Abundant volatiles in mantle lithosphere

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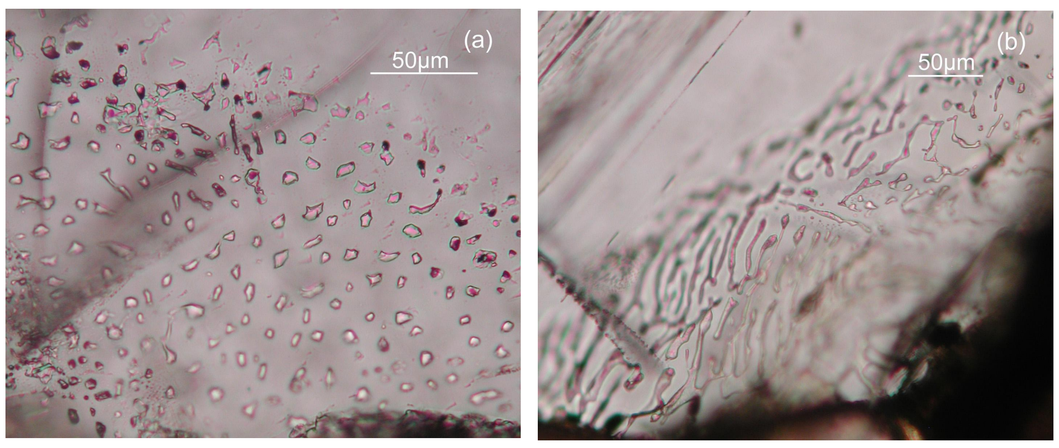
Volatiles in the Earth's mantle must exist as free volatiles trapped in fluid inclusions or as anion complexes incorporated in structural sites in hydrous minerals. Volatiles in nominally anhydrous mantle minerals have long been thought to reside primarily in fluid inclusions or anion complexes. In this study, we show through grain-size reduction experiments that significant amounts of volatiles in fact reside in structural defects/vacancies in mantle minerals.



(a) Early-stage fluid inclusions in Olv crystal interiors.
(b) Late-stage fluid inclusions at Opx crystal edges

1. Samples and analytical procedure

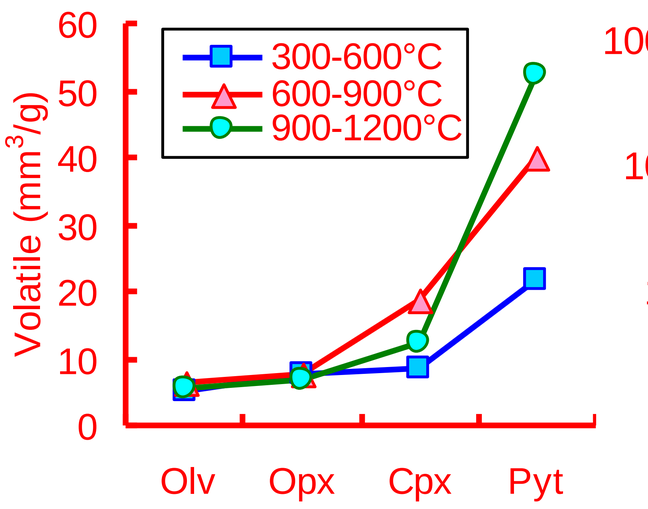
Fresh well-characterized olivine (Olv), orthopyroxene (Opx) and clinopyroxene (Cpx) separates from lherzolite xenoliths and clinopyroxene (Pyt) separate from pyroxenite xenolith sample suites from Hannuoba and Dafangshan in China .

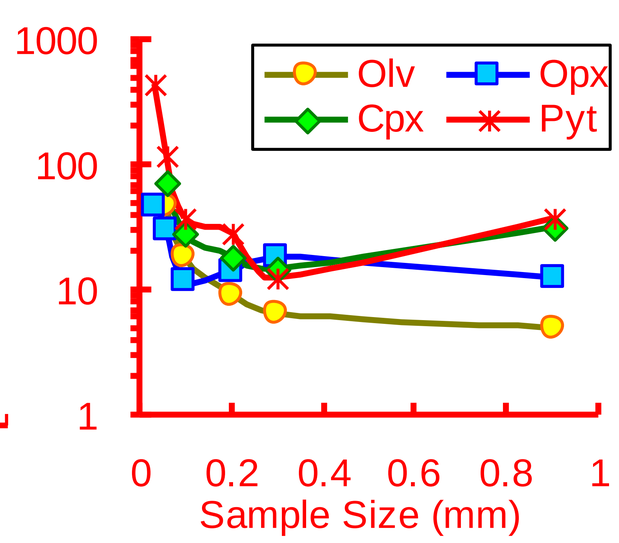
An online vacuum stepwise heating system coupled with a MAT-271 mass spectrometer was used to extract and measure volatiles from mineral separates.

