

A successful partnership between Industry and Academia to assess the potential of black shales to secure vanadium supply

LEIBO BIAN¹, XIAOMEI WANG², HAMED SANEI³,
ANTHONY CHAPPAZ⁴ AND NIELS HEMMINGSEN
SCHOVSBO⁵

¹Research Institute of Petroleum Exploration and Development,
PetroChina

²Research Institute of Petroleum Exploration & Development,
PetroChina, Beijing, China

³Aarhus University

⁴STARLAB - Central Michigan University

⁵Geological Survey of Denmark and Greenland

Vanadium (V) is a recognized critical metal that is required for (i) improving the strength and wear resistance of steel alloys, (ii) storing energy at grid-scale power facilities, and (iii) sustaining the Green Energy Transition. Some black shales display extremely high enrichments of V and may have the potential to become reliable sources to secure V supply. To develop, this market energy companies often collaborate with academics to conduct research that will contribute to assess the economic viability of these alternative V sources.

The Alum Shale Formation in the Scandinavia is known for high organic matter content and elevated V concentrations, which are of particular interests to petroleum and critical metal industries. However, the spatiotemporal distribution and burial pathways of V in this shale remains poorly understood. Therefore, we conducted the most comprehensive compilation of more than 1150 samples from this shale to investigate the spatiotemporal distribution of V. Additionally, we applied the X-ray Absorption Near Edge Structure (XANES) analysis to probe V species and elucidate its burial pathways.

Our results show the V content increases moderately from the Miaolingian to the Furongian, followed by a significant increase in the Ordovician. Spatially, V content generally increases towards the offshore, distal part of the Alum Shale basin. The spatiotemporal distribution of V in the Alum Shale indicates that the highest concentrations are located in Scania, southernmost Sweden. The XANES analysis shows that the presence of a new V(+IV)–S structure that dominates the V speciation (>80%) in the samples deposited in euxinic conditions. This differs from previous work suggesting V is mainly bound to oxygen (O) atoms and/or O–N (nitrogen) groups, when removed from the water column. We suggest the new V(+IV)–S structure may have been formed under strongly sulfidic conditions, with organic matter serving as the dominant host phases for this species.

Furthermore, we present an updated model that outlines the processes involved in V burial under a wide range of redox conditions. This model provides new insights into the biogeochemical cycling of V in the Alum Shale and its implications for both resource potential and paleo-environmental