Integration of Exploration and Production Data Towards an Improved Resource Model of a Marble Quarry

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Abstract. Estimation of marble quarry resources is commonly based on exploration data (drillholes and quarry faces), characterised by experienced personnel (or more recently by some machine-learning based process) as to the aesthetic parameters relevant to the commercially exploitable marble products of the specific quarry, and to the density of natural joints and fractures that affect the percentage of recoverable blocks from the quarried units (slabs). Aesthetic parameters include marble features such as background colour, vein texture, density and homogeneity, and the presence and density of visual defects such as stains, marks, and glass. These parameters are categorical and their representation in exploration databases is based on discrete, non-scaled values. The density of natural joints and fractures is measured as to the prominent joint sets, and the resultant densities are represented in the database as separate parameters of scaled or non-scaled values.

As the drill core surface area is very small compared to the surface area of the slabs, it is difficult, even for experienced personnel, to characterise core samples objectively and consistently as to the considered aesthetic parameters. This issue resembles the change of support problem found in geostatistical resource estimation studies of other mineral deposits, with the additional challenge that the aesthetic variables are not continuous or even numerical in the case of marble. Similar issues are present in the natural joints and fractures density variables. These problems lead to very different distributions for all considered variables between exploration samples and produced slabs, and difficulty in formulating a reliable resource estimation strategy. Spatial clustering of drillholes due to non-regular drilling campaigns further increases the difference between production and exploration data.

The procedure described in this paper takes advantage of georeferenced production data from the extracted marble slabs. This data consists of separate percentage variables for each of the marble product qualities considered. Each slab is represented as a “drillhole sample” in the database and marble product quality percentages are recorded for the entire length (slab height) of the “sample”. Exploration drillhole data is also processed to derive the product quality percentages for each interval using the aesthetic and fracture density variables, and the original intervals are then composited to lengths similar to the heights of the slabs. Both production and exploration data are then transformed to normal scores, as their distributions are highly skewed. This transformation also helps exploration data become compatible with production data so that they can be combined for resource estimation. Variogram models of the normal scores are derived from the combined data set, a block model is estimated using ordinary kriging, and the estimates are transformed back to the original distribution based on the production data transformation. Extra de-clustering weights are calculated and used during estimation.

This procedure ensures that the estimates follow closely the percentages reported from quarry production and eliminates the bias introduced by the non-regular drilling pattern and characterization of drillhole samples based on human interpretation. A case study on a dolomitic marble deposit demonstrates the benefits of this approach.