THE ORDOVICIAN PUNA BASIN OF NW ARGENTINA AND N CHILE: FROM BACK-ARC TO FORELAND BASIN

Heinrich Bahlburg

Institut für Geologie und Paläontologie, Technische Universität, Ernst-Reuter-Platz 1, 1000 Berlin 10, Fed. Rep. Germany

Resumen

Perfiles sedimentológicos, con fauna graptolitica, levantadas en las series turbiditicas ordovícicas de la Puna septentrional (noroeste de Argentina y norte de Chile) permiten una división estratigráfica más detallada de la serie sedimentária. La analisis de cuenca llevó a una nueva interpretación geodinámica de la cuenca desde un tipo tras-arco hacia un tipo ante-pais.

keywords: Puna, Argentina, Ordovician, sedimentology, stratigraphy, foreland basin.

Introduction

In the southern Central Andes of NW Argentina and N Chile Ordovician clastic rocks occur in shelf facies in the Cordillera Oriental and as basinal turbidites in the westwardly adjacent Puna. Measurement of detailed sections in the northern Puna (north of approx. 24°30'S) together with new finds of graptolites led to more precise dating of sedimentary successions and to the proposal of a new stratigraphic subdivision as well as a new geodynamic interpretation of basin evolution (BAHLBURG under review, BAHLBURG et al. under review).

Depositional history of the Puna Basin

In the Tremadoc, sedimentation in the eastern part of the northern Puna (Sierra del Cobre, Fig. 1) began with a transgressive succession of intertidal quartzarenites and intercalated pebbly mudstones giving way to turbidites indicating increased subsidence during the Lower Ordovician.

In the western part of the northern Puna the oldest fossiliferous rocks are represented by a volcanosedimentary unit ('Volcanosedimentary Succession' (VS), Fig. 1) of middle to late Arenigian age, which include the middle Arenigian Aguada de la Perdiz Formation (Fig. 1) in the Chilean Puna and upper Arenigian strata present in the Argentine Puna. The VS is about 3500 m thick and consists in its lower part of basaltic to andesitic lavas, hydroclastitic rocks, tuff breccias and debris flows. In the upper part, alternating ash tuffs and volcanoclastic turbidites document the fining upward trend of the succession. The VS represents a submarine apron on the back-arc flank of a mainly subaerial silicic volcanic arc of an eastdipping subduction zone at the Pacific margin of Gondwana (BREITKREUZ et. al. 1989). There is no evidence of active volcanism in the Ordovician after the Arenig.

To the east of the depositional site of the VS, the 'Puna Turbidite Complex' (PTC) encompassing the 'Lower' and 'Upper Turbidite Systems' (LTS, UTS) formed from the late Arenig to the Llandeilo (-?lower Caradoc)(Fig. 1). The PTC includes parts of the Coquena Formation and the Calalaste Group (Fig. 1)(BAHLBURG et al. under review). The LTS is at least 2700 m thick (BAHLBURG et al. 1988), the UTS at least 900 m. The volcanoclastic turbidites of both systems are usually laterally continuous deposits of depositional lobes. However, channel complexes reach thicknesses of up to 200 m. Sediment transport was axial and almost uniformly directed towards the NNW (Fig. 2). The turbidite successions of the approx. N-S striking elongate Ordovician Puna Basin are comparable to elongate, efficient turbidite systems of active thrust basins (MUTTI 1985).

The absence of regional proximal-distal trends indicates, among other evidence, that the depositional system was not a point sourced submarine fan. Detritus originated almost exclusively in the line source of the magmatic arc (Fig. 2) which seems to have been inactive after the Arenig. Immaturity and bad sorting of turbidite arenites in fining upward as well as coarsening upward cycles of different order attest to short transport distances and minor weathering and reworking in small repositories and shelf areas throughout all cycles and sections. Although 2^{nd} order cycles in both turbidite systems appear to be paralled by respective global sea level changes, 3^{rd} and 4^{th} order cycles have different trends from section to section. In combination the data show that sedimentary trends and apparent sea level changes are primarily related to tectonic activity in source regions and the basin itself. Global sea level changes during the Ordovician (FORTEY 1984) only complemented the influence of tectonic activity on depositional patterns.

