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Geological controls on light dolomite deposits related to polymetallic sulphide deposits, Sala area, Bergslagen, Sweden – insights from whole-rock lithogeochemistry, spectrophotometry and magnetic susceptibility

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Regionally extensive, dolomitic and calcitic marble units comprise a subordinate but important component of a c. 1.91-1.89 Ga supracrustal succession in the Bergslagen lithotectonic unit, southern Sweden. These units occur as interbeds in predominantly felsic metavolcanic successions, and originated as shallow marine, stromatolitic limestone. Upon burial, the limestones were subjected to dolomitization and hydrothermal alteration, and at c. 1.87-1.80 Ga during the Svecokarelian orogeny, greenschist-amphibolite facies metamorphism and ductile deformation led to further modification.

The marble units host abundant replacement-type, syn-volcanic sulphide and iron oxide deposits and locally industrial carbonate deposits. In the Sala area, current mining targets exceptionally light dolomite marble proximal to formerly mined Zn-Pb-Ag mineralization. The geological controls on marble lightness are poorly understood, e.g. the relative importance of primary impurity caused by co-settled volcaniclastic or siliciclastic material as opposed to secondary modifications caused by hydrothermal alteration. The following study addresses these controls based on 179 geospatial dolomitic marble samples analyzed for whole-rock lithogeochemistry, spectrophotometric lightness and magnetic susceptibility.

Centered log-ratio transformed major element data suggest that lightness is positively correlated with Mg, Ca and Tot C, negatively correlated with Fe and Mn, and lack a clear relationship to Al and Si. Robust principal component analysis of major and trace element data allows representation of 81.1% of the cumulative variance by three principal components. PC1 (46.7%) mainly differentiates ‘hydrothermal’ elements such as Zn, Pb and As from elements such as Si, Mg, Ca, Tot C, Al, Zr, Ce, La and Eu. PC2 (21%) differentiates the latter into a ‘volcaniclastic-siliciclastic’ group dominated by Zr, Al, Ce, La and Eu and ‘calcite-dolomite’ group dominated by Ca, Mg and Tot C. PC3 (13.4%) is primarily controlled by Fe and Mn, with Fe+Mn-enriched samples outlining a c. 200 m wide halo around known Zn-Pb-Ag deposits. Optic microscopy and normative mineralogy suggest a negative correlation between lightness and the opaque minerals magnetite, pyrrhotite, pyrite, sphalerite and galena, which are variably enriched in this alteration halo.

Collectively, the results imply that whereas a volcaniclastic component is detrimental to lightness, this effect is negligible relative to the effect of even weak Fe-enrichments (> 1 wt.%) at SiO_2 < 10 wt.% and $Al2O_3$ < 2 wt.%. This likely reflect that in contrast to the opaque minerals, the main silicates tremolite, serpentine, chlorite and phlogopite grind into light powders during processing. Light dolomite and sulphide-mineralized samples cluster in opposite corners in RQ1-RQ3 space and form coherent geospatial clusters corresponding to known deposits. Magnetic susceptibility data effectively differentiate these clusters and is hence useful for outlining prospective marble volumes.

It is speculated that light marble constitutes a peripheral member of the sulphide-associated alteration halo. Thus, light marble is in itself a vector to polymetallic sulphides, and a potential byproduct in operations targeting the latter. High lightness is tentatively attributed to leaching and recrystallization of dolomite under elevated temperatures, either driven by ‘spent’ ore-forming fluids exiting the mineralizing system, or by marine fluids in peripheral, secondary hydrothermal aleration cells.