Natural Resources Canada | Ressources naturelles Canada

Critical Minerals Mapping Initiative

Geological Survey Canada 1842 Commission Géologique

CMU Central Michigan University

REE potential of organic-rich shales

A preliminary assessment

Ardakani, O.[1], Chappaz, A.[2], Mokris, D.[3], Biggart, K.[1], Dewing K.[1],

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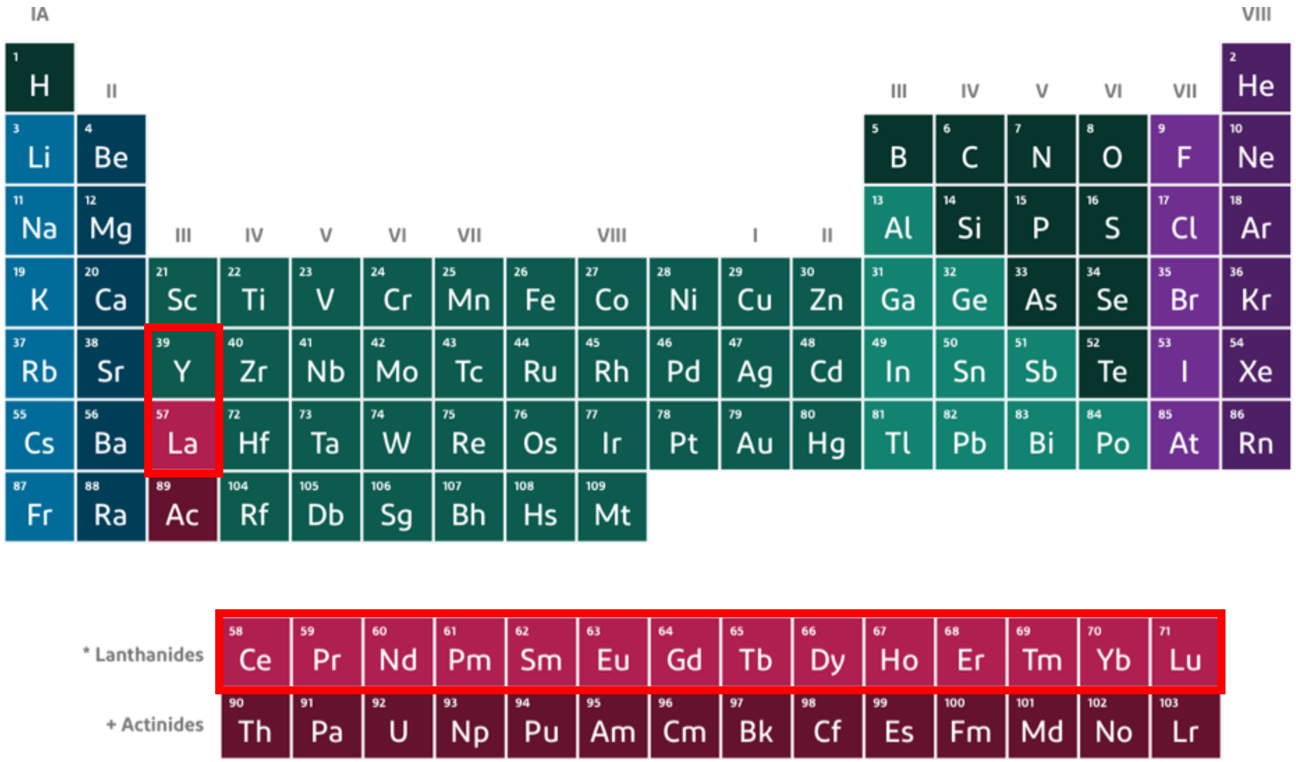
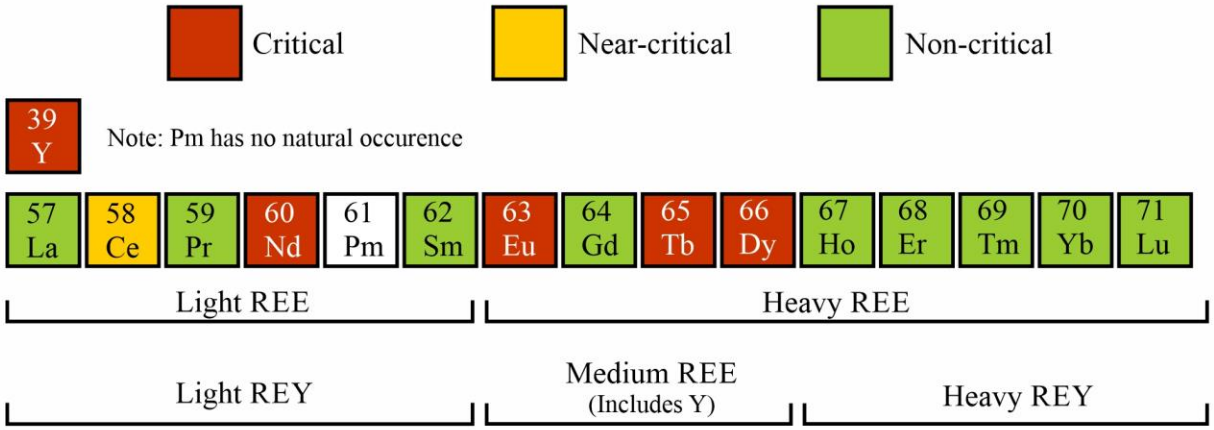
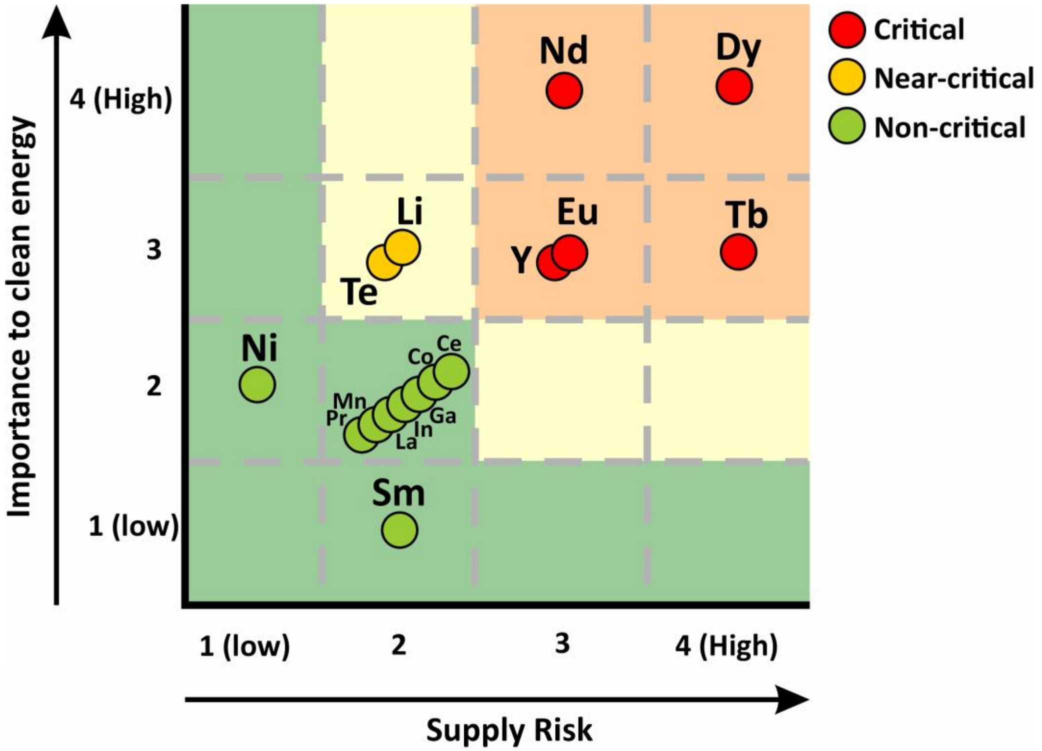
Canada

Rare earth elements (REE)

Rare earth elements (REEs) include the 15 lanthanides from lanthanum (La) to lutetium (Lu) with atomic numbers of 57–71, accompanied by chemically similar yttrium (Y).







Nd: Neodymium; Dy: Dysprosium; Eu: Europium; Y: Yttrium; Tb: Terbium; Li: Lithium; Te: Tellurium; Ni: Nickel; Ce: Cerium; Co: Cobalt; Ga: Gallium; In: Indium; La: Lanthanum; Mn: Manganese; Pr: Praseodymium; Sm: Samarium

