

What's so super about supercritical fluids in subduction zones?

C.E. MANNING¹

¹Dept. of Earth and Space Sci., U. of California, Los Angeles, CA 90095, USA, manning@ess.ucla.edu

It is commonly assumed that fluids in subduction zones have properties intermediate between hydrous silicate melt and H₂O. Such supercritical, intermediate fluids are potentially important because they could dominate mass transfer to the mantle wedge. However, the existence and longevity of such fluids is problematic [1]. Albite-H₂O is typically used as an analogue system, but the favorable position of its critical curve [2] is not representative; critical curves for basalt and peridotite lie at substantially higher *P* [3,4]. In addition, low-porosity natural systems only coexist with intermediate fluids over a restricted *PT* interval. Finally, intermediate fluids, if formed, will exist over short length scales as composition shifts during reactive flow in the mantle wedge.

Although supercritical fluids probably do not play a major role in subduction-zone metasomatism, their chemistry holds a clue to understanding high-*P* mass transfer by water-rich solutions. Full miscibility can only occur by progressive polymerization of dissolved Si, Al, Na and other metals. This behavior yields, e.g., aqueous Si-Si, Si-Al, and Si-Na-Al oxide polymers of varying stoichiometry. High-*P* experimental studies indicate the presence of polymeric complexes even in subcritical, dilute, H₂O-rich fluid [e.g., 5,6]. Silicate polymers in these solutions enhance the solubility of minor elements such as Ti, P, and Zr in high-*P* fluids [7], probably by substitution into their more energetically favorable oxygen-coordinated sites. Sub-critical silicate polymerization thus affords a mechanism for mobilization of nominally low-solubility components. Because they form over a wider *PT* and bulk-compositional range, subcritical silicate polymers in dilute solutions are likely responsible for more mass transfer in subduction zones than intermediate, supercritical fluids.

References

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