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Geophysical evidence of Cretaceous volcanics in Logone Birni Basin (Northern Cameroon), Central Africa, and consequences for the West and Central African Rift System

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ABSTRACT

Detailed analyses and interpretation realized by combining existing 2D reflection seismic and Gravity/Magnetic data of the Logone Birni Basin (LBB) in the West and Central African Rift System (WCAS) have revealed the distribution of the main buried volcanic bodies as well as their relationships with the structural and tectonic evolution of this basin. The volcanic activity in the LBB is restricted to the Cretaceous period. Three main volcanic episodes are identified and are associated to the Neocomian, Late Albian and Cenomanian–Turonian rifting phases respectively. The volcanic bodies within the Lower Cretaceous are either lying directly on basement or are mainly interbedded with the contemporaneous sediments whereas the Upper Cretaceous bodies are morphologically expressed in the forms of dykes and sills. The volcanic activity was more intense in the western region of the central LBB (Zina sub-basin) along the Cameroon–Nigeria border whereas it was scanty and scattered in the other parts of the basin. The main volcanic dykes are found on the flanks of the major faults bounding basement horsts or in crestal positions in association with syndepositional faults.

Although WCAS is associated with large amount of crustal extension and minor volcanism, the intense volcanic activity observed in LBB during the Cretaceous suggests that the intrusive zone during this period was confined to the basement beneath the study area flanked respectively to the north, south and southwest by the Lake Chad, Poli and Chum triple junctions. Tensional stresses generated by this localized domal uplift accounts for most of the observed tectonic structures where major faults transected the entire lithosphere, thus providing conduits for magma migration.

1. Introduction

Widespread igneous activity is documented in West and Central Africa during the Ear1y Mesozoic (Triassic–Jurassic) prior to the development in these regions of major intra-continental rift systems during the Cretaceous (Bertrand and Villeneuve, 1989; Fitton, 1983; Guiraud, 1990; Mascle et al., 1988; Ngako et al., 2006). This activity is translated in the field by doleritic intrusives related to mantle plume upwelling connected with the St. Helena mantle plume beneath the Niger delta–Mt. Cameroon region of West Africa during the Ear1y Cretaceous (Coulon et al., 1996; Guiraud et al., 1992; Wilson and Guiraud, 1992). Previous findings from Cretaceous outcrops in the Upper Benue (Guiraud, 1990, 1991; Popoff et al., 1982, 1983) documented two magmatic episodes. The initial magmatic episode, bimodal in nature, consists of alkaline rhyolites and transitional basalts from Late Jurassic to Neocomian (147 Ma ± 7 to 127 Ma ± 6). The volcanism took place along N60°E trending Bima synsedimentary fractures suggesting that it took place during the early activation of the lower Bima synsedimentary faults. The second magmatic episode is dated from Albian to Turonian times and is made up of transitional alkaline and tholeitic basalts (104 Ma ± 5.2 to 90 Ma ± 4.5) which in the contrary erupted along N120°E to N135°E striking lower Bima synsedimentary faults. In the south of Chad there is a series of troughs including the Bongor, Doba, Doseo, Salamat and Birao basins (Fig. 1), aligned along the Central African Shear Zone (CASZ). These half grabens trending N70°E to E–W were also active from Neocomian to Early Aptian, similar to those of north Cameroon and the Upper Benue (Guiraud and Maurin, 1992; Guiraud et al., 1992). Genik (1992) indicated minor evidence of magmatic activity in the form of sills of altered basalt and basaltic andesite, radiometrically dated Late Albian (97–101 Ma) in Doseo basin.

In the Cenozoic, alkaline magmatic activity occurred widely within West and Central Africa, both within the Cretaceous rift system and outside (Fig. 1). Much of this magmatism is alkali basaltic in composition and is related, at least in part, to the reactivation of major deep seated lithospheric fracture zones (Ngako et al., 2006; Wilson and Guiraud, 1992). Several of the volcanic complexes are associated with broad domal basement uplifts, with diameters which suggest