U.S. Department of Energy, 2011

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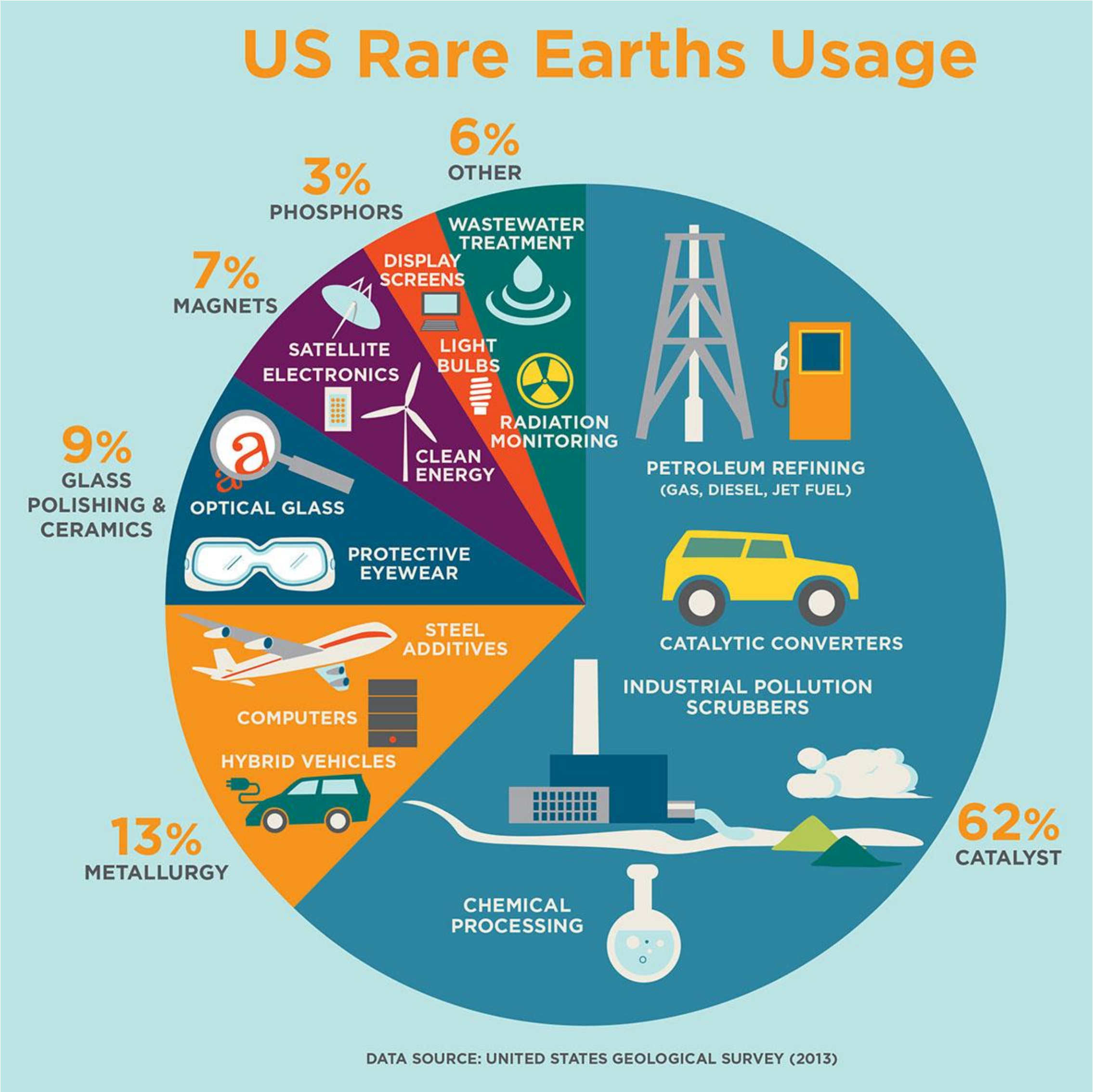
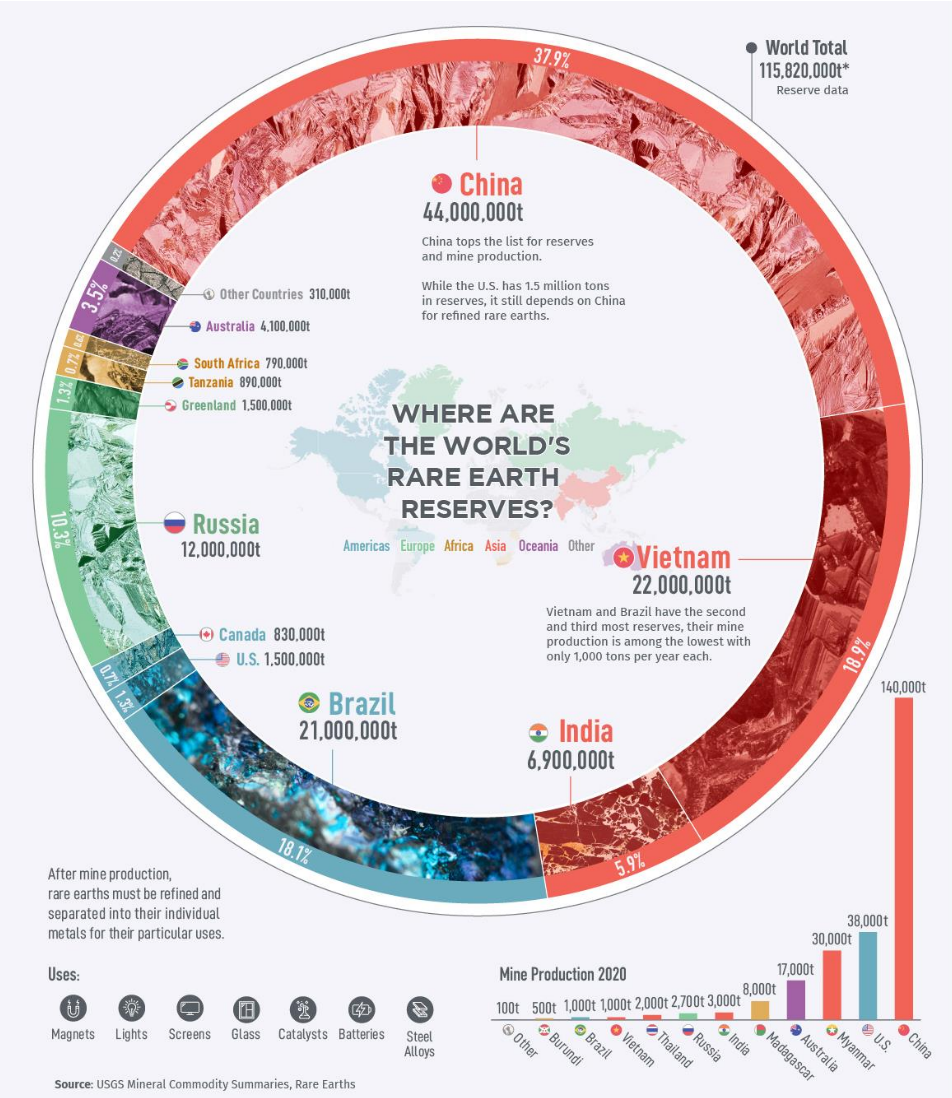
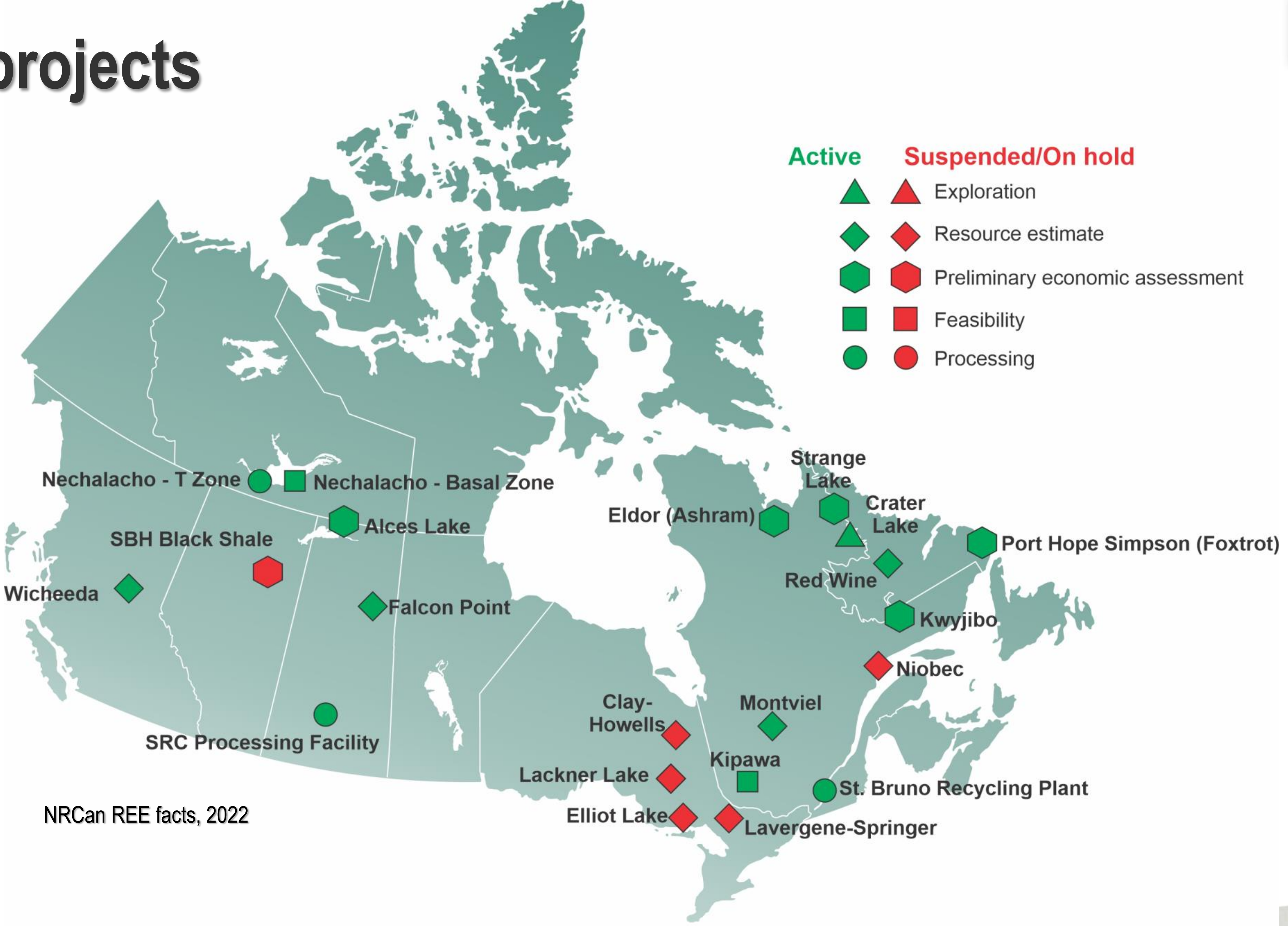
REEs use and resources





