Environment of Deposition of the Sullivan Orebody

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The genesis of the Sullivan orebody is reviewed in terms of current concepts of stratiform ore formation. The source of metals and sulfur, the environment and time of ore formation, and the imprint of subsequent metamorphic events are explained in terms of a model which views the ore as one component of a chemical and clastic sequence formed within a rift basin above a thermal anomaly. Classic primary sedimentary structures are displayed in both the chemical (sulfide) and the clastic (silicate) rocks. Fractures and breccia zones beneath the western section of the mine provided passage-ways for boron and metal-rich sulfur-poor brines. Sulfides formed when the metals combined with reduced marine sulfur. The pattern of metal zoning is a reflection of the location of brine vents. The boron-rich solutions produced the tourmaline alteration zone. The sodium-rich brine produced albite within the ore sequence and in the hanging wall perhaps by the modification of analcite. The manganese variation of sulfide minerals between ore bands and laminations reflect changes in the chemistry of solutions during sedimentation and some degree of partitioning during metamorphism. The metamorphism has modified both the sulfide and silicate assemblages.

INTRODUCTION

Concepts regarding the origin of stratiform base metal deposits have evolved considerably in the past decade. The geologic setting of this large and significant orebody, within the framework of plate tectonics, is of particular interest. Before the language of the new tectonics had evolved, Freeze (1966) supported the view of earlier workers that hydrothermal replacement was important particularly in the western part of the orebody and recognized the strong syngenetic case that could be made for the laminated eastern ores. Jardine (1966) made a major contribution by detailing the relationship of the footwall breccia, conglomerate, mineralization and post-ore adjustments. The Sullivan mine staff first graphically illustrated the footwall breccia zone and provided an overview of the complex epigenetic and syngenetic features displayed in the mine in a paper by Morris (1972). Hutchinson (1973) suggested that deposits of the Sullivan type were formed in zones of rifting of archean crust, and were associated with tholeiitic magmatism, fumarolic activity, and turbidites. Ethier et al. (1976) reviewed the geochronological evidence and concluded...
that the tourmalinization and ores are syngenetic with both a contact metamorphic and regional metamorphic overprint. In discussing ore deposits from the viewpoint of plate tectonics, Sawkins (1976) suggested that the Sullivan type deposits were formed along continental margins or tension-related intracratic troughs. In an update of the view of the mine geological staff, Ransom (1977) concluded that the ores are definitely syngenetic, formed by brines entering the basin along footwall fractures, first developing the boron alteration, then depositing the sulfide ores. Carne (1979) in a tabulation of characteristics of sedimentary-exhalative deposits indicates the tectonic control at Sullivan to be the intersection of fracture zones and normal fault along a possible rift margin.

This paper reviews evidence for the origin of the Sullivan deposit in the light of current concepts and data resulting from our research on the deposit, Campbell and Ethier (1977). Questions posed about the source of the ore metals, the source of sulfur, the environment and time of deposition, and the imprint of subsequent metamorphic events (Freeze, 1966) may be addressed in terms of a model which views the ore as part of a chemical and clastic sedimentary process in a region with a

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Fig. 1. Location of the Sullivan mine, the stippled area indicates the distribution of Purcell (Helikian) and overlying Windermere (Hadrynian) rocks.