Eruptive and depositional characteristics of the Loolmurwak and Eledoi maar volcanoes (Lake Natron - Engaruka monogenetic volcanic field, northern Tanzania)

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1. Introduction

Typically, maar volcanism is associated with phreatomagmatic fragmentation processes, in which rising magma interacts with external water. However, evidence from the field, optical microscopy and geochemical methods indicates that **magmatic fragmentation** is responsible for the formation of the Eledoi and Loolmurwak maars in northern Tanzania (Fig. 1).

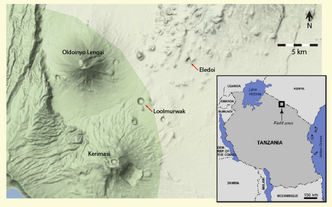
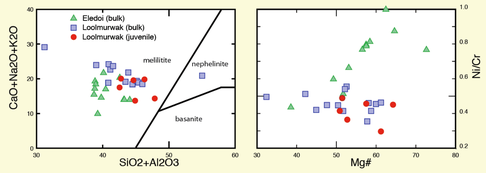


Fig. 1 – Central part of the LNE-MVF, showing the Loolmurwak and Eledoi maars as well as the stratovolcanoes Oldoinyo Lengai and Kerimasi. Figures obtained from Mattsson and Tripoli [2011] (inset) and Google Maps (edited).

2. Geochemistry



Left: Confirming mineralogical observations, XRF analyses show that both the Loolmurwak and Eledoi magmas plot in the melilitite field of the combined oxides diagram (Le Bas, 1989). Right: A clear positive correlation between Mg# and Ni/Cr indicates the presence of varying amounts of mantle debris within the analyzed bulk samples of Eledoi.

3. Loolmurwak maar

The Loolmurwak maar is located roughly 8 km southeast of Oldoinyo Lengai (Fig. 1). The crater cuts more than 100 m into the surrounding topography and the diameter of the crater floor equals roughly 600 m. The crater rim stands about 20 to 25 m above the surrounding topography and gently dips away from the crater with around 10° towards all sides. Two roughly N-S trending normal faults have partly offset both the crater rim deposits and the underlying rocks.

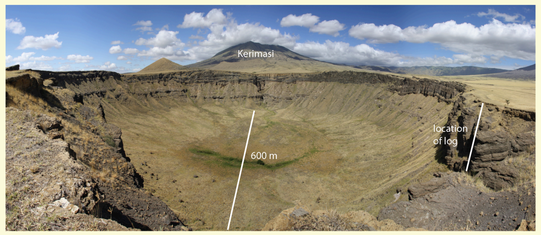
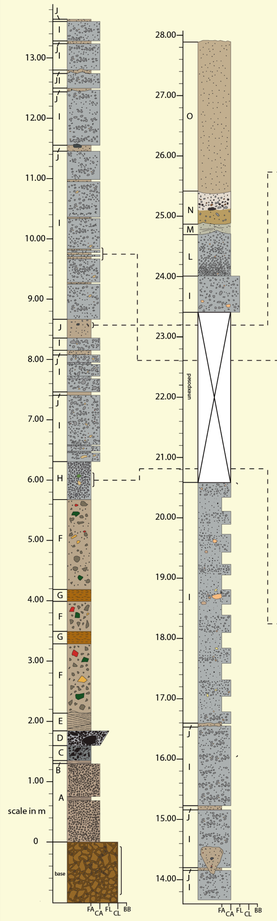
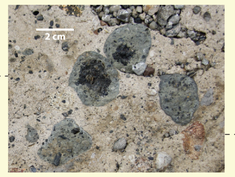


Fig. 2 – Loolmurwak maar crater seen from the NE side of its crater rim, with the extinct stratovolcano Kerimasi is in the background. The diameter of the crater floor equals about 600 m. The approximate location of stratigraphic logging (at the N-NE side of the rim) is indicated.



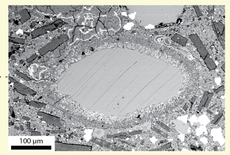


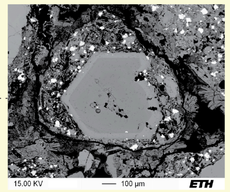
Subspherical melt droplets within an ash-sized matrix. Melt cores consist of olivine, pyroxene and phlogopite.

Three consecutive brown ash layers (unit J) are interbedded with grey layers consisting majorily of 0.5–1 cm sized melt droplets (unit I).

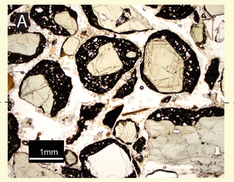
Various kinds of lithic material, most likely originating from previous eruptions of the nearby stratovolcanoes Oldoinyo Lengai and Kerimasi, are plentiful within the ejecta ring.

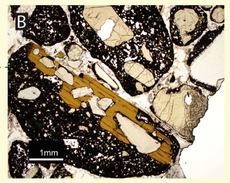
Polished rock sample showing grey juvenile melt droplets (74 vol%) within a brown ash matrix of lithic material (26 vol%). The presence of rounded melt droplets implies a magmatic fragmentation style.





