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THE COMPLEX RE-EVAULATION OF DRILLINGS OF MANGANESE ORE MINING IN BAKONY MOUNTAINS

Theses of Ph. D. Dissertation

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INTRODUCTION, AIMS

Manganese ore mining in the Bakony Mountains commenced in the third decade of the twentieth century. Investigation and mining of the manganese ore started in the Úrkút basin, and later in the Eplény basin in 1932. Mining of the Úrkút manganese is still going on, the Eplény mine closed up in 1975 for good. As a result of the intense investigation during this period a great number of geological, mining and scientific data has accumulated. Nevertheless the circumstances of the formation of the Bakony manganese ore, the spatial distribution of the characteristics of the resources, their relation to the geological formations cannot be considered as being resolved. However, the cognition of these aspect is of crucial importance in the foregoing exploration of ore and raw material.

The purpose of my work was the genetic survey of the manganese ore of the Úrkut and the Eplény territories and the complex characterization of the deposits. The first important step to reach this goal was the routing ot of the available data and information together with the establishment of a serviceable professional database. The latter is built up of more smaller substanive databases. On the apropos of this, on the course of a complex investigation the joint application of different methods (mineralogical-geochemical, prospecting and statistical-GIS) become possible, taking advantage of the inherent mutual advantages.

The establishment of professional databases and their multilateral utilization is current in earth sciences. The professinal databases are of primary importance in many fieds of the exploration of raw materials (including borehole, geologic, geophysic and other data). The are defined by the special questions of the investigation, i.e. the spatial extent of the mineralization (raw material), the variance of the quality of the

mineralization (raw material), or the geological structures that are important from the viewpoint of mining.

In my thesis I present the development of the professional database of the Bakony manganese mineralization, the types of the archive data. Furthermore I demonstrate how the use of different data types, their effective and complex treatment can lead up to the definition of new geological problems and how these can be solved. In my thesis I present the most important outcomes resulting from the processing of different data, including the reinterpretation of the geologic buildup of the Úrkút and the Eplény basins, the most recent results on the genesis of the oxidic ore and the evaluation of a terrain perspective for mining. In the end of the thesis I review the possible applications of the database.

The digitalization of the archive data of the Bakony manganese ore mineralization and mining is an important result in itself, the saving of the findings, since the paper based reports unvittingly perish in time. In many cases these data proved to be remarkably important, since the contemporary descriptions and analyses are singular and unrepeatable.

My PhD thesis is divided into 3 major chapters – besides the geological and mining introduction – in which I present the used data and the process of evolving the professional database, and the 4 major (Chapter 5) and 3 minor (Chapter 6) case studies made by the application of the database. The examples of Chapter 5 constitute independent units as the Chapter 6, nevertheless further exposition of the latter was not possible due to extent reasons. The attached appendixes include the larger tables with continuous numbering and a CD supplement which contains the maps and sections by chapters (105 pc full page maps, 5 pc large-scale sections).

APPLIED METHODS

After the preparation and reappraisal of the different archive data (from drillings, maps and thin sections) I organize them into a relational database which aim was the connection and query of different data.

I used the datasets which I got from the query of the databases for different examinations. To drawing the different maps (concentration, thickness, overlain) of the Úrkút basin (Chapter 5.1.) and Eplény ore deposit (Chapter 5.4.) I used the natural neighbour interpolation method. I computed the univariate statistics (average, median, mode, minimum, maximum, range) and I plotted them in Box-Whisker plot to the statistical characterization of different lithologies.

In the course of the ore genetic examination of the Csárdahegy-type manganese ore (Chapter 5.2.) beside the calculation of the univariate statistics of the chemical analysis (Mn, Fe, Si, P) I used multivariate methods also (hieararchical cluster analysis with Ward method, discriminant analysis to verify cluster analysis and main component analysis).

The mineral resources of Nyírszeg area I estimated with fuzzy sets, thus I described the ore thickness and extensions of the main mangancarbonate ore and the oxidize ore and so the mineral resources as fuzzy sets (the density of the ores are crisp numbers).

I plotted the reverse faults of the Úrkút basin and Eplény ore deposit in Angelier stereographic projection.

I used Markov chain model to examine the main mangancarbonate ore bed of Úrkút basin.

RESULTS, THESES

The following new scientific results have emerged in the course of the data processing:

I. I built up the coherent substantive database of the Bakony manganese ore archive data (borehole, drill core, thin section and map), which contain data from 1532 boreholes, 980 thin sections and 50 maps. I reevaluated the formations revealed by boreholes and maps of the Úrkút and Eplény occurrence and rated them into formations, which are thus implicated in the different database types uniformly. By shaping up the connections between these databases I established the **professional database** of the data on the Bakony manganese ore.

