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Melting anomalies and tectonic activity on "passive" margins

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Passive continental margins are created during the rift-drift transition stage of the oceanization process. These margins are commonly regarded as volcanic or non-volcanic according to the amount of igneous products emplaced during the break-up stage. In this respect, the Atlantic Ocean is acknowledged as a classic example of an ocean bounded by passive margins of both nature. In the north, volcanic margins were generated during the Paleocene. In the central part, non-volcanic margins were generated in the Jurassic-Cretaceous. However, in the central Atlantic, both western and eastern conjugated rifted margins are the site of melting anomalies giving way to small-volume magmatism much later than the rift-drift stage.

A prime example of this type of magmatism is found in Senegal, whose continental margin developed in Middle-Late Jurassic and is generally regarded as a monoclinal structure affected by normal faulting. Nevertheless, this margin is affected by post-rift magmatism of Cenozoic age (35-0.6 Ma). The igneous products are scattered over the Cap-Vert peninsula as alkaline lava flows and shallow level intrusions. Additional saucer-shaped sills have recently been detected in the Senegal offshore on the basis of integrated seismic, magnetic and gravimetric surveys. The occurrence of hydrothermal vents and forced folds related to sill intrusion allows to date the igneous event to the Miocene. The age of magmatism displays a minimum delay of 130 Ma with respect to rifting, with consequent decoupling of cause-effect link between rifting and magmatism.

Additional examples of such delayed melting anomalies come from other central At-

lantic passive margins. The North America margin of Newfoundland-Grand Banks is the site of several examples of alkaline igneous activity (dredged seamounts, lavas and sills drilled by OPD) with ages between 135 and 96 Ma, i.e. from coeval to c. 35 Ma later than the oldest oceanic magnetic anomaly. Seamounts dredged off the conjugate Iberian margin along the Tore-Madeira Rise have alkaline nature and ages between 104 and 80 Ma, that is magmatism has a delay of 25 to 50 Ma after rift-drift. Off the north-western margin of Africa, the Canary Islands are the result of long-lived igneous activity delayed of more than 100 Ma with respect to the rift-drift transition there. Further south, past the Senegal margin, the Cameroon line is the site of linear, long-lived alkaline magmatism showing no time progressive shift and active from 60 to 125 Ma after the rift-drift transition. In the south America margin, seismic surveys in the Sergipe-Alagoas-Jacuípe basins offshore north-eastern Brazil, indicate the occurrence of igneous bodies emplaced later than rift-drift stage.

These examples of “delayed” magmatism on passive margins cannot be explained by the activity of several “ad hoc” mantle plumes because of the small volume of magmatism and the absence of time-progressive tracks of igneous activity. Rather, onshore structural data from Senegal are evidence for magma emplacement on fault arrays conjugate with the geometric impact of oceanic fracture zones into the transitional-continental crust. Evidence for fracture zone reactivation is found also in offshore seismic sections. Moreover, gravity and magnetic modelling of location and shape of offshore sills show evidence for a geometric link with the belt of Atlantic fracture zones. Therefore we propose that the engine for the generation of these melting anomalies active on passive margins tens of Ma after the rift-drift transition is linked to the reactivation of oceanic fracture zones.

This mechanism is currently at work in the Antarctic rift. Here, the main rifting episode is of Late Cretaceous age, while alkaline magmatism is active since the Middle Eocene, some 50 Ma later. The igneous activity shows a tight genetic-geometric-geochronological link with the activity of a dextral strike-slip fault system affecting the continental crust and in turn linked to the Southern Ocean Fracture Zones.

The reported examples call for the inclusion in the inventory of passive margin types of a "new" type of margin: besides volcanic and non-volcanic margins, "delayed-volcanic" passive margin with alkaline magmatism should be accounted for.