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WORLD MINERAL EXPLORATION: TRENDS AND ECONOMIC ISSUES

John E. Tilton, Roderick G. Eggert & Hans H. Landsberg, eds.
Washington, D.C.: Resources for the Future.
1988. Pp. xxvii, 491. \$75.00, h.c.

This collection of mineral exploration studies comes from a 1983 conference at the International Institute for Applied Systems Analysis. Two of the editors, John Tilton and Roderick Eggert, are at the Colorado School of Mines. Hans Landsberg is affiliated with Resources for the Future, a Washington think tank. Consequently the papers present academic, governmental and industry aspects of mineral (non-fuel resources, primarily metals) exploration as evidenced by the backgrounds of the authors. The titles of the eleven papers include references to the Soviet Union, South Africa, Botswana, New Guinea, France, Canada, Australia, the U.S. and the encompassing United Nations. However, they are more than case studies and descriptions. Each paper uses country specific data to directly or indirectly analyze one or more basic questions:

- Exploration Activity: its size, finance, and policy; such as, have private firms neglected exploration in developing countries and how have mineral markets, government policies, changing technology and political risk affected exploration?
- Exploration Productivity: its measurement, trends and prospects; have ore grades declined as theory predicts, do management "teams" and their size and styles affect success rates?
- Exploration Locations: economic system, economic wealth and data collection and reporting systems; that is, have governments collected and reported sufficient exploration data?
- Exploration Economics: economic theories of mineral discovery and depletion confronted with real world experience; what is the ex-post rate of return on exploration investment, are there differences among counties and private companies, and what makes such differences persist?

Insights are provided by reading the volume in its entirety, for each author only touches portions and may do so obliquely. The reader must compare and tie the bits of the strings together, but it is worth the effort. Three conclusions come from my reading:

The first is that data on mineral exploration are incomplete, inconsistent and lumpy. Private firms limit disclosure for proprietary reasons, including concealing evidence from stockholders such as the less than successful diversification by oil companies into mineral exploration and production. Governments collect and report data in many different ways. Ones with

large public ownership, such as France or the Soviet Union, report differently than countries with a large private mining sector, such as Canada and Australia. The differences are caused by the level of economic development, national security motives including reliable supplies (for example, uranium and cobalt), and sensitivity to colonial history and international politics (for example, South Africa).

Data lumpiness occurs because individual discoveries are discrete and vary from insignificant to enormous. Technological advancements in exploration (airborne survey, satellite sensing and geologic modeling) and mining (exploiting low grade, extensive porphyry deposits) have changed the economics of exploration and have resulted in large scale mines. Time and development have shown that the size and characteristics of deposits differ from the original assessment. Authors explain their findings are determined by one or two specific mines. They state repeatedly that there is no "typical" deposit. An associated complicating factor is that various metals and other natural resources are found together. Thus joint production occurs and the relative prices of these co-products dictate the extraction and recovery techniques. For example silver, gold and other metals are important co-products in copper mines.

A second discovery of these studies is that management of exploration is critical to success. The small group led by a skilled and dominant leader appears to be more productive than large scale departments and a "team" approach. The study of United Nations aided exploration failures, the Mackenzie and Woodall finding of higher Canadian exploration productivity compared to Australia, and persistently different discovery success rates among oil companies indicate that management style and size beg for further analysis. The law of large numbers, diversification and economies of scale imply that exploration risk can be reduced to near zero with large programs. These lumpy and site specific data indicate otherwise.

These eleven studies, taken as a whole, reveal difficulties in testing economic theory. Elegant theory was developed during the energy crises and natural resource scare of the 1970s. It predicted increasing real mineral prices, depletion and falling ore grades, and falling exploration investment activity and productivity in an environment of higher interest rates and steady mineral prices. The studies show that the theories have not forecast well. Despite high real interest rates and soft mineral prices, exploration has continued and grown. Data limitations make direct tests of the individual theories nearly impossible (only one of the studies specifically tests an economic theory). Most economic theories of depletion are oversimplified and assume certainty regarding future prices and interest rates. The studies in *World Mineral Exploration* reveal the major reasons for the failure of these predictions: technological innovations in

exploration and mining have reduced costs and improved productivity, materials substitution (for example, plastics, fiber optics and electronics) and efficiencies in production and design (for example, lighter and more fuel efficient automobiles) have reduced demand for metals and government policies have stimulated exploration and production (tax concessions and subsidies, particularly in developing countries which require growth of exports).

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