Original scientific paper
UDC: 622.332.015(497.6 Ljubija)
DOI: 10.7251/afts.2015.0713.001G
COBISS.RS-ID 5434648

IMPORTANCE OF OLISTOSTROME MEMBER FOR METALLOGENY OF LJUBIJA IRON ORE DEPOSITS

Grubić Aleksandar[1], Cvijić Ranko[2], Milošević Aleksej[3], Čelebić Miodrag[3]

[1] *Academy of Sciences and Arts of Republika Srpska, Bosnia & Herzegovina, e.mail. opn@anurs.rs*
[2] *Mining Institute Prijedor, Save Kovačevića bb, Prijedor, Bosnia & Herzegovina*
[3] *University of Banja Luka, Mining Faculty, Save Kovačevića bb, Prijedor, Bosnia & Herzegovina*

ABSTRACT

Ljubija mining area is built of more formations that belong to the Carboniferous, Permian, Triassic and Cenozoic. From all of these, only two are metalliferous to iron: Javorik formation with olistostrome member and Neogene-Quaternary of Prijedor basin. The first includes primary siderite and ankerite partially limonitised ore and in the second only redeposited limonite (limonite pieces and dust, known under the commercial name "brand"). Appearance of iron is also in other members of Javorik formation and other formations, but these are just thin veins. They have no significance for the economic exploitation but are an important element in the interpretation of metallogeny in the region. These findings came from many years of fieldwork and synthesis of all published and unpublished data related to iron ore in this area.

Therefore, this work gives special importance to olistostrome member, its stratigraphic position and metallogenic characteristics.

Key words: *Ljubija area, olistostrome member, metallogenic map, ore formation, control factors*

INTRODUCTION

Ljubija mining area is defined in the south front of Sana fault, on the east border of Jurassic-Cretaceous formations, on the north inner ophiolitic zone of Kozara and the west tectonic predetermined valley of the river Una, deeply carved in relief. It is situated in the internal metallogenic zone of central Dinarids from Triassic age. It extends, by S. Janković and R. Jelenković, figure 1 [1], from Tara-Lim, over central Dinarides, Vareš and Ljubija-Samobor segment to Bistrinja on Medvednica. In this fragmented area, which follows, from the south, ophiolitic belt of Dinarides, long over 300 km, are deposits of polysulfides, iron and barite. This noticeable zone of regularity obviously is not accidental but is associated with geodynamic development and accompanying structures arising in this segment of the Dinaric earth's crust.

Over the time researchers had different opinions about how and where mineralization in Ljubija mining area occurred. Many researchers [2,3,4,5,6,7] assumed that mineralization of iron is of hydrothermal origin and detailed study of the geochemistry of siderite ore in Ljubija definitely confirmed it. Based on a number of different methods, and in particular the study of rare earth elements, the authors conclude that all the results indicate to "hydrothermal-metasomatic origin and

Permian age of mineralization as suggested by Palinkaš [8,9]". Working hypothesis about the sedimentary origin of siderite-ankerite ore is abandoned due to overwhelming evidences of their geochemical characteristics which is contributed by many works of Zagreb's geologists [9,10,11].

Such a genesis of primary indigenous iron mineralization raised many issues related to metallogenic analysis and given the importance of olistostrome member and carbonate olistolitrome bodies which form an integral part. Some of the answers are offered in this work.

JAVORIK METALLIFEROUS FORMATION IN GEOLOGICAL STRUCTURE OF LJUBIJA MINING AREA

In Ljubija mining area there are following stratigraphic units in the geological column: Carboniferous Javorik formation with olistostrome member, then formation of Permian-Triassic clastics, terrigenous-carbonate of lower and middle Triassic, Ladinian volcano-clastic, Triassic terrigenous and carbonate and Neogene-Quaternary formation (Figure 1).

