Smithsonian Microbeam Standards Datasheets

National Museum of National History

Department of Mineral Sciences

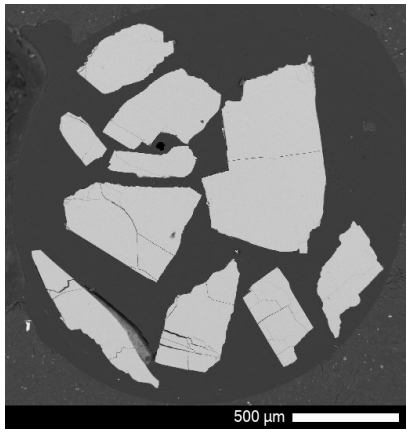
Updated 15 Feb 2019

Anorthite

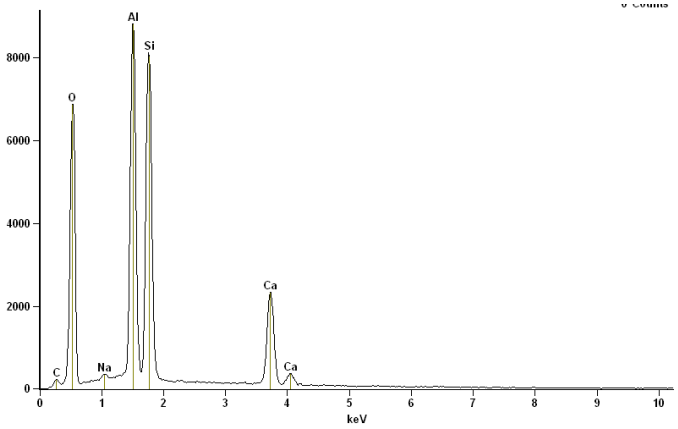
NMNH 137041

Oxide	Composition (wt %)
SiO_2	44.00
Al_2O_3	36.03
FeO	0.62
MgO	<0.02
CaO	19.09
Na_2O	0.53
K_2O	0.03
TiO_2	0.03
Total	100.33

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Great Sitkin Island, Alaska, USA

Size fractions available

- 0.841 mm - 0.250 mm
- 0.250 mm - 0.177 mm

References

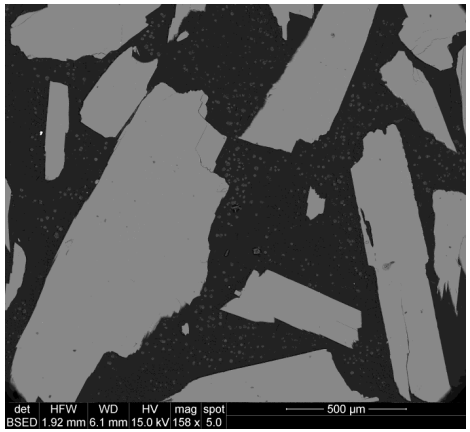
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Anorthoclase

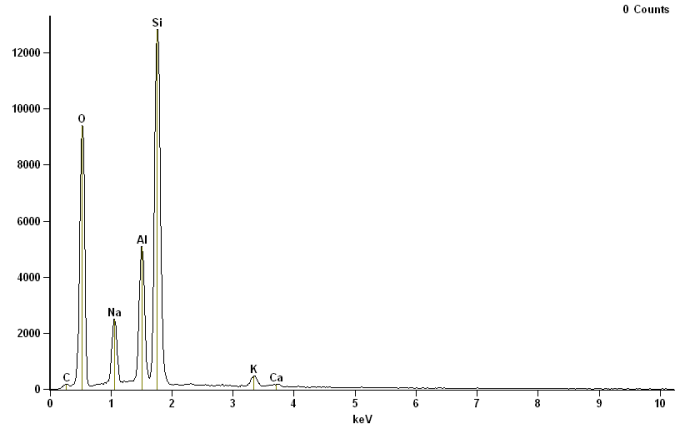
NMNH 133868

Oxide	Composition (wt %)
SiO_2	66.44
Al_2O_3	20.12
FeO	0.20
CaO	0.87
Na_2O	9.31
K_2O	2.35
H_2O	<0.05
Total	99.29

