TERTIARY TECTONICS OF NORTHERN PATAGONIA: THE EVIDENCE OF CHILEAN BASIN REMNANTS

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INTRODUCTION

The tectonic setting of Northern Patagonia is unique and provides one of the most exiting tectonic field laboratories in the world. The South American continent has been bounded by a subduction margin throughout the Tertiary. Today a mid oceanic ridge segment is in the process of subduction at 46°30'S latitude (Cande & Leslie, 1986; Behrmann, Lewis et al., 1992) and ridge subduction has operated intermittently for 14 million years (Cande & Leslie, 1986). Another ridge subduction event may have occurred in the Eocene (Cande & Leslie, 1986). Geophysical data has been used to suggest that subducted ridge segments, or the slab windows postulated to form at the locus of subducted spreading centres, continue to be tectonically active several hundred kilometres east of the trench (Murdie et al., 1993; Murdie et al, in review). Detailed investigations in Argentina have attributed Tertiary basalts, Tertiary molasse basin sedimentation and development of a foreland thrust belt to the history of ridge subduction and slab window development (Ramos & Kay, 1991; Ramos, 1989). Within Chile there are significant topographic and related climatic variations which correspond to the change from the continental margin affected by ridge subduction (south of the Chile Triple Junction) and the margin unaffected by ridge subduction immediately to the north (Forsythe & Prior, 1992). The Chilean segment of Northern Patagonia is pivotal to the tectonic understanding of this region, providing the link between the trench and the region comprising the foreland thrust belt, molasse basin and plateau basalts. Structural analysis of this region is particularly complex since many of the units have a considerable pre-Tertiary tectonic history. This is particularly true of the Palaeozoic basement (Hervé et al, 1987) which has enjoyed significant poly-phase deformation during the Palaeozoic. The Mesozoic volcanic successions (Skarmeta, 1978) provide a poor stratigraphic template. Remnants of Tertiary sedimentary basins provide the best opportunity for a first order analysis of the Tertiary structure and history of this region. This paper presents a summary of work completed on the Tertiary Basin systems of Chile between 46°30' and 47°30'S, expresses the significance of these data and suggests future research directions. Figure 1 shows the location of the main basin remnants.

BASIN TEMPLATE

The Tertiary basins are variably unconformable upon Mesozoic volcanics or Palaeozoic basement. A schematic stratigraphy of the Tertiary of Chile South of 46°30'S is shown in figure 2. Locally the clastic sediments lie conformably over an acidic volcanic succession which is itself

unconformable upon the Upper Cretaceous Divisidero/ Cardiel formation. The status of this younger volcanic formation remains unclear; it has been assigned to the Divisidero/ Cardiel by the geological survey (Skarmeta 1978; Niemeyer et al., 1984) whilst Niemeyer (1975) assigned these to a separate formation, the Chile Chico formation and suggested that these volcanics may be Tertiary in age. Although there is no independent evidence for the Tertiary status of these volcanics we also assign them to the Chile Chico Fm.

The Guadal/ Centinela Formation is the lowermost recognized unit within the Tertiary sedimentary succession. We have distinguished a continental clastic succession usually assigned to the base of the Guadal. This is sufficiently distinct to deserve formation status and we have named this the San Jose Formation. The San Jose formation comprises alluvial-fluvial facies in the west, in the Cosmelli Basin. The San Jose formation of the Cerro Rocoso basin comprises fluvial and perhaps deltaic facies. Palaeocurrents within the San Jose are generally to the East.

The Guadal Formation comprises marine and marginal marine facies. Faunal constraints are poor but suggest an age between Eocene and Miocene. In the Cosmelli basin marginal marine facies of the lowermost and uppermost Guadal sandwich a thin more open marine facies. The lowermost marginal facies, including significant oysterbanks, is of regional significance, being clearly identifiable at Lago Posades in Argentina. Palaeocurrents in the Marginal facies of the Cosmelli basin are dominantly N-S. In the Cerro Rocoso basin the Guadal is restricted to a thin layer within Plateau basalts. The basalts lie conformably above the San Jose formation. here the uppermost San Jose includes a significant coal horizon.