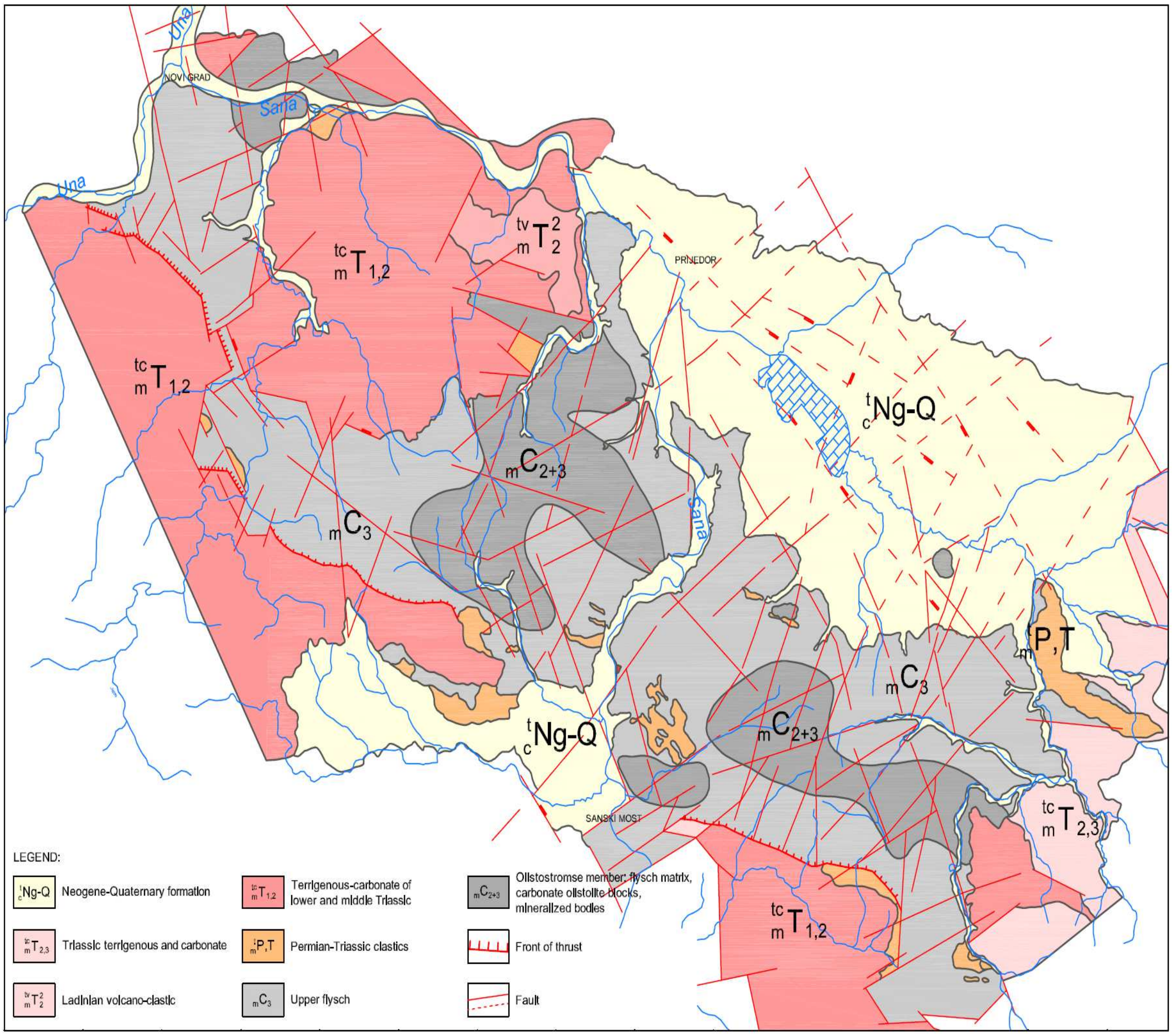

Figure 1. Schematic representation of the geological base for metallogenic map of Ljubija area (Grubić, Cvijić, Milošević and Čelebić, 2015)

On the sites of Paleozoic east of the river Una, the largest distribution have deposits which were distinguished in the area of Javorik hill on the Majdan mountain. They were named after the hill and as the formation for the first time identified by A.Grubić et al. [12]. This formation is separated conditionally, only for the purposes of exploration and exploitation of mineral resources on the Majdan mountain and around, as Sana Palaeozoic still hasn't been studied as a whole and in sufficient detail. In previous geological mapping Sana Palaeozoic is treated as a complex and unique content that is not possible to separate in more details [13,14]. More recent geological work, however, showed that such an interpretation is not correct.

