Relationships between fluid composition and rheology in ecologites from the eastern Alps

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ABSTRACT

Finely banded, dolomite-rich mica gneiss from the Tauern Window equilibrated at ~2 GPa and 800-900°C. Previous work (Selverstone et al. 1992; Getty & Selverstone, 1994) showed that:

- $\delta^{18}O$ varied from -6.4 to -6.0 across layers of peak pressure.
- $\delta^{18}O$ of dolomite varied by up to 1.8% between layers.
- There is no variation in $\delta^{18}O$ of fluid inclusions.
- Fluid inclusions (FIs) are absent in layers with lower $\delta^{18}O$.
- Modern garnet and clinozoisite have complex chemical zoning.
- Some fractures propagate into matrix and/or subgrains.
- The rocks acted as a closed system during high-P metamorphism.

These observations indicate that the rocks acted as a closed system during high-P metamorphism, with little if any fluid communication across layers. This is consistent with the mechanical behavior of the eclogites as a function of fluid composition within individual layers. The mineral assemblage is nearly constant across layers, and there are no internal equilibrium constraints. The results in this study highlight the role that fluid composition plays in controlling rheology in eclogitic metamorphic rocks and may be very important in controlling the evolution of bulk rock rheology during high-P metamorphism.

EXTENSION FRACTURES ARE UBIQUITOUS, BUT ARE CONFINED TO SPECIFIC LAYERS

Fracturing began prior to peak eclogite equilibration at 2 GPa, and continued with same orientation throughout exhumation.

WHY DO FRACTURES OCCUR IN SOME LAYERS BUT NOT OTHERS? EVIDENCE FROM MICROSCOPIC SCALE

- Outcrop-scale evidence for plastic flow and for boudinage/fracturing at eclogite conditions
- Mineral assemblage is constant, but modal abundance varies between layers
- Fractures are best developed in layers with high aspect ratio mineral grains
- Layers without fractures have stronger matrix CPO than layers with fractures

SUMMARY OF KEY OBSERVATIONS

- There is no systematic relationship between grain size and degree of fracturing
- Fractures are best developed in layers with high aspect ratio mineral grains
- Layers without fractures have stronger matrix CPO than layers with fractures
- Fractures are best developed in layers with high concentrations of omphacite and clinozoisite
- Fractures are least abundant in layers with high concentrations of dolomite
- Healed cracks in garnet cores indicate earliest fractures formed prior to eclogite pressure peak

CONCLUSIONS

- Fluid composition controlled deformation mechanisms: dissolution-precipitation creep in layers with high water activity vs. dislocation creep in layers with lower water activity
- Ductile deformation mechanisms (e.g., dissolution-precipitation creep) preconditioned rock to localize brittle failure by affecting porphyroblast aspect ratios
- High water activities can promote brittle failure in addition to facilitating water weakening of silicate minerals
- Eclogite-stage microcracks may have localized macroscopic fractures during early stages of unroofing
- Generation and propagation of small-scale fluid heterogeneities is common in metamorphic rocks and may be very important in controlling the evolution of bulk rock rheology

GARNET ASPECT RATIOS ARE CORRELATED WITH FLUID COMPOSITION

Because aspect ratio differs between layers with fractures and layers without, there must also be a relationship between fluid composition and strain accommodation mechanisms.

Layers without fractures:
- Garnets are equant and show limited but concentric chemical zoning
- Omphacite and clinozoisite have complex chemical zoning, some subgrain development and subgrain extinction, and moderately well-developed CPO and SPO
- Garnets accommodate via dissolution-precipitation creep

Layers with fractures:
- Garnets are elongate and show complex chemical zoning
- Orichalcite and chlorite have complex chemical zoning, few obvious subgrains, and show a strong SPO but only a weak CPO
- Garnets accommodate via dislocation creep / dissolution-precipitation creep

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ACKNOWLEDGMENTS

Funded in part by NSF grants EAR-0509937, EPSL 220-246, and Acta Sinica 1109.197

REFERENCES

Selverstone et al. 1992; Getty & Selverstone, 1994; Hawkins for discussions.

Some relevant references:

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