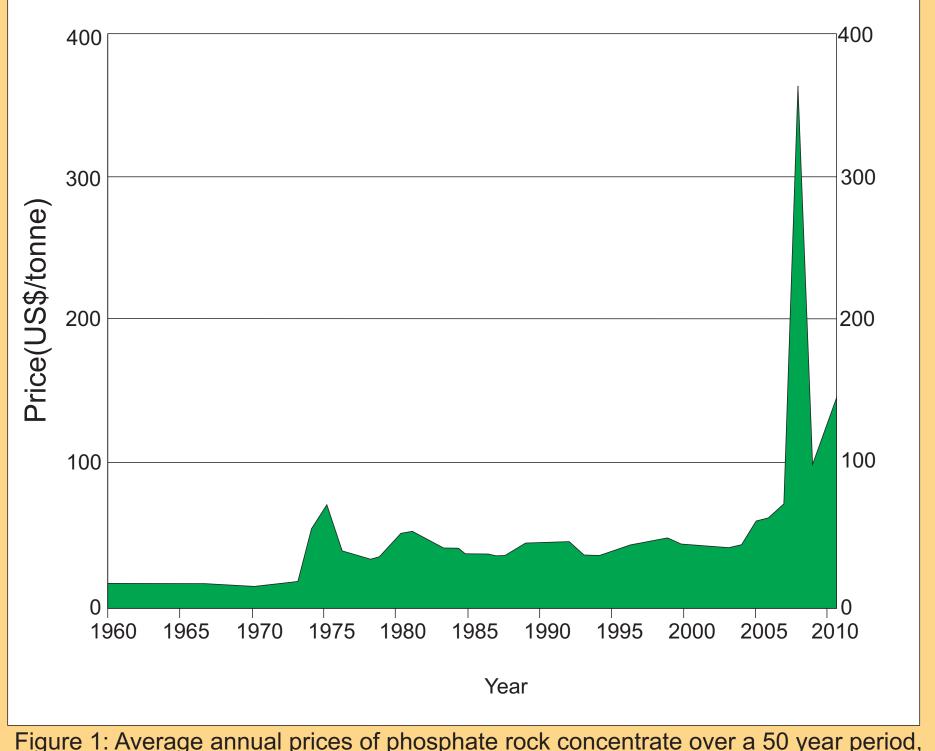


# Rare Earth Element Concentrations in Phosphate Deposits, Sulphur Mountain Formation, Northeastern British Columbia, Canada BCGS-Geofile 2011-09



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concentrations of Rare Earth Elements (REE) exist in the sedimentary phosphate deposits of British Columbia (BC), Canada. T udy to previous work carried out in southeastern BC. This study documents concentrations of REE in phosphate deposits in C, with emphasis on the Whistler Member of the Sulphur Mountain Formation. Samples collected during the mid 1980's were nodern techniques. Currently, the prices of rare earth element oxides (REO) are at an all time high, warranting a follow-up study to investigate the economic potential for extraction of the REE as by-products of the processing of raw materials into phosphate fertilizers.



32-33% P<sub>2</sub>O<sub>5</sub> (~70% BPL) FOB Morocco. Source for historical data is Fertilizer Week and other research publications, British Sulphur Consultants, a division of CRE International Ltd.

## ntroduction

### are Earth Elements

The term "Rare Earth Elements" (REE) includes Y (Yttrium), Sc (Scandium) and the lanthanides (La - Lanthanum, Ce - Cerium, Pr - Praseodymium, Nd - Neodymium, S Samarium, Èu - Europium, Gd - Gadolinium, Tb - Terbium, Dv - Dysprosium, Ho - Holmium, E - Erbium, Tm -Thulium, Yb- Ytterbium and Lu – Lutetium), Promethium (Pm) is a lanthanide but is non-naturally occurring and so is not included in the definition used in this report. Light Market Conditions rare earth elements (LREE) have atomic numbers of less than 64 (La to Eu, Y, Sc) and heavy content of raw materials and products can be reported in parts per million (ppm, equivalent to g/tonne) or in weight (%). Within the industry REE metal content is commonly converted into EO equivalent (conversion factors can be found in Table 1). In this study Sc was not considered due to low concentrations.

hard rock" deposits of economic interest are located in continental settings. Economic or subeconomic 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 (True Blue, Yukon, Canada) and as veins (Hoidas, Saskatchewan, Canada). Economic conditions permiting, Olympic Dam-type deposits (Iron-Oxide, Copper, Gold; IOCG), 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 byproducts of Ti - heavy sands/placer/paleoplacer mining, the processing of uranium ores or phosphate fertilizer production from either igneous or sedimentary phosphate deposits.

