Eruption of kimberlite magmas: physical volcanology, geomorphology and age of the youngest kimberlitic volcanoes known on earth (the Upper Pleistocene/Holocene Igwisi Hills volcanoes, Tanzania)

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Abstract

The Igwisi Hills volcanoes (IHV), Tanzania, are unique and important in preserving extra-crater lavas and pyroclastic edifices. They provide critical insights into the eruptive behaviour of kimberlite magmas that are not available at other known kimberlite volcanoes. Cosmogenic ^{3}He dating of olivine crystals from IHV lavas and palaeomagnetic analyses indicates that they are Upper Pleistocene to Holocene in age. This makes them the youngest known kimberlite bodies on Earth by >30 Ma and may indicate a new phase of kimberlite volcanism on the Tanzania craton. Geological mapping, Global Positioning System surveying and field investigations reveal that each volcano comprises partially eroded pyroclastic edifices, craters and lavas. The volcanoes stand <40 m above the surrounding ground and are comparable in size to small monogenetic basaltic volcanoes. Pyroclastic cones consist of diffusely layered pyroclastic fall deposits comprising scoriaceous, pelletal and dense juvenile pyroclasts. Pyroclasts are similar to those documented in many ancient kimberlite pipes, indicating overlap in magma fragmentation dynamics between the Igwisi eruptions and other kimberlite eruptions. Characteristics of the pyroclastic cone deposits, including an absence of ballistic clasts and dominantly poorly vesicular scoria lapillistones and lapilli tuffs, indicate relatively weak explosive activity. Lava flow features indicate unexpectedly high viscosities (estimated at $>10^{2}$ to 10^{6} Pa s) for kimberlite, attributed to degassing and in-vent cooling. Each volcano is inferred to be the result of a small-volume, short-lived (days to weeks) monogenetic eruption. The eruptive processes of each Igwisi volcano were broadly similar and developed through three phases: (1) fallout of lithic-bearing pyroclastic rocks during explosive excavation of craters and conduits; (2) fallout of juvenile lapilli from unsteady eruption columns and the construction of pyroclastic edifices around the vent; and (3) effusion of degassed viscous magma as lava flows. These processes are similar to those observed for other small-volume monogenetic eruptions (e.g. of basaltic magma).

Keywords: Kimberlite; Igwisi Hills; Explosive eruption; Lava; Monogenetic volcano