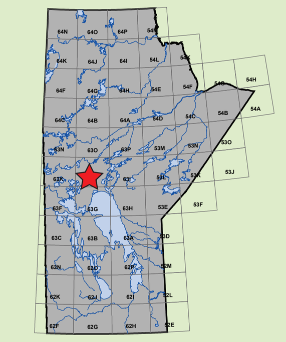
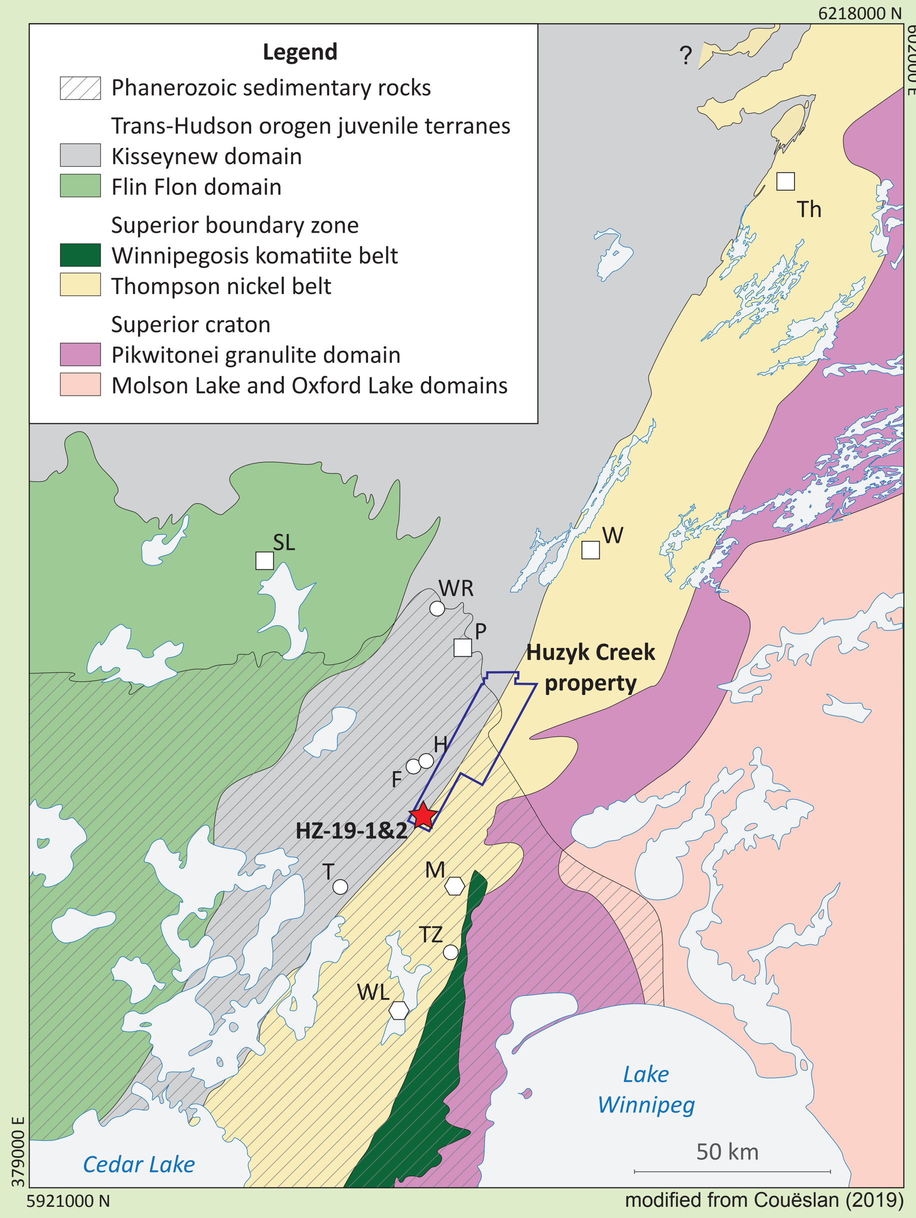
Graphite- and vanadium-enriched metasedimentary rocks from the Huzyk Creek property, sub-Phanerozoic Kisseynew domain

