# Diffuse Reflectance Infrared Spectra of the Meade Peak Phosphatic Shale Member of the Permian Phosphoria Formation, Caribou County, Idaho

By Robert J. Horton



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U.S. Geological Survey

## Introduction

The U.S. Geological Survey (USGS) has studied the Permian Phosphoria Formation in southeastern Idaho and the Western U.S. Phosphate Field throughout much of the twentieth century. In response to a request by the U.S. Bureau of Land Management (BLM), a new series of resource and geoenvironmental studies was initiated by the USGS in 1998. These studies involved many scientific disciplines within the USGS and consist of: (1) integrated, multidisciplinary research directed toward resource and reserve estimations of phosphate in selected 7.5-minute quadrangles; (2) elemental residence, mineralogical, and petrochemical characteristics; (3) mobilization and reaction pathways, transport, and disposition of potentially toxic trace elements associated with the occurrence, development, and use of phosphate rock; (4) geophysical signatures; and (5) improving the understanding of depositional origin.

This report presents the diffuse reflectance infrared Fourier transform (DRIFT) spectra for samples of phosphatic shale collected from the Enoch Valley mine located in the Caribou County, Idaho. These measurements were made to characterize the infrared spectral signatures of different rock types within the more-weathered and less-weathered sections of the Meade Peak phosphatic shale member of the Phosphoria Formation. These sections are described in detail by Tysdal and others (1999).

Infrared (IR) spectra were collected on a Nicolet Magna-IR 760 Fourier transform infrared spectrometer (FTIR) equipped with a liquid nitrogen cooled mercury cadmium telluride (MCTA) detector, a KBr beam splitter, and a Barnes Analytical/Spectra-Tech diffuse reflectance accessory. Diffuse reflectance spectra were collected in two overlapping regions of the infrared spectrum, including the near-IR region from 10,000 to 2,000 $cm^{-1}$ and the mid-IR region from 5,000 to 500 $cm^{-1}$. For the near-IR region a white-light source was used; and for the mid-IR region, an IR glow-bar source was used. The data were collected with a nominal resolution of 2 $cm^{-1}$; typically 200 interferograms were co-added to produce each spectrum.

Ten samples, five from the more-weathered section A, and five from the less-weathered section B, were measured. Samples were selected to represent the upper and lower ore zones and the different waste zones (fig. 1). The bulk mineralogy of the samples, as determined by XRD analysis, are given in table 1 (from Knudsen and Gunter, in press). The measured samples were splits of samples prepared for mineralogical (Knudsen and others, 2000) and chemical (Herring and others, 1999 and 2001) analysis**.** The samples were measured as received. They had been air dried and ground to >100 mesh (<0.15mm). No additional preparation was performed.

**Results**

The DRIFT spectra for each sample are given in figures 2 through 11. The position of absorption bands observed in the spectra can be used to identify minerals present in the samples. The given spectra were corrected for atmospheric water and $CO_2$ absorptions by using a silvered mirror background reflectance spectra as a reference. Band positions and intensities at band minimums, were obtained using the Nicolet peak analysis software (OMNIC, 1999). No additional spectral processing was performed. On the figures the band position of major absorption features are labeled in wave numbers ($cm^{-1}$). Minor absorption features are not labeled on the figures but are given in Appendix 1.

Absorption band intensities are given as percent reflectance, relative to the background reference spectra. When collecting the background spectrum off the mirror, the aperture of the Magna-IR 760 spectrometer typically is closed to a minimum setting. Many of the phosphatic shale samples are black, with very low spectral reflectance. To measure the spectra of these dark samples, the spectrometer's aperture was opened to a maximum setting to compensate for the samples' low reflectance. Due to the wide-open aperture, some of the measured sample reflectance may exceed the background reflectance, resulting in a percent reflectance calculation greater than 100 percent for some parts of the measured spectra.

Ore Zone Samples

Samples wpsa006c and wpsb008c are from the lower ore zone of sections A and B, whereas samples wpsb131c and wpsb133c are from the upper ore zone of section B. These samples primarily consist of apatite, ranging from 75 to 88 percent. These ore zone samples have very similar spectral signatures (fig. 12), regardless of the section (A or B) or ore zone (lower or upper). A characteristic absorption band at 966 $cm^{-1}$ is a fundamental apatite vibrational band (Ross, 1974).

Sample wpsb038c is a carbonate-rich sample from the lower ore zone of the less-weathered section B. The wpsb038c spectrum (fig. 8) is significantly different than other spectra due to the high percentage of calcite. Characteristic calcite absorption bands (White, 1974) are observed at 880, 1,099, 1,409$cm^{-1}$. Other high intensity bands observed at 2,163, 2,336, 2,525, 2,628, 2,898 and 3,022 $cm^{-1}$ are not seen in the noncarbonate sample spectra and, therefore, probably represent overtone and combination bands of calcite fundamental absorption features.

Waste Zone Samples

Samples wpsa085c, wpsa087c, wpsa131c, and wpsb095c are from the middle waste zone. The spectra of these middle waste samples are somewhat similar (fig. 13); however, the spectrum of sample wpsb095c varies due to the relatively high carbonate content. These middle waste samples also contain buddingtonite, an ammonium feldspar, in percentages ranging from ~16 to 53 percent. Figure 14 shows the characteristic absorption band at ~4,717 $cm^{-1}$

produced by the $NH^{4+}$ ion within the buddingtonite crystal structure (Clark and others, 1993).

Sample wpsa156c is from the upper waste zone of the more-weathered section A. The wpsa156c spectrum (fig. 6) is similar to the middle waste spectral signatures; however, it lacks the 4,717 $cm^{-1}$ buddingtonite absorption feature. The 4,527$cm^{-1}$ band is a combination band (OH stretch + OH bend) produced by clay minerals.

<u>Equivalent Interval Samples</u>

Several samples were collected from essentially the same interval, but from different sections. Samples wpsa006c and wpsb008c come from the lower ore zone of the more-weathered and less-weathered sections, respectively. These ore zone samples do have very similar spectra as shown fig. 15. The weathering, which differentiates the two sections has not produced significant differences in the spectral character of these lower ore zone samples. However, subtle differences are present in the higher frequency part of the spectra, particularly in the 3,000 to 5,000 $cm^{-1}$ region. Absorption band position data given in Appendix 1 indicate a 4,526 $cm^{-1}$ clay band in the more-weathered wpsa006c spectra but not in the less-weathered wpsbB008c spectra.

Samples wpsa131c and wpsb131c are from much higher in the section. Although these samples are from the same interval, they are located in different units. Sample wpsa131c is from the middle waste unit, whereas sample wpsb131c is from the D bed of the upper ore zone (Tysdal and others, 1999). These samples have significantly different mineral compositions (table 1) producing markedly different spectral signatures (fig. 16).

**Summary**

DRIFT spectra were collected to characterize the infrared spectral signatures of different rock types within the more-weathered and less-weathered sections of the Meade Peak Phosphatic Shale member of the Phosphoria Formation. The ore-bearing samples have characteristic spectral signatures produced by the high concentration of apatite in the ore zones. No significant differences were observed in the spectra of ore samples from the upper and lower ore zone samples. Minor spectral differences were observed between ore samples from the more- and less-weathered sections, caused by the presence of clay minerals in the more-weathered section. Samples from the different waste zones have significantly different spectral signatures. The spectral signature of carbonate-bearing waste is distinguished easily from that of noncarbonate bearing waste by the presence of characteristic calcite absorption bands. Waste containing buddingtonite is characterized by an absorption band at ~4,717 $cm^{-1}$.

## References


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**Table 1.** Sample mineralogy as determined by XRD analysis (From Knudsen and Gunter, in press).

| Sample | Apatite | Quartz | Muscovite | Illite | Albite | Orthoclase | Buddingtonite | Kaolinite | Dolomite | Calcite |
|---|---|---|---|---|---|---|---|---|---|---|
| wpsa006c | 85 | 6.3 | 6 | 0.1 | 0.1 | 0.1 | 0 | 1.3 | 0 | 0 |
| wpsa085c | 3.4 | 40 | 13 | 0.1 | 7.9 | 8 | 23.5 | 3.4 | 0 | 0 |
| wpsa087c | 10.7 | 5.9 | 34 | 0.1 | 0.4 | 3 | 53 | 2.4 | 1.5 | 0 |
| wpsa131c | 0.5 | 39 | 5 | 0.1 | 23 | 15 | 16.2 | 0.1 | 0.2 | 0 |
| wpsa156c | 9.2 | 53 | 10 | 0 | 5.1 | 9.1 | 0.4 | 6.6 | 0 | 0 |
| | | | | | | | | | | |
| wpsb008c | 88 | 7.3 | 2 | 0.1 | 0.1 | 0.1 | 0.8 | 0 | 0 | 0 |
| wpsb038c | 4.4 | 10.1 | 0.1 | 0.1 | 3.4 | 1.9 | 1 | 0 | 0 | 79 |
| wpsb095c | 10.9 | 40.3 | 9.7 | 0.1 | 10.3 | 4.3 | 17 | 1.3 | 0.4 | 8.7 |
| wpsb131c | 75 | 8.1 | 15 | 2 | 0.1 | 0.1 | 0.1 | 0 | 0 | 0.1 |
| wpsb133c | 83 | 8.8 | 6 | 0.1 | 0.1 | 0.1 | 1.7 | 0 | 0.4 | 0.1 |

