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Characterization of the sub-continental lithospheric mantle beneath the Cameroon volcanic line inferred from alkaline basalt hosted peridotite xenoliths from Barombi Mbo and Nyos Lakes

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ABSTRACT

We carried out detailed petrographic, major and trace element geochemical, microstructural and FTIR analyses on eight characteristic ultramafic xenoliths from Nyos and Barombi Mbo Lakes in the continental sector of the Cameroon Volcanic Line (CVL). The studied xenoliths are spinel lherzolites showing lithologies similar to the other xenoliths reported previously along the CVL. They have protogranular and porphyroclastic textures. One of the Barombi xenolith contains amphibole, which had not been previously reported in this locality. Amphibole is common in the Nyos xenoliths suite. Peridotite xenoliths from both localities show some chemical heterogeneity, but Barombi xenoliths generally are less depleted in basaltic elements with respect to Nyos xenoliths. Trace element compositions of Nyos spinel lherzolites show a moderately depleted initial (premetasomatic) composition and variable enrichment in REE. Evidence for both modal and cryptic metasomatism is present in Nyos xenoliths. Rare earth element patterns of clinopyroxene suggest that interaction between mafic melts and the upper mantle occurred beneath the Nyos locality. Barombi Mbo xenoliths, on the other hand, record a small degree of partial melting. The Barombi Mbo xenoliths have weak, dominantly orthorhombic olivine crystal preferred orientations, whereas Nyos ones have strong axial-[010] patterns, which may have formed in response to transpression. Nominally anhydrous mantle minerals (NAMs) of the Barombi Mbo xenoliths show generally higher bulk concentrations of 'water' (70–127 ppm) than Nyos xenoliths (32–81 ppm). The Barombi Mbo xenoliths could originate from a juvenile segment of the lithospheric mantle, which had been originally part of the asthenosphere. It became a part of the lithosphere in response to thermal relaxation following the extension, forming a weakly deformed lower lithospheric mantle region along the CVL. The Nyos xenoliths, however, represent a shallow lithospheric mantle bearing imprints of several depletion and enrichment events probably prior or following the extension (at ~30 Ma).

1. Introduction

The occurrences of upper mantle xenoliths mainly in alkaline basalts have a great importance because they allow a direct insight into the sub-continental lithospheric mantle. Such studies, with additional numerical modeling and experiments, facilitate the

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understanding the different geochemical and mechanical processes of the lithospheric mantle. In several well-known xenolith localities from Europe (e.g. Pannonian Basin: Downes, 2001; Szabó et al., 2004; Massif Central: Lenoir et al., 2000), Asia (e.g. North China craton: Yang et al., 2008), North America (e.g. Rio Grande Rift: Bussod and Williams, 1991), and South Africa (e.g. Kaapvaal craton, RSA: Grégoire et al., 2005) a vast body of knowledge has been made available. Neogene alkali basalts and their pyroclastic deposits are distributed along the Cameroon Volcanic Line (CVL) in western Africa (Fig. 1). They have entrained great variety of ultramafic and mafic xenoliths. Localities from the oceanic and continental sector of CVL are extremely rich in lithospheric mantle xenoliths, which have been partially studied (e.g., Lee et al., 1996; Tamen et al., 2007; Teitchou et al., 2007; Temdjim et al., 2004; Princivalle et al., 2000; Wandji et al., 2009; Caldeira and Munhá, 2002; Ngounouno et al., 2001; Wandji et al., 2009; Matsukage and Oya, 2010; Temdjim, 2012; Tamen et al., 2015). The xenoliths from the CVL are mostly peridotites, however pyroxenites can also be found. Along the CVL the ultramafic xenoliths show generally protogranular and porphyroclastic textures (Lee et al., 1996; Princivalle et al., 2000; Caldeira and Munhá, 2002: Temdjim et al., 2004: Teitchou et al., 2007; Wandji et al., 2009; Tamen et al., 2015), however, subordinately recrystallized peridotites, pyroxenites and mosaic equigranular textured clinopyroxenites also appear (Wandji et al., 2009; Tamen et al., 2015).

Recent geophysical and petrological studies bring new insights into the magmatism and mantle evolution of the CVL (Déruelle et al., 2007; Milelli et al., 2012; De Plaen et al., 2014). There is no consensus, however, on the processes having occurred beneath the CVL. A recent review (Asaah et al., 2015) on the geochemical characteristic of lavas along the CVL revealed that the lithospheric mantle is rather heterogenous. Ocean island basalt (OIB, plume-related) is their main geochemical signature in these lavas, but the geochemical heterogeneity of the lithospheric mantle complicates this 'primary' signature. The authors pointed out that lavas at the Nyos Lake and Oku Volcanic Group, where the volcanic line bifurcates, show the most variable chemical compositions. To better understand the formation of the CVL a comprehensive study, with combination of seismic shear splitting data and crystal preferred orientation of xenoliths is needed.

