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ELECTRON MICROPROBE MINERAL ANALYSIS GUIDE

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Prepared for
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Electron Microprobe Mineral Analysis Guide is a compilation of X-ray tables and spectra recorded from various mineral matrices. Spectra were obtained using an Applied Research Laboratories (A.R.L.) electron microprobe, model EMX-SM equipped with LiF geared, curved crystal X-ray spectrometers, utilizing typical analytical operating conditions: 15 kV acceleration potential, 0.02 micro-Ampere sample current as measured on a clinopyroxene standard (CP19). Tables and spectra are presented for the majority of elements, fluorine through uranium, occurring in mineral samples from lunar, meteoritic and terrestrial sources. Tables for each element contain relevant analytical information, i.e., analyzing crystal, X-ray peak, background and relative intensity information, X-ray interferences and a section containing notes on the measurement. Originally intended to cover silicates and oxide minerals the tables and spectra have been expanded to cover other mineral phases. Electron Microprobe Mineral Analysis Guide is intended as a "spectral base" to which additional spectra can be added as the analyst encounters new mineral matrices.
PREFACE

The object of this report is to provide a laboratory guide of X-ray spectra used in quantitative electron microprobe analysis of minerals. This compilation of X-ray spectra covers the majority of elements encountered during mineral analysis from the element fluorine (atomic number 9) through uranium (atomic number 92). Spectra were obtained from lunar, meteoritic and terrestrial mineral samples using an A.R.L. EMX-SM electron microprobe. Hopefully, this report would provide in a single source, a reasonable assessment of interference problems which confront the microprobe analyst.
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Introduction

Electron Microprobe Mineral Analysis Guide (EMMAG) is a compilation of X-ray tables and spectra recorded from various mineral matrices. The Guide provides for each element complete documentation of the spectrum in the area of the selected peak and records optimum positions in the X-ray continuum for the measurement of background, and lists interferences, with both peak and background measurements, that may be encountered in mineral analysis.

Initially EMMAG was directed toward silicate and/or oxide mineral analysis and the X-ray lines listed in each table reflect both this and the emphasis of our work which at that time was primarily on lunar samples. To make the guide more general, other mineral matrices have been added as analytical problems arose. Deciding which X-ray lines to include is difficult, at times subjective, and very much dependent on my knowledge of mineral matrices and on the accuracy of the intensity information listed in "X-ray Emission and Absorption Edge Wavelengths and Interchange Settings for LiF Geared Curved Crystal Spectrometer" by E.W. White and G.G. Johnson, Jr., 2nd edition. All of the X-ray line information, i.e., wavelength, KeV, order of reflection (N), intensity (I), etc. is derived from this source. There are bound to be errors of omission in striving to list only the X-ray lines one is most likely to encounter. EMMAG is a guide to X-ray interference and background problems. In laboratory usage it is best kept in a looseleaf notebook and supplemented as one encounters new problems and matrices during the course of microprobe analysis. EMMAG is in part a condensation of
X-ray wavelength information contained in the White and Johnson, Jr. listing: between the ±Δ Bkg for Si_{Ka1,2} are listed 156 x-ray lines - EMMAG lists only 9. The 9 X-ray lines selected are believed to be those most likely to cause problems during mineral analysis.

Tables

X-ray tables are listed by atomic number, i.e., information for fluorine is listed in Table 9. In this manner other elements can be added without disrupting the order of the guide. Each table is divided into four sections. The first section gives the X-ray line information for the element: analytical line \((K_{a1,2}, L_{a1}, M_{a})\), analyzing crystal \((\text{LiF, ADP, PET, RbAP})\), spectrometer setting for a given crystal, and background setting used in this laboratory. The next section, Elemental Scans, lists the minerals for which spectra have been recorded for the particular X-ray line, the wt. % of the element or oxide in the mineral and the background setting which may vary depending on the mineral matrix. The third section, Interferences, lists X-ray lines which occur within the ±Δ Bkg limits of the analysed line, the reflection order \((N)\), the intensity relative to the strongest line (the unresolved \(K_{a2}\)), the spectrometer odrometer setting for the analyzing crystal, and the energy \((\text{KeV})\) of the X-ray line. The spectrometers are the LiF geared type, i.e., with a LiF crystal in use the odometer reads directly in angstroms. Other analyzing crystals indicate an interchange value. The fourth section, Notes, contains comments pertaining to the interferences which occur and how to deal with them plus additional information pertinent to the analytical problem. Typically the use of a Pulse Height Analyzer (PHA) is discussed, the PHA being the main form of electronic pulse discrimination used with proportional X-ray counters.
Spectral Scans

The X-ray scans are an important part of the guide because they give relative intensities, position, and crystal line broadening effects of X-ray lines derived from various mineral matrices. Each scan was recorded on an A.R.L. EMX-SM electron microprobe in the Geochemistry Branch of the Planetary and Earth Sciences Division, Johnson Space Center. The microprobe has a 52.5° X-ray take-off angle and was operated with an acceleration potential of 15 KV and sample current of 0.02 microamperes measured on a clinopyroxene standard (CP19). Crystal spectrometers have a receiver slit width of 0.015" as measured with a feeler gage. Each scan was obtained by motor driving the crystal spectrometer at a speed of 0.02Å/min. synchronously with a Texas Instruments Servo/riter II recorder driven at 1"/min. Recorder output is then 0.02Å/inch of chart paper. Full scale intensity is either 300 or 100 cps as labeled. Due to low values for full scale intensity major X-ray peaks are typically off scale and therefore the associated peak position is not accurately determined. More important than accurate peak position is the relative position of the minor X-ray peaks, the extent of major peak tailing and the slope of the X-ray continuum which together provide information on the interferences present as well as optimum background positions. Each scan is labeled with element symbol, mineral matrix scanned, analyzing crystal utilized, counts per second (cps) full scale deflection and wt. % of element or oxide present in the sample.
Historical Note

Originally X-ray tables and spectra were produced for our laboratory use only; later on I thought they might be of interest to a wider audience. Because the initial intent of production was limited (1 copy) and the data collection time period (approximately nine years), some inconsistencies were propagated. Most notable among these is the use of subscripts. Therefore, let the reader be advised that $K_a 1,2$ and $K_a 1,2$ are the same X-ray line. Other inconsistencies and/or outright errors which may exist are not intentional and are solely the responsibility of the author.