Geodynamic evolution

The Ordovician basin in the Argentine-Chilean Puna developed in the Arenig as a back-arc basin (Fig. 3). Incremental sediment decompaction leading to calculated geohistory plots shows that from the late Arenig onwards the basin in the western part of the northern Puna subsided rapidly at rates of up to 1.1 mm/a. Subsidence rates of this order of magnitude are typical of foreland basins (ALLEN et al. 1986). Basin subsidence most probably originated from the overthrusting of the Arenigian arc complex onto its former back-arc basin which transformed the back-arc basin to a foreland (successor) basin. This was accompanied by tectonically induced deposition of thick turbidite systems (LTS, UTS). The events were probably caused by the onset of collision of the allochthonous Arequipa Massif with the Gondwana margin in NW Argentina and N Chile (e.g. RAMOS 1988). As a consequence of eastward thrusting of the arc complex and the development of a foreland basin, a flexural bulge formed at the eastern margin of the basin. Formation of the bulge led to uplift and eventual emergence of the shelf in the Cordillera Oriental in the early Llanvirn and therefore to the end of the Ordovician stratigraphic record (Fig. 1) in this area during the 'Guandacol diastrophic phase'. The Puna Foreland Basin was closed during the Oclóyic Orogeny at the Ordovician-Silurian transition. Folding of the basin fill was caused by the terminal collision of the Arequipa Massif.

An important role in the geodynamic interpretation of the Ordovician Puna basin and this segment of the Gondwana continental margin plays the extended magmatic belt of the 'Faja Eruptiva de la Puna Oriental'. This belt was interpreted as a magmatic arc consisting of submarine ignimbrites intercalated with and contemporaneous to the sedimentary rocks desribed above (e.g. COIRA et al., 1982). The Puna basin was therefore alleged to have been located in a fore-arc position. However, the outcrops of the Faja Eruptiva Oriental north of 24°30'S consist exclusively of silicic, porphyric and equigranular partly sheared high level granitoid intrusions crosscutting folded Late Ordovician sedimentary rocks. The intrusives therefore have a maximum age of very late Ordovician (see also MENDEZ et al.

	Northern Puna (modified after ACEÑOLAZA & BALDIS (1987))	Northern Puna (this paper)	Sierra del Cobre	Cordillera Oriental
Caradoc				
Llandeilo	Calalaste Group: Lina Formation, Falda Ciénaga Formation	Puna Turbidite Complex: Upper Turbidit System		
Llanvirn	Coquena Formation	Puna Turbidite Complex: Lower Turbidit System		
Arenig	Aguada de la Perdiz Formation	Volcanosedimentary Succession	Cobres Group: Chiquero Formation	Santa Victoria Group: Acoite Formation
Tremadoc			Cobres Group: [illegible] Formation, Taique Formation, Matancilla Formation	Santa Victoria Group: Santa Rosita Formation
Upper Cambrian				

Fig. 1: Stratigraphic table for the region under consideration; modified after ACEÑOLAZA & BALDIS (1987) and MOYA (1988), and own results.

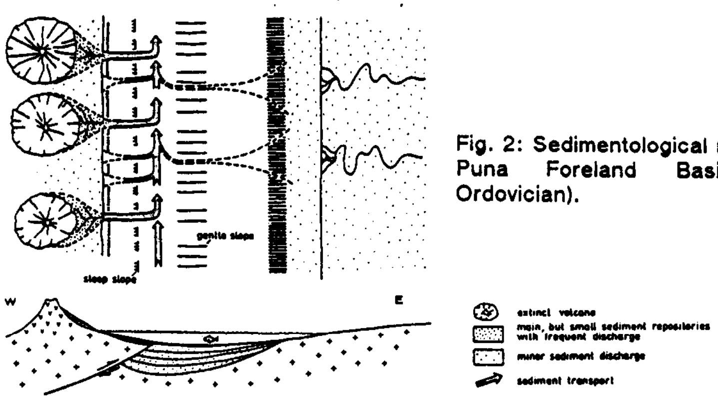

Fig. 2: Sedimentological model of the Puna Foreland Basin (Middle Ordovician).

