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Provenance determination of crystalline marbles from Czech localities: a pilot study from the Krkonoše-Jizera Terrane (Bohemian Massif, Czech Republic)

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Czech Republic is rich in numerous varieties of crystalline marbles that have been quarried in all metamorphic units. Their utilisation for local monuments can be traced from Gothic but peak use occurred during Renaissance and Baroque. Similarity in macroscopic appearance and overall mineralogical composition do not allow precise sourcing of the material without use of more complex analytical approaches.

In this study, mineralogical-petrographic and geochemical methods have been tested (optical microscopy (OM) of the whole rock, petrographic image analysis (PIA) of microstructures, X-ray diffraction (XRD) of the insoluble residuals, stable isotope ratio analysis (SIRA) of carbonates in groundmass and secondary veins, cathodoluminescence (CL) of microfacies, and magnetic susceptibility). The study has been conducted on crystalline limestones (i.e. true marbles) from the west edge of the Krkonoše-Jizera Terrane (north part of the Bohemian Massif).

Petrographic characteristics permit a distinction between fine-grained to medium-grained marbles from Jizera Mountains (amphibolite metamorphic facies) and fine-grained marbles from Ještěd Mountains (low-grade greenschist facies). The samples studied are mainly calcitic, with the exception of those from Raspenava in which dolomit is abundant in two types. Mineralogical composition of the insoluble residuals is clinochlore $\pm$ serpentine $\pm$ tremolite $\pm$ diopside $\pm$ pyrite $\pm$ magnetite in case of the locality Raspenava and clinochlore + muscovite $\pm$ quartz $\pm$ pyrite $\pm$ rutile $\pm$ hematite in case of the localities from Ještěd Mountains. δ^{13}C and δ^{18}O variations in primary and secondary carbonate phases allow characterisation of genetically

different carbonate veins and sourcing of the quarry in one case (Raspenava, Jizera Mountains). The groundmass shows δ^{13}C and δ^{18}O values in the range from -1 per mille to +3 per mille (PDB), respectively from -8 per mille to -20 per mille (PDB). The δ^{13}C and δ^{18}O values of secondary carbonate veins decrease to -3 per mille and reach more negative values up to -26 per mille in case of δ^{18}O. Fabric of cathodomicrofacies allow the distinction between calcite and dolomite, except three localities (Pilínkov, Horní Hanychov, Jitrava rose type) with majority of quenchers (high content of Fe in carbonate). The genetically different calcite is characterised by a pale and dark orange luminescence distribution. Serpentine, tremolite, forsterite, quartz, and opaque minerals have no luminescence. The majority of studied marbles have low values of the magnetic susceptibility, with the exception of those from Raspenava in which magnetite is present.

Sourcing of the marbles from monuments is highly influenced by the amount of material available for the analysis, and by the employed analytical technique. Based on the results of this study, the most effective way for the marble sourcing is combination of petrographic methods (including quantitative approaches), cathodoluminescence, and stable isotopes study. Insoluble residue study is questionably applicable due to the large volumes of materials required for the analysis.