https://elements.visualcapitalist.com

Canadian REE projects



NRCan REE facts, 2022

Canadian REE projects

Bloomberg

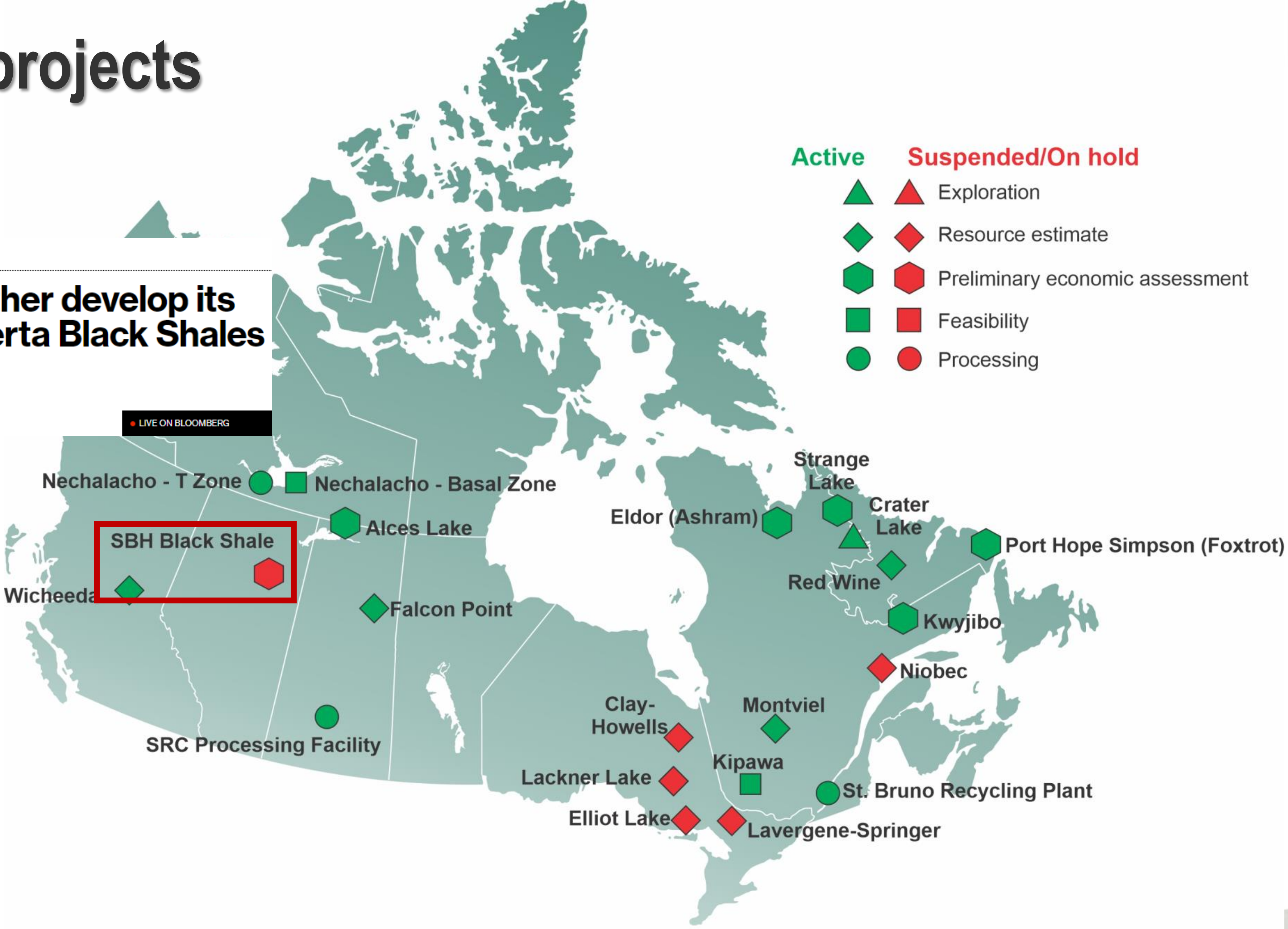
DNI Metals - Signs LOI to further develop its Vanadium / Polymetallic Alberta Black Shales deposit

December 18, 2018, 5:39 AM MST

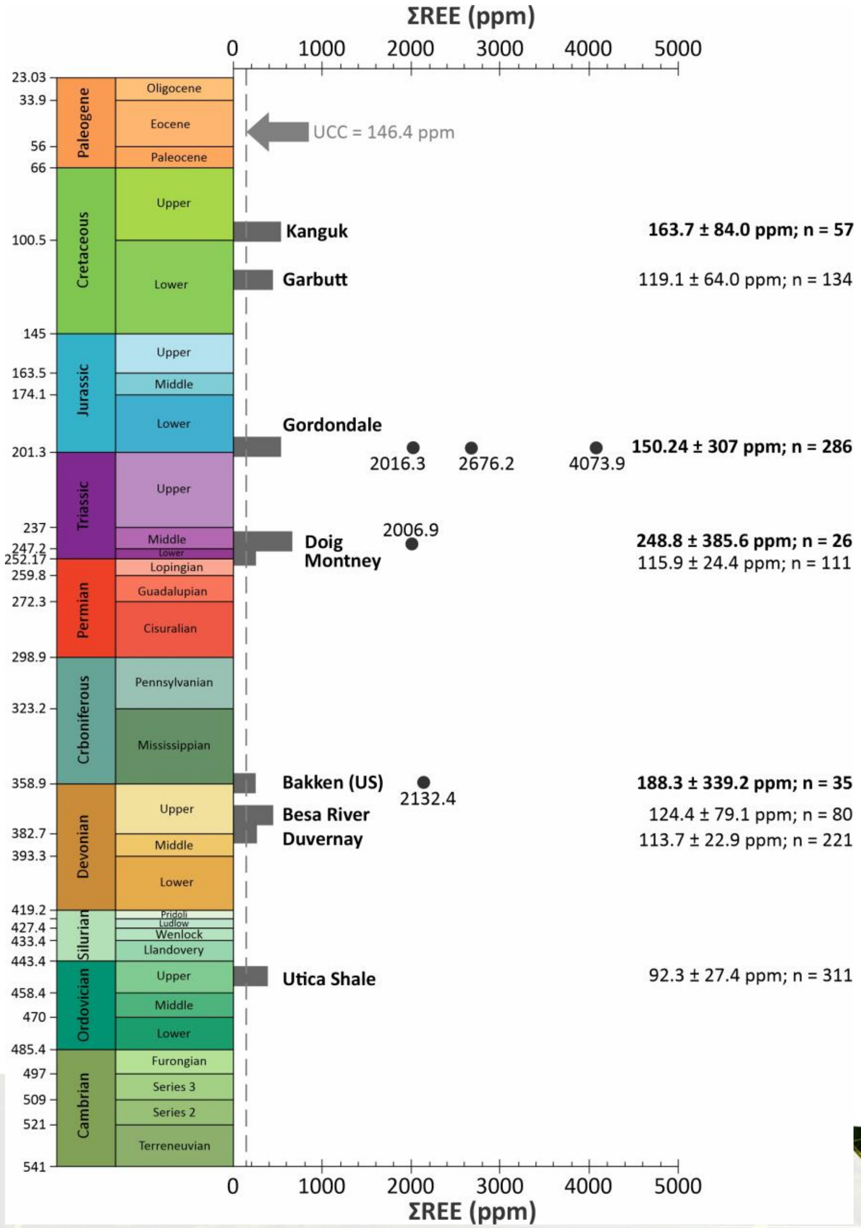
LIVE ON BLOOMBERG

Buckton - Polymettalic Deposit - Alberta Canada

https://www.dnimetals.com/projects-2



Canadian Phanerozoic black shales REE content



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GEOLOGICAL SURVEY OF CANADA
OPEN FILE XXXX

Rare Earth Element (REE) content of shale, coal and coal byproducts, and potential for Canadian REE supply – A literature review and initial assessment

O.H. Ardakani, K. Biggart, K. Dewing

2022

Canada

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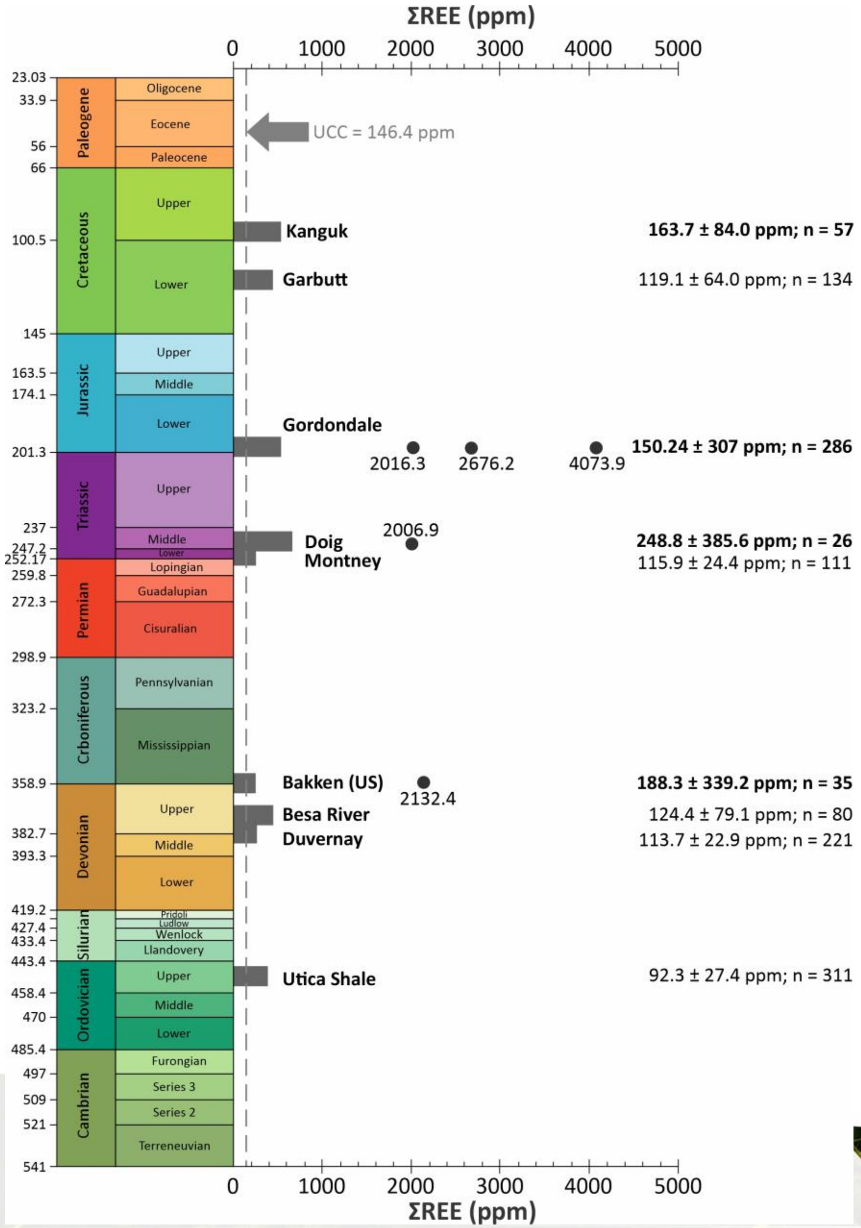

