SEQUENCE STRATIGRAPHY OF THE MESOZOIC DOMEYKO BASIN, NORTHERN CHILE

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INTRODUCTION

The Domeyko basin in northern Chile (Fig. 1) originated as one of a series of Upper Permian to Triassic transtensional rift basins along the western margin of Gondwana. Initial syn-rift continental clastics are overlain by Norian (Upper Triassic) marine limestones in the area of the Precordillera between 23°30'-26°30'S (Fig. 1). Subsequent Jurassic-Early Cretaceous post-rift thermal subsidence is recorded by a 2000 m thick mixed carbonate and siliciclastic marine succession. The depositional system is interpreted as a mixed carbonate and siliciclastic ramp environment, characterised by the deposition of siliciclastic-dominated successions at times of low accommodation space (lowstand and late highstand systems tracts) and carbonate-dominated successions during periods of high accommodation space (transgressive and early highstand systems tracts). The end of the Jurassic is marked by a regional marine regression and followed by continental red-bed deposition of Early Cretaceous age.

SEQUENCE STRATIGRAPHY

Sequence stratigraphic analysis has identified five Exxon-type unconformity bounded sequences which provide a time framework for the understanding of chronostratigraphic development of the Domeyko basin (Fig. 2). Relative sea-level fall in the upper Lower Sinemurian, earliest Pliensbachian, earliest Aalenian, Lower Callovian, earliest Valanginian, and rises in the earliest Hettangian, earliest and Late Toarcian, Lower and Late Bajocian, Late Bathonian and earliest Oxfordian of the Domeyko basin appear time-equivalent to similar events in other southern and northern hemisphere basins and thus are interpreted to be products of eustatically driven, global sea-level cycles (Fig. 3). Relative sea-level falls in the earliest Bathonian, latest Oxfordian, earliest Valanginian and rises in the Late Kimmeridgian are interpreted to be tectonically-driven, continental-scale changes in accommodation space (Fig. 3). Although the earliest Valanginian relative sea-level fall has been documented in northern hemisphere basins, the sequence boundary is interpreted to be tectonically-enhanced through regional uplift in Chile and Argentina.

AN EXAMPLE OF A TECTONICALLY-DRIVEN SEQUENCE BOUNDARY & LOWSTAND SYSTEMS TRACT

The latest Oxfordian (Late Jurassic) of the Domeyko basin is characterised by a 10-200 m thick, sharp-based succession of basinal evaporite facies interpreted as lowstand deposits, directly overlying offshore marine siltstone facies of the previous highstand (Fig. 2). The evaporite facies record an abrupt shallowing and basinward shift in facies seen throughout much of the basin, indicating sequence boundary formation. This interpretation is supported by the biostratigraphic data which shows the evaporites to have a synchronous duration of five ammonite Zones, Bimammatum-Acanthicum (Gygi & Hillebrandt 1991), lasting approximately 7.5 Ma. The latest Oxfordian-Late Kimmeridgian evaporites are predominately subaqueous basinal evaporite facies with limited marginal sabkha evaporite facies seen in the north (22°S).

The Neuquén Basin records similar aged latest Oxfordian-Upper Kimmeridgian evaporite facies (Auquilco Formation) directly overlying marine carbonates (La Manga Formation) interpreted to have resulted from restricted marine connection associated with barring of the basin (Legarreta & Uliana, 1991). The large spatial distribution of lowstand evaporites traceable for over 2000 km along the back-arc basins of Chile and Argentina, with a marked Late Oxfordian unconformity in southern Peru (Jaillard *et al.*, 1990) are interpreted to record a continental-scale tectonic event affecting all the back-arc basins of western Gondwana (Fig. 3). In the Neuquén basin there is abundant evidence for structural inversion in the Late Oxfordian (Vergani *et al.*, 1995). Uplift of the basin floor and volcanic arc caused the barring and relative

