

## Reflectance Spectra of the Boreal Forest Over Mineralized Sites

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### ABSTRACT

Detecting areas of near surface mineralization from spectral reflectance of geochemically stressed vegetation is very challenging in Canada's boreal forest region. This paper provide an analysis of the field spectra of two boreal forest species growing on mineralized areas. Our results show that there is little difference in reflectance between the mineralized and background sites. Less than 1.5 nm difference at the red edge inflection point was observed between the mineralized and background sites. This indicates that the differences in geochemical values are not large enough to produce significant spectral variations between sites. Therefore, detection from airborne spectrometers will be difficult.

Keywords: Geochemical stress, mineralized sites, reflectance spectra, boreal forest

### INTRODUCTION

In Canada, most mining areas within greenstone belts are covered by glacial till and vegetation, which limit the usefulness of conventional techniques for geological mapping and exploration. Recent results have shown that the vegetation on these mineralized areas are influenced by the geochemistry of the soil and rock in terms of reflectance spectra, structure and types [1, 2, 3, 4, 5]. Field and laboratory reflectance spectra on these mineralized sites, compared to background sites have shown have shown that boreal forest species that have been geochemically stressed will respond to changes in their reflectance spectra at specific regions [6, 7, 8]. These changes were observed at the green reflectance peak near 570 nm, the chlorophyll absorption maximum near 680 nm, the red edge between 680 and 750 nm, and the reflectance at the infrared shoulder between 750 and 1100 nm. Stress in plants can result in chlorosis or chlorophyll loss. This phenomenon has been documented, in some cases as "red edge shift", a change in the wavelength position of the inflection point between 680 and 750 nm.

Mapping these changes from airborne imaging spectrometers like *casi* have met to date with several scientific and technical challenges which are still being sorted out in this and many other experiments in the boreal forest region [9, 10]. To date

there are no case where these spectral differences on mineral sites are detected from airborne hyperspectral images. This is in part due to the relatively small differences in reflectance from the mineralized and background sites. This study reports on early experimental field spectral survey in support of airborne campaigns. The goal of this study is to determine whether airborne hyperspectral *casi* images can be used to detect biogeochemical indicators over mineralized sites in the boreal forest areas of the Precambrian Shield.

### METHODOLOGY

To reduce the number of other factors affecting spectral variation, and to isolate the effects of soil geochemistry on vegetation spectra, we conducted detailed soil and leaf geochemistry of the mineralized and background sites (Fig.1). Field spectra were collected at the time of airborne acquisition in mid August 1998, just prior to leaf senescence. The Compact Airborne Spectrographic Imager (*casi*), with a spectral range from 400-944 nm, and 72 contiguous bands each 8.7 nm wide, was flown at an altitude of 3000 m ASL and produced a spatial resolution of 3.5 m. A total of 81 reflectance spectra of white birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*) were taken from both test sites (Fig. 1). Leaves cut from all around the sampled trees were placed in sealed plastic bags and transported in coolers to a nearby facility for spectral measurement. Spectral measurements of the leaves were taken within two hrs of sampling. The GER field spectrometer (400-2200 nm) was set up with a fixed geometry and light source to standardized the measurement procedures. After spectral measurement the leaves were then dried and processed for multi-element chemical analysis.

Spectral analysis of field spectra involves comparisons of the inflection point at the red edge for the two species at both sites. The procedure involves first averaging the birch and aspen spectra both for the anomaly and background test sites. A curve is then fitted to each of the four spectra and the first derivative of the curves are calculated. The inflexion point of the red edge (usually located around 720 nm) is positioned for each curves and the spectral shift is calculated for the two

species. Results show a red edge shift of 0.35 nm for birch and of 1.46 nm for aspen.

#### STUDY AREA

Two test sites were selected along the northeast rim of the Sudbury basin within the *casi* coverage. One site is located over a mineralized zone, and the other on a background site. The mineralized site is an undulating area of breccia bedrock-dominated terrain along the northeast rim of the Sudbury basin [11]. The breccia bedrock is associated with the copper-nickel ores of the Sudbury Nickel Irruptive Complex [12]. Archean granitic rocks underlie the background site. The eastern half of the site is a level area underlain by outwash sediments and the western half is an undulating bedrock-controlled area with a thin and discontinuous cover of glacial sediments [11].

Podzolic soils occur at both sites. The A-horizon is well developed with a layer of humus that overlies an eluviated zone of mineral soil (Ae-horizon). B-horizons are present at most localities. Soil samples were collected of the A-horizon (humus) and B-horizon at 15 m spacing along grid lines [10]

#### RESULTS

We selected the elements, Mg and Fe, which are in a relatively high concentration at both sites. These elements normally produce physiological and morphological changes in vegetation due to metal toxicity. Concentrations in the B horizon are Mg/min = 10022 ppm, Mg/back = 5749, Fe/min = 70250 ppm, and Fe/back = 39651 ppm. Mg accumulation in the leaves is about four times higher than the soil, as expected (Mg/min = 39242 ppm and Mg/back = 21132 ppm). Fe concentration in the leaves is Fe/min = 1294 ppm and Fe/back = 1297 ppm, indicating that there were very little mobilization of Fe in these species. The spectral differences at the inflection point of the red edge less than 1.5 nm shifts for both birch and aspen, between the mineralized and background sites (Fig. 2). This indicates that the differences in soil geochemical values between the mineralized and background sites are not producing significant spectral variations, even at the field level. We expect the subsequent analyses of atmospherically corrected *casi* data will not detect these small spectral differences between sites.