C.G. Couëslan (Manitoba Geological Survey)





modified from Couëslan (2019)

Summary

The Huzyk Creek property lies along the boundary between the sub-Phanerozoic Thompson nickel belt and Kisseynew domain, and is host to graphite-mineralized and vanadium-enriched metasedimentary rocks. The metasedimentary rocks consist of an interbedded wacke-mudstone succession that is tentatively correlated with (although atypical of) the Burntwood group of the Kisseynew domain. A package of hornblende gneiss and calcsilicate is associated with the wacke-mudstone succession and could represent variably altered, mafic volcanic rocks. The graphite mineralization occurs as an intersection of graphite-rich mudstone (14.3–16.7 m wide), which is likely analogues to black shale. The vanadium enrichment correlates closely with the graphite mineralization, and suggests that vanadium was likely entrained by organic particles as they settled to the bottom of the Kisseynew basin. Graphite deposits elsewhere in the Kisseynew domain could prove equally prospective for vanadium. Graphite and vanadium are considered critical elements/minerals by the U.S. Department of the Interior, and are in-demand by the green technologies sector for use in electric motors, lithium batteries, and vanadium redox-flow batteries. The Green Giant and Balama prospects are similar metamorphosed black shale deposits investigated for vanadium and graphite mineralization in Madagascar and Mozambique, respectively.

References

AGP Mining Consultants 2011: Green Giant project, Fotadrevo, Province of Toliara, Madagascar; NI 43-101 report prepared for Energizer Resources, 175 p.

Breit, G.N. and Wanty, R.B. 1991: Vanadium accumulation in carbonaceous rocks: A review of geochemical controls during deposition and diagenesis; Chemical Geology, v. 91, p. 83–97.

Callinex Mines Incorporated 2014: Grades of up to 60.38% carbon graphite confirmed at Callinex' Neuron property; Callinex Mines Incorporated, press release, April 25, 2014.

Couëslan, C.G. 2019: Evaluation of graphite- and vanadium-bearing drillcore from the Huzyk Creek property, East Kisseynew domain (NTS 63J6); in Report of Activities 2019, Manitoba Growth, Enterprise and Trade, Manitoba Geological Survey, p. ##–##.

Kelley, K.D., Scott, C.T., Polyak, D.E. and Kimball, B.E. 2017: Vanadium; in Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply, K.J. Schulz, J.H. DeYoung, Jr., R.R. Seal II and D.C. Bradley (ed.), U.S. Geological Survey, Professional Paper 1802, p. U1–U36.

Robinson, G.R., Jr., Hammarstrom, J.M. and Olson, D.W. 2017: Graphite; in Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply, K.J. Schulz, J.H. DeYoung, Jr., R.R. Seal II and D.C. Bradley (ed.), U.S. Geological Survey, Professional Paper 1802, p. J1–J24.

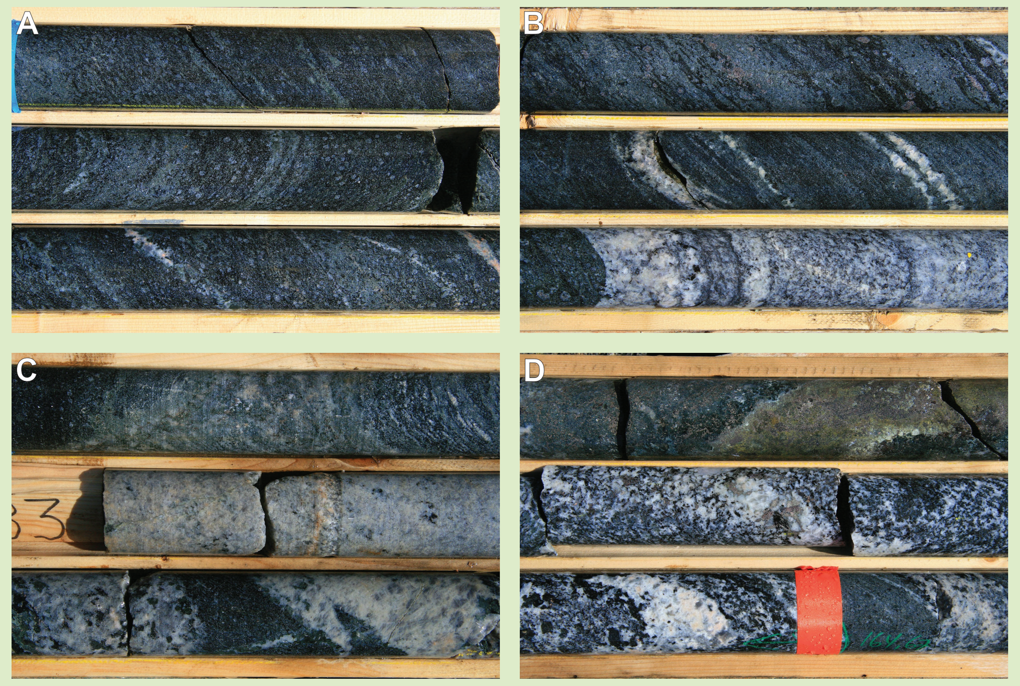
Schulz, K.J., DeYoung, J.H., Jr., Seal, R.R., II and Bradley, D.C., ed. 2017: Critical mineral resources of the United States—Economic and environmental geology and prospects for future supply; U.S. Geological Survey, Professional Paper 1802, 797 p.

