ON THE ONTOGENY OF MINERALS IN THE SUPERGENE ZONE AT THE MIKHAILOVSKOE DEPOSIT (KMA)

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Geographical location of the Kursk Magnetic Anomaly (KMA).

If not specified otherwise, specimens are from Victor A. Slyotov's collection, personally gathered by the author in the 1970s–1990s.

1. **Pyrite** blocky crystals on botryoidal crust of siderite spherocrystals. FOV 0.4 cm. Mikhailovskoe deposit, KMA. Photo: Timofey V. Pashko.

Iron ore deposits at the Kursk Magnetic Anomaly (KMA) are constrained within the Voronezh anteclise at the East European Platform. The lower structural floor corresponds to the Precambrian basement of the platform, and the upper one is made up of gently sloped sedimentary rocks of the platform cover. The iron ores are hosted in the crystalline basement and occur at depths of 60–650 m.

The Mikhailovskoe deposit of iron ores is located not far from the town of Zheleznogorsk, Kursk oblast, 100 km northwest of the town of Kursk, and is developed by an opencast pit.

The deposit was discovered in 1950 and commissioned in 1960. The main resources of the deposit (its Vereteninskii prospect) are constrained to the watershed between the Chern and Rechitsa rivers and make up a large (approximately 7 km long and up to 2.5 km wide) BIF stripe. The Mikhailovskoe deposit is a complicated folded structure 8–10 km long and up to 3 km wide in its central portion. The structure consists of Lower Proterozoic schist–gneiss units, a Middle Proterozoic BIF formation, and overlying upper-floor rocks: carbonaceous–clayey and calcareous shales, tuff breccia, and quartz porphyries.

The upper part of the BIF formation is altered by supergene processes, which produced a linear blanket of weathered rocks. The highest grade ores are related to the ancient weathering crust on BIF: these ores are made up of BIF oxidation and natural enrichment products and are dominated by martite, fine-flaky hematite (so-called *iron mica* and *iron cream*), limonite, and siderite.

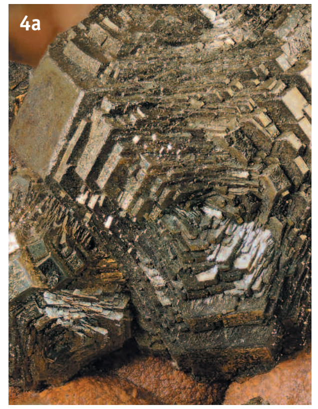
The platform cover consists of Devonian, Jurassic, Cretaceous, Paleogene, and Quaternary sedimentary rocks: clay, limestone, sand, and loam. In places, the clay is intensely pyritized, with sulfuric acidic waters seeping from these rocks in their outcrops. The sedimentary rocks host diverse fossils: Devonian fish remnants and fish teeth, large shells of Jurassic bivalve mollusks (Gryphaea, Lopha), abundant and well preserved remnants of some belemnite species, ammonites, petrified wood trunks (which are often replaced by pyrite), etc. (Ore Deposits of the USSR, 1978).

In the 1970s through 1990s, numerous valuable mineralogical specimens were found at a locality in the Mikhailovskii quarry. This locality was constrained to a thick limestone lens (block) resting on BIF and hosted in sandy–clayey rocks of the cover. No mining operations had ever been carried out at this locality until the end of the 20th century, so that the rocks left in it were seen as a remnant rising amidst the quarry. Near contacts with the limestone, fractures in the BIF abounded in cavities lined with crusts of calcite crystals with pyrite crystals and marcasite spherulites on them (Figs. 1, 2). Where carbonaceous and sulfurous solutions interacted in the peripheries, within 50–100 m around the zone, cavernous limonite with largely unique siderite–pyrite mineralization was formed.

2. **Pyrite** blocky crystals on botryoidal crust of siderite spherocrystals. Octahedron edge is up to 0.35 cm long. Mikhailovskoe deposit, KMA. Photo: Timofey V. Pashko.

3. Group of **pyrite** blocky crystals of three generations on siderite spherulitic crust. The larger octahedrons are to 0.3 cm by edge. Mikhailovskoe deposit, KMA. Photo: Timofey V. Pashko.

4. Structure of split rosettes on octahedral faces of **pyrite** (see text for explanation). FOV 0.4 cm. Mikhailovskoe deposit, KMA. Photo: Timofey V. Pashko.

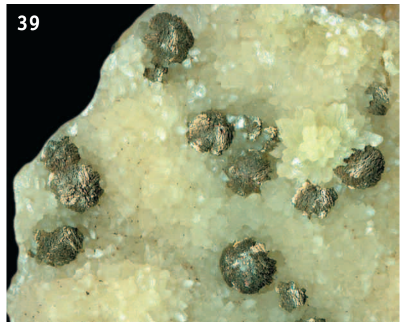


Pyrite: Split Crystals

Numerous cuboctahedral pyrite crystals were found and collected at the deposit by the author in the 1970s. These crystals or their groups overgrew continuous crusts of siderite spherocrystals (Figs. 3, 7) that lined the walls of cavities and wide fractures in oxidized and intensely altered BIF and limonite.

