Effectiveness of use of geological information for geostatistical modeling of metal concentration in deposit

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In order to realize a sustainable society and technological innovation, the demand for metal resources has been increasing. A highly accurate estimation of metal grade in a deposit can elucidate the generation mechanism of the same type of deposit and lead to stable supply of metal resources. For this, two geostatistical methods that incorporate geological information are developed with aiming at estimation of metal grade distribution with high accuracy. Two deposits of kuroko (volcanogenic massive sulfide) type and porphyry copper type are selected for case study sites of the method.

In method 1, a binary set is prepared by giving 1 to the location of targeted geological type in each borehole column and 0 otherwise, and principal component analysis (PCA) is implemented with the concentration data of main metals. The principal component values by PCA are interpolated sequentially by kriging and back-transformed to the original coordinate system. This method is termed PCA-kriging (PCAK). In method 2, the kriging calculation of the main metal concentration is performed for each geological type, and by overlapping with a 3D geological model, the kriging result is limited to the range of each geological type. The geological model is constructed l through PCAK using the binary set of geological data. This method, termed kriging with geological constraint (KGC), focuses on the correlation between geological type and metal concentration.

The first case study is for one of the largest kuroko deposit, the Matsumine mine in Akita prefecture using vertical or sub-vertical 77 drilling data. The size of study area is 420 m×970 m along the horizonal plane and 280 m along the vertical direction. Considering the anisotropic behavior of the spatial correlation structure in the metal concentration data, two variograms along the horizontal and vertical directions are used. The neighboring search is determined so that the kriging calculation could be possible at all grid points in the study area without changing the ratio of the ranges along the two directions.

The estimation accuracies by ordinary kriging (OK), PCAK, and KGC were compared by correlation coefficient (r) in cross-validation. As compared with OK, the KGC’s r of copper increased by 0.014 and the PCAK’s of lead increased by 0.010. The r’s of zinc were almost the same. In the KGC and PCAK results, the estimated values in the medium concentration part are scattered largely, which declines the accuracy, but the accuracy in the high concentration part increases and the smoothing effect can be reduced by KGC. Moreover, as compared with a geostatistical simulation result, the high concentration parts represent well the distribution pattern with more reliable values. Because ore reserve estimation requires accurate location and amount of the high concentration zones, KGC is demonstrated to be the most effective among the methods examined by this study. Furthermore, superposition of the geological model and high concentration zones can contribute to trace the ore solution flows and interpret a deposit formation process. KGC is also applied to a porphyry copper deposit in Sulawesi island, Indonesia and

features of high concentration zones, which are different with metal type, are clarified.

