Red Dog: From Discovery to Recovery Above the Arctic Circle

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Located in remote, northwestern Alaska, approximately 170 km above the Arctic Circle, the Red Dog district hosts one of the world's largest and highest-grade SHMS Zn-Pb-Ag deposit clusters. Showings were first discovered by the USGS in 1968. Cominco staked the Red Dog area in 1978, drilled in 1979, and, in the second hole, intersected 36 ft of 48% Zn and 7% Pb and 135 ft of 20% Zn and 10% Pb. In 1982 an innovative lease and operating agreement was signed between the Northwest Alaska Native Association Regional Corporation, owned by the Iñupiat people of northwest Alaska, and Cominco (now Teck Resources Limited). Production began in 1989 from the Red Dog Main deposit.

District discoveries resulted from many factors, including key people, knowledge, persistence, and methods. Early successes (Su, Lik, Main, Qanaiyaq) principally came from stream sediment sampling, prospecting, and drilling. As structural and stratigraphic knowledge advanced, exploration became increasingly geologically and geophysically driven. Aqqaluk's discovery in 1995 resulted from drilling a coincident barite, gravity, IP, and CSAMT target. Paalaaq followed in 1996 through structural and gravity targeted drilling. Anarraaq was discovered in 1999 through structural modeling, gravity, and downhole radial IP.

Red Dog's deposits are hosted by Mississippian carbonaceous and cherty shale with subordinate limestone and calcareous turbidite. Associated fossil worm burrows, radiolarite, thick barite, and thin phosphorite deposits indicate a suboxic to oxic mid-shelf setting with periodic upwellings. Underlying Mississippian to Upper Devonian oxidized clastic units are inferred metal sources; flanking, evaporitic carbonate platforms were likely brine sources. Sustained mapping has painstakingly unraveled the complex structural architecture of this allochthonous district and its ore deposits.

Red Dog's deposits formed by subseafloor, syndiagenetic, stratabound replacement in host units that locally contained either massive to nodular barite or nodular carbonate. Exceptionally high grade mineralization reflects a multistage paragenesis with (1) stratiform Fe-poor sphalerite and pyrite, followed by (2) medium-grained red-brown Fe-rich sphalerite and galena, overprinted by (3) veins and hydrothermal breccias cemented by quartz-calcite and low-Fe sphalerite. Significant silicification accompanied high-grade mineralization. Peak mineralization resulted from cooling of relatively high T (150°–200°C), hypersaline brines, thermochemical sulfate reduction, and acid generation with sulfide deposition in a self-fueling reactionary front.

The complex paragenesis and overprinting relationships that characterize mineralization in the Red Dog deposits pose significant geometallurgical challenges, which over time have been addressed by increasingly advanced approaches to ore characterization, process, and throughput characteristics. Simplistic Pb, Zn, and Ag recovery models were initially applied to the Main deposit and subsequently improved to include a chemical analysis-based zinc recovery model. In 2004 a comprehensive geometallurgical program on the Aqqaluk orebody resulted in refinement of the existing universal Zn recovery model and development of new Pb and Ag recovery models. Ore characterization studies helped establish SAG and ball mill hardness models and estimated mill throughput. Estimates of lead and zinc recovery as well as mill throughput are now available for each block in the geological model.

Investment in internal and external research, second-generation mapping, geochemistry, modern airborne EM, and ongoing geometallurgy continue to guide exploration, discovery, and recovery in the district.