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Rare Earth Elements of Permian through Cretaceous strata of the Sverdrup Basin

S.E. Grasby and J. Galloway

2021

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A Middle Devonian basin-scale precious metal enrichment event across northern Yukon (Canada)

M.G. Gadd[1], J.M. Peter[1], D. Hnatyshin[2], R. Creaser[2], S. Gouwy[3] and T. Fraser[4]
[1]Geological Survey of Canada, Ottawa, Ontario K1A 0E8, Canada
[2]Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta T6G 2R3, Canada
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Platinum, Pd, Mo, Au and Re deportment in hyper-enriched black shale Ni-Zn-Mo-PGE mineralization, Peel River, Yukon, Canada

Michael G. Gadd*, Jan M. Peter, Simon E. Jackson, Zhaoping Yang, Duane Petts
Geological Survey of Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada

Canada

Classification of shales - outlook for REY composition

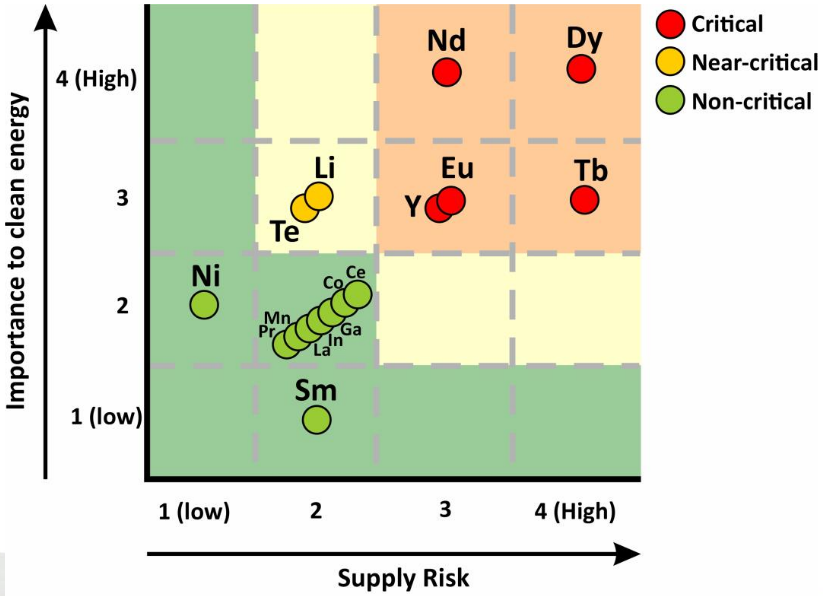
REY are divided into **critical** (Nd, Eu, Tb, Dy, Er, and Y), uncritical (La, Pr, Sm, and Gd) and **excessive** (Ce, Ho, Tm, Yb, and Lu) groups.

$$C_{outl} = \frac{\frac{(Nd + Eu + Tb + Dy + Er + Y)}{\Sigma REY}}{\frac{(Ce + Ho + Tm + Yb + Lu)}{\Sigma REY}}$$

$$\%REY = \frac{(Nd + Eu + Tb + Dy + Er + Y)}{\Sigma REY}$$

Seredin & Dai (2012) International Journal of Coal Geology 94 67–93

U.S. Department of Energy, 2011



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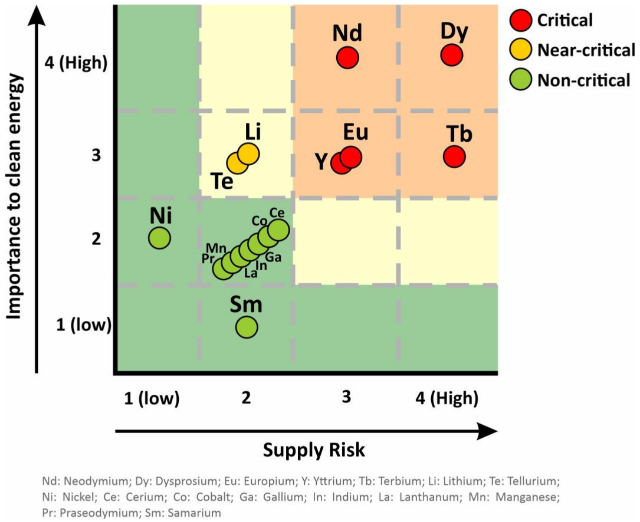
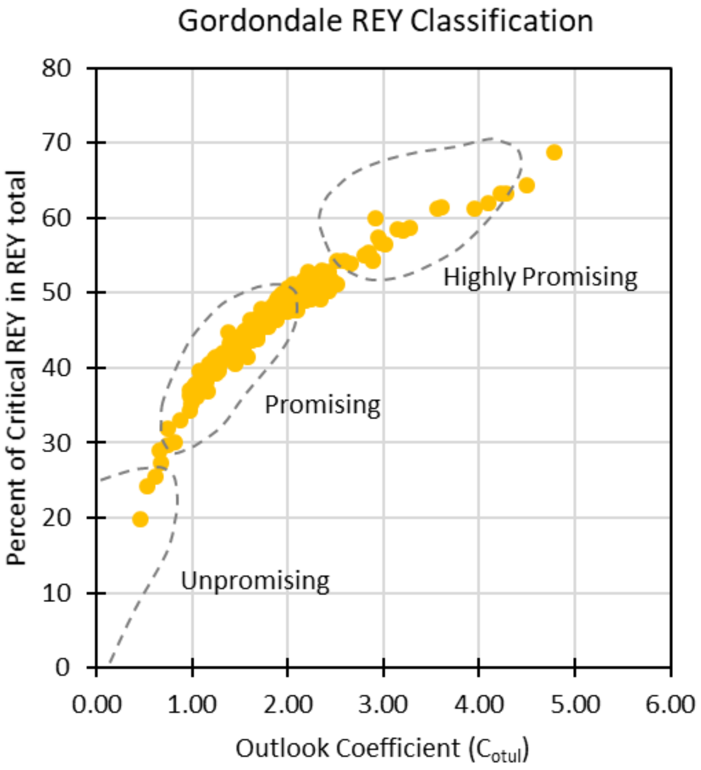
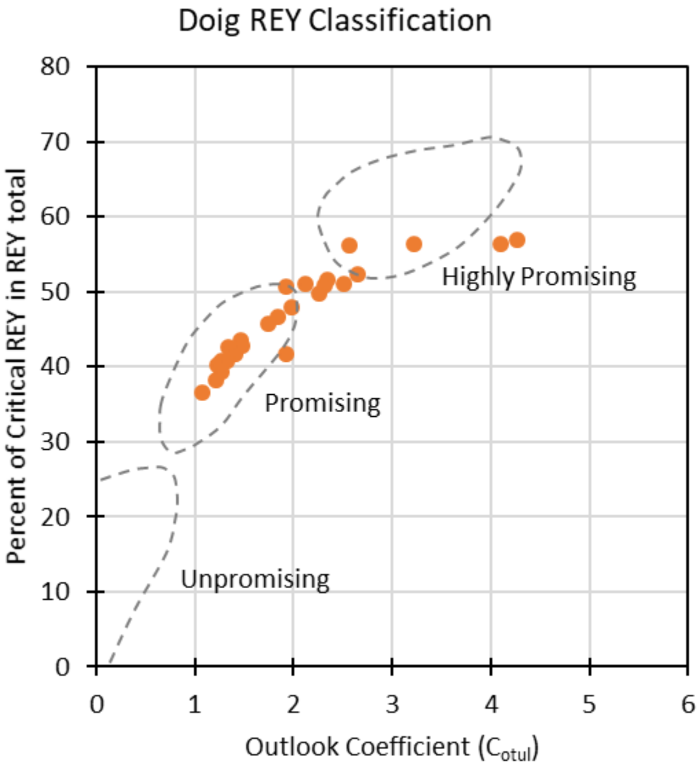
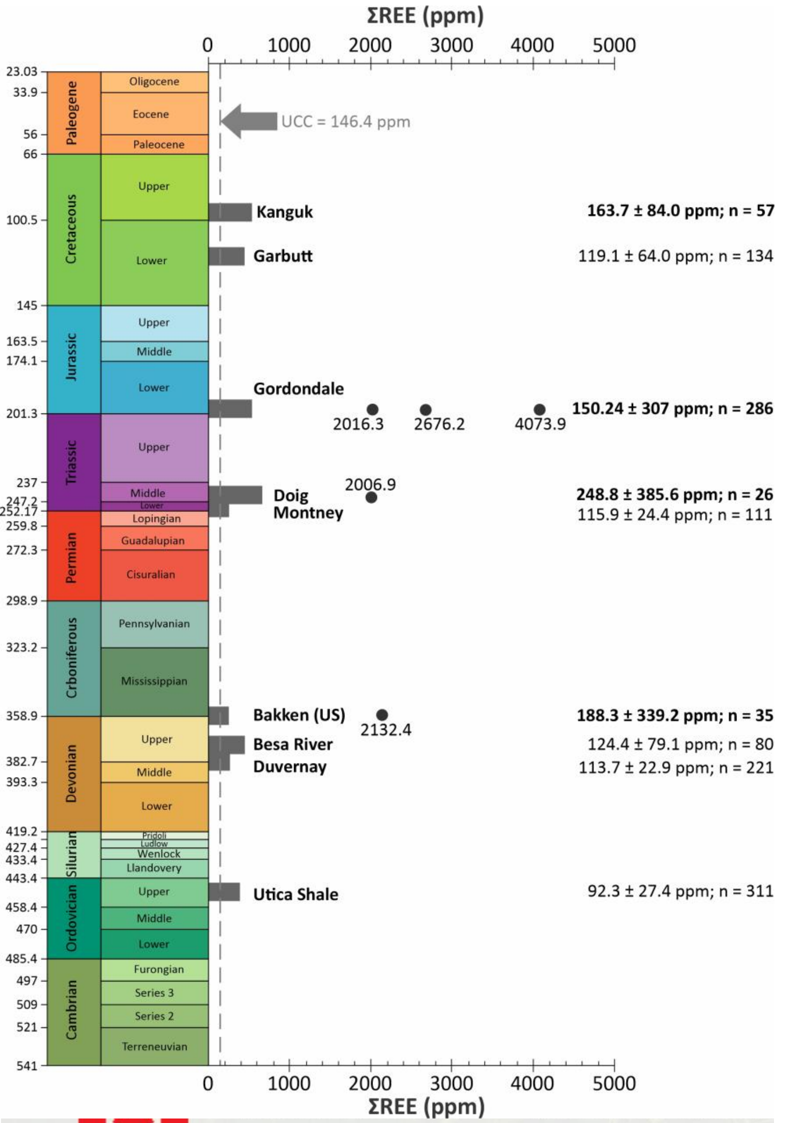


