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Provenance analysis and tectonic setting of late Neoproterozoic metasedimentary successions in NW Argentina

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Abstract

Major, trace, and rare-earth element data for Puncoviscana Formation metasediments were used to constrain their provenance and tectonic setting. This unit, which crops out in northwest Argentina, consists mainly of pelite–greywacke turbidite sequences. Incipient regional metamorphism and a polyphase deformation, with a main deformation during the latest Proterozoic–earliest Cambrian Braziliano orogeny, affected the sedimentary sequences. The enrichment in light rare-earth and other incompatible trace elements over compatible ones, as well as the high and uniform Th/Sc ratios, indicate a predominance of upper-crust acid rocks as parental material. Some chemical characteristics of these rocks, such as their high Th/U, Rb/Sr, and Zr/Sc ratios, imply sedimentary recycling. On the basis of tectonic discriminant diagrams that employ trace elements considered relatively immobile during low-grade metamorphism, a passive margin setting can be inferred. Moreover, the comparison of the trace element contents of Puncoviscana metapelites with those of mudstones deposited in known tectonic settings shows the closest matching with passive margin shales.

Keywords: Geochemistry; Metasediments; Passive margin; Pre-cambrian; Turbidites

1. Introduction

The Puncoviscana Formation (Turner, 1960), which constitutes the basement of the studied area, crops out extensively in the Cordillera Oriental and, to a lesser extent, on the eastern border of the Puna (Salta and Jujuy provinces) in NW Argentina (Fig. 1). The age of this unit, according to K–Ar analyses of fine fractions, is late Neoproterozoic (Do Campo, 1999b; Do Campo et al., 1999), whereas the Puncoviscana ichnofauna recently reinterpreted by Buatois and Mángano (2003) indicate a Vendian–Nemakitian–Daldynian age.

Although analyses of the framework modes of arenites (Jezek, 1990) and geochemical studies of the scattered volcanic rocks interbedded in the clastic sequences (Omarini et al., 1999a,b) have been carried out, the tectonic setting of the basin remains subject to debate. Most previous interpretations of the Puncoviscana Formation have assigned it to a passive margin setting (Ramos, 1988; Jezek, 1990; Sims et al., 1998; Rapela et al., 1998). More recently, it has been considered an intracontinental rifting that might have evolved to an active plate margin (Omarini et al., 1999a,b). On the basis of structural (Kraemer et al., 1995) and geochronological (Keppie and Bahlburg, 1999) data for the Pampean ranges, other authors have hypothesized that it may represent a foreland basin deposit. However, few studies have focused on the geochemistry of the clastic sequences to infer their provenance and tectonic setting (Omarini and Do Campo, 1993; Do Campo, 1999b; Bock et al., 2000).

Geochemical approaches are more suitable than petrographic analyses based on framework modes when evaluating the provenance and tectonic setting of metasandstones that contain substantial amounts of pseudo matrix, because the pseudo matrix biases the framework modes, as we explain subsequently. However, a geochemical approach is possible only when post-depositional processes do not affect the bulk chemistry (McLennan et al., 1993). Major and trace element data also provide constraints on the effects

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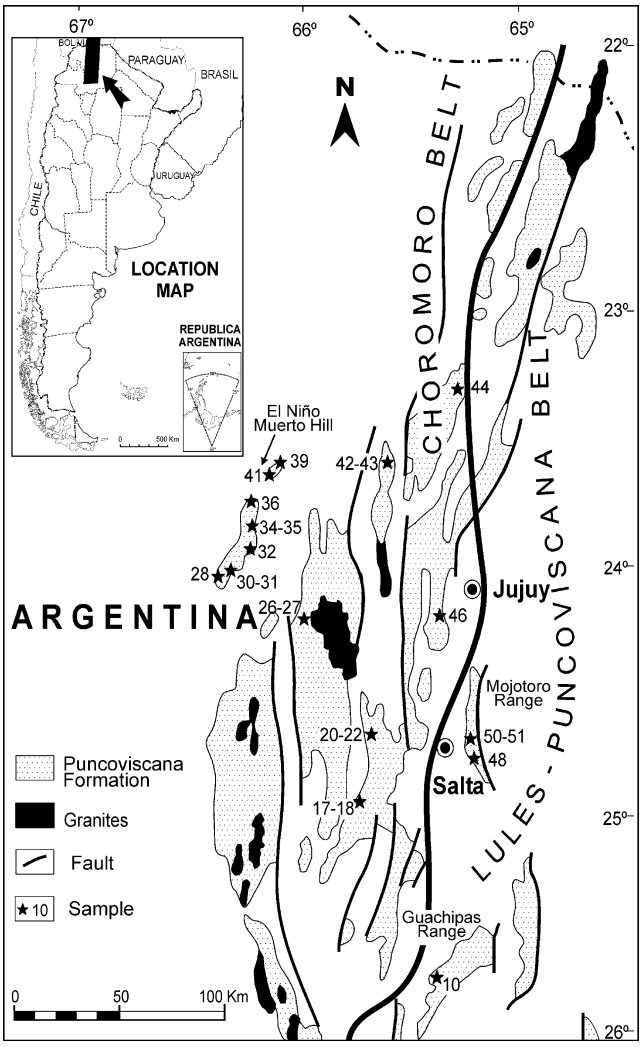

