HYDROTHERMAL ORE-DEPOSITS CONTROLLED BY STRUCTURE AND MAGMATISM IN CENTRAL PERU

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RESUMEN: Fallas regionales de rumbo Noreste con movimientos recurrentes y alternados entre desgarre dextral y basculamiento gravitacional al Sur, controlan la distribución de importantes distritos mineros caracterizados por yacimientos hidrotermales en la costa y sierra del Perú central.

KEY WORDS: Central Peru, faults, hydrothermal ore deposits.

The structural and magmatic evolution of Central Peru is best pictured by Megard (1978) and Pitcher et al. (1985). Their studies were based on regional mapping of mutually exclusive zones: the Western Cordillera and the Altiplano as opposed to the coastal areas, respectively. Topical correlation of tectonic events, magmatic pulses and geochemical fingerprinting has been elaborated for coastal and cordilleran domains (Noble et al., 1974, 1979; Cobbing, 1978; Atherton, 1989, 1992). The structural grain of this Andean transect depicts a plate edge with linear batholiths roughly parallel to paleo-basins, fold belts, volcanic arcs and metallogenetic provinces (Petersen, 1965; Ponzoni, 1980; Petersen and Vidal, 1983). Transverse features such as batholithic and metallogenetic segmentation have been described in a broad sense with little supporting evidence to make their application economically successful (Sillitoe, 1974b, Vidal, 1980). This contribution intends to correlate transverse fault movement with magmatism and hydrothermal activity, both on a regional scale and on a mining district scale.

Major transverse faults across the Andes in Central Peru control the location of Mesozoic and Cenozoic hydrothermal systems, which were driven in relation to subvolcanic and volcanic ediffices. Northeast-trending fault systems such as

exposed at Huaura, Chancay, and Agua Salada, north and east of Lima, are traced continuously over 50 to 70 km in fully exposed mountainous desert. Their movement was long-lived, recurrent and variable; dextral-wrench or strike-slip movements alternate mainly with gravitational downthrows to the southeast. Offsets in the order of several kilometers have been described by Bussell (1983) and by Vidal (1987). Variable nature of fault movement indicates variable stress regimes. Transient compressional periods during relatively rapid plate-convergence induced strike-slip. Tensional periods during slow-down or hault of subduction produced gravitational tectonics.
In the Western Cordillera and Altiplano region the Northeast-trending fault system is continuous although sparsely recognized. Conjugate Northwest-trending sinestral wrench faults with kilometric displacements are exposed in the Atacocha region, east of Cerro de Pasco. Indirect evidence of underlying Northeast faults such as fold deflections, graben- and horst-topography and location of stocks, volcanoes and vein swarms are present. Mining districts characterized by hydrothermal ore deposits which are controlled by structures related to Northeast-trending faults are: the Uchucchacua Ag+Mn skarns, the Río Pallanga, Huámpar, Caridad, Huarón and Casapalca Ag+Pb+Zn veins, the San Cristóbal W+Zn veins, the Santa Cruz de Cocachacra Ba+Zn massive sulfides and some of the Iscaycruz Zn skarns. The structural trend defined by the mining districts of Cerro de Pasco and Colquijirca may also be related to fundamental Northeast-trending basement faulting. Structural controls coincide to locate the newly-discovered ore bodies at the Santa Cruz de Cocachacra and Colquijirca districts to be presented as case studies.

Massive sulfide and barite deposits of middle Cretaceous age are actively mined from the Santa Cruz de Cocachacra mining district, 50 km east of Lima (Vidal, 1987). Estimated production plus reserves add up to 5 million tons of direct-shipping barite ores and 3 million tons of sphalerite ore at plus 8 per cent Zn cut-off. Detailed geological mapping and core-logging have revealed a localized succession of submarine pyroclastic flows, felsic lava domes and hydrothermal vents that overlapped in time with widespread calcareous sedimentation. Volcanism and ore deposition were structurally favored along an Andean trending, rift-like depression or second-order basin. Paleogeographic readjustments across Northeast-trending transverse growth-faults produced clastic reworking of exhalative-sedimentary ores and country rocks into deeper third-order basins. Tectonically-induced slope breccias accumulated adjacent to syn-sedimentary fault-scarps; rock and ore debrii were transported over distances up to 200 m. Redeposited ore material classified by size- and gravity-sorting, formed graded beds and unusually rich pyrite, sphalerite or barite deposits in the deepest parts of the basin. Subsequent erosion of the volcanic ediffice gave rise to proximal volcaniclastic breccias with distal sandstone and mudstone deposits, all of which overlie and preserve the ore-bearing

horizon.

Circa 20 million tons of Cu+Ag ores and 35 million tons of Zn+Pb+Ag ores had been mined from the world-class Cerro de Pasco mining district. Only 10 km to the south, the Colquijirca district has produced at least 100 million ounces of Ag from supergene enrichment zones and more recently 8 million tons of Zn+Pb+Ag ores. Mineral deposits in both districts are of complex hydrothermal nature; their association to the wanning stages of Miocene subaerial volcanism is clear (Silbermann and Noble, 1977; Vidal et al., 1984). The near Northsouth trend defined by the Cerro de Pasco and Colquijirca mining districts is characterized by a red-bed and lacustrine sequence of Eocene-Oligocene age, which unconformably overlies Jurassic limestone, Permian red beds and pre-Ordovician filites. Such a structural corridor is bound by Miocene volcanoes on both ends and longitudinal faulting along the edges. Recurrent fault movement is evidenced by cataclastic and mylonitic Zn+Pb ores in Cerro de Pasco's Cayac Noruega deposit. Evidence of underlying longitudinal faults such as Miocene dykes, intense dolomitization of Pucará limestones and strong East-West fracturing appear west of the Colquijirca district. Structural level as indicated by comparison of volcanic facies, volcanic geomorphology and ore textures appears higher at Colquijirca compared to Cerro de Pasco. Reconstruction of the Miocene configuration is interpreted as a volcano-tectonic depression or graben. Sigmoidal deflection of the graben from regional structure and predominance of east-west tensile features are interpreted as high level structures produced by basement rupture along Northeast-trending dextral-wrench faults.

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