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Provenance, chronostratigraphic framework and volcanosedimentary facies architecture of the permotriassic Mitu Group in Southern Peru, Central Andes

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ABSTRACT

The Permian-Triassic stratigraphic record in the Peruvian Andes is represented by continental basin fills that consist of poorly controlled volcanosedimentary successions known as the Mitu Group and equivalents. The Permian-Triassic time interval is marked by the developments of extensional basins, presumably associated to a back-arc or rift setting, along the southwestern margin of Gondwana. In previous studies, the Upper Permian part of the Mitu Group in Cusco region has been considered to overlie the limestones and subordinate sandstones of the Lower Permian Copacabana Group above a hiatus. However, our results using LA-ICP-MS dating of detrital zircons indicate the absence of significant hiatus in a portion of Cusco region, exhibiting an environmental transition from marine to continental conditions during Middle to Upper Permian between Copacabana and Mitu Group respectively. Additionally, four pyroclastic flow deposits ranging from c. 260 Ma to c. 223 Ma indicate that volcanic events in the Mitu basins took place from Upper Permian to Upper Triassic. For this study, detailed facies analysis and sample acquisition were obtained from four stratigraphic sections from southeastern Peru in Pisac (Umachurco and Pallpa-Oqoruro sections), Sicuani (Ocobamba section) and Abancay (Cachora Alta section). This study provides a first contribution to an improved understanding of volcanosedimentary facies assemblages, sedimentary basin environments, provenance and timespan of basin fillings, as well as magmatic and tectonic evolution that took place in the southern part of the Mitu basin.

Keywords: Mitu Group, provenance of detrital zircons, volcanosedimentary facies, Permotriassic basin.

INTRODUCTION

The transition from the Late Paleozoic magmatic arc regime of western South America to the Andean accretionary orogen initiated in the Early Jurassic is marked in Peru and northern Chile by the development of a system of extensional basins in the course of the Permian and Triassic. Although important records of the magmatic and sedimentary activity are present along the southwestern margin of Gondwana during the Late Paleozoic (Kontak et al., 1990; Bahlburg and Breitkreuz, 1991; López-Gamundí and Breitkreuz, 1997; Llambías, 1999; Cenki et al, 2000; Sempere et al., 2002; Reitsma, et al., 2010; Panca and Breitkreuz, 2011; Perez et al., 2016; Spikings et al., 2016; Boekhout et al., 2018; and others), it is still undecided whether extensional tectonics occurred in a back-arc or a rift setting.

The Permian-Triassic Mitu Group is a widespread stratigraphical and structural element in the evolution of the Peruvian Andes (Mégard, 1978; Laubacher, 1978; Noble et al., 1978; Kontak et al., 1985; Jacay et al., 1999; Sempere et al., 2002; Boekhout et al., 2018). The sedimentary record of the Mitu Group represents a chain of pre.Andean to early Andean extensional basins that underwent complex inversion tectonics during the Andean orogeny from the Early Cretaceous to Cenozoic. In particular, competent blocks, composed of volcanosedimentary successions and faults formed during the Mitu basins evolution, have strongly influenced the tectonic architecture of the Andean orogeny in Peru.

The development of models of the basin evolution of the Mitu Group and its tectonic overprint are complicated by a number of issues. The most important points are insufficient knowledge on volcanosedimentary facies, uncertain definition of depositional environments, lack of biostratigraphic and chronostratigraphic constraints as well as scarcity of data on the temporal and geochemical variations reflected by the volcanosedimentary successions.

Of the different Mitu sub-basins, the segment between Abancay and Cusco regions, located in the Eastern Cordillera of southern Peru, is well suited for a comprehensive study. Here, the stratigraphic record is varied including continental mass-flow and fluvial environments as well as numerous intercalations of alkaline basaltic-andesitic lava flows and felsic pyroclastic flow deposits. In particular, silica-rich pyroclastic layers are widespread along the Eastern Cordillera and serve as excellent marker beds for understanding the tectonostratigraphic history of the Mitu basins system. U-Pb isotopic ages obtained on a rhyolitic lava flow at the base of a Mitu section near Sicuani gave concordia ages of ~234 Ma. Ages on detrital zircons of a sandstone near Abancay point to a maximum depositional age of ~225 Ma (Reitsma et al., 2010; Reitsma 2012). Concordant zircon U-Pb ages of lavas and tuffs, combined with ages from detrital zircons in sandstones constrained the ages of the Mitu Group from ~245 to ~220 Ma (Spikings et al., 2016). These results were taken to suggest that the beginning of the Mitu sedimentation might have occurred during the Middle Triassic (Reitsma et al., 2010; Reitsma 2012; Spikings et al., 2016) and not during the Upper Permian as previously assumed (Marocco, 1974). However, the present study demonstrates that the Mitu sedimentation began in the Guadalupian (upper Permian).

