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Kimberlite discoveries in NW Liberia: Tropical exploration & preliminary results

Stephen E. Haggerty

Earth & Environment, Florida International University, Miami, FL 33155, USA

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ABSTRACT

This report is brief in context and rich in unexpected discovery. With >2 km of erosion, kimberlite models predict the near-complete removal of pipes with exposures to the pipe-root-zones of dikes. Exploration in NW Liberia has, indeed, uncovered eight kimberlite dikes (~10 m wide) but also an *en echelon* pipe, comparable in size to the Kimberley pipe and De Beers' pipe in South Africa. Discoveries are in a narrow 200–300 m wide valley of extraordinary thick bush, undergrowth, and organic overburden. Ilmenite and co-existing *leucoxene* were used as diagnostic tracers for detecting hard rock kimberlite in this tropical terrane. Micro-diamonds show that the redox state of ilmenite is a potentially useful proxy as an index for macro-diamond preservation. The tectonic control of kimberlites is complex, with diverse lithologies. Discoveries include a well-defined regional trend for kimberlite dikes along paleo-fracture zones, Precambrian in age (Liberia Trend), coupled with kimberlite dikes on the craton that are traced to Mesozoic oceanic transform faults (the Sierra Leone Trend). Although long predicted, this is the first report of kimberlite dike-trends in Liberia that are similar in orientation to those in Sierra Leone. An explosive *blow* on a Liberia-Trend dike demonstrates a similarity to the dynamics attendant in rich (50–500 cpht) diamond-bearing dikes in Sierra Leone, and in South Africa of comparable age. The potentially high grade dikes, along with the pipe (~500 × 50 m), now more reasonably accounts for the enormous number of alluvial diamonds (blood and non-conflict), recovered over more than seven decades, downstream from the discovery cluster.

A neglected region since the classic work by Bardet (1974), and with few contributions on Liberia since then, an update is considered timely, particularly in the context of discoveries of diamond-bearing kimberlite.

1. Introduction

West Africa is classically cratonic and diamond-bearing, having supplied at least 10% of the world's diamonds in the 1970s, quite remarkably by artisanal diggings only. Stretching from Mali in the N to adjacent Guinea, Sierra Leone, Liberia, and Ivory Coast (Fig. 1a), the region falls into three age Provinces (Leonian ~3 Ga in the W; Liberian, ~2.7 Ga in the center; and Eburnian ~2 Ga to the E); it is only in the Liberian unit of the Man Shield, however, that bona fide kimberlites have been recognized (Fig. 1a). Those in Ivory Coast are metakimberlites (Bardet, 1974); primary diamond sources have not been found in Ghana, Sino County (Liberia), and E Guinea; the diamonds in Nimba County, North-Central Liberia stem from graphitic schists (Force, 1983). Crustal control on kimberlite intrusions is reasonably well established (Haggerty, 1992) as outlined in Fig. 1b–c, and discussed below.

With periodic uplift of the West African Craton, a minimum of 1.5 km of erosion, to expose the Man Shield, are considered necessary to account for the offshore accumulation of sediments (Tysdal and Thorman, 1983), placed at over 5 km from oil exploration (Schmid, 2013), suggesting that 2.5 km is a reasonable estimate for erosion over a period of ~100 Ma. At these levels, existing pipes would be drastically reduced in surface diameters or levelled to the point that the pipe-root-zones of feeder-dike complexes would ultimately be exposed (Hawthorne, 1975; Kjarsgaard, 2007). Sill complexes are also typically present as described by Tappe et al. (2014).

Brief research visits to Liberia were initiated in 1977 and terminated by the *coup d'état* on 12th April 1980; internal conflicts lasted until 2003. Field work now dedicated to exploration was resumed in 2010. Results from the early work are limited (Haggerty, 1982, 1992), with a supplement only by Skinner et al. (2004). Exploration has produced some interesting results with the discovery of a kimberlite pipe and the recognition of a botanical indicator for kimberlite (Haggerty, 2015). This contribution will provide the details of discovery in the tropical environment of impenetrable bush in NW Liberia. The Gola Forest, comparable in many respects to Amazonia, is one of the last tracts of

E-mail address: haggerty@fiu.edu.

