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Petrogenesis of the eastern part of the Al Haruj basalts (Libya)

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ABSTRACT

The eastern part of the Al Haruj volcanic field (central Libya) is dominated by lava flows with subordinate dykes as well as scoria and spatter cone deposits which formed around 4–0.5 Ma. These rocks are olivine-clinopyroxene- and rarely plagioclase-phyric alkaline to transitional basalts with intersertal to intergranular groundmass. They are fairly primitive rocks (MgO and Ni contents ~10 wt.% and >130 ppm, respectively). A positive correlation between MgO contents and Ni and Cr concentrations is suggestive of olivine (±spinel, ±Fe–Ti-oxide) fractionation. The rocks show LREE- and incompatible trace element enriched patterns on chondrite- and primitive mantle-normalized spider diagrams, respectively. Geochemical modeling revealed that the composition of most East Al Haruj basalts can be reproduced by ~5% melting of an undepleted, garnet-bearing peridotitic source, similar in composition to primitive asthenospheric mantle and typical of within-plate setting. The most incompatible element enriched samples could either represent extremely small degrees of melting of a similar source or, more probably, magmas derived from a more enriched, (lithospheric?) source. East Al Haruj magmatism occurred from predominantly asthenospheric-derived melts which formed and transported along fundamental sub-lithospheric faults of the Tibesti-Sirt basement. These faults were likely related to the late-stage evolution of the Sirt Basin characterized by NW–SE compression and perpendicular tension.

1. Introduction

There are several areas in the territory of Libya where volcanic rocks ranging in age from the Eocene to present day occur. The age of these predominantly basaltic rocks decreases from north to south. The oldest are Eocene Gharyan basalts (Schult and Soffel, 1973) and Miocene volcanics in the As Sawda area (Ade-Hall et al., 1975). Volcanism in the area of Al Haruj Al Aswad occurred from the Miocene to Quaternary (Peregi et al., 2003; Toljić and Turki, 2007; Rundić and Dalub, 2007 and references therein), while basalts of the Tibesti Massif are Pliocene to recent (e.g. Bruschek, 1974).

The Al Haruj Al Aswad basalt province is the largest volcanic area in Libya covering around 32,000 km^2. Horneman (1802) was the first to report about the Al Haruj volcanic rocks and afterwards followed the studies of Desio (1934), Kanter (1940), Bellair et al. (1952) and Lelubre (1952). Klitzsch (1968) recognized six major phases of basaltic lava flows in the Al Haruj area. Radiometric age determinations and paleomagnetic data of the Al Haruj basalts were documented by Ade-Hall et al. (1974) who reported an age of about 6 Ma. Woller (1984) and Vesely (1985) have also done geologic mapping in the Al Haruj Al Aswad area giving their own labels for different volcanic phases (e.g. BF0, BF1, etc.). Similarly, Busrewil and Suwesi (1993) distinguished and described six large volcanic phases and 15 sub-phases in the whole Jabal Al Haruj Al Aswad province. During the last several years new mapping projects provided additional data reported by Peregi et al. (2003), Less et al. (2006), Toljić and Turki (2007) and Rundić and Dalub (2007).

This study presents new data from the eastern part of the Al Haruj Al Aswad area (Fig. 1 inset A) based on systematic regional geological investigations and mapping of central Libya (~5400 km^2). Here we report and discuss major element and ICP-MS trace element analyses along with new K/Ar radiometric data in order to decipher the petrogenesis and geodynamic setting of these basalts. We suggest that these rocks originated after low degrees of melting and fractionation-dominating evolution within an intraplate geotectonic setting.

2. Pre-volcanic basement and regional stress field

The Al Haruj basalts overlie Eocene, Oligocene and Miocene sedimentary formations of the Sirt Basin (Fig. 1). The oldest sedimentary rocks belong to Qrarat Al Jifah Member of the Eocene Wadi Thamat Formation. They are represented by claystones and organogenic limestones occurring in the core of two brachial, NW–SE elongated anticlines. These sediments are overlain by Oligocene silts, fine-grained sandstones and ferruginous sandstones of the