Petrographically these rocks are thoroughly and conscientiously studied and microscopically described by L. Marić and B. Crnković [15]. According to these two authors main Sana Paleozoic rocks in the area of Ljubija are: argiloshist, quartz sandstone, quartz feldspar typo of subgreywackes, quartz sericite sandstones, ortho quarzit, silificated siderite and ankerite limestone and massive siderite (p.114). All these rocks are discussed in detail in the form of studies for the mine [16]. Marić and Crnković also stated that the main forming minerals in the rocks are: quartz, muscovite, relict of acidic plagioclase, predominantly illite or its aggregates. List of types of rocks and their variety is quite expanded later with detailed studies by V. Podubsky [17], N. Vasković [18] and D. Stefanovska [19]. Among the rocks, which are subsequently described, it should be noted discrete phenomena of lydite, because they are important in the reconstruction of conditions of sedimentation in the basin, and neo minerals (chlorite, sericite, muscovite, etc.) incurred in metamorphic changes of protoliths.

Previous researchers have particularly emphasized that this Paleozoic series is monotonous, and consists of rhythmic change of dark gray shales and sandstones that contain horizons built of limestone. It should be noted, however, that only Stefanovska D. [19] correctly noted that this is in fact one of turbidite formations. After that it was definitely established that this is a typical flysch and limestone, which are in it, and represent olistolite [12].

From detailed study of Javorik formation in Adamuša and South Tomašica there was impression that it was possible to distinguish more units. Members are described as: lower flysch, siderite-limonitic, wild flysch, olistostrome and upper flysch [6]. Consideration of the possible application of this subdivision on the whole Sana Palaeozoic, however, has shown that it is too detailed and therefore it is difficult to implement in the whole area of the ore. In addition, basic concept of metallogenic iron mineralization is changed and working hypothesis about the sedimentary origin of the primary siderite and ankerite was abandoned. Due to all this subdivision of geological column of Javorik formation is reduced to only three members: pre-flysch and lower flysch, olistostrome member and upper flysch (Figure 2). Compared to the earlier subdivision the biggest change occurred in olistostrome member. This member now includes siderite-limonitic member, wild flysch and middle flysch. Among other things, this change goes well and with the thickness of olistostrome member who, according to new data, may be up to 300 m (eg. in Vukulja).

OLISTOSTROME MEMBER IN GEOLOGICAL COLUMN OF LJUBIJA AREA

Olistostrome member in the mining area of Ljubija was discovered in the central parts of Sana Palaeozoic, right in the core of alpine Sana antiform (Figure 1). It makes the central part of Javorik metalliferous formation of iron. Below it is pre-flysch and lower flysch member and above it comes member of the upper flysch. It originated in deep-sea conditions.

This member has a very complex composition, dominated by four groups of rocks: flysch matrix, carbonate olistolite blocks, autoclastic melange and partially or completely mineralized bodies (Figure 2).

Flysch matrix occurs in two ways: either in the form of more or less continuous group of strata few tens of meters thick or thinner fleeting sequences between olistolite body. In the first case, in South Tomašica described as the "middle flysch" [6]. It alternates: mostly argilite subflysch, sand-argilite euflysch and sand coarse flysch (Figure 3). In these beds there are often olistostrome lenses and bank massive sandstone and very rarely graded sequence with microconglomerates. The dominant element in the matrix sequences is argilite subflysch. Most are represented by black and dark gray argilofilite, which alternate with rare layers of gray metasiltstone and fine to middle grain size sandstones (often with mica). Main textures in these sequences is parallel lamination. Far less development has euflysch with two and three-interval sequences in which as a structures are gradation, a parallel and wavy lamination. It is interesting that the pelagic interval sequences can meet rare lenses of lydite thick to one centimeter (Figure 3).

