LEONARDITE AT RED LAKE DEPOSIT, BRITISH COLUMBIA, CANADA.

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INTRODUCTION

"Leonardite" and "humate" are loosely used terms covering a variety of naturally occurring lithologies with high humic acid content, including weathered (oxidized) lignite, sub-bituminous coal and a variety of carbonaceous rocks, such as mudstones, shales and claystones (Kohanowski, 1957 and 1970; Hoffman *et al.*, 1993). These raw materials are used mainly as soil conditioners; however they also have applications in wood stains, drilling fluid additives and as binder in iron pelletizing (Hoffman *et al.*, 1993). To be of economic interest, raw humate or leonardite should contain a sufficient concentration of humic acid. New Mexico's humate typically contains 12 to 18% humic acid, but materials used for drilling fluid applications typically contain more than 65% humic acid (Hoffman *et al.*, 1993). Humates are generally mined by front-end loaders, stockpiled to reduce water content, then crushed and screened (Hoffman and Austin, 1994). Materials with high humic acid content may be further processed for use as a component in water-soluble wood stains, as a drilling fluid additive (Odenbaugh and Ellman, 1967, Roybal *et al.*, 1986), as binder in iron ore pellets, and as lignite briquettes.

The greatest growth potential for humic acid-based products is in soil conditioning and agricultural applications.

RED LAKE DEPOSIT

The Red Lake deposit, located approximately 40 kilometres northwest of Kamloops (Figure 1), is currently mined for diatomite-bearing rocks. These rocks are shipped for processing to the Western Industrial Clay Products plant in Kamloops. At the plant, the ore is processed and blended with other materials to produce a variety of industrial absorbents and pet litter products that are marketed in North America and overseas.

Read (1995) described the geology of the deposit, which is interpreted to lie near the base of the Miocene Deadman River Formation. The form and geology of the deposits can be summarized conveniently in north-south and east-west sections (Figures 2a and 2b).

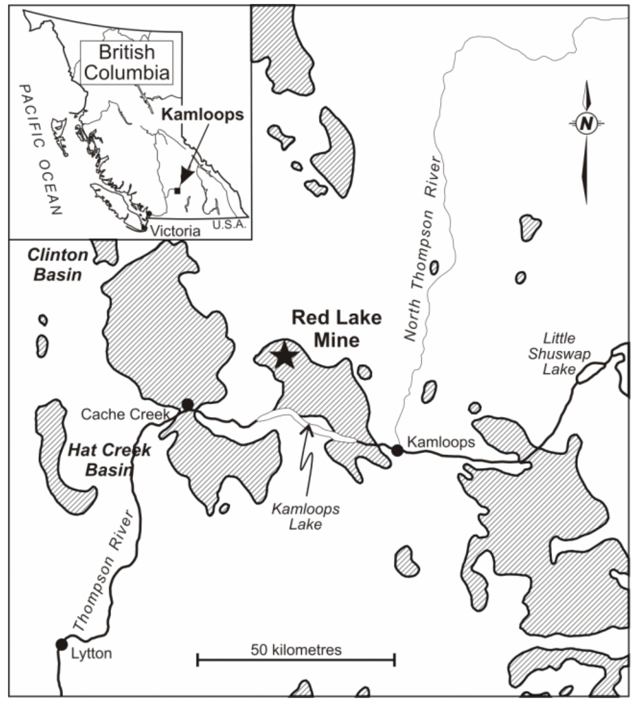

Figure 1: Geological setting of the Red Lake deposit, British Columbia, Canada. Tertiary basins are indicated by shaded areas.

Lithologies at the mine site include Grey Andesite, a basal Carbon-rich unit (*Mbc*), basal Diatomaceous Earth (*Mbd*), an upper Carbon-rich unit (*Muc*), an upper Diatomaceous Earth (*Mde*) unit, and overburden (*Qs*). These units are described in stratigraphic order (from oldest to youngest) below:

Grey Andesite (possibly basalt) is the oldest unit that crops out in the mine area and probably correlates with the Eocene Kamloops Group (Read, 1995). It is basement to the basin that contains the diatomite deposit. The andesite consists essentially of plagioclase laths (50-70%), measuring less than 0.5 millimetres, set in a glassy matrix. Medium grey, vesicular breccia consisting of angular clasts ranging from a few millimetres to a few centimetres (rarely 20 centimetres) was described by (Read, 1995); however it is not shown on the cross sections.

