

## MINERALS AND MINERAL VARIETIES FROM METAMORPHOSED Mn DEPOSITS OF BISTRITA MOUNTAINS, ROMANIA

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The Bistrita Mountains belong to the Crystalline Mesozoic Zone of the East Carpathians, which consists of superposed Variscan and Alpine Nappes, overthrust eastwards over the Flysch Zone. The manganese ore is contained by Tulghes Group (Tg2 level) of the Variscan Putna Nappe, situated over the Pietrosu Bistritei Nappe and supporting the thrusting of the Rebra Nappe. All these Variscan nappes constitute the Alpine Sub-Bucovinian Nappe localised between Alpine Infrabucovinian Nappe in the East and the Alpine Bucovinian Nappe in the West.

The mineralogy of Mn metamorphosed deposits from Bistrita Mts. includes 328 minerals and mineral varieties. They may count among the mineralogically the most complex deposits of the world. Prior to 1970 there were known ca. 50 minerals. The mineral number grew in 1970-1976 period to 70 minerals and in very recent period (1994-2002) the mineral number reached 328. Minerals and mineral varieties from almost all mineral classes have been identified: carbonates 17, silicates 157, oxides 47, sulphides 48, sulphates 5, phosphates 11, wolframates 2, borates 1, arsenates 5, vanadates 1, native elements 1 and 33 minerals from oxidised zone.

The minerals and mineral varieties were determined by combined methods: X-ray, IR, AAS, SEM analysis and optical microscopy. Several of them are very rare species (nambulite, natronambulite, norrishite, bannisterite, parsettensite, manganpyrosmalite, friedelite, schallerite, nelenite, minnesotaite, kellyite, etc.). A lot of determined minerals have Mn as major constituent: tephroite, manganese humite group (manganhumite, sonolite, alleghanyite), leucophoenicite group (ribbeite, leucophoenicite, jerrygibbsite), some of the oxide group, manganiferous phyllosilicates group, etc. Many are secondary, as they occur in veins or are product of retrogressive transformation from the granulite to amphibolite facies, from the amphibolite to blueschist or greenschist facies. Each metamorphic event was a source for new minerals. Frequently, each mineral grain presents chemical variational function of P, T,  $f_{O_2}$ ,  $f_{CO_2}$ ,  $f_{Cl_2}$  etc. on the route of prograde and retrograde polyphasic metamorphism. The zonation of the pyroxenes and amphiboles – marginal and sectoral – is a good evidence of changes of metamorphic conditions. In the case of zoned amphiboles, the core is manganogrunerite (amphibolite facies) and the rim is constituted of alkali blue amphiboles (blueschist facies). The sector-zoned arrangement of pyroxenes developed during rapid crystal growth and involved differences of both composition and cation order. It consists of bands or hour-glass texture of sodic augite and omphacite pyroxenes. Beside the transfor-

mation of some amphiboles and some pyroxenes into other phases, there are drastical transformations of pyroxenes into pyroxenoids (johannsenite into rhodonite), pyroxenoids into pyroxenoids (pyroxmangite into rhodonite), pyroxmangite into manganogrunerite, garnets into garnets (spessartine-calderite into spessartine, spessartine into anisotropic spessartine-andradite-grossular), calderite into pyroxmangite-magnetite, etc. are the best evidences of continuous variation of formation conditions.

The Mn ore have a predominant carbonate rather than silicate mineralogical composition, which means a great CO<sub>2</sub> fluid control in the carbonation and dehydration processes along the many stages of the whole history of the ore and the Tg2 level. The mineral reactions for the tephroite assemblages were of decarbonation type, their temperatures were strongly influenced by composition of metamorphic fluid, that is, the decarbonation reactions took place at high temperature and high X<sub>CO<sub>2</sub></sub> (corresponding to amphibolite facies).

The olivines, carbonates, Mn-humites, garnets, pyroxenes, pyroxenoids, amphiboles, some oxides, some phyllosilicates and some sulphides offer useful petrological information. Metamorphic reactions and P-T path of the Bistrita ores suggest that they have undergone at least five stages of recrystallisation in a subduction zone. The clockwise trend of metamorphism is in agreement to the structure of the complicated tectonic setting of the Crystalline Mesozoic Zone. Many minerals are accessory phases having a scientific importance, enriching the national mineralogical patrimony.

In the Bistrita Mn-deposits three types of assemblages were determined on the basis of the bulk oxidation ratios: oxidised (i.e. containing Fe<sup>3+</sup> and Mn<sup>3+</sup>), reduced (with Fe<sup>2+</sup> and Mn<sup>2+</sup>) and neutral, with Mn<sup>2+</sup> and Fe<sup>3+</sup>.

Closely associated assemblages of diverse mineralogy from Bistrita Mn ore suggest that X<sub>Mn</sub> and X<sub>fluid</sub> rather than physical conditions of metamorphism are the decisive factors in forming the observed mineral diversity. The Bistrita metamorphosed Mn-rich mineral assemblages evolved under a variety of constraints, including the diversity in the character of the protolith and the nature of buffering of the fluid phase during metamorphism. Such a rich mineralogy when compared with the limited number of minerals occurring in the country rocks, make manganese ore from BM very promising potential markers for P,T,  $f_{O_2}$ ,  $f_{H_2O}$ ,  $f_{Cl}$ ,  $f_B$ ,  $f_{As}$ , etc. reconstructions, to supplement the country rocks mineral records (Tg2 level), strongly transformed or even erased by metamorphism.