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Magmatic and Tectonic Controls on the Development of Cenozoic Porphyry Cu-Mo±Au Deposits in the Gangdese Belt, Southern Tibet

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1 Introduction

Porphyry copper deposits are most commonly formed by hydrothermal fluids exsolved from fertile and relatively oxidized subduction-related magmas in arc settings (Richards, 2003; Sillitoe, 2010). However, recently, a number of porphyry-type deposits have been recognized that formed in post-subduction and collisional settings. The origin of these deposits is under debate. The India-Asia continent–continent collisional orogen provides a unique opportunity to study the relationship between collisional tectonism, magmatism, and post-subduction porphyry deposits. The India-Asia collision was accompanied by voluminous but largely barren Paleocene–Eocene magmatism in southern Tibet (Mo et al., 2008). These magmatic rocks constitute a major part of the Gangdese magmatic belt, which extends for more than 1600 km E–W. Following this event, a large number of small-volume calc-alkaline to mildly alkaline granitoids and lavas intruded or erupted in the Gangdese belt between ~30 and 9 Ma, and are commonly associated with porphyry-type deposits (Hou et al., 2009). We propose that the controls on magma fertility reflect fundamental changes in tectonomagmatic processes in the Cenozoic.

2 Paleocene–Eocene

Paleocene–Eocene magmas throughout the Gangdese belt have continental arc features. They have intermediate La/Yb and intermediate-to-low Sr/Y ratios, negative Eu anomalies, and consist mainly of pyroxene and plagioclase (Wang et al., 2014a). These geochemical and mineralogical characteristics suggest that the Paleocene–Eocene magmas had relatively low water contents, and evolved primarily by fractionation of pyroxene and plagioclase. In addition, these magmas had relatively low oxidation states (ΔFMQ -1.2 to +0.8; Wang et al., 2014b). These characteristics may reflect the rollback and final dehydration of the remnant Neo-Tethyan slab, and are not conducive to the formation of magmatic-hydrothermal porphyry deposits; consequently, only three small porphyry Cu-Mo deposits are known to be associated with this suite.

3 Oligo-Miocene

The Oligo-Miocene igneous rocks show a sharp longitudinal distinction in petrography, magmatic geochemistry, and association with porphyry-type mineralization (Wang et al., 2014c). The eastern Gangdese group (east of ~89° E) is characterized mainly by intermediate–felsic calc-alkaline plutons, several of which are related to large porphyry Cu-Mo±Au deposits. These rocks have high La/Yb and Sr/Y ratios, weak or absent Eu anomalies, and amphibole is a common phenocryst phase (Wang et al., 2014a). The parental magmas were more hydrous and fractionated significant amounts of hornblende and lesser plagioclase prior to upper crustal emplacement. In addition, they were also significantly more oxidized than the earlier magmas (ΔFMQ+0.8 to +2.9; Wang et al., 2014b).

In contrast, the western group is characterized by alkaline volcanic rocks with relatively high Th and K_2O contents, low Sr/Y ratios, and low εNd_i values. Only one small Oligo-Miocene-age porphyry Cu deposit is known to the west of ~89°E.

4 Implications for Geodynamic Change and Metallogeny

We suggest that these temporal distinctions between magmatism and metallogenic potential reflect the tectonomagmatic evolution of the Cenozoic Gangdese

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collisional orogen, from early collisional magmatism in the Paleocene–Eocene, to late collisional magmatism in the Oligo-Miocene. The subduction-modified Tibetan lithosphere was partially melted by upwelling asthenosphere following Oligo-Miocene slab breakoff in the east, generating hydrous, oxidized magmas with the potential to form large porphyry deposits. In contrast, underthrusting of the Indian plate to the west in the Oligo-Miocene limited the involvement of asthenospheric melts and thus the extent of lithospheric partial melting. Consequently, few porphyry deposits are associated with these magmas.

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