Continental Collision Zones are Primary Sites of net Continental Crustal Growth: Evidence From the Linzizong Volcanic Succession in Southern Tibet

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The Linzizong volcanics (~ 65–45Ma) and the coeval batholiths (~ 60–40Ma) of granitoid composition (andesitic to rhyolitic *sensu lato*) are magmatic response to the India-Asia continental collision that began at ~ 70–65Ma and ended at ~ 45– 40Ma with convergence continuing to present [1,2]. These syncollisional magmatic rocks are widely distributed along much of the > 1500 km long Gangdese Belt immediately north of the India-Asia suture (Yarlung-Zangbo) in southern Tibet [2-6]. Our study of the Linzizong volcanics from the Linzhou Basin (near Lhasa) encourages the proposal that syncollisional granitoid magmatism may in fact account for much of the net contribution to continental crust growth. The Linzizong volcanics in the Linzhou Basin show a first-order temporal change from the andesitic lower Dianzhong Formation (64.4–60.6Ma), to the dacitic middle Nianbo Formation (~ 54Ma), and to the rhyolitic upper Pana Formation (48.7–43.9Ma). The three formations show no systematic but overlapping Nd-Sr isotope variations. The isotopically depleted samples with $Nd_{(t)} > 0$ (up to + 8) indicate that their primary sources are of mantle origin. The best source candidate in the broad context of Tethyan ocean closing and India-Asia collision is the remaining part of the Tethyan ocean crust [6]. This ocean crust melts when reaching its hydrous solidus during and soon after the collision in the amphibolite facies, producing andesitic melts parental to the Linzizong volcanics (also the coeval granitoids) with inherited mantle isotopic signatures [6]. Ilmenite is abundant in amphibolite [7], and partial melting of amphibolite with ilmenite as a residual phase accounts for the depletion of Nb, Ta and Ti in the melt. The effect of ocean crust alteration plus involvement of mature crustal materials (e.g., recycled terrigeneous sediments) enhances the elevated abundances of Ba, Rb, Th, U, K and Pb in the melt [8,9]. These give the syncolissional Linzizong volcanics characteristic “arc-like” geochemical signature. Residual amphibole that possesses super-chondritic Nb/Ta ratio explains the sub-chondritic Nb/Ta ratio in the melt, typical of continental crust [10]. These observations and reasoning plus the remarkable compositional similarity between the andesitic lower Dianzhong Formation and the model bulk continental crust [11] corroborates our proposal [6] that continental collision zones are sites of net crustal growth (juvenile crust) through process of syncollisional granitoid magmatism. While these interpretations are reasonable in terms of straightforward petrology, geochemistry and tectonics, they require further testing through detailed studies of samples with a greater spatial coverage along the entire Gangdese belt, which are currently underway.

References: [1] Yin & Harrison, *Ann. Rev. Earth Planet. Sci.*, *28*, 211-280, 2000; [2] Mo, Zhao, Deng *et al.*, *Earth Sci. Front.*, *10*, 135-148, 2003; [3] Mo, Dong, Zhao *et al.*, *Acta Geol. Sinica*, *79*, 66-76, 2005; [4] Mo, Zhao, Deng *et al.*, *Geol. Soc. Am. Spec. Pap.*, *409*, 507-530, 2006; [5] Mo, Hou, Niu *et al.*, *Lithos*, *96*, 225-242, 2007; [6] Mo, Niu, Dong *et al.*, *Chem. Geol.*, 2007 (submitted); [7] Niu & Lesher, *Econ. Geol.*, *86*, 983-1001, 1991; [8] Plank & Langmuir, *Chem. Geol.*, *145*, 325-394, 1998; [9] Elliot, *Geophys. Monogr.*, *138*, 23-46, 2003; [10] Foley, Tiepolo & Vannucci, *Nature*, *417*, 837-840, 2002; [11] Rudnick & Gao, *Treatise on Geochemistry*, *3*, 1-64, 2003.

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AB The Linzizong volcanics (ca. 65-45Ma) and the coeval batholiths (ca. 60-40Ma) of andesitic-to-rhyolitic composition are magmatic response to the India-Asia continental collision that began at ca. 70-65Ma and ended at ca. 45-40Ma with convergence continuing to present [1,2]. These syncollisional magmatic rocks are widely distributed along much of the >1500km long Gangdese Belt immediately north of the India-Asia suture (Yarlung-Zangbo) in southern Tibet [2-6]. Our study of the Linzizong volcanics from the Linzhou Basin (near Lhasa) encourages the proposal that syncollisional granitoid magmatism may in fact

account for much of the net contribution to continental crust growth. The Linzizong volcanics in the Linzhou Basin show a first-order temporal change from the lower andesitic formation (64.4-60.6Ma), to the middle dacitic formation (ca. 54Ma), and to the upper rhyolitic formation (48.7-43.9Ma). The three formations show no systematic but overlapping Nd-Sr isotope variations. The isotopically depleted samples with $\epsilon Nd(t)>0$ (up to + 8) indicate that their primary sources are of mantle origin. The best source candidate in the broad context of Tethyan ocean closing and India- Asia collision is the remaining part of the Tethyan ocean crust [6]. This ocean crust melts when reaching its hydrous solidus during and soon after the collision in the amphibolite facies, producing andesitic melts parental to the Linzizong volcanics (also the coeval batholiths) with inherited mantle isotopic signatures [6]. Ilmenite is abundant in amphibolite [7], and partial melting of amphibolite with ilmenite as a residual phase accounts for the depletion of Nb, Ta and Ti in the melt. The effect of ocean crust alteration plus involvement of mature crustal materials (e.g., recycled terrigeneous sediments) enhances the elevated abundances of Ba, Rb, Th, U, K and Pb in the melt [8,9]. These give the syncolissional Linzizong volcanics characteristic "arc-like" geochemical signature. Residual amphibole that possesses super-chondritic Nb/Ta ratio explains the sub-chondritic Nb/Ta ratio in the melt, typical of continental crust [10]. These observations and reasoning plus the remarkable compositional similarity between the lower andesitic formation and the model bulk continental crust [11] corroborates our proposal [6] that continental collision zones are sites of net crustal growth (juvenile crust) through process of syncollisional granitoid magmatism. While these interpretations are reasonable in terms of petrology, geochemistry and tectonics, they require further testing through detailed studies of samples with a greater spatial coverage along the entire Gangdese belt, which are currently underway. References: [1] Yin, Harrison, *Ann. Rev. Earth Planet. Sci., 28*, 211-280, 2000; [2] Mo *et al.*, *Earth Sci. Front., 10*, 135-148, 2003; [3] Mo *et al.*, *Acta Geol. Sinica, 79*, 66-76, 2005; [4] Mo *et al.*, *Geol. Soc. Am. Spec. Pap., 409*, 507-530, 2006; [5] Mo, Hou, Niu *et al.*, *Lithos, 96*, 225-242, 2007; [6] Mo, Niu, Dong *et al.*, *Chem. Geol.* (submitted); [7] Niu, Lesher, *Econ. Geol., 86*, 983-1001, 1991; [8] Plank, Langmuir, *Chem. Geol., 145*, 325-394, 1998; [9] Elliot, *Geophys. Monogr., 138*, 23-46, 2003; [10] Foley *et al.*, *Nature, 417*, 837- 840, 2002; [11] Rudnick & Gao, *Treatise on Geochemistry, 3*, 1-64, 2003.

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