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An updated map of West African mafic dykes

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A B S T R A C T

Studies of mafic dyke swarms may simultaneously provide information on the mechanical, geochemical, geochronological and magnetic environments at the time of their formation. The mafic intrusive history of different cratons can also be potentially used to unravel their assembly into their current configuration. The identification and classification of dykes is a first step to all these studies. Fortunately, even in regions with poor outcrop, we can use the strong magnetic response of mafic dykes to identify and map their extent.

In West Africa the first maps of mafic dyke distribution were made over 40 years ago, but there are still large areas where there are almost no published data. In this paper we present a significantly updated map of mafic dykes for the West Africa Craton based in large part on new interpretations of the regional airborne magnetic database. This map includes the locations of over three thousand dykes across the craton, which locally shows several orientation clusters that provide a minimum estimate for the total number of dyke swarms in this region. Whilst we will have to wait until systematic dating of the different swarms is completed, we can demonstrate that there is a long and complex history of mafic magmatism across the craton, with up to 26 distinct dyke swarms mapped based according to their orientation. The mapping and dating of these swarms will provide key constraints on the assembly of the fragments that make up the modern continents.

1. Introduction

The West African Craton (WAC) has a geological history that spans over 3.5 Ga, and it has witnessed many tectonic upheavals during this time, even after it became a single cratonic block around 2 Ga ago. The craton consists for the most part of a series of sub-parallel greenstone belts trending N–S to NE–SW, separated by either tonalite–trondhjemite–granodiorite (TTG) and granite domains or sedimentary basins affected by repeated deformation episodes (Fig. 1). These terranes are overlain by 1 Ga to Quaternary depocentres. The mafic intrusive record in West Africa itself extends back to at least 2.73–2.68 Ga (Söderlund et al., 2013a, 2014; Tait et al., 2013) and has continued up until at least the last 500,000 years (Crevola et al., 1994). It has attracted continuing attention from researchers since May (1971) interpreted dykes present in the craton in terms of the Late Triassic to Early Jurassic opening of the Atlantic Ocean. Furthermore, mafic dyke swarms may simultaneously provide information on the geodynamic setting, geochemical characteristics of their mantle source areas, age distribution and paleo-magnetic environments at the time of their formation (Ernst, 2014 and references therein), and there have been many studies of West African dykes along these lines. Table 1 shows those we consider the most reliable, (baddeleyite or zircon Pb–Pb and U–Pb mineral ages) and Supplementary Table 1 gives a more complete listing that also includes less reliable ages. It can be seen that published baddeleyite and zircon Pb–Pb and U–Pb ages are currently restricted to the northern reaches of the WAC in Morocco, Mauritania and Algeria. The ages for the younger dyke systems (200 Ma and younger) are less likely to have been altered