- **Analyst:** J. Norberg



Backscatter SEM image



EDS spectrum

Locality

Kakanui, New Zealand

Size fractions available

- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm

References

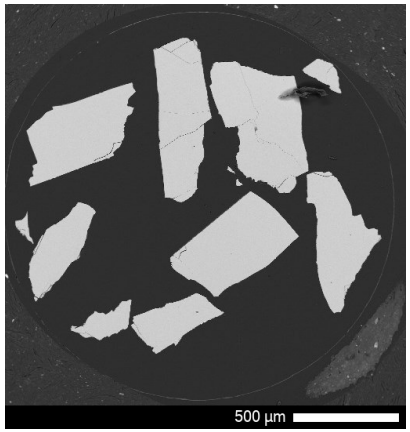
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Chromium augite

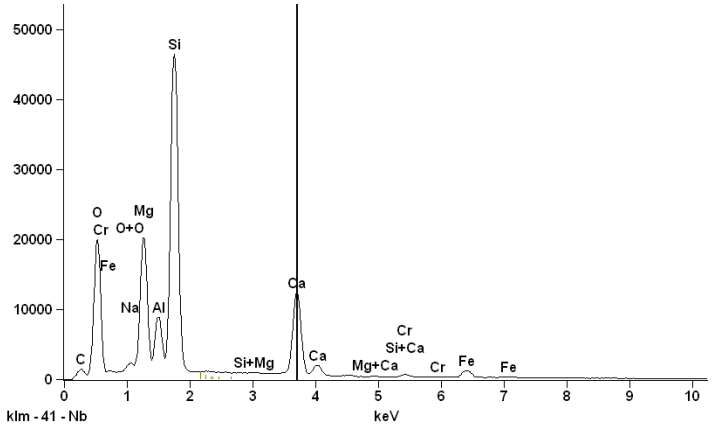
NMNH 164905

Oxide	Composition (wt %)
SiO_2	50.48
Al_2O_3	8.03
Fe_2O_3	1.04
FeO	3.77
MgO	17.32
CaO	17.30
Na_2O	0.84
K_2O	<0.01
MnO	0.12
TiO_2	0.51
P_2O_5	0.00
Cr_2O_3	0.85
H_2O-	<0.10
Total	100.26

- **Analyst:** Jarosewich et al.



Backscatter SEM image



EDS spectrum

Locality

Nye County, Nevada, USA

Size fractions available

- < 0.25 mm
- 0.25 mm - 0.5 mm
- 0.5 mm - 1.00 mm

References

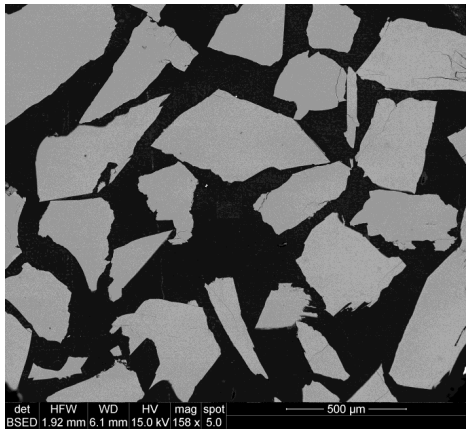
Jarosewich, E. et. al., (1987) Chromium Augite - A New Microprobe Reference Sample. Geostandards Newsletter, 11, p. 197-198

