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HIGH RESOLUTION SEQUENCE STRATIGRAPHIC ANALYSIS OF THE MESOZOIC DOMEYKO BASIN, NORTHERN CHILE

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RESUMEN

The Domeyko basin of northern Chile was initiated as a rift basin during the Permo-Triassic breakup of Pangea. Initial syn-rift continental red beds and volcanic rocks are diachronously overlain by a latest Triassic-Early Cretaceous mixed carbonate/clastic marine system which forms the basis of this study. Partially time-equivalent (post Lias), arc volcanic rocks to the west indicate initiation of eastward-dipping subduction.

The Mesozoic basin fill is characterised by a mixed carbonate/clastic system with interbedded volcanic and volcaniclastic units. The clastic component is present throughout most of the basin history but never became dominate enough to inhibit carbonate production. Carbonate and clastic sequences contain a well constrained palaeontological evolution with 85% of ammonite biochronozones present, exceptions being the Kimmeridgian & Tithonian stages.

Sixteen detailed logged sections comprising 9000 metres of stratigraphic section reveal a wide variety of lithofacies within the Domeyko basin including both continental and mixed carbonate/clastic marine sequences. This dataset has allowed the development of a detailed chronostratigraphy for the Domeyko back-arc basin

OBJECTIVES

Recent advances in sequence stratigraphy have highlighted the importance of relative sea-level fluctuations in the stratigraphic development of passive margins and foreland basins [Van Wagoner et. al. 1990]. These fluctuations are driven by variable frequency eustatic, tectonic and sediment flux variations.

This project aims to understand the controls on stratigraphic development in an active back-arc basin. Additional problems for sequence stratigraphic analysis in such a setting include the effects of the growth, migration and decay of volcanic arcs on subsidence patterns and resultant stratigraphy.

The Domeyko back-arc basin of Northern Chile (figure 1) displays a well exposed Triassic-Cretaceous mixed carbonate/clastic fill with a clear cyclicity on low (2nd/3rd order) and higher (? 4th order) scales [sensu Vail et al 1977].

GEOLOGICAL SETTING

The Domeyko basin was initiated as a rift basin during the Permo-Triassic breakup of Pangea. The pre-rift basement is predominately composed of Palaeozoic plutonic and low grade metasedimentary rocks with a thick syn-rift succession of Permio-Triassic volcanics and Triassic continental redbeds. The Upper Triassic to Lower Cretaceous marine sedimentary rocks are interpretated as representing post rift and initial inversion basin configurations [Chong 1977, Groschke et. al. 1988, Prinz et. al. 1994]. The closing and inversion of the basin occured in Uppermost Jurassic to Middle Cretaceous times with a regional shift to continental redbed deposition and eventually non-deposition.

Two major fault systems (Atacama Fault System (AFS) & West Fissure Fault System (WFS)) appear to control the marine Mesozoic outcrop and are thought to represent the original basin bounding fault systems. The WFS runs N-S through the Domeyko Range and adds the complexity of bedding parallel strike-slip displacements giving juxtaposition of unrelated, time equivalent strata [Reutter et. al. 1991]. This tectonic feature permits study of the eastern margin of the backarc basin with a 500km north-south strike section and 30-40km of continuous exposure in the depositional dip direction. The Jurassic volcanic arc trended N-S and was located along

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the present day position of the Coastal Cordillera. Since Jurassic times the arc has migrated to the east to it's current position (High Andes).

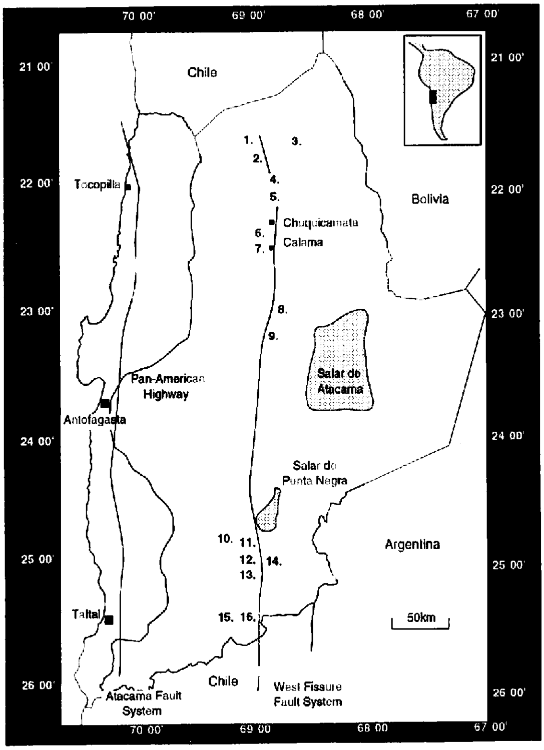

Figure 1 Location map of Northern Chile. Logged sections marked 1 - 16.

