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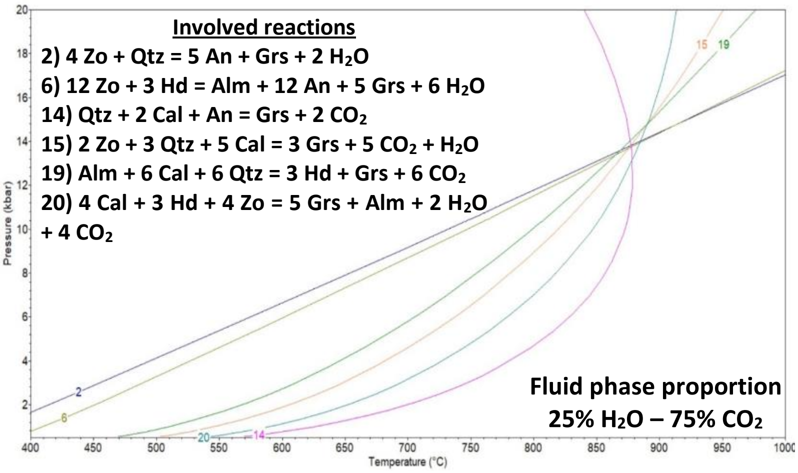
Metamorphism of marbles and carbonate rocks; how they affect the CO_2 cycle?

Norway is a country with very interesting geology and contains various types of rocks that were formed during different orogeneses. The rocks in this study were formed during Caledonian orogeny, at the Silurian period ca. 430 million years ago, and are part of the Western Gneiss Region. The rocks in the Western Gneiss Region have been metamorphosed in high-pressure granulite- to eclogite facies. The initial estimation of the metamorphic conditions yields 870 ± 50°C and 14.5 ± 2 kbar, which means that these rocks were buried approximately 50 km deep in Earth's crust.

The study area is Allmenningen, an island 9 km west of the Roan peninsula in western Norway. The studied rocks are mostly marbles, calc-silicates and mafic knobs that are intercalated within the calcareous succession. The complete mineral assemblage from the three rock types combined, includes calcite, dolomite, clinopyroxene, garnet, amphibole, scapolite, zoisite, epidote, anorthite, phlogopite (Mg-rich biotite), white mica and quartz. Accessory minerals are titanite, apatite, zircon and metallic minerals.



The mineralogy of one mafic knob in a contact marble-amphibolite is peculiar. Thin garnet rims occur that surround the other minerals. This garnet presents different chemisrty depending on its textural position. Garnet in the rims is richer in calcium and aluminium (grossular) compared to the core. Based on chemical analyses of garnet and geothermobarometry equations, an attempt for pressure and temperature estimation during metamorphism was conducted. For that calculation, specific mineral phases have been chosen from microscopy observations.

Does the result coincide with the initial estimation?

The mineral equilibria describe grossular-garnet formation. Grossular formed during heating and devolatilization. The minerals which reacted and released fluids are zoisite and calcite. These minerals were consumed constantly, and the fluid phase was maintained in the closed, deep, metamorphic system. At peak metamorphism, temperature reached approximately 875°C and pressure around 13.8 kbar. The fluid phase composition was 25% H_2O and 75% CO_2. So, what really happens in this CO_2? In fact, it is suggested that the CO_2 was emitted during prograde metamorphism, because the rocks cannot hold all this fluid phase and some of it must escape from the system. Sometimes, the CO_2 quantities are significant and together with other processes like volcanic eruptions and ice cap melting, it contributes to global warming.

Master's Degree Project in Geology 45 credits 2020
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(Figure: Temperature and pressure equilibrium diagram calculated using TWQ software (Berman, 1991), with stable curves and metastable reactions of a garnet-rich mafic knob in contact marble-amphibolite)