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The lithification of ultramafic dominated till with magnesium silicate hydrate: a new green concrete

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The Feragen Ultramafic Body located near the town of Røros in Eastern Norway gives rise to a unique phenomenon: A lithification process involving natural cement of magnesium silicate hydrate (M-S-H). The ultramafic body is covered with moraine deposits that form tills throughout the area. The tills consist mainly of variably serpentinized ultramafic rock fragments, with additional quartz and feldspar grains transported to the area with the glaciers that formed the till. This provides the exceptional combination of ultramafic and Si-rich rocks. Throughout the area, multiple spots can be found where natural cement has resulted in the lithification of the till, forming tillite. This mainly occurs close to mine tailings of ancient chromium mines, as the mine tunnels provide air flow that increases the evaporation and thus the precipitation of the cement. The Weichselian glaciation constrains the age of the moraines to less than 10 ka and the formation of the concrete related to mine tailings suggests that the lithification took place after the termination of the mining activity in 1927. Thus, the cement is formed in-situ at its current location, indicating that it forms in a subarctic climate.

EMP and SEM analysis indicate that the cement is a hydrated magnesium silicate phase, cementing together quartz, feldspar and serpentine grains to form a natural concrete. The cement consist of 31 wt% of MgO and 49 wt% of SiO_2. Quartz and feldspar grains are partly dissolved in the concrete while the resulting pore space is filled with cement, indicating that the Si in the cement originated from the quartz and feldspar phases. Weathering of the ultramafic body involves the dissolution of brucite to create a high pH, Mg-rich fluid, which subsequently can dissolve the quartz and be the source for the M-S-H cement. A dissolution-precipitation process involving the dissolution of both brucite and quartz thus results in the formation of the cement. Future TEM analysis should give more insights in the lithification process at nanoscale and to determine if the cement is crystalline or amorphous.

The search for a new environmental friendly cement is presently an urgent task considering that the widely used Portland cement accounts for about 7 % of the worldwide anthropogenic CO_2 emission. Mg rich cement has been stated to be a good environmental friendly alternative, although it has not been used in a commercial way, mainly due to high production costs and low availability of source material. This study provides new key insights in the formation process of natural CO_2-neutral M-S-H cement, which could be an analog to a convenient construction material.