SEDIMENTOLOGY & LITHOFACIES

1 Continental lithofacies

1.1 Pebble rich braided fluvial conglomerate These are predominately clast supported with subsidiary matrix supported conglomerates. The conglomerates display a large scale bedding with fining-up units and internal erosion surfaces. Internally, many of the conglomerates are chaotic with no particular internal clast imbrication or orientation but contain lenses of coarse sand and pebble conglomerate. The units have erosive bases and channel or sheet geometries. Clast types are dominately volcanic or shallow intrusive origin. The clast size and type indicates an immature, proximal rock of volcanic provenance. These are interpretated as high energy braided fluvial conglomerates.

1.2 Multi-storey braided fluvial sandstone Individual units display fining-upward trends from coarse to fine sand and have erosive bases. There is well developed cross bedding on a variety of scales (2-30cm). within each unit. The sand bodies have lens or sheet geometries and are multi-storey. They are interpretated as multi-storey, incised, fluvial complexes deposited within a sand rich fluvial system with an igneous provenance.

1.3 Single storey braided fluvial sandstone This facies consists of discrete channelised sand bodies within silt grade rock. The sands display erosive bases and fining-up graded bedding from coarse to very fine sand. They have lens geometries which thin laterally within 30-50 metres. The siltstone is commonly red in colour and internally homogeneous, containing continental vertebrate fossils *(Pterodaustro cf. P. guinazui)* and plant remains *(Williamsonia)*.

1.4 Floodplain siltstone facies This facies consists of medium to coarse grained siltstone which is commonly poorly exposed. Some of the siltstones show parallel lamination. The silts contain thin interbedded sandstones with sheet geometries. These facies are interpretated as interfluvial floodplain siltstones with thin crevasse splay sheetflood sandstones.

1.5 Lacustrine siltstone This facies consists of homogenous fine to medium grained red and green siltstone. The siltstone exhibits a fine parallel lamination with no fossil evidence. These are interpretated as lacustrine siltstones.

2 Mixed carbonate/clastic marine Lithofacies

2.1 Framework coral reef This facies consists of an interlocking framework of collonial corals. The facies is interpretated as a shallow water (<10 metres) reefal carbonate representating periods of little or no clastic input.

2.2 Shelly limestone This facies consists of shelly limestone containing bivalve, brachiopod and oyster fossils. The facies is interpretated to represent a shallow water shell bank.

2.3 Bedded limestone This facies consists of well bedded micritic limestone which contains ammonites. The facies is interpretated as being low energy shelfal limestone accumulating during periods of low clastic input.

2.4 Carbonate storm sand This facies is composed of interbedded units of bio-calcarenite (20-50cm in thickness) and calcareous siltstone (20-40cm in thickness). The bio-calcarenite beds are erosively based and sharp topped with shell fragments (bivalve, brachiopod & oyster) throughout but these are concentrated at the bases. These arenites are dominately carbonate in composition and display relic hummocky cross stratification (HCS). The siltstones are fine to medium grained with evidence of minor bioturbation. The facies are interpretated as lower shoreface storm event sands (HCS) with the siltstones being the fine grained background sedimentation.

2.5 Carbonate silt/sand This facies is composed of heterolithic siltstone and sandstone where the predominate lithology is siltstone. The sandstones are thin, with slightly erosive bases and sharp tops. They are interpretated to be shelfal calcareous siltstones from below storm wave base with thin distal sheet sandstones.

2.6 Carbonate silt/limestone This facies is composed of heterolithic siltstone and limestone where the dominate lithology is siltstone. The rocks are interpretated to be outer shelfal calcareous siltstones with thin sheet limestone formed during periods of clastic starvation.

2.7 Anoxic black shale/limestone This heterolithic facies is quite characteristic with the interbedding of black anoxic limestones and black shales. The limestones characteristically contain ammonites indicating open marine conditions with rare bivalves. They are interprctated as being anoxic basinal sediments forming below the mixed layer (below which insufficient circulation causes anoxia).

2.8 Anoxic black shale The shale has a high organic carbon content and is interpretated as being basinal marine shales fromed below the mixed layer.

2.9 Evaporites The evaporitic facies is made up of predominately anhydrite and gypsum with some detrital impurities. This evaporitic facies developed during periods of basin desiccation.

