The intrusion of the Plasencia (Messejana) dike as part of the Circum-Atlantic Early Jurassic magmatism: Tectonic implications in the southwestern Iberian peninsula

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ABSTRACT

The Plasencia dike belongs to a vast Early Jurassic magmatic province that extends around the Central Atlantic. The origin of this magmatic event is related to a thermal anomaly at the base of the lithosphere, and its age has been fixed within a short time span around 200 Ma. In close relationship with this thermal anomaly a process of underplating of the lower crust has been proposed. Assuming the existence of this underplated lower crust, some tectonic features can be explained in the SW Iberian Peninsula such as the nature of the crust, the pattern of Bouguer anomalies and the extension of the area of low relief.

El dique de Plasencia pertenece a una extensa provincia magmática de edad jurásica inferior que abarca ambas márgenes del Atlántico Central. Para el origen de este episodio magmático se ha considerado una anomalía térmica en la base de la litosfera y su edad ha sido establecida en un corto espacio de tiempo, alrededor de los 200 Ma. Como consecuencia de esta anomalía térmica se ha propuesto un proceso de "underplating" en la corteza inferior. Si se tiene en cuenta este proceso de crecimiento magmático de la corteza inferior, se pueden explicar algunas caracteristicas tectónicas del SO de la Península Ibérica, tales como la estructura de la corteza, el patrón de lasanomalías de Bouguer y la extensión del relieve relativamente bajo.

Key words: *Early Jurassic magmatism, SW Iberian Peninsula, Plasencia (Messejana) dike, magmatic underplating.*

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Introduction

Similarities in age and composition with the Foum-Zguid Dike of Southern Morocco led Shermerhorn *et al.* (1978) to include the Plasencia (Messejana in the Portuguese literature) dike of the southwestern Iberian Peninsula within the Circum-Atlantic, Early Jurassic magmatism related to the break-up of Pangea (May, 1971). Since then, new evidences of radiometric ages have corroborated this close relationship between the Iberian diabase dike and the homologous ones in Canada and Morocco. The fact that the Iberian dike belongs to this rift-related, Circum-Atlantic igneous province, allows an explanation of some of the tectonic features of the crust in the southwestern Iberian Peninsula such as its nature and post-Hercynian evolution.

The Early Jurassic Circum-Atlantic igneous province

This magmatic province comprises basaltic dikes, sills and lava flows on eastern North America, on the northern coast of South America, and on the western coast of Africa. The dikes seem to occur in different swarms characterised by northwest, north-south and northeast strikes. To the north, the dikes are less common and become large and continuous as is the case of the Shelburne dike in Canada and the Foum-Zguid in Africa (Fig. 1). In the eastern margin of North America, basalt flows and intrabasinal dikes are related to Triassic fault bounded, "Newark" type, rift basins. In addition, some large plutons of gabbro and syenite composition also occur in the north eastern United States. In eastern North America, the age of this vast igneous province has been fixed around 195-205 Ma by means of conventional K/Ar and $^{40}Ar/^{39}Ar$ techniques (c.f. Cummins *et al.* (1992). The dispersion of K-Ar ages together with the NE-SW direction of some dike swarms (Fig. 1) can be explained in terms of changes in stress configuration and associated thermal effects after the emplacement of the tholeiitic magmas (de Boer, 1992). These ages are in accordance with more precise U/Pb ages of 201 ± 1 Ma and 202 ± 1 Ma for the sills intercalated in the basal continental sediments, assigned on the basis of palaeontology to the Early Jurassic, of the Newark-Gettysburg and Fundy basins respectively (Dunning and Hodych, 1990; Hodych and Dunning, 1992).

On the African side, between Liberia and southern Morocco, this igneous province is also represented by dike swarms, sills and intrabasinal lava-flows (Fig. 1). Conventional K/Ar ages show discrepant results, whereas ages obtained recently by the $^{40}Ar/^{39}Ar$ step-heating method indicate a short time span, between 206 and 195 Ma ago, for the igneous activity (Sebai *et al.*, 1991). These dates are indeed in good accordance with the U/Pb ages obtained in the American margin and one can assume thereafter that the intrusion of the magmas in this vast Early Jurassic Circum-Atlantic province took place in a short time span, around 200 Ma, just before the initiation of sea-floor spreading in the Central Atlantic. In addition, it must be stressed that in eastern North America

