Complete recycling of the magmatic arc in Chile (36°-39°S): Evidence from chemical and isotopic composition of (sub)recent trench sediments

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Introduction

Sediment cores and sedimentary rock dredge samples for this study have been collected during RV Sonne Cruise 161-5 from the Chile trench and the continental slope. Sample locations are north and south of the submarine cañon of the Bio-Bio River (Fig. 1). The sediments from the cores are from depths of 10 - 800 cm below the sediment surface, i.e. they comprise recent to subrecent sediments. The dredged sedimentary rocks from the slope are not completely solidified and probably also present subrecent deposits. Considering the present morphology of this section of the Central Andes, all sediments brought into the trench are from the arc and forearc. The aim of this study is to constrain the contribution of distinct continental sources to the trench and slope sediments.

The active continental margin of the southern Central Andes shows a clear age and compositional segmentation (ca 36-41°S; Fig.1). The present forearc region comprises an accretionary wedge, the Western Series, active in the late Paleozoic – Triassic (Duhart et al., 2001) with siliciclastic (meta) sedimentary rocks and variable amounts of mafic (meta) igneous rocks, Paleozoic siliciclastic (meta) sedimentary rocks of the Eastern Series, late Paleozoic granites (ca. 300 Ma) intruded into the Eastern Series, Triassic continental sediments and rare Triassic granite (ca. 220 Ma, for a recent review see Lucassen et al., 2004). The occurrence of late Paleozoic and Triassic granite and Devonian metamorphic rocks in and east of the present Cordillera (Fig. 1) indicates a coherent Paleozoic crust before the onset of the magmatism, which products dominate the present Cordillera. Magmatism is scarce in the Jurassic, but abundant in the Cretaceous and Cenozoic. Batholiths and volcanic rocks cover a broad compositional range (Fig.2). A basaltic andesite composition is common among the volcanic rocks and is most likely the average composition at the erosional level, although there is no estimate of the surface distribution of the different rock compositions. The Sr-Nd-Pb isotope composition of the Paleozoic – Triassic rocks is that of old continental crust (Fig. 3; Nd model ages in Fig. 1) and very different from the composition of most late Mesozoic and Cenozoic magmatic rocks, which resemble the composition of a depleted mantle source.

Chemical and isotopic composition of the trench sediments

Chemical and isotope composition of possible continental sediment sources had been studied previously (for a recent review of the composition of the Paleozoic to Cenozoic crust see Lucassen et al., 2004 and references therein). Major and trace elements and Sr, Nd and Pb isotope ratios (Fig. 2) of the trench sediments indicate the nearly exclusive sedimentation of material from the late Mesozoic - Present Andean magmatic arc of the Main Cordillera. The composition of the sediments is basaltic andesite to andesite (Fig. 2) and independent of their geographical position, north or south of the Bio Bio River (Fig. 1). The compositionally different mainly late Paleozoic to early Mesozoic rocks of the forearc (including the old accretionary wedge) contribute little material to the isotope composition of the trench and slope sediments and even the sensitive Pb isotope system preserved the distinct signature of the late Mesozoic-Cenozoic arc related rocks (Figs. 3, 4).

