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# Advancing beyond May 1971: How Do We Deal with the Possibility of Complicated Dyke Geometries, Long-Lived Lips, and Contrasting Basement Geological Provinces?

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The iconic image of a giant radiating dyke swarm subsequently fragmented into three pieces via supercontinental breakup was produced by Paul May in 1971 (see next page). That figure presented a large part of the conceptual basis for the LIP-barcode method of supercontinent or supercraton reconstruction (Bleeker 2004; Bleeker and Ernst 2006) which has now been applied in many Proterozoic examples around the world (e.g., French and Heaman 2010; Peng et al. 2011; Ernst et al. 2013, 2016). The method requires the original dyke swarm geometry to be radial; it is strengthened if the magmatism is very short-lived, on the order of a few Myr or less; and it ideally would be bolstered by compatible pre-LIP geological basement provinces among the now-fragmented cratons. Can the radial LIP-geometry method or LIP barcode method be considered reliable if any of these factors is demonstrably disproven?

The first assumption of a radial (i.e. spoke-like) geometry can be definitively ruled out in several dyke swarms across large, internally rigid cratons. To name a few, the ca. 720-Ma Franklin LIP includes Clarence Head dykes striking orthogonal to the "spoke" (Denyszyn et al. 2009), the ca. 1370-Ma Lake Victoria dyke swarm with its spectacular concentric geometry (Mäkitie et al. 2014), the ca. 1780-Ma North China dyke swarm criss-crossing basement uplifts in a mesh-like pattern (Peng et al. 2008), and the ca. 2660-2670 Ma Rykoppies and Wit Mfolozi swarms intersecting at nearly right angles (Gumsley et al. 2016). Perhaps the most bizarre aggregate geometry of dykes is the ca. 1210-Ma Marnda Moorn LIP across the Yilgarn craton in Western Australia (Pisarevsky et al. 2014). Although such well-documented instances are rare, there are many examples of less well exposed dyke swarms for which the broader LIP geometry can only be surmised.

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The second criterion of the May (1971) method is a short duration of the magmatic pulse. This has been shown for CAMP at 200 Ma (Blackburn et al. 2013) and other LIPs such as Mackenzie at 1267 Ma (LeCheminant and Heaman 1989), but there is increasing recognition of parallel dyke swarms with age ranges spanning 10 Myr or more: as examples, Matachewan dykes in Superior craton (summarized in Evans and Halls 2010), and Rabbit Creek/ Powder River dykes in Wyoming (Kilian et al. 2015).

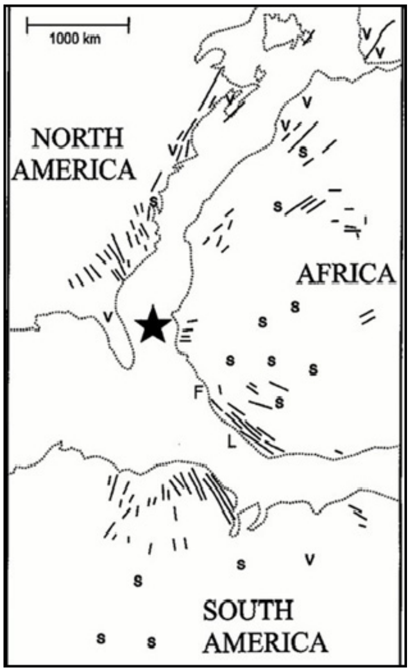


Figure 1. The essence of May's (1971) figure showing the radiating dykes and central focus (start) of Central Atlantic Magmatic Province (CAMP). From Ernst et al. (2001).

The final criterion, supplemental to the LIP barcode method, concerns basement geological similarities. Such an approach was employed by Bleeker (2003) to group Archean cratons into "clans" with distinct stabilization ages and cover successions. Recently, however, the LIP-barcode method has been used to juxtapose cratons of decidedly different basement characteristics. Examples include the suggestion that Zimbabwe (Sclavia clan) lay adjacent to Superior and/or Yilgarn (Söderlund et al. 2010; Smirnov et al. 2013), or that Vaalbara was in close proximity to western Superior (Kilian 2015), or that Eburnian (Paleoproterozoic) basement of the West African craton abutted against the Archean North Atlantic craton (Kouyaté et al. 2013).

These examples illustrate how the radiating-dyke-geometry and LIP-barcode methods, by themselves, can lead to surprising cratonic juxtapositions that are perhaps ill-founded. Some, perhaps many, similarities in dyke ages between cratons might be more parsimoniously explained by near-coeval magmatic events occurring in separate areas of the globe (for example, the 1110-Ma mid-latitude Keweenawan and low-latitude Umkondo LIPs; Swanson-Hysell et al. 2015). Complementary approaches, including geochemistry and paleomagnetism (e.g., Halls et al. 2008) can provide independent constraints on whether blocks with simultaneous mafic magmatism were joined together or far apart.

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