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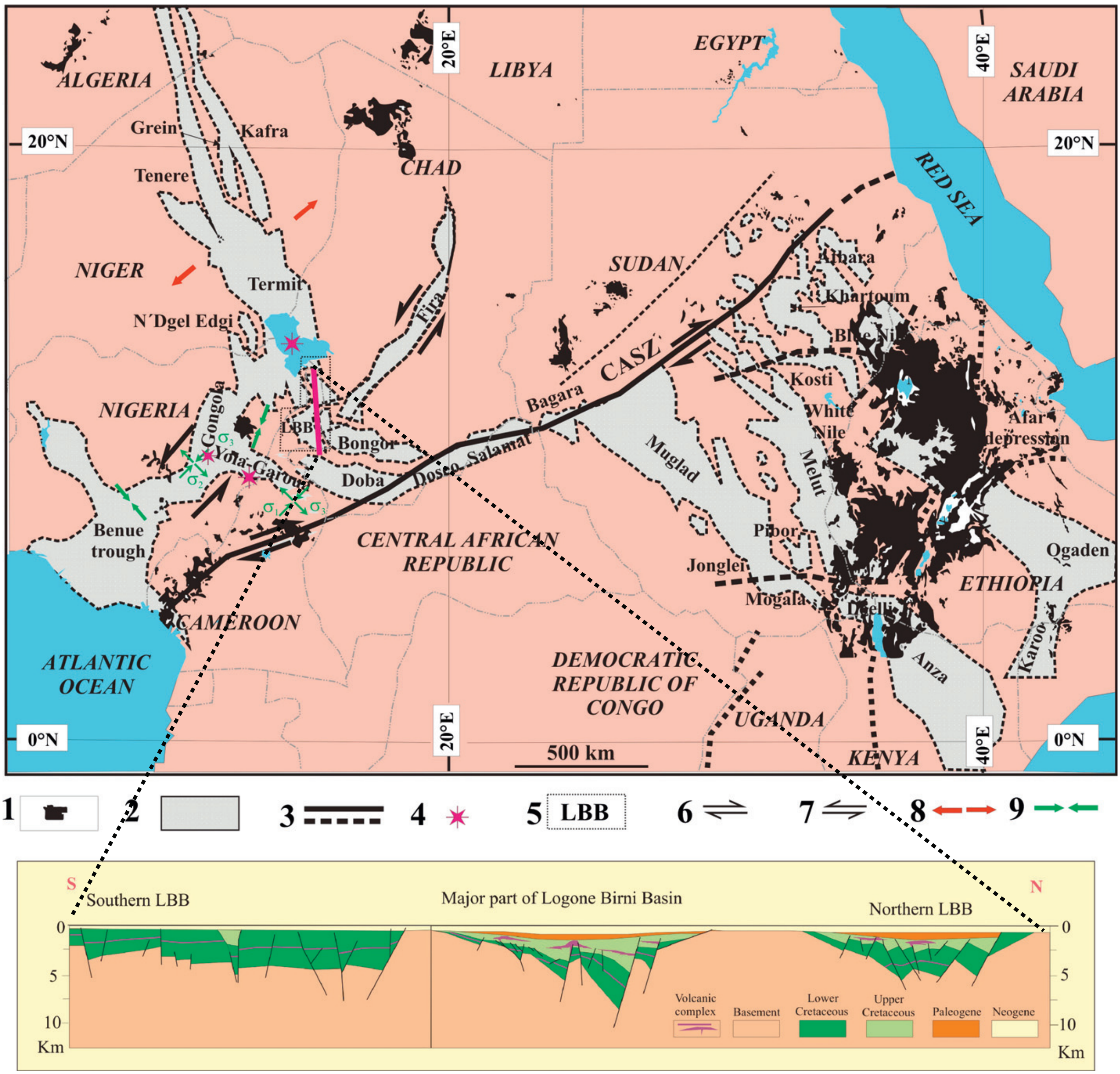

Fig. 1. West and Central African Rift System (WCAS) and East African Rift System (EARS). 1: Exposed Quaternary–Tertiary volcanics, 2: Mesozoic rifts, 3: main fault zones and rift margins, 4: documented triple junctions (Lake Chad, Poli, Chum) in the West African Rift sub-System, 5: location of Logone Birni Basin (LBB), 6: Central African Shear Zone (CASZ), 7: West African Strike-Slip Fault and Chad Shear Zone, 8: average direction of extension in Cretaceous, 9: average direction of shortening in Cretaceous. Interpreted schematic cross-section through LBB below shows the lateral distribution of Cretaceous buried volcanics.
Adapted from Genik (1992).

that uplift may have been initiated by diapiric upwelling within the upper mantle above 650 km depth (Nnange et al., 2000). The timing of uplift in these areas is, in general, poorly constrained and this remains an area for further research. The relationship between the activity of mantle plumes and the geodynamics of rifting is complex, with some mafic magmas being derived from plume-modified mantle sources more than 100–150 Ma after the actual activity of the plume ceased beneath a particular part of the African plate (Guiraud et al., 1992; Ngako et al., 2006; Wilson and Guiraud, 1992).

In the north of Cameroon there are many small basins of Neocomian–Early Aptian age (ca. 130–118 Ma) which have a general E–W trend. They are older than the large Albo-Aptian basins in the adjacent Benue Trough, Eastern Niger and southwestern Chad (Guiraud and Maurin, 1992). These small basins contain interstratified alkali basalt flows (Fig. 2), associated with dolerite dykes and sills as well as post sedimentary intrusive igneous bodies which cut through the sedimendary sequence (Brunet et al., 1988; Loule et al., 1997). The dykes are numerous, often up to 50 km long, and strike N70°E to E–W parallel to the basin bounding faults. Some of these dykes were deformed during the Santonian compressional tectonic event, thus constraining their minimum age to Coniacian (>85 Ma) (Guiraud, 1993; Guiraud and Maurin, 1992; Maurin and Guiraud, 1990).