Discussion of

The "Plate" model for the genesis of melting anomalies

by

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26th December, 2006, Rex H. Pilger

Foulger (this volume) writes that the Easter melting anomaly is located close to a ridge triple junction and is associated with a microplate. Pilger & Handschumacher (1981) showed that the Easter "hotspot" could have produced both the Tuamotu and Nazca ridges as well as the Sala y Gomez trace, especially if the Hawaiian-Emperor bend were older than 43 Ma, significantly predating the triple junction and the Easter plate. The oblique trends of the Tuamotu and Nazca ridges to magnetic chrons implies that the first stress mechanism proposed by Beutel & Anderson (this volume) is not applicable, but the second, melting anomaly mechanism (also part of the "Plate" model of Foulger) could still apply.

Foulger also states, "The direction of propagation [of the Hawaiian-Emperor chain] changed by ~ 60° at ~ 47 Ma, at the time of the "bend" … No corresponding change in the direction of Pacific plate motion occurred at this time …" There is indeed no evidence of a change in Pacific plate motion relative to adjacent plates at 43 Ma. However, there are ~ 47 Ma kinks in motion loci of all adjacent continental plates relative to Pacific plate (Norton, 2000, Fig. 10). North and South American-Pacific loci show comparable deflections to the Hawaiian-Emperor bend.

Loci of Pacific and Farallon (-Juan de Fuca) plate motion and North American and Hawaiian "hotspot" motion are shown in Figure 1, interpolated at 5 Ma intervals, using parameters from Pilger, 2007. The circled nodes indicate the 45-Ma reconstructions and bends (finer interpolation would show bends from 45 to 48 Ma). A possible explanation for these correspondences is presented in Pilger (2007).

The oft-stated lack of correspondence of the "bend" with plate motions is apparently erroneous, but this does not invalidate the "plate" hypothesis for the origin of anomalous volcanic traces.

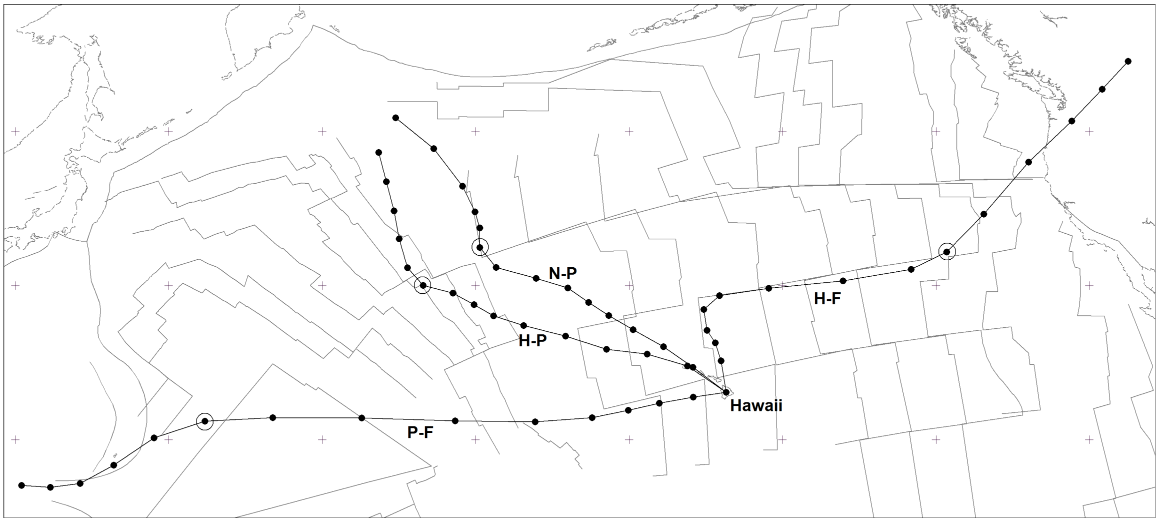

Figure 1. Calculated loci at 5 Ma intervals, from Hawaii: H-P (Hawaiian “hotspot” relative to Pacific plate); N-P (North American to Pacific); P-F (Pacific to Farallon plate); H-F (Hawaii to Farallon). Circled nodes are at 45 Ma.

8th February, 2007, Gillian R. Foulger & William W. Sager

In his comment of 26th December, Pilger makes two points. First, he writes that a fixed Easter “hotspot” could have produced the Tuamotu, Nazca, and Sala y Gomez ridges. In a region containing widespread volcanism it is to be expected that some can be found that conform with fixed hotspot models. However, the Easter and Sala y Gomez chains emanate from the southern edge of the Easter microplate, and this is unlikely to be coincidence.

Pilger’s second comment is to take issue with a statement in Foulger (this volume) that there was no change in plate motion corresponding to the Hawaiian-Emperor Bend. Models of plate motion based on the Hawaiian-Emperor and Louisville chains only, and assuming the fixed hotspot hypothesis predict a large change. However, other reconstructions do not, e.g., that of Raymond et al. (2000) which is based on hotspot propagation models for the Indian and Atlantic plates, reconstructing them to the Pacific plate using relative spreading models from magnetic lineations.

Pilger argues for a significant shift in plate motion based on kinks in his plate motion trends for the South American and North American plates relative to the Pacific. However, the contemporaneous changes in his Figure 1 for plates adjacent to the Pacific are small or non-existent. Furthermore, the paths of the North American and South American plates relative to the Pacific plate are highly uncertain as a result of errors in the long chains of relative plate motions that must be used to make such reconstructions and uncertainty concerning the long term rigidity of Antarctica as a single plate. These uncertainties are large, and not shown in Figure 1 (above).

The fact that the bend in the Hawaiian-Emperor chain is accompanied by very small changes, if any, in the major fracture zones of the Pacific is a first-order observation that cannot be readily dismissed. The 60˚ change in trend in the Hawaiian-Emperor chain, now known to have occurred at ~ 50 Ma (Sharp and Clague, 2006), can correspond to only a small change in plate motion if any. Atwater (1989) attributes a small change in plate motion at about this time to the breakup of the Farallon plate into north (Vancouver Plate) and south parts. The small change in direction she postulates is accompanied by only very small changes in the fracture zones. If the plate changed direction, new plate rotation poles would be set up and large changes in the transform faults would be expected. The orientations of fracture zones are, after all, *prima facie* testimony of the direction of plate motion, in contrast to other data that usually require careful processing to extract plate motion direction information.

The time of the bend correlates with a radical change of behavior of the melting anomaly, where it ceased rapid southerly migration with respect to the geomagnetic pole (Tarduno et al., 2003; Sager, this volume). The evidence is consistent with most of the north-south motion implied by the Emperor seamounts being due to migration of the locus of melt extraction, and not by plate motion, whereas the reverse is the case for the Hawaiian chain. In the deep-rooted, fixed hotspot hypothesis, the occurrence of this change in behavior simultaneously with a major plate motion change would have to be coincidence. We find this unlikely. The conclusion is inevitable, that the bend in the Hawaiian-Emperor volcano chain is probably largely due to a change in migration behavior of the melt extraction anomaly, and not to a change in plate motion direction.

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