The Guadal is overlain by the Galera/Santa Cruz Formation. The nature of this contact is a little cryptic but in general seems to be erosive. The Santa Cruz is an extensive Molasse type fluvial facies system extending several hundred km into Argentina. Palaeocurrents are dominantly to the east. In Argentina further plateau basalts of Pliocene age lie above the Santa Cruz. Mammalian fossils and K/Ar ages of tuffs have been used to constrain the ages of the Santa Cruz between 22 and 12Ma, with younger ages in the north.

BASIN STRUCTURE

Fold and fault structures are identified in both the Cosmelli and Cerro Rocoso basins. These structures accommodate E-W shortening and almost certainly connect to the foreland thrust belt identified to the south and east in Argentina. An east dipping fault defines the west margin of the Cosmelli basin. In both the south and north of the Cosmelli basin this structure has a thrust like geometry, although emplacing Tertiary over older strata. In the north of this basin, the latest movements recorded on the western basin margin fault have a significant N-S strike slip component. The Cosmelli basin has an overall synformal form. In the west of the basin the San Jose and Guadal formations are stacked in a complex imbricate fan suggesting thrusting to the east. The structural complexity decreases up stratigraphy so that the lowermost Galera is only gently folded. Internal disconformities and palaeocurrent patterns suggest that this structure was growing during the sedimentation of the uppermost Guadal.

In Cerro Rocoso the Chile Chico, San Jose, basalts and Guadal are carried by a large scale east directed thrust over the top of lowermost Galera fluvial sediments. The Chile-Chico to basalt stratigraphy now defines a hanging-wall antiform structure. Soft sediment deformation within the lowermost Galera show identical kinematics to the major structure and suggest that the structure was active here during deposition of the lower Galera. An unusual recumbent fold structure in sills within the plateau basalt complex is geometrically comparable to other folds.

The Patagonian fold and thrust belt is thought to have propagated from South to North through time (Ramos, 1989; Ramos & Kay unpublished data). Data from the Chilean Tertiary basins also suggests an overall propagation from west to east, so that tectonic activity in the Cosmelli basin occurred during Guadal deposition , whereas deposition further to the east in the Cerro Rocoso basin occurred

during Galera deposition. The latest strike-slip movements of the fault bounding the Cosmelli basin may also suggest that there is a component of superposed northward propagation.

TECTONIC SIGNIFICANCE

Ramos (1989) and Ramos & Kay (1991) have suggested that the Patagonian molasse basin and the foreland thrust belt relate to the history of ridge subduction. The degree of coincidence of continental topographic, sedimentation and deformation patterns with the region which has experienced ridge subduction is a powerful suggestion of a link between these processes. However, the majority of the dating information suggests that the molasse basin sedimentation and at least some of the deformation initiated before the first ridge collision so that the link between continental plate processes and the plate margin is not so simplistic. It is possible that the initial generation of topography and the molasse basin was in response to subduction of younger and more buoyant crust as the ridge approached.

Further qualification of these models requires an analysis of how the topography and deformation have evolved with time along the margin. The key obstacle to this is the unraveling of Tertiary structures in the Mesozoic and Palaeozoic. In the Mesozoic an understanding of the spatial distribution of volcanic facies and the identification of any regional marker horizons is crucial. In the Palaeozoic it is important to understand fully the Palaeozoic deformation history to establish what has been superposed on this.

