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U-Pb geochronologic evidence for the Neoproterozoic – Palaeozoic evolution of the Gondwanan margin of the North-Central Andes

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Introduction

The Neoproterozoic – Early Paleozoic evolution of the Gondwanan margin of the north-central Andes has been investigated by a U-Pb zircon geochronology study. The investigated samples comprise Palaeozoic rocks of the Eastern Cordilleras of Peru and Ecuador (Fig. 1) and Neoproterozoic glacial sequences which overlie Precambrian basement gneisses of the Arequipa massif in southern Peru (Fig. 2). LA-ICPMS and ion microprobe analysis of detrital zircon has been integrated with dating of syn- and post-tectonic Palaeozoic intrusives by TIMS and ion microprobe.

Neoproterozoic sequences - detrital zircon data

Detrital zircon populations in cover sequences overlying the Arequipa massif basement (an exotic crustal block to Amazonia) are likely derived from the proto-Andean margin. These cover sequences (the Chiquerío and San Juan formations in southern Peru) record the only documented Neoproterozoic glacial episode in the Andean belt. The Chiquerío Formation yields U-Pb detrital zircon ion microprobe data with a restricted age distribution of 950-1300 Ma. Turbiditic dolomitic sandstones in the overlying San Juan Formation yield a similar 950-1300 Ma peak, but also contain grains dated as 1600-2000 Ma and 700-820 Ma (Chew *et al*., 2007a). Based on the presence of a cap carbonate and two negative C isotope excursions the Chiquerío and San Juan formations probably represent a Sturtian–Marinoan couplet (c. 750 – 635 Ma). The strong link between the Arequipa massif cover sequences and the proto-Andean margin during the Late Neoproterozoic rules out accretion of the Arequipa massif during the early Paleozoic Pampean and Famatinian orogenies, and strongly implies accretion to Amazonia during the 1000–1300 Ma Grenville–Sunsas orogeny (Chew *et al*., 2007a; *cf* Loewy *et al*., 2004).

Palaeozoic sequences – detrital zircon data

In the Palaeozoic metamorphic belts of the Eastern Cordilleras of Peru and Ecuador, the majority of detrital zircon samples exhibit prominent peaks in the ranges 0.45 - 0.65 Ga and 0.9 - 1.3 Ga, with minimal older detritus from the Amazonian craton. The detrital zircon data demonstrate that the basement to the western Gondwanan margin was likely composed of a metamorphic belt of Grenvillian (0.9 – 1.3 Ga) age, upon which an Early Paleozoic magmatic belt (0.45 – 0.5 Ga) developed in a similar way to the Sierra Pampeanas and Famatina in northern Argentina (Chew *et al*., 2007b). These two orogenic belts are interpreted to be either

buried underneath the present-day Andean chain or adjacent foreland sediments. However the source for detritus in the 0.55 – 0.65 Ga age range, broadly age-equivalent to the Brasiliano/Pan-African Orogeny in eastern Amazonia, remains puzzling.

Evidence for a Neoproterozoic active margin in the detrital zircon data?

No obvious source for 0.55 – 0.65 Ga detritus is known in the northern and central Andes. Derivation from eastern Amazonia is considered unlikely due to the stark paucity of detritus derived from the core of the Amazonian craton. Instead, we propose that a Late Neoproterozoic magmatic belt is buried beneath the present-day Andean belt or Amazon Basin, and was probably covered during the Eocene – Oligocene. If this inferred Neoproterozoic belt was an active margin, it would record the initiation of Proto-Andean subduction and imply at least partial separation of West Gondwana from its conjugate rift margin of eastern Laurentia prior to ca. 650 Ma. This separation may be linked to the ca. 770 – 680 Ma A-type magmatism found on eastern Laurentia in the southern Appalachians (e.g. Tollo *et al.*, 2004) and on the Proto-Andean margin in the Sierra Pampeanas (Baldo *et al.*, 2006) and in the Eastern Cordillera of Peru.