Acknowledgments

I would like to thank those NASA staff scientists and visiting scientists to the Johnson Space Center who encouraged me to formalize the guide book and have it printed for circulation. I would also like to thank "LEMSCO", Lockheed Engineering and Management Services Co., Inc., for granting me the time to work on the project and Lina Romero for doing all the typing of tables and labels without complaint.
TABLE 9

ELEMENT: F
ANALYTICAL LINE: $K_{\alpha}$
CRYSTAL: RbAP
SPECTROMETER SETTING: 2.8241
BACKGROUND SETTING: ±0.063

ELEMENTAL SCANS:

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>WT. %</th>
<th>BACKGROUND SETTING</th>
</tr>
</thead>
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<tr>
<td>Topaz</td>
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INTERFERENCES:

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<th>N</th>
<th>I</th>
<th>RbAP (100)</th>
<th>KeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>P $K_{\alpha}^6$</td>
<td>3</td>
<td>.01</td>
<td>2.8040</td>
<td>2.04</td>
</tr>
<tr>
<td>F $K_{\alpha}''$</td>
<td>1</td>
<td>30</td>
<td>2.8056</td>
<td>0.58</td>
</tr>
<tr>
<td>F $K_{\alpha}'$</td>
<td>1</td>
<td>35</td>
<td>2.8086</td>
<td>0.68</td>
</tr>
<tr>
<td>P $K_{\alpha}^5$</td>
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<td>.01</td>
<td>2.8095</td>
<td>2.04</td>
</tr>
<tr>
<td>Co $L_1$</td>
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<td>9</td>
<td>2.8197</td>
<td>0.68</td>
</tr>
<tr>
<td>F $K_{\alpha}$</td>
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<td>100</td>
<td>2.8241</td>
<td>0.68</td>
</tr>
<tr>
<td>P $K_{\alpha}^4$</td>
<td>3</td>
<td>5</td>
<td>2.8251</td>
<td>2.03</td>
</tr>
<tr>
<td>P $K_{\alpha}^3$</td>
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<td>5</td>
<td>2.8287</td>
<td>2.03</td>
</tr>
<tr>
<td>Ce $M_2$</td>
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<td>2.8353</td>
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<tr>
<td>P $K_{\alpha}1,2$</td>
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<tr>
<td>Ca $K_{\alpha}1,3$</td>
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<td>15</td>
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</tr>
<tr>
<td>Dy $M_6$</td>
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<td>45</td>
<td>2.8848</td>
<td>1.33</td>
</tr>
</tbody>
</table>

NOTES: Fluorine is typically of interest in apatites, mica and topaz. Interferences are P and Ca, both major constituents of apatites. Both are higher order X-ray lines and a PHA can be used effectively to discriminate against them. From experience with topaz analysis, it is extremely important to match the standard and sample matrix as closely as possible due to uncertainties in the absorption correction.
## TABLE 11

<table>
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<tr>
<th>ELEMENT:</th>
<th>Na</th>
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<tr>
<td>ANALYTICAL LINE</td>
<td>Ka(^1,2)</td>
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<td>CRYSTAL:</td>
<td>RbAP</td>
</tr>
<tr>
<td>SPECTROMETER SETTING:</td>
<td>1.8360</td>
</tr>
<tr>
<td>BACKGROUND SETTING:</td>
<td>±0.062</td>
</tr>
</tbody>
</table>

### ELEMENTAL SCANS:

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>WT. % OXIDE</th>
<th>BACKGROUND SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligoclase</td>
<td>8.68</td>
<td>±0.062</td>
</tr>
<tr>
<td>Kaersutite</td>
<td>2.80</td>
<td>±0.062</td>
</tr>
<tr>
<td>Apatite</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Zirconium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
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</tr>
</tbody>
</table>

### INTERFERENCE:

<table>
<thead>
<tr>
<th>LINE</th>
<th>N</th>
<th>I</th>
<th>RbAP</th>
<th>KeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>P Ka(^3)</td>
<td>2</td>
<td>3</td>
<td>1.7869</td>
<td>2.139</td>
</tr>
<tr>
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<td>1.7893</td>
<td>2.136</td>
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<td>Fe Ka(^1,2)</td>
<td>6</td>
<td>150</td>
<td>1.7919</td>
<td>6.398</td>
</tr>
<tr>
<td>Zr L(^\epsilon)</td>
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<td>45</td>
<td>1.7993</td>
<td>2.124</td>
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<td>Na SKa(^6)</td>
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<td>1</td>
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<td>1.061</td>
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<td>Na SKa(^5)</td>
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<td>1.80f(^1)</td>
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<td>10</td>
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<td>Zn L(^\epsilon)</td>
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<td>26</td>
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<tr>
<td>LINE</td>
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<td>I</td>
<td>RbAP (100)</td>
<td>KeV</td>
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<td>------------</td>
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<tr>
<td>Ba Lβ2,15</td>
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<td>5.156</td>
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<td>Cu Lβ3,4</td>
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<td>1</td>
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<tr>
<td>Zr La1</td>
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<td>100</td>
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<td>2.042</td>
</tr>
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<td>P SKα4</td>
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<td>5</td>
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</tr>
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<td>P SKα3</td>
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<td>1.8858</td>
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</tr>
<tr>
<td>Zn La1,2</td>
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<td>100</td>
<td>1.8890</td>
<td>1.012</td>
</tr>
<tr>
<td>P Ka1,2</td>
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<td>150</td>
<td>1.8985</td>
<td>2.013</td>
</tr>
<tr>
<td>Ca KB1,3</td>
<td>4</td>
<td>15</td>
<td>1.9051</td>
<td>4.012</td>
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</tbody>
</table>

NOTES: Minerals with high P concentrations might cause high background counts.

Interference with Na Ka1,2 peak measurements could occur in a Zn matrix (Zn Lβ1). Energies of the Zn Lβ1 (1.03 KeV) and Na Ka1,2 (1.04 KeV) peaks are essentially identical and not separable by PHA methods.

Background measurements can be difficult in a high P matrix (PKa1,2 2nd order line) but P line should be excluded with use of PHA window.