Another case of flysch matrix, which is widely described also from South Tomašica [6]. It is mostly about two-interval sequences, type Ta-b in which the lower part is gray and dark gray middle grain size sandstone and the upper part is black parallel laminated metasiltstone. On the lower surfaces of sequences sometimes there are loadcasts.

The matrix sandstones are either quartz or, more commonly, greywacke, subgreywackes and greywacke with poorly metamorphosed clay cement. Siltstones and shales are finely laminated, sometimes alternating with marl and also weakly metamorphosed.

Carbonate rocks in the section appear in the form of fragments, blocks, boulders and leaves which belong already in olistoplaque with hectometers dimensions. Their larger forms were found particularly in the wider region of South mines. These carbonates are made of black micrites, gray biomicrites and biomicrosparites with crinoids, foraminifera, brachiopods, gastropods and calcareous algae. In addition, there are dolomitic limestones and dolomites. Carbonate bodies are often with traces of metasomatic changes so it comes to ferruginous and siderite or ankerite limestones and dolomites.

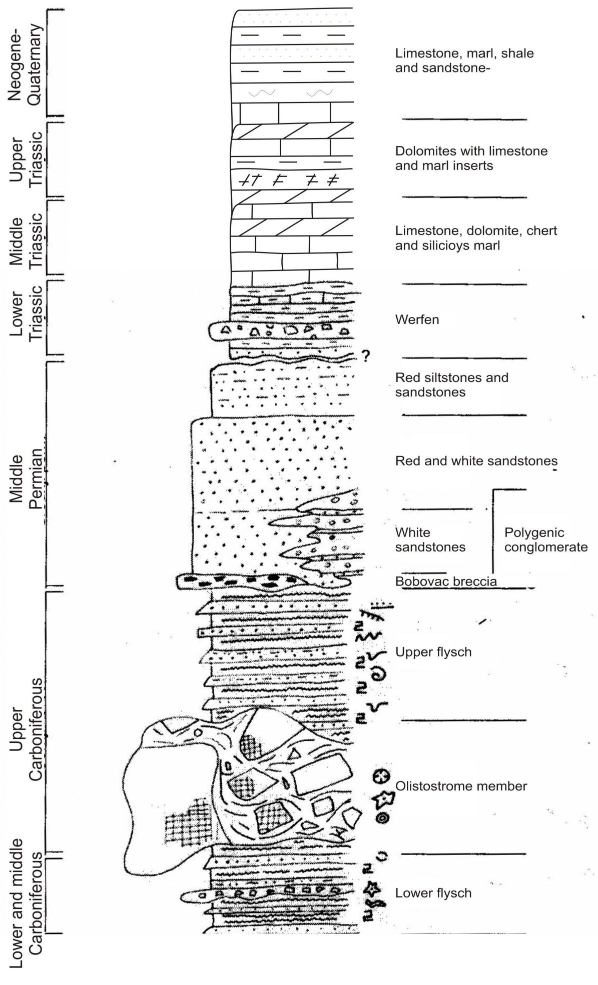

Figure 2. Olistostrome section in geological column of Ljubija ore region

There is a discontinuous but very prominent element in olistostrome section conditionally designated as "autoclastic mélange." Earlier in the literature was described as "wild flysch" [6]. This interpretation was suggested by the fact that in these subjects were determined elements made of siderite [19] and siderite has been considered as primary Carboniferous sedimentary deposit. In such conditions, these rocks could be interpreted only as sedimentary formations of the "sand ball" type, which occurred by the destruction of their own layers in series. The best ones were discovered in Adamusa and further to the south, then in the southern parts of the field and partly in South Tomasica.

In Adamusa, on its eastern side, these rounded forms appear in three horizons. The bottom two are around 7 m thick and third, the upper one, about 6 m. Separated by the laminated and schistose meta - siltstone. In the first and third horizon the matrix is made of very schistose and sandy metasiltstone, and in the second one is made of sandstone. Chaotically deployed lens-shaped and rounded shaped bodies which resemble concretions lie in the matrix. Their dimensions reach up to 50 cm. Around each of these bodies is flaking siltoze aureole which is thick one to four centimeters, which follows their outward form.

