

The Regular Distribution of Intraplate Volcanism in the Pacific Basin

Alan D. Smith

CIE-UNAM, Temixco, Morelos, Mexico, as@cie.unam.mx

Before the concept of hotspots/plumes was widely invoked, Jackson and Shaw (1975) proposed the distribution of intraplate volcanism in the Pacific basin was controlled by plate tectonic processes producing changes in the stress field of the plate. At the time such concepts could not be proven as the bathymetry of the ocean floor and the tectonic history of the basin margins were poorly known. With the increasing popularity of the mantle plume concept, interpretations switched to emphasis of a random distribution of volcanism generated from deep-seated thermal anomalies. However, few examples of intraplate volcanism in the basin have been shown to conform to the predictions of the plume model. Potentially only three examples (Easter-eastern Mid Pacific Mountains, Louisville-Ontong Java, Marquesas-Hess/Shatsky) possess the oceanic plateau-island chain sequence as expected from the plume head-tail model (Clouard and Bonneville 2001). Non-linear age progressions are found in many island chains, including the Cook-Austral-Marquesas, Marshall-Gilberts, and Line Islands. Even the Hawaiian-Emperor chain, generally considered the archetypical example of plume volcanism, does not the features expected in the plume model. The volcanism lacks an associated plateau, eruption rates have increased rather than decreased over time, and paleomagnetic evidence (Sager 2002) indicates any hotspot could only have been stationary for half its history.

Correlations between volcanic output along the ocean island chains can now be correlated with basin-wide plate re-organisations such as at 25 and 5 Ma (Kamp 1991) suggesting the stress field model was essentially correct more than a quarter century ago. Reconstruction of the evolution of the Pacific basin (Fig. 1) demonstrates that oceanic plateaus were generated in zones of tension in the wake of retreating triple junctions, and that ocean island chains may be divided on the basis of propagating- or leaky- fracture origin. The latter, including the Louisville, Marshall-Gilbert, Line Island, and Cook-Austral-Marquesas chains are those characterised by non-linear age progressions. Such volcanism followed pre-existing NNW–SSE trending fracture zones such as the Kashima-Eltanin and Emperor-Easter megatrends (Smoot 1999). The fracture zones form part of a pattern of orthogonally intersecting lineaments initiated by transform faulting along ridge systems during the early history of the Pacific plate. Volcanism that can be attributed to propagating fractures includes the Sala y Gomez, Juan Fernandez, and Caroline chains which extrapolate to breaks in nearby subducting slabs suggesting stressing of the plate by convergent margin geometry. The Emperor chain is unique in the stress field model in representing volcanism along a propagating fracture induced at a divergent margin. The location and orientation of this chain is attributed to the geometry of the Kula-Pacific ridge following plate re-organisations at 82 Ma which prematurely halted triple-junction volcanism on Meiji seamount. Subsequent volcanism along the Hawaiian chain can be explained by re-orientation of the stress field to control by convergent margin geometry following abandonment of the Pacific-Kula ridge, and does not require a change in Pacific plate motion at the time of the Hawaiian-Emperor bend (43 Ma).

The distribution of Pacific intraplate volcanism is therefore more regular than would be expected than in the plume model, and can be explained as a result of shallow

volatile-bearing sources tapped under developing hotcell conditions, with the change from oceanic plateau to island chain volcanism reflecting changes in the stress field as the Pacific plate changed from having an intra-oceanic setting bordered by ocean ridge systems, to subducting beneath the basin margins (Smith 2003).

References

Clouard, V., and Bonneville, A., 2001. How many Pacific hotspots are fed by deep-mantle plumes? *Geology* **29**, 695-698.

Jackson, E.D., and Shaw, H.R., 1975. Stress fields in central portions of the Pacific plate: delineated in time by linear volcanic chains. *Journal of Geophysical Research* **80**, 1861-1874.

Kamp, P.J.J., 1991. Late Oligocene Pacific-wide tectonic event. *Terra Nova* **3**, 65-69.

Sager, W.W., 2002 Basalt core paleomagnetic data from Ocean Drilling Program Site 883 on Detroit Seamount, northern Emperor seamount chain, and implications for the paleolatitude of the Hawaiian hotspot. *Earth and Planetary Science Letters* **199**, 347-358.

