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Geochemical and isotopic characterization of the recent magmatic activity of the Dilo-Dukana and Mega volcanic fields (Ririba rift, southern Ethiopian Rift)

Eleonora Braschi [1], Zara Franceschini [2,3], Raffaello Cioni [3], Giacomo Corti [1], Federico Sani [3] and Ameha Muluneh [4]

1. Istituto di Geoscienze e Georisorse, Consiglio Nazionale delle Ricerche **2.** Dipartimento di Scienze della Terra, Università degli Studi di Pisa **3.** Dipartimento di Scienze della Terra, Università degli Studi di Firenze
2. **4.** School of Earth Sciences, Addis Ababa University

e-mail: eleonora.braschi@igg.cnr.it

We provide new petrological, geochemical and isotopic data on the magmatic products emplaced during the volcanic activity of the Ririba rift, with the aim of investigating the source of the older Pliocene lava basement and the Late Pleistocene-Holocene alkaline basalts as well as their pathways to the surface

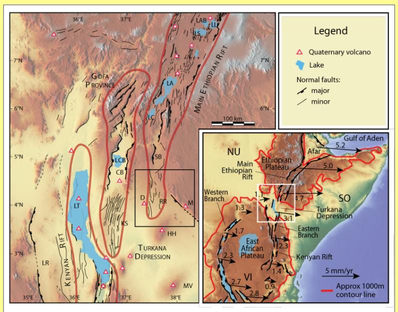

Fig. 1 Schematic fault pattern and present-day plte kinematics of the East African Rift. The studied area is located within the area enclosed in the white square and showed in panel B. The black square indicate the investigated region of Diol and Mega showed in Fig. 2.

The Ririba rift represents the southern termination of the Main Ethiopian Rift and formed from the southward propagation of this latter (Fig.1) during, or shortly after, the emplacement of subalkaline basalts that produced a widespread basaltic lava basement, at ~3.7 Ma

The activity of the Ririba rift was short-lived and ceased between 2.8 and 2.3 Ma, when deformation migrated westward into an oblique, throughgoing rift zone directly connecting the Ethiopian and Kenyan rifts. Rifting was followed by the eruption of limited volumes of Late Pleistocene-Holocene alkaline basalts, associated to several, monogenetic volcanic centres, forming the Dilo-Dukana and Mega volcanic fields (VF) (Fig.2).

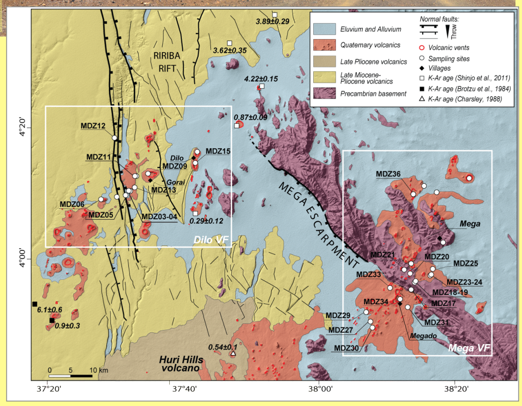

Fig. 2 Geology of the Ririba rift (modified from Corti et al., 2019; Shinjo et al., 2011). White boxes indicate the Dilo and Mega vlcanic fields.

Major and trace elements, besides discriminating the Pliocene lavas from the other younger alkaline products, reveal that the Dilo-Dukana and Mega samples always overlap in composition (Figs. 3-4).

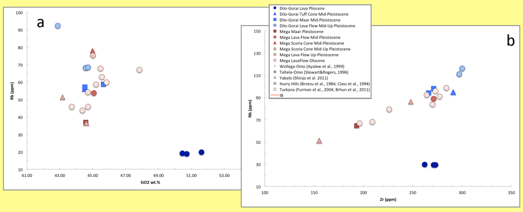

Fig. 4 Rb vs silica (a) and Nb vs Zr (b) diagrams showing the variation in trace elemento content and the different trends related to the alkaline Quaternary and subalkaline Pliocene products.

Major and trace element contents show evident variations compared to a limited range in silica (43-46wt.%) (Figs 3-4a). Regular trends are observed comparing some incompatible trace elements (e.g., Rb, Ba, Zr, Nb), pointing to an important role of fractional crystallization for their differentiation (Fig. 4).

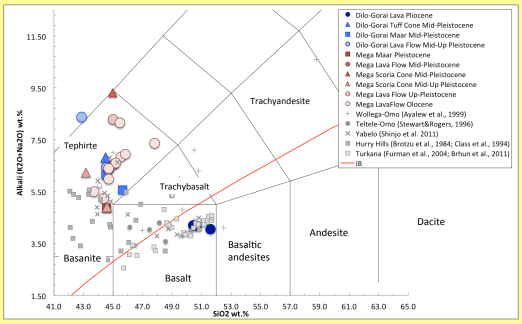

Fig. 3 Total Alkalies vs. SiO_2 diagram for the studied samples compared to selected rocks from the literature. The red line separates the fields of alkaline and subalkaline rocks.