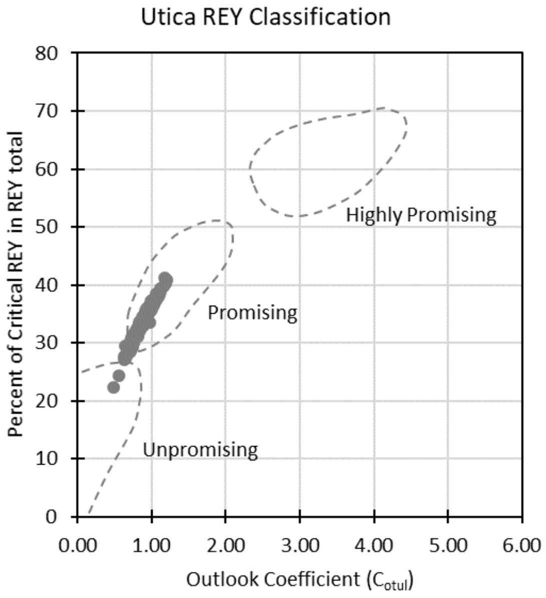
U.S. Department of Energy, 2011

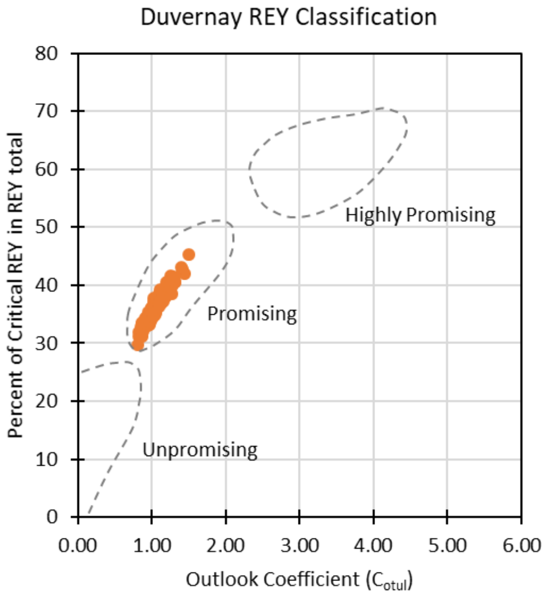


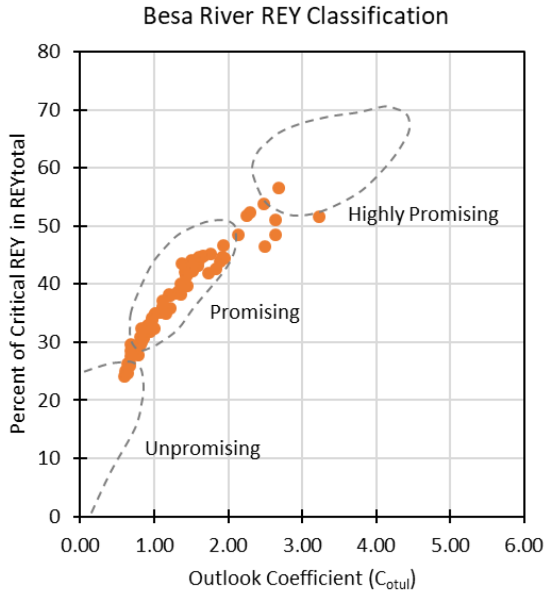


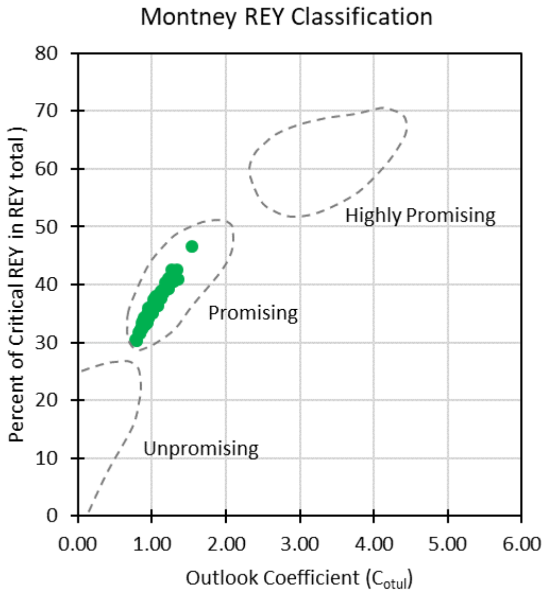
Classification of shales

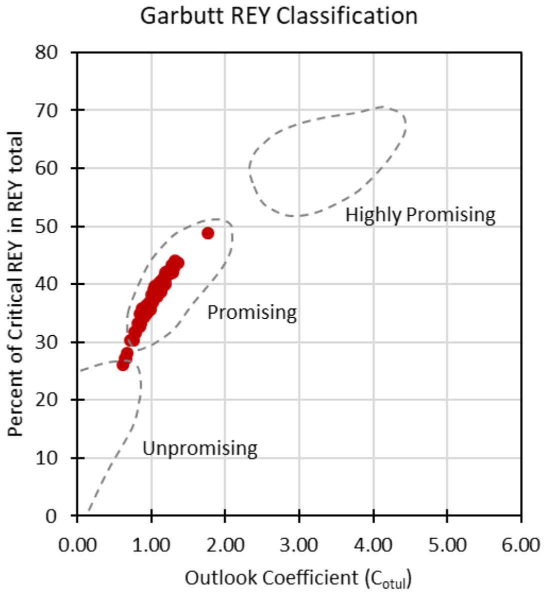


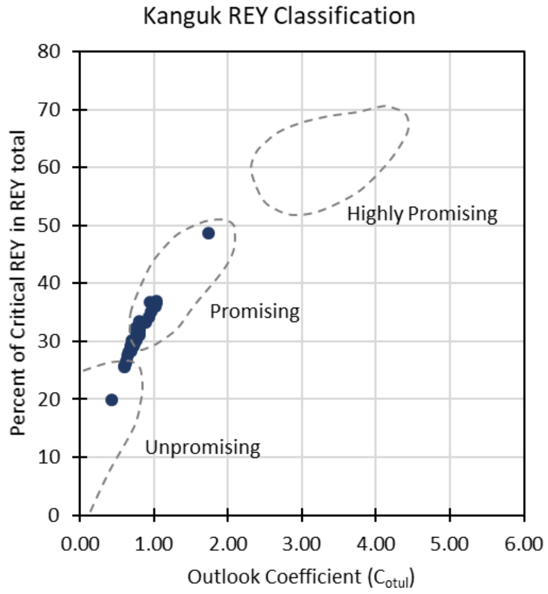








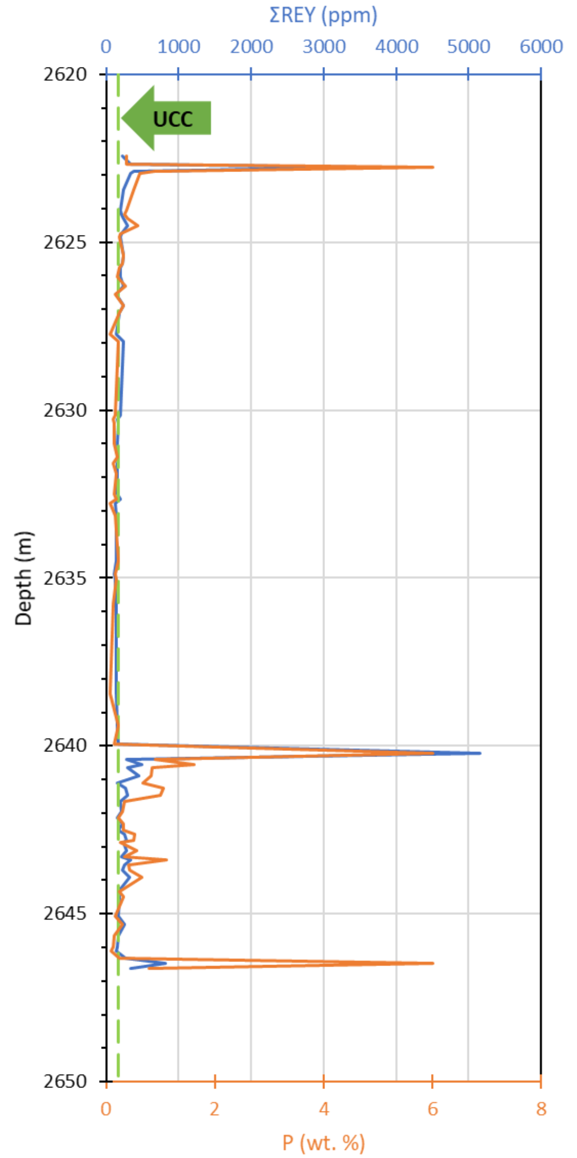


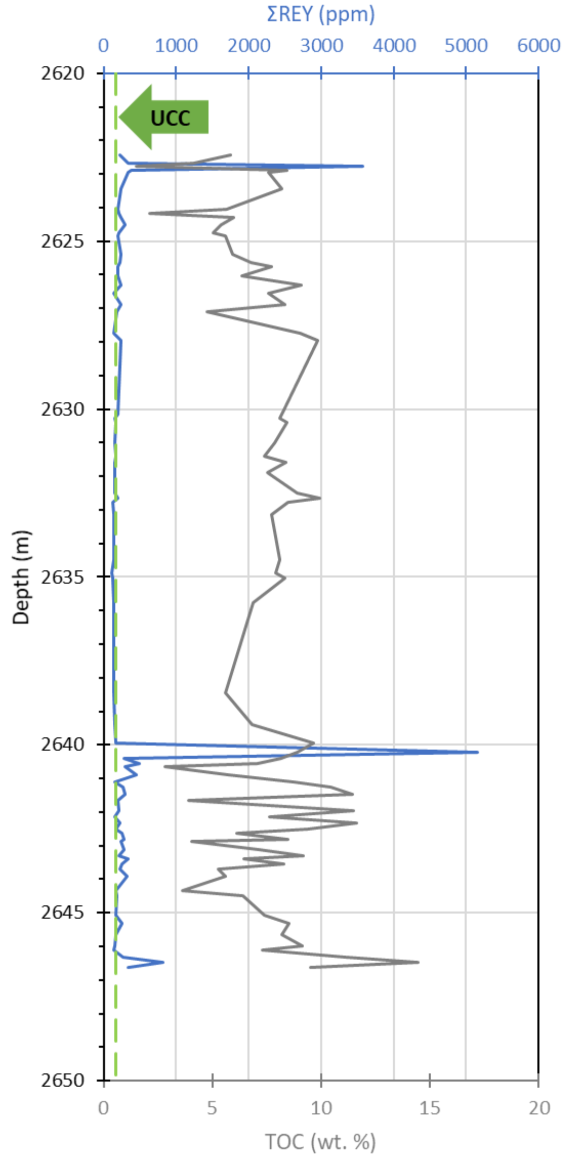


REY content of phosphatic shales

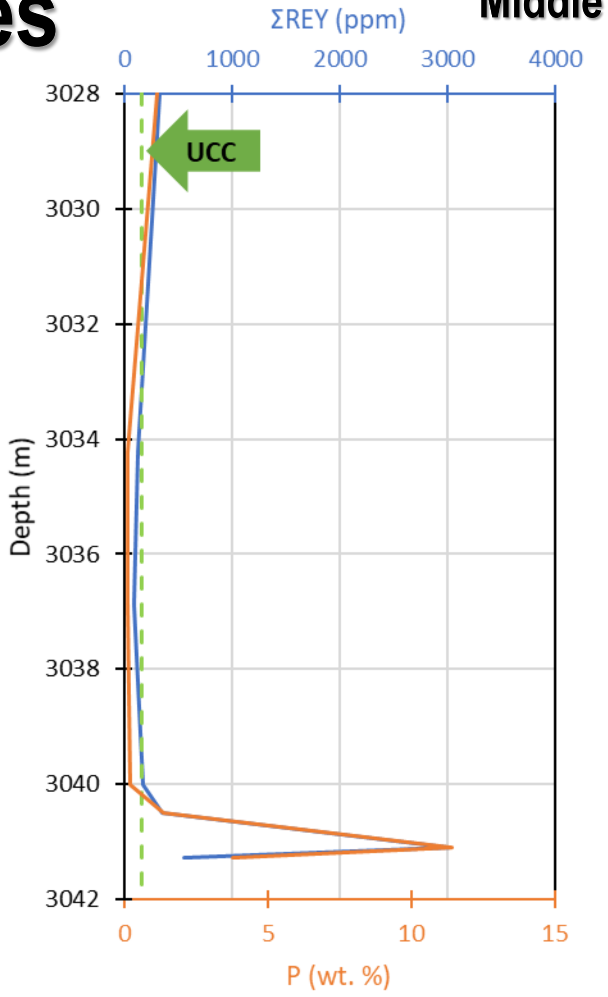
UCC ΣREY = 168.4 ppm

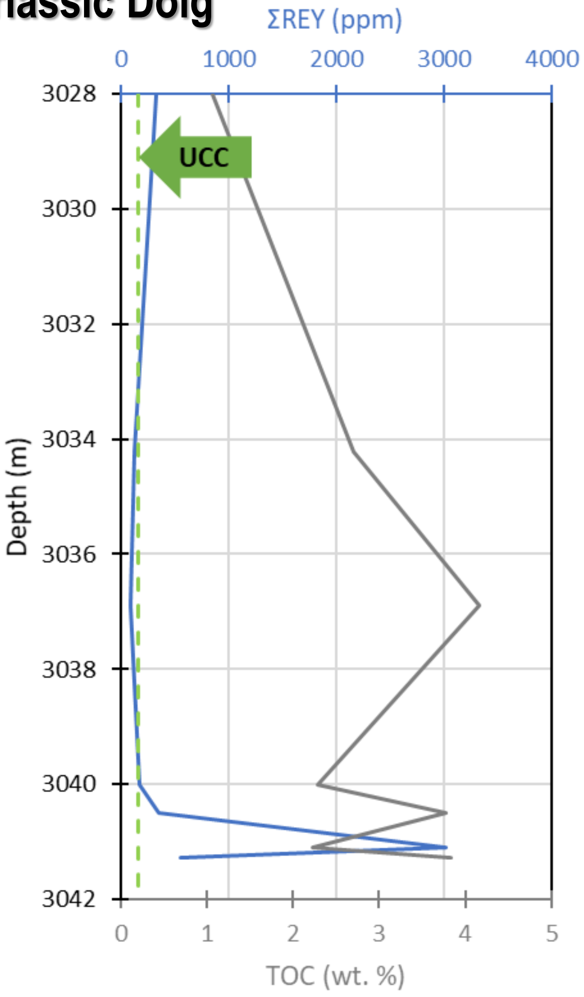
Early Jurassic Gordondale