These rounded bodies were examined in details by D. Stefanovska [19]. She found that they are built of different rocks: greywacke, laminated metasiltstone and fine-grained sandstones, then, of finely crystalline siderite and brecciated aggregates of siderite, ankerite and dolomite.

The new interpretation of the genesis of Ljubija siderite, by which it is considered that their origin was hydrothermal and metasomatic, and that it was in the Triassic, old hypothesis of its sedimentary creations had to be abandoned.

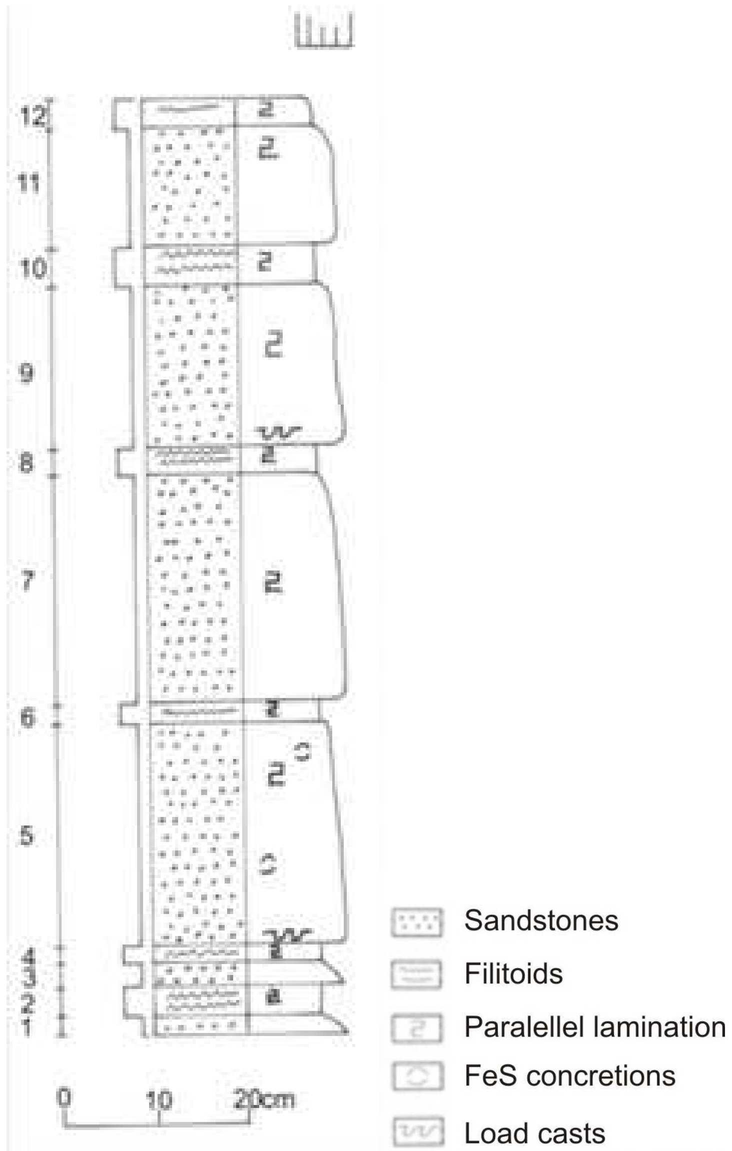

Figure. 3. Detailed local column of sequences of flysch matrix in olistostrome member

Another interpretation of the genesis of oval bodies in Paleozoic rocks can only be tectonic. Such forms arise by shearing in transcurrent faults or overthrust zones. Portions of fragmented fractured microlithons, between two shear surfaces rotate due to strong friction and thereby round out. In this interpretation, however, rounded bodies and their schistose matrix in fact represent autoclastic mélange. Therefore, they do not have definite or stable stratigraphic position.

IMPORTANCE OF OLISTOSTROME MEMBER FOR FORMING OF IRON ORE DEPOSITS

In lithological terms primary iron ores are found in carbonate olistolitic bodies of Javorik formation. In the limestones there are siderite and limonite ore deoisits and in dolomites there are ankerite and limonite. Full olistolite or only their parts can be replaced by ore. In some areas (in Vidrenjak, Adamusa, Litica and Brdo), a primary or secondary tectonic lens-shaped ore bodies have the appearance of deposits with stratiform morphology. Besides other features, this occurrence mislead earlier researcher when interpreting the genesis of iron ore in the region.