Backscattered electron images show: (top) a reaction rim around a phlogopite crystal, around which dark, lath-shaped melilitite crystals stand out from a finer matrix; (bottom) euhedral zoned olivine situated in a mm-scale melt droplet.





Photomicrographs of cored melt droplets within unit I of the Loolmurwak deposits: (A) Droplet cores consist of clinopyroxene, olivine and phlogopite; (B) Clinopyroxene is enclosed by a phlogopite crystal, suggesting that the latter mineral was formed later.

7. References

Le Bas, M.J., 1989. JP 30: 1299-1312
Mattsson, H.B., Tripoli, B.A., 2011. JVGR 203: 23-34.
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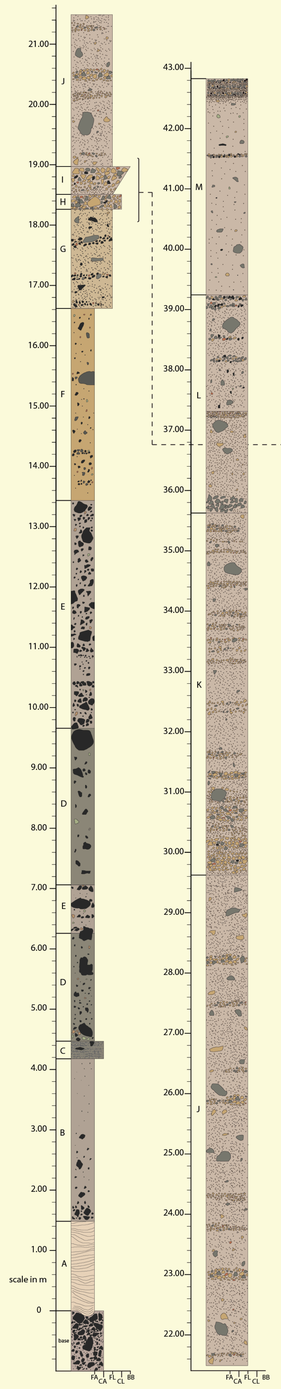
Sparks, R.S.J., Baker, L., Brown, R.J., Field, M., Schumacher, J., Stripp, G., Walters, A., 2006. JVGR 155: 18-48.



4. Eledoi maar

The Eledoi maar, situated 12 km east of Oldoinyo Lengai (Fig. 1), is somewhat smaller in diameter than Loolmurwak, as its crater floor measures around 430 m across. However, it has much higher crater rims, at most reaching more than 200 m above the crater floor and 160 m above the surrounding topography. The ejecta ring is highly asymmetrical and much lower on the southern and western sides, where it reaches to only about 30 m above its surroundings.

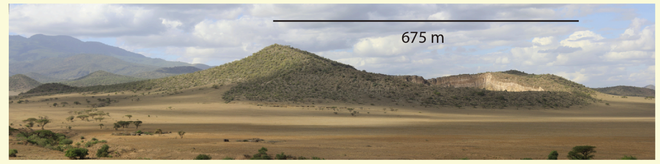


Fig. 3 – Eledoi maar crater as seen from the west. Note the strong asymmetry of the ejecta ring. Finer deposit fractions are concentrated on the northern side of the rim, suggesting a dry eruption column that allowed effective eolian segregation of differently sized pyroclasts during deposition.

Lenses of coarse material display inverse grading resulting from grain flow.

Using Stoke's Law and the maximum size of mantle xenoliths found in the Eledoi deposits, a minimum value of 0.85 m/s can be obtained for the average **magma ascent rate**. This rate is similar to that associated with the adjacent scoria cone of Pello Hill (Mattsson et al., 2012) as well as those of kimberlitic magmas (Sparks et al., 2006).

Mantle xenoliths (predominantly dunites and wherlites) occur on all sides of the Eledoi crater rim but are especially abundant on the S–SE side. They are frequently cut by several generations of mesatomatic veins.

5. Magmatic fragmentation and dry deposition?

- absence of typical 'wet' deposition indicators (accretionary lapilli, vesiculated tuffs, plastering against objects)
- wind-induced asymmetry of crater rim suggesting eolian segregation of pyroclasts of different sizes (Eledoi)
- dominance of sub-spherical armored lapilli, often slightly flattened towards bedding plane (Loolmurwak)
- degraded edges of phlogopite crystals

6. Preliminary conclusions

The emplacement mechanism of the Eledoi and Loolmurwak maar craters much resembles that typical for many **kimberlites** (cf. Sparks et al., 2006):

- rapid ascent rate of magma from upper mantle depths
- exsolution of abundant volatiles
- magmatic fragmentation and dry depositional characteristics

The preliminary results of this MSc project thus indicate that a detailed study of pyroclast textures, mineralogy and chemistry of the Eledoi and Loolmurwak deposits can provide valuable new insights into maar emplacement processes.