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A Comparison of Physical Property Borehole Logs With Geology, Mineralogy and Chemistry in a Borehole at Les Mines Selbaie, Northwestern Québec, Canada

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INTRODUCTION

A geological log, that is a macroscopic geological identification with descriptions, has been supported by chemical, mineralogical and physical property measurements in a deep exploration hole at Les Mines Selbaie (Reed, 1997). The geological log using the standard Selbaie site terminology has been revised using chemical and mineralogical studies on the core. Comparisons of the two geological logs (referred to here as geology and lithology) with physical property logs show broad correlations between the two geological logs and the physical properties, but the physical property logs are more closely related to the mineralogical/chemical (lithology) log. The mineralogical/chemical log has tended to consolidate the geological units, and this is generally supported by the physical properties. There remain some differentiations within units by the physical properties, that are not seen by either the visual geological log or mineralogical/chemical revision.

The geological logging and the chemical and mineralogical work was carried out by staff at Les Mines Selbaie, while the physical properties logging was accomplished by the Borehole Geophysics Section of the Mineral Resources Division of the Geological Survey of Canada (GSC) (Killeen, 1991). The synthetic seismogram in Figure 2 was developed with the assistance of Dave Eaton at the Continental Geoscience Division of the GSC. The images of the borehole data have been produced by Logview, a borehole log imaging program developed at the GSC (Open File 3055).

GEOLOGY AND PHYSICAL PROPERTIES

The standard geological description (Mercier, 1995) of the geology is presented in Figure 1 under the column heading Geology. The revised description from mineralogy and chemistry is in the column headed Lithology. It will be seen that the names in the upper two thirds of the hole change from predominantly dacitic (Dacite Tuff—DT, Dacite lapilli Tuff—DTl) to rhyolitic (Rhyolite—Rhy, Rhyolite lapilli Tuff—RTl). The term dacite used at Selbaie, has long been recognized as a felsic rock (Bouillon, 1990). The present analysis confirms that the rocks are chemically and mineralogically more rhyolitic than dacitic in composition. There is not space here to define all the terms used in these logs, and unfortunately there is overwriting of some of the names on the log presentation. The lower third of the sequence is more recognizably andesitic (Andesite lapilli Tuff—ATl) although it retains some of the dacite nomenclature (DT). The Selbaie sequence is recognized as bimodal (rhyolite-andesite). The geological description that follows uses the revised terminology identified by the lithogeochemistry and mineralogy (Taner, 1995; 1996).

The physical properties are shown with the geology and chemistry to illustrate how these relate and contrast. The total natural gamma response (Figures 1 and 2; TC1, CPS) provides the most distinctive correlations with the geology and lithology. The total gamma count conforms with the potassium chemistry (Figure 1; $K2O$, %). The total count originates mainly from the potassium in the rocks. The induced polarization (Figure 1; IP, mV/V) shows mainly conductive mineralization, although there are some modest background variations. The magnetic susceptibility (Figure 1; MS, micro SI) although generally low, shows some localized magnetite concentrations as well as some variations associated with lithology. The single point resistivity (Figure 2; SNGLPT, Ohms) and the resistivity (Figure 2; RHO, Ohm-m) show broad similarities, with some differences such as the lower resistance from surface down to 865 metres, while resistivities remain high in this section. The single point resistance provides some lithologic discrimination not available in the resistivities, but in general these measurements do not provide much lithological discrimination. Similarly the velocity, density and synthetic seismogram (Figure 2) do not provide more than modest discrimination of the lithology. The velocity and density response of the mineralization (MSpy) at the top of the hole and various felsic dykes (FD) and a few contacts are exceptions.