A very high Fe concentration matrix could conceivably cause a problem but could also be discriminated against with use of a PHA window. Zr has two X-ray peaks (Zr La1, Zr Lβ1) in this region — both should be excluded by PHA methods. Au Ma1,2 also occurs in this region but is commonly not a problem.
Na oligoclase
RbAP 300 cps.
Na₂O 8.68 wt. %
Na kaersutite
RRAP 300 cps.
Na$_2$O 2.80 wt. %
FeO 11.87 wt. %
Na Zirconium (99.9)
RbAP 300 cps.
Na  Zinc (99.9)
RbAP  300 cps.
### TABLE 12

**ELEMENT:** Mg

**ANALYTICAL LINE:** Ka1,2

**CRYSTAL:** RbAP

**SPECTROMETER SETTING:** 1.5246

**BACKGROUND SETTING:** ±0.093

**ELEMENTAL SCANS:**

<table>
<thead>
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<th>MINERAL</th>
<th>WT. % OXIDE</th>
<th>BACKGROUND SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olivine, Marjalahti</td>
<td>47.42</td>
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</tr>
<tr>
<td>Lake Co. plagioclase</td>
<td>~600 ppm</td>
<td></td>
</tr>
<tr>
<td>Kaersutite</td>
<td>11.36</td>
<td>±0.093</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>9.77</td>
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<tr>
<td>Chromite</td>
<td>8.09</td>
<td>±0.093</td>
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**INTERFERENCES:**

<table>
<thead>
<tr>
<th>LINE</th>
<th>N</th>
<th>I</th>
<th>RbAP (100)</th>
<th>KeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cr Ka1,2</td>
<td>4</td>
<td>150</td>
<td>1.4126</td>
<td>5.411</td>
</tr>
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<td>Ca Ka1,3</td>
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<td>Ba La2,15</td>
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<td>20</td>
<td>1.4825</td>
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</tr>
<tr>
<td>Fe Ka1,2</td>
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<td>6.398</td>
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<tr>
<td>Co Kα1,3</td>
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<tr>
<td>LINE</td>
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</tr>
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<td>Ni</td>
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NOTES: Problems with Mg measurement might occur with a high Ca, Ni or V matrix. All 3 lines are on the high angle side of the Mg\(_{kal,2}\) peak. Ni\(_{kal,2}\) sixth and V\(_{kal,2}\) fourth are closest to the Mg peak but do not occur in sufficient concentration in a typical silicate matrix to be a problem, however, their energies are sufficiently different from the Mg line so that they could be discriminated against with a PHA. A more common problem is a high Ca matrix (plagioclase). Fortunately the most intense Ca line (Ca\(_{kal,2}\)) can also be removed with a PHA. (See scan labeled Lake Co. Plagioclase.) In choosing a background delta value, consideration should be given to the presence of numerous possible X-ray lines occurring in the Mg\(_{kal,2}\) region.
Mg Lake Co. Plagioclase
RbAp 300 cps.
MgO ~0.09 wt. %

Scan with PHA window (ΔE) set.

Ca Kα1,2 = 3.69 KeV
Mg Kα1,2 = 1.25 KeV

Scan without PHA window.

E = 1.30
ΔE = 1.90
ALUMINUM
TABLE 13

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<tr>
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<td>ELEMENTAL SCANS:</td>
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<table>
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<td>(ADP)</td>
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<td>Al-Fe Spinel</td>
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<td>Armalcolite</td>
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NOTES: Measurement of $\text{Al}_{\text{K}a1,2}$ can be difficult due to the numerous peaks occurring in the region of the Al peak. Only one X-ray line ($\text{Cr}_{\text{K}a1,2}$) interferes directly with the peak measurement and it can be excluded with a PHA window.

Ti$\text{K}a1,2$ can also interfere with an Al determination, due to its close proximity to the Al peak (see ilmenite scan). Fortunately a PHA window can also be used to minimize the Ti peak. Other elements occur in sufficiently low concentration in typical silicate matrices and also are high order lines and therefore less likely to present a problem.
Al  ilmenite
RbAP  300 cps.
Al$_2$O$_3$  0.26 wt. %
Al kaersutite
ADP 300 cps.
Al$_2$O$_3$ 14.69 wt. %
Al bytownite
ADP 300 cps.
Al$_2$O$_3$ 32.05 wt. %
Al chromite
ADP 300 cps.
$\text{Al}_2\text{O}_3$ 12.77 wt. %
Al armalcolite
ADP 300 cps.
Al₂O₃ 1.28 wt. %
TABLE 14

ELEMENT: Si

ANALYTICAL LINE: Kα1,2

CRYSTAL: ADP

SPECTROMETER SETTING: 2.6969

BACKGROUND SETTING: ±0.060

ELEMENTAL SCANS:

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NOTE: No interference with peak measurement in typical silicate matrix. Avoid FeKα1,3 peak when choosing background positions.
SI clino.pyroxene (CP19)
ADP 300 cps.
SiO$_2$ 48.39 wt.

Fe$_{eq}$/FeO: 2.66
2.64
2.62
2.60
2.58

SiKα1.2
Si  Fe
ADP 300 cps.
Fe 99.9 wt.%
Si clinopyroxene (CP19)
PET 300 cps.
SiO₂ 48.39 wt. %
TABLE 19

ELEMENT: K

ANALYTICAL LINE: Ka1,2

CRYSTAL: ADP, PET

SPECTROMETER SETTING: 1.4163(ADP); 1.7238(PET)

BACKGROUND SETTING: ±0.070

ELEMENTAL SCANS:

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INTERFERENCES:

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NOTES: By using a background setting of ±0.070 the possible background interference from Mn Kβ1,3 and Fe Ka1,2 should be avoided. (See scans.)
PHOSPHORUS
### TABLE 15

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**ANALYTICAL LINE:** Ka\(_{1,2}\)  
**CRYSTAL:** PET  
**SPECTROMETER SETTING:** 2.8364  
**BACKGROUND SETTING:** ±0.060  

**ELEMENTAL SCANS:**

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<td>Schreibersite</td>
<td>≈15.5 % P</td>
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**NOTES:** The Ca\(_{Kβ1,3}\) interferes with the P\(_{Kα1,2}\) measurement, however, it does not usually present a problem in silicate analysis because the Ca line is a 2nd order line and requires ≈20.0 wt. % CaO concentration before the line is observed (see diopside scan). Therefore, Ca would typically only be a problem in minerals such as apatite or a high Ca glass. Where it is a problem it can be discriminated against with a properly set PHA window.
P apatite
PET 300 cps.
P₂O₅ 41.29 wt. %
schreibersite
PET 300 cps.
P = 15.5 wt. %
P diopside
PET 100 cps.
CaO 24.7 wt. %
SULFUR
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**NOTES:** Sulfur appears to be a difficult element to analyze for depending on the mineral matrix. Of particular importance are PbM3, PbM2, GaKα1,2, CsLα1, CoKα1,2, IrL1, MoLα1 and TlMα1. Of these, Pb, Mo and Tl are first order X-ray lines of almost identical energy as S_Kα1,2 (2.31 KeV) and therefore not separable from sulfur with a PHA. Other interfering lines can be discriminated against with a PHA.
S trillite
ADP 100 cps.
S 36.47 wt. %
S  Co 99.9
ADP 300 cps.
TABLE 17