More, less or fully mineralized carbonate bodies into olistostrome member are its very characteristic trait. Elements of different sizes were constructed wholly or partly of siderite, ankerite of sideritic limestone and ankeritic dolomite that can be limonitised. Some of these bodies in Adamusa, Vidrenjak, Brdo, G. Litica, Bjeljevac and S. Tomasica have a lens-shaped to stratiform morphology and even internal macro-stratified texture. This noticeable stratified trait of ore bodies significantly affected the interpretation of sedimentary genesis of iron ore in the region for a long time.

In the disposition of ore bodies in olistostrome member have been empirically established two regularities. First, if those bodies are found in deeper parts of the member, bodies are insomuch fully mineralized. Secondly, as these mineralized bodies are located at shallow depths so far they are fully limonitised.

There are few irregularities in mineralization of olistostrome member which are important for metallogeny of region. First, the distribution of carbonate olistolitic bodies in the member is irregular, ie, chaotic which is very important due to the special significance of their commercial mineralization (Figure 2). Second, the extremely unevenness and varied size, shape and morphology of these bodies and their boundaries both when they are primary and when tectonic. Changes in the thickness of ore bodies range from a few dozens to 100 m and are mostly in the form of sudden thickening and thinning. Side ore bodies gradually transformed into the surrounding rocks are wedging or are abruptly interrupted. Only exceptionally ore bodies have the stratiform morphology and internal texture.

Third, not all olistolitic bodies are mineralized, but only some of them. In addition, two adjacent bodies can both be mineralized but, also, one may be mineralized and the other completely free of mineralization. Fourth, olistolitic bodies can be completely mineralized, or only partially, and some are only minimally mineralized (up to the level ferrous limestone or dolomite). Because of all this both ore bodies and deposits "don’t have continuity but occurring in isolation" [20]. With all of the above and "metal content in carbonate iron ores and their secondary products vary within wide intervals" [20]. These irregularities in mineralization of olistostrome member put Ljubija iron ores into deposits such as bauxite and antimony, in which is the very strong level of risk in the research works on hidden ore bodies.

CONCLUSION

Ljubija ore region implies full metalliferous territory area of about 1 500 km^2, which is part of Dinaridic metallogenic province (as a major metallogenic unit) and which is characterized by identical geological conditions and development of certain ore formations and types of economic deposits of iron and other minerals.

All economically significant primary mineralizations are related to Olistostrome member which makes the middle part of Javorik formation. This member covers middle parts of the studied field and is made up of three types of rocks: flysch matrix, carbonate olistolitic blocks and mineralized bodies. It originated in deep-sea conditions. Below it is a member of the lower flysch which was discovered only in drill-holes, and above it lays member of upper flysch.

Extensive field and laboratory studies, with knowledge of the hydrothermal - metasomatic genesis of iron, have determined certain regularities, but also irregularities in the distribution of iron ore. Disposition of carbonate olistolitic bodies in olistostrome member is irregular, and so are the morphology, shape, size and thickness of the ore bodies. Mineralized are only some ore bodies in whole or in part. With varying content of iron in the carbonate ore bodies, Ljubija ores belongs into deposits in which there is a very strong level of risk in the research works on hidden ore bodies.

(Received Oktober 2015, accepted November 2015)

LITERATURE

[1] Janković, S. i Jelanković, R. (2000). Metallogeny of the Dinarides. Zbornik radova geologija i metalogenija Dinarida i Vardarske zone, str. 281-305. Akademija nauke i umjetnosti. RS. Banja Luka.

[2] Katzer, F. (1910). Die Eisenerzvorrete Bosnie und der Hercegovina. Sonderband Berg und Huettenmann. Jahrbuch, Bd. 58. Wien

[3] Katzer, F. (1926). Geologija Bosne i Hercegovine. Izdanje državnih rudarskih preduzeća u Sarajevu. Sarajevo.