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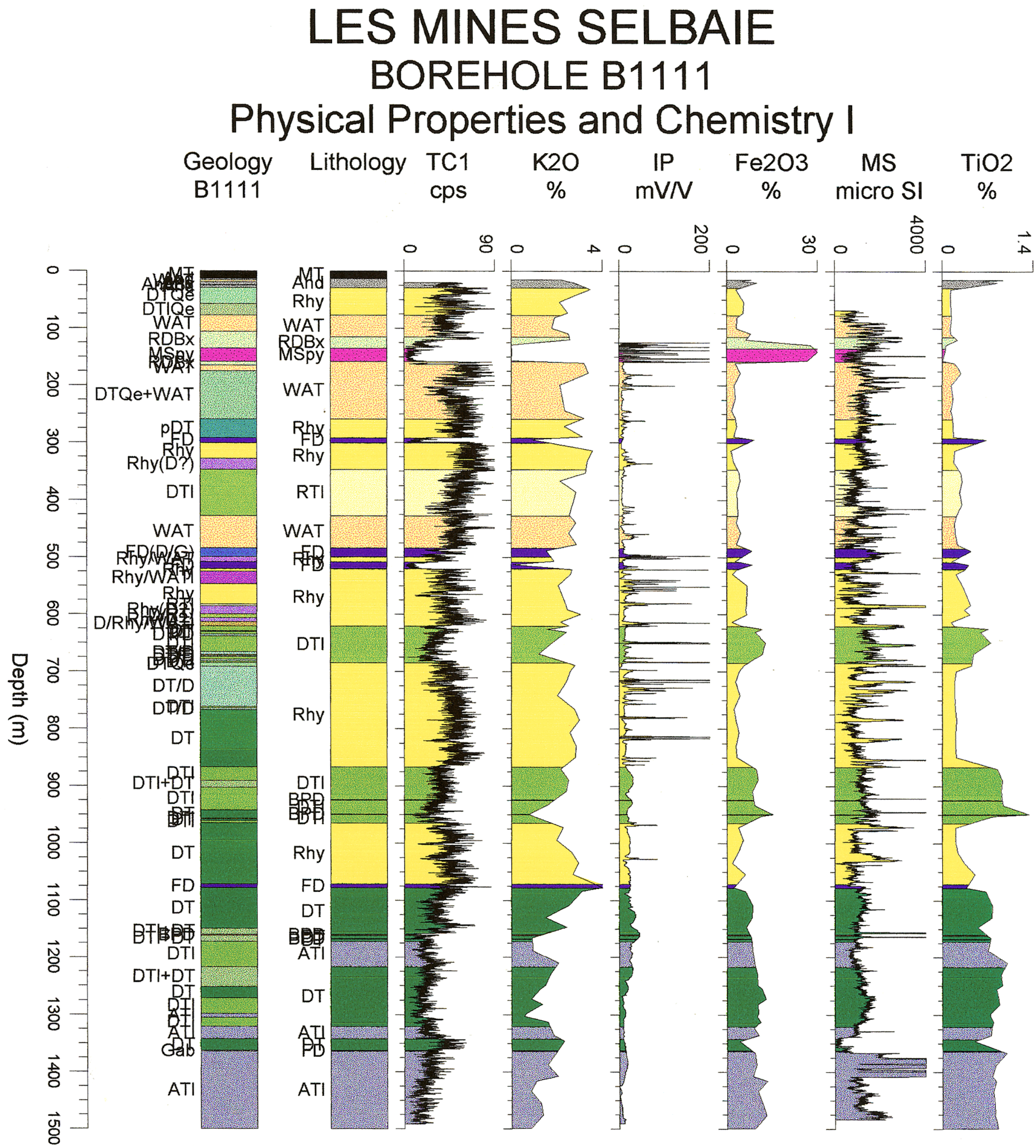

Figure 1: *Logview presentation of geology (macroscopic visual), lithology (revision of geology from chemistry and mineralogy), total count natural gamma (TC1, cps), whole rock chemistry - potassium (K2O%), induced polarization (IP, mV/V), whole rock chemistry - iron (Fe2O3%), magnetic susceptibility (MS, micro SI), and whole rock chemistry - titanium (TiO2%).*