**ELEMENT:** Ce  
**ANALYTICAL LINE:** Ka1,2  
**CRYSTAL:** PET  
**SPECTROMETER SETTING:** PET 2.1781  
**BACKGROUND SETTING:** ±0.030  

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**NOTES:** Ck is commonly found in sodalite, apatite and scapolite associated with REE, Sr, Th, As, V and F. Of these elements the REE could create most of the interference problems but they commonly occur in sufficiently low concentrations so as not to interfere with the Ck determination. All but the Nb L$_{62,3}$ line could be discriminated against with a PHA window.
Cl scapolite
PET 300 cps.
Cl 2.19 wt. %
POTASSIUM
K kaersutite
ADP 300 cps.
K$_2$O 1.59 wt. %
K kaersutite
PET 300 cps.
$K_2O$ 1.59 wt. %
CALCIUM
TABLE 20

ELEMENT: Ca

ANALYTICAL LINE: Kα1,2

SPECTROMETER SETTING: 1.2714(ADP); 3.3595(LiF); 1.5474(PET)

BACKGROUND SETTING: ±0.046(ADP); ±0.052(LiF); ±0.034(PET)

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<tr>
<td>Ni Kα1,2</td>
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<td>Nb Kβ3</td>
<td>5</td>
<td>7</td>
<td>1.2608</td>
<td>3.3317</td>
<td>1.5346</td>
<td>18.6J</td>
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<tr>
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<td>01</td>
<td>1.2619</td>
<td>3.3346</td>
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</tr>
<tr>
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<td>2</td>
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<td>1.5370</td>
<td>3.72</td>
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<tr>
<td>Ca SKa3</td>
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<td>2</td>
<td>1.2640</td>
<td>3.3401</td>
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<td>Po Lα1</td>
<td>3</td>
<td>100</td>
<td>1.2646</td>
<td>3.3416</td>
<td>1.5391</td>
<td>11.13</td>
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<td>Yb Lα1</td>
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<td>1.2654</td>
<td>3.3438</td>
<td>1.5402</td>
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<td>1.5474</td>
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<tr>
<td>Dy Lβ6</td>
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<td>1</td>
<td>1.2732</td>
<td>3.3643</td>
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</tr>
<tr>
<td>Dy Lβ3</td>
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<td>6</td>
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<td>1.5497</td>
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<tr>
<td>Tb Lβ2,15</td>
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<td>20</td>
<td>1.2738</td>
<td>3.3630</td>
<td>1.5504</td>
<td>7.37</td>
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</table>
NOTES: No interference problems typically exist due to the low concentrations of REE in most silicates. A high Ni concentration might present some problem but a PHA should be helpful in that case. If K is present and the analyzing crystal is PET, careful background selection is required. (See kaersutite scan.)
Ca Clinopyroxene CP19
LIF 300 cps.
CaO 18.13 wt. %
TITANIUM
TABLE 22

ELEMENT: Ti
ANALYTICAL LINE: Ka1,2
CRYSTAL: LiF, PET
SPECTROMETER SETTING: 2.7497, 1.2665
BACKGROUND SETTING: ±0.058

ELEMENTAL SCANS:

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>WT. % OXIDE</th>
<th>BACKGROUND SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>rutile</td>
<td>100.00</td>
<td>±0.080</td>
</tr>
<tr>
<td>ilmenite</td>
<td>50.04</td>
<td>±0.058</td>
</tr>
<tr>
<td>kaersutite</td>
<td>5.64</td>
<td>±0.058</td>
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<tr>
<td>Ti metal (99.9)</td>
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INTERFERENCES:

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<th>N</th>
<th>I</th>
<th>LiF</th>
<th>PET</th>
<th>KeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs Lα4</td>
<td>1</td>
<td>5</td>
<td>2.6730</td>
<td>1.2312</td>
<td>9.28</td>
</tr>
<tr>
<td>La Lα2</td>
<td>1</td>
<td>10</td>
<td>2.6753</td>
<td>1.2323</td>
<td>4.63</td>
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<tr>
<td>Nd L1</td>
<td>1</td>
<td>2</td>
<td>2.6760</td>
<td>1.2326</td>
<td>4.63</td>
</tr>
<tr>
<td>Cs Lα1</td>
<td>1</td>
<td>50</td>
<td>2.6837</td>
<td>1.2361</td>
<td>4.62</td>
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<tr>
<td>U Lα1</td>
<td>3</td>
<td>100</td>
<td>2.7319</td>
<td>1.2583</td>
<td>13.61</td>
</tr>
<tr>
<td>La Ln</td>
<td>1</td>
<td>1</td>
<td>2.7400</td>
<td>1.2621</td>
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</tr>
<tr>
<td>Lu Lβ15</td>
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<td>20</td>
<td>2.7430</td>
<td>1.2634</td>
<td>9.04</td>
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<tr>
<td>Hf Lβ1</td>
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<td>50</td>
<td>2.7482</td>
<td>1.2658</td>
<td>9.02</td>
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<tr>
<td>Ti Kα1,2</td>
<td>1</td>
<td>150</td>
<td>2.7497</td>
<td>1.2665</td>
<td>4.51</td>
</tr>
<tr>
<td>Po Lβ1</td>
<td>3</td>
<td>50</td>
<td>2.7650</td>
<td>1.2740</td>
<td>13.44</td>
</tr>
<tr>
<td>Ba Lα1</td>
<td>1</td>
<td>100</td>
<td>2.7760</td>
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<tr>
<td>Sc Kβ1,3</td>
<td>1</td>
<td>20</td>
<td>2.7796</td>
<td>1.2803</td>
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<td>Rb Kα1,2</td>
<td>3</td>
<td>150</td>
<td>2.7808</td>
<td>1.2808</td>
<td>13.37</td>
</tr>
<tr>
<td>Pr L1</td>
<td>1</td>
<td>2</td>
<td>2.7841</td>
<td>1.2824</td>
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<tr>
<td>Cu Kβ1,3</td>
<td>2</td>
<td>20</td>
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<td>1.2825</td>
<td>8.90</td>
</tr>
<tr>
<td>Cu Kα3</td>
<td>2</td>
<td>6</td>
<td>2.7852</td>
<td>1.2829</td>
<td>8.90</td>
</tr>
<tr>
<td>Ba Lα2</td>
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<td>2.7855</td>
<td>1.2830</td>
<td>4.45</td>
</tr>
<tr>
<td>Zr Kα1</td>
<td>4</td>
<td>18</td>
<td>2.8069</td>
<td>1.2929</td>
<td>17.67</td>
</tr>
<tr>
<td>U M2-N4</td>
<td>1</td>
<td>5</td>
<td>2.8170</td>
<td>1.2975</td>
<td>4.40</td>
</tr>
</tbody>
</table>

