

Rare Earth Element Concentrations in Phosphate Deposits, Fernie Formation, Southeastern British Columbia, Canada



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Executive Summary

Our research addresses the existence of non-negligible concentrations of Rare Earth Elements (REE) in the sedimentary phosphate deposits of British Columbia (BC), Canada. The Fernie Formation is examined in detail. Currently, the prices of REE are at or near an all time high, warranting a follow-up study to investigate the economic potential of REE extraction as a by-product of the processing of raw materials into osphate fertilizers.



32-33% P₂O₅ (~70% BPL) FOB Morocco. Source for historical data is Fertilizer week (1987, 1988 and 1998). and other research publications, British sulphur consultants, a division of CRE International Ltd.

are Earth Elements

The term "Rare Earth Elements" (REE) includes Y (Yttrium), Sc (Scandium) and the but is non-naturally occurring and so is not included in the definition used in this report. Heavy (8%); permanent magnets (7%); electronic devices (3%); and other applications (3%). rare earth elements (HREE) have atomic numbers of 64 or higher(Gd-Lu) and light rare earth elements (LREE) have atomic numbers of less than 64 (La to Eu, Y, Sc). The REE (metal) content of raw materials and products can be reported in parts per million (ppm, equivalent to a/tonne) or in weight (%). Within the industry REE metal content is commonly converted into REO equivalent (conversion factors can be found in Table 1). In this study Sc was not considered due to low concentrations.

economic REE concentrations are known in a variety of deposits including carbonatites and carbonatite complexes (Mountain Pass, California; Daluxiang and Maoniuping, China), peralkaline complexes (Thor Lake, NWT, Canada; Strange Lake, Que., Canada; Kipawa, Que, Canada), in metasomatic zones with or without exposures associated with igneous activity (Bayan Obo(Fe–Nb-REE), China; Rock Canyon Creek (REE-F) BC, Canada), in skarns (1 Blue, Yukon, Canada) and as veins (Hoidas, Saskatchewan, Canada). Economic conditions permiting, Olympic Dam–type Iron-Oxide Copper-Gold (IOCG) deposits, peraluminous complexes and granitic pegmatites may also contribute REOs to the market.

REE are also present in secondary environments, such as ion adsorption clay deposits (also referred to as "weathered crusts"), which overlie granitic rocks (Xinxiu and Heling, China), as well as laterites and karst that are associated with carbonatites (Mount Weld, Australia). Ion adsorption clay deposits are a major source of HREE. Under the right circumstances, ionic clays containing 500 ppm total REE are considered ore grade (Simandl, 2010a). REE can potentially be derived as a byproduct of Ti - heavy sands/placer/paleoplacer mining, the processing of uranium ores and phosphate fertilizer production. Deposits in south-eastern BC may contain sufficient REE concentrations to justify recovery during phosphate processing

Phosphate Occurrences

In BC. phosphorite deposits are located within pericratonic terrains adjacent to the western margin of ancient North America near the BC -Alberta border. Phosphate is found in at least 33 stratigraphic zones within the Canadian Cordillera (MacDonald, 1987). The Devonian-Mississippian Exshaw Formation, the Permo-Pennsylvanian Rocky Mountain Supergroup, the Jurassic Fernie Formation and the Triassic Spray River Group contain most of these zones and the grades and thicknesses vary considerably. The occurrences on the Alberta side of the provincial boundary were reviewed by MacDonald (1987) and those on the BC side were reviewed by Butrenchuk (1996).

Crows occurrence (MINFILE No. 082GNE025), located in the Fernie area, gives an example of phosphate-bearing rocks (Figure 3) in southeastern B C

Fifty three samples of phosphate-bearing rock collected in southeastern B.C. by Butenchuk (1986) were re-analysed using moder ICP-MS methods. Based on this very limited data set, Fernie Formation has relatively high P_2O_5 and REE content (Figure 4). Relative proportions of the REE content in Fernie Formation, based

on 30 samples, is shown on Figure 5. The geology of the Fernie area was summarized by Butrenchul georeferenced. Instead, the readily available Digital Geology Map of British Columbia (Massey et. al., 2005), which can be downloaded from MapPlace, was used as a base map before sample locations were plotted (Figure 6). This highly generalized map is sufficiently detailed for the purpose of this report. The subdivision of the Rocky Mountain Supergroup is schematically depicted on Figure 7 (modified from Butrenchuk, 1996 and Monahan, 2000).

recovered substantially and are currently around US\$600/tonne.





F - Fragment of crinoid stem in phosphate-bearing rock.



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0	REE to REO	REO	Prices as of	"Theoretical" Value*
nula	Conversion	Concentration	March-07-2011	Based on
	Factor			March-07-2011 Prices
		[kg/tonne]	[US\$/kg]	[US\$/tonne of phosphate rock]
.a ₂ O ₃	1.173	0.2019	93.10	18.80
CeO ₂	1.228	0.1437	96.10	13.81
r ₆ O ₁₁	1.208	0.0409	140.50	5.75
Id_2O_3	1.166	0.1724	156.00	26.90
m_2O_3	1.160	0.0348	85.10	2.96
u_2O_3	1.158	0.0090	815.00	7.35
d_2O_3	1.153	0.0418	135.00	5.64
b ₄ O ₇	1.176	0.0068	812.00	5.52
)y ₂ O ₃	1.148	0.0412	475.00	19.58
10 ₂ 0 ₃	1.146	0.0097	-	•
Er_2O_3	1.143	0.0294	170.00	5.01
m_2O_3	1.142	0.0041	26600.00	108.09
′b ₂ O ₃	1.139	0.0255	49.00	1.25
u_2O_3	1.137	0.0041	424.00	1.74
Y_2O_3	1.270	0.4852	130.00	63.08
		Total: 1 2506		Total: 460.20**

Conclusion and Recommendations

The availability of REE raw materials is essential for Western countries in terms of national security, reducing environmental impacts and to supply their high technology industries. This conceptual study indicates that nonneglible concentrations of REE are present in the Fernie Formation, and a follow-up study is justified to assess the economics of the recovery of REE as part of phosphate mining and fertilizer manufacturing. If reasonable resources of phosphate-bearing raw materials are established in BC, then the recovery of REE and F as by-products should be seriously considered. Based on currently available information, in southeastern BC, the Fernie Formation appears to be the most promising. Northeastern BC requires separate investigation.

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