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Mineralogical and isotopic indicators of palaeoclimatological conditions during Precambrian time, Aldan Shield, Siberia

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Sedimentary sulfates in Precambrian rocks are direct evidences that free oxygen was important component in the atmosphere-hydrosphere system at that time and may be reflections of evaporate deposition in old sedimentary basins.
Rocks with sulfates were early identified in the Fedorovskaya Formation of the Aldan Shield (V. Vinogradov et al., 1975). Geological works in different sectors of the Aldan Shield reveal presence of anhydrite, barite, gypsum and celestine in metamorphic sedimentary rocks of the Fedorovskaya Formation. The rocks are metamorphosed to the granulite and amphibolite faces, and their U-Pb age is 1.8 – 2.0 Ga.
Carbon and oxygen isotope compositions of different sectors confirm that each of these carbonate rocks represents a clearly defined and isotopically distinct sedimentary facies. Anhydrite, gypsum and celestine were collected from the borehole cores of the Seligdar, Mustolaakh, Birikeen and Chukurdan apatite deposits. Samples of barites came from outcrops of the Hematitovoe deposits. All these minerals commonly are heterogeneous and composed of several generations.
First generations of anhydrite form concordant layers, lenses or segregations in marbles, gneisses and geologically oldest sulfate-bearing apatite-carbonate rocks underlying the Seligdar ore body. Last generations of the sulfates form pods and branching veinlets in the apatite–bearing carbonate rocks of the Seligdar deposit with a thickness of 1.5 – 5 cm, and veins up to 3 – 5 m thick. Fine-grained and platy gypsum, white and pink in color, predominates over anhydrite, which concentrates toward the axial portions of the veins and forms aggregates of tabular burred crystals of lilac color. At the Mustolaakh, Birikeen and Chukurdan deposits sulfates were sporadically found in borehole cores as separated nets and clear late veins. Three generations of barite occur in barite-quarts-hematite ores. First generations of the minerals are smaller in size (1 – 2 mm), scattered in the ores, and minerals of the last generations form big crystals (up to 5 cm).
The studied minerals are characterized by mainly positive sulphur isotopic values (up to +32.1 permil). Relatively low sulphur isotopic values (5.7 – 10.6 permil) have barites. Isotopic compositions of first anhydrite generations yield sulphur isotopic values from 5.4 to 6.9 permil, and its following generations are distinctly higher – from 20.3 to 32.1 permil. The studied gypsums are characterized by similar high sulphur isotopic values – from 22.5 to 30.1 permil as well as celestine – 24.0 permil.
The isotopic investigations showed that first generations of minerals commonly have more heavy sulfur isotopic compositions. It is in accordance with isotopic C and O records in coexisting carbonates, which are enriched in 13C. Apatite-sulfate-carbonate rocks are products of complex alternation of sedimentary processes at different regimes of basin salinity occasionally marked by the decomposition of older sediments under sub-aerial conditions. High sulphur isotopic values in late generations of sulfates are connected with depletion of carbon and oxygen isotopic compositions. They were produced by post sedimentation alterations under the effect of surface waters and/or metasomatic processes.