NOTES: Commonly no interferences occur with a Ti determination with the exception of a high Ba matrix, i.e., benitoite. Other interferences will probably not be encountered. Ba interference cannot be separated with a PHA.
T1 TiO₂,
LIF 300 cps.
TiO₂ 100.0 wt. %
T1  ilmenite, Elliot Co.
LIF 300 cps.
TiO₂ 50.04 WT. %
Ti (Kaersutite, Spring Mtn.)
LiF 300 cps.
TiO₂ 5.64 wt. %
Ti  Ti metal
PET  1000 cps
TABLE 23

ELEMENT: V
ANALYTICAL LINE: Ka1,2
CRYSTAL: LiF
SPECTROMETER SETTING: 2.5048
BACKGROUND SETTING: ±0.057, ±0.029

ELEMENTAL SCANS:

<table>
<thead>
<tr>
<th>MINERAL</th>
<th>WT. %</th>
<th>BACKGROUND SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>V2O5</td>
<td>99.99</td>
<td>±0.057</td>
</tr>
<tr>
<td>magnetite</td>
<td></td>
<td>±0.029</td>
</tr>
<tr>
<td>ilmenite</td>
<td></td>
<td>-0.029</td>
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<tr>
<td>V, Ti overlay</td>
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INTERFERENCES:

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<th>N</th>
<th>I</th>
<th>LiF (200)</th>
<th>KeV</th>
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</thead>
<tbody>
<tr>
<td>La Lα4</td>
<td>1</td>
<td>5</td>
<td>2.4493</td>
<td>5.04</td>
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<tr>
<td>La Lα1</td>
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<td>50</td>
<td>2.4589</td>
<td>5.04</td>
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<tr>
<td>Pr Lα1</td>
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<td>100</td>
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<td>5.03</td>
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<td>Sm L1</td>
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<td>2</td>
<td>2.4823</td>
<td>4.99</td>
</tr>
<tr>
<td>Ba Lα6</td>
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<td>1</td>
<td>2.4826</td>
<td>4.99</td>
</tr>
<tr>
<td>Y Kα1,2</td>
<td>1</td>
<td>150</td>
<td>2.4907</td>
<td>14.93</td>
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<tr>
<td>Ti Kα5</td>
<td>1</td>
<td>0.02</td>
<td>2.4985</td>
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</tr>
<tr>
<td>V Kα1,2</td>
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<td>150</td>
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<td>4.95</td>
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<tr>
<td>Ge</td>
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<td>1</td>
<td>2.5120</td>
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</tr>
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<tr>
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<td>100</td>
<td>2.5615</td>
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</table>

NOTES: The most likely problem to occur is the Ti Kα1.3 interference on VKα1,2. A PHA cannot be used as a discriminator due to the similar energies of the two lines. Using a V free sample, i.e. TiO₂, ilmenite, etc. determine the intensity contribution at the V peak position and subtract off the appropriate amount from the V counts. See Geissman and Essene, "A graphic method of resolving X-ray interference on the electron microprobe", 13th Proceedings of the Microbeam Analysis Society. Ge interference can be discriminated against using a PHA.
V magnetite, section 3A
LiF 300 cps.
$V_2O_3 \text{ ? wt. %}$
V ilmenite, Elliot Co.
LIF 300 cps.
$V_2O_5$ ?
Composite $V_{K_{a1,2}}-T_{K_{a1,3}}$
LIF 300 cps.
$V_{K_{a1,2}}$-chromite, CS3-IN-8
$T_{K_{a1,3}}$-ilmenite, Elliot Co.
CHROMIUM
### Table 24

**Element:** Cr

**Analytical Line:** Kα₁,₂

**Crystal:** LiF

**Spectrometer Setting:** 2.291

**Background Setting:** ±0.064

**Elemental Scans:**

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<thead>
<tr>
<th>Mineral</th>
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<th>Background Setting</th>
</tr>
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<tbody>
<tr>
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<td>38.76</td>
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</tr>
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<td>Armalcolite</td>
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<td>±0.046</td>
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</table>

**Interferences:**

<table>
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<th>I</th>
<th>LiF (200)</th>
<th>KeV</th>
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</thead>
<tbody>
<tr>
<td>Ba Lγ₁</td>
<td>1</td>
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<td>2.2415</td>
<td>5.53</td>
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<tr>
<td>Pr Lβ₄</td>
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<td>5</td>
<td>2.2550</td>
<td>5.50</td>
</tr>
<tr>
<td>Pr Lβ₁</td>
<td>1</td>
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<tr>
<td>V Kβ₅</td>
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<tr>
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</tr>
<tr>
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<td>.1</td>
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<tr>
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<td>2.3109</td>
<td>5.36</td>
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<tr>
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<tr>
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<td>1</td>
<td>50</td>
<td>2.3561</td>
<td>5.26</td>
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</table>

**Notes:** Chromium in a high concentration of V, Ba, or REE may be a difficult determination because of the similar energies of all the interfering X-ray lines. The use of a PHA as a discriminator is hopeless.
Cr armalcolite
LiF 300 cps.
Cr₂O₃ 6.69 wt. %
### TABLE 25

**ELEMENT:** Mn  
**ANALYTICAL LINE:** Ka1,2  
**CRYSTAL:** LiF  
**SPECTROMETER SETTING:** 2.1031  
**BACKGROUND SETTING:** ±.080 for Rhodonite; ±.030 low concentration samples

#### ELEMENTAL SCANS:

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<tr>
<th>MINERAL</th>
<th>WT. % OXIDE</th>
<th>BACKGROUND SETTINGS</th>
</tr>
</thead>
<tbody>
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<td>Rhodonite</td>
<td>40.77</td>
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</tr>
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<td>Diopside</td>
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<td>±.035</td>
</tr>
<tr>
<td>Chromite</td>
<td>0.17</td>
<td>Determination difficult</td>
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#### INTERFERENCES