Syrah Resources Ltd. 2015: Balama graphite feasibility study and corporate update – May 2015; Syrah Resources Inc., presentation, May 29, 2015.

Vanadian Energy Corporation 2019: Vanadian Energy intersects 0.22% V2O5 over 9.74 metres on the Huzyk Creek property; Vanadian Energy Corporation, press release, May 21, 2019.

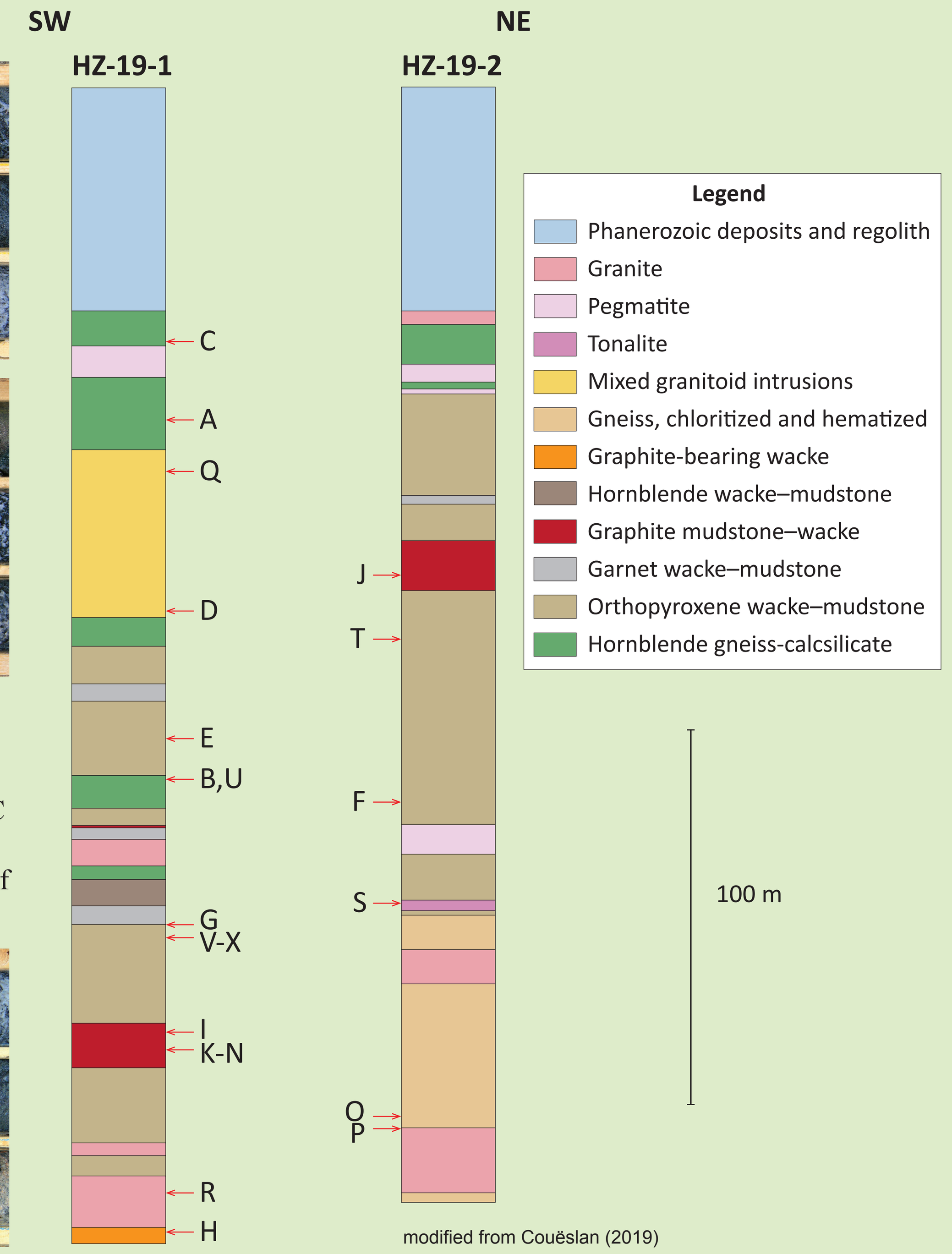
Zwanzig, H.V. 2008: Correlation of lithological assemblages flanking the Kisseynew Domain, Manitoba (parts of NTS 63N, 63O, 64B, 64C): proposal for tectonic/metaollogenic subdomains; in Report of Activities 2008, Manitoba Science, Technology, Energy and Mines, Manitoba Geological Survey, p. 38–52.