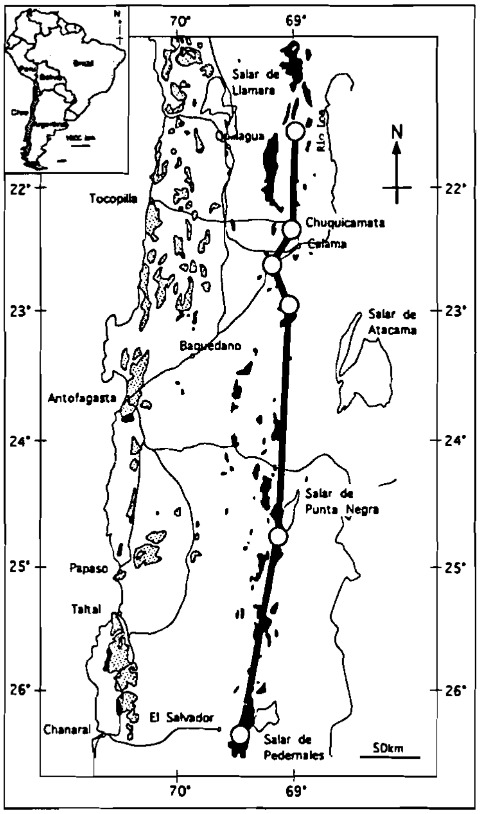

Figure 1 Map of northern Chile showing the Jurassic volcanic arc (La Negra Formation) in stipple outcropping along the Coastal Cordillera and the Jurassic marine rocks in black outcropping predominately along the Chilean Precordillera, (modified from Prinz et. al., 1994).

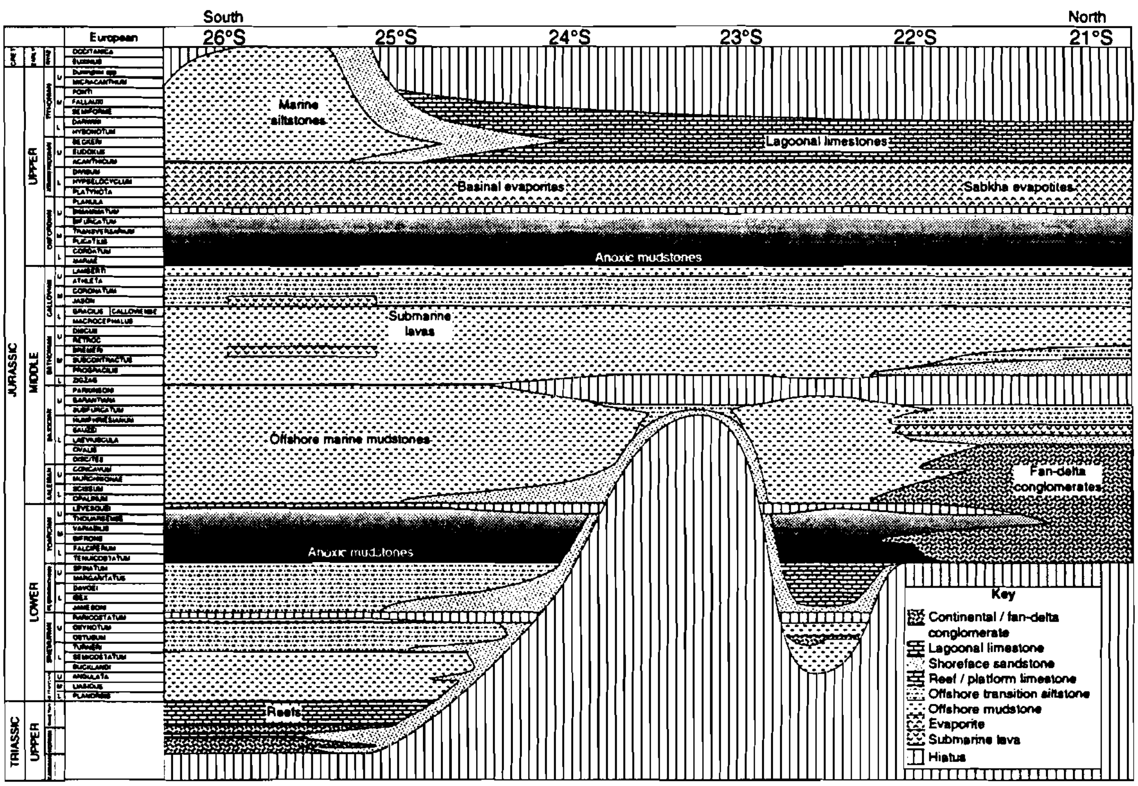

Figure 2 Chronostratigraphy of the Domeyko basin from Late Triassic-Early Cretaceous.