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<tr>
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<th>I</th>
<th>LiF (200)</th>
<th>KeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd La2.15</td>
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<td>2.0360</td>
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<td>100</td>
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<td>2.0487</td>
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<tr>
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<td>10</td>
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<td>17.44</td>
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<td>50</td>
<td>2.1669</td>
<td>5.72</td>
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</table>

**NOTES:** Typically no interference problems except with a Cr-rich matrix, i.e., chromite, where CrKα1,3 will interfere. PHA window is of no help.
Mn rhodonite
LIF 300 cps.
MnO 40.77 wt. %
Mn diopside glass doped with Cr, Mn, Ni.
LiF 300 cps.
MnO 1.41 wt. %
Mn chromite
L1F 300 cps.
MnO 0.17 wt. %
<table>
<thead>
<tr>
<th>ELEMENT:</th>
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<td>ANALYTICAL LINE:</td>
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<tr>
<td>CRYSTAL:</td>
<td>LiF</td>
</tr>
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<td>SPECTROMETER SETTING:</td>
<td>1.937</td>
</tr>
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<td>BACKGROUND SETTING:</td>
<td>±0.062</td>
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**ELEMENTAL SCANS:**

<table>
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<tr>
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<th>BACKGROUND SETTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP19</td>
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</tr>
<tr>
<td>Rhodonite</td>
<td>3.60</td>
<td>±0.062</td>
</tr>
</tbody>
</table>

**INTERFERENCES:**

<table>
<thead>
<tr>
<th>Line</th>
<th>N</th>
<th>I</th>
<th>LiF (200)</th>
<th>KeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nd Lγ1</td>
<td>1</td>
<td>5</td>
<td>1.8779</td>
<td>6.60</td>
</tr>
<tr>
<td>Pt Lγ</td>
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<td>.01</td>
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**NOTES:** Typically no problem except in a high Mn matrix. See rhodonite scan. Platinum lines are included for the benefit of experimental petrologists using Pt capsules.
Fe clinopyroxene CP19
LiF 300 cps.
FeO 8.49 wt. %
Fe rhodonite
LiF 300 cps.
FeO 3.60 wt. %
MnO 40.78 wt. %
COBALT
TABLE 27

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>Co</th>
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<tr>
<td>CRYSTAL</td>
<td>LiF</td>
</tr>
<tr>
<td>SPECTROMETER SETTING</td>
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<tr>
<td>BACKGROUND SETTING</td>
<td>±0.080</td>
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**ELEMENTAL SCANS:**

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<th>BACKGROUND SETTING</th>
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<th>KeV</th>
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<tr>
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<td>1.8118</td>
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NOTES: Typically no problem except in a high Fe matrix. (See kamacite scan.) Undoubtedly there is some contribution to Co ka1,2 from Fe kβ1,3. Due to similar energies of the X-ray lines a PHA is not helpful. Best method of analysis would be to choose a standard with as similar composition as the sample as possible.
Co Kamacite
Yamato Meteorite
LIF 300 cps.
Co 99.9
LiF 300 cps.
NICKEL
TABLE 28

ELEMENT: Ni
ANALYTICAL LINE: Ka1,2
CRYSTAL: LiF
SPECTROMETER SETTING: 1.6592
BACKGROUND SETTING: ±0.0065

ELEMENTAL SCANS:

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<tr>
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INTERFERENCES:

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<th>KeV</th>
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<tr>
<td>Eu Ly1</td>
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<td>5</td>
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<tr>
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<td>1.6592</td>
<td>7.47</td>
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**NOTES:** Typically no problem although a high Co matrix may present an overlap problem due to tailing effects, but at the 5% Co level there does not appear to be a problem.
Ni 99.9
LIF 300 cps.
Ni 75 Ni10 Co5
LiF 300 cps.
Ni 10 wt.%
Ni Yamato Meteorite
LIF 300 cps.
STRONTIUM
### Table 38

**Element:** Sr  
**Analytical Line:** La1  
**Crystal:** ADP; PET  
**Spectrometer Setting:** 2.5972; 3.1610  
**Background Setting:**

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</table>

NOTES: Sr occurs at the trace level in silicates such as feldspars and clinopyroxenes and rarely occurs as a major constituent except in some SO₄ and CO₃ phases. At trace levels the adjacent Si SK line causes a background as well as an overlap problem and background position should be chosen on the high angle side only. The energy of the Si SK line is identical to the Sr La line and therefore use of a PHA is hopeless. Better PK/BKg ratio can be achieved by using an electron beam of 30KV rather than 15KV acceleration potential.
Sr Lake County Plagioclase
ADP 100 cps.
Sr ~600 ppm
Sr: CELESTITE
ADP: 300 cps.
SrO: 56.41 wt. %
ZIRCONIUM
**TABLE 40**

**ELEMENT:** Zr  
**ANALYTICAL LINE:** Zr La1,2  
**CRYSTAL:** PET, ADP  
**SPECTROMETER SETTING:** 2.7961; 2.2973  
**BACKGROUND SETTING:** ±0.060  

**ELEMENTAL SCANS:**

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<table>
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<th>N</th>
<th>I</th>
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<th>ADP (101)</th>
<th>KeV</th>
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<tbody>
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**NOTES:** Chief source of interference with Zr determination is P Ska5. Although of low intensity it occurs at the same position and is the same energy as the Zr La1 therefore a PHA is not helpful. Aside from P the REE Sm, Er, Nd, Tm and Gd all have x-ray peaks within the background region but can be discriminated against with a PHA. Ca Kβ1,3 is probably far enough away so as not to present a problem.
Zr  Armalcolite
ADP  300 cps.
ZrO$_2$  6.31 wt. %
TABLE 56

ELEMENT: Ba

ANALYTICAL LINE: Lal
CRystal: LiF (200)
SPECTROMETER SETTING: 2.7760
BACKGROUND SETTING: +0.056

ELEMENTAL SCANS:

<table>
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<tr>
<th>MINERAL</th>
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<th>BACKGROUND SETTING</th>
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<td>+0.056</td>
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<td>Benitoite</td>
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INTERFERENCE:

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<th>KeV</th>
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<tr>
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<td>2</td>
<td>5</td>
<td>2.7282</td>
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<tr>
<td>Ti Kal,2</td>
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<td>150</td>
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<td>Zr KB2</td>
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<td>4</td>
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<td>100</td>
<td>2.7760</td>
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<td>Rb Kal,2</td>
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<td>2.8091</td>
<td>17.65</td>
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NOTES: Barium typically occurs as a minor to trace level constituent in feldspars and as a major component of some carbonates, sulfates and halides. There should be little or no interference on the BaLal line with the exception of TiKal,2 which is of such similar energy (see TABLE) that use of a PHA will not discriminate against it.
LANTHANUM
### TABLE 57