## Ahosphate Occurrences

In BC, phosphate rocks are located within the outer margin of the Western Canada Sedimentary Basin, near the BC Alberta border. Phosphate is found in at least 33 stratigraphic zones within the Canadian Cordillera (MacDonald, 1987 Devonian-Mississippian Exshaw Formation, the Permo-Pennsylvanian Rocky Mountain Supergroup, the Triassic Spray River Group (containing the Sulphur Mountain Formation with phosphate occurrences in both the Whistler and Vegaphroso members), and the Jurassic Fernie Formation contain most of these zones. 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 (1998). Forty two samples of phosphate-bearing rock collected in northeastern B.C. by Butenchuk (1987) and Legun and Elkins (1985) were re-analysed using modern ICP-MS methods. In addition, four samples from the Besa River formation in northeastern BC were also collected. A highly generalized view of the geology of northeaster BC as well as a map of the sample locations and a list giving sampling thickness and relevant chemical composition is given on Figure 3. A stratigraphic column (Figure 4) describes the dominant lithologies of phosphate-bearing and relevant barren

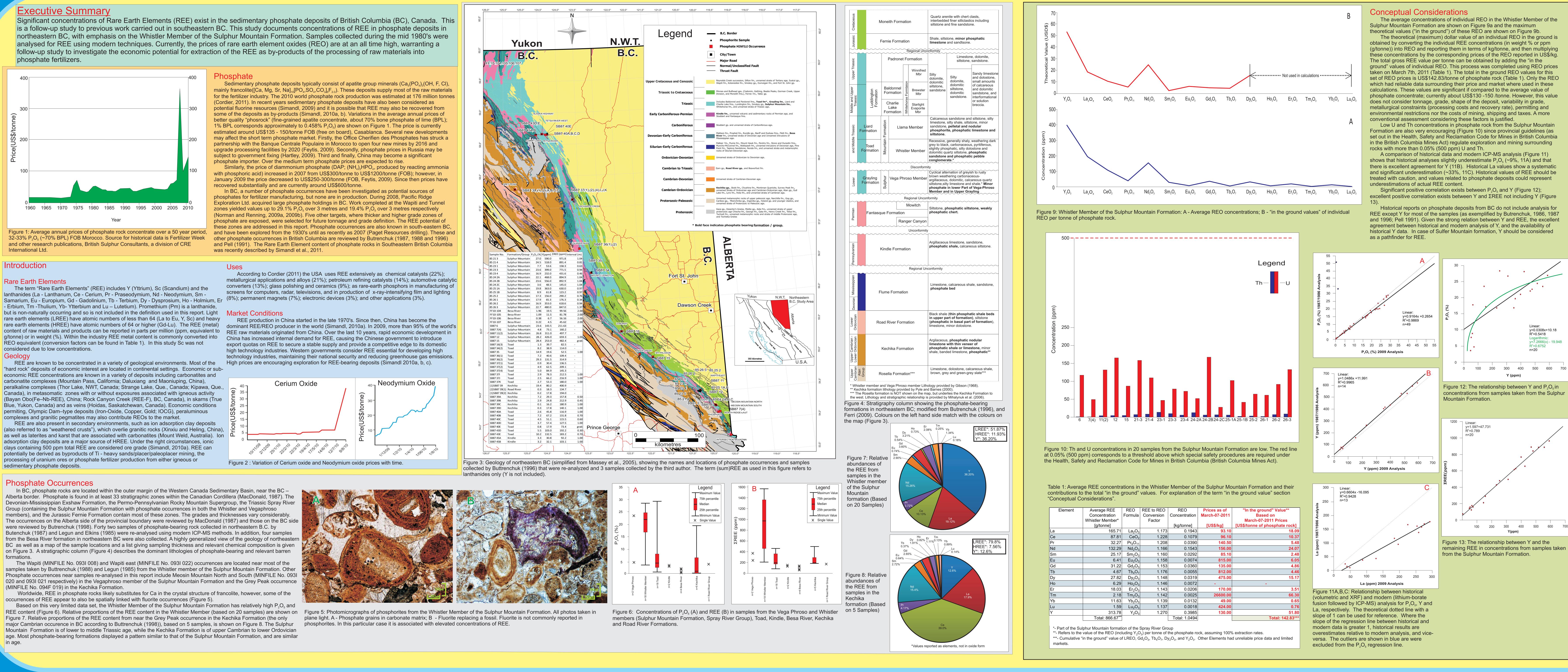
The Wapiti (MINFILE No. 093I 008) and Wapiti east (MINFILE No. 093I 022) occurrences are located near most of the samples taken by Buttrenchuk (1988) and Legun (1985) from the Whistler member of the Sulphur Mountain Formation. Other Phosphate occurrences near samples re-analysed in this report include Meosin Mountain North and South (MINFILE No. 093) 020 and 093I 021 respectively) in the Vegaphroso member of the Sulphur Mountain Formation and the Grey Peak occurrence (MINFILE No. 094F 019) in the Kechika Formation.