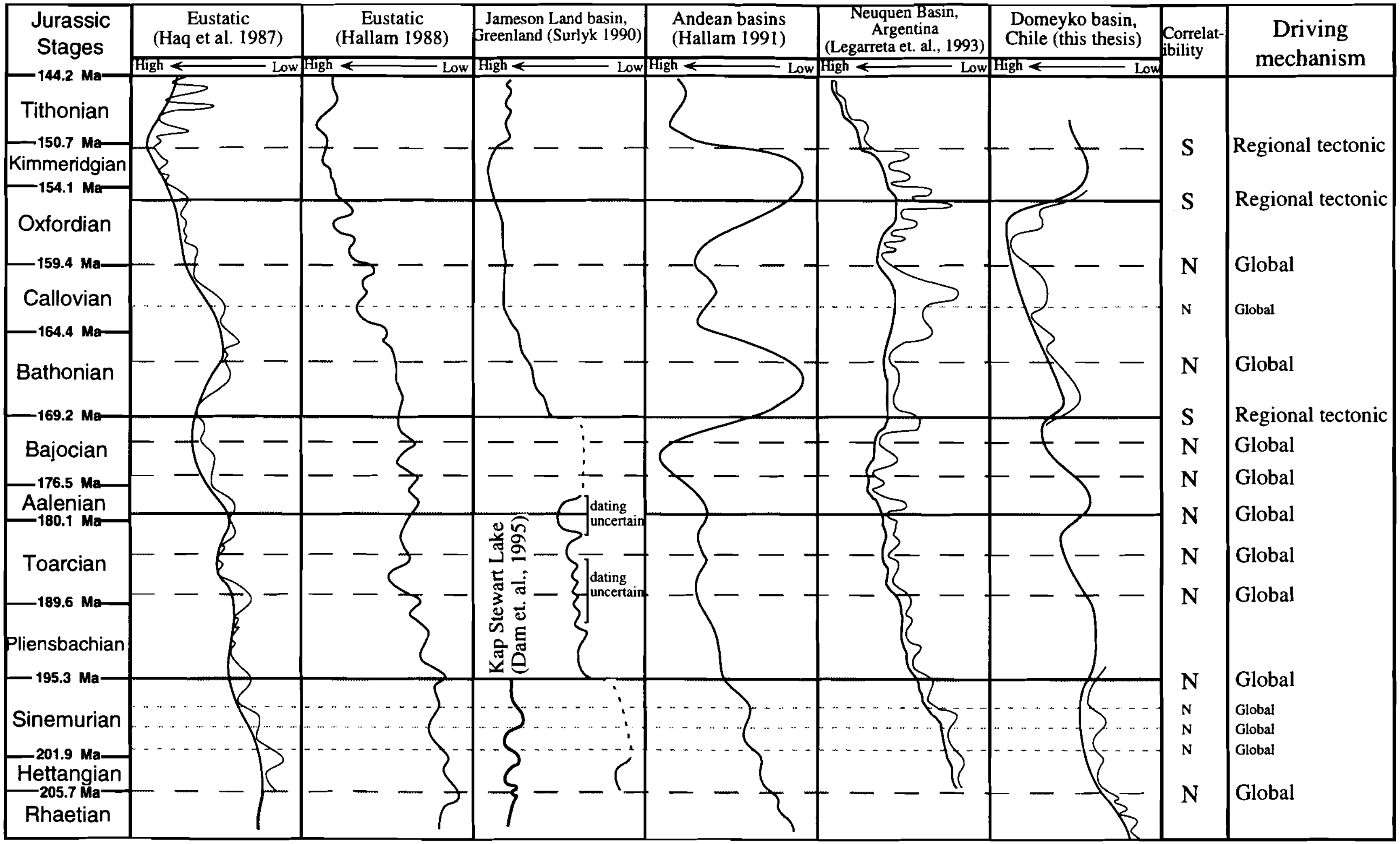

Figure 3 Comparison of Jurassic relative sea-level changes in northern Chile with global (Haq et al. 1987; Hallam 1988) and relative sea-level changes in the Jameson Land basin, Greenland (Surlyk 1990), Andean basins (Hallam 1991) and Neuquen Basin (Legarreta et. al., 1993). Absolute ages of stage boundaries are taken from Gradstein et. al., (1994). The F' and R' inflection points mark sequence boundaries (Solid lines) and flooding surfaces (Dashed lines) respectively with prominent third-order surfaces (Dotted lines) indicated. Correlatability of events is based on whether the event is seen throughout the South American basins (S) or if it can be traced into the northern hemisphere basins (N). The subsequent interpretation of principle driving mechanism is explained in the text and indicated as either regional tectonic or global.

sea-level fall within the basins (Legarreta & Uliana, 1996), despite a pronounced Late Jurassic global eustatic sea-level rise (Haq *et al.*, 1988) (Fig. 3).
The first episode of oceanic spreading within Gondwana took place with its bisection along the Somali, Mozambique and Weddell Sea Basins. Upper Jurassic sea-floor has been recognised along the length of this ocean strait (Simpson *et al.* 1979). Oceanic onset is well constrained particularly midway along the strait in the Mozambique Basin, where the Jurassic Magnetic Quiet Zone has been detected adjacent to the continental margin (Simpson *et al.* 1979) and the onset unconformity on the Mozambique shelf is dated at 157 Ma (Salman & Abdula 1995). The effect of Gondwana bisection on the southern Andes was to introduce northward transgression from the newly formed ocean in the south. Previously all marine transgressions entered the basins from the north, through Peru and northern Chile (Jaillard *et al.* 1990). We suggest that it was this intra-Gondwana spreading event that caused regional contraction, resulting in barring of the Andean back-arc basins and triggering regional evaporite precipitation. The scale of the evaporite deposits is similar to that of the Messinian evaporites of the Mediterranean and such an ocean-spill model has provided an analogue (Legarreta & Uliana 1996). This continental-scale relative sea-level fall was effected during rising global eustatic sea-level.

IMPORTANCE OF SUPERCONTINENTAL FRAGMENTATION EPISODES