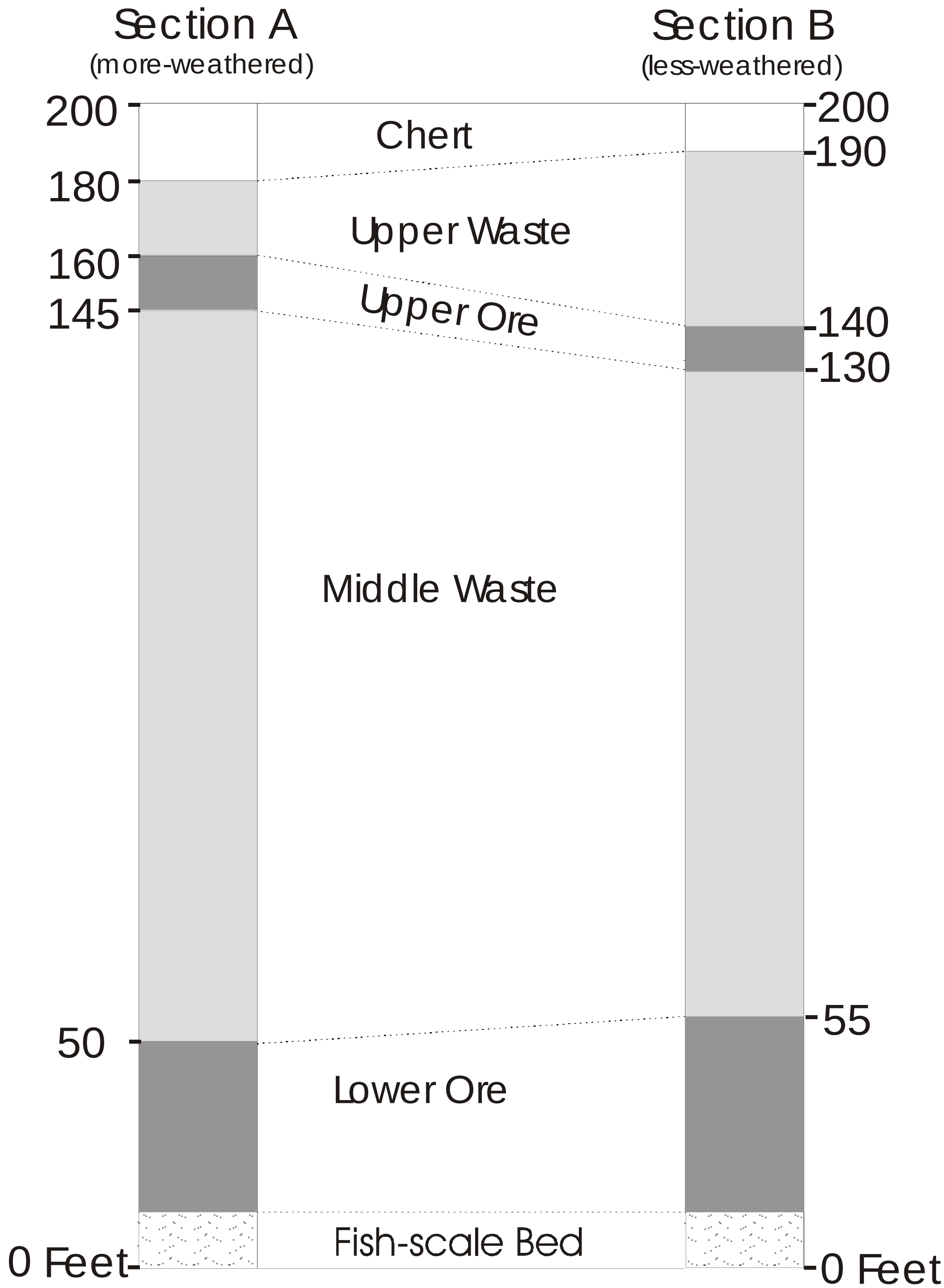



Figure 1. Simplified stratigraphic sections A and B of the Mead Peak phosphatic shale member of the Phosphoria Formation. Numbers are in feet, using the base of the Fish-scale bed as a datum. Modified from Herring and others (2001). Note the figure is not to scale.

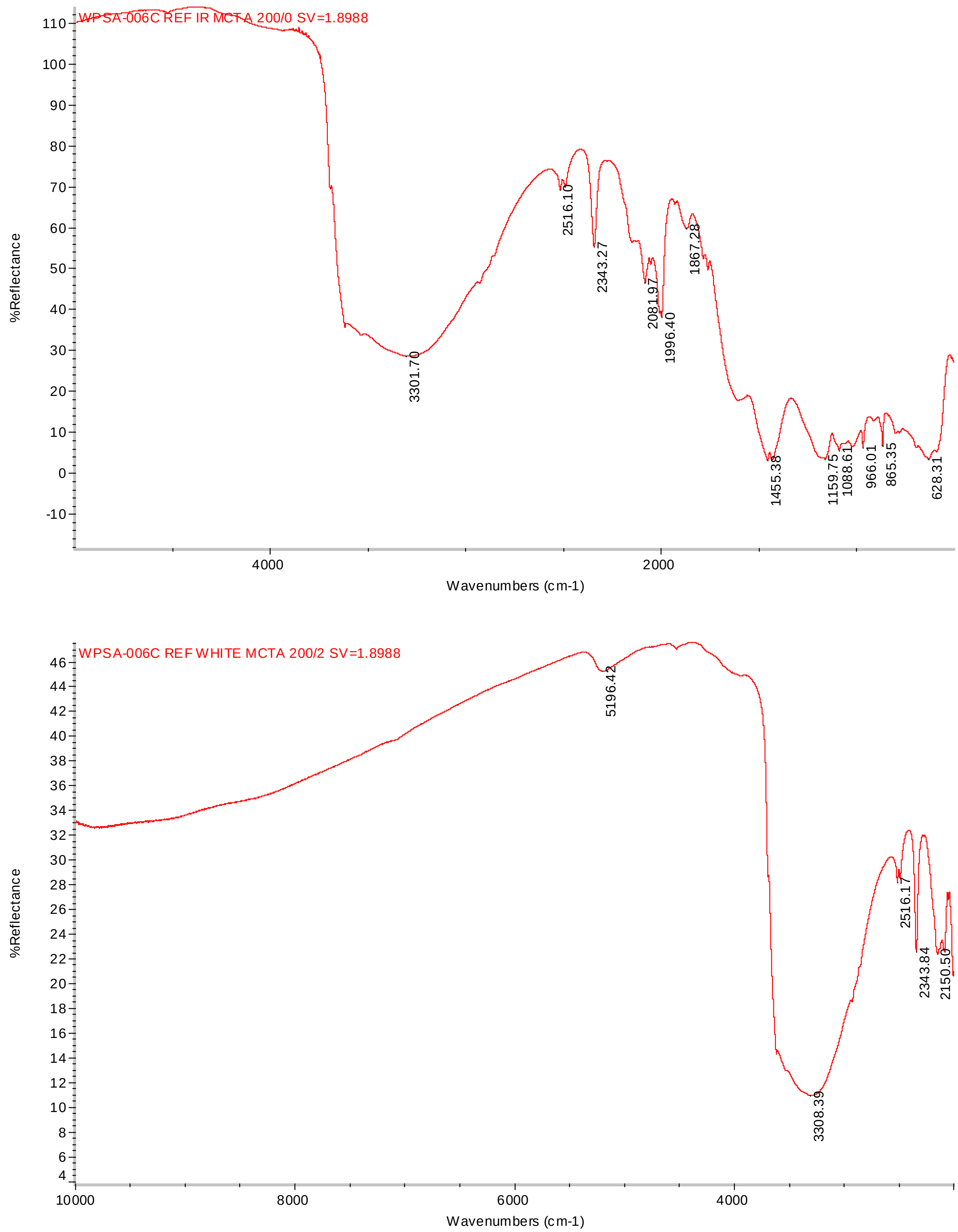
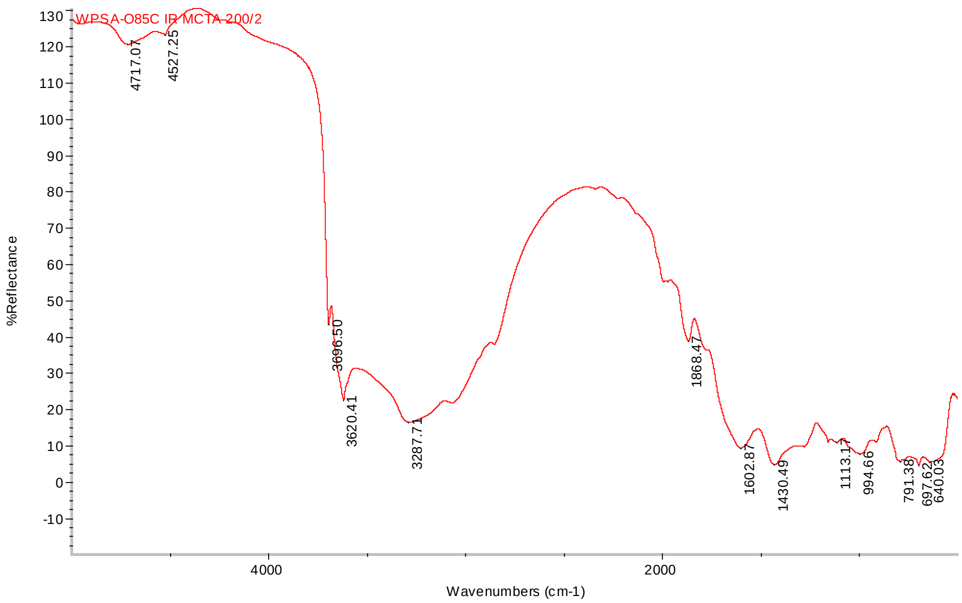



Figure 2. Mid-IR (top) and near-IR (bottom) spectra of sample wpsa006c from the lower ore zone of the more-weathered section A.