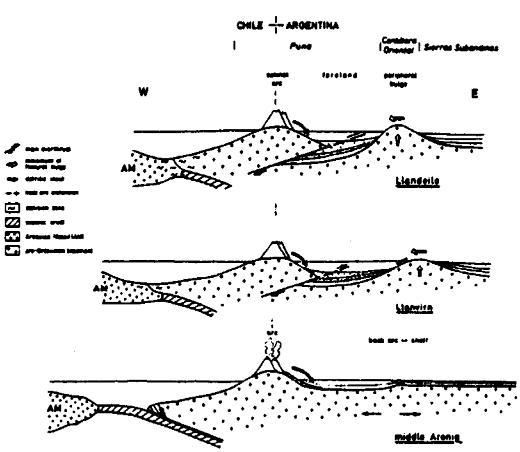

Fig. 3: Schematic sketches of the geodynamic evolution of the Ordovician Puna Basin.

1973). Geochemical data and the abundance of (meta)sedimentary xenoliths indicate that the granitoid magmas suffered considerable crustal contamination. The granitoids are cut by N-S striking subvertical shear zones along which leftlateral strike-slip movements of yet unknown extend occurred. Shearing took place in a low pressure regime at temperatures of between 300° and 500°C: as opposed to quartz grains, feldspars show no recrystalization phenomena.

Conclusively, the Faja Eruptiva de la Puna Oriental in the northern Puna is not the magmatic arc contemporaneous to the studied Ordovician sedimentary rocks but a belt of late- to post-tectonic intrusions of very Late Ordovician to Silurian age. The axis of the actual Early Ordovician magmatic arc was probably located to the west of the VS. This arc may have been related to the magmatic belt of the 'Faja Eruptiva de la Puna Occidental' (PALMA et al. 1986) situated west of the Puna in northern Chile.

References

ACEÑOLAZA, F.G. & BALDIS, B. (1987): The Ordovician system of South America. Correlation chart and explanatory notes.- IUGS Publication No. 22, 68 S.

ALLEN, P.A., HOMEWOOD, P. & WILLIAMS, G.D. (1986): Foreland basins: an introduction.- Int. Ass. Sediment. Spec. Publ. 8, 3-12.

BAHLBURG, H. (under review): The Ordovician basin in the Puna of NW Argentina and N Chile: geodynamic evelution from back-arc to foreland basin.- Geotekt. Forsch.

BAHLBURG, H., BREITKREUZ, C. & MALETZ, J. (under review): The Ordovician sedimentary rocks in the Puna of Argentina and Chile: New stratigraphical data based on graptolites.- Newsl. Stratigr.

BAHLBURG, H., BREITKREUZ, C. & ZEIL, W. (1988): Geology of the Coquena Formation (Arenigian-Llanvirnian) in the NW Argentine Puna: constraints on geodynamic interpretation.- Lect. Notes Earth Sci. 17, 71-86.

BREITKREUZ, C., BAHLBURG, H., DELAKOWITZ, B. & PICHOWIAK, S. (1989): Volcanic events in the Paleozoic central Andes.- Jour. South Amer. Earth Sci. 2, 171-189.

COIRA, B., DAVIDSON, J., MPODOZIS, C. & RAMOS, V. (1982): Tectonic and magmatic evolution of the Andes of northern Argentina and Chile.- Earth Sci. Rev. 18, 303-332.

FORTEY, R.A. (1984): Global Earlier Ordovician transgressions and regressions and their biological implications.- In: Aspects of the Ordovician System (Ed. by D.L. BRUTON), Paleont. Contrib. Univ. Oslo 295, 37-50.

MENDEZ, V., NAVARINI, A., PLAZA, D. & VIERA, V. (1973): Faja Eruptiva de la Puna Oriental.- 5. Congr. Geol. Argent Actas 4, 89-100.

MOYA, M.C. (1988): Lower Ordovician in the southern part of the Argentine Eastern Cordillera.- Lect. Notes Earth Sci. 17, 55-70.

MUTTI, E. (1985): Turbidite systems and their relation to depositional sequences.- In: Provenance of arenites (Ed. by ZUFFA, G.G.), Nato ASI series C 148, 65-93, Reidel, Dordrecht.

PALMA, M.A., PARICA, P.D. & RAMOS, V.A. (1986): El granito de Archibarca: Su edad y significado tectonico, provincia de Catamarca.- Rev. Asoc. Geol. Argent. 41, 414-419.

RAMOS, V.A. (1988): Late Proterozoic-Early Paleozoic of South America - a collisional history.- Episodes 11, 168-174.