Smith, A.D., 2003. A re-appraisal of stress field and convective roll models for the origin and distribution of Cretaceous to Recent intraplate volcanism in the Pacific basin. *International Geology Review* **45**, in press.

Smoot, N.C., 1999. Orthogonal intersections of megatrends in the Western Pacific ocean basin: A case study of the Mid Pacific mountains. *Geomorphology* **30**, 323-356.

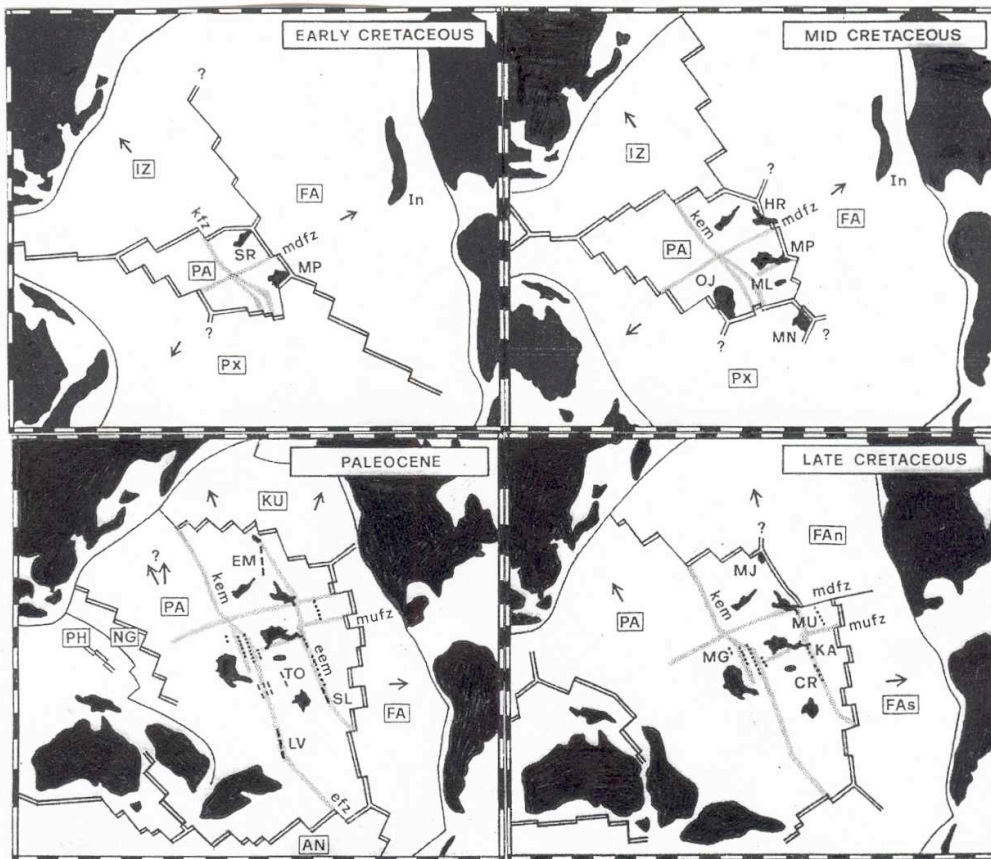


Figure 1. Evolution of the Pacific basin from the Early Cretaceous through Paleocene illustrating the relationship of oceanic plateaus to triple junctions and ocean island chains to pre-existing lineaments (after Smith 2003). The lineaments (grey) form an orthogonal pattern reflecting their origin as predominantly as transforms along spreading centres bounding an initially rhombic Pacific plate. Plates FA Farallon (FAn north, FAs south), IZ Izanagi, KU Kula, NG North New Guinea, PA Pacific, PH Philippine, PX Phoenix. Lineaments: kem Kashima-Eltanin megatrend, eem Emperor-Easter megatrend, mdfz Mendocino fracture zone, mufz Murray Fracture zone. Oceanic plateaus: SR Shatsky Rise, MP Mid Pacific Mountains, ML Magellan Rise, OJ Ontong Java, MN Manahiki, HR Hess Rise, MJ Meiji. Ocean island chains (dashed and dotted lines): MG Marshall-Gilbert, CR Christmas Ridge, KA Karin, MU Musicians, SL South Line, TO Tokelau, LV Louisville, EM Emperor.