U-Pb dating of syn- and post-tectonic Palaeozoic intrusives and discussion

Plutons associated with the Early Paleozoic subduction-related magmatic belt have been identified in the Eastern Cordillera of Peru, and have been dated by U-Pb zircon TIMS and ion microprobe to 474 – 442 Ma (Chew *et al.*, 2007b). This is in close agreement with the ages of subduction-related magmatism in the Arequipa – Antofalla Basement (e.g. Loewy *et al.*, 2004). This Early Paleozoic arc is clearly not linear as it jumps from a coastal location in the Arequipa – Antofalla Basement to several hundred kilometers inland in the Eastern Cordillera further to the north. This is interpreted as an embayment on the Proto-Andean margin at the time the arc was initiated; if this is the case the northern termination of the Arequipa-Antofalla Basement in the vicinity of Lima is an Ordovician or older feature.

The arc magmatism pre- and post dates phases of regional metamorphism in the Eastern Cordillera of Peru. U-Pb zircon ion microprobe dating of zircon overgrowths in high-grade leucosomes demonstrates the presence of a metamorphic event at c. 478 Ma, and refutes the previously-assumed Neoproterozoic age for orogeny in the Peruvian Eastern Cordillera (Chew *et al.*, 2007b; Cardona 2006). The presence of an Early – Middle Ordovician age magmatic and metamorphic belt in the north-central Andes demonstrates that Famatinian metamorphism and subduction-related magmatism was continuous from Patagonia (Pankhurst *et al.*, 2006) through northern Argentina and Chile to as far north as Colombia and Venezuela, a distance of nearly seven thousand kilometres. The presence of an extremely long Early – Middle Ordovician active margin on western Gondwana invites comparison with the Taconic – Grampian orogenic cycle of the eastern Laurentia margin (which is of similar age and strike length) and supports models which have these two active margins facing each other during the Ordovician.

U-Pb zircon ion microprobe dating of zircon overgrowths in migmatites yields ages of c. 312 Ma, and represent a previously unreported high-grade Gondwanide event which has affected the Peruvian segment of the Proto-Andean margin. The original relationship between the Carboniferous and Ordovician metamorphic belts is uncertain as it has been affected by later Andean (Eocene – Oligocene) thrusting, but overall the pattern of

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crustal growth in the north-central Andes implies that it was dominated by a series of progressive crustal accretion events, which results in a series of age domains that young away from an old Amazonian core (Chew *et al.*, 2007b).

