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Hybrid Fuzzy Weights of Evidence and Artificial Neural Networks for Mineral Potential Mapping: A case study from the Bushveld Complex, South Africa

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Abstract

Artificial neural networks (ANNs) and hybrid fuzzy weights of evidence (HFWofE) modelling approaches were used to produce a predictive mineral potential map of chromium in the far westward extension of the western limb of the Bushveld Complex (BC), in South Africa. The study area is poorly explored due to the availability of large platinum and chromium resources elsewhere in the BC. The geology of the area comprised of three broad lithologic domains, *viz*. from the oldest to the youngest; the Transvaal Supergroup, the BC and the Karoo sedimentary rocks, dolerite dykes and sills. The chromium deposits in the BC often occur as stratiform chromitite seams within the mafic layered rocks consisting of pyroxenite, norite and anorthosite, which collectively form cyclic units in the Upper Critical Zone of the BC. The deposit recognition criteria defined in this study includes, the chromitite seams are often confined to a specific stratigraphic horizons in the Upper Critical Zone, which suggests that stratigraphy of the mafic rocks and lithology are among the deposit recognition criteria that characterize the distribution of the deposits.

The ANNs and HFWofE were applied to five critical layers of spatial evidence that represent the recognition criteria for the distribution of chromium deposits. The location of 35 known deposits was compiled from publicly available sources of data and a subset of 25 deposits was used to train, while the remaining 10 deposits were used for validation of the performance of the ANNs and the weights of evidence (WofE). In addition, 10 non-deposits were selected for training within the study area based on prior knowledge. The two sets of the training data were combined for further analysis. In an attempt to reduce the effect of the use of insufficient training data on the dimensionality and performance of the neural network, the most suitable predictor maps were chosen. The number of neurons and iterations were varied over a wide range of values with a step of 25 until optimum total sum of errors was achieved.

The cumulative favourability value versus the cumulative area for the HFWofE was plotted in order to define the threshold (low favourability) and the upper (high favourability) values. The results show that 6.2%, 13.4% and 80.2% of the area correspond to high, intermediate and low favourability values, respectively. The high favourability area contains 74.2% of the validation deposits and 82.5% of the training points. The ANNs shows that the high favourability area covers 6.7% of the study area and contains 81.4% of the validation deposits and 86.3% of the training points. Comparison of the two sets

of results suggests that the ANNs is more robust than the HFWofE in predicting the chromium potential map of the area, though the differences are not significant. However, the contrast in the results of the two modelling approaches may be attributed to differences in model parameters, assumptions and the number of training and validation points used in the modelling algorithms. The contrast in model sensitivity to one or the combination of the parameters may give rise to contrasting results. In general, the two sets of results show that the far westward extension of the BC is potentially favourable for the occurrence of chromitite seams. The highly favourable zone coincides with the E-W striking pyroxenite, which can be equated to the pyroxenite, norite and anorthosite cyclic units of the Upper Critical Zone, which is found elsewhere in the eastern and western limbs of the BC. The present results can be further enhanced through the use of additional training points and re-processing of the predictor maps.