CORRESPONDENCE

Evidence from Longonot volcano, Central Kenya, lending further support to the argument for a coexisting CO_2 rich vapour in peralkaline magma

(Plate 1)

SIR–Bailey (1978) argued that if isochemical melting has taken place, the world wide chemical coherence of peralkaline magmas generated below rifted continental regions requires that the lithosphere below each complex be chemically preconditioned prior to melting. He suggested that metasomatic preconditioning through the action of a separate vapour is the only way of producing the required convergence of lithospheric compositions. The chemistry of oversaturated peralkaline obsidians, which are potentially generated from such a source, demonstrates that the vapour must be deficient in H_2O and, in order to leave little record of its previous activity in the final volcanic glass composition, must have a low solubility in silicate melts. Bailey argued, using field and experimental evidence, for a vapour phase rich in carbon gases; CO_2 at low temperatures and pressures, CO and CH_4 at high temperatures and pressures. New textural and mineralogical data from the crystalline peralkaline trachyte lavas of the Quaternary volcano Longonot, Central Kenya, provide further evidence in support of this argument.

The Longonot peralkaline trachytes are aphyric to mildly porphyritic, containing a maximum volume of 8% phenocrysts. Anorthoclase (0.7–9.0 mm), fayalitic olivine (0.4–1.2 mm), iron rich clinopyroxene (0.15–1.0 mm) and titanomagnetite (0.05–0.6 mm) comprise euhedral phenocryst phases which are set in a groundmass of alkali feldspar, alkali clinopyroxene, aenigmatite, alkali amphibole and, in the earlier flows, titanomagnetite. Low temperature secondary alteration of the silicates and oxides is absent, the lavas being completely fresh in both hand specimen and thin section. Within the groundmass of many massive and vesiculated lavas, widely scattered patches of fine grained carbonate also exist. The carbonate in each patch occupies an interstitial position with respect to groundmass feldspar, pyroxene, aenigmatite and amphibole. The unaltered nature of the enclosing silicate phases demonstrates that the carbonate is a primary, residual crystallization product in equilibrium (or near equilibrium) with the enclosing silicates. A similar occurrence of primary carbonate associated with analcime lenses was also recorded by Webb (1973) in the flow banded groundmass of a phonolite from South Turkana, Kenya. In the Longonot trachytes, the occurrence of carbonate patches in the groundmass immediately surrounding some vesicles suggests the presence of small residual quantities of a CO_2 rich vapour phase.

Turning to the phenocryst assemblage, many of the euhedral olivines have suffered partial replacement. In the most advanced example observed (Plate 1 a) the replacing mineral assemblage is alkali pyroxene, an opaque phase and a carbonate arranged in zones parallel to the original crystal boundary. The optical properties that could be determined on the fine grained carbonate, and its association with fayalitic olivine, suggest it may be siderite or ankerite. Many less advanced replacement structures show only alkali pyroxene and a minor opaque phase replacing the olivine phenocryst (Plate 1 b). Microprobe analyses from such a structure (Table 1) reveal a pyroxene of sodic hedenbergite composition replacing fayalite.

The replacement is interpreted as having taken place during the late stages of crystallization by reaction with a high temperature, coexisting CO_2 rich vapour for the following reasons.

(i) Several olivines are entirely fresh and unreplaced indicating that replacement is selective and not caused by the wholesale reaction of olivine with the surrounding melt. Even the altered phenocrysts show no rim corrosion, simply marginal replacement from the rim inwards.

(ii) The replacing phases constitute a high temperature assemblage, not a low temperature, secondary alteration assemblage which would be expected to include iddingsite, serpentine or chlorite.

(iii) Only olivine has suffered such partial replacement, all other phenocryst and groundmass minerals being entirely fresh and unreplaced. This suggests that the olivine became unstable owing to a crtical change in oxygen fugacity, a change which did not affect the other minerals. A residual CO_2 rich vapour phase could have promoted the reaction of olivine. In order to produce the selective

EXPLANATION OF PLATE

Plate 1 (*a*). Partial, multicrystal replacement of a euhedral fayalitic olivine phenocryst (Ol) by pyroxene (Py), an opaque phase (Op) and a carbonate (Cb). A zoned structure is evident in the replacement assemblage. Holes (H) may be due to volume change during transformation or plucking during the slide making process. Scale bar = 0.5 mm. (Slide number L54)