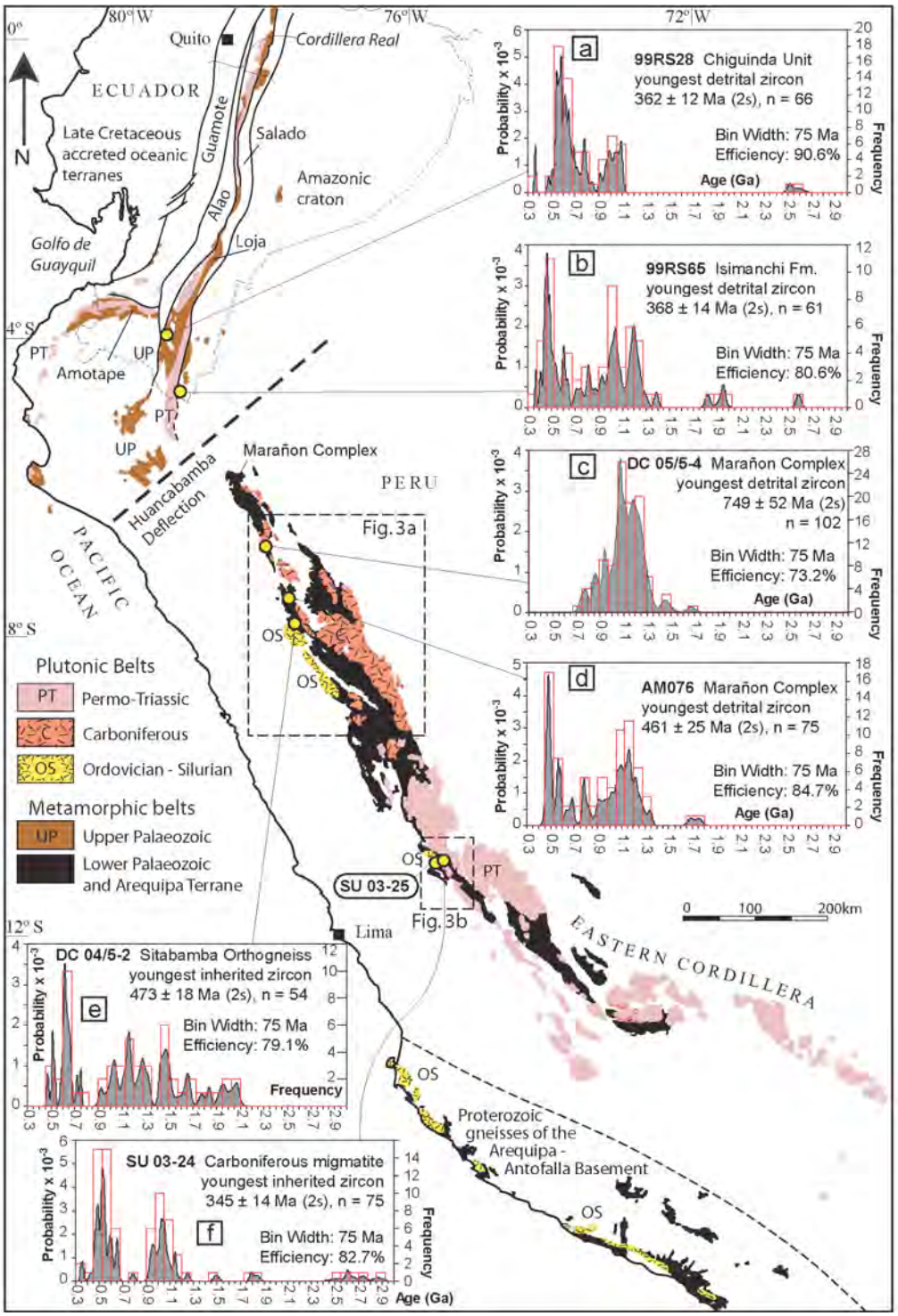

Figure 1. Geological map of Peru and Ecuador from Chew *et al.* (2007b) illustrating the major Palaeozoic metamorphic and magmatic belts along with the Proterozoic gneisses of the Arequipa massif. Inset figures a-f illustrate zircon probability density distribution diagrams for both metasedimentary and magmatic (inherited cores) samples.

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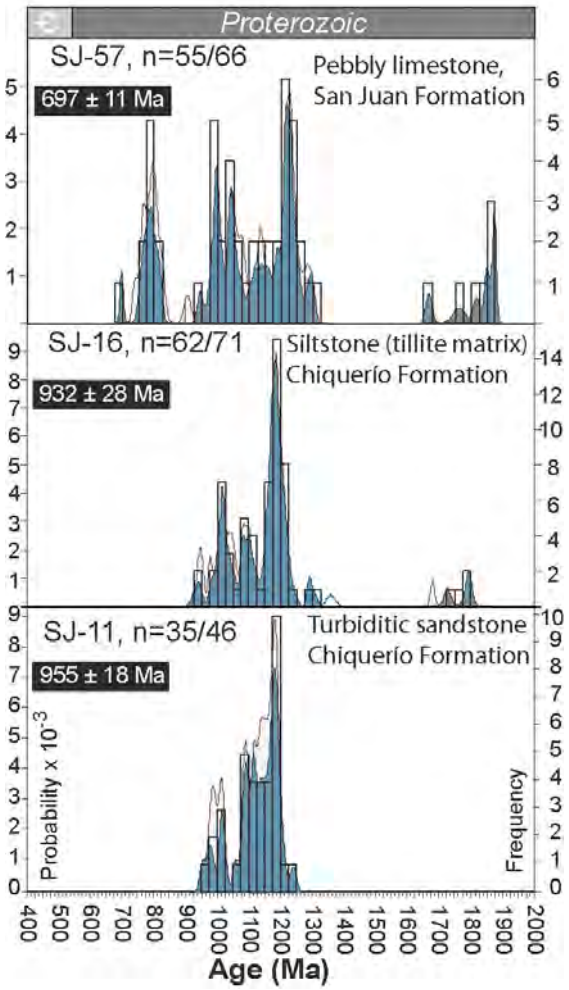

Figure 2. Zircon probability density distribution diagrams from the Chiquerío Formation (SJ-11, SJ-16) and the San Juan Formation (SJ-57) (Chew *et al*., 2007a).

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