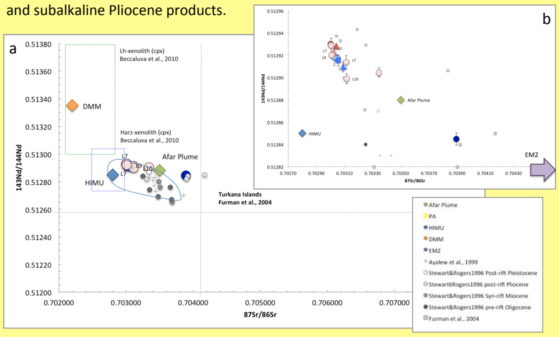

Fig. 5 Sr vs Nd isotope results of selected samples compared to selected literature data and mantle end-members (Rooney et al., 2020 and references therehin).

It is noteworthy that Sr-Nd isotopes among younger Holocenic lavas of Mega VF describe a negative trend (fig. 5b), that is correlated with a silica increase among the same samples as well as the xenolith content, suggesting a possible role of some contamination process during the recent magmatic activity in the study area.

All the isotope data corroborate the evidence that the younger products of Dilo-Dukana and Mega VF are well distinct from the Pliocene basaltic lava basement (as well as with respect to all the older magmatic rocks of the area) and are characterised by a more prominent mantle-plume signature (Figs. 5-6-7).

Dilo-Dukana VF products are isotopically homogeneous and clustered around $^{87}Sr/^{86}Sr$ values of 0.70303 and $^{143}Nd/^{144}Nd$ values of 0.51292, whereas the Mega VF lavas and pyroclastics display a small but wider variability, partially overlapping the Dilo-Dukana samples (Fig. 5a). This is also confirmed by Pb isotopes that display a limited variation with a small trend between the Afar Plume and the DMM mantle sources (Fig. 6a-b). Some scatter are observed by comparing Pb with Sr isotopes (Fig. 7a) pointing to a possible role of limited crustal contamination processes.

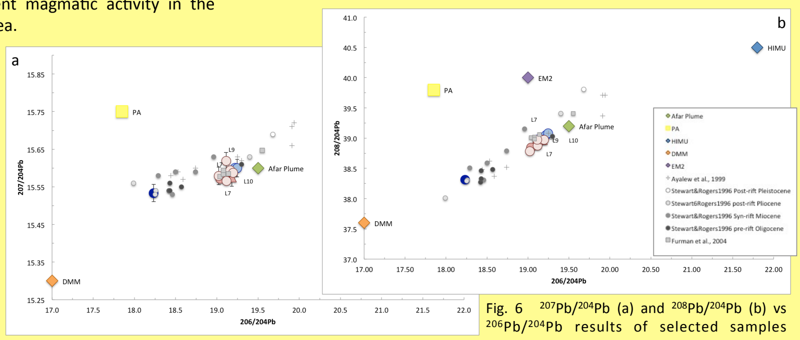

Fig. 6 $^{207}Pb/^{204}Pb$ (a) and $^{208}Pb/^{204}Pb$ (b) vs $^{206}Pb/^{204}Pb$ results of selected samples compared to selected literature data and mantle end-members (Rooney et al., 2020 and references therehin).

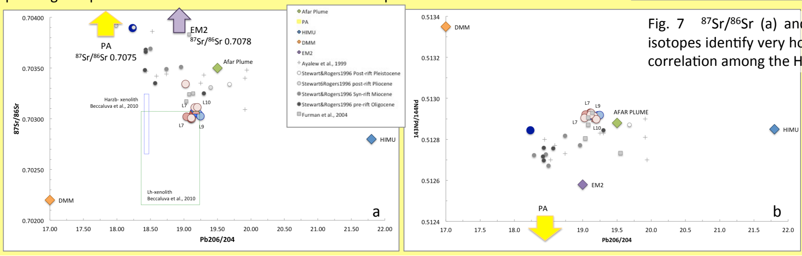

Fig. 7 $^{87}Sr/^{86}Sr$ (a) and $^{143}Nd/^{144}Nd$ (b) vs $^{206}Pb/^{204}Pb$. Nd and Pb isotopes identify very homogeneous composition with a small inverse correlation among the Holocenic Mega lava flow samples.

Our data are consistent with the interpretation that the two young Dilo-Dukana and Mega VF are fed by deep structures directly transferring mantle melts up to the surface, as also suggested by the large abundance of mantle xenoliths in the different products. This corroborates the interpretation that the two volcanic fields are not related to the major faults of the Ririba rift, but are associated to different, deep, NE-SW-trending inherited structures which cut the roughly N-S boundary faults of the rift.