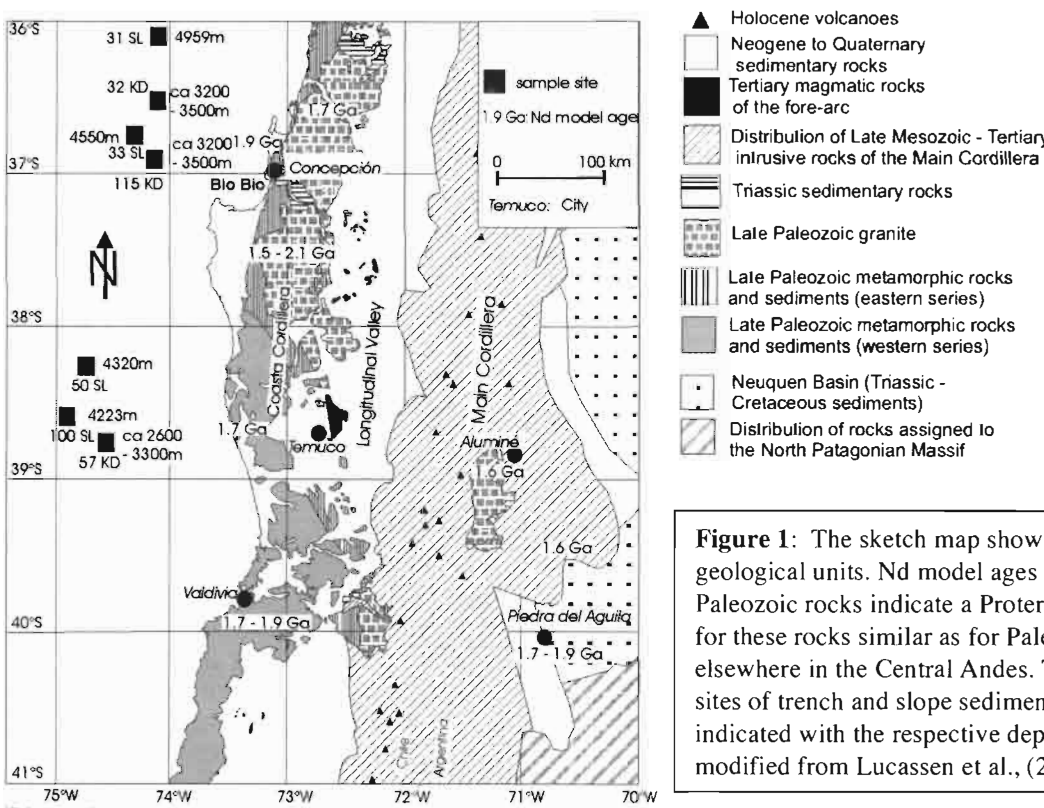

Figure 1: The sketch map shows the geological units. Nd model ages of the Paleozoic rocks indicate a Proterozoic protolith for these rocks similar as for Paleozoic rocks elsewhere in the Central Andes. The sample sites of trench and slope sediments are indicated with the respective depth. Map modified from Lucassen et al., (2004).

Discussion

Shallow late Paleozoic intrusions, the preservation of the late Paleozoic Triassic accretionary wedge and Triassic sedimentary rocks on late Paleozoic igneous and metasedimentary rocks and the lack of deeply eroded crust indicate the absence of substantial erosion since the Mesozoic. This is underlined by apatite fission track ages between ca. 65 - 53 Ma from the Coastal Cordillera, i.e. exhumation was less than 4 km since early Tertiary in the mainly Paleozoic forearc and most of it occurred before Miocene (Graefe et al. 2002). Many fission track ages in the main Cordillera are < 6 Ma and strong, young exhumation is inferred for this area (Graefe et al., 2002). There is strong evidence that near exclusive deposition of detritus from magmatic rocks of the active arc is a stable feature at a time-scale longer than that of sediment transport in the subduction channel down to the depth of fluid and melt generation and eclogite formation. Main inferences for geochemical and physical processes are:

(1) The compositionally nearly unchanged arc material is the major source of contamination in the mantle wedge. Recycling of subducted material into the mantle wedge estimated from the composition of magmatic rocks from the arc could be much more voluminous if the trench sediment composition is taken as the crust endmember instead of the composition of the Paleozoic local continental crust.

(2) Basaltic andesite to andesite compositions reach much higher densities during blueschist and eclogite metamorphism than the local granitic continental crust or quartz-rich sediments from this crust and could be easier subducted.

References

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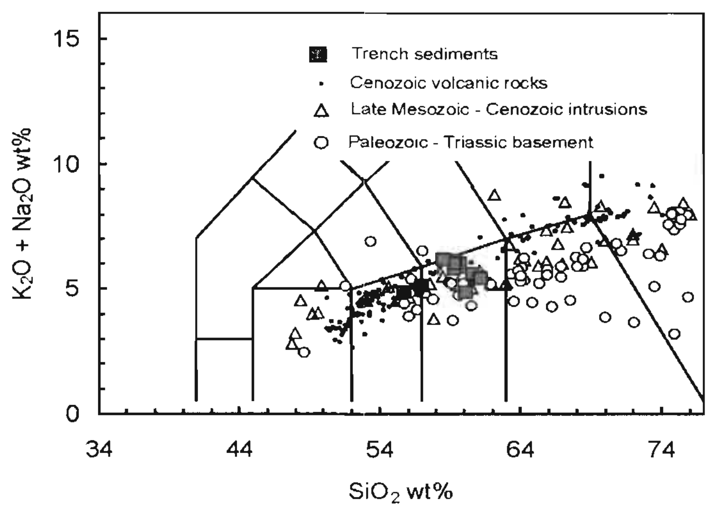