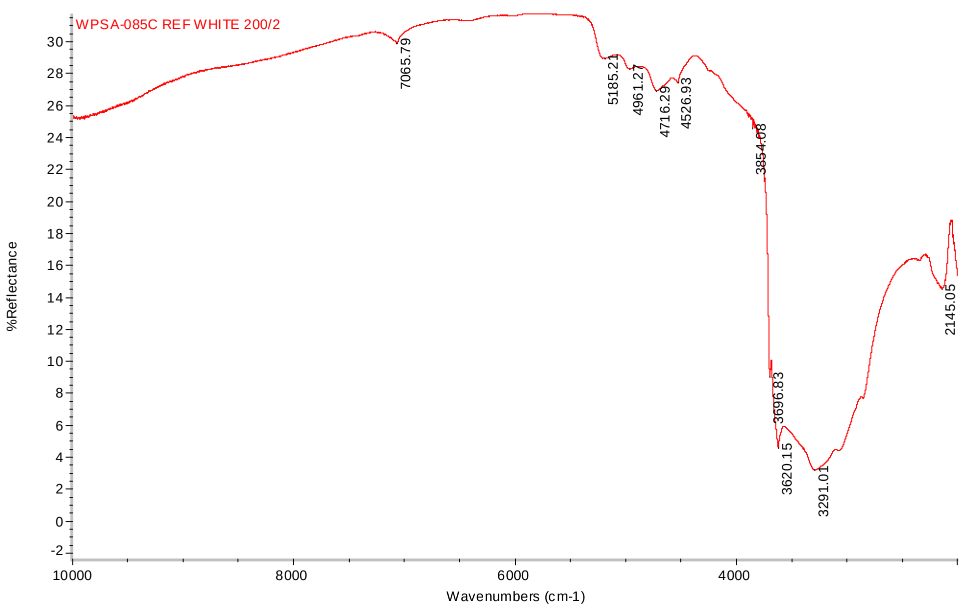
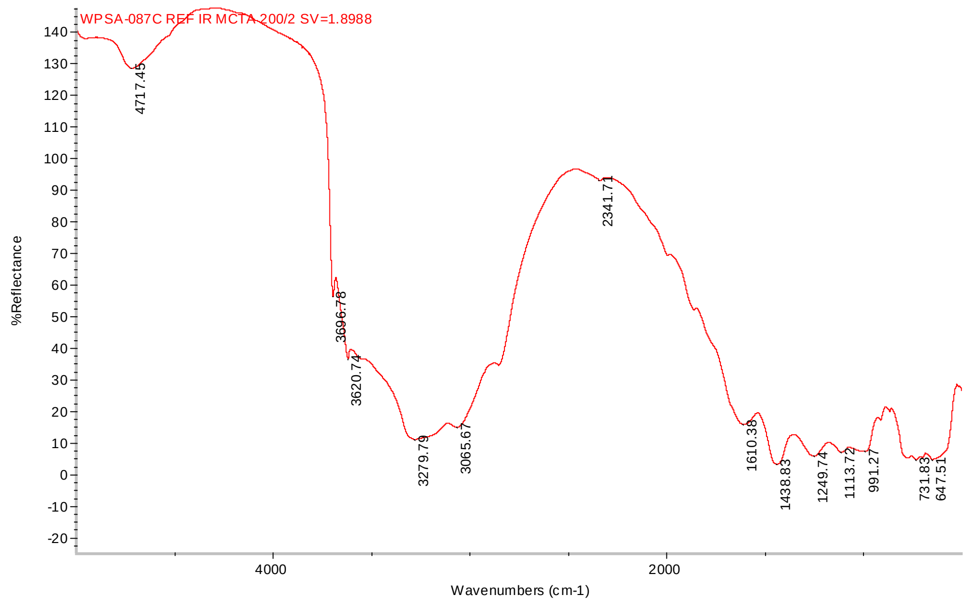




Figure 3. Mid-IR (top) and near-IR (bottom) spectra of sample wpsa085c from the middle waste zone of the more-weathered section A.



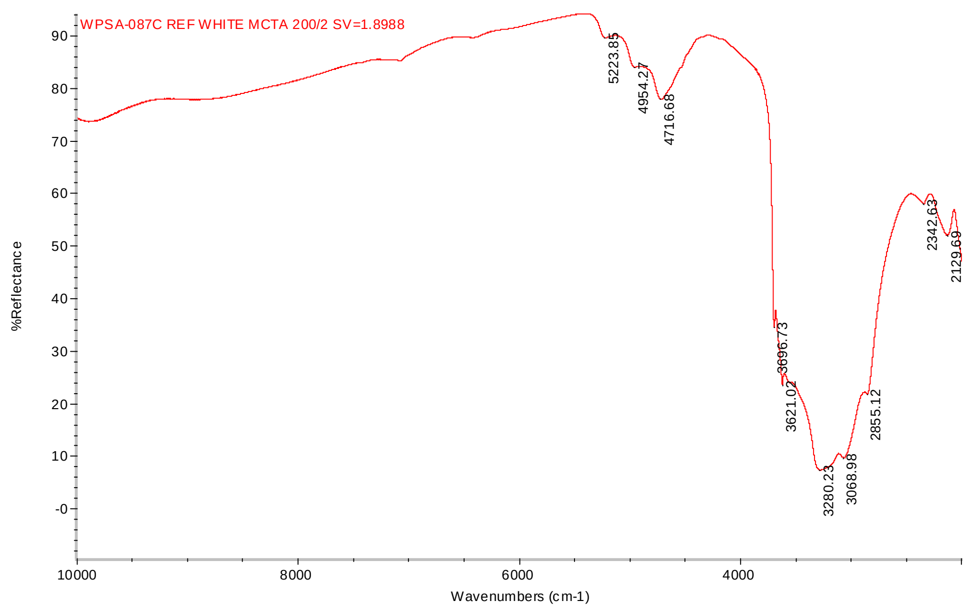
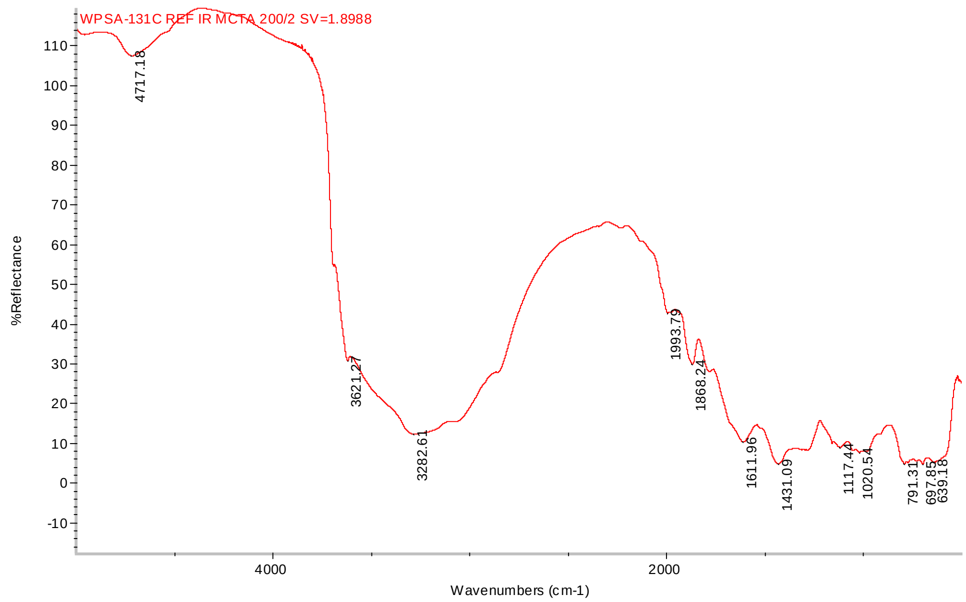




Figure 4. Mid-IR (top) and near-IR (bottom) spectra of sample wpsa087c from the middle waste zone of the more-weathered section A.



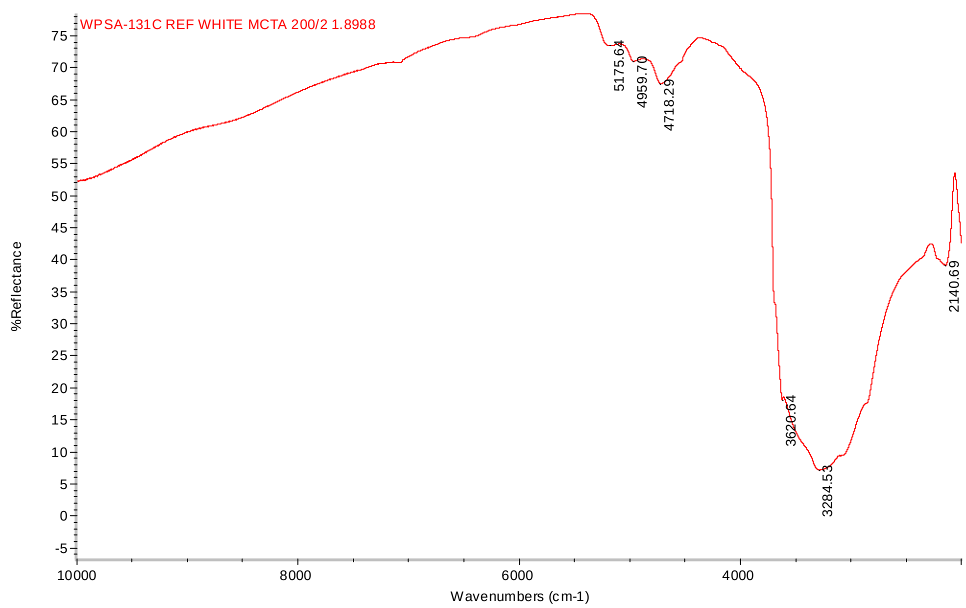
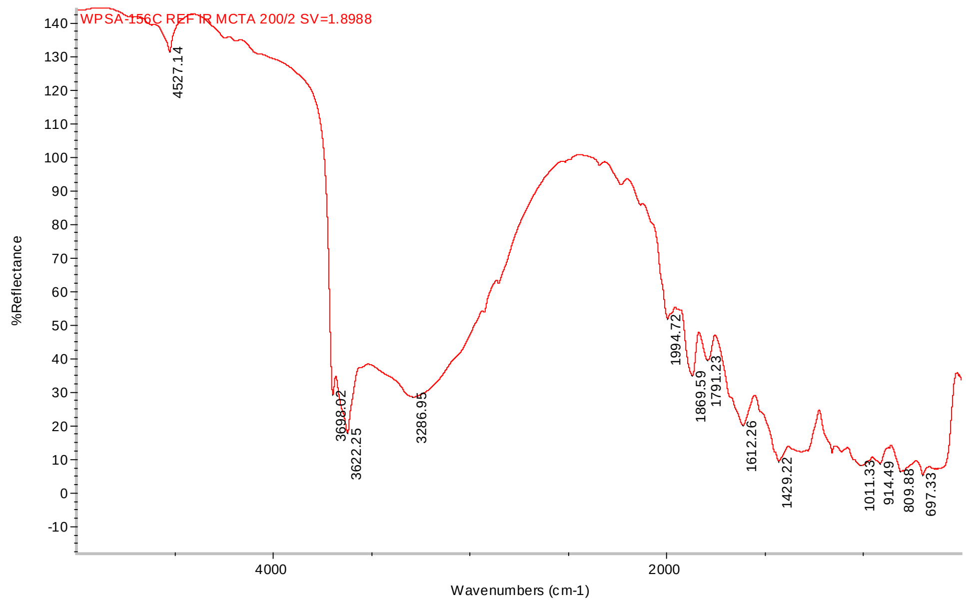




Figure 5. Mid-IR (top) and near-IR (bottom) spectra of sample wpsa131c from the middle waste zone of the more-weathered section A.