Certain issues of the morphology and ontogeny of these crystals were discussed elsewhere (Dymkov et al., 2004). Among other things, it has been demonstrated that these crystals exemplify the simultaneous growth of the growth pyramids on octahedron dislocation–deformation and practically defect-free cube faces of a single crystal.

The small pyrite crystals are octahedral (Figs. 7, 8), whereas the larger individuals (0.4–0.5 cm, occasionally up to 0.7 cm) are cubeoctahedral, with the relative surface area of the cube faces increasing in the course of crystal growth (Figs. 1, 4). When splitting in the process of its growth, a blocky crystal gradually loses the morphology of a geometrically regular space polygon, its surface shows both preexisting and newly formed steps on octahedron faces, which are truncated by cube faces (Figs. 4–6). The octahedron faces gradually disappear and are transformed into ensembles of the outer parts of the block-subindividuals consisting of overgrowing stripes of faces {111} and more and more strongly dominant steps of {100} planes. The crystal looks as if radiating with octahedron faces, as an opening flower, and thus acquires more and more rounded contours.



39. **Marcasite** spherocrystals and spherulites on **calcite** crystal crust from fissure in the recrystallized limestone. FOV 6 cm wide. Mikhailovskoe deposit, KMA, find of 1973. Photo: Victor A. Slyotov.

this portion of the deposit was completely depleted and abandoned. In some specimens, marcasite epitaxially overgrowth pyrite and vice versa.

Conclusion

Pyrite multiaggregates at the Mikhailovskoe deposit are prone to decompose when the specimens are stored in contact with air, and many of our specimens collected in the 1980s did not survive for this exact reason. However, analogous material is obviously found again and again. Unfortunately, searches for such and analogous mineralogical beauties are not possible anymore at the deposit because public access to the quarry is nowadays limited to the so-called observation site, and mineralogical specimens can now be searched for, found, and collected exclusively by the staff of the mine. The author can only hope that this publication will attract attention of mineralogists and mineral lovers to the Mikhailovskoe deposit and to finding ways for passing the obstacles. I also hope that this paper will be useful for those interested in searches of scientifically interesting, and/or valuable for collectors of mineral specimens of Kursk Magnetic Anomaly deposits.

Acknowledgments

The author thanks Timofey V. Pashko and Pavel A. Martynov for help with photograthing for the article. Boris Z. Kantor and Igor V. Pekov are thanked for valuable comments on and editing the text, Dr. Peter Modreski for English style improvement.

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Dictionary

1. **Spherocrystalline spherulites** are "*complicated individuals consisting of radiating spherocrystalline bundles. When botryoidally crusts and other aggregates are formed, spherulites of different organization levels are individuals, and sperocrystals are the subindividuals of spherocrystalline spherulites. The subindividuals of spherocrystals are the growth pyramids of spherical and partly flat crystal faces. Split growth pyramids, and eventually a spherocrystal as a whole, are made up of subindividuals of higher orders, which are crystalline fibers*" (Dymkov, 1973).

2. **Pseudostalactites** are a group of intricate mineral aggregates with a gravity-controlled texsture. In contrast to stalactites, which grow in air-filled cavities (caves) from solution flowing downward according to gravity, pseudostalactites are formed via overgrowing thin membrane tubes (of osmotic origin) or globular garlands, which sag according to gravity in cavities, with spherulitic crusts or crystals. Pseudostalactites may also be produced by overgrowing other gravity-controlled shred-shaped bodies (Godovikov *et al.*, 1978).

3. **Spheroidolites** are asymmetric spherocrystalline spherulites with twisted fibers-subindividuals. The degree of twisting of the fibers increases away from the main axis and in the course of growth of the spheroidolite. The growth zones are of variable thickness (in contrast to those of spherulites) and become thinner away from the main axis. The crystalline fibers are always normal (perpendicular) to the surface and growth zones at any point. They were described by V.I. Stepanov with reference to todorokite and Yu.M Dymkov with reference to pitchblende and sulfides. "*The reason for the distortion of the shapes of spherulites during their growth and the development of asymmetric spheroidolites is the difference in the growth rates at various points at the surface of a spherulite as a consequence of the unequilibrated crystallization conditions or the heterogeneity of the growth medium, when a concentration gradient can result from the anisotropy of the medium, the symmetry of material transfer (gravitation, thermal convection), and/or other factors. Radial diffusion produces highly symmetric spherocrystals, whereas linear diffusion brings about spheroidolites*" (Dymkov, 1973).

4. **Multiaggregates** are an intergrowth or co-growth of different types of aggregates that form simultaneously and syngenetically in the same crystallization environment (Self and Hill, 2003).

5. **Spheroidolitic dendrites** are aggregates consisting of branching spheroidolites (Dymkov, 1973, p. 153).