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Liquid immiscibility in the residual glass of a basaltic flow from the Piton de la Fournaise, La Réunion island.

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The 2004 flow of the Piton de la Fournaise is a so-called “cotectic” (saturated with olivine, plagioclase and pyroxene) basalt, compositionally transitional between tholeiitic and alkaline (Peltier et al. 2009). This flow shows remarkable lavas tubes, whose walls have been petrographically characterized.
The phenocrysts include more-or-less oxidized olivine Fo81 (occasionally enclosing chromian magnetite), plagioclase An70 and clinopyroxene Wo38En51Fs11 with subophitic texture. In accordance with the conditions of relatively slow cooling rate in contact with the atmosphere, the groundmass is largely crystallized and the mineral association (plagioclase, cpx, opx, oxides and glasses) witnesses oxidized conditions of crystallization. For instance, the groundmass pyroxene is remarkable by its bright yellow colour contrasting with the light brown of the phenocrysts. This yellow colour corresponds to high Fe3+ contents, with a Fe3+/ΣFe atomic ratio in the range 0.3-0.6, and reaching up to 1 at the edge of the lava tube. Magnetite is extremely abundant with compositions ranging from Mte40Usp58Sp2 to Mte86Usp6Sp7, and Mg contents increasing with decreasing Ti (mg# mostly between 10 to 30). Magnetite is commonly unmixed due to oxidation, and the secondary ilmenite-magnetite pairs correspond to ∼850°C, NNO + ∼1.5. At the very edge of the lava tube, a thin and discontinuous layer of magnesioferrite is observed, in sharp contact with magnetite.
Glass occurs as abundant interstitial patches associated with alkali-rich feldspar and enclosing magnetite and tiny skeletal crystals of apatite. This glass, invariably rhyolitic in composition, is remarkable by the ubiquitous presence of brown spherical globules, up to 3 micrometers in diameter, partly crystallized (apatite and magnetite). A typical globule composition is 34 wt.% SiO_2, 10% TiO_2, 2.5% $Al2O_3$, 17% FeO, 8% MgO, 13% CaO, < 1% Na2O and K2O , 9% P2O5. Such globules, classically described in the residual glasses of basaltic flows, are interpreted by liquid immiscibility (e.g., Philpotts 1982). The interesting point is that oxidized conditions disfavor liquid immiscibility, owing to the major influence of the Fe-enrichment of the liquid on the miscibility gap. For instance, Philpotts & Doyle (1983) described a tholeiitic basalt flow in which immiscibility is observed at any place except in its lower part, in relation with oxygen fugacities estimated to have been close to QFM where immiscibility is present and close to NNO where immiscibility is lacking. In the 2004 basalt flow from the Piton de la Fournaise, immiscibility took place in spite of the high oxygen fugacity, probably in response to its high phosphorus content. Therefore immiscibility and the ensuing production of rhyolitic liquids is expected to occur widely in the low-pressure evolution of alkaline basalts.

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