METHODOLOGY

In this study we present first results of our analysis of the facies evolution and provenance of the Upper Permian and Upper Triassic basins fills in southern Peru. Our study aims at constraining the sedimentology, chronology, spatial development and tectonic setting of evolving depocenters. This study covers field and analytical techniques including single grain geochemical analysis of heavy minerals, whole rock and trace element analysis, U-Pb geochronology of detrital zircons and rutile, and Lu-Hf isotope analysis of dated zircons.

FACIES ANALYSIS OF THE MITU BASIN

Based on facies development, external and internal geometries, and bounding surfaces, several depositional elements have been identified including intermediate lava flows, pyroclastic flow deposits, volcanoclastic deposits, clast supported sheet conglomerate, clast supported massive conglomerate, class supported horizontally stratified conglomerate, coarse lithic pebbly sandstone, massive sandstone, cross bedded sandstone, horizontally bedded sandstone, trough cross bedded coarse grained sandstone, massive muddy siltstone, laminated siltstone, laminated silty mudstone and silty calcareous sandstone.

Our fieldwork in the Pisac area (Pallpa-Oqoruro and Umachurco sections) showed that deposition of the Mitu Group and equivalents was initiated by a transition from the carbonates of the Copacabana Group via a mixed carbonate-siliciclastic interval of c. 30 m thickness to the siliciclastic and volcanic Mitu Group. The latter is characterized by widespread alkaline and calc-alkaline volcanic rocks interbedded with thick continental successions deposited in fluvial and alluvial environments. The beginning of Mitu sedimentation in the Cusco region is characterized by short-lived intermediate and felsic volcanism interbedded with fluvial deposits, followed by an extended development of floodplain facies and a lack of volcanism. This transits to a coarsening-upward evolution of fluvial facies associated with increasingly voluminous intermediate volcanic rocks. Increased rates of deposition and volcanism took place in semi-grabens accommodating alluvial fans at the top of the Mitu Group.

ANALYTICAL RESULTS AND CONCLUSIONS

We constrain the provenance and geochronology of the depositional record by single-grain studies of heavy minerals and LA-ICP-MS dating of detrital zircon and rutile. Here we present first detrital zircon age dates of key strata at the transition to and at the base of the Mitu succession. Two calcareous sandstones from the top of Copacabana Group gave a maximum depositional age of 262.6 ± 1.5 Ma (Umachurco section) and 262.5 ± 1.4 Ma (Pallpa-Oqoruro section, POS; upper Guadalupian, Permian) respectively. These sandstones are within 2 m of the basal contact of the Mitu succession. The stratigraphically oldest sample of the Mitu Group from 1 m above its base yielded a maximum depositional age of 260.1 ± 3.7 Ma (POS) and a second one from 3 m above yielded a maximum depositional age of 261.4 ± 1.2 Ma (POS).

In the Cachora Alta Section (Abancay), maximum depositional ages indicate that the timespan of Mitu sedimentation developed here from 236.85 ± 0.74 Ma to 224.10 ± 1.5 Ma (Middle to Upper Triassic). A calcareous sandstone from the Tarma Group located 2 m below the basal erosional contact of the Mitu succession gave a maximum depositional age of 287.3 ± 6.7 Ma (Lower Permian) in the Ocobamba section in Sicuani. The oldest detrital zircons in Sicuani from 1 m above its base yielded a maximum depositional age 246.9 ± 1.5 Ma (Lower to Middle Triassic). However, volcanic zircons from an eutaxitic crystal-rich ignimbrite at the base of the Mitu section at the easternmost part of Sicuani yields a concordia age of 252.9 ± 1.3 Ma, indicating that the Mitu basin filling began still during the upper Permian.

Concordia ages on volcanic zircons from crystal-rich ignimbrites exhibit consistent ages for establishing, at least, 4 volcanic episodes during the development of the southern Mitu basin ranging from 260.2 ± 1.9 Ma (POS; Guadalupian to Lopingian, Permian) to 223.0 ± 2.0 Ma (Ocobamba section, Upper Triassic).

The preliminary ages obtained in the Pisac area (POS and Umachurco sections) are similar within error and pertain to the upper Permian. The outcrop evidence and these dates indicate a transition from the Copacabana Formation to the Mitu deposits in this region. The beginning of the Mitu sedimentation appears to be characterized by temporally variable initiation of basin filling and subsequent asynchronous development of the semi-graben depocenters. A sandstone at the top of the Mitu succession at Pallpa-Oqoruro with a maximum depositional age of 197.5 ± 2.7 Ma indicates that Mitu sedimentation may have persisted in southern Peru until the Early Jurassic.

