6th International Symposium on Andean Geodynamics (ISAG 2005, Barcelona), Extended Abstracts: 821-823

INVITED TALK

The composition of the upper mantle beneath the Central Andean continental margin

Friedrich Lucassen [1] & Gerhard Franz [2]

[1] GeoForschungsZentrum Potsdam, Telegrafenberg, 14473 Potsdam, Germany; lucassen@gfz-potsdam.de
[2] Technische Universität Berlin, Petrologie-BH 1, Straße des 17.Juni 135, 10623 Berlin, Germany

During the Phanerozoic the Central Andes had a simple principal geotectonic setting with prolonged periods of subduction in the Early Palaeozoic and from latest Palaeozoic onwards and Cordilleran-type mountain building in the Early Palaeozoic and Cenozoic. No accretion of exotic material occurred at least since mid Palaeozoic or even earlier since Proterozoic considering the section north of the Argentine Precordillera as a non-collisional margin. The geotectonic scenario and the geological history determine possible compositional domains of the mantle along an E-W section (Fig. 1). Beneath the arc, convective mantle formed the different mantle wedges or occasional asthenosphere flare-ups (e.g., Salta Rift) behind the arc. The sub-arc non-convective lithospheric mantle comprises material of older 'frozen' mantle wedges or remnants of older sub-continental mantle lithosphere. Both could be variably alterated by material flux from ongoing subduction. The old lithospheric mantle below the Brazilian Shield could have contributed also to the margin's mantle during orogenies with substantial crustal shortening.

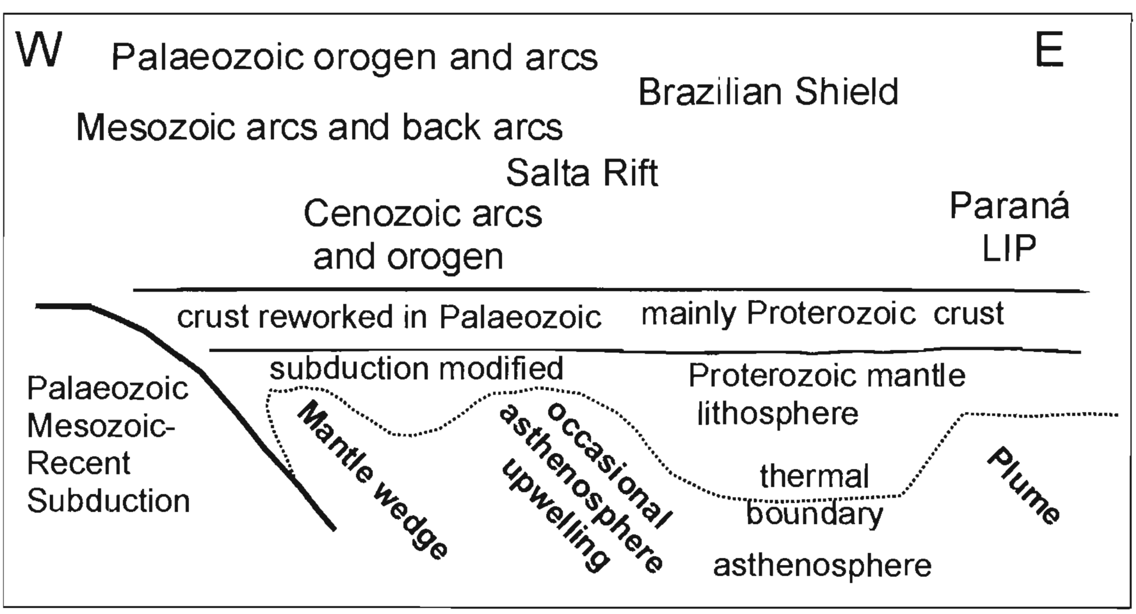

Figure 1: W-E cross section through the South American lithosphere at 26°S showing different mantle and crustal domains. Intraplate magmatism behind the arc occurred between late Palaeozoic and Cenozoic with a peak of activity in the Cretaceous, e.g. in the Salta Rift. It is most likely linked to occasional disturbance of the thermal boundary between lithosphere and asthenosphere rather than to substantial tectonic thinning of the whole lithosphere.