2.10 Subaqueous volcanic ash This facies is very distinctive and is only developed in one key locality (Quebrada Corralas). It consists of thick units of white volcanic ash which lie directly over framework coral facies. This is interpretated as being subaqueous fallout ash deposits directly related to volcanic activity.

2.11 Bivalve rich sandstone This facies is a fine to medium grained bioclastic sandstone rich in small bivalves. It is interpretated to be estuarine or marginal marine, based on the monospecific, stunted faunal assemblage.

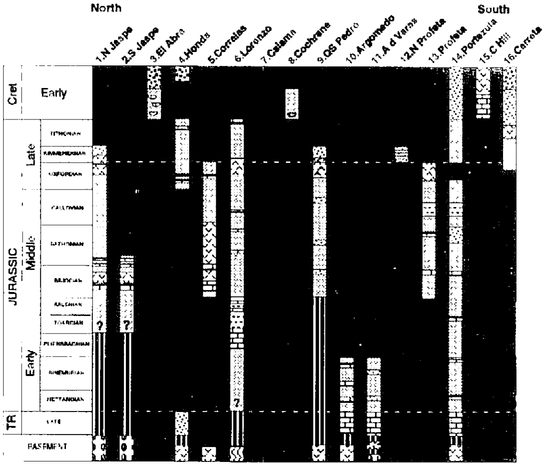

Figure 2Generalised chronostratigraphic facies summary for each section. See figure 1 for location of numbered sections.

CHRONOSTRATIGRAPHY

The initial marine flooding of the Domeyko basin is diachronous with the south being flooded in the late Triassic and the north not being flooded until the Bajocian. The late Triassic marine flooding in the south of the basin is represented by shallow water carbonates (Shelly limestone Facies (2.2) & Bedded limestone facies (2.3)) unconformably overlying Triassic to Lower Jurassic volcanics.

Lower Jurassic The Lower Jurassic marine rocks in the south are shelfal carbonates (Carbonate silt/limestone facies (2.6)) with a basinal high around Quebrada San Pedro (locality 9) and another depocentre to the north at Sierra San Lorenzo (locality 6). The depocentre in the North records some Lower Jurassic redbeds (Single storey braided fluvial facies (1.3)) with the first marine incursion in the Pliensbachian (Shelly limestone facies (2.2)). The Toarcian/Aalenian of Sierra San Lorenzo (locality 6) shows an abrupt deepening with open marine anoxic sedimentation (Anoxic black shale facies (2.8) & Anoxic black shale/limestone facies (2.7)).

Middle Jurassic The Bajocian records marine flooding of the Quebrada San Pedro high (Carbonate storm sand facies (2.4)) and the Sierra Jaspe areas (Bedded limestone facies (2.3)). The section at Quebrada Corralas (locality 5) records a unique history with Bajocian limestones (Framework coral facies (2.1)) being interbedded with and overlain by Bathonian/Callovian volcanic ash (Subaqueous volcanic ash facies (2.10)). The Sierra Jaspe areas include a Bajocian lava (40 metres thick) which is time equivalent to the lower ash units of Quebrada Corralas (locality 5). The Bathonian and Callovian show condensed sedimentation probably due to basinwide flooding and clastic starvation.

Upper Jurassic The Upper Jurassic is characterised by a distinct change in facies stacking patterns. The Oxfordian/Kimmeridgian records a marked basinward shift in facies with two dessication events recorded at this time (Evaporitic facies (2.9)). The Kimmeridgian records a subsequent marine transgression with initial esturine conditions (Bivalve rich sandstone (2.11)). The majority of the basin transition from marine to continental occurs in the Tithonian with Carreta Hill (locality 15) being the only area to record marked marine Lower Cretaceous sedimentation (Bedded limestone facies (2.3)). The marine/continental transition is well recorded at Quebrada Caretta (locality 16) where the typical Lower Cretaceous redbed sequence is seen (Floodplain siltstone facies (1.4), Single storey braided fluvial facies (1.3), Multi-storey braided fluvial facies (1.2), Pebble rich braided fluvial facies (1.1)).

CONCLUSIONS

Initial work has laid down a provisional outline for Mesozoic basin evolution with current work being concentrated on detailed facies analysis. This detailed facies analysis will highlight many of the more suttle shifts in facies and allow a sequence stratigraphic breakdown of the basin history. From this detailed chronostratigraphic history it is hoped to isolate the controls on back-arc basin sedimentation patterns and to compare the results to better studied, time-equivalent Andean basins such as the Neuquen Basin [Legarreta 1991].

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