

# Short-Wave Infrared Spectroscopy (SWIR) in Magnesite Exploration

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## INTRODUCTION

Short-wave infrared spectroscopy (SWIR) analysis with field-based spectrometers is widely used in exploration for a variety of types of mineral deposit (Thompson et al., 1999). This manuscript reports the results of an orientation study conducted for the purpose of evaluating the applicability of SWIR technology to exploration for magnesite deposits. Magnesite is used mainly in production of caustic, dead burned and fused magnesia (MgO) and magnesium metal. These products have a wide range of industrial, chemical, environmental and agricultural applications (Simandl and Hancock, 1996; Brown, 1999, Coope, 1999). Magnesite deposits in British Columbia belong to sparry variety as defined by Simandl and Hancock (1999), and are spatially associated with sparry dolomite bodies. Several field methods were developed in the past to distinguish between magnesite and dolomite during exploration programs (Simandl et al., 1993), but all of them have limitations. The use of SWIR spectrometers provides a rapid and non-destructive field test for the presence of high-grade magnesite.

## ORE AND HOST ROCK CHARACTERISTICS

In British Columbia, Precambrian to Cambrian sedimentary rocks host sparry magnesite deposits, mainly within dolostones (Simandl and Hancock, 1996 and 1999). Magnesite-rich rocks that form deposits are typically white, light gray and massive or are characterized by sparry, pinolitic and zebra textures. Typically, major impurities are quartz and dolomite, while minor quantities include pyrite, calcite, clay and iron oxides, chlorite, calcite, mica, palygorskite and aragonite. These impurities occur as fracture fillings, in vugs or along bedding planes. The MgO and CaO proportions in sparry magnesite are variable. MgO content is the most important parameter in exploration for magnesite deposits.

The dolomite host rocks are either of planar or sparry variety. Planar dolomite (the most common host to magnesite deposits) is texturally and mineralogically heterogeneous on the hand specimen scale. Textures may be massive, thick bedded to thinly laminated, brecciated, stromatolitic, oolitic, or displayed by prominent partings. The dolomite host consists predominantly of dolomite but may also contain some magnesite or calcite.

## METHODOLOGY

Seventeen samples, including eleven magnesite-bearing rocks and six dolomites, were chosen from the Mount Brussilof, Anzak, Driftwood Creek, Topaz, Red Mountain and Boots Lake deposits in British Columbia. The samples were cut and approximately 2 kg were sent for chemical analysis by XRF. A flat slab was kept for reference and analysed using the PIMA-II short-wave infrared spectrometer. The instrument has an internal light source, allowing collection of laboratory quality data in the field or office.

Short-wave infrared spectroscopy detects the energy generated by vibrations within molecular bonds. These bonds have bending and stretching modes within the 1300 to 2500nm region of the electromagnetic spectrum. SWIR is particularly sensitive to certain molecules and radicals, including CO<sub>3</sub>. The positions and shapes of absorption features in the spectrum are a function of the molecular bonds present in the mineral. The CO<sub>3</sub> molecule has a large, deep feature in the 2310-2360 nm range that shifts in position as a function of carbonate mineral chemistry. The major carbonate mineral compositions are shown in Figure 1.

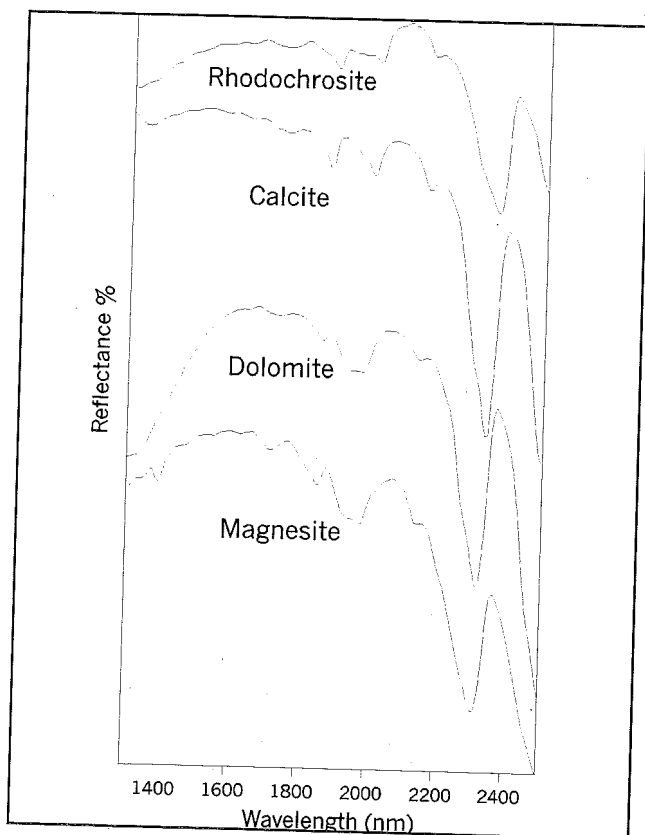


Figure 1. Representative spectra for calcite group carbonates showing variation in the dominant feature position references from SPECMIN™; Hauff, 2001). Reflectance offset for clarity.

## RESULTS

The results are summarized in Table 1, which includes sample type, major element analyses and the position of the dominant carbonate feature in the 2300nm range. Feature positions were calculated using a hull subtraction. Representative spectra are shown in Figure 2. Overall, the magnesite samples exhibit a very narrow range of wavelength values, from 2298-2303nm with most having a value of 2298nm. The only exception is the sample from the JAB deposit that contains talc and exhibits an apparent feature position of 2308 nm.

