Machine learning-based till geochemical pattern recognition applied to mapping and targeting of potential area for lithium mineralization in Västernorrland region, Sweden

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The increasing demand for lithium driven by the "green transition" is leading to the application of new and innovative exploration methods to numerous mineral systems, including lithium- cesium-tantalum (LCT) pegmatites. Sweden hosts numerous LCT pegmatite mineralisations in the Västernorrland (VNL) region, and as part of the Exploration Information Systems project (Horizon Europe grant no. 1010557357; eis-he.eu), which aims to create an open sourced QGIS toolkit for mineral prospectivity mapping, the Geological Survey of Sweden (SGU) has undertaken preliminary data preparation for MPM using principle component (PC) analysis and k-means clustering to applied to geochemical analysis of till to identify potential prospective areas for further Li exploration.

The Geological Survey of Sweden and Nämnden för Svenska gruvor (NSG) (Lax and Selinus 2005) collected till samples for analysis in the VNL region during the 1980s with a total sample density of around 1 sample per 7km^2 and the samples were analyzed for major and trace elements using ICP-AES and XRF (Al, Ca, Fe, K, Mg, Mn, Ba, Be, Co, Cu, La, Li, Ni, Pb, Sr, Zn (SGU) + Sc, As, V, Y, Ti, P, Na, - Be (NSG)). NSG data were levelled to the SGU data.

Robust PC-analysis and K-means clustering were applied to the till data, both major and trace element data together and trace element data only. PC results from all element data displayed positive scores along PC1 associated with Cu-Co-Mg, and negative PC1 Scores associated with La-Sr-Ca. This result indicated that the first principle component can be used to distinguish till with a mafic component with that of a more felsic origin. The second PC of the all-element analysis provides a further delineation of till samples with mafic, potentially doleritic origin along the negative axis, and more fractionated granites with strong positive PC2 scores associated with Li and Ba.

Examination of the PC scores for only trace elements shows similar discrimination of the mafic and felsic components along the first principle component axis, with similar loading scores to the all-element data. The 3rd principle component shows strong negative scores associated with Be, Li and Zn. The correlation of Be and Li on the negative axis is an indication that negative score can be associated with highly fractionated granites or mineralized LCT pegmatites due to the enrichment in Be in VNL pegmatites. K-means clustering identified six clusters, with the 6th cluster being best associated to potential Li mineralization.

In summary, both PCA and K-means clustering seem likely to be useful in the interpretation and classification of samples into different groups which can be correlated to the existing interpretations of the regional geology and known Li pegmatite mineralization. Outputs of this statistical approach with geological interpretation and knowledge may provide promising information on sites that may represent previously unknown occurrences of mineralization and can therefore be directly used in the selection of possible future additional study. Detailed geological mapping and lithogeochemical study, higher-density sampling and geochemical re-analysis of till samples with modern ICP-MS combined with novel and experimental approaches to indicator element selection may be a way forward in this and other previously glaciated regions with regards to LCT-type granitic pegmatites of this character.

References

Lax K. & Selinus O., 2005: Geochemical mapping at the Geological Survey of Sweden. Geochemistry: *Exploration, Environment, Analysis 5*, 337–346