Na-RICH IGNEOUS ROCKS AND CRUSTAL THICKENING IN THE ANDES

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Na-rich plutonic and volcanic rocks are not uncommon in the Andes. They vary in age from Lower Palaeozoic to Tertiary. The Na-rich volcanic rocks described so far include those in North Chile of Quaternary age (Feeley & Hacker, 1995), which overlie the thickest part of the crustal keel (>70km, Fig. 1). Compositionally similar rocks are also present in the Miocene/Quaternary volcanoes of Tupungato and Marmolejo, east of Santiago again over thick crust. Plutonic rocks with similar chemistry can be divided into two groups. The <u>first</u>, those in a similar setting to the volcanic rocks form Tertiary plutons (Eocene, Miocene and possibly Pliocene) which also lie along the spine of the Andes, where crustal thickness ≥50km (Fig.1). They include the Cordillera Blanca, Peru, El Abra, N. Chile and a series of small Tertiary plutons in Chile near the Chile/Argentina border which extend southwards to the latitude of Santiago at least.

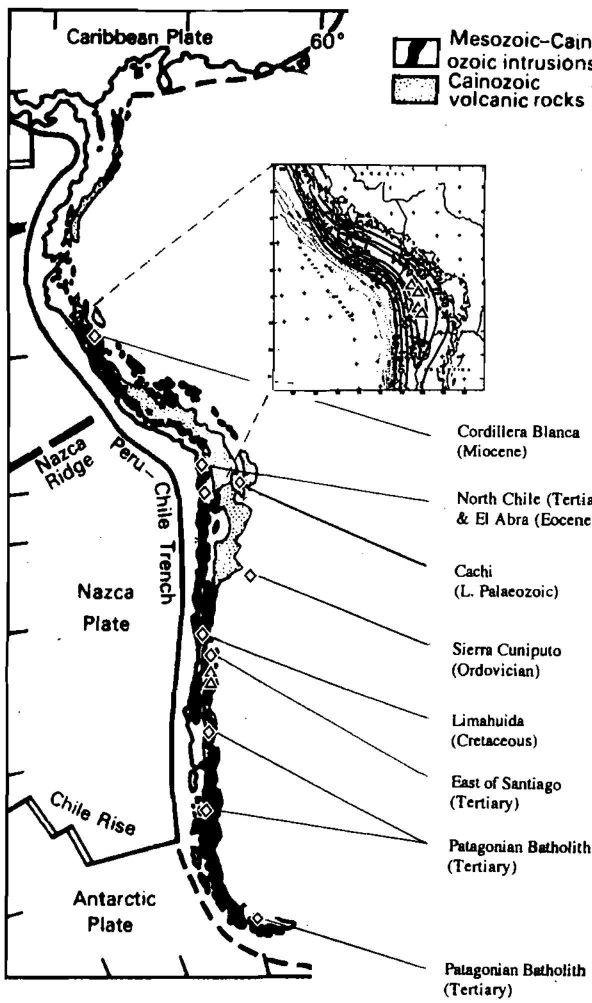

Fig. 1. Map of the Andes showing locations of Na-rich plutons (diamonds) and Quaternary volcanic rocks (triangles) in north Chile (inset) and east of Santiago.

The second group, with poorly understood geotectonic settings are of Ordovician to Tertiary age eg, Tertiary plutons in the Patagonian Batholith and Lower Palaeozoic plutons such as Cachi in Argentina Fig.1. This group intrudes crust where structure and history is unclear.

Rocks from these plutons and volcanoes have high $(La/Yb)_N$, Sr/Y ratios, high Na_2O contents and low Y and Yb values, compared to the more voluminous Cordilleran Batholithic plutons such as the Coastal Batholith, Peru (Fig.2 and Atherton & Petford, 1993).

