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SEDIMENTOLOGY AND TECTONIC SETTING OF THE DEVONIAN-CARBONIFEROUS BASIN IN N CHILE

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INTRODUCTION

During the Devonian-Early Carboniferous, a basin including an eastern shelf in the area of the Sierra de Almeida and a western deeper basin in the actual Cordillera de la Costa formed in N Chile. Geotectonic interpretations of the basin vary between a fore-arc and an extensional marginal setting.

STRATIGRAPHY

On the shelf, the clastic Zorritas and Lila Formations comprise a c. 2700 m thick fossiliferous marine succession of sandstones and shales ranging from the Early Devonian to the Early Carboniferous (Isaacson et al. 1985; Bahlburg et al. 1987). The deposits unconformably overly Ordovician-Silurian granitoids.

The oldest biostratigraphically dated rocks in the Cordillera de la Costa of northern Chile are turbidite successions up to 3600 m thick of Devonian to Carboniferous age. They are grouped into the El Toco, Sierra del Tigre and Las Tórtolas Formations (Fig. 1; ETF, STF and LTF, respectively; Maksaev & Marinovic 1980; Naranjo & Puig 1985; Niemeyer et al. 1985; Bahlburg et al. 1987). Stratigraphic contacts to underlying units are not exposed. Due to the presence of Cambrian and Ordovician granitoids, and the absence of outcrops of contemporary oceanic crust, these formations are inferred to rest on sialic basement.

SEDIMENTOLOGY

The shallow marine facies associations on the shelf record repeated changes from intertidal to shallow or deep subtidal environments as

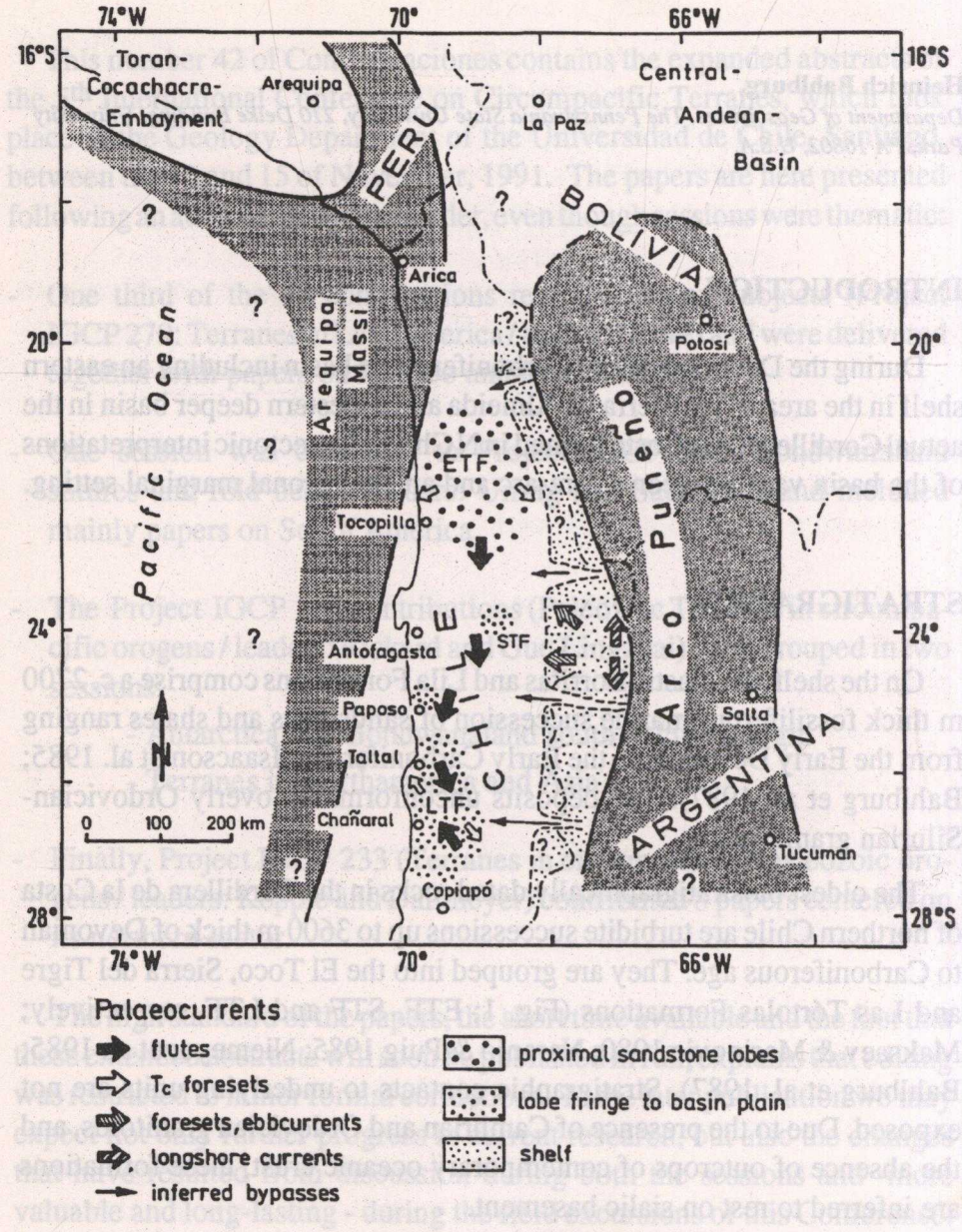

Fig. 1: Palaeogeographic framework and depositional model of the Devonian-Carboniferous shelf-deeper basin system in northern Chile. Palaeogeographic framework modified after Padula et al. (1967) and Isaacson (1975).

evidenced by medium to coarse grained cross-bedded or bioturbated sandstones, offshore tidal dunes and sand waves, mudstones and tempestites. An emersion surface indicates a significant regression during the Early Devonian. The relative sea-level changes recorded by the succession coincide with global ones which controlled the development of two succeeding type 1 sequences.

