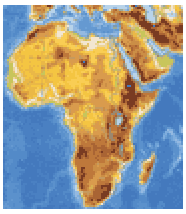
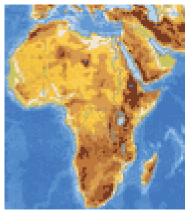


Magmatism Within Africa: Lithophere Control and Global Tectonics



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Since the original concept of plumes as an explanation for intraoceanic volcanism, they have become a popular choice for the cause of intracontinental igneous activity, where the most numerous eruptions, in time and space, are small volume melts in the alkaline igneous-carbonatite-kimberlite range. Such activity is most intense in interior Africa, which has been anorogenic for 550 Ma, with a lithosphere record > 3 Ga. Because continental alkaline magmatism is characteristically repetitive through the same segment of the lithosphere over geologic time, this long record is ideal for defining constraints on processes of magma generation.

Plume models for African magmatism are numerous and highly divergent, but in the absence of hot spot tracks none can claim the primary attribute of plumes, namely, lithosphere independence. On the contrary, the typical pattern in Africa is that the magmatism is sited on pre-existing structures in the lithosphere, notably rifts and rift intersections. Some have a record of repeated activity over periods of 2 Ga, during which time the African plate has moved long distances over the deep mantle.

When the canvas is broadened to other parts of the plate the constraints are multiplied, because with increasing age data it is becoming apparent that in many cases igneous episodes in different provinces are synchronous (Figure 1). Repeated, synchronous magmatism at the same sites across Africa is incompatible with any plume model. As many of the eruptives carry ocean island basalt (OIB) type chemical signatures, it follows that these are not exclusive to plume melting. Petrogenetic options are still further constrained when the African igneous episodes are found to coincide with external, global events.

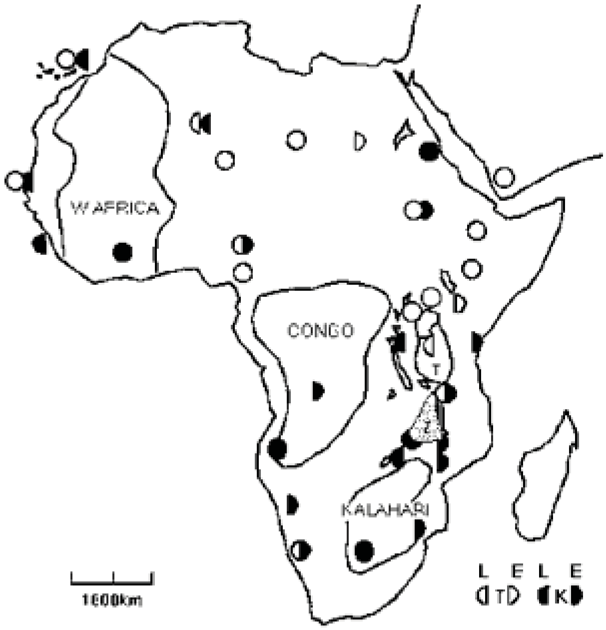


Figure 1: Synchronous repetition of CALK (Carbonatite-Alkaline igneous-Kimberlite activity) in widely scattered provinces across the African plate. Since Gondwana break-up the activity peaks E-K, L-K, E-T, T-R in Figure 2, are registered in 29 provinces, most of which have already yielded records of two or three of the four episodes. This space-time distribution requires that triggering of CALK eruptions must be a plate-wide episodic phenomenon, exploiting pre-existing anisotropies in the lithosphere. (For localities and references see Bailey, 1992). T is the Tanzania craton. The stippled area (Z) south of L. Tanganyika shows the approximate position of the Precambrian upland bounded by the rift zones of Luangwa-Zambesi-Malawi.

Since the late Precambrian, the carbonatite/alkaline igneous age histogram for Africa reveals spikes of activity, which until 140 Ma are of similar amplitude, but between 130-80 Ma and 40-0 Ma, there were unprecedented levels of activity (Figure 2). The Cretaceous "storm" is also signaled in kimberlite activity peaks, especially in southern Africa. The clearly-defined surge in igneous intensity during the Cretaceous correlates with the Magnetic Quiet Zone (CN superchron), and is matched by major magmatic bursts in other plate interiors, and by changes in sea floor spreading rates, sea levels, sedimentation and chemical stratigraphy (Figure 3).

Figure 2. (Overleaf) Frequency vs. age histogram of CALK activity across Africa (A&L combined). Episodes: P-A, Pan-African; E-C, Early Caledonian; L-C, Late Caledonian; A, Armorican; G, Gondwanaland starts to break up. Africa/Europe start to collide: O, according to Olivet et al. (1987) D, according to Dewey et al. (1989). C-N shows span of CN superchron. Cretaceous-Recent peaks: E-K; L-K; E-T; T-R. From Bailey & Woolley, 1995. Details on igneous ages, data, methods, sources, in Woolley (2001).

