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Deciphering the tectonic evolution of the Peruvian segment of the Gondwanan margin

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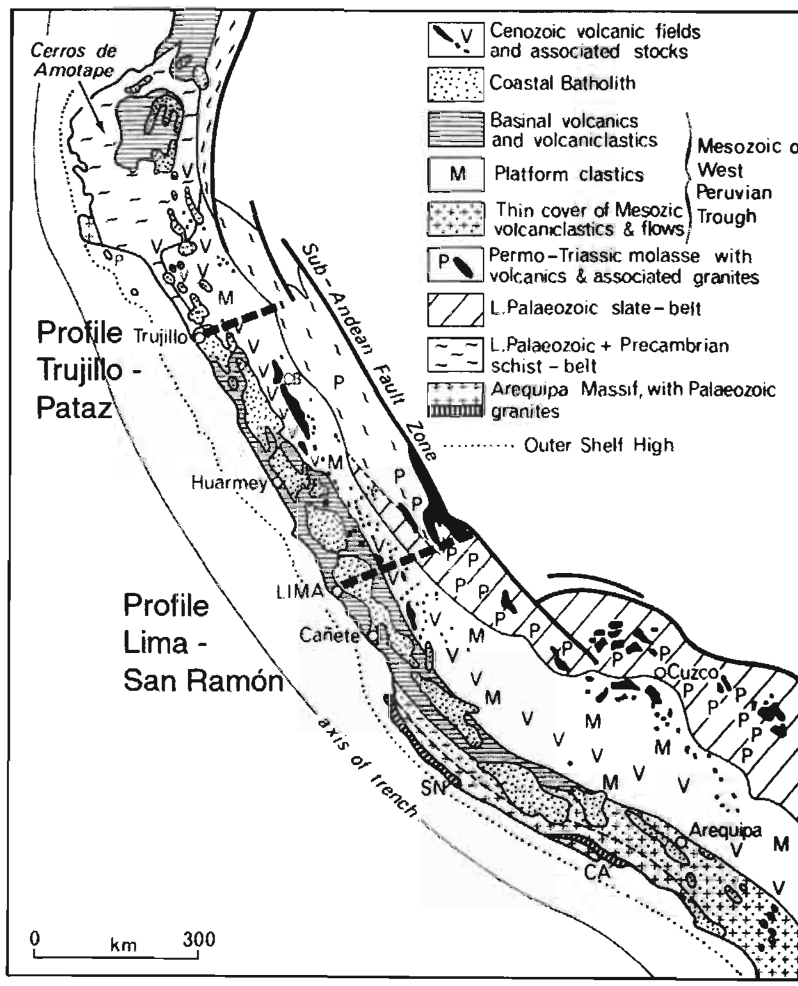
Introduction

Pre-Andean basement is only sporadically exposed along the western margin of South America, primarily due to the ubiquitous Cenozoic volcanism. It was recognized as a collage of old terranes and continental fragments, which have been partly identified and dated, principally in the northern Argentinean sector. Remnants of the Cambrian Brasiliano-Panafrican-Pampean as well as the Ordovician-Silurian Famatinian orogenies have been identified (Pankhurst and Rapela, 1998). These orogenies coincide with the collision of microcontinents with the S American mainland, such as the Pre-Cordilleran Terrane in Chile and Argentina or the Arequipa-Antofalla terrane in S Peru (e.g. Pankhurst and Rapela, 1998). The purpose of this study is to determine whether similar processes took place during the Palaeozoic along the Peruvian segment of the pre-Andean margin.



Sampling strategy

The data were collected from two sampling transects which were undertaken in Central and Northern Peru respectively. These two transects are superimposed on a geological map of Peru in Figure 1. Both transects run from the present coastline through the Western and Eastern Cordilleras, and were undertaken with the aim of characterising the basement to each cordillera. As the basement to the Western Cordillera is not exposed, we use magmatic rocks to probe the lithosphere and to ascertain the nature of underlying crust and mantle, by employing a combination of Sr, Nd, Hf and Pb isotopes. A similar approach has also been performed in the Eastern Cordillera, but in addition we are also able to directly sample rocks (high grade metasediments) that clearly represent pre-Andean basement.

Results

Geochemical and isotopic data from the first sampling transect (Lima to San Ramón, Figure 1) indicate that the Eastern Cordillera is underlain by old continental crust while the Western Cordillera and the Cretaceous Coastal Batholith are built upon young and juvenile arc crust. For the Western Cordillera, initial $^{87}Sr/^{86}Sr$ and epsilon Nd values are in the range of 0.703-0.704 and +2 to +7, respectively, whereas the eastern Cordillera basement has Sr isotopic values as high as 0.716 and epsilon Nd values as low as –7. The Sr, Nd isotopic data are in perfect agreement with initial Hf isotopic compositions of dated zircon crystals, ranging around +5 to +9 in the Western Cordillera, and at around 0 to –10 in the eastern Cordillera. The Western Cordillera basement is composed of juvenile material derived from underplated oceanic crust and/or accreted arc material, forming the source for calc-alkaline plutonism and magmatism between 120 and 50 Ma ago (see, e.g. Polliand et al., 2005). The absence of old continental crust underneath the Western Cordillera is tentatively interpreted to be the result of the rifting-off of an Arequipa-type terrane during a Mesozoic (possibly Triassic?) rifting period.