Middle Triassic Doig





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journal homepage: www.elsevier.com/locate/gr

GR focus review

Rare earth elements in sedimentary phosphate deposits: Solution to the global REE crisis?

Poul Emsbo [a,*], Patrick I. McLaughlin [b], George N. Breit [a], Edward A. du Bray [a], Alan E. Koenig [a]

[a] U.S. Geological Survey, Box 25046, MS-973, Denver Federal Center, Denver, CO 80225, USA

Canada

REY content of phosphatic shales

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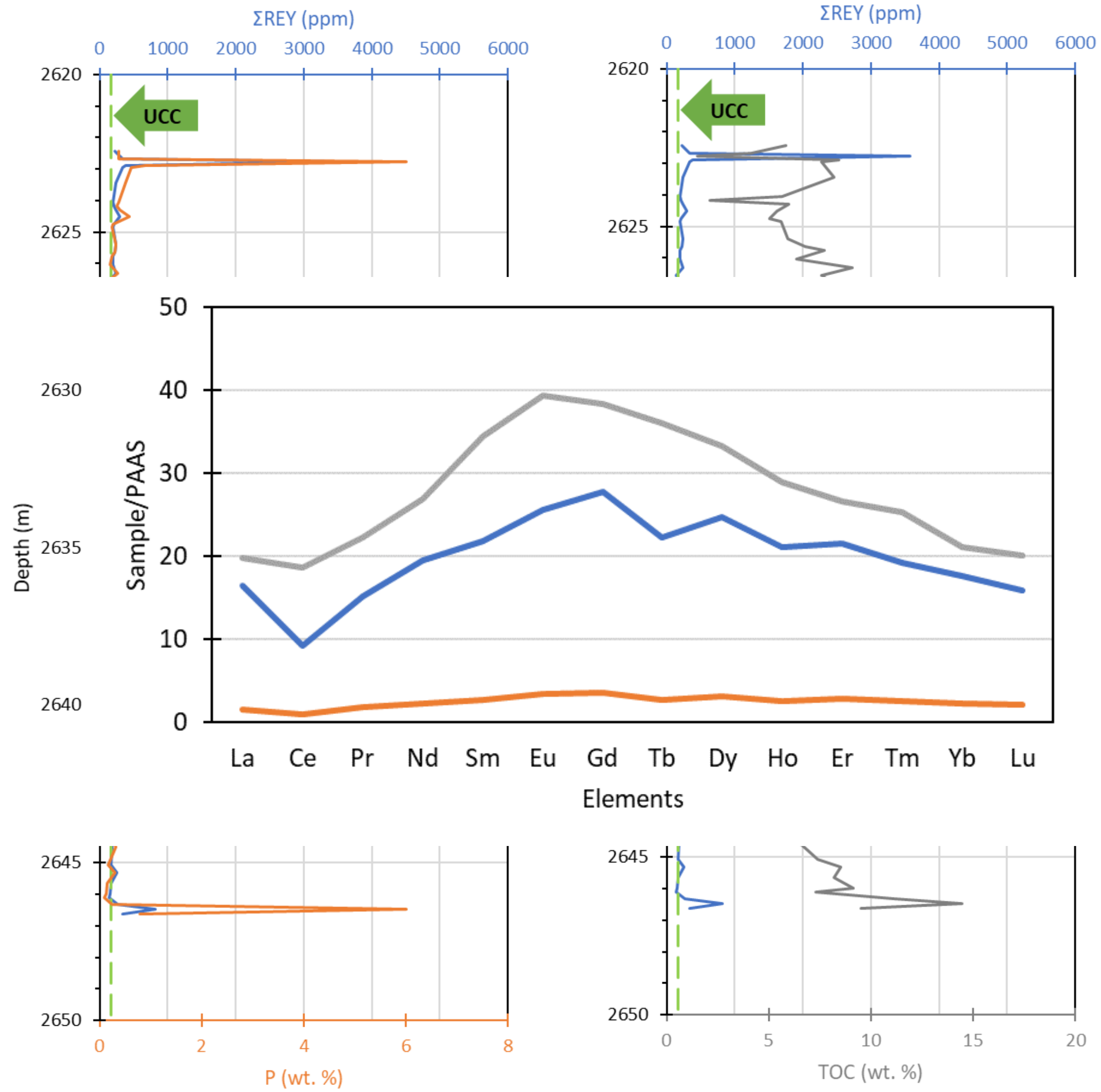

