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THE ROLE OF THE LOWER TRIASSIC SILICICLASTIC ROCKS IN THE FORMATION OF THE IRON AND BASE METAL ORE DEPOSIT IN RUDABÁNYA

Theses of Ph. D. Dissertation

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1. INTRODUCTION, AIMS

After centuries of base metal and silver mining, the open pit and underground iron ore mining of Rudabánya (NE Hungary) went on from 1872 until 1985. The re-exploration of the Rudabánya ore deposit began in 2007 and it is resulted in the delimitation of the Fe, Pb, Zn, Ag and Cu enrichments and the determination of their formation.

My Ph.D. thesis is part of this research and I made the petrological and geochemical study of the Lower Triassic siliciclastic formations, the Bódvaszilas Sandstone and Szin Marl in Rudabánya during my Ph.D. studentship. The oldest mineralized formation in the Rudabánya ore deposit is the Bódvaszilas Sandstone, and the so-called acidic sparry iron ore in the formation formerly was recorded as unworkable ore. Nevertheless the formation of the acidic sparry iron ore (creamspar) is far unclarified therefore I tried to solve the problem. To explore the reason of the absence of the base metals in the Bódvaszilas Sandstone was an another purpose of mine. The detailed examination of the Szin Marl due to the meanwhile explored Pb-Zn mineralization was remarkable. The aim of my work was the determination of the role of the siliciclastic succession in the ore formation therefore the accurate recognition of the Rudabánya ore forming system.

It was reasonable to examine the two formation in the non-mineralized areas since the syngenetic and diagenetic features from the effects of the ore formation was clearly separable.

2. SAMPLING, ANALYTICAL METHODS

87 samples of Bódvaszilas Sandstone, 20 samples of acidic sparry iron ore, 24 samples of Szin Marl, 5 samples of sparry iron ore and 5 samples of Perkupa Evaporite were investigated during this study. I selected the examined Bódvaszilas Sandstone samples from the drillcores, drilled between 2008 and 2010 in the Rudabánya open pit, and from a surface outcrop in Rudabánya, and I collected samples from the non-mineralized area (Aggtelek Mts.) as well.

The acidic sparry iron ore occured most of the Bódvaszilas Sandstone samples of Rudabánya, furthermore I collected samples from the transition layers between Bódvaszilas Sandstone and Szin Marl Formation.

I selected Szin Marl samples from the drillings in the Rudabánya open pit, from surface outcrops and from the Aggtelek Mts also.

I collected sparry iron ore samples which occurs in the Middle Triassic limestones and dolomites from the open pit also.

Detailed macroscopic and microscopic petrographic investigations were done before other analyses. Electron microprobe analyses by the means back-scattered electron imaging (BSE) and energy dispersive spectrometry (EDS) was done at the Institute of Mineralogy and Geology, and at the Department of Physical Metallurgy and Metalforming, University of Miskolc, Hungary. X-ray powder diffraction (XRD) of bulk rock samples was performed at the Institute of Mineralogy and Geology.

Chemical analyses (major, trace and rare earth element) was made on Bódvaszilas Sandstone samples with ICP-MS and ICP-AES method, the $^{13}Cc_{arb}$ and $^{18}O_{carb}$ stable isotopic analyses were carried out on acidic sparry iron ore samples and total organic carbon analysis on both formations in the Institute for Geological and Geochemical Research and in the Geographical Institute, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences (Budapest, Hungary).

3. RESULTS, THESES

1. I defined the provenance and the sedimentary environment by microscopic petrographic, scanning electrone microscopic investigation and chemical analyses of the Bódvaszilas Sandstone and Szin Marl.

1.1. The Bódvaszilas Sandstone and Szin Marl is a recycled sediment derived from an acidic source area, which is mixed with micrite in the Szin Marl. Their provenance presumably was the same. My observations reinforces the opinion of KOVÁCS et al. (2004), that the source area was the Permian molasse in the basement of the Gemericum.

1.2. According to the geochemical environment indicators I have calculated and the absence of buried organic matter and sulphate reduction the sedimentary (depositional) environment was oxic.