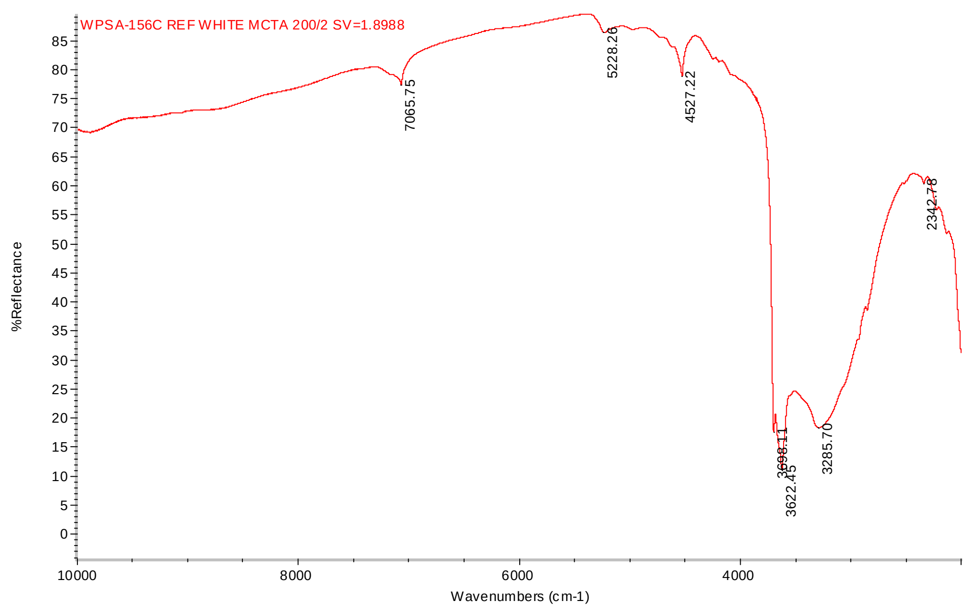
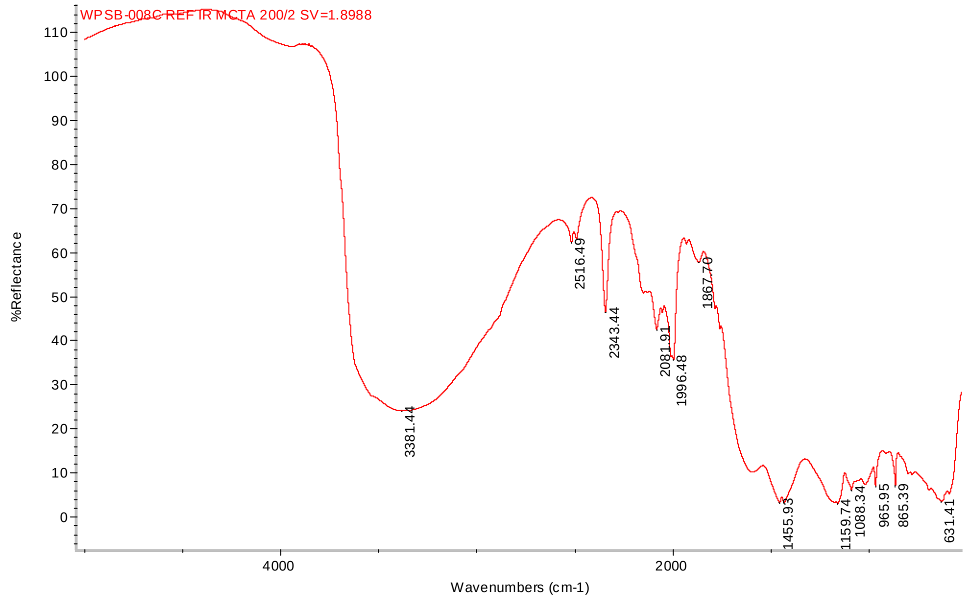




Figure 6. Mid-IR (top) and near-IR (bottom) spectra of sample wpsa156c from the upper waste zone of the more-weathered section A.



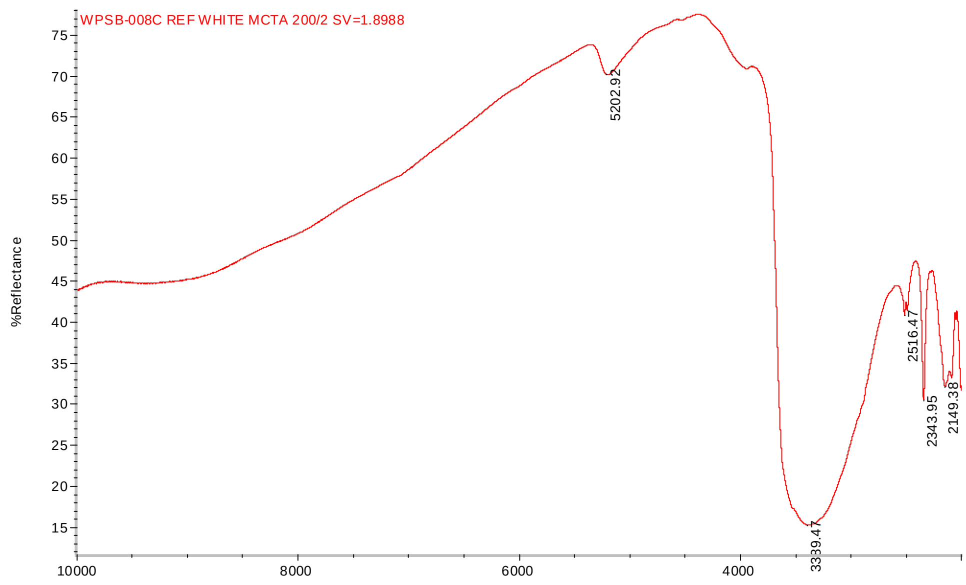




Figure 7. Mid-IR (top) and near-IR (bottom) spectra of sample wpsb008c from the lower ore zone of the less-weathered section B.