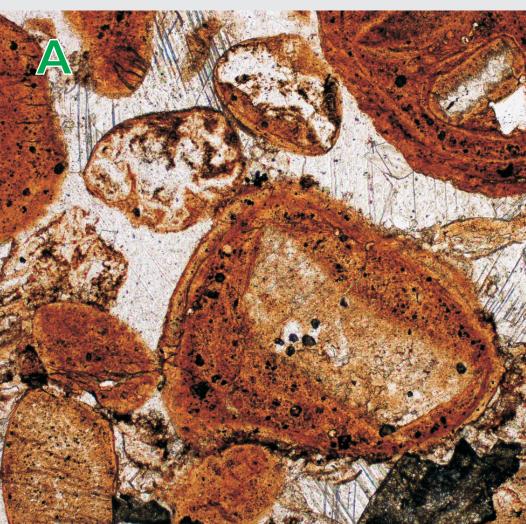
Worldwide, REE in phosphate rocks likely substitutes for Ca in the crystal structure of francolite, however, some of the occurrences of REE appear to also be spatially linked with fluorite occurrences (Figure 5). Based on this very limited data set, the Whistler Member of the Sulphur Mountain Formation has relatively high P<sub>2</sub>O<sub>5</sub> and

REE content (Figure 6). Relative proportions of the REE content in the Whistler Member (based on 20 samples) are shown on major Cambrian occurence in BC according to Buttrenchuk (1998)), based on 5 samples, is shown on Figure 8. The Sulphur Mountain Formation is of lower to middle Triassic age, while the Kechika Formation is of upper Cambrian to lower Ordovician age. Most phosphate-bearing formations displayed a pattern similar to that of the Sulphur Mountain Formation, and are similar

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

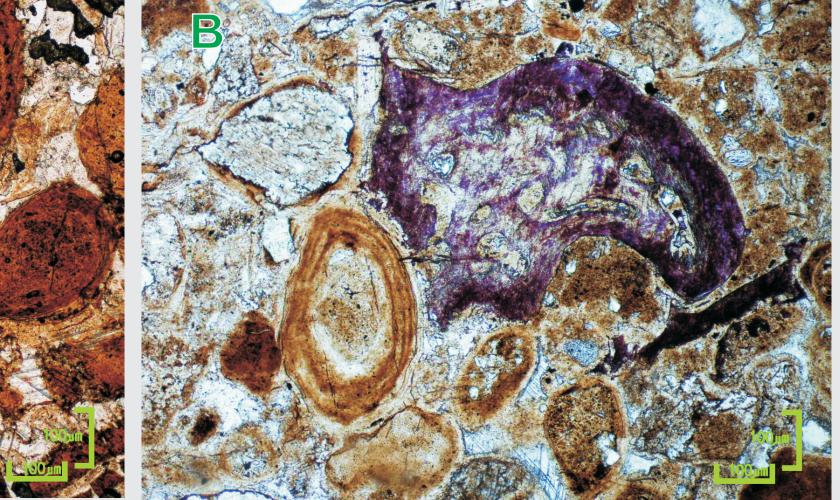
was recently described by Simandl et al., 2011.

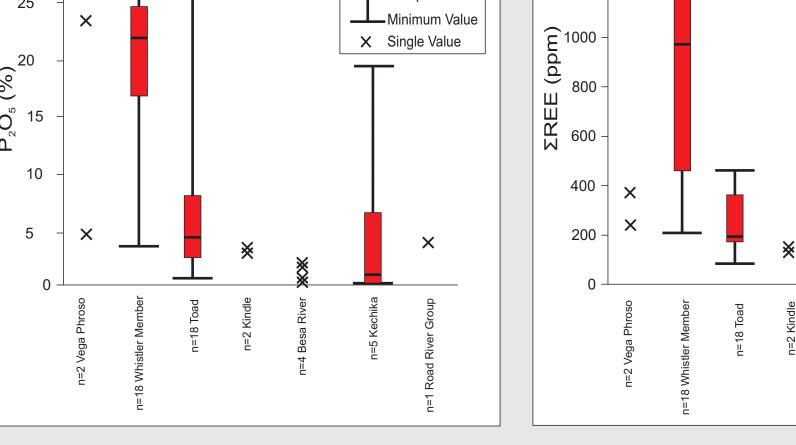




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Previous work has shown that significant concentrations of REE exist in the Fernie Formation (Southeastern BC). This Mountain Formation contains similar REE concentrations. relative proportions of the REE may differ substantially betwee formations (eg. Sulfur Mountain and Ketchika Formations). There is excellent correlation between historical (volumetric and XRF) an modern (lithium-borate fusion followed by ICP-MS) analyses for Y and  $P_2O_5$  analyses. Historical analytical methods significantly underestimate La content when compared with modern techniques There is significant positive polynomial correlation between Y and  $P_2O_5$ , and excellent positive correlation between Y and other REEs The "in the ground" value of the REO contents of the Sulphur Mountain Formation is comparable to the value of the phosphat rock products for fertilizer production that it could produce. Th current (July 2011) REO prices are much higher than those used i the calculations. If reasonable resources of phosphate-bearing ra materials are established in BC, then the recovery of REO and F a by-products of phosphate mining and processing should be seriously considered.

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