

# Miocene Landscape Evolution and Geomorphologic Controls on Epithermal Processes in the El Indio-Pascua Au-Ag-Cu Belt, Chile and Argentina

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## Abstract

The world-class breccia-, stockwork-, and vein-hosted epithermal Au-Ag-Cu deposits of the central Andean El Indio-Pascua belt, latitudes 29°20' to 30°30' S, were emplaced between 6.2 and 9.4 Ma, immediately beneath the shoulders of an actively uplifting north-south tectonic block along the axis of the Cordillera Principal. The deposits of the Pascua-Lama, Veladero, El Indio, and Tambo districts are hosted by largely felsic volcanic units of late Oligocene-Early Miocene and Late Paleozoic age, but were associated with small hypabyssal bodies of dacitic porphyry, the Pascua Formation. There is no evidence that the epithermal centers were overlain by substantial volcanic edifices.

The preglacial Miocene landscape, previously undocumented, incorporates three planar erosional landforms of regional extent: (1) the ca. 15- to 17-Ma Frontera-Deidad Surface; (2) the ca. 12.5- to 14-Ma Azufreras-Torta Surface; and (3) the ca. 6- to 10-Ma Los Ríos Surface. These pediplains are each vertically separated by 200 to 400 m and, by analogy with the enormous erosion surfaces of the Atacama desert of northern Chile and southern Peru, are considered to have formed in a semi-arid climate in direct response to uplift events. Although the Azufreras-Torta Surface immediately overlies most of the major hydrothermal systems, and hence influenced their evolution, ore formation was contemporaneous with the development of the younger Los Ríos pediplain, and was almost entirely focused around the upper extremities of stage III valley pediments. In contrast, precursor high-sulfidation hydrothermal alteration zones in the main mineralized districts, ranging in age from 10.0 to 13.6 Ma and associated with Vacas Heladas Formation dacitic magmatism, developed before incision of the Los Ríos pediments and are barren.

The areal and temporal relationships between economic epithermal centers and the heads of Upper Miocene valley pediments provide, at the least, clear, empirical exploration guidelines for the El Indio-Pascua belt. However, it is further proposed that changes in the surficial hydrodynamic environment, including the rapid lowering of the water table, increased lateral ground-water flow, and fluid boiling and mixing, all favoring ore deposition, may have been directly induced by pediment incision in this and other semi-arid cordilleran environments in which epithermal mineralization was not associated with significant volcanic edifices.