Plate 1 (*b*). Multicrystal rim replacement of a euhedral fayalitic olivine microphenocryst (Ol) by a fine grained aggregate of pyroxene and an opaque mineral (R). Scale bar = 0.25 mm. (Slide number L65C)
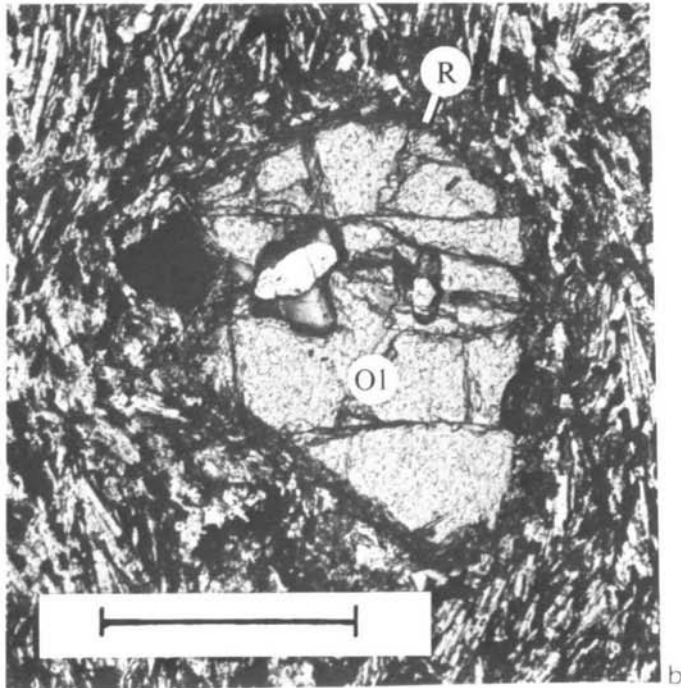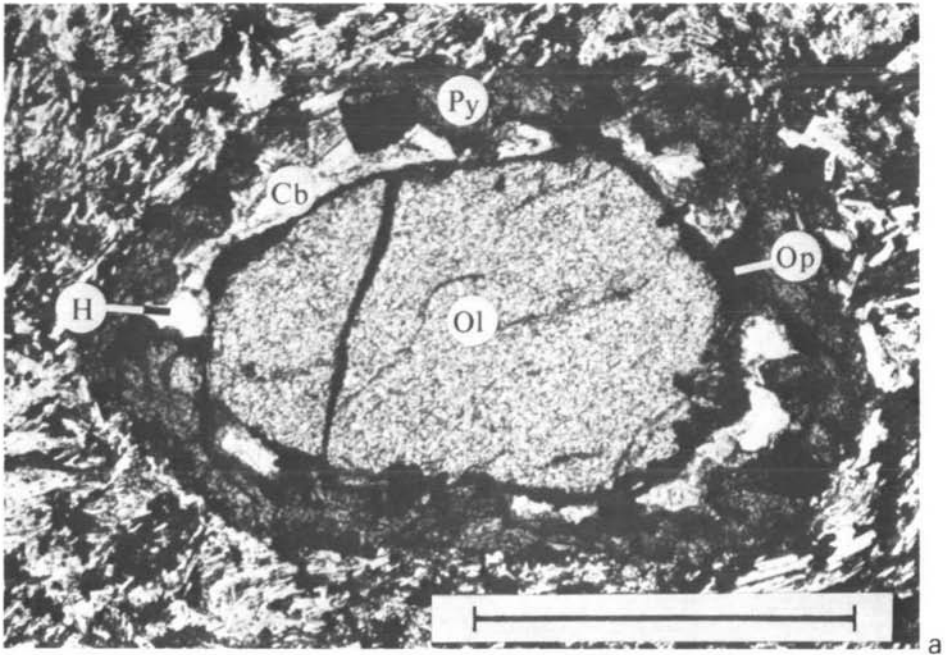
Plate 1. Phenocryst assemblage, Longonot volcano.

Table 1. Electron microprobe analyses of an olivine phenocryst and replacing pyroxene from peralkaline trachyte sample L56.

wt%	1	2	n	1 6	2 4
SiO_2	48.87	30.07	Si	1.987	1.003
Al_2O_3	0.18	0.00	Al	0.009	0.000
TiO_2	0.36	0.13	Ti	0.011	0.003
FeO	20.34*	62.22	Fe^{2+}	0.692	1.736
Fe_2O_3	5.57	—	Fe^{3+}	0.171	—
MnO	1.17	3.80	Mn	0.040	0.108
MgO	2.72	2.36	Mg	0.138	0.117
CaO	17.87	0.68	Ca	0.779	0.024
Na_2O	2.16	0.05	Na	0.171	0.003
K_2O	0.03	0.03	K	0.001	0.001
Total	99.27	99.34	Z	2	1.003
			Y	0.993	1.992
			X	1	—

Atomic %		Mol. %	
Ca	47.24	Fo	6
Mg	8.35	Fa	94
$Fe^{2+}+Mn$	44.41		

* Total iron determined as FeO, and Fe_2O_3 calculated by alloting equivalent molecular amounts of Fe_2O_3 to Na_2O.
1 – Pyroxene replacing olivine phenocryst around rim.
2 – Centre of olivine phenocryst replaced around rim.
n – Number of oxygens per formula unit.
Analysed at University College London, using a Cambridge Instruments Microscan 5 electron microprobe.

replacement of olivine phenocrysts the residual vapour phase must have accumulated in discrete, localized regions within the rock.

(iv) The presence of a carbonate phase and the lack of any hydrous or halogen bearing phases in the replacement products indicate that CO_2 was a major constituent of the vapour. However, the well documented loss of small amounts of F and Cl during crystallization of these halogen rich peralkaline magmas suggests that this vapour did contain a minor halogen constituent.

This textural and mineralogical record of a coexisting CO_2 rich vapour during the late stages of crystallization does not, on its own, prove that the vapour coexisting with the Longonot *magmas* was CO_2 rich. However, when taken in conjunction with the other field and experimental evidence quoted by Bailey (1978) for abundant CO_2 in the rift environment, the record of a late-stage CO_2 rich vapour in the Longont rocks takes on a fresh significance, providing additional evidence from the rocks themselves, for the presence of small amounts of CO_2 in solution in peralkaline magma. This evidence, when combined with that quoted by Bailey, lends further support to the argument for a coexisting, low solubility, CO_2 rich vapour phase in peralkaline magmas. The high halogen and low H_2O content of Kenyan peralkaline obsidians also suggests that this vapour might have contained a significant halogen component.

References

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