**ELEMENT:** La  
**ANALYTICAL LINE:** La1  
**CRYSTAL:** LiF  
**SPECTROMETER SETTING:** 2.6657  
**BACKGROUND SETTING:** ±0.027  
**ELEMENTAL SCANS:**

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<th>MINERAL</th>
<th>WT % OXIDE</th>
<th>BACKGROUND SETTING</th>
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</thead>
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<td>Perovskite</td>
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**INTERFERENCES:**

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<th>LiF (200)</th>
<th>KeV</th>
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</thead>
<tbody>
<tr>
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<td>2.6306</td>
<td>9.42</td>
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<tr>
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<td>2.6450</td>
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<tr>
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<td>10</td>
<td>2.6486</td>
<td>9.36</td>
</tr>
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</table>
NOTES: Chief interferences come from 1st order CsLβ4 and NdLγ x-ray lines. Due to the similar energy of these lines with La Lα, a PHA is of no use as an energy discriminator. All 2nd order lines can be dealt with using a PHA.
CERIUM
### Table 58

<table>
<thead>
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<th>MINERAL</th>
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**INTERFERENCES:**

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<th>KeV</th>
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**NOTES:** Chief interference is from Ba Lβ1 and Lβ4. Similar X-ray energies prevent energy discrimination with a PHA. All other lines can be discriminated against using the PHA.
PRASEODYHIUM
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</table>

**NOTES:** Interferences which occur and which the analyst is helpless against are: ThM1-03, U92-04, La L64, LaL81, SmI, and BaL86. La would be the most likely problem. All other lines can be discriminated against with a PHA.
NEODYMIUM
### Table 60

**ELEMENT:** Nd  
**ANALYTICAL LINE:** La1  
**CRYSTAL:** LiF  
**SPECTROMETER SETTING:** 2.3704  
**BACKGROUND SETTING:**  

**INTERFERENCES:**

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**NOTES:** Intense X-ray lines from elements such as Zr, Pb are more energetic than Nd La and can be discriminated against with a PHA. Elements such as Ce, La and Ba, if present in the matrix, cannot be discriminated against and interfere with the measurement.
### TABLE 62

**ELEMENT:** Sm  
**ANALYTICAL LINE:** La1  
**CRYSTAL:** LiF  
**SPECTROMETER SETTING:** 2.1998  

**BACKGROUND SETTING:**

**ELEMENTAL SCANS:**

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<th>MINERAL</th>
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<th>BACKGROUND SETTING</th>
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**INTERFERENCES:**

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<tr>
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<td>1</td>
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</table>

**NOTES:** Ce, Cs, Pr, or La in the sample matrix can present a problem. Ce is the chief problem, but the continuum is loaded with other lines of similar energy. PHA is only useful for Pt and Po.
EUROPIUM
## Table 63

**Element:** Eu  
**Analytical Line:** La1  
**Crystal:** LiF  
**Spectrometer Setting:** 2.1209  
**Background Setting:**  
**Elemental Scans:**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Weight % Oxide</th>
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<th>KeV</th>
</tr>
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<tbody>
<tr>
<td>Glass KEE 1</td>
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**Background Setting:** ±0.030

**Interferences:**

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<th>LiF (200)</th>
<th>KeV</th>
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<tr>
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<td>Pr Lanes9</td>
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<td>5.90</td>
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<tr>
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<td>150</td>
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<tr>
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<td>2.1194</td>
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<td>5.82</td>
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<td>2.1315</td>
<td>5.82</td>
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**Notes:** All of the x-ray lines occurring near Eu are of similar energies and therefore impossible to discriminate against with a PHA. Aside from La, Pr, Nd and Ba occurring very near the peak, MnKa1,2 is apt to be more of a problem, and depending on the Mn concentration level, the Eu might be sitting in the Mn peak tail.
GAUDLNIUM
## TABLE 64

<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>Gd</th>
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<tbody>
<tr>
<td>ANALYTICAL LINE</td>
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<tr>
<td>CRYSTAL</td>
<td>LiF</td>
</tr>
<tr>
<td>SPECTROMETER SETTING</td>
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<tr>
<td>BACKGROUND SETTING:</td>
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### ELEMENTAL SCANS:

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<th>MINERAL</th>
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### INTERFERENCES:

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<th>KeV</th>
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<tbody>
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<td>.01</td>
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<td>6.09</td>
</tr>
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<td>1</td>
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</tr>
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<td>5</td>
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**NOTES:** Chief interferences are Nd, Pm and Ce. A PHA will not help since all x-ray lines are of similar energy.
TABLE 65

**ELEMENT:** Tb
**ANALYTICAL LINE:** La1
**CRYSTAL:** LiF
**SPECTROMETER SETTING:** 1.9765
**BACKGROUND SETTING:** ±0.026

<table>
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<th>BACKGROUND SETTING</th>
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</thead>
<tbody>
<tr>
<td>Glass REE 1</td>
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<td>±0.026</td>
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**INTERFERENCES:**

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<th>KeV</th>
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**NOTES:** Chief interferences for Tb measurement are Sm, Pr, and Pm. As with other REE, interfering x-ray lines are of sufficiently similar energy that a PHA is of no help.
DYSPROSIUM
TABLE 66

ELEMENT: Dy
ANALYTICAL LINE: La1
CRYSTAL: LiF
SPECTROMETER SETTING: 1.9088

BACKGROUND SETTING:

ELEMENTAL SCANS:

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<th>BACKGROUND SETTING</th>
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<tbody>
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INTERFERENCES:

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<th>I</th>
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<th>KeV</th>
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</thead>
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**NOTES:** Dy in a mafic mineral will be almost impossible to analyze due to the large Fe and Mn concentrations. In fact, the Dy (peak) is apt to be sitting in the Fe tail and MnKa1 is right on top of the Dy peak. All X-ray lines, with the exception of Th, are of similar energy and impossible to discriminate against with a PHA. These problems aside, Eu and Sm will also cause interference. Very difficult to analyze.
### Table 67

**Element:** Ho  
**Analytical Line:** LaI  
**Crystal:** LiF  
**Spectrometer Setting:** 1.8450  
**Background Setting:** ±0.030

#### Elemental Scans:

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<tr>
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#### Interferences:

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<th>Line</th>
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<th>I</th>
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<th>KeV</th>
</tr>
</thead>
<tbody>
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**NOTES:** Chief Ho interferences are Gd, Rb, Lu, U, and Eu. U and Rb are the only X-ray lines which can be discriminated against using a PHA.
ERBIUM
TABLE 68

ELEMENT: Er
ANALYTICAL LINE: La1
CRYSTAL: LiF
SPECTROMETER SETTING: 1.7843
BACKGROUND SETTING: ±0.030

ELEMENTAL SCANS:

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<th>MINERAL</th>
<th>WT % OXIDE</th>
<th>BACKGROUND SETTING</th>
</tr>
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<tbody>
<tr>
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<td>±0.030</td>
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INTERFERENCES:

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<th>KeV</th>
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<tbody>
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NOTES: Major sources of interference are Co Kα1,2; Fe Kβ1,3; Tb Lβ4 and Tb Lβ1. All lines except Sr are of similar energy and therefore a PHA cannot discriminate against them.
TABLE 69

ELEMENT: Tm
ANALYTICAL LINE: La1
CRYSTAL: LiF
SPECTROMETER SETTING: 1.7268

BACKGROUND SETTING:

ELEMENTAL SCANS:

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BACKGROUND SETTING: -0.043

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**NOTES:** Dy, Sm, Fe, Gd, and Sr can interfere with the Tm determination. Of these, only Sr can be excluded with a PHA.
YTTERBIUM
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**NOTES:** Of the interfering lines Ni Kα1,2; Y Kα1,2; DyLβ3 and TbLβ2,15 a PHA will only be useful to discriminate against Y. All other X-ray lines are of similar energy and impossible to exclude.
LUTETIUM
### TABLE 71

**ELEMENT:** Lu  
**ANALYTICAL LINE:** La1  
**CRYSTAL:** LiF  
**SPECTROMETER SETTING:** 1.6195  
**BACKGROUND SETTING:**

**ELEMENTAL SCANS:**

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**NOTES:** Chief interferences are from Co, Dy, Er and Gd. A PHA is of no help as an energy discriminator since all the lines are of similar X-ray energy.
La GLASS REE 3
LiF 300 cps.
La$_2$O$_3$ 4.28 wt. %

Nd GLASS REE 2
LiF 300 cps.
Nd$_2$O$_3$ 4.26 wt. %

Ce GLASS REE 3
LiF 300 cps.
Ce$_2$O$_3$ 4.00 wt. %
REE IGWISI Hill Perovskite
LiF 300 cps.
Pr GLASS REE 3
LIF 300 cps.
$\text{Pr}_2\text{O}_3$ 4.45 wt. %
Sm  GLASSREE2
LiF  300 cps.
Sm$_2$O$_3$  4.26 wt. %
Eu  GLASS REE 1  
LiF  300 cps.  
EuO  4.21 wt. %  

Gd  GLASS REE 1  
LiF  300 cps.  
Gd₂O₃  4.47 wt. %
Tb GLASS REE 1
LiF 300 cps.
Tb$_2$O$_3$ 4.27 wt. %
Tm  GLASS REE 1
LiF  300 cps.
Tm₂O₃  4.36 wt. %
**TABLE 78**

**ELEMENT:** Pt  
**CRYSTAL:** PET  
**ANALYTICAL LINE:** Ma  
**SPECTROMETER SETTING:** 2.7853  
**BACKGROUND SETTING:** ±0.158  

**ELEMENTAL SCANS:**

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**NOTES:** With a material so widely used in experimental research it is difficult to decide which matrix will not present a problem and which will. The X-ray lines listed above should cover most of the geologic materials normally encountered. A PHA is useful in discriminating against some of the interfering lines — but not all of them. The following is a list of the lines where use of a PHA should be helpful: MnKβ1,3, FeKα1,2, ThLα1, NiKβ1,3, CaKβ1,3, CrKβ1,3, MnKα1,2. For the following x-ray lines a PHA is of little or no help: NbLα1, ZrLβ1, AuMα1, ZrLα1, Pka1,2, YLβ1.
### TABLE 90

**ELEMENT:** Th  
**ANALYTICAL LINE:** Th Mα1,2  
**CRYSTAL:** PET  
**SPECTROMETER SETTING:** 1.91  
**BACKGROUND SETTING:** ±0.020

**ELEMENTAL SCANS:**

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<th>WT. % OXIDE</th>
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<td>Hibunite</td>
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**INTERFERENCE:**

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<td>Lu Lβ15</td>
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<td>20</td>
<td>1.8952</td>
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</tr>
<tr>
<td>Gd La2</td>
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<td>10</td>
<td>1.8957</td>
<td>6.02</td>
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<tr>
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<td>1</td>
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<tr>
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NOTES: There are several X-ray lines of similar energy as Th Ma and therefore not excluded with PHA. These include Bi, Tl, Rh, Pd, Ag, Ru, Ar and Cd. None of these however would typically be found in a Th matrix. Some REE might present a problem, but usually are of sufficiently low concentration that higher order reflections will not be seen.
URANIUM
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<th>Background Setting</th>
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<td>GLASS X (Probe Society)</td>
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**INTERFERENCES:**

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<th>I</th>
<th>PET (002)</th>
<th>KeV</th>
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NOTES: All 1st order x-ray lines occurring within ±Bkg are listed even though (1) background is only counted on the + side of peak and (2) many of the lines are not common to uranium minerals. Higher order lines for elements commonly occurring in uranium minerals are also given, i.e. Pb, Th, Fe, REE. X-ray lines from Th, REE, Fe, Zr and Pb Lα1 can be excluded with a PHA; the remainder of x-ray lines cannot be discriminated against with a PHA. Most important of these lines is Th Mβ.

Between oxides, carbonates, sulfates, phosphates, arsenates, vanadates, silicates, niobates, tantalates, titanates, and molybdates there are 100 uranium minerals listed in the "Handbook of Geochemistry" Vol. II-1, Springer-Verlag, 1969. Most commonly occurring uranium mineral is uraninite.
X-RAY OVERLAP AMONG TRANSITION ELEMENTS
### TABLE 001

**X-RAY OVERLAP AMONG TRANSITION ELEMENTS**

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<thead>
<tr>
<th>ANALYTICAL LINE</th>
<th>INTERFERENCE</th>
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<th>$\Delta \text{KeV}$</th>
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<td>Cr KB</td>
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<td>0.14 (Co in kamacite)</td>
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X-RAY OVLRLAP AMONG RARE EARTH ELEMENTS
### TABLE 002
**X-RAY OVERLAP AMONG RARE EARTH ELEMENTS**

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