Huzyk Creek drillcore

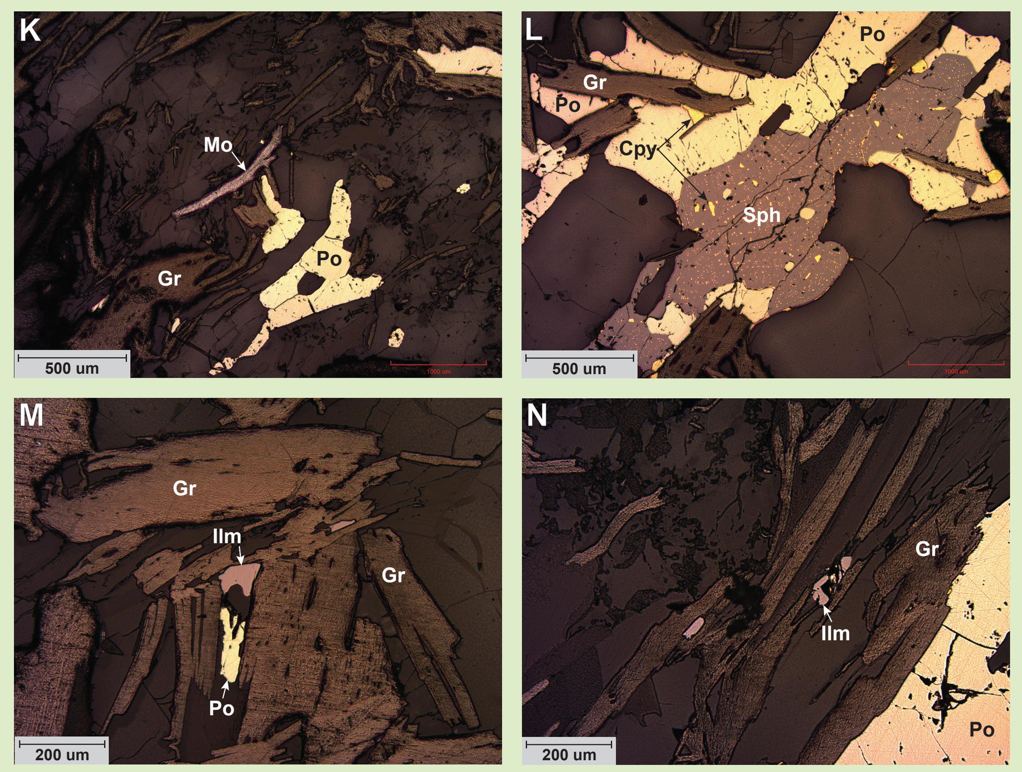


Hornblende gneiss with diffuse interlayering of calcsilicate (A) occurs towards the top of the Precambrian in both drillholes. The calcsilicate can be texturally similar to the hornblende gneiss (A and B) or can be texturally diverse with variable enrichment in diopside, sulphide, titanite, and epidote (C and D; top rows). The hornblende gneiss and calcsilicate could represent variably altered basalt similar to occurrences along the north and east flanks of the Kisseynew domain (Zwanzig, 2008).