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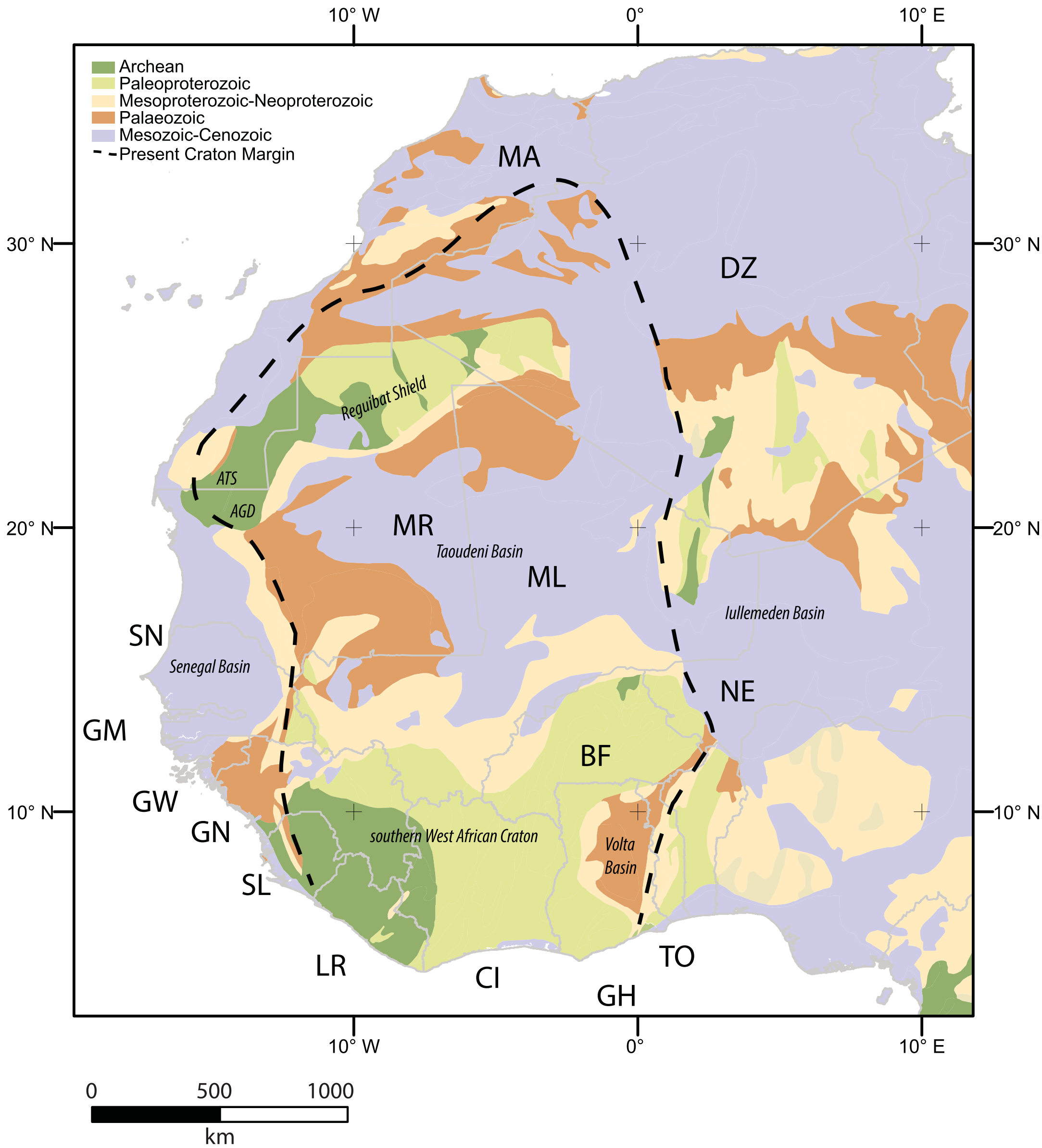

Fig. 1. Map of West Africa showing the ages of the major terranes, modified from the Geological Survey of Canada 1:35 M map of the world (Chorlton, 2007), showing the approximate limit of the present day WAC as a heavy dashed line (after Ennih and Liégeois, 2008). *AGD*: Ahmeyim Great Dyke; *ATS*: Aousserd–Tichla swarm. Two-letter country codes: BF: Burkina Faso; CI: Côte d'Ivoire; DZ: Algeria; GH: Ghana; GM: The Gambia; GN: Guinea; GW: Guinea Bissau; LR: Liberia; MA: Morocco; ML: Mali; MR: Mauritania; NE: Niger; SL: Sierra Leone; SN: Senegal; and TO: Togo.

by subsequent thermal events and thus other dating techniques (i.e. Ar–Ar, K–Ar and Sm–Nd) will probably still give approximately accurate ages.

One of the most important characteristics of the regional dyke swarms identified in this study is that they represent part of the plumbing system of Large Igneous Provinces (LIPs). LIPs are large volume, >100,000 km^3, mainly mafic magmatic events of generally intraplate character that are typically emplaced in a single short duration pulse or multiple such pulses (<1–5 Ma in duration) (Coffin and Eldholm, 1994; Bryan and Ernst, 2008; Bryan and Ferrari, 2013; Ernst, 2014). In the young Mesozoic–Cenozoic record LIPs are expressed as continental flood basalts or oceanic plateaus (Ernst, 2014) and the largest of these are the Siberian Trap continental flood basalt event (~4 Mkm^3) and the Ontong Java oceanic plateau (44 Mkim^3). However, in the case of older LIPs of Paleozoic and Proterozoic age the flood basalts have typically been removed by erosion thus exposing the plumbing system component which consists of regional dyke swarms, sill provinces and associated mafic-ultramafic intrusions. Silicic magmatism and carbonatites and kimberlites can also be associated (Ernst and Bell, 2010; Bryan and Ferrari, 2013). LIPs and their feeder dyke swarms are linked with continental breakup (or attempted breakup), regional domal uplift, environmental catastrophes including global extinction events, and major ore deposits, most notably of the Ni–Cu–PGE type (Ernst and Jowitt, 2013; Ernst, 2014).

Many regional dyke swarms associated with LIPs have a length greater than 300 km, and can even extend up to a maximum of >2000 km. They can be linear (and parallel to rifting), curvilinear such as the giant 1.37 Ga arcuate Lake Victoria Dyke Swarm in eastern Africa (Mäkitie et al., 2014) or have a radiating distribution with the focal point of the swarm interpreted to mark a mantle plume centre (e.g. Ernst and Buchan, 1997).