The ***Basal Carbon-rich unit (Mbc)*** forms lenses up to 2 metres in thickness (Figure 2a and 2b). This layer

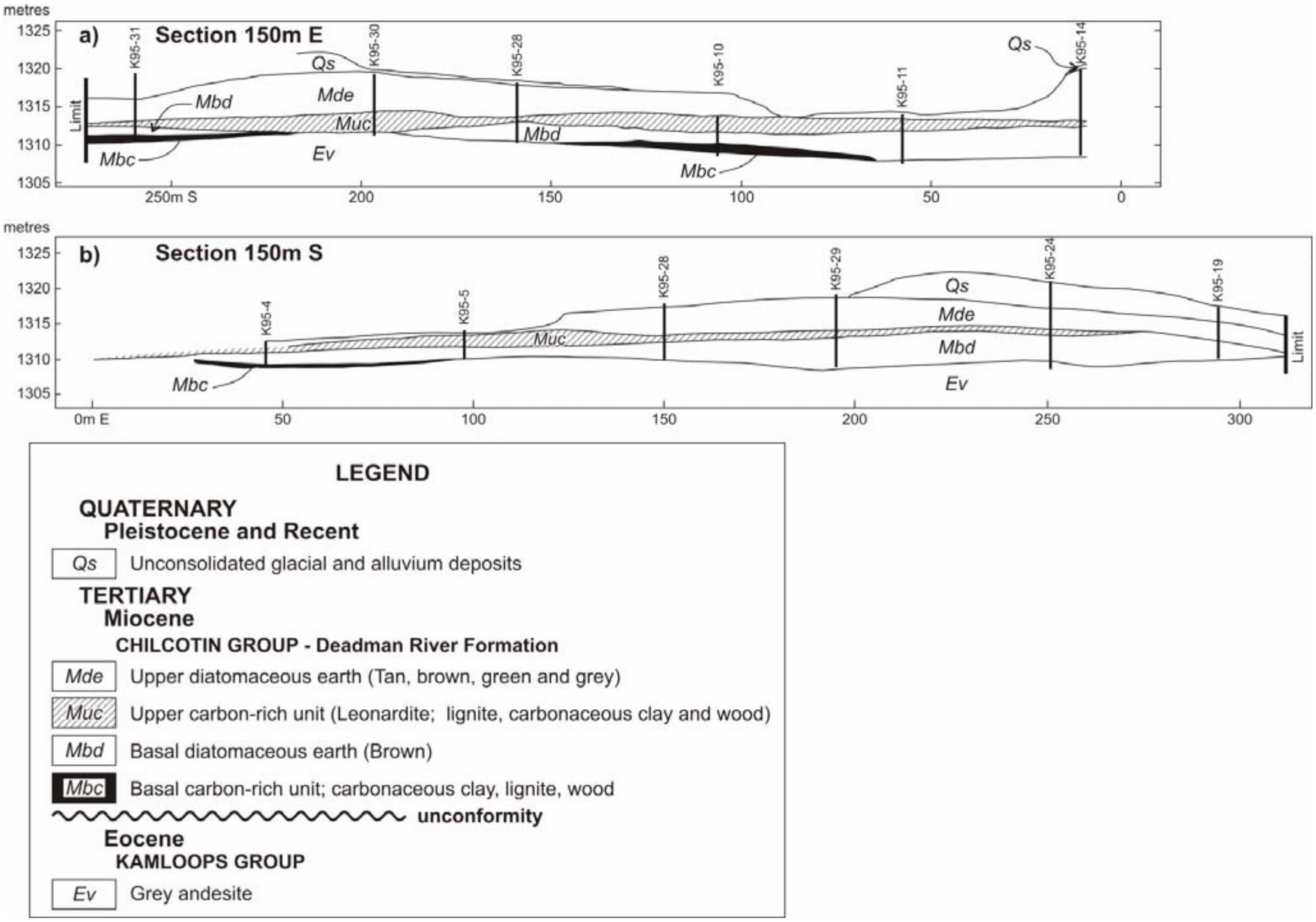

Figure 2: North-south (a) and east-west (b) sections across the Red Lake deposit (modified from Read, 1995).

was not exposed at the time of our visit and therefore was not studied or sampled.

The ***Basal Diatomaceous Earth (Mbd)*** unit is a brown diatomite layer, locally over 5 metres thick, that overlies the lower organic-rich horizon. This layer is porous, soft and relatively ductile. It has a massive appearance and consists mainly of clay (probably montmorillonite) and diatoms.

The ***Upper Carbon-rich unit (Muc)*** is described as carbonaceous shale, coal-like material and black wood fragments (Read, 1995). The unit is locally over 2 metres thick and it separates the previously described brown Basal Diatomaceous Earth from the Upper Diatomaceous Earth unit. It was exposed in the floor of the mine at the time of our visit and nine samples were collected. The unit also contains crumbly, sand-like diatomite-bearing lenses or layers and represents a potential source of leonardite or humate.