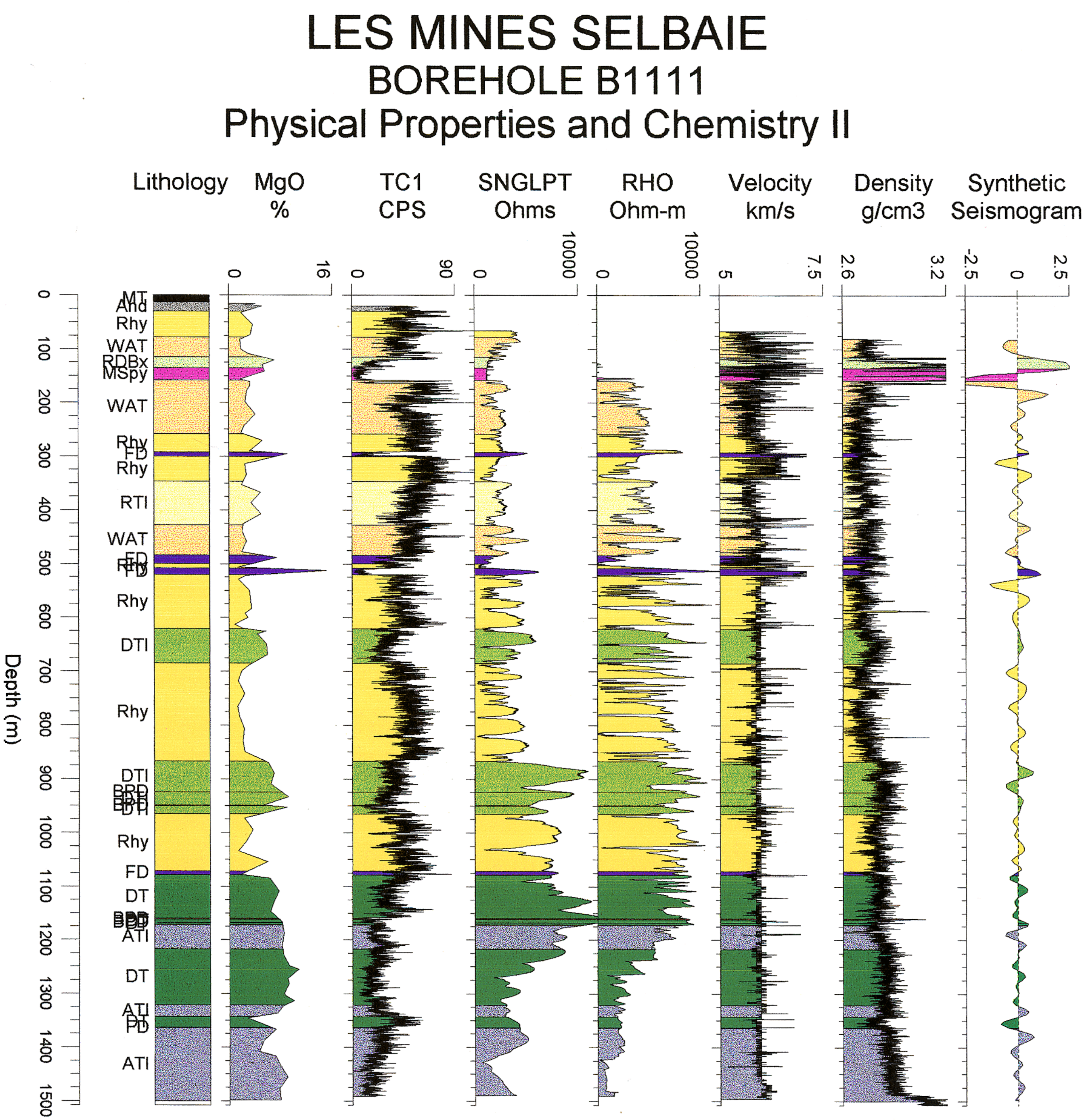

Figure 2: *Logview presentation of lithology (from chemistry and mineralogy), whole rock chemistry - magnesium, total count natural gamma (TC1, cps), single point electrical resistance (SNGLPT, Ohms), electrical resistivity (RHO, Ohm-m), acoustic velocity in kilometres per second, density (or specific gravity) in grams per cubic centimetre, and a synthetic seismogram derived from the velocity and density.*

Volcanics — Andesite

Andesites (And, ATl) appear at the top and bottom of this hole. The unit at the top (And) is part of a sequence thrusted from the east over the mine sequence rocks. Above this, and not in the hole are the tonalitic rocks of the Brouillan batholith. The upper andesite sequence is too high in the hole to be measured by the physical properties, except for the total count (and potassium chemistry), which indicates high values. This contrasts with the radiometric response of the lower andesite unit which has low counts. It has not been clearly established if the upper andesite and lower andesite are the same rocks. They may be the same, with the potassium difference being due to the state of the alteration of these rocks.

The deeper andesite sequence from about 1075 m in the hole occurs as massive flows and/or their pyroclastic products (DT, ATl). The lower andesite sequence is characterized on the logs as having lower gamma counts (and lower K2O), as noted above. The plots of the chemistry show elevated iron and titanium (Figure 1; FE2O3, TIO2) and magnesium (Figure 2; MGO). The magnetics (Figure 1) seem to discriminate between the andesite lapilli tuff (ATl) and the dacite tuff (DT), but the behaviour is not consistent. Two dacite tuff units are relatively high, but one (at 1360 m) is very low magnetically. There is a strongly magnetic unit within the andesite lapilli tuff at about 1400 m that is not discriminated in either the geology or lithology logs. There is a dacite tuff (DT) from 1075 m to 1150 m that shows gamma, magnetic, and density characteristics common to two dacite lapilli tuff (DTl) units at 650 m and 900 m up in the rhyolite sequence, suggesting that the DTl may be part of the andesite sequence interdigitated with the rhyolite sequence. The iron, titanium and manganese chemistry supports this. The upper part of this section is resistive high, while quite low resistivities appear at the bottom. The lithologies are not discriminated by this.

