The origin of melanophlogite, a clathrate mineral, in natrocarbonatite lava at Oldoinyo Lengai, Tanzania

Andrew D. Beard1,*, Kieran Howard2, Laura Carmody3 and Adrian P. Jones3

1Department of Earth and Planetary Sciences, Birkbeck, University of London, Malet Street, London WC1E 7HX, U.K.
2Mineralogy Department, Natural History Museum, Cromwell Road, London SW7 5BD, U.K.
3Department of Earth Sciences, University College London, Gower Street, London WC1E 6BT, U.K.

ABSTRACT

We report new observations of a clathrate mineral, melanophlogite [46SiO2·6(N2,CO2)-2(CH4,N2)], as part of a tuffaceous layer within a sample of the 2006 natrocarbonatite lava, whose composition reflects the typical magma erupted passively at Oldoinyo Lengai throughout the last ~50 yr. The mineral has been identified by chemical composition, micro-X-ray diffraction, and transmitted light optical characteristics. This is the first reported occurrence of a clathrate in an igneous carbonatite, and we conjecture that this mineral may be recognized elsewhere in alteration products of natrocarbonatite ash and in particular, combeite-bearing carbonatite lithologies. Specifically, melanophlogite is a rare polymorph of SiO2 with guest molecules (e.g., CH4, CO2, SO2, N2, OH, Xe, and Kr) within a silicate framework. It occurs in an ash pellet-rich layer within the natrocarbonatite lava, as abundant groundmass crystals and as cores of individual ash pellets, with pseudocubic and pseudohexagonal habits, ranging from 50 to 100 μm in size, with numerous inclusions of nepheline laths aligned parallel to the crystal margins. It has high-C contents (up to 2.25 wt%) and CO2 is considered to be the guest molecule due to crystallization within an alkaline carbonatitic-CO2-rich environment.

Keywords: Oldoinyo Lengai, melanophlogite, natrocarbonatite, combeite

INTRODUCTION

Oldoinyo Lengai (OL), situated in the Eastern Africa Rift Valley in NW Tanzania (Fig. 1a), is the world’s only active carbonatite volcano, forming a steep-sided stratocone rising to an altitude of 2960 m. Although OL is well known for its unique natrocarbonatite lavas that have characterized activity since at least 1966, it is predominantly composed of nephelinitic and phonolitic lavas and pyroclastic deposits (Dawson 1962, 1989, 1998). In this paper, we report the first occurrence of melanophlogite pseudomorphs after combeite, identified by electron microprobe (EMP) and confirmed by micro-X-ray diffraction, from an ash pellet-rich layer within the March–April 2006 lava flows that occurred on the western flanks of OL. Melanophlogite is a very rare tetragonal (pseudocubic) polymorph of SiO2 with structure-stabilizing guest molecules (e.g., CH4, CO2, SO2, N2, OH, Xe, and Kr) trapped within a clathrate-type silicate framework. This occurrence of melanophlogite is the first from Africa and the first from a carbonatite. The presence of broken melanophlogite pseudomorphs after combeite crystals requires that these pseudomorphs formed before the ash pellets were deposited. We present compositional and textural information in an attempt to understand its origin and significance at OL.

SAMPLE LOCATION

The largest natrocarbonatite lava flow reported from OL occurred from March 25 and continued until April 5, 2006. The first effusive eruption on March 25, 2006, was associated with hornito collapse, overfilling of the summit crater, and emplacement of a 3 km long lava flow on the western flank (Kervyn et al. 2008). The lava tongue was initially confined to a deeply incised erosional gully, 15–20 m wide, before coming to a halt on the rift floor at an altitude of 1500 m and forming a distal lobe 150 m wide (Fig. 1b). A second effusive event occurred on April 3, 2006, producing a flow passing through the same mid-slope gully on top of the cooled earlier lava flow (Kervyn et al. 2008). Flow morphologies are highly variable, changing considerably over a few meters, including scorciaceous, rubbly pahoehoe, and blocky aa-type surfaces (Kervyn et al. 2008). The volume of lava produced during this eruptive event has been estimated at 9.2 (±3.0) × 106 m3. During the period between the eruptions OL was continuously active, producing a large ash plume with ash fall observed over a wide area. In September 2007, three samples (OLD1–3) from the 2006 flows were collected from an altutude of 1850 m (Latitude 2°45′35″S; Longitude 35°53′43″E), by Colin Church.

ANALYTICAL METHODS

A concentrated separate of melanophlogite crystals from the ash pellet layer was obtained by lightly crushing a subsample in a steel piston and sieving the crushed material into >850, 450, and <450 μm fractions. As melanophlogite does not react readily with dilute acid, the <450 μm fraction was washed in 10% HCl to remove carbonate and to concentrate the sample. It was then rinsed with distilled water to remove acid residues and dried under heat lamps. The acid-washed material was then divided using 250 and 63 μm sieves. The melanophlogite crystals were mostly in the concentrated >63 μm fraction and were then handpicked using fine acupuncture needles and prepared as polished grain mounts for SEM, EMPA, and

* E-mail: ubfb018@mail.bbk.ac.uk