The main aim of this study is to determine the composition and petrophysical characteristics of representative xenoliths from the two volcanic fields of the continental sector (the Barombi Mbo and Nyos volcanic maars) and compare them to those published previously from the other continental and oceanic sectors of the CVL (e.g. Lee et al., 1996; Caldeira and Munhá, 2002; Wandji et al., 2009; Tamen et al., 2015). In addition to the generally used analytical techniques (optical microscope, EMPA, LA-ICP-MS), we used some complementary analytical methods (such as FTIR and EBSD), which provide a solid dataset for a more detailed vision into the upper mantle beneath the CVL.

2. Geological background

2.1. Cameroon volcanic line (CVL)

In the western part of Cameroon there is a chain of Tertiary to Recent alkaline volcanoes, plutons and grabens extending over more than 1600 km, which is usually referred to as the Cameroon Volcanic Line (CVL) (Fig. 1a). This line stretches from the Island of

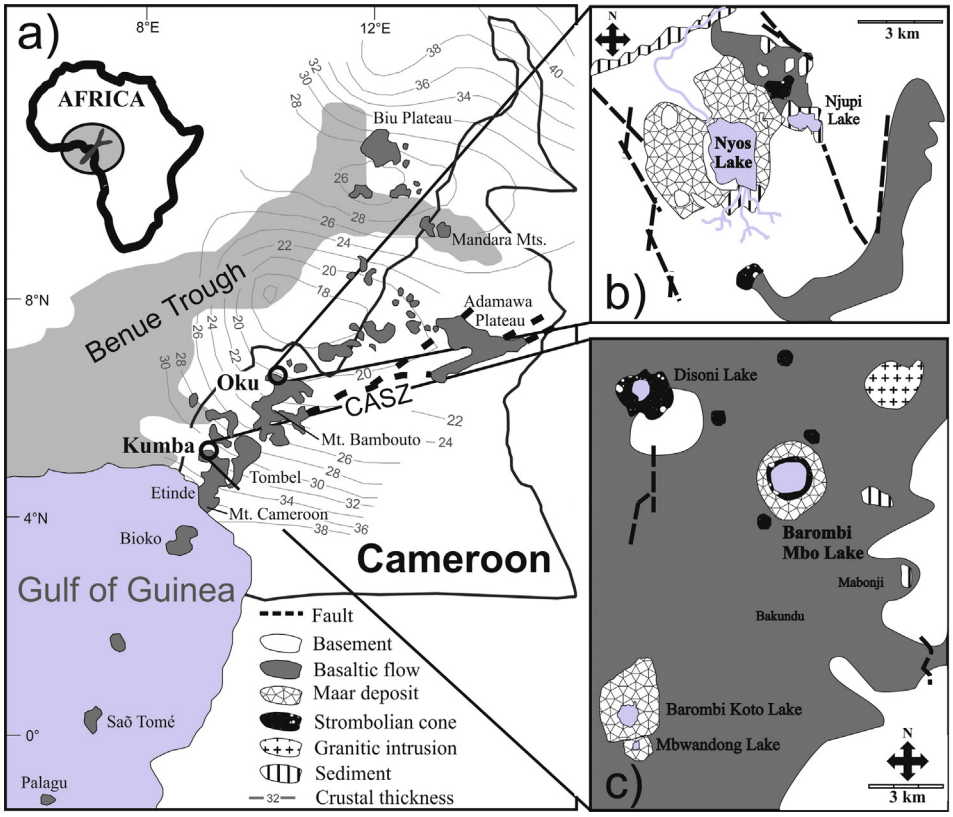

Fig. 1. (a) Simplified geological map of the Cameroon Volcanic Line with the major Cenozoic volcanic centers (after Déruelle et al., 2007), the Central African Shear Zone (CASZ) after Njiekak et al. (2008) and references therein and the crustal thickness (with gray lines) after Poudjom Djomani et al. (1995). Insets of Nyos Lake at Oku area (b) and of Barombi Mbo Lake at Kumba area (c) (after Teitchou et al. (2007) and Temdjim et al. (2004)) show locations of the studied xenoliths.