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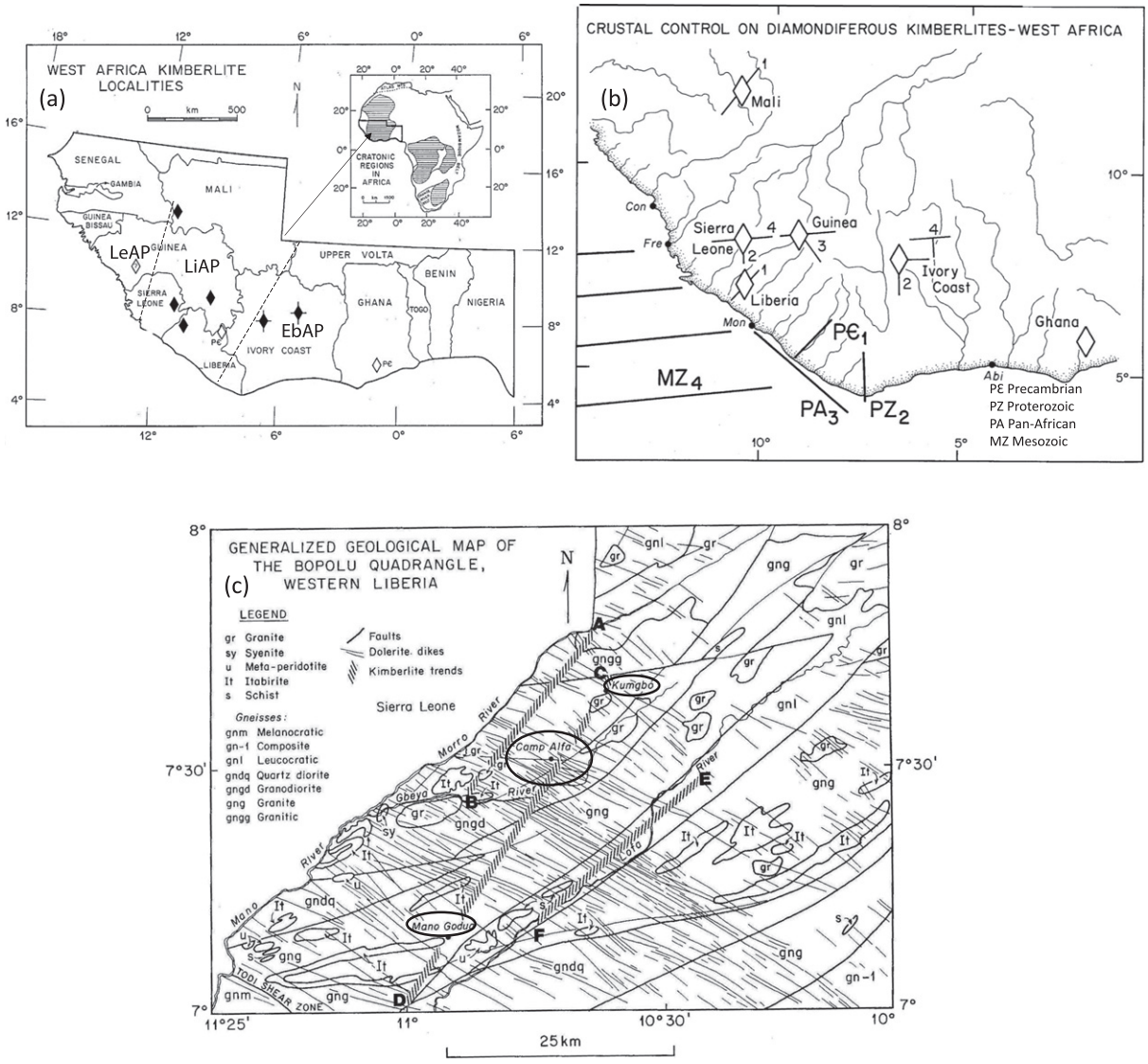

Fig. 1. (a) The Man Shield (West African Craton) in relation to other cratons on the continent showing the distribution of known and inferred kimberlites from Mali to Ghana. Boundaries to the three age provinces (AP) are schematic: Leonian (LeAP-3.0 Ga); Liberian (LiAP-2.7 Ga); and Eburnian (EbAP-2.7). Filled diamond symbols are known kimberlites; crossed diamond symbols in Ivory Coast are meta-kimberlites; and open diamond symbols in Guinea, Liberia, and Ghana are alluvial with no known, or doubtful parent source. Modified from Haggerty (1992). (b) Simplified drainage pattern map of West Africa in the region of the Leo Uplift. Major diamond locations and kimberlite dike trends (1–4) are illustrated with the dominant fracture patterns that were reactivated (Precambrian Pε to Mesozoic MZ), and along which kimberlites were intruded (~140 Ma and 90–120 Ma). Con Conakry (Guinea); Fre Freetown (Sierra Leone); Mon Monrovia (Liberia); and Abi Abidjan (Ivory Coast). Modified from Haggerty (1992). (c) Generalized geological map of the Bopolu Quadrangle, NW Liberia (Wallace, 1977), illustrating the three dominant kimberlite dike trends (A–B, C–D, and E–F) that cut the earlier (180 Ma) dolerite dike swarm; these intrusions parallel the coast-line with injection along stress fractures created by the breakup of Gondwana. Known diamond-bearing kimberlite pipes are at Mona Godua and Camp Alpha (Fig. 2). Current exploration has focused on the C-D Kimberlite Trend. Modified from Haggerty (1992).

equatorial forest, and so environmental concerns are paramount and duly practiced by exploration companies under the watchful eye of the Ministry of Lands, Mines and Energy.

2. Logistics

Geological mapping by France and the UK in West Africa has not advanced since colonial independence was obtained. But Liberia, with its Lone Star affiliation to the USA, enjoyed a mapping bonanza between 1965 and 1972, in which the entire country was flown, and in which excellent maps were produced (topographic, magnetic, and radiometric) at a scale of 1:250,000 (Tysdal and Thorman, 1983). Photogrammetry was followed up with ground-truth expeditions to the interior by USGS and Liberian Geological Survey personnel. The end result covers 110 mkm^2 in 10 quadrangles. Drafted from the Bopolu Quadrangle (Wallace, 1977), the map in Fig. 1c of NW Liberia is an overview of the regional geology that is limited in accuracy to stream bed exposures as the area is totally obscured by thick equatorial, tropical vegetation. Access to the diamond district is limited to a pot-holed-laterite road to Kumgbo (Fig. 1c). Further access in any direction is via machete-hacked bush paths as the country remains a no-fly zone to all except the UN Peace Keeping Force. With a wet and dry season calendar, field work is limited with a monsoon (July–November) that registers 200–500 mm of rain annually, log bridges are routinely replaced (not maintained), enormous amounts of rock, gravel, and sand are transported yearly, and tropical weathering is deep with significant alteration of kimberlites and kimberlitic indicator minerals (KIMs).

3. Regional geology

The crustal cratonic basement throughout the Regional Province is dominated by granite, granitic gneiss, and members of the TTG suite,