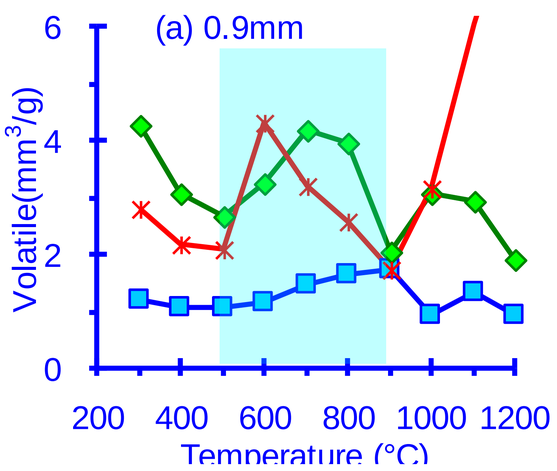
2. Results and Discussions

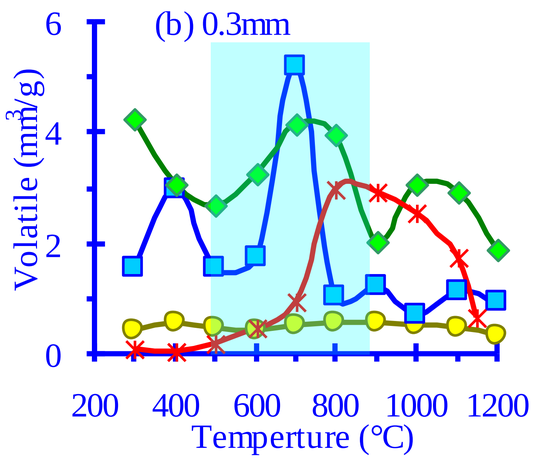
Stepwise heating on mineral separates at a given crushing size reveals that:

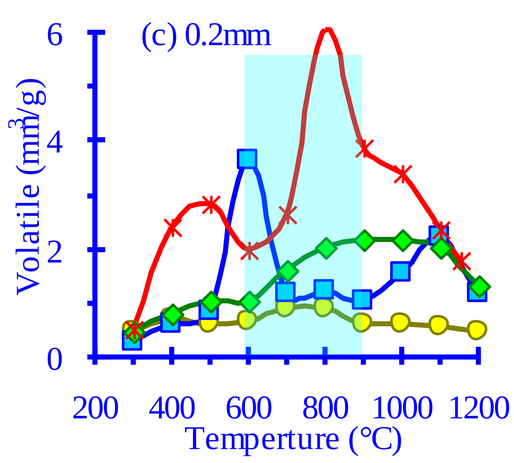
(1) the total amount of volatiles released increases from Olv (av. 17.17 mm3/g), to Opx (21.92), to Cpx (39.48) in lherzolite xenoliths, and to Pyt in the pyroxenite xenolith (113.74 mm^3/g)

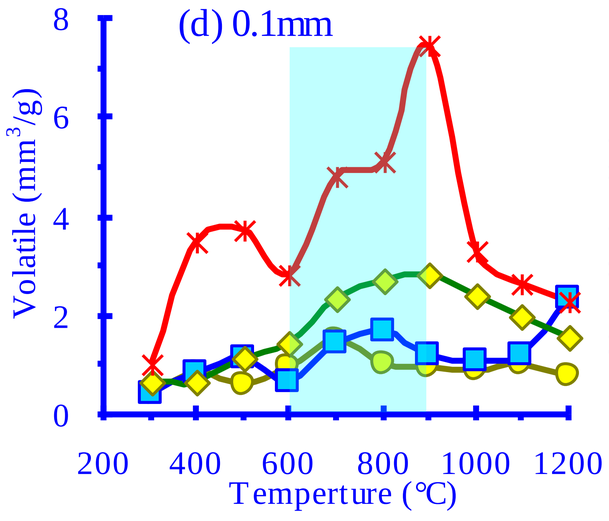


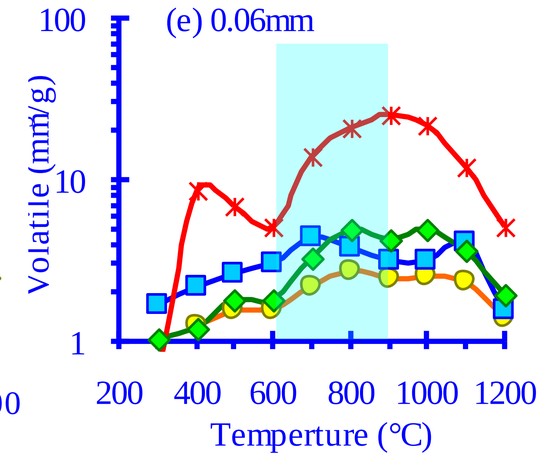


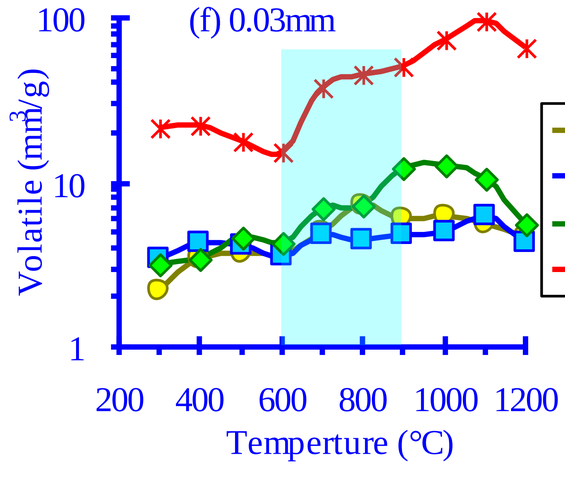












(2) The volatiles released from constituent minerals tend to be released and concentrated at three temperature intervals of 300-600 ℃, 600-900℃ and 900-1200 ℃.

3. Summary

(1) Much of the mantle volatiles must in fact reside in structural defects/vacancies, which are volumetrically more important than fluid inclusions.

(2) Mantle volatiles in early-generation fluid inclusions and structural defects/vacancies are more reduced, dominated by CO and H_2 etc, implying lower fO_2 than current view on the basis of fluid inclusion analysis.

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