The Metallogeny of Ancient Greenstone Belts and Implications for Modern Submarine Hydrothermal Systems

Mark Hannington[1], H.L. Gibson[2], S. Petersen[3], U. Schwarz-Schampera[4], T. Monecke[1]

[1]Department of Earth Sciences, University of Ottawa, Ottawa, Canada
[2]Department of Earth Sciences, Laurentian University, Sudbury, Canada
[3]Leibniz Institute for Marine Sciences, IFM-GEOMAR, Kiel, Germany
[4]Federal Institute of Geosciences and Natural Resources, Hannover, Germany

Abstract

Ancient ore deposits provide important clues for the understanding of the origin and distribution of modern submarine hydrothermal systems. An analysis of the formation conditions, tectonic settings, and preservation of ancient seafloor mineral deposits from the recent geological past to the late Archean sheds light on the time-space relationships and diversity of mineral deposit types likely to be found in the modern oceans. Microplate tectonics that characterized ancient ore-hosting greenstone belts were strikingly similar to those active in volcanic arc environments of the western Pacific today. In such complex settings, oblique collisions, opposing subduction zones, and rapid changes in stress regimes (e.g., from compressional to tensional and back to compressional) were common, causing juxtaposition of diverse styles of mineralization. The world-class base metal deposits of the late Archean Abitibi greenstone belt of Canada, for example, were formed within a relatively short time span of ~20 m.y., in response to successive arc rifting, back-arc basin development, and exhumation of accretionary complexes along major arc-parallel crustal-scale faults. Similar processes and environments are important settings for metallogenesis in modern submarine volcanic arcs. Active marginal basins of similar size and representing similar stages of evolution are well represented in the western Pacific today and contain a similar suite of mineral deposit types. Examples from the eastern Manus Basin and adjoining New Ireland Basin (PNG) and in the Lau-Tonga-Kermadec arc-backarc system illustrate these similarities. Certain gold-rich volcanogenic massive sulfide deposits at the southern margin of the Abitibi greenstone belt (e.g., Bousquet and LaRonde deposits in the eastern Blake River Gp.) may be important ancient analogs of newly discovered gold-rich black smoker deposits found along the active fronts of today's submarine volcanic arcs. However,

there are some important differences between modern seafloor hydrothermal systems and the style and volcanic settings of major ore deposits that formed in the ancient oceans. For example, the abundance of black smoker vents at the volcanic fronts of modern arcs contrasts with the interpreted settings of most ancient volcanogenic massive sulfide deposits, which are considered to have formed mainly during arc rifting and in deep back-arc basins. The extensive geological record of mineral deposits that formed in ancient oceans, and are now preserved in greenstone belts on land, provides a useful guide to the future prospects for marine mineral resources in the modern oceans.

Mark Hannington

Mark Hannington received a PhD. from the University of Toronto in 1989 and spent 15 years as a Research Scientist at the Geological Survey of Canada before moving to the University of Ottawa. His research combines the study of ancient volcanic environments that host many of the world's largest and most valuable mineral deposits on land with research on active volcanoes of the ocean floor and associated metal-depositing "black smoker vents". During the last 20 years, Dr. Hannington has been a member of an international team of researchers from the U.S., Germany, and Canada, participating on 19 research cruises to submarine volcanoes on the East Pacific Rise, the Juan de Fuca Ridge, the Mid-Atlantic Ridge, Iceland, New Zealand, Antarctica, and Papua New Guinea. The team's work has focused on understanding the origins of base and precious metal deposits at submarine volcanoes and has contributed to the discovery of a number of previously unknown mineral deposit types on the seafloor. Their comparisons between modern volcanoes and ancient volcanic environments are leading to new and improved models for both land-based and marine mineral exploration. Dr. Hannington is the editor of the international research journal *Economic Geology*, which deals with the geosciences applied to mineral deposits.