2. In the course of the additional study of the formerly identified stratiform Pb-Zn sulphide, pyrite and barite mineralization in the Szin Marl of Rudabánya (FÖLDESSY et al. 2010, NÉMETH et al. 2013), which is the oldest phase of the ore formation, I determined the following theses: The stratiform Pb-Zn-barite mineralization occurs only in the Bódva facies-area (Rudabánya), while in the az Aggtelek facies-area is absent which suggests that during the early Triassic the Pb-Zn accumulation went on only the Bódva facies-area.

3. I studied in detail the acidic sparry iron ore which occurs in the Bódvaszilas Sandstone Formation and in its upper parts (transition between Bódvaszilas Sandstone and Szin Marl) thus several new information were come to light from this kind of mineralization:

3.1. By EDS the creamspar is always inhomogeneous in elemental composition, but it is always Fe and Mg carbonate with low Mn content (never pure siderite or pure magnesite, it is always with excess substitution of Mg and Fe). The Fe and Mg ratio changes in steps of several micrometers, it is independent of textural characteristics. The crystal structure of creamspar is similar to siderite and magnesite also.

3.2. The bacterial origin texture which encompasses the pore-filling cement and the margin of the Bódvaszilas Sandstone's clasts, and the negative C isotopic composition and the organic matter remnants suggest that the pore-filling creamspar's formation was two-cycled microbial Fe(II) oxidation. First microbial cycle: autotroph metabolism, suboxic Eh, neutral pH environment, ferrihydrate formation; second microbial cycle: heterotroph metabolism, suboxic/anoxic Eh, neutral pH environment, creamspar formation. The succession had not contained any intergranular carbonate cement, compacted significantly before the ore formation neither.

3.3. I determined that the bedded, massive acidic sparry iron ore occurs in the transition layers between Bódvaszilas Sandstone and Szin Marl was formed by the same metasomatic processes producing siderite in the Middle Triassic limestones and dolomites according to the similar texture observed by scanning electrone microscope and $\delta^{13}C$ and $\delta^{18}O$ values. The minor microbial marks at the cleavage plains in the massive creampar evidence that in the incipient carbonatic sections the sparite was formed due to the metasomatism and slight microbial Fe(II) oxidation may have occured although its ratio to the metasomatism was negligible.

As a result of the examination of the carbonate sections of the Szin Marl Formation of Rudabánya the metasomatism had affected the formation although the replacement was not complete due to the low permeability.

3.4. The source of the iron was presumably the basic volcanic rocks related to the Middle Triassic rifting interacted with the sea-water thus may have developed to ore forming solutions. The solution contacted with the surrounding sediments and early diagenetic sedimentary rocks and due to the different nature of sediment and rock effective microbial Fe(II) oxidation, and metasomatism and subordinate microbial Fe(II) oxidation happened as well.

3.5. Minor Fe addition may have occured both in Szin Marl and Bódvaszilas Sandstone in Aggtelek Mts. also, in the latter case the pore-filling cement is microbial origin also. In this area presumably there was not so intensive Fe-bearing fluid flow that generates iron ore (further area from rifting).

3.6. In this Ph.D. thesis cassiterite in Rudabánya was first published. According to its crystal habit cassiterite is not of clastic origin, and it is presented in a creamspar section in Bódvaszilas Sandstone.

4. The first published textural features mainly in the Bódvaszilas Sandstone, but in Szini Marl also, suggest the post-ore forming processes:

4.1. Considering concavo-convex grain contacts and the syntaxial quartz overgrowths on monocrystalline quartz grains which replaces the earlier creamspar, and the low $\delta^{13}C$ and $\delta^{18}O$ values and the thickness of the Lower Triassic – Jurassic cover formations the succession underwent deep burial diagenesis.

4.2. According to the deep burial diagenetic quartz cementation and compaction the permeability of Bódvaszilas Sandstone was low therefore the solutions was able to move only along the fractures, and the base metal sulphides, which occur in the cover formations of Bódvaszilas Sandstone, enriched only in the fracture zones of the formation.

5. Based on my examinations the lower formations of the Silicikum (Bódvaszilas Sandstone, Szin Marl) suffered not only (deep burial) diagenesis but least anchimetamorphism both in the studied areas (Rudabánya, Aggtelek Mts.).

The new ore-forming model elaborated by me can be used in the examination of other similar iron ore deposits.

It is important to emphasize that the results confirm that the geology and biology can not be separated as the inorganic and organic systems are in interaction continuously with each other.

4. Acknowledgements

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