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Geochemical characteristics of upper Cambrian black shale from southern Sweden – regional perspective

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The Paleozoic black shale occurs from Finnmark in northern Norway to Scania in southern Sweden, along the Caledonian mountain front and as platform outliers in southern Sweden. Black shale belongs to the Alum Shale Formation that was deposited in a marine environment in the Late Cambrian to Early Ordovician and it has been of economic interest for hundreds of years. Black shale was mined for alum salts, oil, and uranium, and used as fuel source in lime production. The economic and environmental significance of black shale is a topic of an active debate in Nordic countries.

The focus of this study is to characterise the chemical composition of the black shale which occurs in southern Sweden in relation to its spatial distribution. The carbon and sulphur contents in fresh and unaltered black shales vary in the region, with average 14 % of carbon and 3 % of sulphur. Locally, carbon-rich shales (> 20%) can be observed at Billingen, north of Skövde and at Kvarntorp, south of Örebro. Black shale is also known to be enriched in uranium, vanadium, molybdenum, and nickel. Uranium content varies from 2 to 104 ppm, with mean of 44 ppm and highest content at Latorpsbruk and Kvarntorp. Vanadium, an important critical raw material is strongly enriched in black shale from the north side of Kinnekulle (up to 928 ppm), Ekedalen, east of Falköping (>900 ppm) and in Scania where maximum concentration of 1250 ppm has been measured by the coast. Average molybdenum content in black shale is ca 130 ppm and the most enriched samples were collected at southern Kinnekulle (235 ppm), northern Billingen (230 ppm), western Hunneberg (211 ppm), southeast of Falköping (211 ppm) and at Kvarntorp (180 ppm). The positive correlation between carbon and uranium and molybdenum indicates that organic matter is a major sink/host for these metals. For potentially toxic elements such as As, Sb, Cu and Zn the positive correlation with sulphur can present an environmental risk during black shale weathering and under oxidation conditions which may accelerate the release of harmful elements into the water courses and soil.