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Invited Discussions:
1. G.D.J. Boldy

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very problems expressed by Harris. The weaknesses in the basic data and assumptions used can be expressed properly when the communication is in the form of a scientific paper exchanged between consenting adult earth scientists. The problem arises when the quantitative conclusions are taken out of context by members of the communications media, politicians or bureaucrats, and unknowingly used in an improper manner. Such misuse, as noted earlier, can lead to unwise expenditure of public or private funds, unfair taxation and unrealistic mining laws.

To close on a more positive note, a few words about the various approaches to — predictive metallogeny. The one which currently appeals most to me is the type presented in recent Geological Survey of Canada resource assessment studies for various parts of northern Canada. As described in a recent paper by Findlay and Sangster (delivered at the Annual Meeting, CIMM, Quebec City, 1982), the reports are subjective geological assessments that present areas or packages of rocks "in terms of their perceived potential to contain undiscovered mineral deposits". The ratings are essentially qualitative, and are derived by matching the geological characteristics of selected terrains with the diagnostic features of the conceptual models of various mineral deposits. The appraisals are documented abundantly so that the user can see clearly how the rating was determined. Findlay and Sangster note that the asessments are "broadly equivalent to the initial compilation stage of many exploration programs", which probably explains why they are so acceptable to me!

References

Findlay, D.C. and D.F. Sangster, 1982, Recent G.S.C. Resource Assessment Studies and Their Potential as Mineral Exploration Guides: preprint of paper presented at Annual Meeting of CIMM, Quebec City, May 1982.

Harris, DeVerle P., 1973, A subjective probability appraisal of metal endowment of Northern Sonora, Mexico: Economic Geology, v. 68, p. 222-242. See also p. 1344-1346 of same volume, including discussion by Harvey L. Sobel and author's reply.

Invited Discussions

G.D.J. Boldy
Placer Development Limited
Toronto, Ontario

I will try to present the view of an exploration geologist about predictive metallogeny, what in the old days we used to call "having a nose for ore".

The panellists have outlined various methods: empirical, qualitative methods using subjective judgement with or without mathematical computations, quantitative methods with objective judgement. Predictions are done by a variety of people, ranging from those closest to the scene, i.e., field geologists, to exploration managers, pure scientists, mathematicians and even astrologers. Predictions are commonly based on an analysis of a control area and an effort to apply it to the area that is being assessed. By analyzing the total geological picture, ore deposit models and frequency distributions, one sets probabilities of occurrence in this and that area.

To me, predictive metallogeny has two major levels. When it is applied to a mature mining district that has a good data base obviously the events are more predictable and you have more confidence. It is like finding blueberries in a blueberry patch: you know you're in a patch and even can tell after some time what size, quality and shape the berries will have. The real rub comes when you go into an unknown area where there is a poor data base and events are less predictable. But this is where predictive metallogeny really has to reach, this is where it is most important to be able to answer the question, "are we in elephant country?". And the second level is the "exploration surprise factor". Quite often in the field when you least expect it you find yourself on candid camera. No one said there was going to be ore there, but by God it's there! Anyway, reviewing the past 30 years of Precambrian discoveries, I can think of 10 or 12 camps, Manitouwadge, Snow Lake, Thompson, Elliot Lake, Kidd Creek, Detour Lake, Athabasca Basin—I won't name them all— about which who cannot say that, despite all the data present at the time, they were surprised when these discoveries were made; and made by others!

Let's take Case 1, the uneven endowment factor. Timmins: a pre-1964 major gold district, over a quarter of Canadian Precambrian gold production, 50 years of history, 2 or 3 minor copper-zinc deposits. Now who in all honesty would have predicted to his exploration management that he needed certain funds because he knew there was going to be a world-class copper-zinc-silver deposit just 10 miles out of town? The Kidd Creek deposit in itself is equal to all the production of the the gold mines in the Timmins area.

This fantastic deposit is 25 times larger than the average Precambrian deposit. It is even three times larger than the largest known Precambrian deposit. Mathematically, you cannot predict an event like that because of its uneven endowment factor and you have no control over it. Now you can draw contours around it mathematically and as you move in closer to the bull's eye you come in second, because you'd have homed in on Kamkotia which is about 6 million tons. Eighteen years have passed since that discovery and nothing of any consequence in massive sulphides has been found there. Who will care to predict the next discovery— its size, grade and location?

Case number 2 exemplifies the surprise factor— geological surprise. The Athabasca basin, pre-1968, consisted in essence of the Beaverlodge deposit, a classic vein model type deposit with a 25-year history. Despite the uranium exploration going on around Uranium City, the unconformity model was developed, with Cluff Lake, Key Lake, etc. Unknown to the geologists or the mathematicians or anyone else, there happened to have been a change of ore deposit habitat. The ore locale changed. The ore was in the area but it wasn't in the veins anymore. So how can you predict that quantitatively?

From the viewpoint of exploration, I am inclined towards the use of a qualitative method, subjective approach and, to coin a phrase, "simple intuitive method", and to review areas in terms of their having or not having a tendency toward containing either a high, medium or low probability of discovery of the type you are looking for. When you are working in a mature district where there is abundant data you can afford the luxury of a semi-quantitative or perhaps even a quantitative approach. In a very restricted area, where perhaps 20 discoveries have been made over 30-50 years, and the geometry, the ore deposit size, shape and grade and the frequency distribution are known, then you can perhaps afford the luxury of calculating to one decimal place, but I wouldn't go beyond that.

Also, I am inclined toward using predictions expressed in relative terms and not necessarily in absolute terms. That is where the trouble begins, when you become absolute.

In closing, I believe that predictive metallogeny is really an art and not necessarily a science. The artistic aspect is that of predicting with reasonale accuracy from minimum data and in minimum time. And to quote Niels Bohr, "Prediction is a very difficult business, gentlemen, especially when dealing with the future".