Dolomite samples are generally less reflective than the magnesite and have poorer spectra. One analysis was dropped (Bay-00-13) because of a very low reflectance response either due to a lack of carbonate in the analysed sample or possible pyrite contamination that reduced the overall signal. The dolomite samples have wavelength positions > 2306 nm and in the pure dolomite samples typical values range from 2313 to 2319nm. One sample with a large amount of Si in the chemical analysis has a wavelength position of 2302nm, either reflecting contamination, or the presence of Mg-rich carbonate.

## DISCUSSION AND CONCLUSIONS

The results of this reconnaissance study show that there is good correlation between MgO content, determined by XRF major oxide analysis, and the wavelength positions determined with the PIMA-II spectrometer. In addition, microprobe analyses of the magnesite from British Columbia sparry magnesite deposits shows remarkably uniform

TABLE 1  
A REPRESENTATIVE ANALYSIS IS SHOWN FOR EACH SAMPLE

Spectrum	Sample No.	Deposit	Rock Type	Wavelength	MgO %	CaO %
Carb001b	A24/11-220c	Anzak	Dolomite	2307	26.16	25.76
Carb002c	B34/06-307	Topaz	Magnesite	2299	41.03	0.31
Carb003a	B35/17-314		Dolomite	2319	20.39	29.65
Carb004b	B38/03-331	Red Mtn	Magnesite	2298	40.14	0.32
Carb005a	B40/04-346	JAB	Magnesite (plus talc)	2308	41.85	0.35
Carb006a	B41/02-358A	Clelland L.	Magnesite	2298	41.12	1.14
Carb007a	B44/01-386	Botts L.	Si, Mg-rich Dolomite	2301	28.8	10.64
Carb008b	D29/14-259	Driftwood Cr.	Mg-rich Dolomite	2316	30.08	19.21
Carb009b	D33/05-290	Driftwood Cr.	Magnesite	2303	38.3	0.83
Carb010c	D49/01-449	Driftwood Cr.	Magnesite	2296	38.62	0.1
Carb011a	M7/5-32	Marysville	Magnesite	2298	42.14	1.03
Carb012b	P52A	Baymag	Magnesite	2299	48.34	0.43
Carb013a	Bay-00-11	Baymag	Magnesite	2298	46.77	0.4
Carb014c	Bay-00-12	Baymag	Dolomite	2318	21.15	28.17
Carb015a	Bay-00-13	Baymag	Dolomite (low reflect)	2207	22.09	25.63
Carb016a	Bay-00-14	Baymag	Magnesite	2298	44.25	0.55
Carb017b	Bay-00-15	Baymag	Magnesite	2298	46.27	0.46

chemical composition on the crystal scale, consistent with the observed narrow range in wavelength positions in this study. The correlation is not as good for the dolomite samples, due to greater variability in bulk chemistry, textural variability and field of view limitations. The following conclusions can be drawn from this preliminary study:

- Spectral analysis successfully identifies magnesite with the dominant feature exhibiting a very narrow range of values from 2298-2302nm (within instrument error).
- Dolomite samples have wider range of values for the 2300nm position, correlating with a broader range in composition. The dolomites typically have values ranging from 2306-2319 nm.
- The observed variations provide a technique for use in exploration for magnesite deposits. Future work should include analysis of a much larger sample set in order to verify these results with greater statistical confidence.

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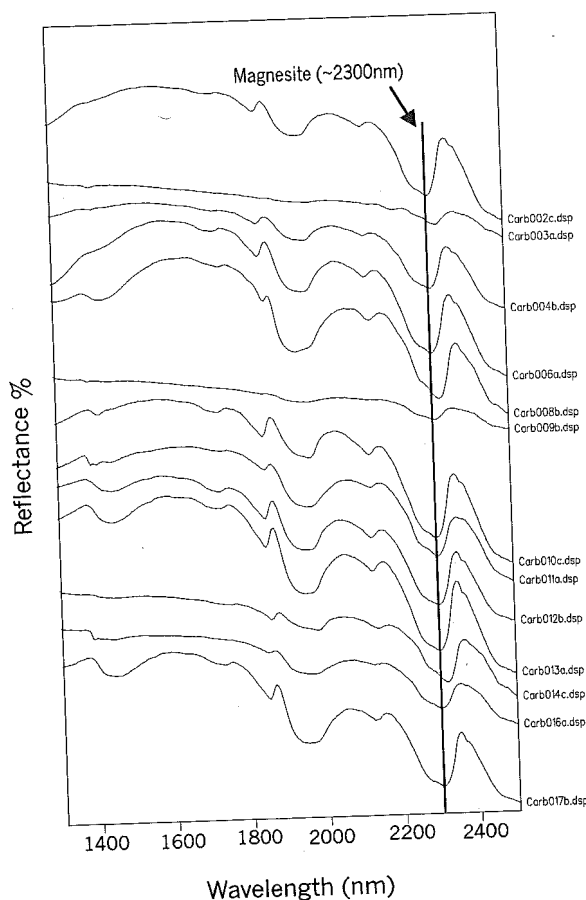


Figure 2. Representative spectra for magnesite and dolomite samples from deposits in British Columbia. Spectra with minima to the right of the magnesite line represent dolomite samples. Reflectance offset for comparison of