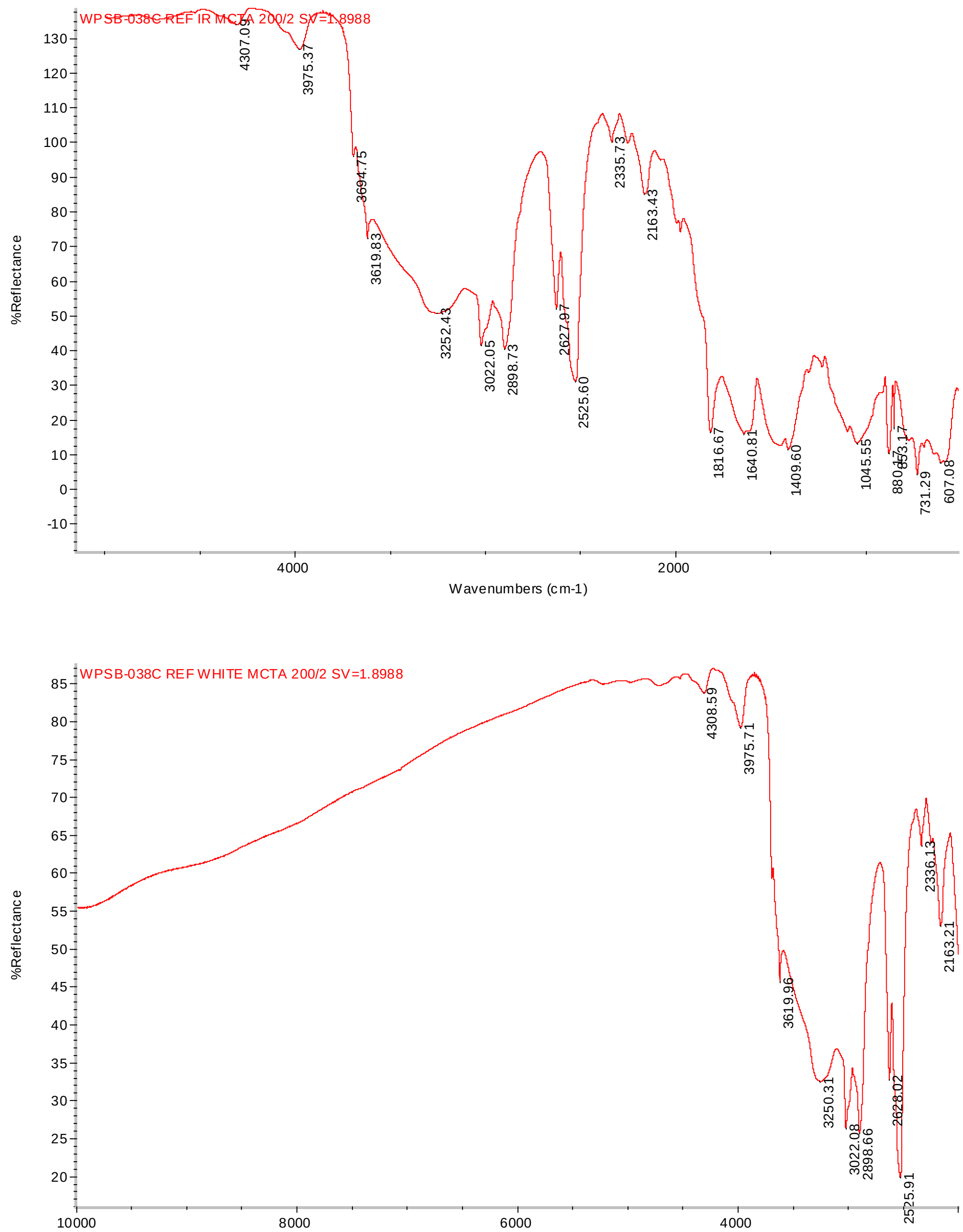
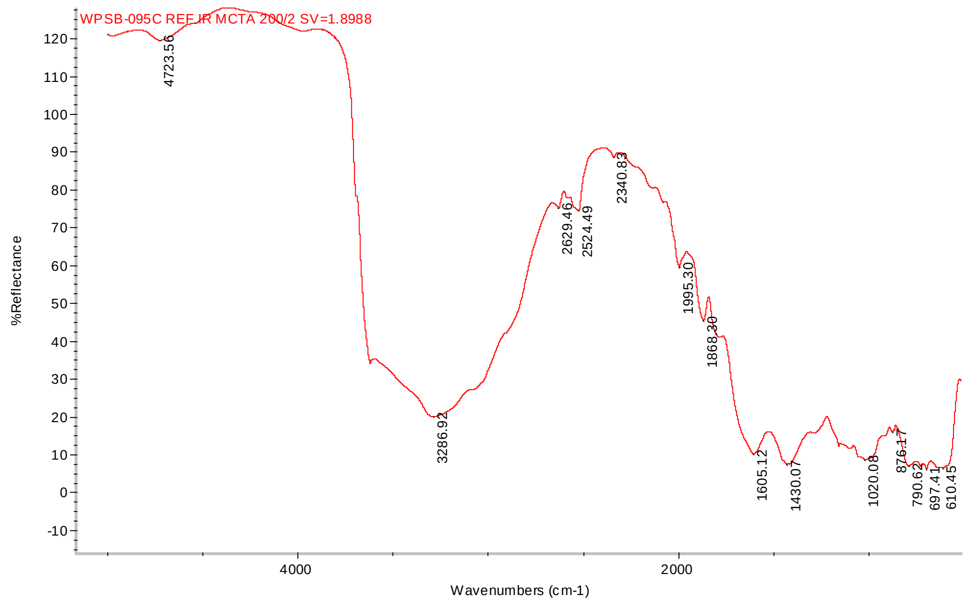



Figure 8. Mid-IR (top) and near-IR (bottom) spectra of carbonate-rich sample wpsb038c from the lower ore zone of the less-weathered section B.



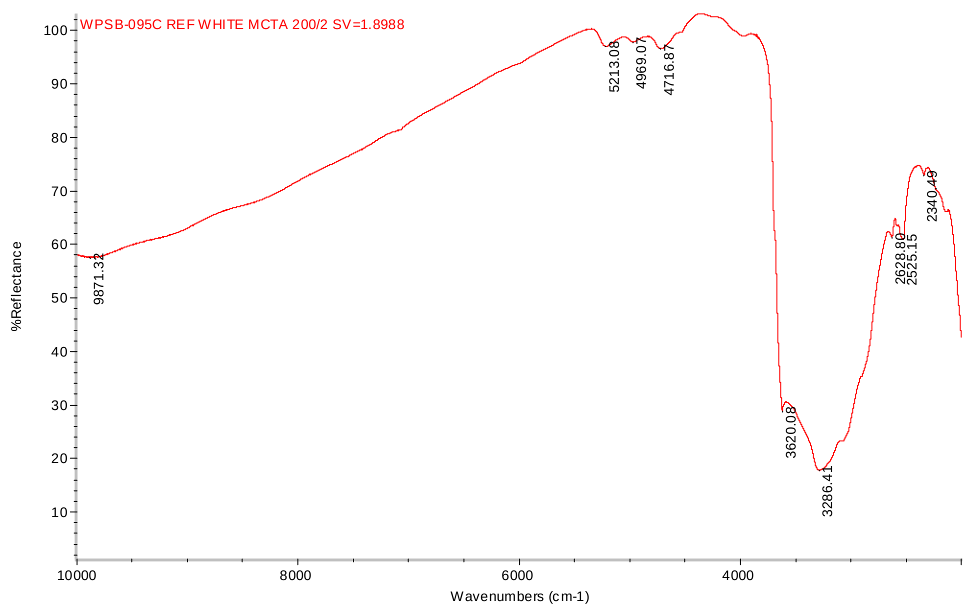
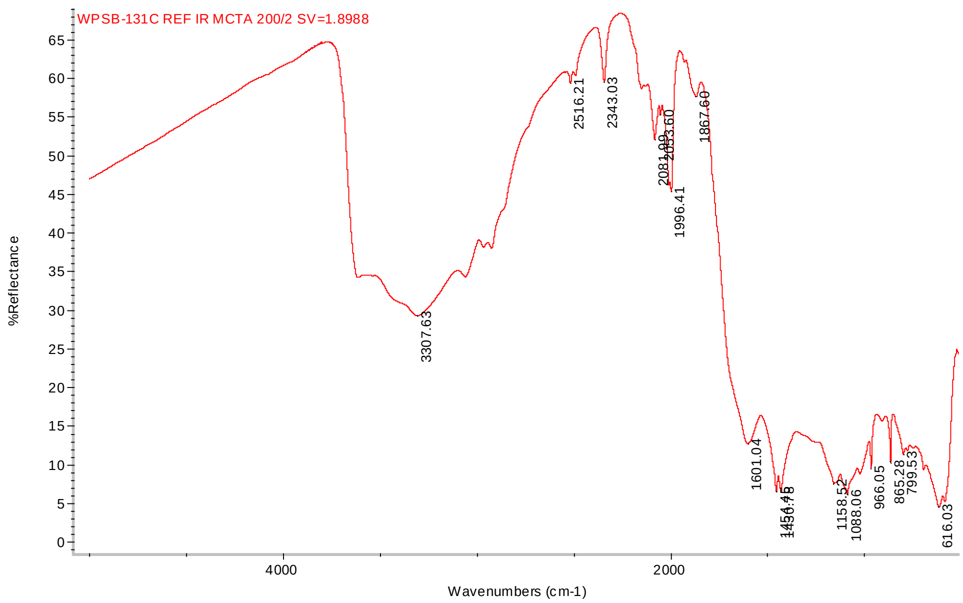




Figure 9. Mid-IR (top) and near-IR (bottom) spectra of sample wpsb095c from the middle waste zone of the less-weathered section B.



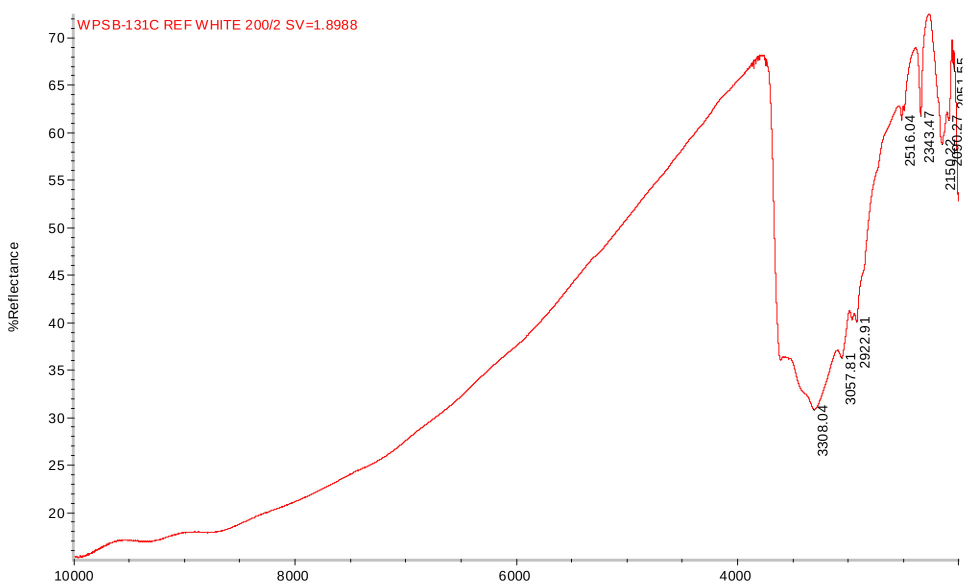
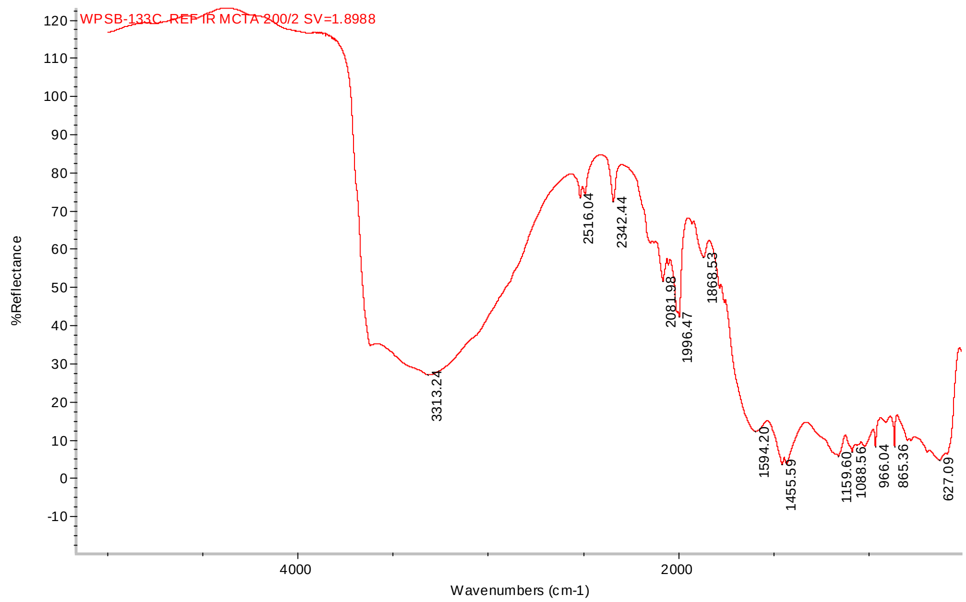




Figure 10. Mid-IR (top) and near-IR (bottom) spectra of sample wpsb131c from the upper ore zone of the less-weathered section B.