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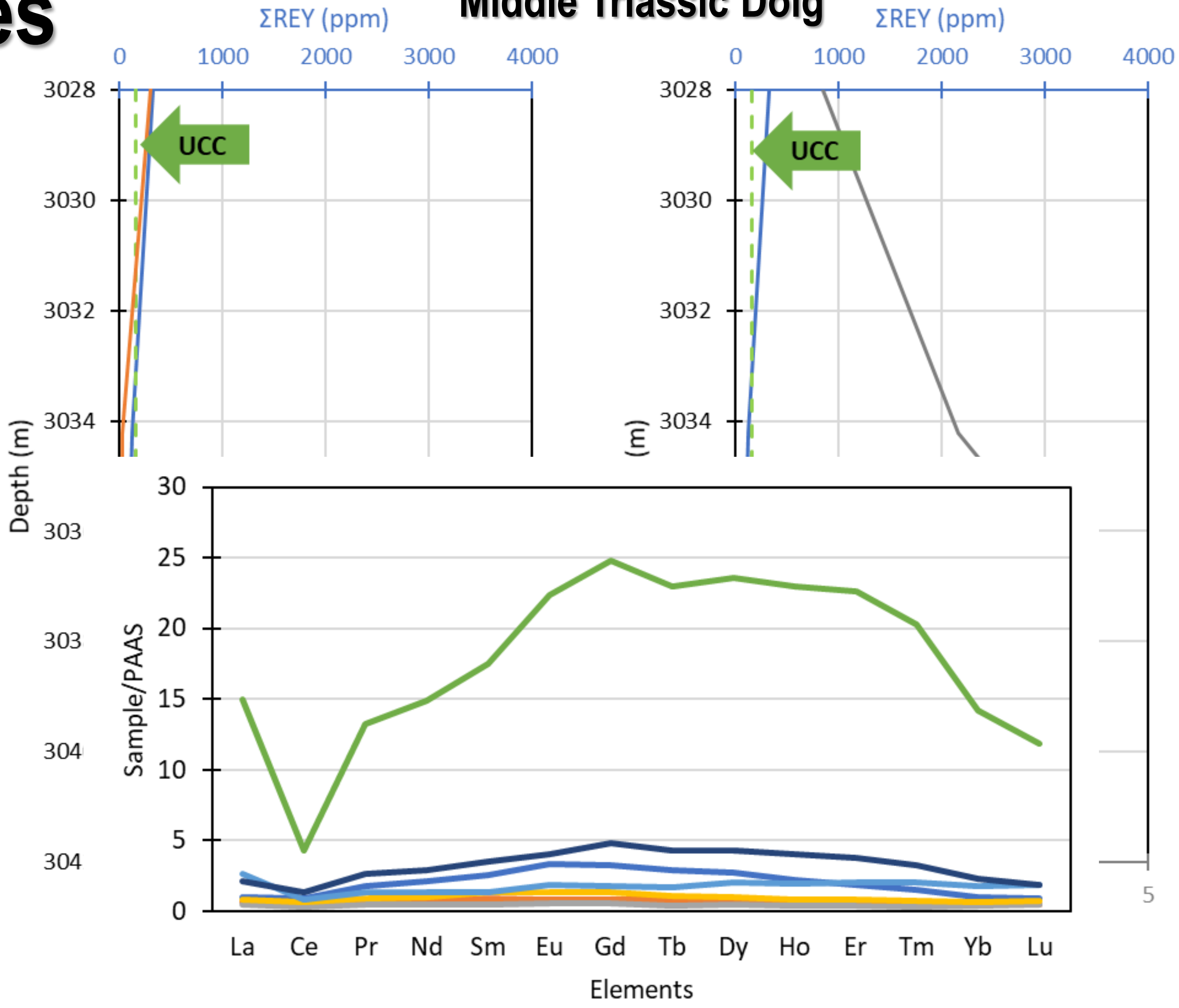

Canada

Sequential extraction scheme used for speciation of metals

The sample was sequentially leached in three steps following the modified BCR (European Communities Bureau of Reference) extraction scheme used for operational speciation of metals.

Davranche et al. (2011) Chemical Geology 284 127–137

Step	Soil phases	Extractant	Shaking time and temperature
F1	Water- and acid-soluble and exchangeable	40 mL 0.11 M CH_3COOH	16 h at room temperature
F2	Reducible	40 mL 0.5 M $NH_2OH.HCl$ (pH 2)	16 h at room temperature
F3	Oxidizable	10 mL 8.8 M H_2O_2(pH 2)	1 h at room temperature
		10 mL 8.8 M H_2O_2(pH 2)	1 h at 85 °C
		50 mL 1 M NH_4Oac (pH 2)	16 h at room temperature
F4	Residual	15 mL aqua regia	Heating to dryness
		10 mL aqua regia	

Bai et al. (2011) J Fuel Chem Technol, 39 (7) 489-494

Process	Fraction	Extraction solution	Operation condition
I	Exchangeable fraction	$MgCl_2$ (1 mol/L pH=7)	Shake for 4 h at room temperature
II	Carbonate bound fraction	CH_3COONa (1 mol/L pH=5)	Shake for 5 h at room temperature
III	Ferromanganese oxyhydroxides bound fraction	CH_3COOH (25% 0.04 mol/L $HONH_3Cl$)	Shake for 5 h at 90°C
IV	Sulfide bound fraction	HNO_3(2 mol/L)	Shake for 6 h at 90°C
V	Organic matter bound fraction	HNO_3 (0.02 mol/L)+H_2O_2 (30%)	Shake for 2 h at 90°C,
		CH_3COONH_4 (3.2 mol/L 20%HNO_3)	Shake for 1 h at room temperature
VI	Aluminosilicate bound fraction		Wet digestion

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REY speciation variations

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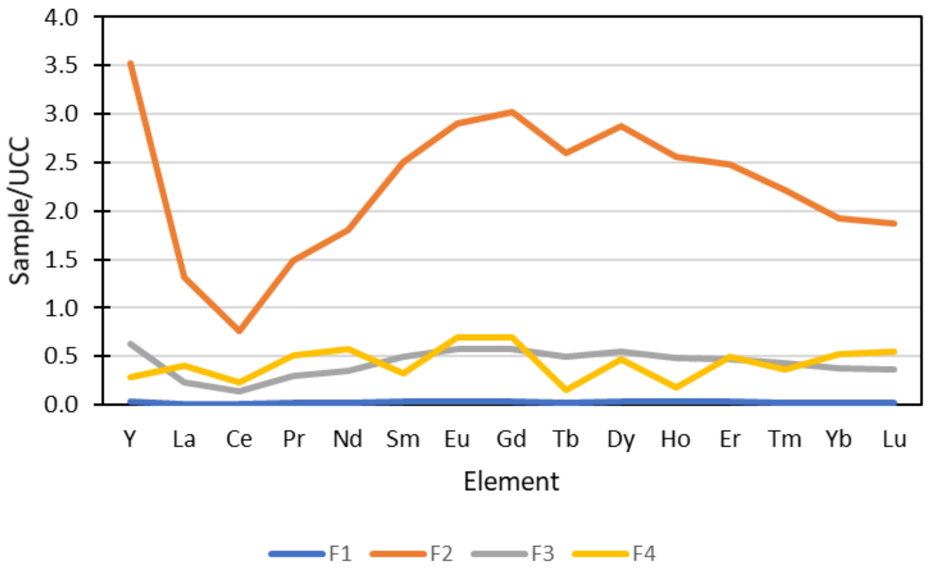
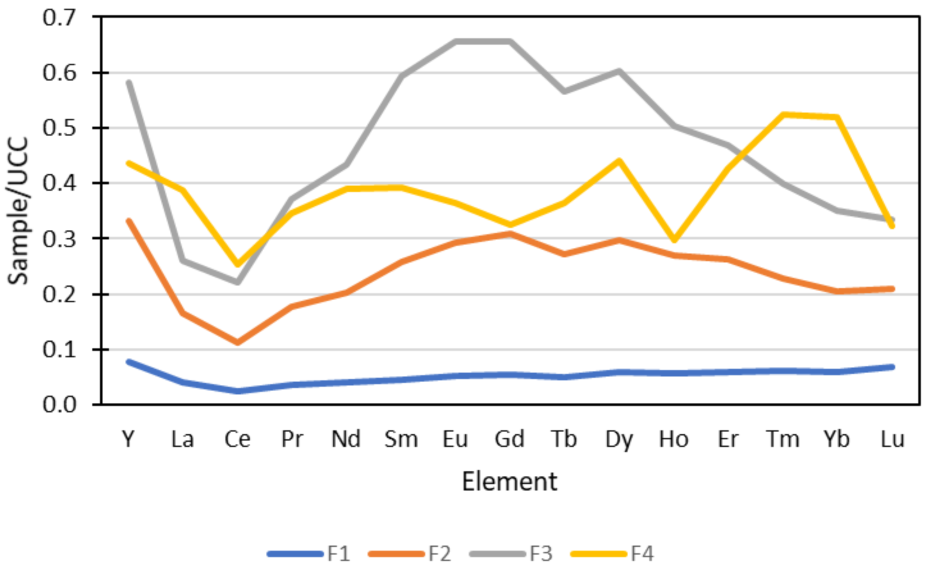
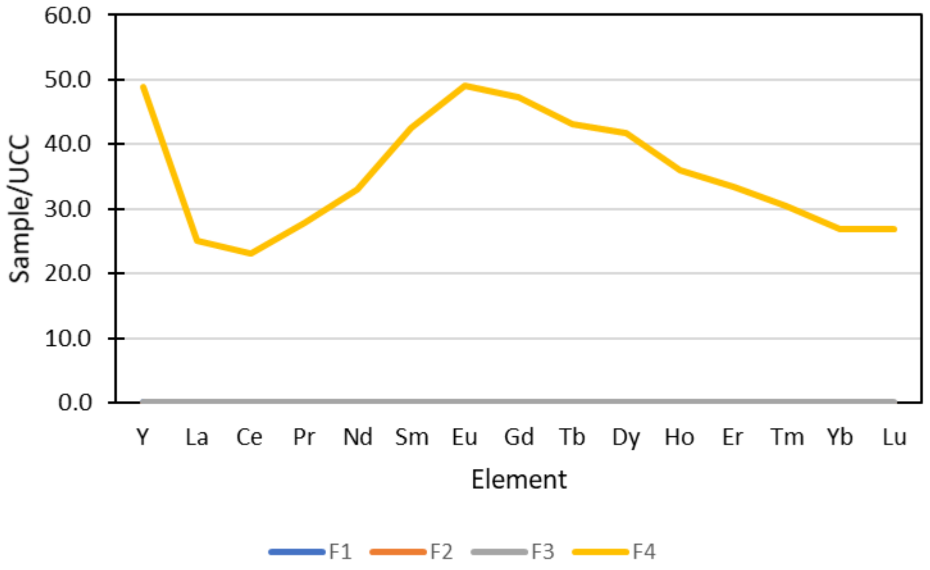
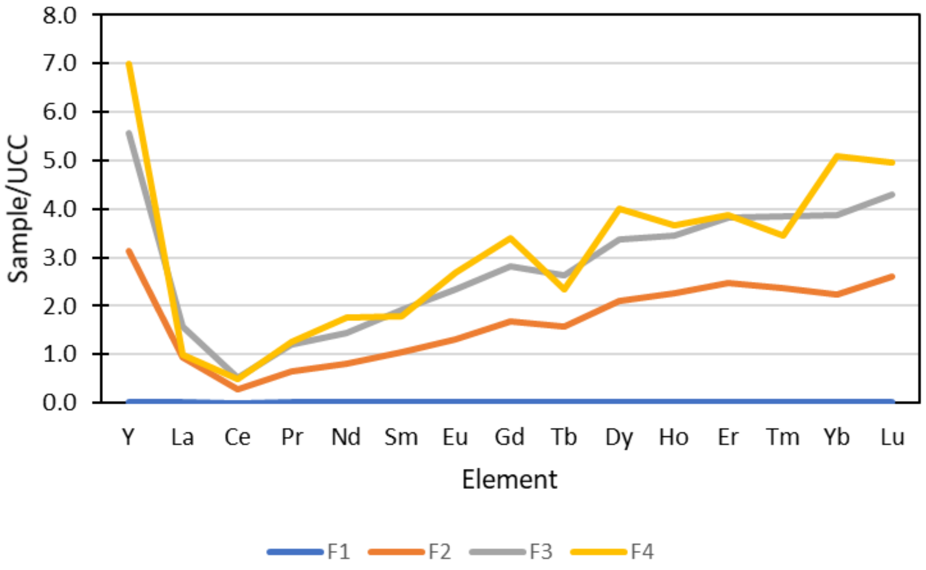
F2	Sulfide phase
F3	Organic matter
F4	Silicates, crystalline phases, clays