II. In the course of the reevaluation of the borehole sections of the **Úrkút basin**, I created the formation-based stratigraphy of the schematic geologic buildup. Suchlike general stratigraphy has not been created since the work of Német Cseh (1963), and this is the first formation based study of the geologic buildup. The following new statements can be drawn by means of the revaluation:

1. In case of the sequence regarded as ideal the underlying of the Úrkút Manganese Ore Formation is the Bocskorhegy Member of the Kishát Limestone Formation (greenish-grey cherty calcareous marl), while the overlying is the Kisgerecse Marl Formation (ammonite marl). In case of these sequences the Úrkút Manganese Ore Formation is always represented by carbonaceous manganese ore. Suchlike boreholes can be found in the western part of the basin and in a north-south syncline (Nyírszeg field), where the formation reaches its maximum thickness.

2. I estimated the geological mineral resource of the Nyírszeg field with fuzzy sets method, which suggest that the field includes potentially explorable mineral resource.
3. Out of the carbonaceous manganese ores the „brown striped green" ore contains the most Mn in average (median). This statement is based on the statistic analyses of the samples taken from the drill cores.
4. The carbonaceous sequence, i.e. the main ore bend, was formed as a result of a cyclic event, which was disturbed several times by an extraneous impact. The cycle is represented by grey, brownish-green, brown and brownish-black manganese carbonates. Based on the Eh relationships of the strata that represent the cycle indicates suboxic character.
5. As a result of the geomathematical processing of the samples the primary oxide csárdahegy-type ore possibly formed due to hydrothermal and bacterial effects. The two main ore-forming processes are most intensive along the Csárdahegy bolsons.
6. The most frequent underlying formation of the locally oxidized secondary ores (UMF) is the leached limestone, striped cherty clay (Isztimér Limestone Formation, Káváshegy Limestone Member), while the most frequent overlying formation is the argillite with chert and manganese debris (Tés Clayey Marl Formation Kepekő Member).
7. The redeposited ore (allochthonous, oxidized ore) is Albian and stratigraphically belongs to the Kepekő Member of the Tés Clayey Marl Formation. This formation thickens towards the north eastern part of the basin.
8. The most frequent underlying formation of the redeposited ore is the leached limestone and the striped cherty clay (Isztimér Limestone Formation, Káváshegy Limestone Member).

9. Based on the sixth and the seventh statements the redeposition occurred in the Albian, in the course of which not only the oxidized ore were formed, but possibly the underlying limestones also altered („leached"). Thus the leached limestone formed as a result of the post-sedimentary effect that went through in the Albian.
10. There is a group of the oxidized ore that lies under the „in situ" carbonaceous manganese ore along the boundary of the underlying bed. This type of oxidized manganese ore implies an effect that originates from the underlying bed (hydrothermal?) that possibly represents the earliest phase of the ore formation.
11. The denudation that can be observed in the basin is becoming more pronounced towards northeast, what is constrained by the Szentgál and Városlőd borehole sections.

III. As a result of the reevaluation of the borehole sections of the **Eplény ore occurrence** I have created the formation based schematic geological buildup sequence of the basin (with average thickness values). Based on the reevaluated sequences the following new statements can be drawn:

1. „In situ" non-redeposited (concordant) sequences can be found in the middle part of the basin, which is cross cut by faults. Besides the radiolarian marl radiolarian clayey marl also occurs in the sequence, which was not formed a result of posterior alteration (oxidation), contrary to the Úrkút basin.
2. Redeposited manganese ores are contained in two formations, depending on the time of the redeposition. If the time of the redeposition is Early Cretaceous then the occurrence should be rated into the Kepekő Member of the Tés Clayey Marl Formation, or into the

Szarvaskút Member of the Kisgyón Formation in case of Middle Eocene redeposition.

3. Denudation can also be observed in the Eplény ore occurrence, the degree of which increase towards southeast.

IV. In the course of the **tectonic features** of the heading maps I refined the tectonic events of the ore occurrences:

1. In case of the Úrkút basin the reverse faults indicate east – west compression, which possibly operated in the Early Cretaceous as an effect of the Alpine deformation.
2. In the Eplény ore occurrence the normal faults also indicate that the basin was formed as a result of Early Cretaceous (Aptian–Albian) tension.

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