# Lithologic control on fluid evolution during contact metamorphism in the Eastern Monzoni thermal aureole

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The Monzoni intrusive complex in the western central Dolomites intruded previously unmetamorphosed Permo-Triassic sediments during Mid Triassic time. The country rocks comprise a sequence of limestones alternating with dolomitic, marly, and siliciclastic members. We use petrologic and stable isotope systematics from three distinct lithologies of the Skythian Werfen Formation to evaluate the extent of lithologic control on fluid evolution during contact metamorphism. The selected lithologies are a siliciclastic interval of the Campil Member with subordinate marly layers, a pure dolomite oolite and a marl-limestone interbedded sequence of the Cencenighe Member.

## Contact metamorphism

In the dolomite oolite contact metamorphism is evident from the successive formation of tremolite and forsterite and the disappearance of dolomite towards the intrusive contact. Forsterite formation by the reaction 1 tremolite + 11 dolomite = 8 forsterite + 13 calcite + 1 $H_2O$ + 1 $CO_2$ is inferred from mineral textures at 300 m from the contact. Calcite–dolomite thermometry yields 450°C and thus indicates $XCO_2 > 0.1$ for these rocks.

In the marly layers of the Cencenighe and Campil Members the first low temperature metamorphic minerals are clinozoisite and tremolite at 850 m from the contact. The first appearance of garnet by the reaction 2 clinozoisite + 5 calcite + 3 quartz = 3 garnet + 1 $H_2O$ + 5 $CO_2$ is very well defined at 650 m from the contact. This limits the fluid composition to $XCO_2 < 0.04$ at temperatures $\leqslant 400^\circ C$. The typical high temperature paragenesis in the marly layers consists of garnet-diopside-wollastonite-calcite.

In pure limestone layers the only effect of contact metamorphism is a significant grain coarsening. In limestone layers with silicate phase impurities grain coarsening is hampered and calcite remains fine grained up to the intrusive contact.

## Stable isotope systematics

The oxygen isotope compositions of the carbonates within the contact aureole are generally shifted towards lower values with respect to the unmetamorphosed equivalents. The extent of the oxygen isotope shifts is largely controlled by lithology.

Pure carbonates, both calcitic and dolomitic, show only a moderate $^{18}O$ depletion from $\delta^{18}O$ (SMOW) =26‰ in the unmetamorphosed to 22‰ in the contact metamorphic samples.

Impure carbonates and marly layers show significant oxygen isotope depletion from $\delta^{18}O$ =25‰ down to as low as 15‰.

In all lithologies there is a similar $\delta^{13}C$ depletion trend towards the contact with $\delta^{13}C$ (PDB) changing from +3‰ to −2‰ as a minimum. The extent of $\delta^{13}C$ shifts correlates with metamorphic temperature and with the extent of decarbonation reactions, indicating Rayleigh distillation. Lithologic control on $^{13}C$ depletion through decarbonation is observed on a cm-scale in layered limestone-marl samples.

## Conclusions

Both the petrologic and the stable isotope systematics indicate that pure carbonaceous lithologies are impermeable to external fluid. In these lithologies the composition of the pore fluid is internally controlled by decarbonation reactions. In contrast, lithologies with silicate phase impurities are permeable to external, isotopically light fluid and fluid composition is externally controlled. The role of the silicate phase impurities in the carbonate matrix is to supress grain boundary migration and grain coarsening and to maintain relatively high permeability during contact metamorphism. Heterogeneities in the permeability structure are manifest on a cm-scale.