Oldoinyo Lengai natrocarbonatite derives from classical calciocarbonatite

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Carbonatites are rare magmas containing almost no silica; the corresponding crystallized rocks represent the main rare earth elements (REE) deposits in production. Oldoinyo Lengai (Tanzania) is the only active carbonatite volcano on Earth, and may be used as a natural laboratory to identify the parameters responsible for the genesis of the >500 reported fossil occurrences of carbonatite magmas. Nevertheless the carbonatites emitted at Oldoinyo Lengai are unique as alkali-rich (natrocarbonatites), and their origin may not be representative of the fossil carbonatites (calcio-, ferro-, magnesio-carbonatites). Here we use three-phases melt inclusions trapped in clinopyroxenes and nephelines from cognate cumulates – that sample the active magma chamber of Oldoinyo Lengai – emitted during the 2007-08 sub-plinian explosive eruption to track the carbonatite presence within the plumbing system, and to eventually quantify its composition at depth. We show that although natrocarbonatites are emitted at Oldoinyo Lengai summit, more classical calciocarbonatites are present at magma chamber depth, consistent with rare natrocarbonatites being derived from more classical calciocarbonatites by further magma differentiation. Those unique cognate samples allows us to provide the first direct measurements of partition coefficients for major and trace elements of natural coexisting in equilibrium carbonatite and silicate melts. Partition coefficients suggests that natrocarbonatites derive from calciocarbonatites by fractionating Ca-rich, and Na-poor phases. The Oldoinyo Lengai can therefore be used as a perfect analogue of fossil igneous systems that are now exhumed, commonly lacking any relation with the initial geodynamic setting, and form REE mineral deposits.