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PREFACE

The scientific school of Academician A.P. Vinogradov, one of whose followers is the author of this monograph, attaches much significance to the physicochemical aspects of the origin of hydrothermal mineralization and the genesis of various aureoles (metasomatically altered rocks, changes in the distribution character of elements and isotopes leached from or introduced into the rocks, etc.) around orebodies. The basis for the physicochemical description of phenomena thereby taking place was provided by experimental research of the speciation of ore and nonore components in the hydrothermal systems and the conditions under which they could be incorporated into the solution and deposited from it, determination of the thermodynamic constants of the solid phases and solute species participating in the hydrothermal process, study of the "signatures" of this process (natural thermometers and barometers based on rare metals, isotopes, etc., providing evidence of its relations with a variety of geologic environments), and, finally, the development of computer programs for simulating the equilibrium state of these physicochemical systems.

However, it was eventually understood that laboratory experiment, knowledge of regularities in the variations of the thermodynamic constants, or even the ability to calculate the equilibrium states of multicomponent natural systems prove insufficient, in spite of all their importance and necessity, for reconstructing the mechanisms responsible for the genesis of orebodies and mineral deposits. N.I. Khitarov, an eminent geochemist and experimentalist, was among the first to emphasize that "...any more or less complete reconstruction of a process (meaning a hydrothermal mineralizing process) and development, on this basis, of a general model (or a series of models) calls for using various approaches extending far beyond the framework of physical chemistry. This became ultimately clear after many years of hopes placed on the experimental study of systems and the physicochemical approach as universal techniques of the solution of problems in the genesis of hydrothermal mineralization." (Khitarov *et al.*, 1980). In fact, the mechanism producing hydrothermal mineralization and a model of this mechanism include, in addition to the necessary purely physicochemical information, also "...several other factors and parameters without which the description of the process cannot be regarded as comprehensive. These are the deposition and replacement dynamics of minerals, material source and balance, volumes and velocities of hydrothermal solutions, the means by which these solutions migrate, and several other parameters. The settling of this problems requires information of geological–mineralogical character, data of hydrodynamics and sciences other than physical chemistry... ." (Khitarov *et al.*, 1980).

M.V. Borisov's research is among those reconstructions of natural processes that can today as much as possible take into account data borrowed from many fields of knowledge. The structure of this study is very logical. First, relatively simple but realistic models of hydrothermal systems are used to reveal and analyze the dependence of the development of ore mineralization in uranium-vein and wall-rock alteration aureoles on the hydrodynamic structure of ore-forming solutions under isothermal conditions. Then the system is further complicated, and the genesis of quartz veins with base-metal mineralization is modeled in a gradient field of temperature and pressure with the examination of various filling mechanisms of fractures: the layer-by-layer deposition of the material without its chemical reaction with earlier minerals and the deposition of the material with its reactions with preexisting layers of vein minerals.

The models proposed here involve numerous discoveries valuable in the context of the theory of hydrothermal mineral and ore formation. It is clearly demonstrated that such important characteristics of hydrotherms as Eh and pH are controlled by rock–water interactions, and, hence, interactions of this kind predetermine the extraction, transport, and deposition of ore components by solutions. A very important fact, first established by Borisov, is the drastic intensification of Pb, Zn, and Cu extraction from granite after the preliminary leaching of its accessory pyrite and a decrease in the overall concentration of sulfide sulfur in the granite. Such a dependence of the behavior of certain components on other components is characteristic not only of base-metal mineral deposits and can be justifiably referred to as *Borisov's effect.* Borisov demonstrates how and why the structure of metal distribution in primary wall-rock aureoles can be disturbed during the hydrothermal process and that these aureoles, which develop simultaneously with the origin of mineralized veins, can be dissimilar at different depth levels.

Borisov's monograph is interesting not only because it provides insight into some aspects of hydrothermal ore formation, many of which were obscure before, but also because it demonstrates which problems can be

attacked nowadays by applying physicochemical simulations and how these problems can be settled with the use of these techniques in a complex with other approaches borrowed from other fields of knowledge pertaining to the deposits in question. The monograph should be interesting for a wide circle of geologists, mineralogists, and geochemists dealing with orebodies and mineral deposits of different associations and will certainly significantly accelerate understanding of their genesis.

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Geochemical and Thermodynamic Models for the Genesis of Low- and Medium-Temperature Vein Mineralization and Metasomatism in the Wall Rocks

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Abstract—The paper presents a systematic analysis of the genetic conditions and principal features of zoning in orebodies and related wall-rock aureoles at low- and medium-temperature vein hydrothermal deposits from the standpoint of the thermodynamic simulation of mineralizing processes. The author employs the equilibrium–dynamic approach, in which any process is visualized as a succession of equilibrium states with certain dynamical elements. Generalized models are developed for ore-forming hydrothermal systems at base-metal and uranium deposits, including the regions in which the primary mineralizing solutions are formed and those of ore deposition and the development of aureoles. The monograph is addressed to geologists dealing with mineral deposits and to geochemists and can be utilized by students and postgraduates as a guide to simulating mineralizing processes.