PREFACE

By Paul B. Barton

Conceptual models that describe the essential characteristics of groups of similar deposits have a long and useful role in geology. The first models were undoubtedly empirical attempts to extend previous experiences into future success. An example might be the seeking of additional gold nuggets in a stream in which one nugget had already been found, and the extension of that model to include other streams as well. Emphasis within the U.S. Geological Survey on the synthesis of mineral deposit models (as contrasted with a long line of descriptive and genetic studies of specific ore deposits) began with the collation by R. L. Erickson (1982) of 48 models. The 85 descriptive deposit models and 60 grade-tonnage models presented here are the culmination of a process that began in 1983 as part of the USGS-INGEOMINAS Cooperative Mineral Resource Assessment of Colombia (Hodges and others, 1984). Effective cooperation on this project required that U.S. and Colombian geologists agree on a classification of mineral deposits, and effective resource assessment of such a broad region required that grade-tonnage models be created for a large number of mineral deposit types. A concise one-page format for descriptive models was drawn up by Dennis Cox, Donald Singer, and Byron Berger, and Singer devised a graphical way of presenting grade and tonnage data. Sixty-five descriptive models (Cox, 1983a and b) and 37 grade-tonnage models (Singer and Mosier, 1983a and b) were applied to the Colombian project. Because interest in these models ranged far beyond the Colombian activity, it was decided to enlarge the number of models and to include other aspects of mineral deposit modeling. Our colleagues in the Geological Survey of Canada have preceded this effort by publishing a superb compilation of models of deposits important in Canada (Eckstrand, 1984). Not surprisingly, our models converge quite well, and in several cases we have drawn freely from the Canadian publication.

It is a well-known axiom in industry that any excuse for drilling may find ore; that is, successful exploration can be carried out even though it is founded upon an erroneous model. Examples include successful exploration based on supposed (but now proven erroneous) structural controls for volcanogenic massive sulfide deposits in eastern Canada and for carbonate-hosted zinc in east Tennessee. As the older ideas have been replaced, additional ore has been found with today's presumably more valid models.

Although models have been with us for centuries, until recently they have been almost universally incomplete when descriptive and unreasonably speculative when genetic. What is new today is that, although we must admit that all are incomplete in some degree, models can be put to rigorous tests that screen out many of our heretofore sacred dogmas of mineral formation. Examples are legion, but to cite a few: (1) fluid-inclusion studies have shown conclusively that the classic Mississippi Valley-type ores cannot have originated from either syngenetic processes or unmodified surface waters; (2) epithermal base- and precious-metal ores have been proved (by stable-isotope studies) to have formed through the action of meteoric waters constituting fossil geothermal systems; and (3) field and laboratory investigations clearly show that volcanogenic massive sulfides are the products of syngenetic, submarine, exhalative processes, not epigenetic replacement of sedimentary or volcanic rocks. Economic geology has evolved quietly from an "occult art" to a respectable science as the speculative models have been put to definitive tests.

Several fundamental problems that may have no immediate answers revolve around these questions: Is there a proper number of models? Must each deposit fit into one, and only one, pigeon-hole? Who decides (and when?) that a model is correct and reasonably complete? Is a model ever truly complete? How complete need a model be to be useful?

In preparing this compilation we had to decide whether to discuss only those deposits for which the data were nearly complete and the interpretations concordant, or whether to extend coverage to include many deposits of uncertain affiliation, whose characteristics were still subjects for major debate. This compilation errs on the side of scientific optimism; it includes as many deposit types as possible, even at the risk of lumping or splitting types incorrectly. Nevertheless, quite a few types of deposits have not been incorporated.

The organization of the models constitutes a classification of deposits. The arrangement used emphasizes easy access to the models by focusing on host-rock lithology and tectonic setting, the features most apparent to the geologist preparing a map. The system is nearly parallel to a genetic arrangement for syngenetic ores, but it diverges strongly for the epigenetic where it creates some strange juxtapositions of deposit types. Possible ambiguities are accommodated, at least in part, by using multiple entries in the master list in table 1.

In considering ways to make the model compilation as useful as possible, we have become concerned about ways to enhance the ability of the relatively inexperienced geoscientist to find the model(s) applicable to his or her observations. Therefore, we have included extensive tables of attributes in which the appropriate models are identified.

Our most important immediate goal is to provide assistance to those persons engaged in mineral resource assessment or exploration. An important

secondary goal is to upgrade the quality of our model compilation by encouraging (or provoking?) input from those whose experience has not yet been captured in the existing models. Another target is to identify specific research needs whose study is particularly pertinent to the advance of the science. We have chosen to err on the side of redundancy at the expense of neatness, believing that our collective understanding is still too incomplete to rule out some alternative interpretations. Thus we almost certainly have set up as separate models some types that will ultimately be blended into one, and there surely are groupings established here that will subsequently be divided. We also recognize that significant gaps in coverage still exist. Even at this stage the model compilation is still experimental in several aspects and continues to evolve. The product in hand can be useful today. We anticipate future editions, versions, and revisions, and we encourage suggestions for future improvements.