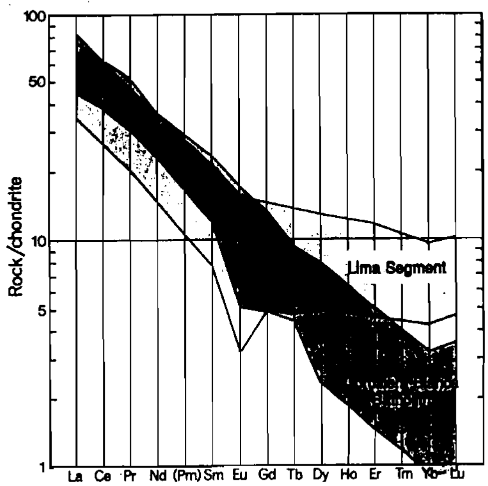

Fig. 2

Consideration of the Miocene Cordillera Blanca Batholith in north central Peru, for which we have considerable data and a good understanding of the crustal structure below the Batholith, indicates that together with the characteristics outlined above there is also a marked decrease in FeO, MgO, TiO_2 and CaO in the granites, compared to the more basic rocks. Furthermore the values are lower than rocks with similar SiO_2 contents (70-75%) from the Coastal Batholith (Fig.3), which were derived by shallow partial melting or high level fractional crystallization (Atherton, 1990). The 'dramatic' decrease in these elements and increase in SiO_2 in partial melts when garnet was stabilised at 12-18 kb was first described by Rushmer (1993) in experiments on melting hydrated basalt. Chemical modelling of the Cordillera Blanca rocks is compatible with this, with melts leaving residues of pyroxene + garnet ± hornblende ± plagioclase (Petford & Atherton, in press). Such residues are present in the experiments and are typically found in mafic lower crustal xenoliths (Rushmer, 1993).

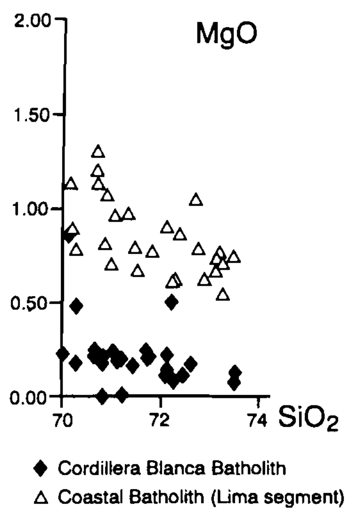

Fig. 3

Rocks similar in many respects to those described here ie, high $(La/Yb)_N$, Sr/Y ratios, high Na_2O contents and low Y, Yb values have been considered to characterise Archaean high grade gneiss terrains eg. TTG (Tonalite Trondhjemite Granodiorite) suites (Fig.4). A common interpretation of the data and thermal considerations suggest that they were melts of hydrated subducted ocean crust (see Atherton & Petford, 1993 for brief review). Indeed such a genesis is attractive considering the importance and longlife of subduction along the Andean margin. However it is clear the rocks of the Cordillera Blanca Batholith formed by melting of *thickened* crust as the slab is too old, cold and dehydrated to melt (Atherton & Petford, 1993). As the age of the batholith rocks youngs systematically with increasing acidity over the period 13-5 Ma the marked decrease in the major elements described above marks the incoming of garnet as a major component in the source mineralogy. This relates to the well documented Miocene thickening of the crust below the batholith.

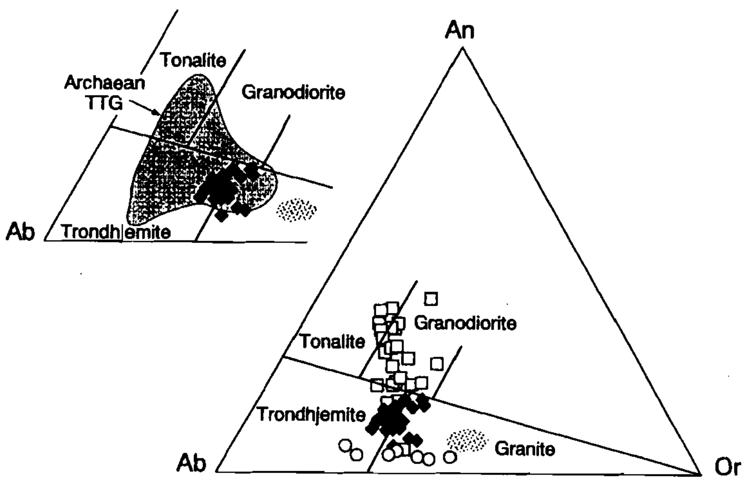

Fig. 4 An - Ab - Or diagram showing Cordillera Blanca tonalities + granodiorites (squares), leucogranodiorites (black diamonds) and pegmatites (circles), with the Coastal Batholith granite field (dotted) shown for comparison. In set shows Archaean TTG field with Cordillera Blanca leucogranodiorites.

The *thickened* crust melting model may, we think, be extended to the rest of the Na-rich rocks above the Andean keel (Group 1) reflecting the thickening of the Andean crust during the Tertiary. It may also relate to the second group of plutons, where information on crustal thickness is absent or where, in the case of the older plutons, it may have changed due to delamination or lower crustal erosion.

If this is the case, the intrusion/extrusion of these Na-rich rocks in the Andes marks periods of major crustal thickening and their absence periods of quiescence.

Finally, the presence in the Andes, of Na-rich rocks with a chemistry similar to Archaean, apparently slab derived melts, but here formed by lower crustal melting of hydrated basalt, suggests the origin of Archaean TTG rocks is still problematic.

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