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Review

Giant metallic deposits—A century of progress

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ABSTRACT

Giant (and super-giant) metallic deposits are defined as those that store the trace metal (and some major metal like Fe, Al) equivalent in10^{11} (10^{12}) tons of continental crust in Clarke (mean crust content) concentration. Deposits of metallic ores that have very contrasting Clarke values (like Fe, Cu and Au) can be compared on geochemical basis, with political–economic and technologic factors minimized. Under these terms, there are now 1171 giant and 137 supergiant accumulations of 37 metals worldwide, contained in 915 deposits, as several deposits have two or more giant metal accumulations (Olympic Dam has 5). These deposits store and supply between 60 and 95% of global metallic resources on land, with several individual deposits monopolizing the supply. It is predicted these exceptional deposits will remain the principal metal source for the industry at least through this century. The "ore giants" are dominated by gold and copper (278 and 268 entries), followed by Mo (166), Ag (119) and Pb (90). This metal selection is more the consequence of demand and price than geological availability, proving that when there was a demand and the "right" price, the resources industry has been able to discover and develop new deposits to satisfy this demand. This may change in the future so unconventional metal sources are reviewed and compared with the classical, high concentration factor ores.

I have not been able to find a single case where a giant deposit would be a unique, one-of-a-kind product. In all instances, the ore giants are magnitude end members of a population of lesser deposits of the same, or similar, type so they are only quantitatively distinct from the rest. For that reason discovery of the ore giants is statistical and cannot be exclusively targeted, despite the fact that in some cases the "giants" were among the first deposits discovered. Although the ore giants are not qualitatively different from the lesser members of the same type, they are the product of the best optimized mineral system. A number of metal accumulation magnifiers have been suggested in the literature and they are briefly reviewed here.

More than 70% of the ore giants have been discovered in the past sixty years; the discovery rate grew steadily since the Industrial Revolution in the 19th Century when a number of new chemical elements had been discovered, to accelerate in the 1890s, then again in the 1950s. The 1965–1970 and 1990–1995 intervals had the greatest number of giant deposits discovered (38 and 43, respectively) and this not only replenished the consumed metals, but provided a significant surplus. These periods may have been discovery peaks followed by diminishing ore finding rate, suggesting future metal supply scarcity. With continuing depletion of ore discoveries exposed at the surface the number of deposits found under cover has grown almost exponentially; by 2010, close to 150 partially to completely buried ore giants have been found, some in a depth approaching 3000 m. This has only been possible by continuously increasing complexity and cost of ore finding, from visual on-foot discoveries prevalent before 1950 to the instrument-assisted discoveries by corporate teams. The prevalent technique of ore discovery (followed by proving) is drilling, positioned by geochemical and geophysical anomalies, in turn the product of practical geological models and creative human reasoning. As metal mining is an economic activity made possible by geological availability of resources, it is believed that the production costs (combined with environmental and political considerations) will govern the future transition from the "classical" (high concentration factor) ores to the lower-grade and more difficult to extract sources of tomorrow like oceanic resources, with increased role of recycling.

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Contents

1. Introduction

Humanity is obsessed with magnitude and ranking of objects, events and processes with special attention paid to the largest, longest, best or worst examples. This could be accomplished in a subjective way usually based on limited facts blended with emotion and a variety of beliefs as in tabloid newspapers or political pronouncements, or it could be accomplished in a more respectable fashion based on serious quantitative data gathering (e.g. the world's countries, cities, population, income statistics). The magnitude and rank preoccupation is also ubiquitous in geosciences and mining where it sometimes overlaps with classification and organization of objects. In the past hundred years the purely subjectively defined magnitudes underwent gradual quantification driven by increasing abundance of numerical data.

Organized and localized metal mining, as opposed to opportunity collecting of naturally occurring loose pieces of metals like gold, meteoric iron and copper at the surface, goes back mere 9000 years in human history, and this only in few places with advanced ancient civilizations (Hauptmann, 2007). Starting from surface ore outcrop the highly selective mining soon progressed to shallow depth, resulting in a mine. The numbers of mines and intensity of mining fluctuated with politics and economics of the day, increasing in times of high demand for the few "antiquity" metals (Au, Cu, Sn, Ag, later Fe) in time of state- and empire-building periods as in Sumeria (~4000 B.C.), Pharaonic Egypt (3500–2000 B.C.), early China dynasties like Shank, Chou and Han (~1500 B.C. to ~220 A.D.), the Phoenician state (~1000 B.C.), the Athens Republic (Conofagos, 1980) and the Roman Empire (~300 B.C. to ~400 A.D.; Fig. 1.1). It is estimated that before A.D. 1 there were about 20 areas ("districts") of metal mining around the world, complete with benefication and smelting facilities (Aitchinson, 1960). Their numbers kept slowly increasing through the Middle Ages, accelerating after the (re)discovery of the Americas by Europeans, then