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Forum Reply

Revision of Paleogene plate motions in the Pacific and implications for the Hawaiian-Emperor bend

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The comment by Wilson (2016) promotes an alternative view for the formation of the Hawaiian-Emperor bend (HEB). Here, we address the concerns raised by Wilson, and explain why our reasoning results in a different interpretation. Wilson's alternative view prefers the HEB as a result of minimal (or no) hotspot motion and a large-scale plate motion change, and explains the decreasing Emperor seamount paleolatitudes as a result of true polar wander. Little hotspot motion is inferred based on errors in global plate circuits (e.g., Koivisto et al., 2014), in particular, errors in East–West Antarctica spreading. This alternative view was once the "conventional wisdom" for the HEB, prior to insights from a number of geodynamic, paleomagnetic, and global plate circuit studies (previously outlined, e.g., Tarduno et al., 2003, 2009) that have led to a new appreciation of the role of mantle dynamics in shaping hotspot tracks.

Wilson argues that our conclusions in Wright et al. (2015) are consistent with a large change in Pacific plate absolute motion. He raises concerns in the uncertainties in the geomagnetic polarity time scale (GPTS) and both relative and absolute plate motion models (i.e., due to assumed symmetrical spreading and global plate circuits). Further, he suggests the HEB involved a small change in hotspot motion and a large-scale change in plate motion.

We acknowledge that there are uncertainties in the GPTS, which is why we chose to show Pacific-Farallon relative plate motions and our plate velocity diagrams (Wright et al., 2015, our figures 2 and 3) in two time scales: Cande and Kent (1995) and Ogg (2012). We also suggest the assumption of Pacific-Farallon spreading symmetry is not unreasonable, as the Nazca plate preserves symmetric Pacific–Farallon spreading at HEB time (Wright et al., 2016). Wilson states that the Pacific absolute motion models, shown in our figure 3, share common errors in the global plate circuit that we do not discuss. However, we did not require a global plate circuit for our analysis—the Pacific plate is a common link between Pacific absolute motion and Pacific-Farallon relative motions, and the Pacific absolute motion models used were all constructed without utilizing a global plate circuit.

Wilson correctly states that, due to spherical geometry, a decrease in Pacific-Antarctic rates at the Pitman Fracture Zone is expressed as an increase at the location of the Hawaiian hotspot. When calculated at the Hawaiian hotspot, Pacific-Antarctic motion would result in ~25–30° change at ca. 47.5 Ma. However, ~30° of the required ~60° change for the HEB is still unaccounted for, which Wilson does not explain. Further, Wilson makes no attempt to relate the change in Pacific-Antarctic relative motion to the mantle, unless he assumes West Antarctica has remained fixed to the mantle in the Cenozoic (an unreasonable assumption, considering that West Antarctica was separating from East Antarctica after HEB time, forming the West Antarctic Rift System and seafloor spreading in the Adare Trough).

Critically, Wilson has failed to demonstrate why a change in Pacific-Antarctic motion (Wilson, 2016, his figure 1) is crucial for a change in Pacific absolute motion. If all the HEB requires is a small change in Pacific-Antarctic motions, one should expect large bends in the Hawaiian-Emperor seamount chain at other times corresponding to a change in Pacific-Antarctic velocities, e.g., chrons 24o, 26o, and 27o (ca. 54, 59, and 62 Ma, respectively) (Fig. 1). However, no such correlation can be found along the Hawaiian-Emperor seamount chain (or the Louisville seamount chain), suggesting more than a small change in Pacific-Antarctic motion is required for a bend as large as the HEB. These changes in Pacific-Antarctic velocities are likely recorded as minor deviations in the linear path of the Emperor seamount chain. Wilson suggests the HEB involved a small change in hotspot motion (30–50 mm/yr) and a large-scale plate motion (50–70 mm/yr) change; however, no explanation for the derivation of these values is given.

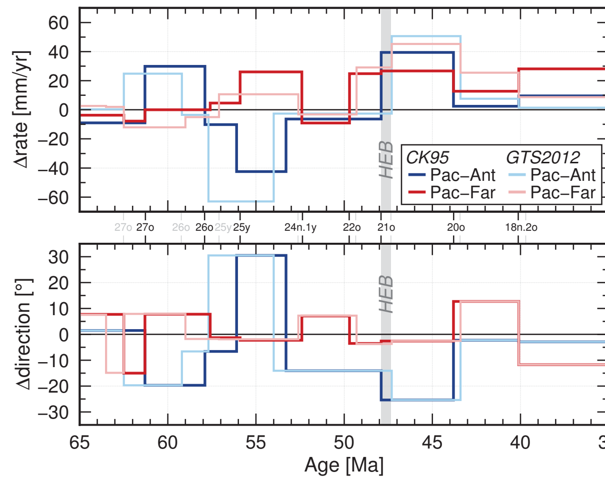

Figure 1. The change in rates (mm/yr) and direction (°) between stages for Pacific-Antarctic (Pac–Ant) and Pacific-Farallon (Pac–Far) motion, calculated at Hawaii. Velocities are shown in Cande and Kent (1995; CK95) and Ogg (2012; GTS2012). A change in velocities and large bend (Hawaiian-Emperor Bend; HEB) occurs at ca. 47 Ma (gray). All other changes in velocities are not accompanied by a bend.

While Wilson (2016) highlights some issues regarding the HEB, we find our original conclusions still stands—that the history of plate motions from around the Pacific basin are most consistent with the HEB being primarily due to the motion of the hotspot.

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