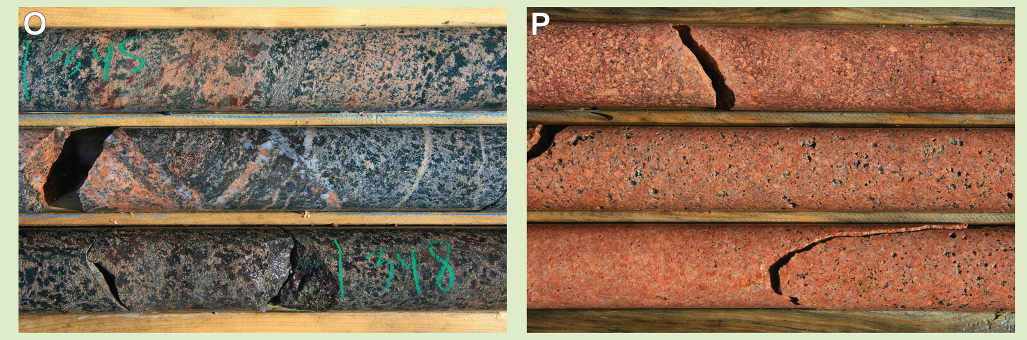
The graphite- and vanadium-enriched horizon is hosted by a thick package of interbedded wackes (E; top and bottom rows) and mudstones (E; middle row). The sequence consists largely of orthopyroxene-bearing wacke-mudstone (E and F), which is locally interbedded with garnet-bearing wacke-mudstone (G and H). Graphite-rich mudstone occurs as a discrete horizon within the wacke-mudstone succession (I). The graphite-rich mudstone contains local beds of graphite- and pyrrhotite-bearing sandstone (J, top row). Assay results presented by Vanadian Energy (2019) suggest a close correlation between graphite-mineralization and vanadium-enrichment. The wacke-mudstone sequence is tentatively correlated with the Burntwood group of the Kisseynew domain.



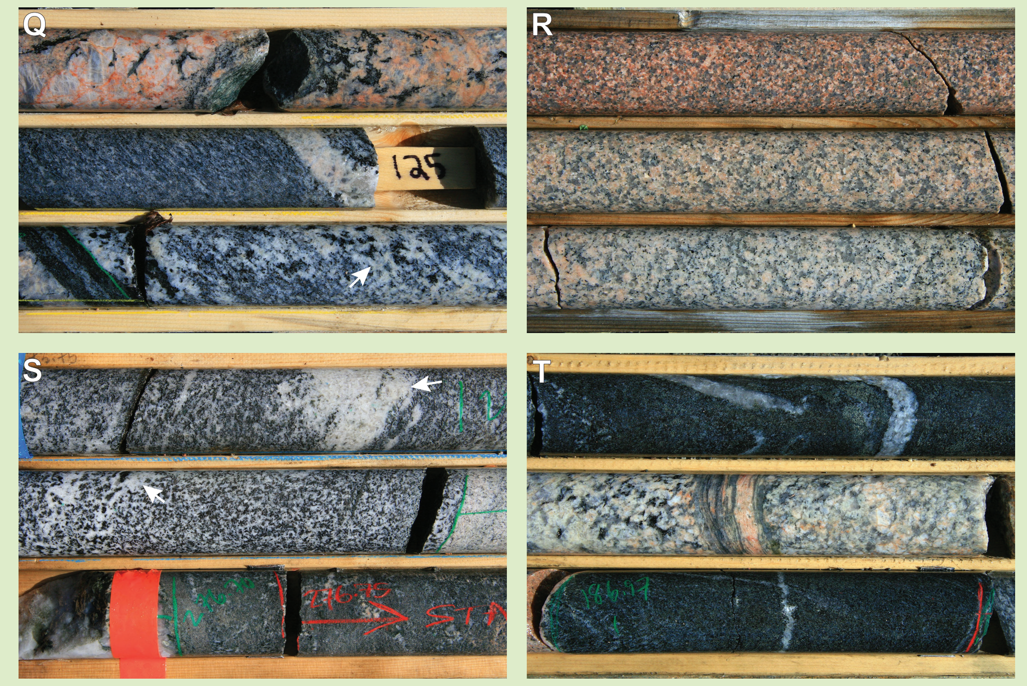
modified from Couëslan (2019)