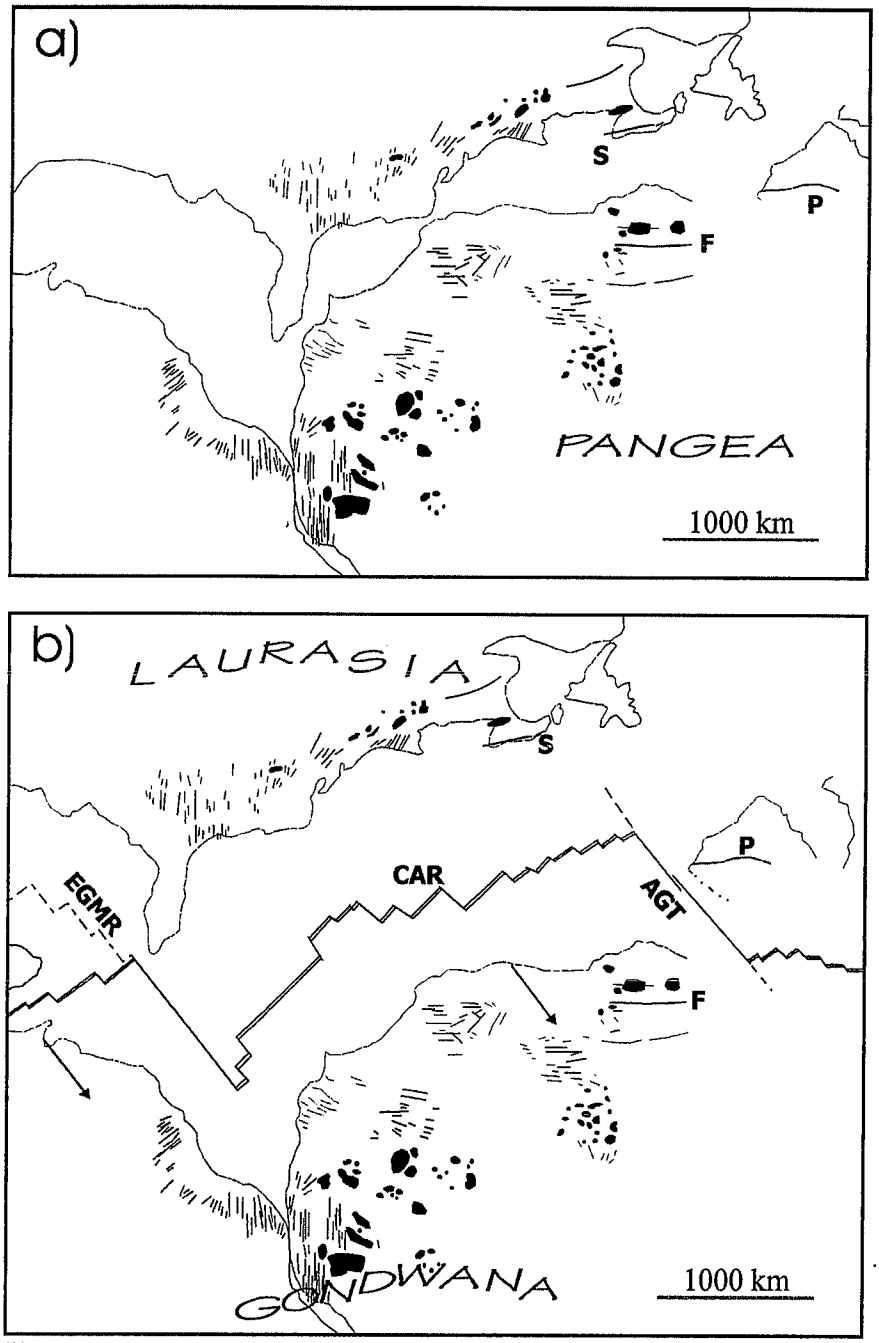


Figure 1. - Extension of the Early Jurassic Circum-Atlantic magmatic province; a) at 180 Ma prior to drifting in the Central Atlantic, b) at 140 Ma. AGT, Azores-Gibraltar transform; CAR, Central Atlantic ridge; EGMR, Extinct Gulf of Mexico ridge; F, Foum-Zguid dike; P, Plasencia dike; S, Shelburne dike.

Figura 1.- Situación de la provincia magmática circum-atlántica; a) hace 180, Ma antes de la apertura del Atlantico Central, b) hace 140 Ma. AGT: Zona transformante de Azores-Gibraltar; CAR: dorsal del Atlántico Central; EGMR: dorsal inactiva del Golfo de Mejico; F: dique de Foun-Zguid; P: dique de Plasencia: S: dique de Shelburne.

this short-lived, Early Jurassic magmatic event is clearly distinct from older intrusions (240 to 210 Ma) related to the pre-rift domal uplift, as well as from an Early Cretaceous (95-135 Ma) magmatic province ascribed to the separation of Newfoundland from the Iberian Peninsula.

