

## **Geochemistry and Metal Extraction from Black Shales: Unconventional source of critical metals**

ROBERT BOWELL<sup>1,2</sup>, **MR. JULIEN DECLERCQ, MSC,  
PH.D.**<sup>2</sup>, MATTHEW LEYBOURNE<sup>3</sup>, DANIEL LAYTON-  
MATTHEWS<sup>3</sup> AND JAMES KIDDER<sup>4</sup>

<sup>1</sup>Queens University

<sup>2</sup>SRK Consulting

<sup>3</sup>Queen's University

<sup>4</sup>Geological Survey of Canada

Presenting Author: [jdeclercq@srk.co.uk](mailto:jdeclercq@srk.co.uk)

Shale is the most abundant of the sedimentary rocks, accounting for roughly 70 percent of this rock type in the crust of the Earth. Shales are characteristically comprised of clay minerals, iron minerals, feldspars, micas, and substantial amounts of quartz, amongst others. In addition, in the case of black shales, they also contain abundant organic matter and much of the iron occurs as sulfide minerals.

Geochemically, black shales are highly enriched in many redox-sensitive and/or sulfide-forming metals and metalloids, including Cr, V, Mo, Re, Tl, U, As, Cd, Sb, Se, Ag, Cu, Ni, Zn, Co, Pb, and P, and in some cases also Hg, Li, Au, PGE, Y, graphite, or rare earth elements (Wignall, 1994; Wei et al., 2021). Various syn-sedimentary to early diagenetic processes of metal concentration have been proposed but in general the critical factors in metal enrichment are the presence of bacterial sulfate reduction and utilization of organic matter to liberate metal(loid)s. Metal distribution in black shales is complex and includes uptake in sulfide minerals as well as adsorption on particles such as dead organic matter, clay, sulfide minerals, and oxide minerals, in the water column and bottom sediment (e.g., Wignall, 1994).

Understanding the mineralogy of such deposits is essential to predicting response in metallurgical circuits. Given the low concentration of metals compared to more conventional sources, lower intensity processing is economically attractive, such as heap leaching (both chemical and biological) or In Situ Recovery. To apply these predictive chemical calculations can help to estimate recovery efficiency and determine potential geometallurgical processes. However, before this can be initiated, a comprehensive characterization of black shales is critical.

Wei W, Ling S, Wu X, Li X, Liao X 2021 Investigations on mineralogy and geochemistry of a black shale profile on the northern Yangtze platform, China: Weathering fate of rare earth elements and yttrium (REY) and its implications. Applied geochemistry, 2021, 126,1-12

Wignall, P. B. 1994 Black shales. Oxford : Clarendon Press ; New York : Oxford University Press. 127p.