Evolution of the Eastern Cordillera

The basement to the Eastern Cordillera of Peru is exposed as a series of inliers beneath the intensely deformed Mesozoic - Early Cenozoic sedimentary cover. It consists of a series of high-grade metasediments of possible Late Neoproterozoic to Lower Palaeozoic age, which are cut by a variety of intrusives of hitherto uncertain age. It is presumed that the basement to the Eastern Cordillera represents the former continental margin of Gondwana, but currently the tectonic setting of this margin and the possible existence of separate terranes remains speculative. Through detailed U-Pb dating, utilizing both high-precision and in-situ techniques, we can decipher several orogenic and magmatic stages of the E Cordillera evolution:

Pre-existing Constraints

In particular, although the presence of high-grade metamorphism in craton-derived metasediments (former passive margin of Gondwana?) has long been recognized in Peru (e.g. Dalmayrac 1980), the timing of this orogenic event remains very poorly constrained. There are three existing age constraints: i) sediments resting unconformably on the high-grade metamorphics have yielded Middle Ordovician graptolites. ii) The Pacococha Adamellite east of Junín is thought to be the oldest post-tectonic intrusive in Central Peru on structural grounds (Mégard, 1978). However, the sole age constraint on this pluton is a K-Ar biotite age of 360 Ma, which it is felt may reflect later resetting by tectonism and / or magmatism. iii) granulites in the high-grade metamorphics have yielded discordant U-Pb zircon ages on bulk zircon fractions, with lower intercepts at 630 – 610 Ma that are probably without geological significance as they are likely to containing a mixture of inherited components of different ages (Dalmayrac *et al.*, 1980).

Metamorphism

Work is currently in progress to assess the timing and PT conditions of orogeny in the Eastern Cordillera. Discordant ID-TIMS U-Pb results in gneisses and syn- and post-tectonic S-type granites converge to a poorly defined Early Paleozoic age at around 400-500 Ma for high-grade metamorphism and anatexis.

Ar-Ar thermochronology on mica and hornblende and microprobe work is currently being pursued in order to reconstruct P-T-t paths for the Eastern Cordillera. Thermobarometric data from interleaved metagranitic and metabasaltic rocks in the northern portion of the Eastern Cordillera (northern transect, Figure 1) both yield PT estimates of ~ 700° C, 12 kb, while metapelites in the central part of the Eastern Cordillera (southern transect, Figure 1) yield a PT of ~ 600° C, 10 kb. Foliation-defining muscovite from this same metapelitic sample has yielded a ^{40}Ar-^{39}Ar plateau of 204 ± 1 Ma. This young age is attributed to probable thermal resetting by later magmatic pulses, and demonstrates that isotopic dating of mineral systems with significantly higher closure temperatures will be required in order to establish the age of metamorphism in the Eastern Cordillera. This is currently being pursued by Sm-Nd and Lu-Hf dating of metamorphic garnet. Future work will also include ICPMS U-Pb dating of detrital zircons in the metasediments in order to characterize the source area of the metasediments of the Eastern Cordillera.

Magmatism

Preliminary U-Pb ID-TIMS zircon ages from a variety of magmatic rocks from the Eastern Cordillera of Central and Northern Peru suggest a polyepisodic evolution with crust-forming events at 480-440, 330-305, and 240-230 Ma. These ages were obtained on calc-alkaline and S-type granitoid intrusions and high-grade gneisses along the La Oroya – Tarma – San Ramón transect, a granite to the east of Laguna de Junín and on granitic gneisses and the calc-alkaline Pataz Batholith in the northern part of Peru (La Libertad). The involvement of Proterozoic crust is demonstrated by inherited zircon cores pointing to upper intercept ages of 1.3 Ga.

Conclusions

From the present data we tentatively conclude that the Eastern Cordillera represent part of the active continental margin of Gondwana, which underwent (multiple episodes?) of Palaeozoic collisional tectonics during terrane accretion, and possibly rifting and departure of a continental domain during the Triassic. Magmatic pulses in the Eastern Cordillera have been dated at 480-440, 330-305 and 240-230 Ma. Juvenile oceanic material and possibly oceanic arc material was accreted during the Jurassic and Cretaceous, forming the Western Cordillera basement. This basement composes at least partially the source of the voluminous Cretaceous magmatism of Coastal Batholith and coeval volcanism in the Western Peruvian Trough.

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