Kakanui augite

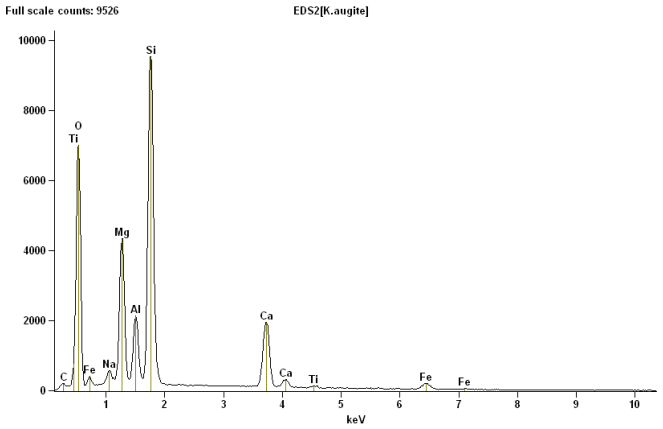
NMNH 122142

Oxide	Composition (wt %)	Preferred (wt %)
SiO_2	50.73	50.73
Al_2O_3	7.86	8.73
Fe_2O_3	3.69	1.08
FeO	3.45	5.37
MgO	16.65	16.65
CaO	15.82	15.82
Na_2O	1.27	1.27
K_2O	0.00	0.00
TiO_2	0.74	0.74
MnO	0.13	0.13
H_2O	0.04	0.04
Total	100.38	100.56

- **Analyst:** B. Wiik, Finland Geologic Survey
- **Notes:** The original published composition was apparently done in Finland (Jarosewich et al , 1980). The preferred working value above was distributed by Gene Jarosewich. We do not know when the sample was reanalyzed.



Backscatter SEM image



EDS spectrum

Locality

Kakanui, New Zealand

Size fractions available

- 0.42 mm - 0.25 mm
- 0.3 mm - 0.25 mm
- 0.18 mm - 0.13 mm
- > 0.3 mm

Impurities

- **Common:** Calcite and barite
- **Rare:** Grains with lower Na, Al and higher Fe, Mg, Ca

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Mason, B. (1966) Pyrope, augite and hornblende from Kakanui, New Zealand. J. Geol. Geophys. 9 (4), p. 474-480

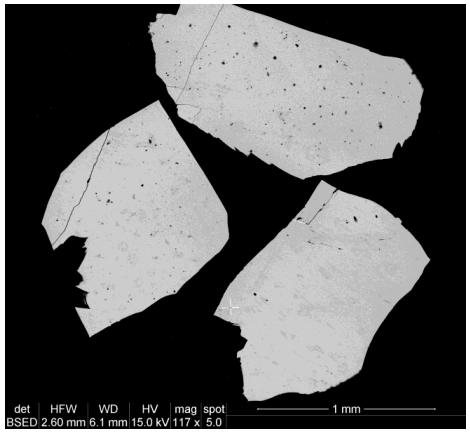
Mason, B. and Allen, R.O. (1973) Minor and trace elements in augite, hornblende and pyrope megacrysts from Kakanui, New Zealand; New Zealand Journal of Geology and Geophysics, 16(4), p. 935-947