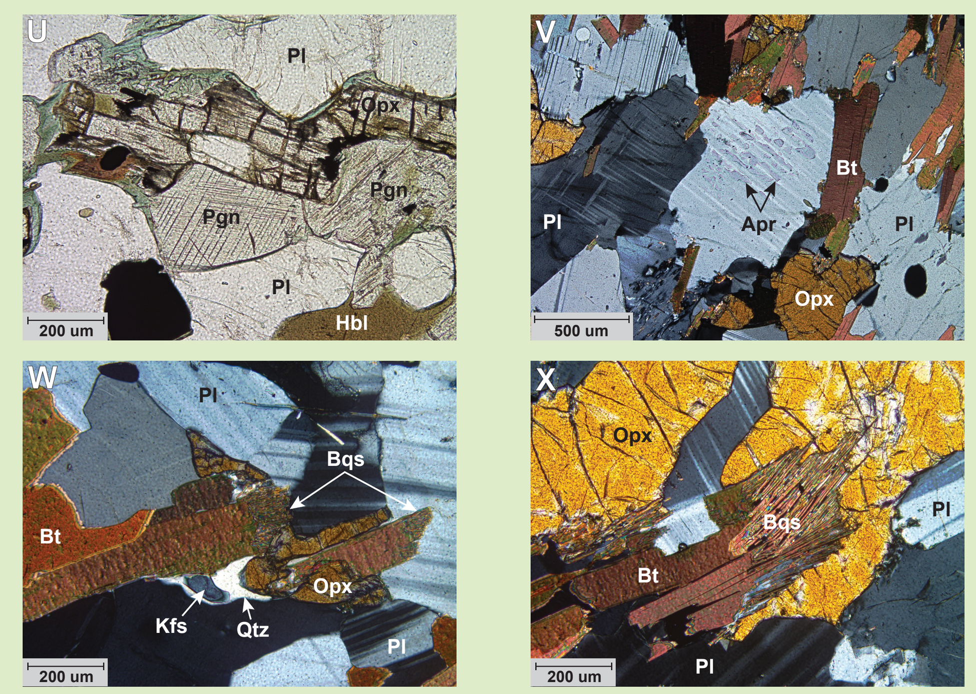
The graphite-rich mudstone contains abundant pyrrhotite, along with minor molybdenite (K), sphalerite, and chalcopyrite (L). A minor oxide phase is also present (M and N). The oxide has been tentatively identified as ilmenite; however, the optical properties of more obscure vanadium oxides are not well constrained. Abbreviations: Cpy, chalcopyrite; Gr, graphite; Ilm, ilmenite; Mo, molybdenite; Po, pyrrhotite; Sph, sphalerite.



A thick intersection of chloritized and hematized gneiss occurs towards the bottom of drillhole HZ-19-2 (O). Relatively late, weakly foliated intrusions within the gneiss are also altered (P). Sparse zones of quartz-vein breccia with void-filling specular hematite occur within this package of altered rocks.

