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Neogene to Quaternary basalts of the Jabal Eghei (Nuqay) area (south Libya): Two distinct volcanic events or continuous volcanism with gradual shift in magma composition?

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ABSTRACT

This study reports and discusses a set of new K/Ar age and new petrochemical data on basalts of the Jabal Eghei (Nuqay) area (south Libya). This area is part of a >1000 km long NNW–SSE Libyan volcanic field that stretches from the Mediterranean coastal near Tripoli to the Tibesti massif in Chad. Whole rock K/Ar ages, stratigraphy, volcanology and rock petrochemistry indicate that the Jabal Eghei developed during two volcanic events. The first occurred from the Middle Miocene to the Pliocene (K/Ar ages from ~16 to ~5 Ma) when large volumes of low aspect ratio lava flows of transitional basalts formed. The second event happened in Pliocene–mid-Pleistocene time (4–≤1 Ma) and it gave rise to basanite spatter to scoria pyroclastic cones and subordinate lava flow facies. The transitional basalts are less primitive and less enriched in incompatible trace elements than the basanites. Petrochemical characteristics reveal that the transitional basalts underwent weak to moderate olivine-dominated fractionation and that crustal assimilation had negligible effects. REE geochemical modeling shows that primary magmas of both transitional basalts and basanites formed by melting of a similar garnet-bearing, primitive mantle-like source with degree of melting of 3–5% and ≤1%, respectively. It is also demonstrated that the transitional basalts show systematic compositional changes in time because progressively younger rocks are petrochemically more similar to basanites. We argue that our data definitely prove that the age pattern along the entire Libyan volcanic field is much more complex than it was thought before.

1. Introduction

The volcanic area of Jabal Eghei (also referred to as Jabal Nuqay, see Farahat et al., 2006) is the southernmost province of a NNW–SSE stretching volcanic field in Libya (Fig. 1A). The entire field covers an area of 66,000 km^2 (Goudarzi, 1980). Going from the Jabal Eghei area (JE) towards the north-northwest the field encompasses the Jabal Al Haruj Al Aswad province (AH; Busrewil and Wadsworth, 1980a; Németh et al., 2003; Farahat et al., 2006; Cvetković et al., 2010a; Bardintzeff et al., 2011; Miller et al., 2012; Abdel-Karim et al., 2013), which also includes the supposedly active volcano of Waw an Namous (WN; Bardintzeff et al., 2011; Miller et al., 2012), then the much smaller provinces of Jabal as Sawada (JS; Ade-Hall et al., 1974; Woller and Fediuk, 1980; Busrewil and Esson, 1991) and Jabal Al Hasawinah (JH; Jurak, 1978), and terminates with the Gharyan province (GH; Piccoli, 1970; Almond et al., 1974; Busrewil and Wadsworth, 1980b; Lustrino et al., 2012), that is situated near the Mediterranean coast, around 60 km south of Tripoli (Fig. 1A). Further to the south of Jabal Eghei, the Libyan volcanic field can be traced towards the Tibesti massif (TB) that is almost completely situated in Chad (e.g. Gourgaud and Vincent, 2004).

The petrogenetic and geodynamic interpretations of the origin of the entire Libyan volcanic field merely followed the existing explanations for other African volcanic belts, at first place of the NW–SE stretching Ougarta–Tibesti–Darfur line (Schilling, 1973; Dautria and Lesquer, 1989; White and McKenzie, 1989; Dupuy et al., 1993; Marty et al., 1993; Franz et al., 1994; Pik et al., 1999; Aït-Hamou et al., 2000; Liégeois et al., 2005) and the NE–SW directed Cameroon line (e.g. Halliday et al., 1990; Kagou Dongmo et al., 2010). In general, two opinions predominate. Some authors associate this volcanism to deep mantle plumes (e.g. Sleep, 1990; Burke, 1996; Aït-Hamou et al., 2000), whereas others argue in favor of shallow asthenospheric upwelling in response to active tectonic processes (e.g. Liégeois et al., 2005; Pik et al., 2006; Beccaluva et al., 2007a, 2008).

Hegazy (1999) proposed that deep mantle plumes have played a crucial role for generating the Libya volcanic field. This opinion was mainly based on earlier age determinations (Schult and Soffel, 1973; Ade-Hall et al., 1974; see also references above), more specifically on the observation that there was an age progression from SSE to NNW