Mantle composition beneath the Central Andean margin and the compositional evolution of the mantle in response to the extended periods of subduction and mountain building along this margin from Early Palaeozoic onwards has not been assessed on large regional and time scales. This is certainly due to the fact that the active margin developed on continental crust which is made up mainly by Proterozoic material. Therefore, most Palaeozoic to Recent magmatic rocks of the arcs are hybrid in composition or even crustal melts. Mafic rocks with little or no crustal additions are the principal source of information about upper mantle composition, because mantle xenoliths are generally absent in the arc volcanism and tectonically exhumed sections of the upper sub-arc mantle are also missing at this non-collisional section of the margin. In the early Palaeozoic magmatic arc(s) mafic magmatic rocks are scarce and partly metamorphosed. Large volumes of arc-related mafic to intermediate rocks occur in the extensional arc(s) in the Coastal Cordillera of northern and central Chile (~18 - 34°S; mainly Jurassic to early Cretaceous), and in the geographically static arc of the main Cordillera of southern central Chile (~36 - 40°S; mainly Cretaceous to Recent). These rocks constrain, together with other hybrid magmatic rocks the composition of the early Palaeozoic and Mesozoic to Recent convective sub-arc mantle. Alkaline intraplate magmatism occurs along what is now the eastern plateau area or back-arc of the Central Andes (~17 - 34°S, e.g., Salta Rift, Fig. 1). The small volume basanite, alkali basalts, and alkaline intrusions have mainly Cretaceous ages but late Palaeozoic and Cenozoic ages have been also found. These rocks together with rare upper mantle xenoliths constrain the composition of the lithospheric mantle.

Key results are based on the comparison of radiogenic isotope composition (Sr, Nd, Pb).

- The composition of the Mesozoic to Recent sub-arc mantle is that of depleted mantle, but different from MORB mantle. The difference between MORB composition and arc magma composition is uniform for different rock types (plutonic, volcanic), different ages, and distant locations. Deviations from the 'most primitive' composition of the sub-arc mantle in the arc-magmas are completely explained by variable additions of the ambient old crust. Small systematic differences between the older rocks in the north (~24°-27°S for a reference section) and younger in the south (~36°-40° for a reference section) are largely caused by radiogenic growth of the respective Nd and Pb isotope ratios in the sub-arc mantle.
- Early Palaeozoic mafic rocks are from a depleted sub-arc mantle according to their Nd and Sr isotope composition.
- Early Palaeozoic mafic and hybrid magmatic rocks and Mesozoic to Recent mafic and hybrid magmatic rocks show the same mixing pattern between depleted mantle and ambient, regional old crust.
- The lithospheric mantle sampled by intraplate magmatism and upper mantle xenoliths is mainly depleted mantle. The composition of this mantle shows similar variations in magmatic rocks and xenoliths. Rare samples with radiogenic Sr isotope ratios or the common variations in $^{206}Pb/^{204}Pb$ isotope ratios at are explained by relative enrichment of Rb and U in the lithospheric mantle, which occurred already in the Palaeozoic. The enrichment was followed by radiogenic growth of respective isotopes during long-term separation from convection.
- In the arc-magmas possible contributions of the depleted lithospheric mantle are difficult to trace due to the similarity of convective and lithospheric sub-arc mantle.

• Compositionally very different old sub-continental mantle which is similar to that beneath the Brazilian Shield has been also sampled at few locations by the intraplate magmatism. Contributions of the old lithospheric mantle are not seen in the composition of the arc magmas.

The composition of the Mesozoic to Recent sub-arc mantle is uniform on the regional extension and the time scale of observation. We speculate that the compositional difference compared to a large convective reservoir such as MORB-type depleted mantle could be the effect of a long-time separation of the sub-arc mantle from such reservoirs and addition and homogenisation of crust derived material into the sub-arc mantle during prolonged phases of subduction in the Phanerozoic. This sub-arc mantle provided the dominant mantle source during Mesozoic to Recent and a similarly depleted composition of the sub-arc mantle is assumed as the source of juvenile magmas in the Early Palaeozoic magmatic arc.