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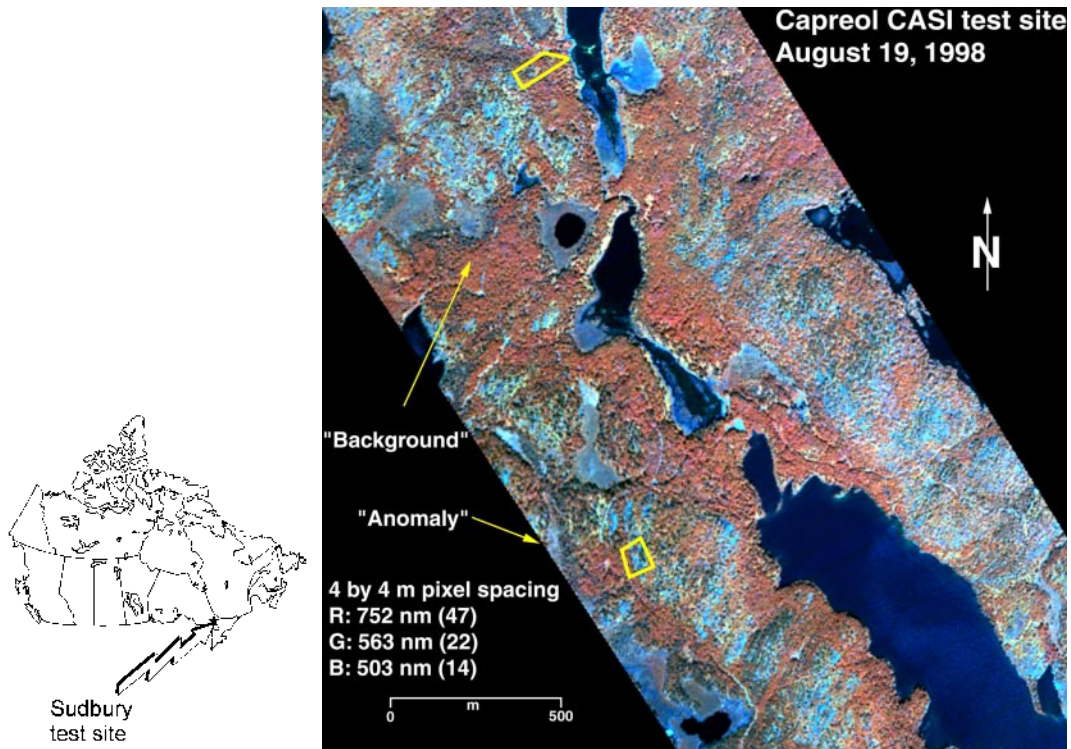


Fig. 1 Location of the "Background" and "Anomaly" test sites northeast of Sudbury, Ontario, Canada.

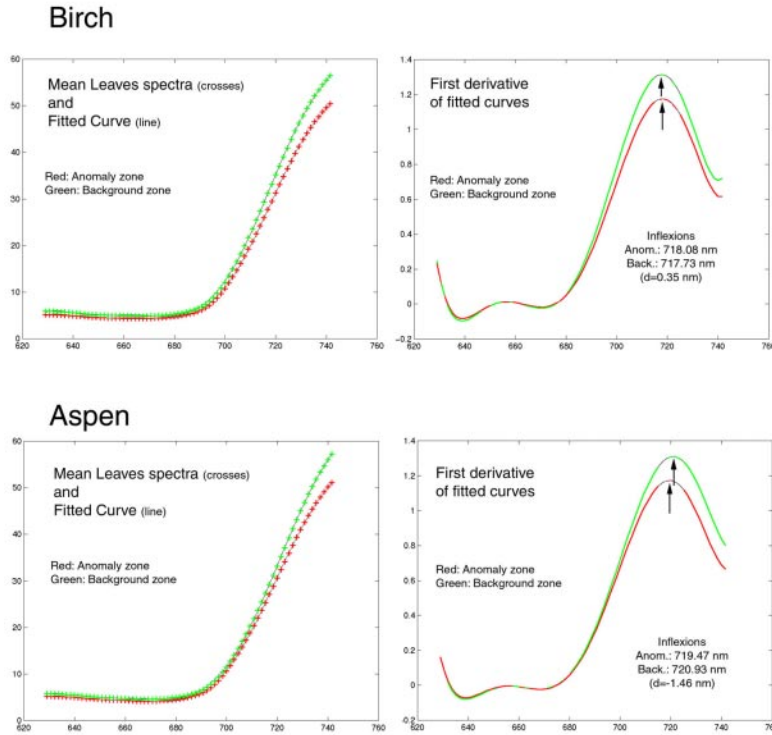


Fig. 2 Partial spectra curves and first derivative curves for both tree species at the anomalous and background test sites.