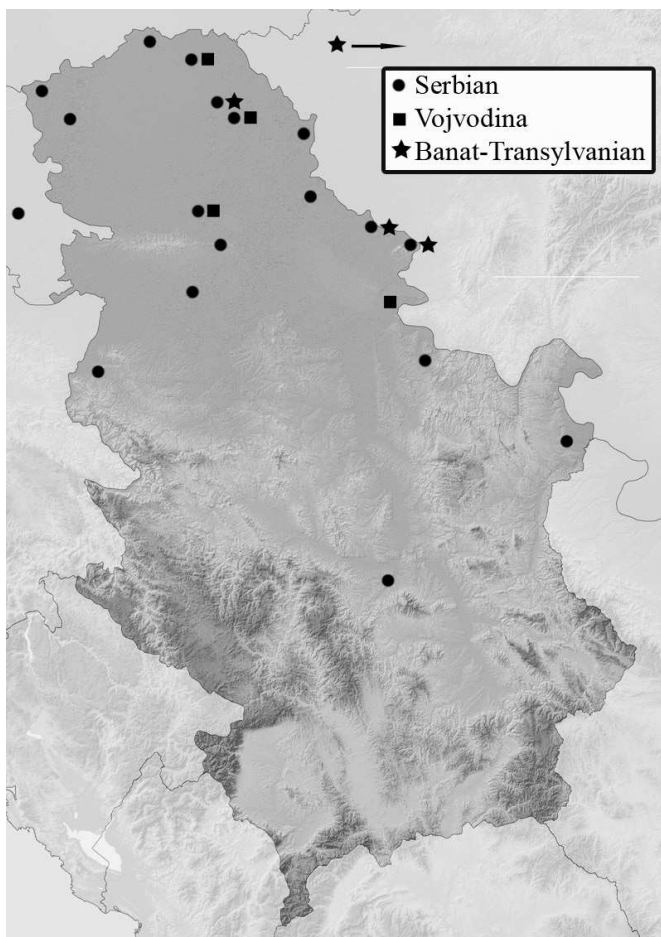


Fig. 4 - Sites from which analyzed artifacts originate.
Сл. 4 - Локалитети са којих потичу анализирани предмети.

³⁰ Bankoff *et al.* 2013: 63.

³¹ Huska *et al.* 2014: 486–487.

³² I was informed by geologist Miroslav Stojanović and colleague Olga Starčević from National Museum in Aranđelovac that there were no extensive geological surveys conducted in the area of Bukulja since late 80s. Therefore, in this paper I am presenting the data Aleksandar Durman provides.

Mountain (Fig. 2/6).³³ Tin is also detected in the composition of *hemusite* mineral, which had been discovered in copper deposits near Chelopech in central Bulgaria (Fig. 2/7).³⁴

Tin ore deposits are detected in several mineral formations on the territory of Greece,³⁵ although cassiterite has only been confirmed on the island of Thinos in Cyclades (Fig. 2/8).³⁶ Recently, a more intensive research is conducted on detecting tin ore deposits, or possible routes which supplied this territory with tin.³⁷

We should also briefly mention several tin ore deposits that are not located on Balkans itself, but have to be taken under consideration when speaking of origin of tin in this territory. First, we have ore deposits that are connected with Apuseni Mountains and Carpatians in present day Romania (Fig. 2/9). Recent isotopic analysis of bronze artefacts dated to Early and Middle Bronze Age from the territory of Romania pointed out the Alps and present day Slovakia as the origin areas of the copper ore.³⁸ It remains unclear whether various ore deposits in Romania were even large scale exploited in Bronze Age. Tin ore deposits are also known from Anatolia in present day Turkey: such as Kestel³⁹ on Taurus Mountains which is connected with prehistoric metallurgy traces at nearby Göltepe site (Fig. 2/10),⁴⁰ or deposits on mountain Ercyes near Kültepe site (Fig. 2/11).⁴¹

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The question of origin and distribution of tin in Balkans and Eastern Mediterranean still remains unanswered, although, lately an increased number of papers on this subject are being produced. Some basic steps are certainly made, yet, for a detailed debate on questions of distribution of tin in Balkans it seems necessary, if possible, to obtain accurate data on which deposits and to what extent were exploited in prehistory. Such data could be integrated in existing distribution patterns (e.g. copper, amber), and thus provide even more precise information on prehistoric trade and exchange routes.

³³ Durman 1997: 10.

³⁴ Terziev 1971: 1847 and further.

³⁵ In the papers from the beginning of 20th century Oliver Davies primarily speaks of existence of cassiterite deposits in Greece (Davies 1932: 145 and further), but soon dismisses such views (Idem 1939: 253 and further). As the problem of tin ore deposits and distribution of tin in Greece remains in focus even today, and modern researchers seem to neglect the works of Oliver Davies, they are not taken under consideration in this contribution.

³⁶ Skarpelis 2003: 159–164.

³⁷ E.g. Gillis, Clayton 2008: 133 and further, with previous literature.

³⁸ Pernicka *et al.* 2016: 477 and further.

³⁹ Sharp, Mittwede 1994: 155–158; Yener 2000: 71–76.

⁴⁰ Yener, Vandiver 1993: 207 and further.

⁴¹ Yener *et al.* 2015: 596 and further.

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Огњен Младеновић
Београд

О ЛЕЖИШТИМА РУДЕ КАЛАЈА НА ТЕРИТОРИЈИ БАЛКАНА

Проблем порекла калаја на територији Балкана у стручној литератури се појављује почетком XX века. Од тада, радови нпр. Роџера Пеналурика (Roger D. Penhallurick) и деценију касније Александра Дурмана помињу различита лежишта калаја на територији Балкана, но и поред тога чини се да поједини аутори и данас преvide територију Балкана када расправљају о потенцијалним путевима трговине и размене калаја, бакра и бронзе између области централне и југоисточне Европе, нарочито у периоду бронзаног доба. Неколико алувијалних лежишта у којима се јавља калајна руда каситерит (SnO_2) познато је из планинских сливова планина Враница (Сл. 2/1), Мотајица и Просара на територији Босне и Херцеговине (Сл. 2/2). У више река и потока који се спуштају са планине Цер у западној Србији измерена је знатна количина каситерита, са тиме да су реке Милинска и Церница пружиле најбоље резултате са 0,5%, односно 0,4% каситерита у узорцима (Сл. 2/3). Праисторијска експлоатација ових лежишта могла би бити потврђена недавно спроведеним изотопским анализама на преко 90 бронзаних предмета са територије Србије и Румуније. Сви анализирани предмети су хронолошки опредељени у позно бронзано доба и прелазни период. Слична алувијална лежишта доводе се у везу са Букуљом (Сл. 2/4) и бујановачким гранитним масивом (Сл. 2/5), међутим, неопходна је интензивнија геолошка проспекција како би се обим поменутих лежишта детаљније установио. Када говоримо о територији Македоније и Бугарске, извесна алувијална лежишта се помињу источно од реке Струмице, док би сама руда потицала са граничне планине Огражден (Сл. 2/6). Калај је такође потврђен као саставни део минерала *хемусит* који потиче из лежишта бакра код Челопеча у централној Бугарској (Сл. 2/7). Калај се на територији Грчке јавља у различитим минералним формацијама, док је као самостална руда откривен једино на Кикладима, односно острву Тинос (Сл. 2/8). Са територија које стоје у непосредној вези са Балканом позната су нам лежишта на обронцима Карпата и Апусени планинама у Румунији (Сл. 2/9), као и лежишта која се доводе у везу са планинским системом Таурис у Анадолији (Сл. 2/10, 11).