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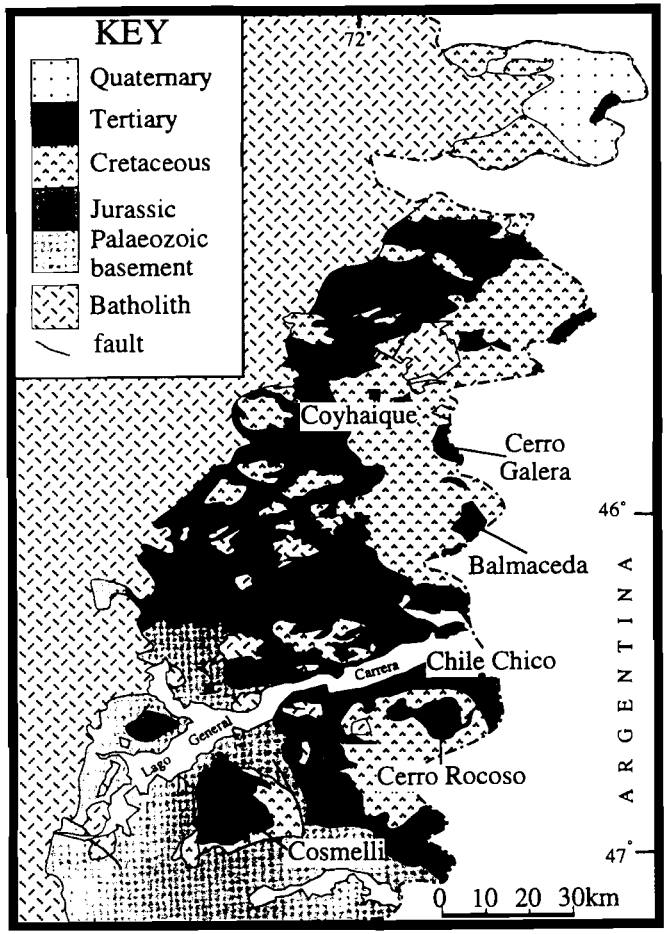
KEY
Quaternary
Tertiary
Cretaceous
Jurassic
Palaeozoic basement
Batholith
fault
72°
Coyhaique
Cerro Galera
46°
Balmaceda
Chile Chico
Carrera
General
Lago
Cerro Rocoso
Cosmelli
47°
ARGENTINA
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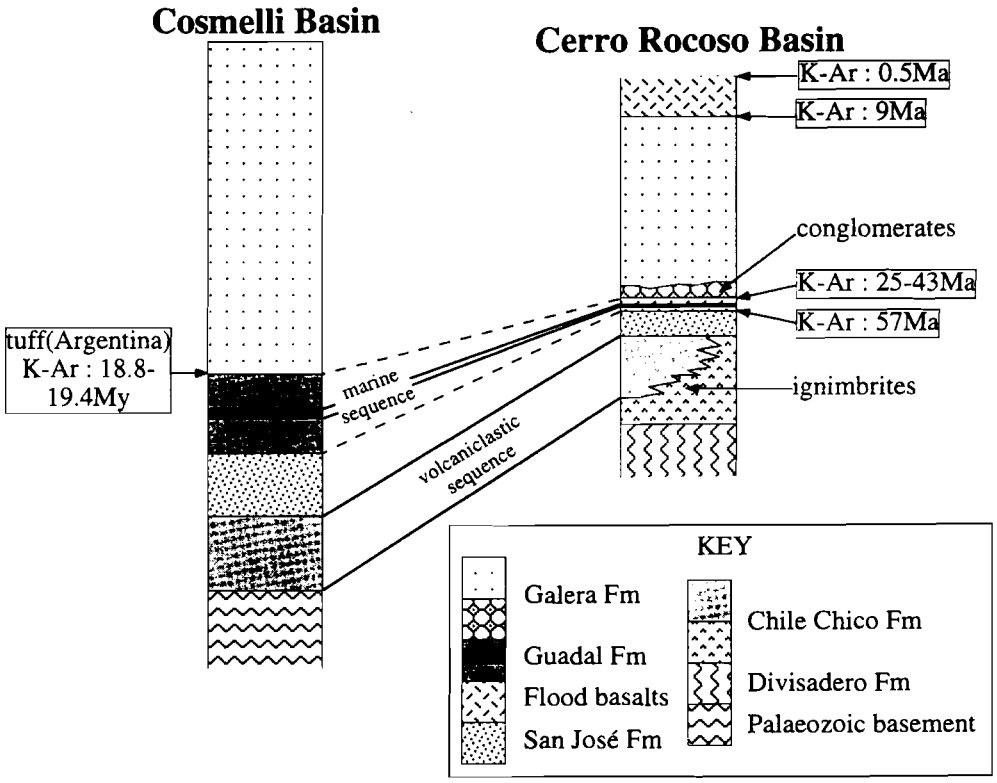
Cosmelli Basin
Cerro Rocoso Basin
tuff(Argentina)
K-Ar : 18.8-19.4My
marine sequence
volcaniclastic sequence
K-Ar : 0.5Ma
K-Ar : 9Ma
conglomerates
K-Ar : 25-43Ma
K-Ar : 57Ma
ignimbrites
KEY
Galera Fm
Guadal Fm
Flood basalts
San José Fm
Chile Chico Fm
Divisadero Fm
Palaeozoic basement