HYPERCUBE: MINING EXPLORATION DATA, A CASE STUDY USING THE MILLENNIUM URANIUM DEPOSIT, ATHABASCA BASIN

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The Canada Mining Innovation Council (CMIC) Data Integration Technology Group, as part of a five-year commitment to research and innovation in mineral exploration, is applying predictive analytics to characterize quantitatively the footprints of well-known ore deposits in Canada. Data mining was used to evaluate meaningful associations in geological, geophysical, geochemical, mineralogical and petrophysical data at numerous sites and here we report initial results on a case-study, conducted on the Millennium deposit (indicated resource of 1442.6 t at 2.39% U_3O_8). Market basket analysis was used to establish sets of "association rules" among 3D variables, including lithogeochemical, mineralogical and geophysical variables, at various distances from the core to periphery at the Millennium deposit. The methodology implemented identifies "association rules" using BearingPoint, HyperCube® (HC) rule mining technology. Different ranking statistics were applied to select optimal rule-sets in the mineralized basement and in the overlying sandstone units of the Manitou Falls Formation. To evaluate HC results, systematic exploratory data analysis (EDA) was conducted to examine observed associations for all the variables considered. Results obtained suggest that HC correctly identifies the change in U associations due to compositional variations attributed to different mineralogy of the host-rock. Together, EDA and HC analyses show positive correlation of U with $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios, Mo, and to a lesser extent V in all analyzed stratigraphy indicative of primary dispersion. Positive associations of U and HREE+Y are dominant in sandstones above the deposit, whereas at the fringes of the deposit, U is associated with Rb, Pb, and Th in the basement. Anticorrelations with U were recorded for major/trace elements in the basement (e.g., Mn, Si, Ca, Ba, Na and Fe), reflecting the transition from altered clay-dominated assemblages to unaltered rocks with plagioclase and feldspar. Anticorrelations with U in sandstone-cover for Ce, Th, Zr and Hf reflect a transition from U phases within detrital minerals (e.g., zircon, monazite, apatite) to U in hydrothermal phases such as uraninite, APS and other REE-hosting oxides. Furthermore, HC simple lift analysis indicates that radiogenic $^{206}Pb/^{204}Pb$ ratios higher than 30 can be located in the MFd unit above the deposit consistent with secondary dispersion of radiogenic Pb several hundreds of metres from the deposit.