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New approaches in dimension stone exploration: an example from the "Dorato Valmalenco" quarry (central Alps, northern Italy)

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The Valmalenco area (western Alps, northern Italy) is famous all over Italy and the world as a source of dimension stones, especially "green stones" (serpentinites and soapstones), but also gneisses, such as the "Dorato Valmalenco", a unique type of orthogneiss, highly appreciated in the market because of peculiar mechanical and esthetical characteristics (a grayish, schistose rock with peculiar silver-golden reflections). This gneiss is extracted only in one open-cast hillside quarry, in the Sabbionaccio - Monsù site, close to the village of Chiesa in Valmalenco (SO), and the annual output amounts to 15.000 m3 of stone blocks, obtained by a combined use of detonating cord and diamond wire. From a geological standpoint, it is a single orthogneiss body (Permian protolith), intruded in metasedimentary country rocks (micaschists and paragneisses), belonging to the crystalline basement of the Margna nappe (lower Austroalpine). The alpine orogeny has further deformed and metamorphosed the rock, thus determining the peculiar features of the "Dorato Valmalenco". It is a fine grained homeoblastic stone with gneissic texture, a marked plain-parallel foliation, defined by the alternating quartz- feldspathic levels (quartz, albite, K-feldspar) and phyllosilicatic domains (white mica, biotite, chlorite), associated with epidote and other accessory minerals. Considering the metamorphic origin and the several deformation events undergone by the "Dorato Valmalenco", the stone deposit has several textural and mineralogical defects on a decimetric to metric scale such as: mylonitic bands, quartz-feldspathic lenses, aplitic veins, chlorite-epidote aggregates and folds. Such defects, associated with fractures, cause discontinuity in the foliation, thus causing a major issue in terms of quarrying and production. Furthermore, close to the limits of the extractive area, the Dorato pinches out in paragneisses: if a similar "closure" of the orthogneiss lens could be detected also in depth, it would indicate that the deposit is close to depletion. To tackle these issues, the first step consisted in performing a detailed survey and a representative sampling of each "lithology" (including individual defects) within the quarry. Further mineralogical analyses, carried out by quantitative X-Ray Powder Diffraction (XRPD) and SEM-EDS, allowed a complete characterization of all rock samples, defining the mineralogical assemblages of each "lithology". Five drill holes were carried out in the two areas at the borders of the deposit: sampling of the cuttings was performed every 1.5 m, and XRPD analyses allowed rock characterization. A following Optical Borehole Televiewer (OPTV) technique collected images from the borehole walls, and performed a geomechanical survey. Geophysical analyses (seismic refraction) have determined the thickness and composition of debris layer over the rock deposit. The correlation between mineralogy (XRPD), geomechanical survey, video inspection of the drilling holes and geophysical surveys allowed the modeling of the two areas taken into consideration: the abandoned area is overall homogenous and "enriched" with "Dorato Valmalenco", whereas the adjoining sector is deeply fractured and characterized by heterogeneous "lithologies" ("Dorato Nuvolato"). By introducing the "Dorato Nuvolato", it could be possible to compensate the ever diminishing "Dorato Valmalenco", and present a wider, more flexible commercial portfolio.