

# **Molybdenum-Uranium-Vanadium geochemistry in the lower Paleozoic Alum Shale of Scandinavia: Implications for Vanadium exploration**

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Redox sensitive trace elements such as molybdenum (Mo), uranium (U), and vanadium (V) in metalliferous shales have economic value. The lower Paleozoic Alum Shale Formation of the Scandinavian region is known for its highly elevated concentrations of trace elements such as Mo, U, and V. However, the systematical investigation on enrichment of the three metals has been scarce. This study conducted the most comprehensive compilation so far of more than 1,100 samples to investigate the spatial and temporal distributions and geochemical controls for Mo, U, and V to explain their hyper-enrichment in the lower Paleozoic Alum Shale Formation of Denmark, Sweden, Norway, and Estonia. The results show that Mo and U are mainly associated with organic matter and the highest contents are found in the Furongian part of the Alum Shale. This Furongian hyper-enrichment of Mo and U commenced with the Steptoean Positive Carbon Isotope Excursion (SPICE) event. The temporal distribution of V content increases moderately from the Miaolingian to the Furongian, followed by a significant increase in the Early Ordovician. In addition, the V content generally increases towards the offshore, distal part of the Alum Shale basin. The geochemical affinity of V seems to change from organic matter in the Cambrian to minerals in the Early Ordovician. The hyper-enrichment of V in the Lower Ordovician succession appears to result from upwelling of deep oceanic water. The present-day spatial distribution of V in the Alum Shale indicates that the promising V exploratory area is the Furongian and Lower Ordovician Alum Shale in Scania, southernmost Sweden. Moreover, the Öland area in eastern Sweden and the area of northern Estonia also show potential for V mining in the Lower Ordovician succession.