TECTONIC CONTROLS ON GONDWANA BREAK-UP MODELS: EVIDENCE FROM THE PROTO-PACIFIC MARGIN OF ANTARCTICA AND THE SOUTHERN ANDES

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RESUMEN: Se presenta un modelo placa interacción para las primeras etapas del desmembramiento de Gondwana el que vincula una zona ancha de fusión de la astenósfera a un cambio en fuerzas de la subducción placa límite. La presencia de uno plumo astenósferico haya debilado termalmente la litósfera y haya inducido hendeduramiento local contribuir para sino causar la separación final del este y oeste de Gondwana.

KEY WORDS: Gondwana break-up, rifting, magmatism, subduction

INTRODUCTION

Although the association between continental extension, supercontinent break-up, mantle plumes and massive bursts of igneous activity is well recognized, their causal relationship remains a matter of conjecture [Sengor and Burke, 1978]. According to active mantle hypotheses, rifting and associated magmatism are initiated by doming above a mantle plume (Richards et al. 1989) whereas alternative hypotheses consider the presence of a plume enhances break-up only if the stress field is such that initial rifting is likely to occur (White and McKenzie, 1989). In the West Antarctic and Andean sector of Gondwana, initial stages of Gondwana break-up are associated with the large Antarctic-Karoo-Tasman basalt province. Formation of this within-plate province was synchronous with active margin tectonics and development of both a proto-Pacific margin magmatic suite along the Antarctic margin and the extensive Tobífera volcanic suite associated with the Rocas Verdes marginal basin system of southern South America and South Georgia. Consequently the West Antarctic and Andean sector of Gondwana affords an excellent location in which to investigate possible relationships between tectonism, magmatism and the onset of seafloor spreading in continental extension zones (Storey and Alabaster, 1991).

BREAK-UP MODEL

The magmatic record along the proto-Pacific margin of Gondwana records important changes in subduction zone parameters during the initial stages of Gondwana break-up consistent with extension in the overriding plate (Storey et al. 1992). This, together with the

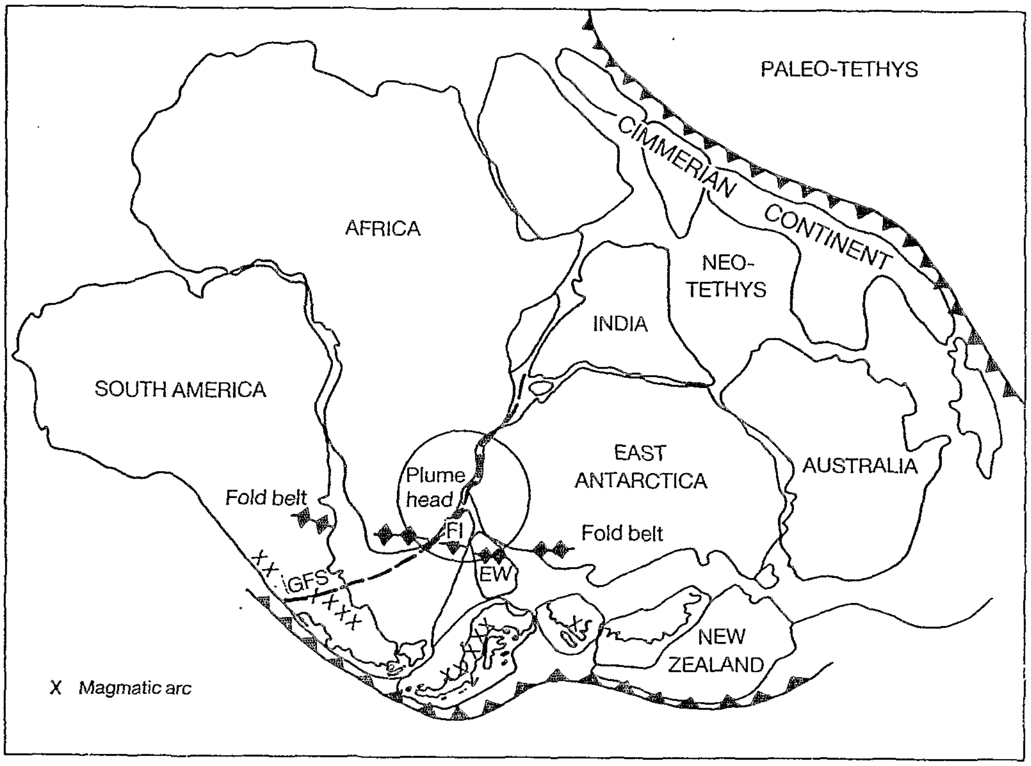

Figure 1. Pre-break-up (early Mesozoic) Gondwana reconstruction illustrating subduction on both sides of the continent, the Gondwanian fold belt and the plume head of White and McKenzie (1989). GFS, Gastre Fault System; FI, Falkland Islands.

record of subduction along the Tethyan margin, suggests that subduction pull on the opposite sides of the supercontinent (Fig. 1) may have given rise to tension within the Gondwana plate leading eventually to break-up. The gravitational potential of crust overthickened during the Permo-Triassic compressional event may have been a contributing factor also. A mantle plume beneath the Karoo province, although not essential to the model, may have thermally weakened the lithosphere, increased magma production rates and induced local rifting, contributing to, but not causing, the eventual separation of East and West Gondwana. Regional tensional forces may have been weak at this time such that sea-floor spreading and continental break-up did not, as far as we know, commence until approximately 155 Ma, 40 Ma after the main plume-related volcanic event of the Karoo (195±4 Ma).