Volcanics—Rhyolite

Rhyolitic rocks are the most voluminous rocks at Selbaie. They host the copper-rich mineralized veins in the A2 and B zones and the copper and zinc-rich veins of the A1 zone. This hole passes through the south edge of the A1 zone. The following are units within the rhyolitic sequence.

Welded Acid Tuff (WAT)

WAT is a name established at Selbaie by the appearance of the rock. It may not be classic welded acid tuff. The WAT is petrographically composed of chlorite rich patches (named “fiamme”, which are thought to be devitrified volcanic glass, although this is uncertain), quartz phenocrysts, and a matrix of equigranular quartz sericite +/- K-feldspar. These have undergone strong hydrothermal alteration with intense seritization and silicification. The main mineral assemblage is: quartz-sericite-+/-K-feldspar. The high potassium content and therefore strong alteration, is readily identified by the high total gamma count in the WAT, especially from 165 m to 200 m.

Typical Rhyolite (Rhy)

This rhyolite is a highly altered and recrystallized felsic volcanic rock with quartz phenocrysts. The macroscopic geology identifies these variously as dacite tuff with quartz eyes (DTQe), pisolitic dacite tuff (pDT), dacite tuff (DT), or dacite (D). The high gamma (potassium) and low iron, titanium and magnesium bring these rocks together, in part at least as significantly altered rocks. These felsic rocks are mostly composed of quartz, sericite, K-feldspar, chlorite, +/-carbonate, +/- opaques (mostly pyrite, and a little sphalerite and chalcopyrite). The presence of pyrite and chalcopyrite is indicated by the induced polarization highs and the electrical resistance and resistivity lows within these rocks. Some of the velocity highs correlate with these metallic mineral indicators, and arise from the high velocity contrast between pyrite and the host rocks.

Rhyolitic Lapilli Tuff (RTL)

These fragmental rocks consist mainly of felsic fragments (after typical rhyolite) within a chlorite-sericite rich matrix. The macroscopic description of dacite lapilli tuff arises from its dark green matrix, from chlorite. This is a highly altered rock, as the high gamma count shows. Elevated MgO at 400 m (Figure 2) correlates with the chlorite.

Sedimentary sequence

Small structural basins identifying volcano-tectonic subsidence within the deposit area, are filled with chemical and detrital sedimentary materials of volcanic origin. Rhyodacite breccia (RDBx) describes a detrital, bedded, cherty and conglomeratic sedimentary rock. This rock, important to the deposit, as it hosts much of the ore, is seen only as a small intersection at 125 m in this hole. It is well mineralized. It lies above a bedded massive pyrite unit at 150 m (MSpy) which is one of the chemical sediments in the deposit. The RDBx shows low gamma, K2O and TiO2 response. It has high IP, Fe2O3, velocity and density from the mineralization. The high velocity and density is dominated by the response of adjacent massive pyrite, and produces the largest response on the synthetic seismogram.

Dykes

A series of dykes of varied composition cut all geologic units in the mine sequence. Felsic dykes (FD) are the principal dyke rock in the area. They were so named because of their light grey colour. These compositionally are mafic dykes. They are not all the same, as the physical properties and chemical logs show. For the most part these are low in gamma response; high in iron, titanium and magnesium; high in resistance, velocity and density. In places the dykes carry medium to coarse pyrite crystals, up to 1 cm in size, that increase their IP response and reduce their resistivity. One of these at 510 m produces the second largest synthetic seismogram response on the record. Another type of mafic dyke, a picritic basalt (BPD), has little impact on the logs at this scale.

CONCLUSIONS

Physical property logging has provided a useful support for the development of a lithological log based on mineralogy and chemistry in this hole at Les Mines Selbaie. The total gamma log, which principally represents potassium, fits more closely to the lithological log than to the macroscopic visual geological log. It is evident however that the visual log is differentiating features not "seen" by the chemistry, mineralogy or physical properties. Conversely, there are events in the physical property logs that are not recorded by the other two geological logs.

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