[4] Noeth, L. (1952). Die Eisenerzlagerstaetten Jugoslawiens. XIX Intern. geolog. Congr., Symposium sur. les gisements de fer du mond. Alger, vol. 2, pp.529-563.

[5] Karamata, S. 1976. Raspored ležišta gvozdenih ruda u svetlu geološke koncepcije tektonike ploča. Geološki glasnik br. 21, Sarajevo, str. 17-29.

[6] Grubić, A. i Protić, Lj. (2003). Studija strukturnih i genetskih karakteristika tomašičkog rudnog polja. U A. Grubić i R. Cvijić, editori: Novi prilozi za geologiju i metalogeniju Rudnika gvožđa Ljubija. Rudarski institut, Prijedor. Prijedor. str. 63-137.

[7] Strmić-Palinkaš, S., Spangeberg, J.E. i Palinkaš, A.L. (2009). Organic and inorganic geochemistry of Ljubija siderite deposits, NW Bosnia and Herzegovina. Miner.Deposita, Springer-Verlag, vol.44, no.8, pp. 893-913.

[8] Palinkaš, A. L. (1990). Siderite-barite-polysulfide deposits and early continental rifting in Dinarides. Geološki vjesnik, Zagreb, vol. 43, pp. 181-185.

[9] Palinkaš, A.L., Borojević, S., Strmić, S., Prochaska, W. and Spangeberg, J.E. (2003). Siderite-hematite-barite polysulfide mineral deposits, related to the Earlyintra –continental Tethyan rifting. Inner Dinarides. U Eliopoulos i dr. editori: Mineral Exploration and Sustainable Development, Millpress. Roterdam. pp. 221-224.

[10] Strmić-Palinkaš, S., Spangeberg, J.E. and Palinkaš, A.L. (2009). Organic and inorganic geochemistry of Ljubija siderite deposits, NW Bosnia and Herzegovina. Miner. Deposita, Springer-Verlag. vol.44, no.8, pp.. 893-913.

[11] Garašić, V. and Jurković, I. (2012). Geochemical charasteristic of different iron ore types from the Southern Tomašica deposit, Ljubija, NW Bosnia. Geologia Croatica, Zagreb,vol.65/2, pp 255-270.

[12] Protić, Lj. i Grubić.,A.,(2000). Paleozoic iron deposits in the Ljubija metallogenic district. Zbornik radova geologija i metalogenija Dinarida i Vardarske zone. Akademija nauke i umjetnosti Republike Srpske. Banja Luka, str. 309-311.

[13] Katzer, F. (1926). Geologija Bosne i Hercegovine. Izdanje državnih rudarskih preduzeća u Sarajevu. Sarajevo.

[14] Jurić, M. (1971). Geologija područja sanskog paleozoika u sjeverozapadnoj Bosni. Posebna izdanja Geološkog glasnika, knj. XI, Sarajevo, str.. 1-146.

[15] Marić L., Crnković B. (1961). Sedimentne stijene sanskog paleozoika u rudnoj oblasti Ljubije. Geološki vjesnik, br. 14. Zagreb, str. 143-156.

[16] Jurković, I. (1961). Minerali željeznih rudnih ležišta Ljubije kod Prijedora. Geološki vjesnik, br. 14, Zagreb, str. 161 - 220.

[17] Podubsky, V. (1969). Litostratigrafski razvitak paleozoika u sjeverozapadnoj Bosni.Geološki glasnik, br. 12, Sarajevo, str. 165-195.

[18] Vasković, N. (1984a). Petrološka ispitivanja na uzorcima (iz Ljubije). Geoinstitut Beograd. Ibid, str. 1-30.

[19] Stefanovska, D. (1990). Zaključci o rezultatima sedimentoloških ispitivanja karbonskog kompleksa. Rudarsko-geološki fakultet, Beograd, Beograd. Ibid, str. 1-8.

[20] Šarac, M. (1981). Metalogenetske karakteristike rudonosne oblasti Ljubije. Doktorska disertacija, Rudarsko-geološki fakultet u Beogradu, Beograd, str. 1-135.