The change from Gondwanide compression to lithospheric extension maybe linked in Early Jurassic times to a reduction in plate boundary forces and a change from a shallow to a steeply dipping subduction zone. During the initial rifting stage a broad extensional province developed in southern South America and West Antarctica (Fig. 2) behind an oceanward migrating magmatic arc. Initial rifting magmas were formed by decompression

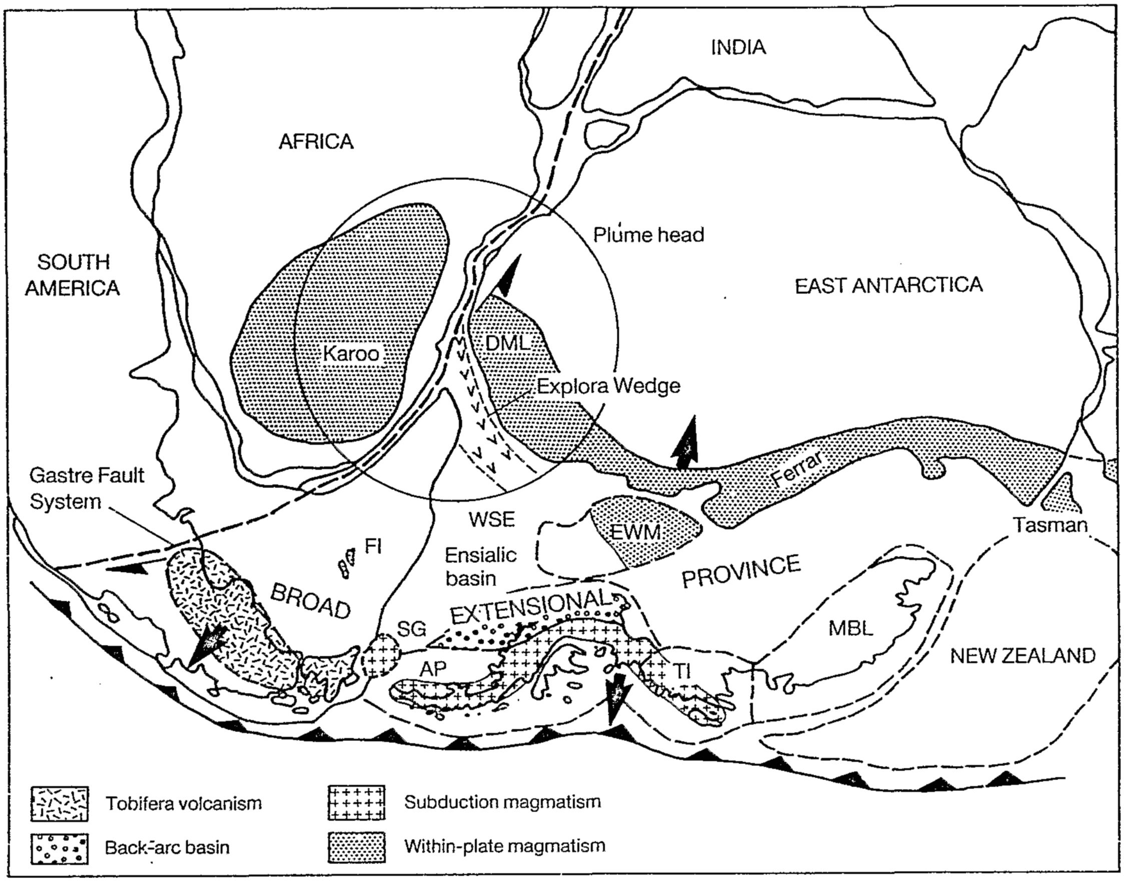

Figure 2. Initial rifting stage of Gondwana break-up illustrating a subduction related magmatic belt, a within-plate magmatic province and a broad extensional province in a back-arc setting.

melting of a mantle source previously enriched (as in the case of the Ferrar magma) or enriched by contemporaneous subduction-induced processes. The mantle may have risen passively in response to crustal extension associated with changing plate boundary forces or possibly by subduction induced convective flow. Anatectic melting at the base of the crust and fractionation of the mafic magmas formed silicic magmas on the margin of the extending basin. A plume beneath the Karoo provinces may have increased magma production rates, formed dipping reflector sequences and induced local rifting.

The broad extensional province is separated from the stable cratonic areas by a major transfer fault zone represented in southern South America by the Gastre Fault System (Rapela & Pankhurst, 1992). Its easterly continuation cuts across the axis of the plume head and may have been controlled by the plumes position. Movement (possibly transtensional) along this zone may have resulted in translation and rotation of the Falkland Islands and the Ellsworth-Whitmore mountains crustal block of West Antarctica during the early break-up stages, and NE movement of East Antarctica relative to Africa (Fig. 2).

The coincidence of break-up with emplacement of high magnesian andesites (155-160 Ma) indicative of atypical thermal conditions during subduction, suggest that geothermal gradients may have been high at this stage and influenced break-up.

CONCLUSIONS

Although the true causes of Gondwana break-up may never be firmly established the data indicate the importance of a plate interaction model encompassing a reduction in subduction plate boundary forces. The combination of subduction pull on the opposite sides of Gondwana combined with the more local tensional effects of a mantle plume and collapse of overthickened lithosphere may have been sufficient to cause break-up and the final separation of east and west Gondwana. The delay of ca. 30 Ma between the Karoo magmatism and final separation suggests the mantle plume did not provide the essential trigger for Gondwana break-up but it may have controlled the ultimate position of break-up and of major fault systems.

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