Benitoite

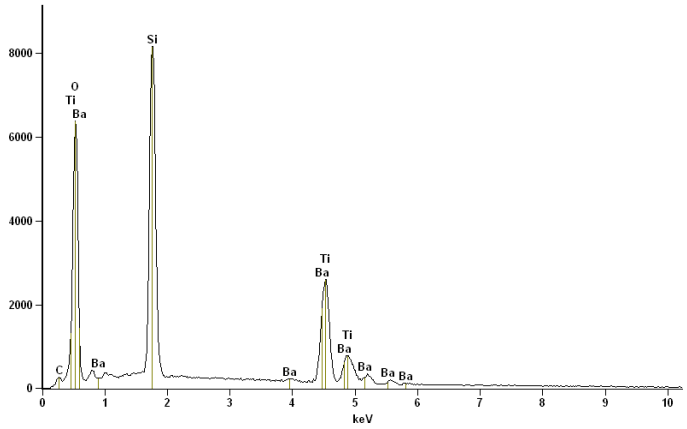
NMNH 86539

Oxide	Composition (wt %)
SiO_2	43.75
TiO_2	19.35
BaO	37.05
Total	100.15

- **Analyst:** J. Nelen



Backscatter SEM image



EDS spectrum

Locality

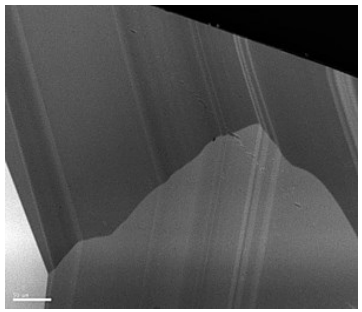
San Benito Co., California, USA

Size fractions available

- > 1.19 mm
- 1.0 mm - 0.5 mm
- > 0.5 mm

Notes

- The spectacular cathodoluminescence (see image above) of benitoite has been used for optimization of electron microbeam instruments for decades
- Preliminary CL spectroscopy reveals a peak at about 420 nm



CL image

References

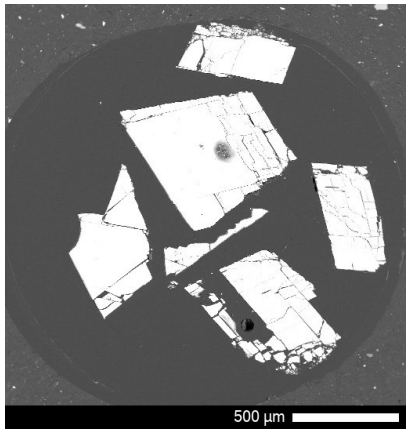
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Calcite

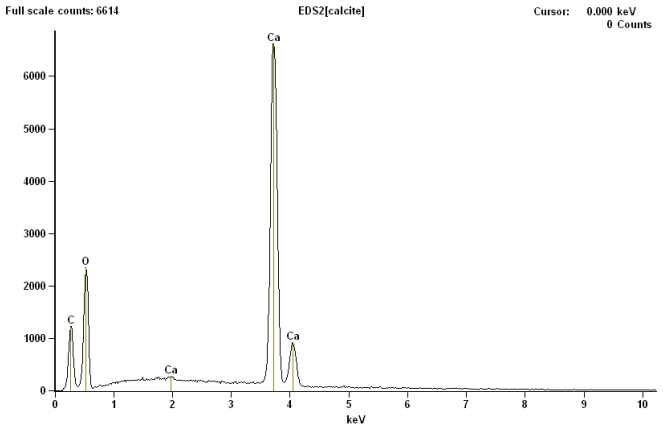
NMNH 136321

Oxide	Composition (wt %)
CaO	56.10
Co_2	44.01
Total	100.11

- **Analyst:** Jarosewich et al. (1983)



Backscatter SEM image



EDS spectrum

Locality

Unknown

Size fractions available

- 0.42 mm - 0.25 mm

Notes

- Preliminary cathodoluminescence study reveals peaks at 370 and 615 nm

References

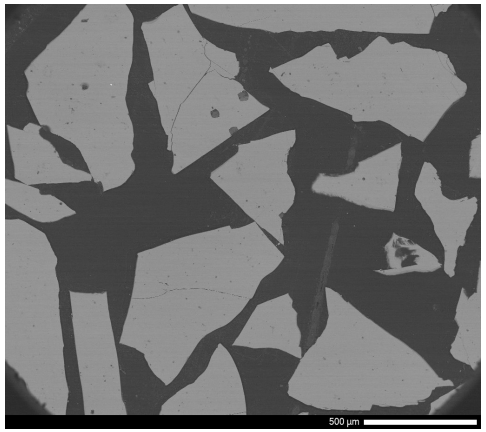
Jarosewich, E. and MacIntyre, I. G. (1983) Carbonate reference samples for electron microprobe and scanning electron microscope analyses. J. of Sedimentary Petrol. 52 (2), p. 677-678

