The sources can be different for different components. At uranium deposits, the sources of the metals and precipitator components are different: the precipitants (sulfide sulfur or methane) are mobilized when the solutions react with rocks under reduced conditions (graphite- and pyrite-bearing schists), while the metals are extracted from rocks of normal granitoid composition under more oxidized conditions. The large drainage areas (and, hence, great volumes of the recycled rocks from which the metals are extracted) usually predetermine significant or giant reserves of these deposits (this applies, first and foremost, to unconformity-type deposits and large vein-type deposits).

The base-metal deposits discussed in this publication most probably had the same sources of the metals and sulfide sulfur: this was the Sadon granite, which was low in sulfide sulfur. The ore components were mobilized from restricted areas, and, as a consequence, the deposits have intermediate or even small reserves.

Ores were formed in all of our models without variations in the external conditions.

In our models for the genesis of U mineralization, the temperature, pressure, and the compositions of the primary barren and metalliferous solutions remain constant. The main cause of ore precipitation is the mixing of hydrothermal solutions either at *stationary* hydrodynamic geochemical barriers, which are determined by the heterogeneity of the filtration characteristics of the host geological environment (as at the Chauli deposit), or at *mobile* geochemical barriers of hydrodynamic nature, which are created by flows of filtrating solution from "black schists" (as at unconformity-type deposits). Changes in the filtrations regime of the flows of the metalliferous solution and the "precipitant" solution result in the formation of various mineral assemblages, up to monomineralic orebodies.

In the genetic model for base-metal ore mineralization, the composition of the primary "barren" solution also does not vary throughout all mineral "stages," and the vertical temperature gradient can also remain constant. The main causes of ore precipitation, which control the variations in the composition of the filling veins with time, are *the compositional evolution of the metalliferous hydrothermal solution in the zone where the ore components are mobilized* and *the temperature decrease in the fracture–vein systems.*

The models demonstrate that the spatially uneven development of vein and wall-rock mineral assemblages, including their separation in space and rhythmical alternations, are the natural consequences of the hydrodynamic conditions under which the vein ores are formed (as is exemplified by the Chauli deposit). Thus, the scarcity of wall-rock alterations near fractures or, more often, even their absence cannot be regarded as evidence of the absence of active material exchange between the wall rocks and solution in the fracture. This material exchange is mediated not by the rocks but by the pore solution in equilibrium with them.

In this context, it is pertinent to recall G.L. Pospelov's [1963] comment that "...it is reasonable to believe that the formation of a deposit requires such a combination of conditions that is less probable than the existence of potentially efficient metalliferous hydrothermal solutions that are able to precipitate ore mineralization." At least, our models with the active action of hydrothermal barriers justify this statement.

GENERAL CONCLUSIONS

(1) We elaborated new methods for assaying the composition of hydrothermal solutions based on the results of simulations of metasomatic alterations in rocks exerted by rock–solution reactions. The study of interactions in the rock–water system makes it possible to predict geochemical phenomena in naturally occurring systems of rocks and thermal waters. The interaction of barren solutions with granitoids gives rise to metalliferous solutions that can be parental for the hydrothermal systems in question. The metalliferous potential of these solutions is significantly enhanced in the course of the mobilization process because of the progressive leaching of sulfide sulfur from the rocks without any variations in the external conditions.

(2) The self-mixing mechanism is able to maintain conditions necessary for the formation of ores from metals disseminated in the country rocks: extraction of ore elements from large volumes of rocks, migration of the metals extracted by the solutions into the local volumes of fracture conduits, and the concentrated (sometime selective) precipitation of the metals at hydrodynamic geochemical barriers. This process can proceed under constant P, T conditions and without any variations in the composition of the barren solution that comes into the hydrothermal system. A natural consequence of the process is the spatial separation of syngenetic metasomatic rocks and ores.

(3) The interaction of the solutions with graphite- and pyrite-bearing rocks results in flows of barren reducing solutions with dissolved hydrogen sulfide and methane. When these solutions mix with metalliferous solutions equilibrated with granitic rocks, mineralized veins or unconformity-type deposits can be formed in crosscutting fractures or regional unconformity zones. Changes in the filtration regimes and mixing proportions of the solutions (at unchanging other conditions) are an efficient mechanism that brings about systematic variations in the mineral assemblages of the orebodies. Hydrothermal solutions of this type can produce rich ores practically devoid of gangue minerals.

(4) The first data were obtained on the fine distribution structures of ore elements in wall rocks around veins at hydrothermal deposits of the vein base-metal type. It is demonstrated that detailed structures of the aureoles can be used as the basis for models of the genesis of aureoles and ores. The aureoles are classified

into types, and mechanisms are proposed that can form infiltration-controlled aureoles of deposition, redeposition, and leaching.

(5) We devised a structure of a model and techniques for thermodynamic simulations and constructed a model of an ore-forming hydrothermal system for deposits of the vein base-metal type.

(6) Water–rock interactions are the main factors controlling ore formation. Their action is obvious throughout all evolutionary stages of the hydrothermal system: this is the main mechanism generating metalliferous solutions in the mobilization zone, it is manifested in the form of intramineral metasomatism in the zone of ore formation, and these processes are the main driving force of aureole growth in the wall rocks around the veins. Stages of ore formation are controlled by the evolution of a single source of ore components, which are extracted from the country rocks. Our model describes the spatiotemporal evolution of the hydrothermal system, regularities in the distributions of elements in vein bodies and aureoles, and highly accurately reproduces the quantitative and qualitative characteristics of natural mineral assemblages.

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