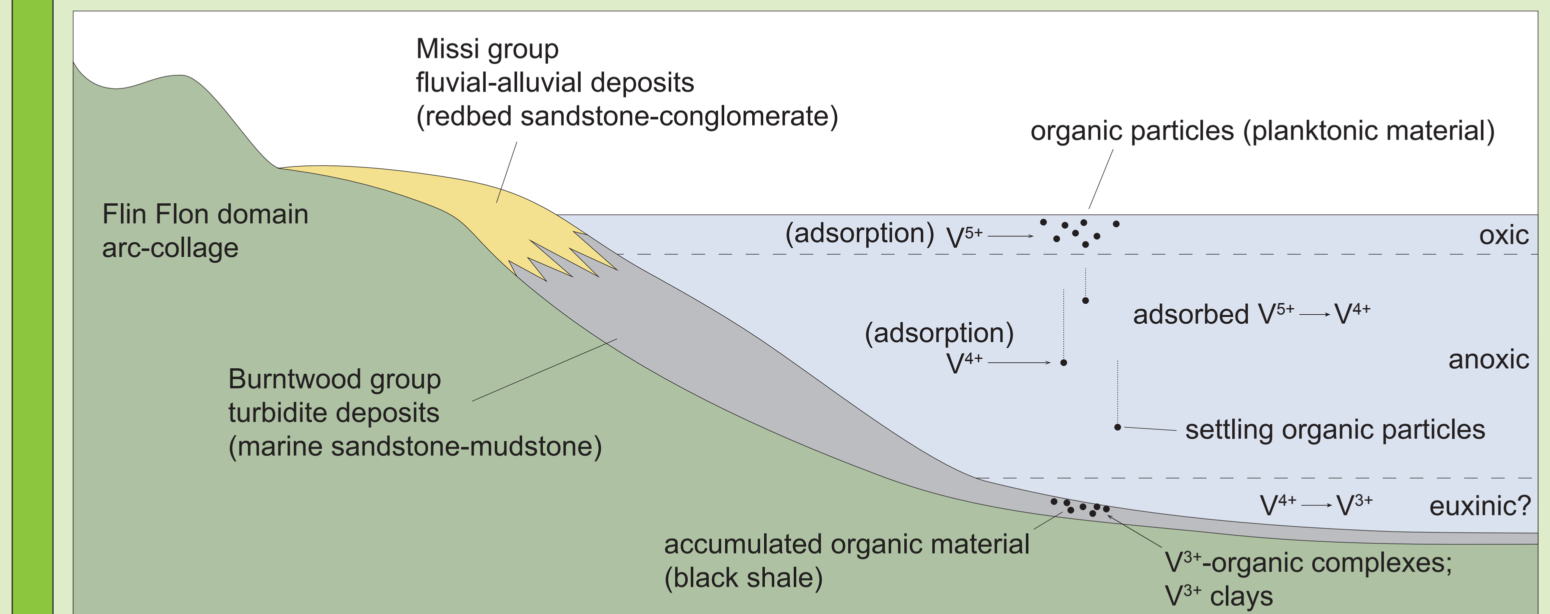


The hornblende gneiss-calcsilicate and wacke-mudstone are intruded by various granitoid phases including pegmatite (Q; top row), granodiorite (Q; middle row), tonalite (Q; bottom row), and granite (R). The granite is even grained and weakly foliated, suggesting it is a relatively young; while the other phases are typically strongly foliated and migmatitic (Q and S; arrows indicate leucosome in tonalite). Local bands of mylonite were observed in pegmatite intrusions (T; middle row).



Rocks from the Huzyk Creek area are characterized by granulite-facies mineral assemblages including orthopyroxene and inverted pigeonite in hornblende gneiss (U), and orthopyroxene and antiperthite (V), and orthopyroxene and K-feldspar (W) in orthopyroxene-bearing wacke. Biotite-quartz symplectite in W and X indicate subsolidus replacement of orthopyroxene and K-feldspar. Abbreviations: Apr; antiperthite; Bqs; biotite-quartz symplectite; Bt, biotite; Hbl, hornblende; Kfs, K-feldspar; Opx, orthopyroxene; Pgn, inverted pigeonite; Pl, plagioclase; Qtz, quartz.