The ***Upper Diatomaceous Earth (Mde)*** unit is beige to pale grey or brownish in colour and up to 7 metres thick (Figure 2a and 2b). It is commonly laminated but can be massive. Centimetre-scale parting is a dominant texture. This highly absorbent, light-weight unit (density 0.61 g/cm^3) consists mainly of montmorillonitic clay, but contains 20 to 35% diatomite skeletons. Up to now, this rock has provided the bulk of the raw material shipped to the Western Industrial Clay Products plant.

Overburden (Qs) consists mainly of unconsolidated glacial and alluvial deposits. Local areas are covered by material that was relocated during mining.

GEOCHEMISTRY OF THE UPPER CARBON-RICH UNIT *(Muc)*

The nine samples of ***Upper Carbon-rich unit (****Muc)* that were selected and described in the field were analyzed for their humic acid content. Determinations made using both the colorimetric and chemical precipitate methods on air-dried samples are shown in Table 1.

The data indicates extreme variations in humic acid concentrations perpendicular to the strike and possibly along strike. These variations indicate that a much broader systematic sampling is required to obtain a representative humic acid content for the *Upper Carbon-rich unit* at the mine site. It also suggests that careful blending would be needed to obtain and maintain a consistent humic acid

TABLE 1: HUMIC ACID CONTENT OF THE UPPER CARBON-RICH UNIT (MUC) DETERMINED USING COLORIMETRIC AND CHEMICAL PRECIPITATION METHODS.

SAMPLE *	% Humic Acid Colorimetric	% Humic Acid Chemical precipitate
RED-007	5	-
RED-00-15	12	-
RED-00-16	52	75.0
RED-00-17	43	45.2
RED-00-19	9	5.8
RED-00-20	47	48.8
RED-00-22	22	7.0
RED-00-23	13	3.7
RED-00-24	20	13.8

* all samples were air-dried

content if leonardite material from Red Lake were to be mined and marketed as a soil conditioner. Some of the samples listed in table 1 were also analyzed for major and trace elements.

Major element analyses shows that SiO_2 (41 to over 80%), Fe_2O_3 (1.62 to 28.14%) and Al_2O_3 (5 to 23%) are the major constituents in the ash. High SiO_2 content was expected because the host is diatomite-bearing. The Al_2O_3 values reflect the relative clay content. There appears to be no relationship between Fe_2O_3 and SO_3, which confirms the absence of sulphides previously established by visual observation and fully expected in the highly oxidized environment.

Trace element data, reported on a "total rock" basis (not in ash), indicate that silver (Ag), arsenic (As), gold (Au), beryllium (Be), bismuth (Bi), cadmium (Cd) and selenium (Se) are below the detection limit. Other elements are present in trace, but detectable quantities including Ba (< 291 ppm), Co (< 96 ppm), Cr (< 19 ppm), Cu (< 32 ppm), La (< 119 ppm), Mn (< 187 ppm), Mo (< 44 ppm), Ni (< 107 ppm), P (< 0.087 %), Pb (< 47 ppm), Sb (< 16 ppm), Sr (< 86 ppm), Th (< 5 ppm), U (< 5 ppm), V (< 270 ppm), W (< 23 ppm), Zn (< 74 ppm). Boron levels (19 to 547 ppm) most likely reflect the original playa-type environment.

'Ultimate analysis' consists of H_2O, C, H, N, ash, S and oxygen content and is reported as A.R. (as received), A.D. (air dried) and Dry (oven dried). The ultimate analysis results indicate that within the pit, water represents 30 to over 67%, and ash 8.6 to over 50% of the unprocessed raw material from the Upper Carbon-rich unit (*Muc*). Sulphur content varies from 0.17 to 0.71%, nitrogen from 0.01 to 0.77% and oxygen from 2.64 to 16.15% on an as received basis. Upon drying the proportions of all of these constituents, except water, increase substantially.

CONCLUSION

Although this preliminary study is not based on systematic sampling, it indicates extreme fluctuations in humic acid content within the *Upper Carbon-rich unit*. Consequently, we can not speculate on its average humic acid content. Depending on the average humic acid content of this unit, the material could become a valuable co-product of diatomite-rock mining and be marketed as leonardite or humate.

Concentrations of deleterious trace elements (As, Se, base metals and radionucleids) in ash from these samples are low. Such low concentrations would not limit the use of the humic acid-bearing material from the Red Lake deposit in agricultural and horticultural applications. The *Lower Carbon-rich* unit was not sampled but it is possible that it may also have high humic acid content and should be evaluated.

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