The Circum Atlantic Jurassic magmatism in the Iberian Peninsula

Due to drifting first in the Central Atlantic (Fig.1 a) and then north of the Azores–Gibraltar transform, the extreme north of this igneous province became isolated in the Eurasian plate as part of the south western Iberian Peninsula. This Early Jurassic magmatism is mainly represented by the Plasencia dike that corresponds to the northern zone containing the longest dikes. Conventional K/Ar dates of the Plasencia dike turned out to be highly discrepant, between 132 and 192 Ma (Schermerhorn *et al.*, 1978; Schott *et al.*, 1981; Vegas *et al.*, 1997), but recently identical $^{40}Ar/^{39}Ar$ age determinations of 203 ± 2 Ma have been established for both the Shelburne and Plasencia dikes (Dunn *et al.*, 1998). This age determination gives evidence for the extension of the magmatic province in the Iberian Peninsula as well as for an unique and short period of intrusion for the Plasencia dike in the vicinity of 200 Ma ago. Apart from the Plasencia dike, some basalt flows in the Algarve basin could be included in this Early Jurassic province after their K/Ar age determination of 188 Ma (Portugal Ferreira and Regencio Macedo, 1977; 1979). As anywhere in this magmatic province, conventional K/Ar ages seem to be younger than those obtained by the $^{40}Ar/^{39}Ar$ method.

It is noteworthy that in the Iberian Peninsula, as for the Eastern North America, the Triassic magmatism, precursor of the rift-related extension, is represented by older dikes (García de Figuerola *et al*, 1974; Portugal Ferreira and Regencio Macedo 1979), for which K/Ar ages of 230 Ma have been reported by the latter authors. On the other hand, the volcanics of Lisbon and the silicic plutons of Monchique, Sines and Sintra should correspond to the Cretaceous separation of the Iberian Peninsula from North America.

Tectonic implications

The existence of a vast magmatic province extending more than 2500 km in width and 5000 km in length (Fig.1 a), suggest a thermal anomaly at the base of the lithosphere under such a large region in the interior of the Pangea supercontinent. Apart from the intrusive and extrusive magmatism resulting in this thermal anomaly, a process of underplating at the base of the crust can be envisaged (de Boer, 1992). This underplating of the lower crust offers an explanation for the genesis of coeval and younger (Middle Jurassic, and Cretaceous) silicic plutons in Eastern North America (McHone and Butler, 1984, Heaterington *et al*, 1999).

Assuming the correlation of the underplating of the lower crust with the extension of the magmatic province, the