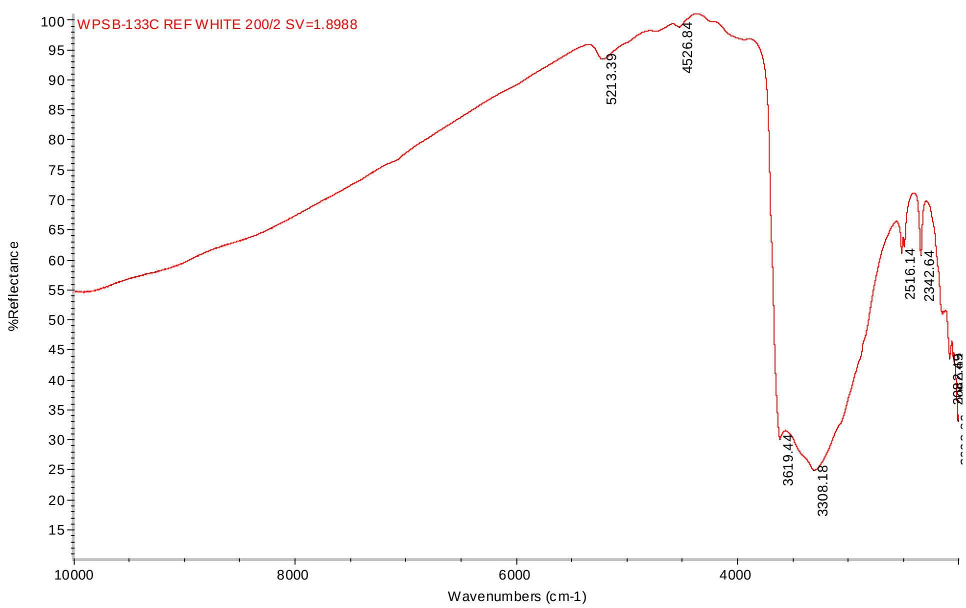




Figure 11. Mid-IR (top) and near-IR (bottom) spectra of sample wpsb133c from the upper ore zone of the less-weathered section B.

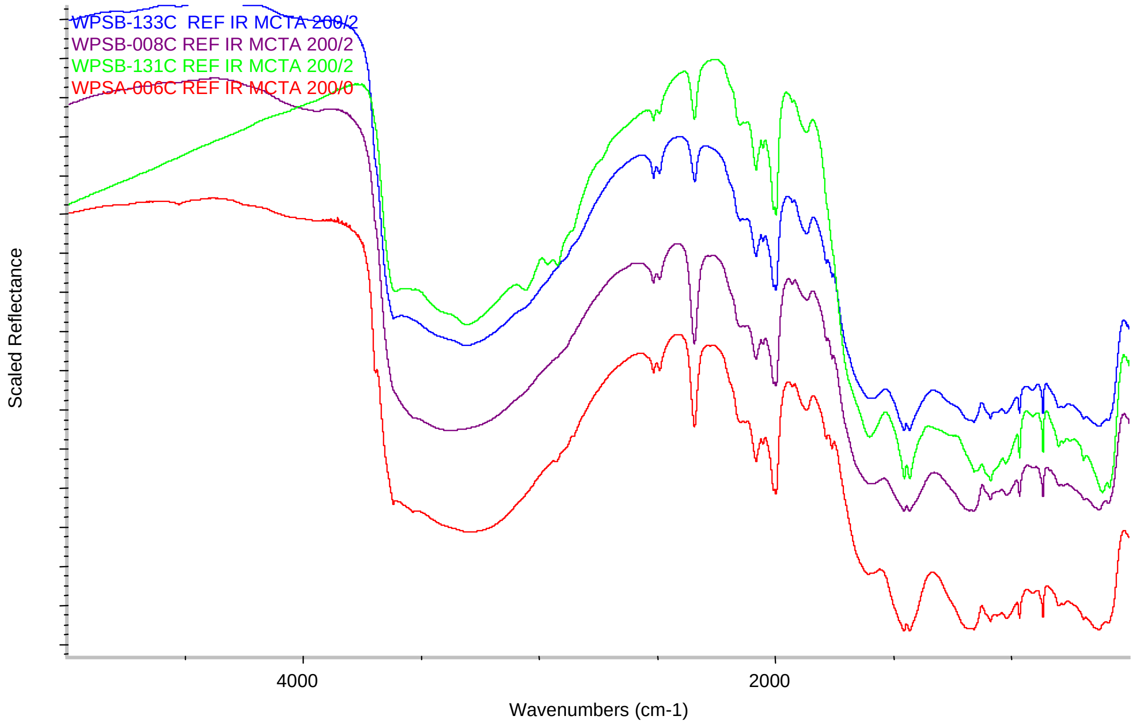



Figure 12. Stacked mid-IR spectra of ore samples. These samples are 75 to 88 percent apatite, resulting in similar spectral signatures.

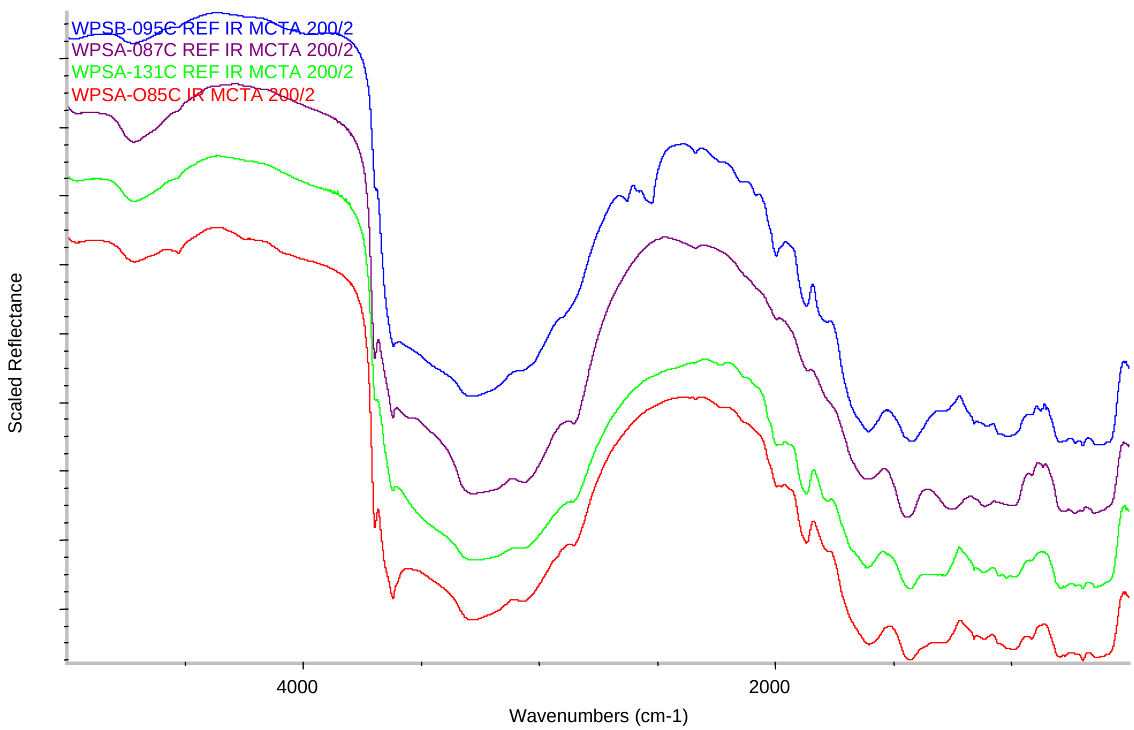



Figure 13. Stacked mid-IR spectra of middle waste samples.