In the deeper basin, turbidites accumulated in coarse-grained proximal sand lobes in the N, and in fine-grained lobe fringe and basin plain environments in the S. Progradational trends are not developed. In N and S, facies associations are arranged unchangingly through time in alternating thickening upward and thinning upward cycles typical of tectonically controlled aggradational turbidite systems linked to extensional tectonics. Sea-level changes recorded on the adjacent shelf did not find their expression in the depositional patterns in the deeper basin.

PROVENANCE

The shelf sandstones have an average framework mode of $Q_{94}F^{1}L_{5}$. The ETF, STF and LTF invariably consist of quartz-rich turbidites. Average framework modes vary between $Q_{81}F_{12}L_{7}$ and Q83F9L8. There is a conspicuous absence of volcanic rock fragments in the turbidites of all grain sizes. The source area was the N-S striking Arco Pune$o, a Late Ordovician-Early Silurian orogen located in the actual High Andes Cordillera (Fig. 1). It consisted of (meta)sedimentary rocks and granitoids of late Proterozoic to Silurian age (Hervé et al. 1987; Bahlburg 1991).

BASIN GEOMETRY AND PALAEOCURRENTS

Relative to presentday coordinates, the Devonian-Carboniferous basin in N Chile had a N-S orientation. The sediment dispersal system on the shelf is characterized by N-S oriented longshore currents and ebbcurrents directed towards W and NW. In the deeper basin, axial palaeocurrents indicated by flutes were mainly directed southward. Palaeocurrents inferred from T_c foresets are frequently directed towards the E and SE, i.e. towards the marginal source. These palaeocurrents probably indicate that the basin

had a western margin from which these currents originated or which caused oblique reflection of eastwardly derived transverse currents at the opposite (here: western) slope or ramp (Kneller et al. 1991). The western margin is inferred to represent a peninsular southern prolongation of the Arequipa basement terrane (Fig. 1).

DEFORMATION

The shelf successions of the Sierra de Almeida are only weakly deformed and diagenetically altered. Contrastingly, the very low-grade metamorphic turbidite formations in the Cordillera de la Costa were intensively folded in a dominantly SW to W verging pattern during the Early and early Late Carboniferous Toco Orogeny (Bahlburg & Breitkreuz in press). Conspicuous units within the ETF, STF and LTF are dismembered formations which formed along weakly NE dipping thrust plains. In the area of Chañaral, these are exposed along the coast in the c. 5 km wide Chañaral Melange (e.g. Bell 1987).

TECTONIC SETTING

Based on studies of the Chañaral Melange, Bell (e.g. 1987) assigned the LTF to the fore-arc and accretion prism areas of a Devonian-Carboniferous subduction complex at the Chilean margin. The shelf rocks, and the ETF and STF were accordingly interpreted as fore-arc deposits (Hervé et al. 1987). However, thick and extensive slope failure deposits which are widespread and common in trench depositional systems are very rare. Large scale coarsening upward trends typical of subduction complexes did not develop. Tectonic subsidence data indicate that shelf and deeper basin formed due to extension in the order of a stretching factor ß=1.4-1.7. Turbidite systems grew by aggradation, i.e. balanced subsidence and accumulation vs uplift of the margins typical of some extensional basins. Reflected T_c palaeocurrents indicate the presence of an opposite, western basin margin. The deposits lack detritus indicative of a contemporary magmatic arc. No Devonian-Carboniferous magmatic arc is exposed in N Chile. Alkaline and tholeiitic basalt intercalations in the LTF have geochemical features of continental within-plate lavas. In conclusion, shelf

and deeper basin are interpreted as part of a single, N-S striking ensialic extensional basin at the Devonian-Early Carboniferous margin of N Chile. A modern analogon for the broad geotectonic framework of this basin may be represented by the transtensional pull-apart basin of the Gulf of California, although extension appears to have been less pronounced in northern Chile as no oceanic crust was formed. The deformational features of the turbidite formations developed during the Toco Orogeny correspond well to a tectonic regime governed by dextral transpression, i.e. the transpressive collision of the inferred western margin with the shelf.

AUTOCHTONY VS ALLOCHTONY OF THE DEEPER BASIN RELATIVE TO THE SHELF

Palaeomagnetic data indicate that Jurassic dextral strike-slip movements displaced the Late Palaeozoic Pichidangui fore-arc terrane in the Coastal Cordillera of Central Chile along the margin northward by c. 15° latitude (Forsythe et al. 1987). A similar development was assumed by Ramos (1988) for the Chañaral terrane including the LTF and Chañaral Mélange. There are no palaeomagnetic data available from northern Chile. However, contemporaneously during Jurassic-Early Cretaceous times, the north Chilean Atacama Fault Zone accomodated sinistral strike-slip movements of over 34 km (Hervé 1987). This has been linked to oblique subduction of the oceanic Phoenix plate towards the SE under the Chilean margin. A northward displacement of the Pichidangui and Chañaral terranes by c. 1500 km is difficult to reconcile with the plate tectonic context of oblique subduction towards the SE. Consequently, an autochtonous position of the deeper basin in the Coastal Cordillera relative to the shelf is likely.

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