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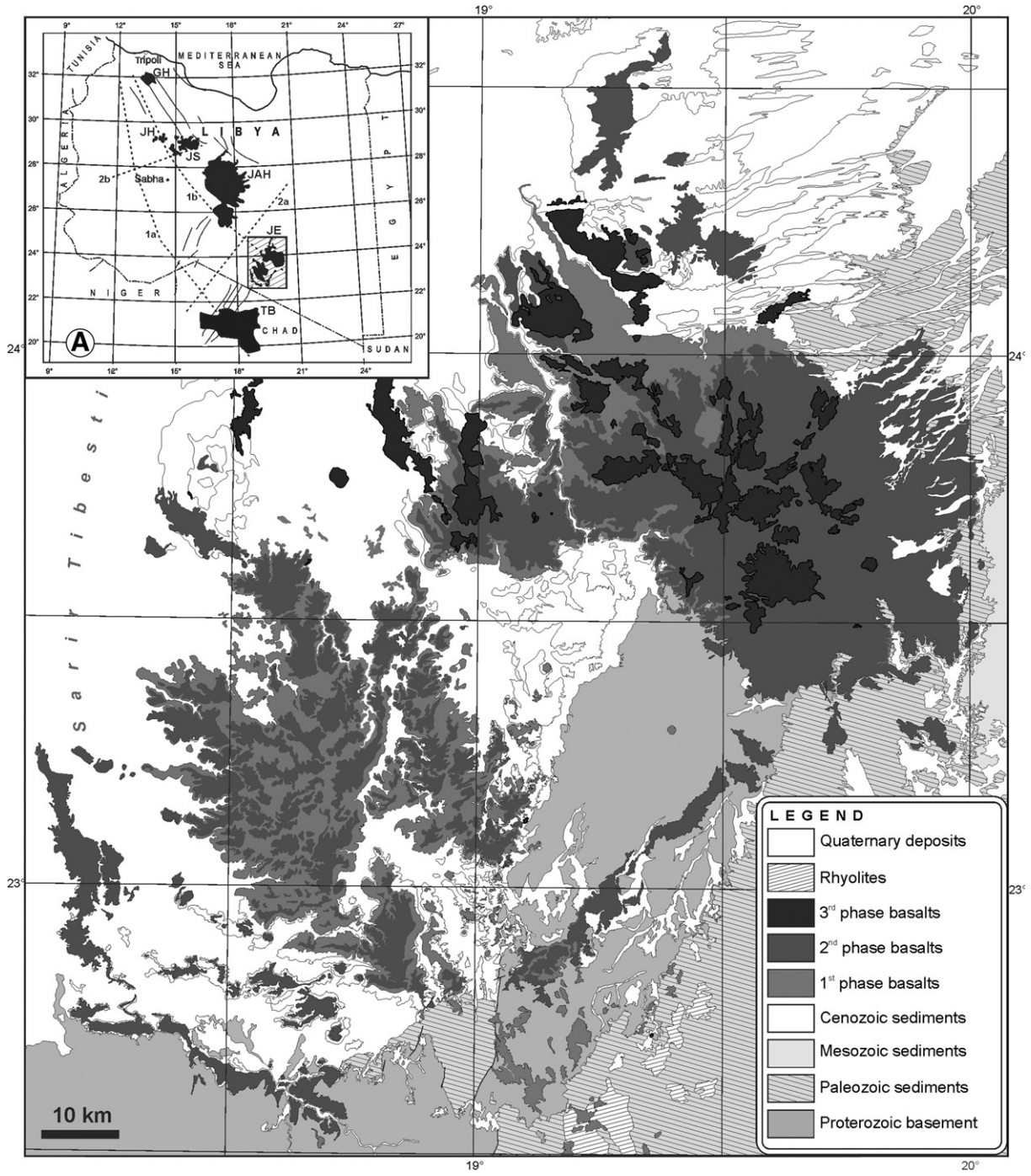

Fig. 1. Simplified geological map of the Jabal Eghei (Nugay). The inset (A) shows the distribution of other provinces of the Libyan volcanic field with main structures according to Woller and Fediuk (1980). Explanations: JE — Jabal Eghei; AH — Jabal Al Haruj Al Aswad; WN — Waw an Namous; JS — Jabal as Sawada; JH — Jabal Al Hasawinah; GH — Gharyan province; TB — Tibesti Massif; faults and lineaments: 1a — Tripoli–Tibesti; 1b — Al Haruj; 2a — Tibesti–Sirt; 2b — Al Quaraqaf.

(Woller and Fediuk, 1980). However, several recent studies have increased the number of available radiometric ages and this led to revisiting the previous views about a consistent age pattern along strike (e.g. Cvetković et al., 2010a; Bardintzeff et al., 2011; Lustrino et al., 2012). These authors generally pointed out that the southwestward decrease in age, originally proposed by Woller and Fediuk (1980), was insufficiently constrained, and that the volcanic rocks of individual provinces of the Libyan volcanic field, in fact, exhibit more complex age systematic than it was thought before. It appears that the Libyan volcanic field was active more than 50 m.y., from the early Eocene to present day. These studies clearly show that for better constrained petrogenetic and geodynamic interpretations more analytical data are needed, and that it is particularly valid for the provinces for which the existing data are very poor.

In this study we report and discuss a set of new K/Ar ages and major and trace element geochemical data for basalts of the Jabal Eghei area. We integrate these analytical data with volcanological and petrographic observations that were acquired during the Geological Mapping of south Libya (campaign in 2008), which was carried out in cooperation between the Industrial Research Centre (Tripoli) and the Geological Survey of Serbia (Belgrade). The study provides an important insight into the petrogenesis of one of the least known provinces in Libya. Furthermore, it sheds more light into present day understanding of geodynamic causes of this voluminous intraplate volcanism.