



Stable isotopic and petrologic evidence for open-system degassing during the climactic and pre-climactic eruptions of Mt. Mazama, Crater Lake, Oregon

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Evaluating the extent of volatile element recycling in convergent margin volcanism requires delineating likely source(s) and compositions of magmatic volatiles. This is facilitated by stable isotopic characterization of sulfur (S), hydrogen (H), and oxygen (O) in erupted tephra with appropriate assessment of modification by magmatic degassing. Isotopic compositions of whole rocks, matrix glasses and minerals from Mt. Mazama climactic (caldera-forming eruption) and pre-climactic tephra were determined to identify likely source(s) of magmatic H₂O and S. Integration of stable isotopic data with petrologic data from melt inclusions and pyrrhotite inclusions has allowed for estimation of pre-eruptive dissolved volatile concentrations and placing constraints on the extent, conditions and style of degassing.

Sulfur isotope analyses of climactic rhyodacitic whole rocks yield $\delta^{34}\text{S}$ values ranging from +2.8 to +14.8 per mil with corresponding matrix glass $\delta^{34}\text{S}$ values of +2.4 to +13.2 per mil. $\delta^{34}\text{S}$ values of whole rocks and matrix glasses generally increase with stratigraphic height consistent with open-system degassing. Dissolved sulfur concentrations in melt inclusions from Cleetwood and climactic pumices varies from 80 to 330 ppm, with highest concentrations in inclusions with 4.8 - 5.2 wt. % H₂O (by FTIR). Up to 50 % of the initial sulfur may have been lost through pre-eruptive degassing at depths of 4 - 5 km. Ion microprobe $\delta^{34}\text{S}$ analyses of pyrrhotites in climactic

rhyodacitic tephra range from -1.0 to +5.6 per mil and from -1.0 to +4.0 per mil in climactic andesitic scoria. The variation in pyrrhotite $\delta^{34}\text{S}$ most likely tracks the sulfur isotopic evolution of the melt and the magnitude of this variation requires pre-eruptive, open-system loss of sulfur from the melt \pm vapor system. Initial $\delta^{34}\text{S}$ of rhyodacitic and andesitic magmas was likely near the mantle value of 0 per mil. Hydrogen isotope and total H_2O analyses of rhyodacitic obsidians (and vitrophyres) from the climactic pumice fall deposit yield δD values from -103 to -53 per mil with 0.23 wt.% to 1.74 wt.% H_2O , respectively. Values of δD and wt. % H_2O of obsidians decrease towards the top of the fall deposit. Samples with depleted δD , and mantle $\delta^{18}\text{O}$, have elevated $\delta^{34}\text{S}$ consistent with open-system degassing. These results imply that more mantle-derived sulfur is degassed to the Earth's atmosphere/hydrosphere through convergent margin volcanism than previously attributed. Isotopic compositions of magmatic sulfur can be modified by $\geq +14$ per mil and of hydrogen by -90 per mil by pre- and syn-eruptive degassing that may obscure recognition of primary volatile sources.