Previously the origin of contractional tectonic events affecting the South American margin have been difficult to explain (Vergani *et al.* 1995). Almost exclusively changes in subduction activity associated with oceanic spreading and ocean plate splitting in the Pacific area have been proposed as their principal cause (Vaughan 1995). This is despite the fact that there are no particular signatures in terms of the variation in spreading rates (Larson 1991) that stand out to explain each of the compressional episodes that we document. We believe that thermally induced Gondwanan fragmentation episodes provide a more immediately viable explanation, in that they provide a mechanism for plate re-organisations driving changes along the circum-supercontinental subduction zone. Increased subduction coupling is considered to result in uplift recorded in the marginal basins as tectonically-driven sequence boundaries. Specific basin responses include: (a) Type-1 and -2 sequence boundaries in fully marine successions; (b) basin barring and regionally extensive evaporite formation by spill replenishment; (c) incremental and overall changeover from marine to continental deposition systems; and (d) stepwise eastward migration of the volcanic arc. Plate tectonic theory emphasises the dynamic interaction between adjacent plates, whereby relative rates of motion can be fixed to either the underiding or overriding plate as a reference frame. With reference to the circum-Gondwana subduction zone, we believe that in the past an overemphasis has been placed on the motions of plates in the Pacific region, while our conclusions point to the importance of thermally induced spreading effecting relative motions of plates *within* Gondwana as the principal driving agent promoting subductional coupling. Thus, careful sequence stratigraphic analysis of active margin sedimentary basins provides a high resolution record, presently under-utilised in detecting, identifying and analysing global tectonic events in time.

CONCLUSIONS

The Domeyko basin succession thus appears to be dominantly controlled by global sea-level fluctuations during the Early-Middle Jurassic and by continental-scale (but not global) fluctuations during the Middle Jurassic to Mid-Cretaceous. The global sea-level fluctuations are interpreted to have been driven by glacio-eustasy, while the continental-scale tectonic events are interpreted to have been driven by the break-up of Pangea and subsequent fragmentation of Gondwana.

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