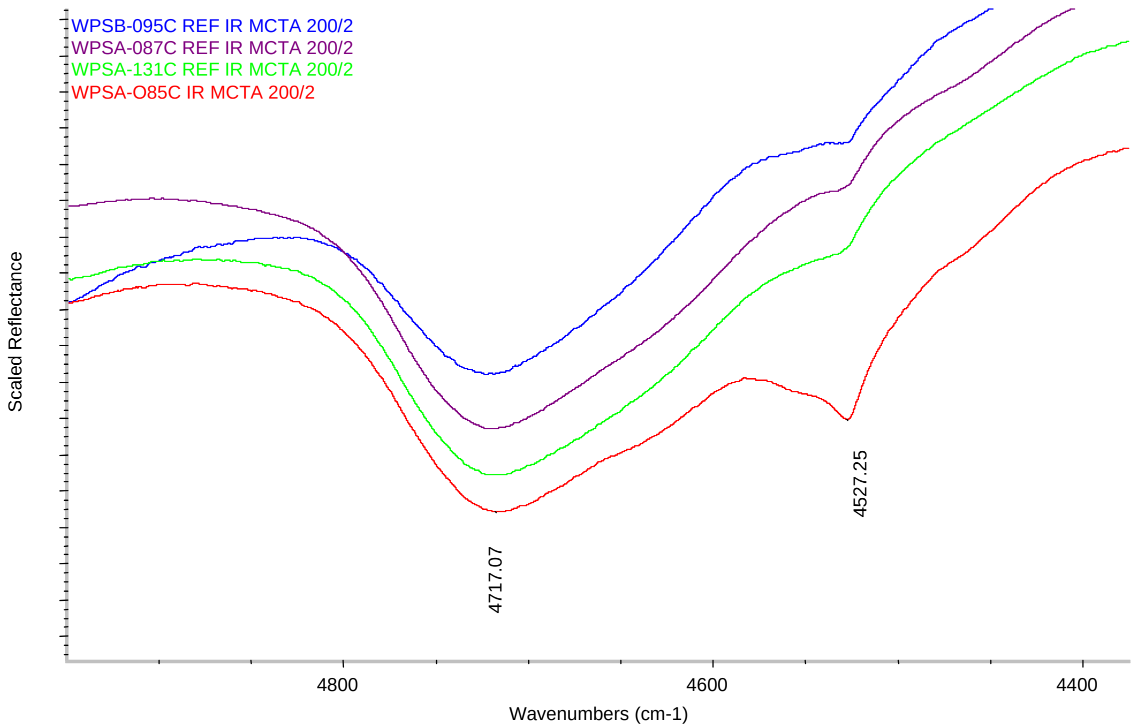



Figure 14. Stacked mid-IR spectra of middle waste samples showing the 4717cm$^{-1}$ absorption band produced by the $NH^{4+}$ ion within the buddingtonite structure. The 4527 cm$^{-1}$ feature is a clay band.

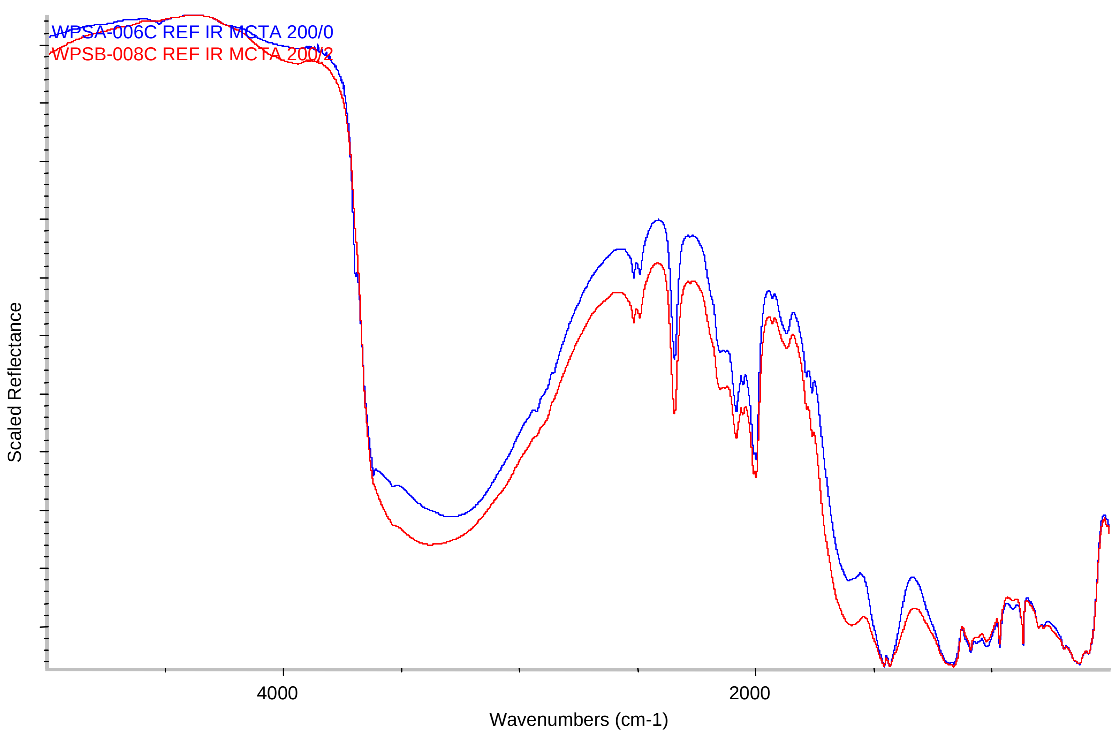



Figure 15. Mid-IR spectra of samples wpsa006c and wpsb008c from the lower ore zone. These samples were collected from essentially the same interval, but from the different sections.

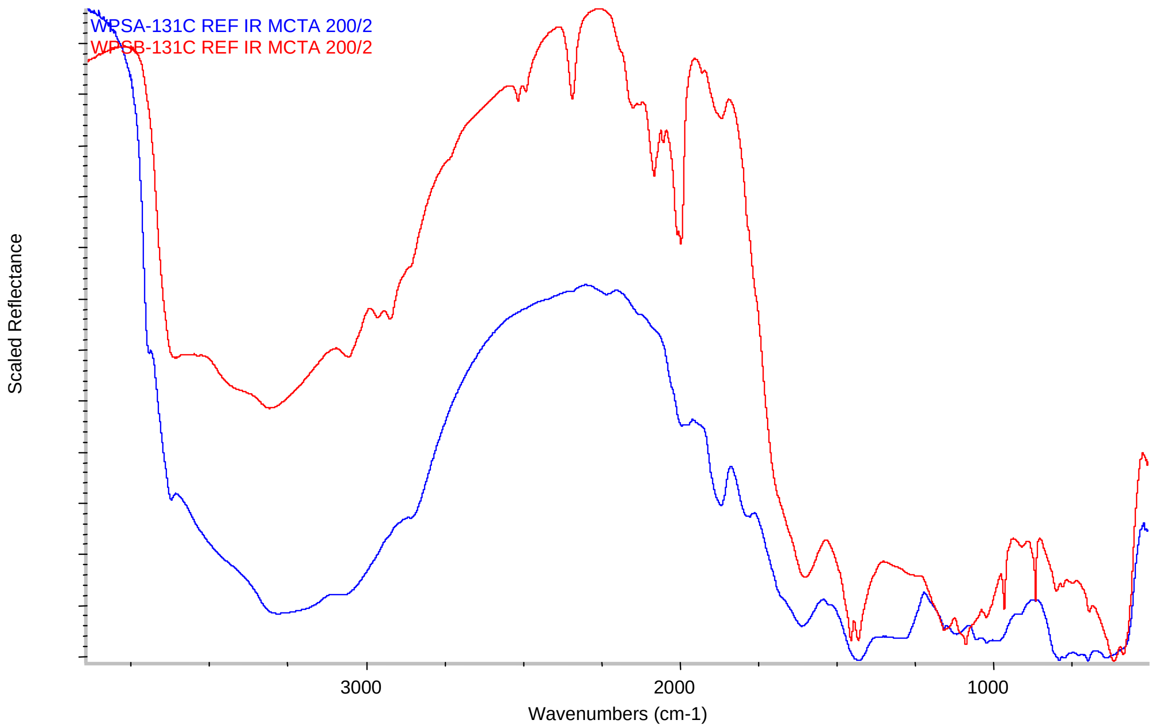



Figure 16. Mid-IR spectra of samples wpsa131c and wpsb131c. These samples were collected from essentially the same interval, but from the different sections. The different spectral signatures indicate these samples have significantly different mineralogy.

## APPENDIX 1

DRIFT absorption band positions ($cm^{-1}$) and intensities (% reflectance), at band minimums, obtained by using the Nicolet peak analysis software (OMNIC, 1999). Absorption band intensities are given as percent reflectance relative to a background reference spectra. Many of the phosphatic shale samples have very low diffuse reflectance. To measure the spectra of these dark samples, the spectrometer's aperture was opened to a maximum setting to compensate for the samples low reflectance. Due to the large aperture setting, the measured sample reflectance may exceed the background reflectance resulting in a greater than 100 percent intensity calculation.

**WPSA-006C**

| Region: | 5000-500 |
|---|---|
| Position: | Intensity: |
| 628.31 | 3.143 |
| 799.52 | 9.338 |
| 865.35 | 6.283 |
| 911.34 | 12.475 |
| 966.01 | 5.988 |
| 1021.63 | 6.104 |
| 1088.61 | 5.296 |
| 1159.75 | 3.12 |
| 1430.98 | 2.8 |
| 1455.38 | 2.754 |
| 1605.32 | 17.429 |
| 1760.35 | 49.403 |
| 1785.43 | 52.017 |
| 1867.28 | 59.493 |
| 1929.49 | 65.392 |
| 1996.4 | 37.886 |
| 2053.69 | 50.714 |
| 2081.97 | 46.215 |
| 2343.27 | 55.062 |
| 2490.77 | 69.638 |
| 2516.1 | 68.897 |
| 3301.7 | 28.258 |
| 3619.62 | 35.314 |
| 3694.21 | 69.071 |
| 3858.95 | 107.643 |

| Region: | 10000-2000 |
|---|---|
| Position: | Intensity: |
| 2054.74 | 26.674 |
| 2085.33 | 22.42 |
| 2150.5 | 22.278 |
| 2343.84 | 22.485 |
| 2490.73 | 28.382 |
| 2516.17 | 28.058 |
| 3308.39 | 10.811 |
| 3619.62 | 14.135 |
| 4526.48 | 46.975 |
| 5196.42 | 45.183 |
| 9762.08 | 32.465 |

**WPSA-O85C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 522.47 | 23.651 | 2145.05 | 14.422 |
| 640.03 | 5.095 | 3291.01 | 3.096 |
| 697.62 | 4.279 | 3620.15 | 4.474 |
| 791.38 | 5.236 | 3696.83 | 8.947 |
| 913.94 | 10.618 | 3854.08 | 24.502 |
| 994.66 | 7.373 | 4716.29 | 26.841 |
| 1113.17 | 10.453 | 7065.79 | 29.79 |
| 1158.84 | 10.484 | | |
| 1430.49 | 4.389 | | |
| 1602.87 | 8.985 | | |
| 1868.47 | 38.509 | | |
| 1973 | 54.875 | | |
| 2341.78 | 80.378 | | |
| 2854.45 | 37.515 | | |
| 3069.6 | 21.46 | | |
| 3287.71 | 16.041 | | |
| 3620.41 | 22.263 | | |
| 3696.5 | 43.08 | | |
| 4527.25 | 122.918 | | |
| 4717.07 | 120.374 | | |
| 4964.12 | 126.069 | | |