REFERENCES

Bahlburg, H., Breitkreuz, C., 1991. Paleozoic evolution of active margin basins in the southern Central Andes (northwestern Argentina and northern Chile). Journal of South American Earth Sciences,v. 4, 171-188.

Boekhout, F., Reitsma, M., Spikings, R., Rodriguez, R., Ulianov, A., Gerdes, A., Schaltegger, U., 2018. New age constrains on the palaeoenvironmental evolution of the late Paleozoic backarc basin along the western Gondwana margin of southern Peru. Journal of South American Earth Sciences, v.82, 165-180.

Cenki, B., Jaillard, E., Carlotto, V., 2000. Estudio Petrográfico–Geoquímico del vulcanismo Pre–Huancané de la región de Cusco–Sicuani (Sur del Perú): Interpretación Geodinámica. Boletín de la Sociedad Geológica del Perú, v. 89, 45-56.

Jacay, J., Sempere, T., Carlier, G., Carlotto, V., 1999. Late Paleozoic–Early Mesozoic plutonism and related rifting in the Eastern Cordillera of Peru. IV International Symposium on Andean Geodynamics, Göttingen, 358-363.

Kontak, D.J., Clark, A.H., Farrar, E., Strong, D.F., 1985. The rift associated Permo–Triassic magmatism of the Eastern Cordillera: a precursor to the Andean orogeny. In: Pitcher, W.S., Atherton, M.P., Cobbing, J., and Beckinsale R.D. (Eds.), Magmatism at a plate edge: The Peruvian Andes. Blackie, Glasgow, and Halsted Press, New York, 36-44.

Kontak, D.J., Clark, A.H., Farrar, E., Archibald, D.A., and Baadsgaard, H., 1990, Late Paleozoic-early Mesozoic magmatism in the Cordillera de Carabaya, Puno, southeastern Peru: Geochronology and petrochemistry: Journal of South American Earth Sciences, v. 3, p. 213-230.

Llambías, E.J., 1999. Las rocas ígneas gondwánicas. El magmatismo gondwánico durante el Paleozoico Superior-Triásico. In: Caminos, R. (Ed.) Geología Argentina. Instituto de Geología y Recursos Minerales, Anales 29, 349-363.

Laubacher, G., 1978. Géologie de la Cordillère Orientale et de l'Altiplano au nord et nord–oust du lac Titicaca (Pérou). Travaux et Documents de l'ORSTOM 95, 217 pages.

Lopez Gamundi, O. R., Breitkreuz, C., 1997. Carboniferous-to-Triassic evolution of the Panthalassan margin in southern South America. - In: Dickins, J. M., Zungyi, Y., Hongfu, Y., Lucas, S. G., Acharyya, S. K. (Eds.), Late Palaeozoic and Early Mesozoic Circum-Pacific events and their correlation, (World and Regional Series, 10), Cambridge University Press, pp. 8-19.

Mégard, F., 1978. Etude géologique des Andes du Pérou central. Travaux et Documents de l'ORSTOM, Paris 86, 310 pages.

Panca, F. and Breitkreuz, C. 2011. The Mitu Group in the Urubamba valley, NE of Cuzco, Peru: volcanosedimentary facies analysis of an early Andean inverted basin, Bol. Soc. Geol. Peru 102: 5-35.

Perez, N., Horton, B., Carlotto, V., 2016. Structural inheritance and selective reactivation in the central Andes: Cenozoic deformation guided by pre-Andean structures in southern Peru. Tectonophysics, vol. 671, 264-280.

Reitsma, M., Schaltegger, U., Spikings, R., Winkler, W., Carlotto, V., 2010. Constraining the age of the Mitu Group, south–east Peru: U–Pb ages of detrital and igneous zircons. Geophysical Research, vol. 12, EGU2010–0.

Reitsma, M.J., 2012. Reconstructing the Late Paleozoic: Early Mesozoic Plutonic and Sedimentary Record of South-East Peru: Orphaned Back-Arcs along the Western Margin of Gondwana. Univ. Geneva (no. Sc. 4459).

Sempere, T., Carlier, G., Fornari, M., Carlotto, V., Jacay, J., Arispe, O., 2002. Late Permian-Middle Jurassic lithospheric thinning in Peru and Bolivia, and its bearing on Andean-age tectonics. Tectonophysics, vol. 345, pp. 153-181.

Spikings, R., Reitsma, M.J., Boekhout, F. Mišković, A., Ulianov, A., Chiaradia, M., Gerdes, A., and Schaltegger, U., 2016. Characterization of Triassic Rifting in Peru and implications for the early disassembly of western Pangaea. Gondwana Research 35, 124–143.