Twin Hotspot Tracks and Ridge Jumps: The Evolution of the Cocos-Nazca Spreading Center

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Two prominent submarine ridges in the Eastern Panama Basin, the Cocos and Carnegie ridges, formed as twin tracks fed by the Galápagos hotspot: an area where a plume of hot mantle reaches the Earth's surface. They began to form when the Cocos-Nazca spreading center began to open about 23 million years ago (Ma) (Meschede et al., 1998; Barckhausen et al., 2001).

It has been demonstrated that the products of the hotspot volcanism covered a complex pattern of oceanic crust formed at three subsequently active, symmetric spreading systems of different orientation. The identified extinct spreading systems represent precursors of the presently active Cocos-Nazca spreading center. During the Earliest Miocene, the Farallon plate split into the Cocos and Nazca plates following a global rearrangement of plate boundaries. Based on the analysis of magnetic anomalies and on age datings from ODP drillings (DSDP Leg 84, ODP Leg 170) and dredge samples from various research programs, a three stage development of the Cocos-Nazca spreading center could be obtained (Fig. 1). Splitting of the Farallon plate has been dated as 22.7 Ma (magnetic chron 6B1) resulting in the first spreading axis (CNS-1) which was active until 19.3 Ma (magnetic chron 6). The second spreading axis (CNS-2) with a slightly different orientation was abandoned at 14.7 Ma (magnetic chron 5ADr) when spreading jumped to the presently active, E-W oriented CNS-3 axis (Fig. 2).

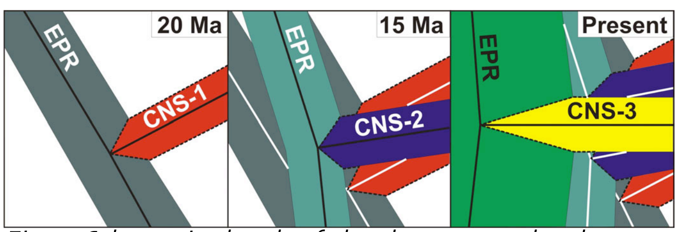

Fig. 1: Schematic sketch of the three-stage development of the Cocos-Nazca spreading system. EPR: East-Pacific Rise, CNS: Cocos-Nazca Spreading System.

A major question was the origin of the Cocos ridge, whose location north of the Cocos-Nazca spreading center seemed to preclude a direct relation to the Galápagos hotspot, which is today located more than 300 km south of the spreading center (Fig. 2). The Carnegie ridge, in contrast, is in line with the Galápagos hotspot and there is no question about its origin. Plate tectonic restorations based on modern absolute plate motion vectors of the Cocos and Nazca plates (e.g., Meschede and Barckhausen, 2000), respectively, demonstrated that since the onset of the CNS-3 axis the spreading axis constantly shifted northward and passed over the main production area of the Galápagos hotspot. Therefore, in the beginning, when spreading has jumped to the CNS-3 axis, the major part of material produced at the Galápagos hotspot has been deposited on the Cocos plate forming the Cocos ridge. Later on, the amount of material deposited on the Cocos plate decreased whereas the amount deposited on the Nazca plate forming the Carnegie ridge increased. Characteristic irregularities of both submarine ridges reflect the changes in material deposition over time.

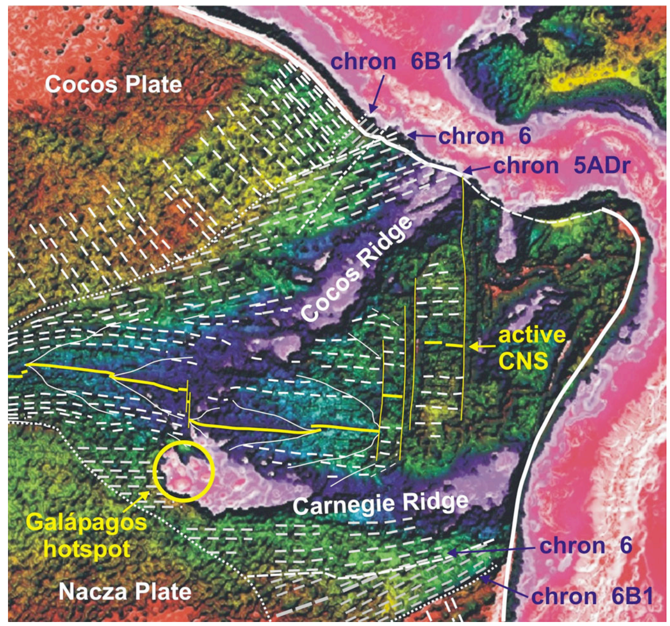

Fig. 2: Bathymetric relief of the Eastern Pacific, magnetic anomalies from Barckhausen et al. (2001)

In conclusion, we consider that both the Cocos and Carnegie ridges have been fed by the Galápagos hotspot, that the amount of hotspot material deposited on either side of the spreading center depends on its location relative to the hotspot, and that the morphological partitioning of the Carnegie ridge into two parts reflects the shift from CNS-2 to CNS-3 at 14.7 Ma when the spreading center jumped southwards. The geometric relationship of the Cocos and Carnegie ridges indicates symmetric spreading and a constant northward shift of the presently active Cocos-Nazca spreading center.

References:
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