**WPSA-087C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 647.51 | 4.168 | 2041.7 | 52.861 |
| 731.83 | 4.108 | 2129.69 | 51.717 |
| 774.48 | 4.692 | 2342.63 | 57.745 |
| 865.38 | 19.447 | 2855.12 | 21.501 |
| 913.85 | 16.836 | 3068.98 | 9.378 |
| 991.27 | 6.848 | 3280.23 | 7.073 |
| 1113.72 | 6.518 | 3621.02 | 23.24 |
| 1249.74 | 5.456 | 3696.73 | 34.274 |
| 1438.83 | 2.822 | 3856.41 | 83.143 |
| 1610.38 | 15.5 | 4716.68 | 77.675 |
| 1861.38 | 51.735 | 5223.85 | 89.438 |
| 1994.25 | 68.835 | 7068.01 | 84.98 |
| 2341.71 | 92.673 | 8934.74 | 77.594 |
| 2854.83 | 34.148 | 9896.17 | 73.415 |
| 3065.67 | 14.5 | | |

**WPSA-087C continued**

| Region: | 5000-500 |
|---|---|
| Position: | Intensity: |
| 3279.79 | 10.702 |
| 3620.74 | 36.041 |
| 3696.78 | 55.938 |
| 4717.45 | 128.193 |

**WPSA-131C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 639.18 | 4.773 | 2140.69 | 38.908 |
| 697.85 | 4.312 | 3284.53 | 6.862 |
| 791.31 | 4.421 | 3620.64 | 17.816 |
| 1020.54 | 7.199 | 4718.29 | 67.239 |
| 1117.44 | 8.602 | 4959.7 | 70.818 |
| 1158.61 | 9.467 | 5175.64 | 73.258 |
| 1431.09 | 4.366 | | |
| 1611.96 | 9.907 | | |
| 1778.72 | 27.691 | | |
| 1868.24 | 29.581 | | |
| 1993.79 | 42.416 | | |
| 2236.91 | 63.807 | | |
| 3282.61 | 11.958 | | |
| 3621.27 | 30.369 | | |
| 3693.5 | 54.221 | | |
| 3857.13 | 109.117 | | |
| 4717.18 | 107.282 | | |
| 4958.94 | 112.61 | | |

**WPSA-156C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 632.35 | 6.644 | 2133.17 | 51.467 |
| 697.33 | 4.709 | 2222.51 | 55.637 |
| 809.88 | 5.841 | 2342.78 | 60.101 |
| 914.49 | 8.203 | 2854.07 | 38.3 |
| 1011.33 | 7.791 | 3285.7 | 18.037 |
| 1111.79 | 11.795 | 3622.45 | 10.75 |
| 1159.09 | 11.531 | 3698.11 | 17.327 |
| 1314.85 | 11.58 | 3856.38 | 74.7 |
| 1429.22 | 8.924 | 4527.22 | 78.628 |
| 1612.26 | 19.626 | 4974.82 | 86.762 |
| 1791.23 | 39.08 | 5228.26 | 86.194 |

**WPSA-156C continued**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 1869.59 | 34.547 | 7065.75 | 77.127 |
| 1994.72 | 51.43 | 9879.49 | 68.956 |
| 2133.67 | 85.354 | | |
| 2235.13 | 91.541 | | |
| 2341.83 | 97.137 | | |
| 2853.81 | 61.92 | | |
| 3286.95 | 28.124 | | |
| 3622.25 | 17.303 | | |
| 3698.02 | 28.812 | | |
| 4527.14 | 130.89 | | |

**WPSB-008C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 590.52 | 4.895 | 2009.36 | 31.796 |
| 631.41 | 3.155 | 2052.06 | 40.208 |
| 778.79 | 9.259 | 2090.97 | 33.009 |
| 865.39 | 6.625 | 2149.38 | 31.946 |
| 965.95 | 6.661 | 2343.95 | 30.305 |
| 1020.75 | 7.005 | 2491.43 | 41.218 |
| 1088.34 | 5.66 | 2516.47 | 40.675 |
| 1159.74 | 2.712 | 3389.47 | 15.035 |
| 1431.73 | 2.817 | 3937.16 | 70.745 |
| 1455.93 | 2.784 | 5202.92 | 70.032 |
| 1593.76 | 9.847 | 9414.98 | 44.523 |
| 1760.03 | 42.356 | | |
| 1784.87 | 46.991 | | |
| 1867.7 | 57.52 | | |
| 1929.41 | 61.646 | | |
| 1996.48 | 35.281 | | |
| 2053.68 | 46.048 | | |
| 2081.91 | 42.11 | | |
| 2148.51 | 50.484 | | |
| 2343.44 | 46.158 | | |
| 2491.14 | 62.797 | | |
| 2516.49 | 61.883 | | |
| 3381.44 | 23.708 | | |
| 3937.98 | 106.452 | | |

**WPSB-038C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 607.08 | 7.227 | 2163.21 | 52.913 |
| 696.51 | 11.637 | 2336.13 | 63.403 |
| 731.29 | 3.817 | 2525.91 | 19.644 |
| 853.17 | 17.23 | 2628.02 | 32.557 |
| 880.17 | 10.01 | 2898.66 | 25.451 |
| 1045.55 | 12.815 | 3022.08 | 26.125 |
| 1099.14 | 16.062 | 3250.31 | 32.339 |
| 1230.84 | 34.815 | 3619.96 | 45.466 |
| 1409.6 | 11.118 | 3694.4 | 59.147 |
| 1453.4 | 12.208 | 3975.71 | 79.028 |
| 1640.81 | 15.584 | 4308.59 | 83.626 |
| 1816.67 | 16.088 | 4723.92 | 84.638 |
| 1975.04 | 73.845 | | |
| 2163.43 | 84.817 | | |
| 2251.86 | 99.504 | | |
| 2335.73 | 99.75 | | |
| 2525.6 | 30.634 | | |
| 2627.97 | 51.612 | | |
| 2898.73 | 40.111 | | |
| 3022.05 | 41.17 | | |
| 3252.43 | 50.372 | | |
| 3619.83 | 72.005 | | |
| 3694.75 | 95.745 | | |
| 3975.37 | 126.524 | | |
| 4307.09 | 133.786 | | |
| 4724.53 | 135.224 | | |

**WPSB-095C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 610.45 | 6.042 | 2340.49 | 72.671 |
| 697.41 | 5.727 | 2525.15 | 60.684 |
| 730.1 | 6.487 | 2628.8 | 61.034 |
| 790.62 | 6.611 | 3286.41 | 17.458 |
| 876.17 | 15.611 | 3620.08 | 28.575 |
| 1020.08 | 8.258 | 3975.41 | 98.777 |
| 1099.62 | 11.35 | 4716.87 | 96.37 |
| 1158.86 | 11.832 | 4969.07 | 97.621 |
| 1430.07 | 7.029 | 5213.08 | 96.833 |
| 1605.12 | 9.813 | 9871.32 | 57.248 |
| 1868.3 | 45.039 | | |

**WPSB-095C continued**

| Region: | 5000-500 |
|---|---|
| Position: | Intensity: |
| 1995.3 | 59.098 |
| 2340.83 | 88.348 |
| 2524.49 | 74.204 |
| 2629.46 | 74.803 |
| 3286.92 | 19.626 |
| 3619.71 | 33.757 |
| 3969.7 | 121.723 |
| 4723.56 | 119.319 |

**WPSB-131C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 616.03 | 4.368 | 2051.55 | 67.252 |
| 799.53 | 11.159 | 2090.27 | 61.183 |
| 865.28 | 10.083 | 2150.22 | 58.632 |
| 966.05 | 9.363 | 2343.47 | 61.635 |
| 1088.06 | 5.962 | 2516.04 | 61.225 |
| 1158.52 | 7.314 | 2922.91 | 39.935 |
| 1430.78 | 6.376 | 3057.81 | 36.114 |
| 1454.45 | 6.339 | 3308.04 | 30.707 |
| 1601.04 | 12.53 | | |
| 1867.6 | 57.518 | | |
| 1996.41 | 45.216 | | |
| 2053.6 | 55.195 | | |
| 2081.99 | 51.934 | | |
| 2343.03 | 59.452 | | |
| 2516.21 | 59.272 | | |
| 2923.29 | 37.855 | | |
| 3058.14 | 34.18 | | |
| 3307.63 | 29.108 | | |

**WPSB-133C**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 627.09 | 4.316 | 2050.93 | 43.53 |
| 779.58 | 9.429 | 2082.49 | 43.274 |
| 865.36 | 7.813 | 2148.73 | 50.744 |
| 913 | 14.246 | 2342.64 | 60.494 |
| 966.04 | 7.852 | 2491.35 | 61.878 |

**WPSB-133C continued**

| Region: | 5000-500 | Region: | 10000-2000 |
|---|---|---|---|
| Position: | Intensity: | Position: | Intensity: |
| 1023.38 | 7.896 | 2516.14 | 60.907 |
| 1088.56 | 6.504 | 3308.18 | 24.677 |
| 1159.6 | 5.301 | 3619.44 | 29.801 |
| 1431.78 | 3.312 | 4526.84 | 98.643 |
| 1455.59 | 3.226 | 5213.39 | 93.263 |
| 1594.2 | 11.944 | | |
| 1785.27 | 49.362 | | |
| 1868.53 | 57.505 | | |
| 1996.47 | 41.981 | | |
| 2053.57 | 55.537 | | |
| 2081.98 | 51.2 | | |
| 2342.44 | 72.057 | | |
| 2491.24 | 74.157 | | |
| 2516.04 | 73.071 | | |
| 3313.24 | 26.757 | | |