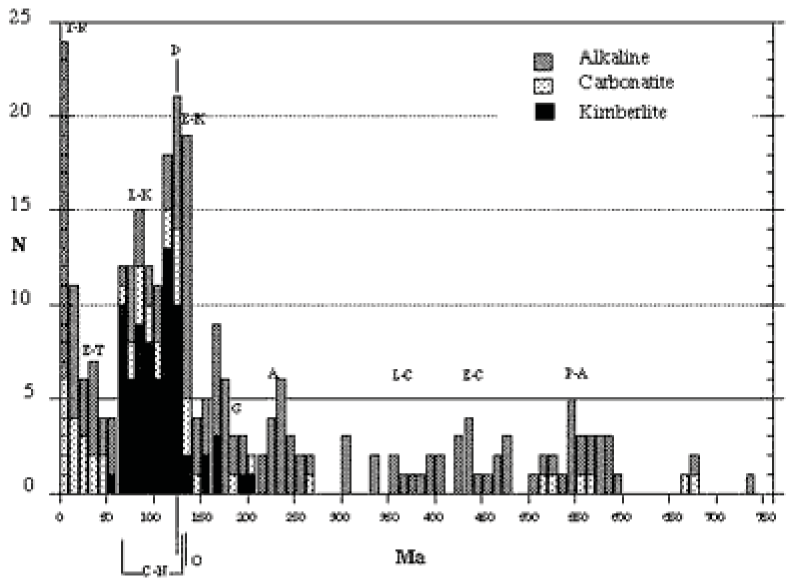
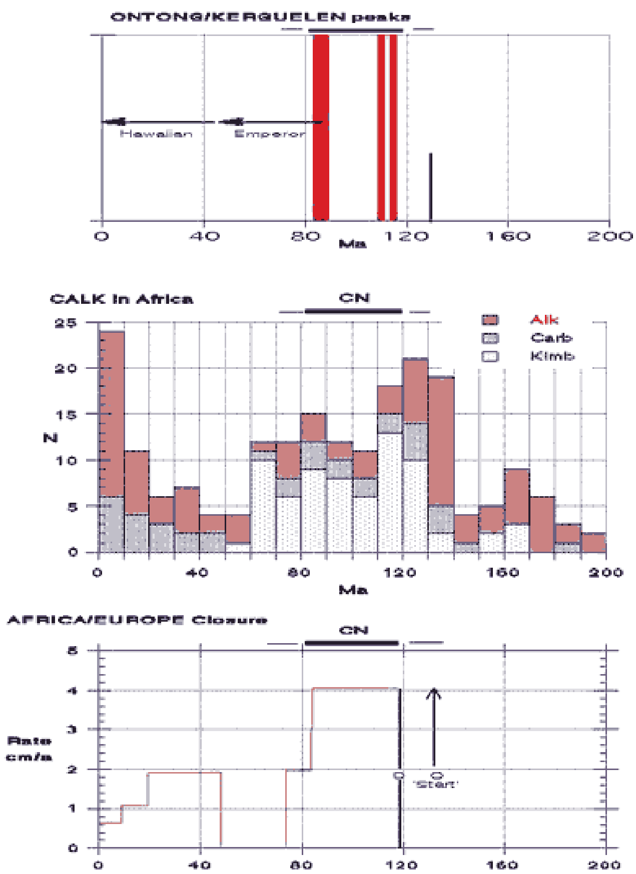


Figure 3. Age correlations of magmatic events with the CN Superchron (time span shown at top). Two main age peaks of the large igneous provinces of Kerguelen and Ontong-Java plateaux (Pringle et al., 1995; M. Coffin, pers. comm. 1995; A.D. Saunders, pers. comm. 1995), and key dates in Emperor-Hawaiian line. Igneous ages histogram for CALK across Africa (sources as for Figure 2). Closure rates for Africa/Europe collision (calculated from Dewey et al, 1989: Figure 1, east end of Mediterranean). D and O as in Figure 2.



Globally, the magmatic outbursts marking Early and Late Cretaceous are neither exclusively alkaline, nor continental. Both of the biggest oceanic Large Igneous Provinces, the Ontong-Java and Kerguelen plateaux, have their main eruption dates around 120 Ma and 85 Ma. Such correlations are consistent with the geophysical inference that the CN superchron marks a critical perturbation in mantle dynamics over this period. Further details may be found in *Bailey & Woolley* (1995,1999).

Petrogenetic hypotheses currently in vogue are clearly inapt for the new scenario emerging from the improving chronology of magmatism, tectonics and other worldwide phenomena. African magmatic episodes, therefore, must be manifestations of larger, global processes, capable of re-activating old zones of weakness in plate interiors. Each re-opening of channels allows a new flux of volatile and incompatible elements to move into the lithosphere, with all the potential for metasomatic enrichment, and ultimately for near-solidus melting and typical alkaline magmatism. No matter what melt mechanism is preferred, magmatism within Africa declares that the final control is in the plate structure, and the process cannot be lithosphere independent.

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