

Dypingite as a series and its formation from serpentinite weathering

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Dypingite, $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 5\text{H}_2\text{O}$, is one of the hydrous magnesium carbonate phases which also include lansfordite ($\text{MgCO}_3 \cdot 5\text{H}_2\text{O}$), nesquehonite ($\text{MgCO}_3 \cdot 3\text{H}_2\text{O}$), and hydromagnesite ($\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{H}_2\text{O}$). Weathering of serpentinite by water and atmospheric CO_2 induces the formation of hydrous magnesium carbonates including dypingite (Power et al. 2013). Recently, dypingite has been found to be relevant for CO_2 sequestration (Ballirano et al. 2013) and water purification (Naqvi, 2014). However, the fact that its structure and formation in natural settings are still largely unknown hampers further applications of dypingite. Supported by the NATSORB project, this work collected hydrous magnesium carbonates from Dypingdal and the Feragen Ultramafic Body, Norway, to study the formation of dypingite, which contributes to refinement of dypingite structure, synthesis and environmental application of dypingite.

Deviations in most X-ray diffraction (XRD) patterns of dypingite compared to the first dypingite pattern in Raade (1970) has been ascribed to undefined “dypingite-like phases” (Hopkinson et al. 2012). In our samples, both dypingite showing the same XRD pattern as that in Raade (1970) and dypingite-like phases have been found. The former one is called dypingite *sensu stricto* (*s.s.*). Synchronous variation between structure parameters analyzed by XRD and molecular water contents measured by thermogravimetric analyses and Infrared spectroscopy is shown from dypingite *s.s.* via dypingite-like phases to hydromagnesite. Subsequently, humidity incubation experiment conducted under room temperature showed that high humidity (> 95%) induced phase transformation toward dypingite *s.s.*, whereas low humidity (< 23%) reversed the phase change direction, but failed to attain hydromagnesite. Therefore, dypingite *s.s.* and dypingite-like phases are a continuous series connected by reversible phase change. Dypingite *s.s.* as one endmember is the fully hydrated version, while on the other end is the minimally hydrated dypingite.

Hydrous magnesium carbonates encrusting serpentinite can be composed of three zones, which are moderately hydrated dypingite (Zone 1), nearly fully hydrated dypingite (Zone 2), and nesquehonite or lansfordite (Zone 3). In Zone 1, platy crystals of dypingite are perpendicular to the serpentine surface, whereas in Zone 2, some dypingite crystals grow in similar way on surface of serpentine fragments but also as radiating morphology. The $\delta^{13}\text{C}$ values well distinguish dypingite in Zone 1 from that in Zone 2. Values of Zone 2 are in the same area of those in Zone 3. Accordingly, the dypingite in Zone 2 might be transformed from nesquehonite or lansfordite or precipitated in one type of weathering fluid. The dypingite in Zone 1 is proposed to be formed directly from another fluid.

References

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