Improvement of accuracy of metal content modeling using geostatistics in consideration of geological information

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Because most geological data are obtained at irregularly spaced points, a 3D modeling method is indispensable to estimate spatial distribution of value or category. In addition, geological data are multivariate that have several variables at the same point in many cases. For this data type, multivariate geostatistics has been widely used which assigns the optimal weights to each datum through a spatial correlation structure, termed cross-semivariogram. Kriging is a spatial estimator founded on this principle. Correlation of a variable pair naturally differs with the selected variables and also, geological type: the correlation of a pair may be strong in a certain geological type, but weak in the other types. This nominal information such as the geological type is difficult to be considered in multivariate geostatistics. For this problem, this study applies principal component analysis (PCA) to incorporate the dependence of data-pair correlation on geological type and decorrelate it by the orthogonal transformation, which can increase the estimation accuracy and decrease the calculation amount by requiring the calculation of only semivariogram of the principal components.

This idea is tested to a problem of metal content modeling over a deposit, because its accurate estimation is essential to reserve assessment and ore body characterization and moreover, contribute to resource exploration of the same deposit type. Matsumine and Fukazawa mines, typical large kuroko deposits in the Hokuroku district, Akita Pref., northern Japan, are selected for a case study. Kuroko is a Japanese term for massive, compact black-ore mainly composed of sphalerite, galena, and pyrite. Kuroko deposits were originated from felsic to intermediate submarine volcanic activity (e.g. Yamada and Yoshida, 2013). The metal contents of Cu, Zn, and Pb for both the mines and Au and Ag for the Fukazawa mine in the drilling cores were used for the data analyses.

The number of drillholes are Matsumine: 77 and Fukazawa: 58 and the target areas are 420 m ×940 m (along the horizontal) ×390 m (along the vertical) and 1100 m ×2400 m ×450 m, respectively. Main rock types are selected from the geological columns. PCA is applied to a dataset composed of the metal contents and binary data of the geological type: 1 for the presence of a geological type and 0 for the other types. The principal components are used for semivariogram modeling and kriging calculation, and by the inverse transformation of PCA, metal contents and geological type can be given to each grid point. This method, termed PCA-kriging (PCAK) incorporates the information on the spatial correlation structure of data pair and its dependence on geological type into the spatial modeling. The estimation result of metal content distribution is compared with the results of ordinary kriging (OK) and co-kriging (CK).

Common to both the mines and all metals, the CK results are mostly underestimate and, despite the similar distribution patters of OK and PCAK, the PCAK result contains less smoothing effect. This difference is particularly remarkable in a large content range, which causes large difference in reserve assessment between OK and PCAK, such as double amounts of Cu and Pb by PCAK than the OK amount. Another PCAK advantage is to draw a geological model using the geological types output, which is apparently harmonious with the preceding model. Overlay of the high content zones upon the geological

model is revealed to be effective to detection of the ore-solution paths and interpretation of the deposit-generation process.

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References

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