Fig. 1. Outcrop map of Puncoviscana Formation rocks in NW Argentina. Sample numbers are indicated.

of sedimentary processes, such as weathering and sedimentary sorting. Moreover, geochemical approaches are suitable for fine-grained lithologies that are difficult to study through more traditional petrographic approaches. In recent years, tectonic discrimination based on major elements has received considerable criticism (Winchester and Max, 1989; Bahlburg, 1998), whereas schemes that depend on trace elements have been considered more reliable. Elements such as rare-earth elements (REE), Y, Th, and Sc, which have low residence times in ocean waters, constitute good provenance markers because they are transferred almost quantitatively into clastic sedimentary rocks (Taylor and McLennan, 1985). Because any sedimentary mass balance calculation for these elements is largely controlled by shale, it is very important to include fine-grained components in geochemical analyses (McLennan et al., 1993). Conversely, discriminant diagrams of tectonic settings based on framework modes of sandstones (Dickinson, 1985) are of limited value in rocks that have been affected by low-grade metamorphism, because framework modes will be biased toward the quartz apices of the diagrams due to the conversion of labile fragments, such as feldspar and rock fragments, into clay minerals (pseudo matrix).

In this article, we present new chemical data for the Puncoviscana metasediments with the double objective of identifying their provenance components in terms of the terrane types defined by McLennan et al. (1993) and constraining the tectonic setting of the sedimentation. The characterization of the provenance and tectonic setting of this unit is important for understanding the late Neoproterozoic–Cambric evolution of South America. Preliminary results were provided by Do Campo and Ribeiro Guevara (2002).

2. Geological setting

The Puncoviscana Formation is mainly composed of a pelite–greywacke turbidite sequence, with subordinate sandstones and locally interbedded conglomerates, shelf limestones, and volcanic rocks (Omarini, 1983; Omarini and Baldis, 1984; Jezek, 1990). This unit constitutes the basement of the study area and is unconformably overlain by Cambrian sandstones of the Mesón Group. The Puncoviscana Formation was affected by polyphase deformation and can be separated into two N–S-trending, eastern and western units of contrasting tectonic evolution (Mon and Hong, 1991, 1996) (Fig. 1). The main deformation occurred during the latest Proterozoic–earliest Cambrian Braziliano orogeny (Ramos and Basei, 1997; Do Campo, 1999b). The complex deformational history of this unit, as well as its lithological and mineralogical uniformity, has hampered its division into sections or the attainment of reliable stratigraphic correlations between different outcrops. Buatois and Mángano (2003) recently pointed out the lack of an integrated stratigraphic column for this unit.

At Quebrada del Toro and the San Antonio de los Cobres range, the sequence consists of 0.1–2 m thick tabular beds of dark grey and grayish-green arenites intercalated with 0.01–0.6 m thick layers of grayish-green, dark grey, brownish-grey, or reddish-brown pelites and siltstones. Parallel lamination and fining-upward gradation textures that transition to pelitic layers are common features in arenite beds. Less commonly, cross-bedding is present. The sequence is folded in tight chevron folds overturned to the east with near vertical to vertical axial planes. However, in the outcrops near El Gólgota (middle zone of Quebrada del Toro), more open folds are observed. In contrast, at San Antonio de los Cobres range and El Niño Muerto Hill, a conspicuous slaty cleavage (s_1), which intersects s_0 at 30°, is present.

At Guachipas range, the sequence consists of 0.7–1.2 m thick arenite beds that gradually pass to 0.2–0.35 m thick siltstone beds. Arenite/pelite bed thickness ratios range from