PLUTONISM AND THE GROWTH OF ANDEAN CRUST IN CENTRAL PERU FROM 100 TO 3 MA

ATHERTON, Michael P. , Department of Earth Sciences, University of Liverpool, Liverpool, L69 7GP, UK.

Abstract

The growth of the continental crust is commonly thought to have been essentially complete by the end of the Precambrian, and the generation of 'new' (juvenile) crust in the Phanerozoic is considered small. Recent work in the Andes suggests that since the Permo-Triassic and specifically over the period 100 to 3 Ma the plutonic input has been dominantly juvenile and models involving an increasing deep crustal component into the continent reaching a maximum over the Andean Cordilleran crust (>70km thick) do not account for the systematic chemical and isotopic variation in magma composition. The data are consistent with melting of "new" basaltic crust in a shallow intraplate at the continental margin, and in increasingly deeper underplate inboard as the thick keel of the Andes evolved over the period 100-3 Ma. Recycling of old continental crust by partial melting at depth did not occur although there is minor high level contamination in some plutons in the southern segment of the Coastal Batholith.

Key words: Cordilleran Blanca Batholith, Coastal Batholith, Transverse Variations, Trondhjemite.

Introduction

The Andes have been considered to be the archetype of a mountain belt produced by subduction of oceanic crust beneath continental crust. In Peru magmatism is confined to belts parallel to the present trench and coast and from 100-3 Ma there was a migration of the plutonic locus with time towards the interior, with the youngest Batholith, the Cordillera Blanca, being emplaced at 10-3 Ma in the high Western Cordillera over the thick, Miocene crustal keel (60 km).

Such progressions are usually coupled with a change in composition considered to reflect thickening, reworking of old continental crust and uplift, which according to some authors reflects a fundamental plutonic cycle (e.g. Pitcher 1983). Thus the Mesozoic batholiths of western North America show an eastwards change in composition and isotopic signature related to the leading edge of the continental shield.

Here the transverse changes in chemistry of the plutonic rocks in the central Andes of Peru are described which are not consistent with generalised models but relate essentially to changes in depth of melting and source.

Geological setting

The Cordillera Blanca Batholith lies 300 km inboard of the Coastal Batholith and together they represent almost continuous plutonism over the period 100 to 3 Ma, apart from a gap between 36-13 Ma which is filled by minor intrusions lying between the two batholiths. Here we contrast the two batholiths and relate the differences to the evolution of the Andean margin over the period 100-3 Ma. Aspects of the geological setting are outlined below.

COASTAL BATHOLITH	CORDILLERA BLANCA BATHOLITH
Intruded – along the continental margin; with Andean trend;	Intruded – over the deep crustal keel (60 km) with Andean trend;
within the Albian marginal basin, + 10km deep, entirely volcanogenic in origin; along a major crustal lineament, 1600 km long;	within the axial zone of the Jurassic basin, containing mainly graphitic shales + sandstones, along a major, deep megafault + 400 km long;
within an extensional lineament, 100-37 Ma;	within a transtensional strike-slip pull apart, 12-3 Ma;
Uplift in U. Cretaceous and L. Tertiary	Uplift in Miocene.

Specifically, both batholiths were intruded into basinal systems related to continental margin extension which started in the Jurassic at least.

Both batholiths are calc-alkaline with tonalitic rocks dominating in the Coastal Batholith and granitic rocks with trondhjemitic character dominating the Cordillera Blanca Batholith (Atherton & Petford 1993). Variations in composition with distance from the present trench are given below.

West	East
Coastal Batholith	Cordillera Blanca Batholith

Increasing distance from present trench
No K/Si, Rb/Si, Th/Si, Ce/Si increase inboard

But increase in Na_2O*, Sr, Ta, A/CNK*,* Ce_N/Yb_N
and a subtle decrease in CaO, Th, Y, Ce.

The increase in peraluminosity is not related to an old crustal component in the source. Indeed there is no old crust beneath this sector of Peru (Atherton & Petford 1993). Rather it relates to late deformation associated with fluid infiltration and alkali loss (Petford & Atherton 1992).

Note the lack of an increase in K etc inboard, and the increase in Na_2O etc, which is contrary to the variation found in most arcs (Gill 1981), and is certainly inconsistent with an increasing old continental crust component into the continent.

Discussion: Basalt to Cordilleran Batholith

Transverse chemical and mineralogical variations in Peru do not conform to any of the simple models put forward for continental margins. Rather, variations in magma composition into the continent relate to shallow melting (<10km) of Albian basaltic crust to produce the Coastal Batholith (Atherton 1990) and deep melting (ca. 50 km) of the newly thickened basaltic keel of the Andes in the Miocene to produce the Cordillera Blanca Batholith (Atherton & Petford 1993). Coastal Batholith magmas are calc-alkali with compositions ultimately determined by slab enriched mantle mineralogies with residues of mainly olivine and pyroxene. In contrast the Na-rich magmas of the Cordillera Blanca Batholith are more alkalic and relate to garnet-hornblende residues in the source. Thus the latter are similar to adakite and Archean high Al-TTG (Atherton & Petford 1993). Similar Tertiary Na-rich magmatism in Chile and Ecuador indicate that this transverse variation is not unique to Peru. It is an Andean pattern occurring in thin and thick crust, where hydrous basalt is partially melted on extension. An estimate of the contribution of these plutonic rocks to the crust in a 90km segment of the Western Cordillera indicate batholith material makes up of 40% of the area or 2,585km^2. With a minimum average batholith thickness of 5km, this indicates 14,290km^3 of mantle derived batholithic material was intruded into the upper few kilometres of the crust in this segment (Atherton & Petford 1996).

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