Figure 2: Composition of the trench sediments (recalculated to dry 100%) compared to the rocks from the Paleozoic - Triassic basement. The restricted basaltic andesite - andesite composition is typical for the magmatic arc.

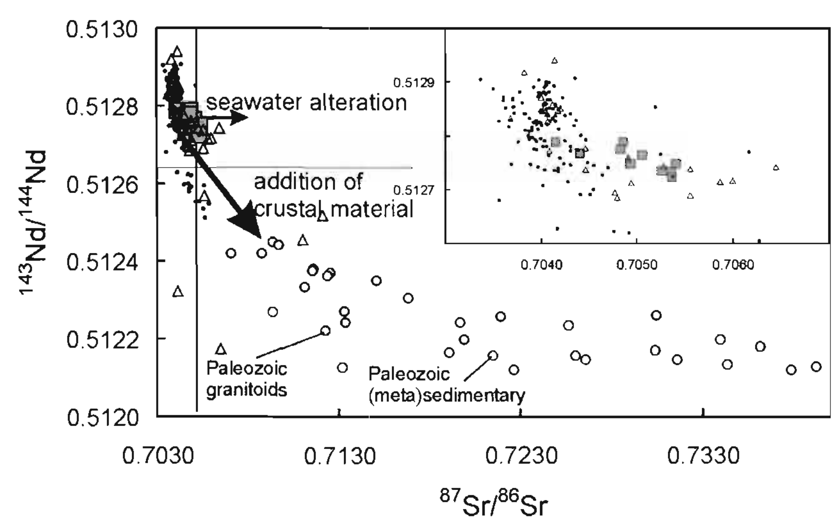

Figure 3: Sr and Nd isotope composition of the various source rocks and the trench sediments. Trench sediments show slightly less radiogenic Nd isotope ratios and slightly more radiogenic Sr isotope ratios compared to those of the volcanic rocks. Nd and Sr isotope ratios of the trench sediments are well correlated (inset). This suggests if the volcanic rocks are considered as one endmember mainly the addition of small amounts of Paleozoic material rather than effects of seawater alteration.

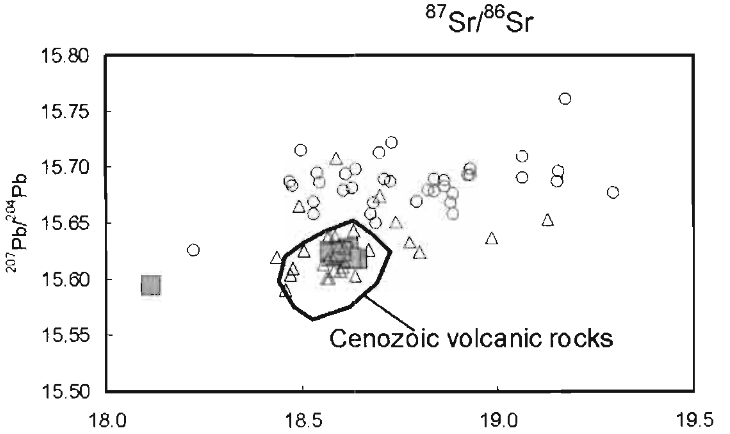

Figure 4: Uranogenic Pb isotope composition. The trench sediments and magmatic rocks show a similar composition, which is different from the composition of the Paleozoic-Triassic basement (circles), under lining the small amount of basement recycled by the sediments. Data base Figs 2, 3, 4: Lucassen et al. (2004) additional volcanic rocks 36 42°S from http://georoc.mpch-mainz. gwdg. de/ georoc/