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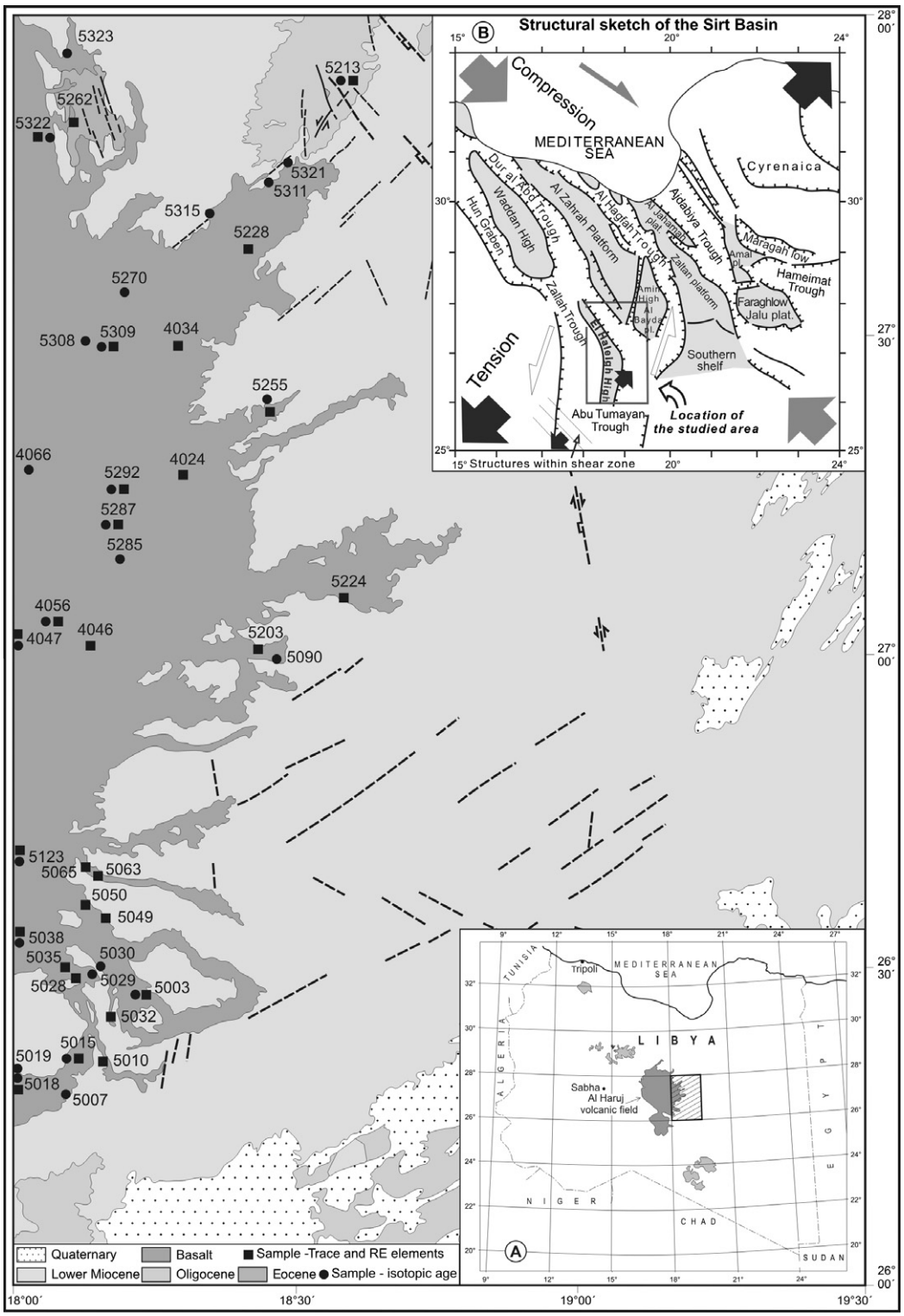

Fig. 1. A simplified geologic map of the eastern part of the Al Haruj Al Aswad basaltic province. The location of samples taken for laboratory analyses as well as the position of the studied area (inset A) and structural sketch of the Sirt Basin (insert B) are also given.

Dur Al Talah Formation, which were deposited under transitional marine to continental conditions. They are covered by Lower Miocene shallow water marine sediments of the lower part of the Qarat Jahanam Member of the Maradah Formation. This unit is divided into the lower part consisting of clastic sediments represented by microconglomerates, various sandstones and silts without marine macrofossils, and the upper part composed of carbonaceous sandstones, gypsum-bearing sandstones, gypsum, calcarenites and bedded micrites containing rare relicts of ostracodes (Peregi et al., 2003; Less et al., 2006; Toljić and Turki, 2007; Rundić and Dalub, 2007).

The stress field, in which brittle deformations were manifested during the Eocene, Oligocene and Lower Miocene, is characterized by NW–SE extension (Fig. 2 D_1). It is suggested that such stress