El Tesoro Exotic Copper Deposit, Antofagasta Region, Northern Chile

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The El Tesoro exotic copper deposit is located ~150km northeast of Antofagasta, northern Chile. Prior to the involvement of Anaconda Chile S.A. in 1990, the area was known historically as a group of small copper deposits where small-scale mining had taken place intermittently since 1886. Between 1980 and 1990, several exploration programs designed to search for the source of the exotic mineralization - then considered to be the only valid target in the area- were undertaken by a number of companies, including Anaconda. A new exploration effort in the area by Anaconda Chile, originally designed to outline a small copper oxide resource around the old workings at El Tesoro, was quickly modified after intersection of important mineralization in the first two holes drilled in September 1990. The modified program was carried out in several stages between 1990 and 1995, and included drilling of 54,500m of RC holes at El Tesoro itself and an additional 23,500m in the nearby Tesoro NE target area. Discovery was the direct result of geological mapping and modelling, drilling, and the strong support of company management. The program defined two major exotic copper bodies at El Tesoro (206 Mt @ 0.86%TCu; 0.45%TCu cut-off) and Tesoro NE (50Mt @ 0.91% TCu; 0.45% TCu cut-off), and led to later development at El Tesoro. Mining by Compañía Minera El Tesoro (61% Antofagasta Minerals S.A., 39% S.C.M. Leonor) commenced in November 2001, and current production is ~85,000 t of copper cathodes per year. At present-day mining rates of 25,000 t per day, mine life is estimated to be 19 years.

The regional geology is characterized by a basement composed of Late Paleozoic intrusive and volcanic units (Limón Verde intrusive complex; Cas Fm) and several sedimentary and volcanic sequences of Mesozoic age (Caracoles Gp; Quebrada Mala Fm), which are intruded by Cretaceous granitoids at Caracoles. An Early Tertiary volcanic sequence (Cinchado Fm) unconformably overlies the Mesozoic units. At El Tesoro, it comprises a series of structurally controlled flow-dome complexes of Middle-Late Eocene age, which constitute part of the immediate basement to the gravels that host the mineralization. Remaining parts of the area are covered by a thick sequence of moderately consolidated gravels of Middle-Late Tertiary age (Tambores Fm), which are typically sealed by a 10-Ma ignimbrite. The main northeast-trending fault system, part of the regionally extensive Domeyko Fault System, runs through the area and offsets all rock units, including the 10-Ma pediment surface. These faults display evidence for both strike-slip and reverse movements, which is believed to have been accompanied by the minor folding observed in the host gravel sequence.

The copper deposit, completely contained by the Tertiary gravel sequence, is composed of several, northeast-striking, northwest-dipping mantos with a maximum thickness of ~150 m and an areal extent of ~2x2.5 km. The gravels are dominated by semi-massive, pebbly to bouldery, chaotic horizons interbedded with coarse-grained sandy and silty layers, some of which are distinctly calcareous. Clast composition is varied, although several horizons are characteristically dominated by clasts of Paleozoic granitoids and quartz-sericite-altered porphyries and andesites. The oxide copper resource is dominated by atacamite and paratacamite, accompanied by subordinate chrysocolla. These minerals occur in the sandy matrices of the gravels where they cement the various clastic components. The clasts themselves are not mineralized, although may locally contain minor amounts of remnant chalcoite and encapsulated copper oxides. The mineralization is clearly controlled by original host permeability, with the silty horizons for the most part being barren of copper. A copper-depleted, hematite-rich ferricrete horizon is locally interbeded in the deposit and correlates with nearby exposures of “Gravas Rojas” to the east. A broad zoning includes a central zone of atacamite and paratacamite concentrated in upper mantos and a zone of chrysocolla that dominates the lowermost horizons of the deposit. Copper wad is common and irregularly distributed throughout the deposit.

El Tesoro constitutes a classic example of an exotic copper deposit formed by lateral migration of copper-charged solutions with deposition in favorable gravel horizons. Its mineralogy and mineralogical zoning, together with its intimate association with alluvial fan-type gravel deposits, are characteristics that indicate a distal position, perhaps several kilometers, from its source.

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