

## 5.3.16

### Quantitative models for the composition of slab-derived fluids

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To predict the composition of slab-derived hydrous fluids, and how they change with depth in a subducting slab, requires knowledge of both slab mineralogy and fluid-mineral partition coefficients. New data on trace element partitioning for hydrous minerals, combined with similar data on other minerals from previous studies and phase equilibria experiments, now allow us to estimate bulk fluid-rock partition coefficients for the evolving mineralogy of a subducting slab. The bulk partition coefficients, in conjunction with measured trace element concentrations in altered oceanic crust, enable us to predict quantitatively the trace element compositions of subduction zone fluids and thus better assess the implications of trace element patterns in island arc lavas.

Our models predict across-arc geochemical trends that have been found in some arcs (e.g. the Kuriles and Kamchatka). By comparing the across-arc geochemical trends with the fluid composition models, we can constrain the amounts of residual accessory phases permissible in the slab. For instance, residual mica must be less than 1% beyond 100 km slab depth in order to explain the Ba and K enrichment often observed in the back-arc.

The thermal structure of the subduction zone plays a very important role in determining the amount and composition of fluids released as subduction proceeds. The Sr/Y ratio, for example, is strongly dependent on the relative proportions of lawsonite, zoisite, and garnet, the reactions governing which are strongly temperature dependent. A cold slab may never leave the lawsonite stability zone, in which case the Sr composition (and Sr/Y) of the fluid is relatively low. A warmer slab, in contrast, may pass out of the lawsonite stability field, and ultimately out of the zoisite stability field, releasing much larger amounts of Sr and H<sub>2</sub>O and generating fluids with very high Sr/Y.

Quantitative predictions of slab-derived fluid compositions attained using our model can ultimately be incorporated into models for arc magma generation, improving our ability to model geochemical trends measured in subduction zone lavas.

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### Lawsonite eclogite from the Dominican Republic: Implications for cold subduction

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Lawsonite eclogite is a rare rock type that has been described from only five natural occurrences. In contrast, laboratory experiments and thermal models predict that lawsonite eclogite should be widespread in subducted oceanic crust deeper than 1.5 GPa. Here we report a new lawsonite eclogite find from the Dominican Republic [1] that provides further constraints on the conditions of subducted crust. In this sample, lawsonite coexisting with omphacite occurs as both inclusions in garnet and as large porphyroblasts, the latter being partly replaced at their margins by epidote and zoisite. Peak pressure conditions estimated from lawsonite-phengite-omphacite-garnet assemblages were ca 1.6 GPa at a temperature of 360 °C, implying formation under a geotherm of ca. 8 °C/km. Peak temperature conditions of 410-450 °C were in the zoisite eclogite field, suggesting that the sample crossed from the stability field of lawsonite eclogite into that of zoisite eclogite as a result of increasing temperature.

A comparison with other reported occurrences indicates that most lawsonite eclogite exhumed at the Earth's surface formed in accretionary wedges. The rarity of lawsonite eclogite at the Earth's surface may be principally due to two factors: (i) that in 'normal' subduction settings lawsonite eclogite enters the subduction factory and hence is usually not exhumed; and (ii) that in accretionary wedge settings, where the *PT* path leaves the stability field of lawsonite eclogite due to heating, lawsonite eclogite is only preserved if the exhumation path is constrained to a narrow window where the terminal stability of lawsonite is not crossed.

The few existing natural lawsonite eclogite samples therefore provide unique material where several geochemical key parameters can be extracted such as trace-element partition coefficients and stable-isotope compositions in rocks approaching the zone of arc-related fluid release.

#### References

- [1] Zack T., Rivers, T., Brumm, R., and Kronz, A. (2004) *EJM*, submitted.