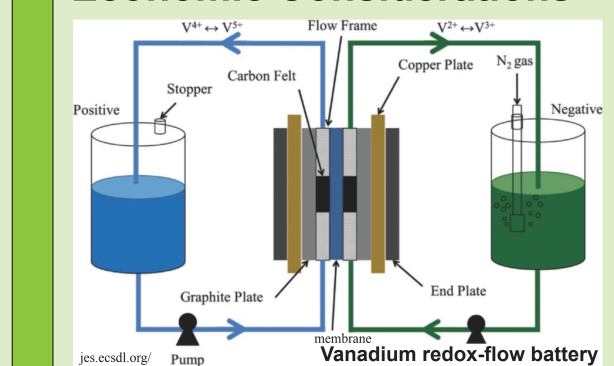
Petrogenetic model



Semi-solid graphite occurs across relatively wide intersections at Huyzk Creek (graphite mudstone, 14.3–16.7 m), and is disseminated throughout the wacke-mudstone sequence. This is suggestive of a sedimentary-metamorphic origin (i.e. metamorphosed black shale), rather than a discrete, shear- or vein-hosted (hydrothermal) origin for the graphite (i.e. 'lump' graphite). This interpretation is further strengthened by the basin-wide presence of graphite in the Kisseynew domain.

The drilling results by Vanadian (2019) suggest a close correlation between graphite mineralization and vanadium enrichment. The basin-wide presence of graphite ±pyrrhotite in the Burntwood group suggests that the rocks were deposited in an anoxic environment, and remained so during diagenesis. Vanadium is considered relatively immobile in the reduced state (V^{3+}), so it is unlikely that the vanadium was mobilized during diagenesis (Breit and Wanty, 1991). It is more likely that the vanadium was deposited alongside carbonaceous material at the time of sedimentation and remained immobile. A general model proposed by Breit and Wanty (1991) involves dissolved V^{5+} in oxidized surfaces waters becoming adsorbed to organic (planktonic) particles in seawater. If the organic particles settle into anoxic conditions at depth, the adsorbed vanadium can be reduced to V^{4+} by dissolved organic compounds or hydrogen sulphide. Upon burial and diagenesis it can be further reduced to V^{3+} and partitioned into clay minerals. Assuming the graphite is largely derived from organic carbon, this model also provides a direct causal relationship between the graphite and vanadium-enrichment in the Huzyk Creek rocks.

Economic Considerations



Both graphite and vanadium are considered critical minerals by the U.S. Government (Schulz et al., 2017). Some of the many uses of graphite include refractory applications, brake linings, motor brushes, and steel making; however, higher-valued coarse-grained graphite is used in high-temperature lubricants, and battery and fuel cell applications (Robinson et al., 2017). Vanadium is used primarily in the production of high-strength steels, and specialty alloys. In the field of green technology there is growing interest around the use of vanadium redox-flow batteries for large-scale energy storage (Kelley et al., 2017). These batteries boast the potential for nearly unlimited storage capacity and unlimited lifespan.

There appears to be a direct relationship between graphite mineralization and vanadium enrichment in the Huzyk Creek sedimentary rocks. A proposed model calls for dissolved vanadium in the water column to be removed by settling organic material that accumulated on the basin floor. Burial, diagenesis, and metamorphism of these deposits produced the vanadium-enriched graphite mineralization present at Huzyk Creek. Thick accumulations of graphite are widespread in the Kisseynew domain (Callinex Mines Incorporated, 2014; Assessment File 93001). Assuming water circulation in the basin was unrestricted, it stands to reason that other graphite deposits in the Kisseynew domain should also be prospective for vanadium.

Black shales can be enriched in vanadium as well as other metals (molybdenum, copper, nickel, zinc, PGEs). Metamorphosed examples of vanadium-enriched black shales include the Balama and Green Giant prospects in Mozambique and Madagascar, respectively (AGP Mining Consultants, 2011; Syrah Resources Ltd., 2015). The Green Giant prospect hosts a 43-101 compliant resource estimated at 60 Mt grading 0.69% V_2O_5.

Acknowledgments

The author thanks K. George and I. Robinson for their assistance in the field, as well as E. Anderson and M. Schreckenbach for logistical support. T. Martins provided assistance as well as discussions in the field regarding the core and units of the central Kisseynew domain. Thanks to Gogal Air Services for providing space at their helicopter base in Snow Lake to layout the drillcore, and Kinross Gold Corp. for allowing access to the core splitting facility. Thanks to M. Simpson of Vanadian Energy Corp. and T. Tuba for providing access to the drillcore and core logs, and allowing for sampling and an early viewing of the core during drilling in April of 2019.

Manitoba