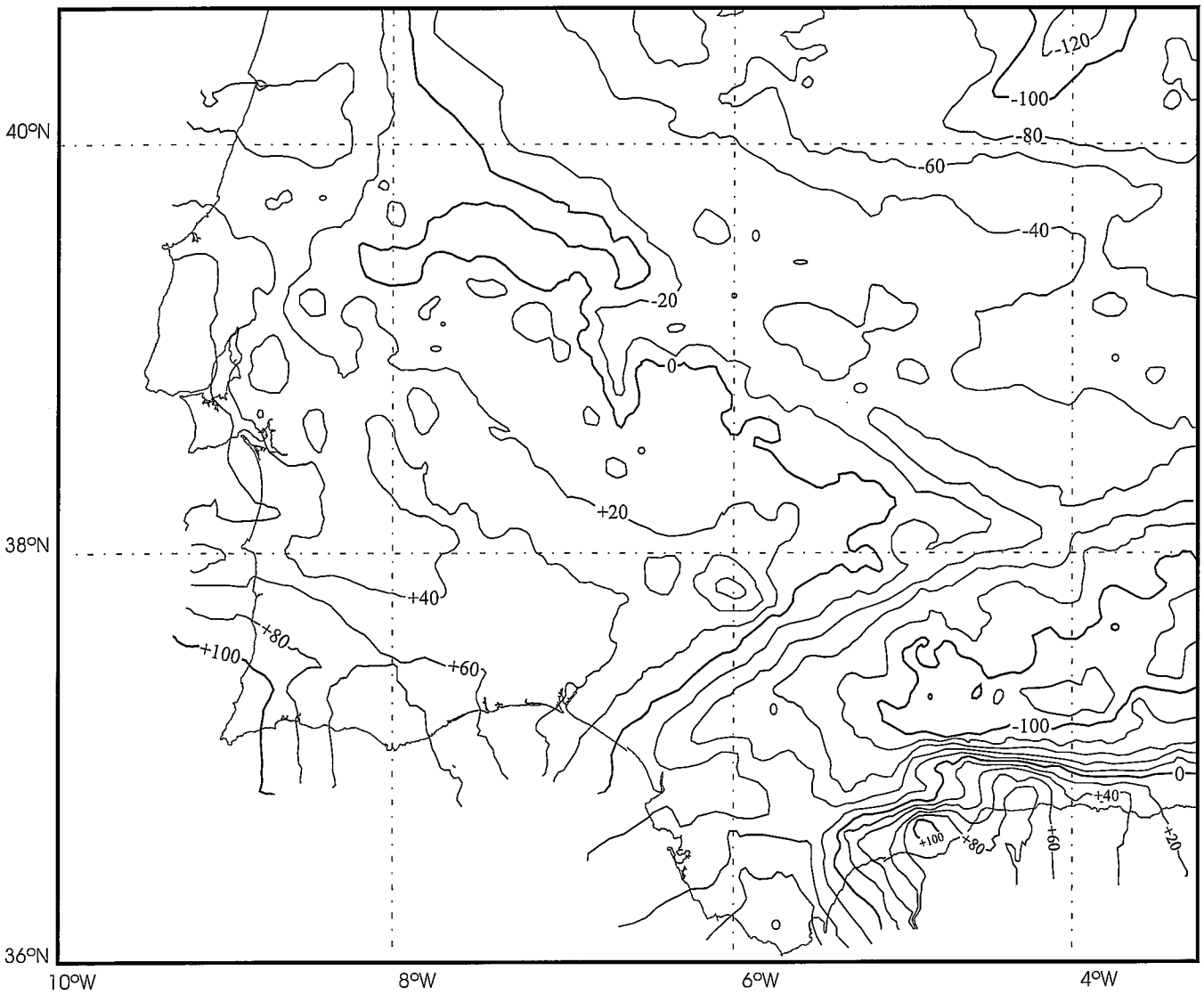
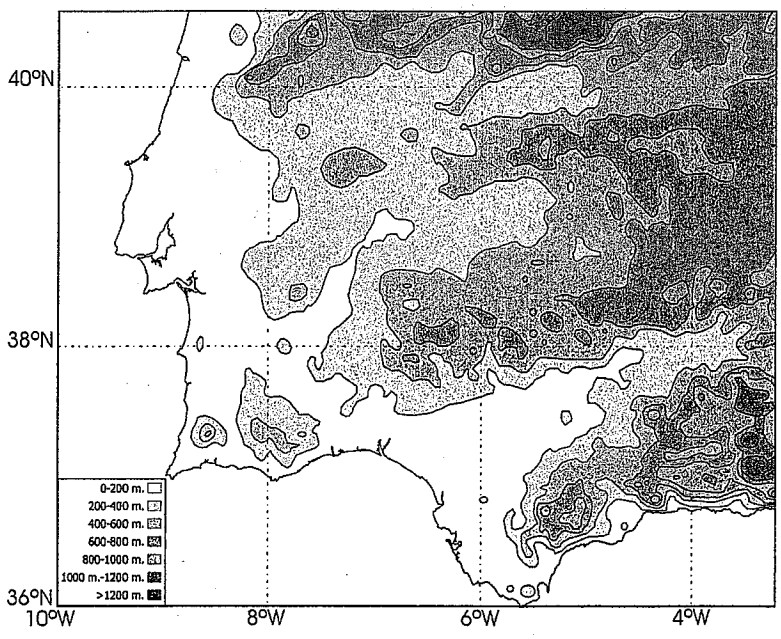


Figure 2. - Bouguer anomaly map of the SW Iberian Peninsula. Notice the situation far inland of the 0 mgal line.

Figura 2.- Mapa de anomalías de Bouguer en el SO de la Península Ibérica. Notese la situación tierra adentro de la isolinea de 0 mgls.



crust in the south west Iberian Peninsula must record this thickening of its lower layer. In fact, wide angle refraction-reflection seismic profiles around the Gulf of Cadiz and the South Central Portugal show a thick lower crust with the crust-mantle interface at depths of 32-35 km (Gonzalez *et al.*, 1998). In this context, the Uppermost Cretaceous intrusive granitic bodies of Monchique, Sintra and Sines can be related to this abnormal lower crust. Moreover this underplated lower crust can explain the pattern of the Bouguer anomalies in the

Figure 3 – Digital topographic map of the SW Iberian Peninsula.

Figura 3.- Mapa topografico digital del SO de la Peninsula Ibérica.

south west corner of the Iberian Peninsula (Fig. 2), which suggests a more dense continental crust than in the rest of the Peninsula. Thereafter this relatively thick crust corresponds to the major extension of low relief in the southern border of the Iberian Meseta (Fig. 3). On the other hand, the existence of this underplated crust in the south west corner of the Iberian Peninsula must condition the localisation and intensity of the seismic activity in close relationship with its differential strength relative to the rest of the crust in the interior of the Iberian Meseta.

Acknowledgements

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