

## Continuum of peak metamorphism in anatectic terrains

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Anatectic melting in high-grade metamorphism is an effective process for trapping the volatiles released by contemporaneous prograde metamorphic reactions. Crystallization releases these volatiles, which can be transported into adjacent rocks and induce metamorphism.

High-grade marbles on the island of Naxos in the Greek Cycladic archipelago accurately record these phenomena. Two generations of mineral assemblage are observed within and adjacent to the anatectic migmatitic core (Table 1). The second generation (2r) developed along contacts between prograde amphibolites and calcite marbles, as boudinaged veins that crosscut siliceous dolomites and calcite marbles, and at the contacts between pegmatites and calcite marbles. Phase equilibrium calculations indicate a water-rich fluid. The 2r silicate minerals are clearly distinguished from the prograde (1r) minerals by their significantly lower  $\delta^{18}\text{O}$  values (Table 1).

Table 1 Summary of marble assemblages and  $\delta^{18}\text{O}$  values

	Prograde (1p) Assemblages	Retrograde (2r) Assemblages
Siliceous dolomites	tr ta di, tr di	tr ta cc, tr ta di cc
Amph-bearing calcite marbles	amph, cpx plag <sub>1</sub> ± q ± gt ± scap	amph <sub>2</sub> cz cpx ± plag <sub>2</sub> ± mica
Vsv-bearing calcite marbles	vsv gt cpx cc	cz gt scap cc cpx ± gt ± vsv ± wo ± q
Mineral $\delta^{18}\text{O}$ (SMOW)‰ ranges	dol >27‰; cc >24‰ amph=17-20‰; di= 18-20‰ mica (bi)=16-17‰	cc= 10-18‰ gt=9-10‰ di=10-11‰ amph= 11‰

dol = dolomite; q = quartz; cc = calcite; plag = plagioclase; amph = calcic amphibole (hornblende); tr = tremolite; ta = talc; di = diopside; cpx = clinopyroxene (diopside-augite); gt = garnet (grossular-andradite); scap = scapolite; vsv = vesuvianite; cz = clinozoisite (epidote); wo = wollastonite.

The calculated  $\delta^{18}\text{O}$  values of water in equilibrium with 2r minerals are identical with the values calculated for the fluids exsolved from pegmatite dykes that formed during the late-stage crystallization of the anatectic melts. Thus the peak metamorphic processes involve a continuum of both prograde and retrograde high temperature reactions, whereby the exsolved anatectic volatiles induce a highly focussed (channelized), petrologically distinguishable, overprint of the prograde metamorphic assemblages.

## Fluid inclusions as micro-chemical systems: evidence and modelling of fluid-host interactions in plagioclase

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Dense,  $\text{CO}_2$ -rich fluid inclusions hosted by plagioclases, An<sub>45</sub> to An<sub>54</sub>, of the O.-v.-Gruber Anorthosite body, central Dronning Maud Land, East Antarctica, contain varying amounts of small calcite, paragonite and pyrophyllite crystals (Fig.1) detected by micro-Raman spectroscopy.

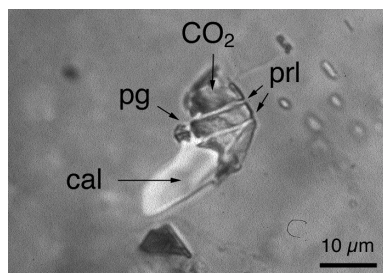


Figure 1.  $\text{CO}_2$ -rich inclusion in plagioclase with various birefringent crystals.

These crystals are reaction products that have formed during cooling of the host and the original  $\text{CO}_2$ -rich  $\text{H}_2\text{O}$ -bearing enclosed fluid. Variable amounts of these reaction products illustrate that the reaction did not take place uniformly in all fluid inclusions, possibly due to differences in kinetics as caused by differences in shape and size, or due to variation in the originally trapped fluid. The reaction (plagioclase +  $\text{H}_2\text{O}$  +  $\text{CO}_2$  = calcite + paragonite + pyrophyllite) was thermodynamically modelled with consideration of different original fluid composition. Although free  $\text{H}_2\text{O}$  is not detectable in most fluid inclusions, the occurrence of OH-bearing sheet silicates indicates that the original trapped fluid was not pure  $\text{CO}_2$ , but contained significant amounts of  $\text{H}_2\text{O}$ . Compared to an actual fluid inclusion, it is obvious that volume estimations of solid phases can be used as a starting point to reverse the retrograde reaction and recalculate the compositional and volumetrical properties of the original fluid. Isochores for an unmodified inclusion can thus be reconstructed, leading to a more realistic estimation of PT conditions during earlier metamorphic stages or fluid capturing.