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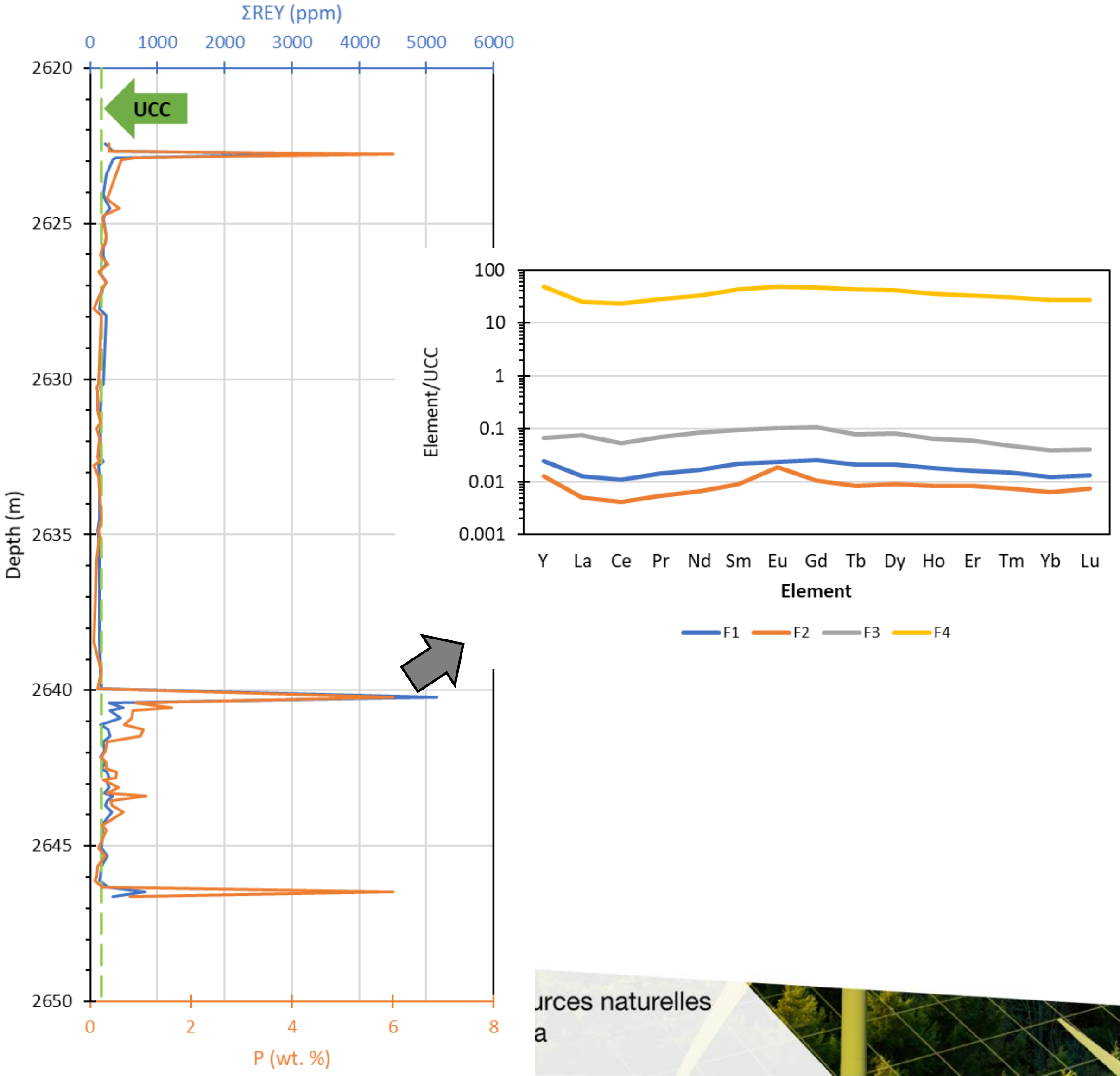

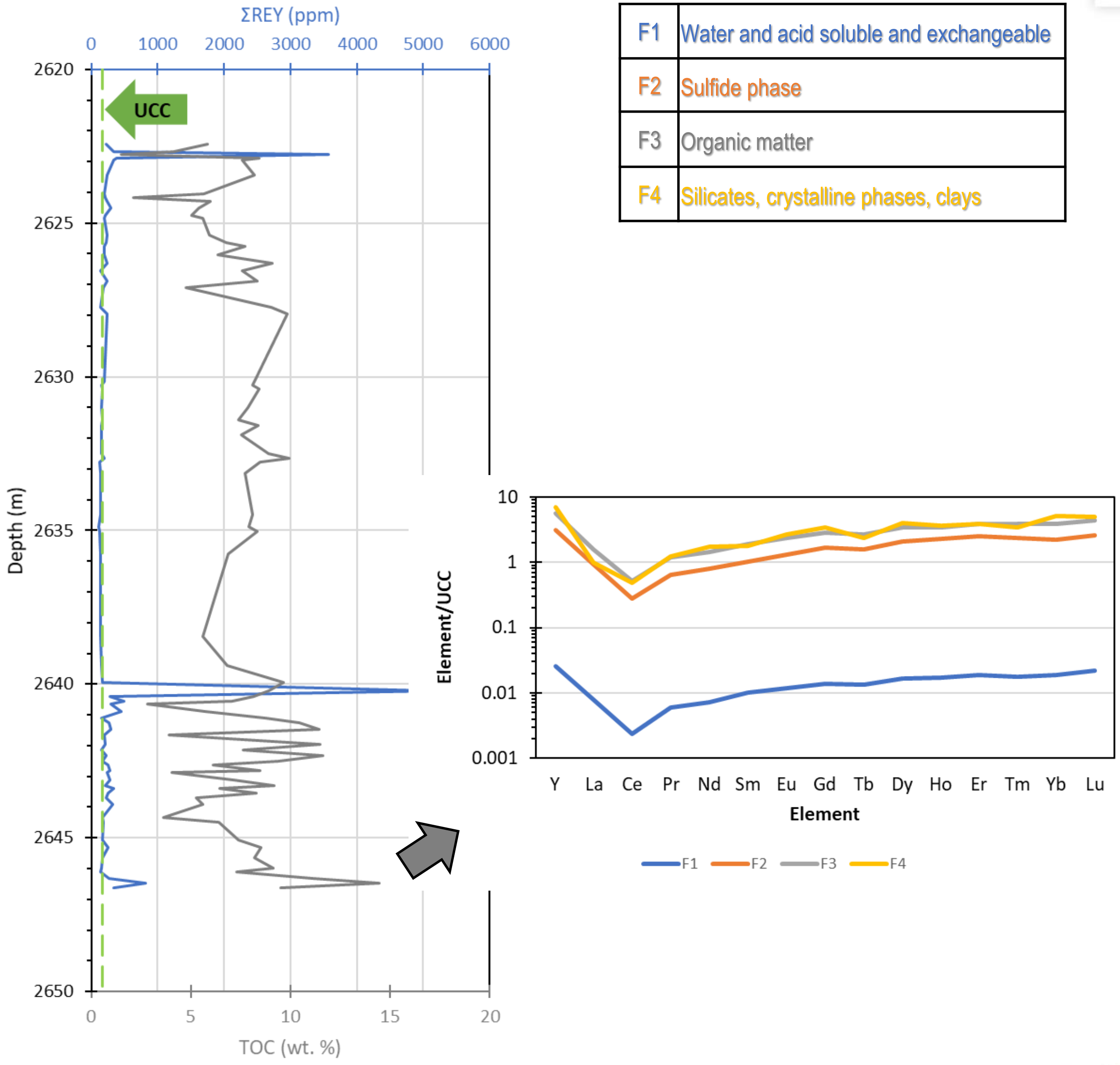

Summary

- The mean ΣREY of the major Canadian organic-rich source rocks are close or greater than mean UCC ΣREY, however, the range if variation throughout the unit is large.
- The highest ΣREY are associated with phosphatic intervals.
- REYs are mostly associated with silicate and clay phases, organic matter and sulfidic minerals are the second dominant hosts for REYs in black shales.
- Variation of REY speciation throughout the black shale intervals would be the major challenge for economic recovery of element.
- The initial results of this study suggest black shales can be considered a viable alternative source for critical REYs.