Chromite

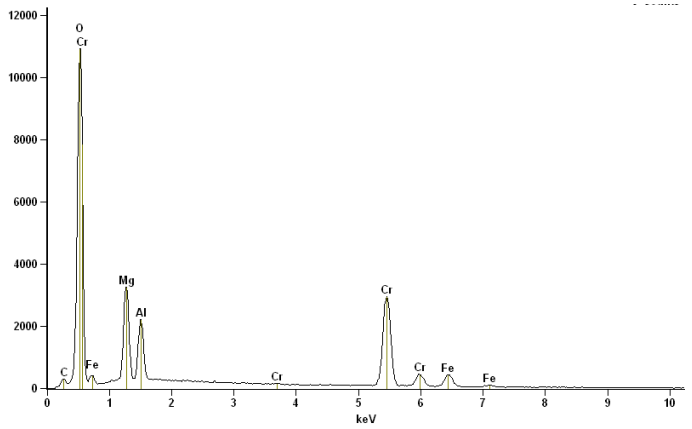
NMNH 117075

Oxide	Composition (wt %)
Al_2O_3	9.92
FeO	13.04
MgO	15.20
MnO	0.11
Cr_2O_3	60.50
Total	98.77

- **Analyst:** J. Nelen



Backscatter SEM image



EDS spectrum

Locality

Tiebaghi Mine, New Caledonia

Size fractions available

- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm

References

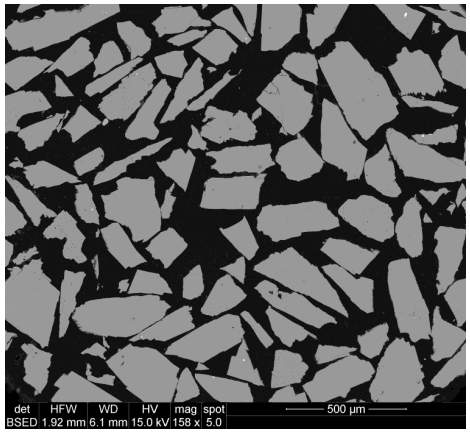
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Diopside

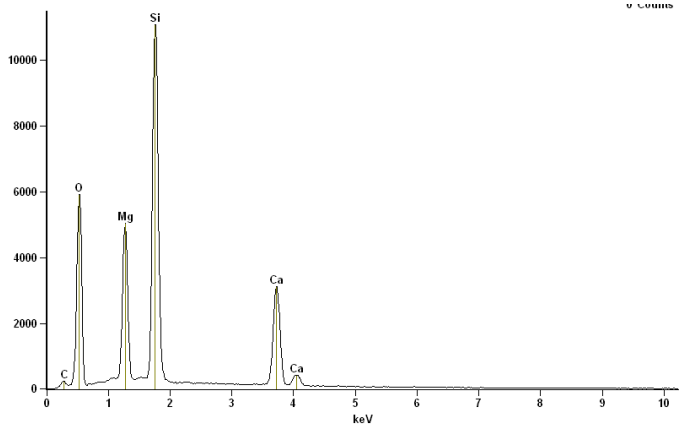
NMNH 117733

Oxide	Composition (wt %)	Preferred (wt %)
SiO_2	54.87	55.81
Al_2O_3	0.11	0.11
FeO	0.24	0.25
MgO	18.30	17.79
CaO	25.63	25.28
Na_2O	0.34	0.25
MnO	0.04	0.04
Total	99.53	99.53

- **Analyst:** J. Nelen
- **Notes:** Reanalyzed by E. Jarosewich. Personal communication from Glenn MacPherson.



Backscatter SEM image



EDS spectrum

Locality

Natural Bridge, New York, USA

Size fractions available

- > 1.0 mm
- 1.0 mm - 0.42 mm

Impurities

- **Rare:** Apatite and pyrite

References

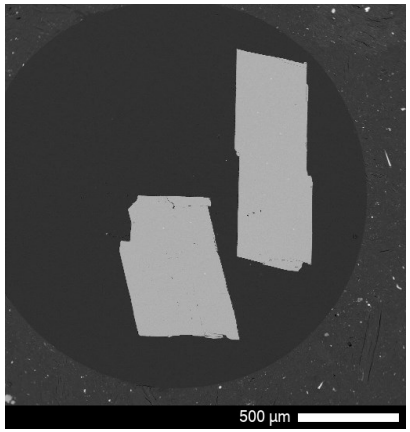
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Dolomite

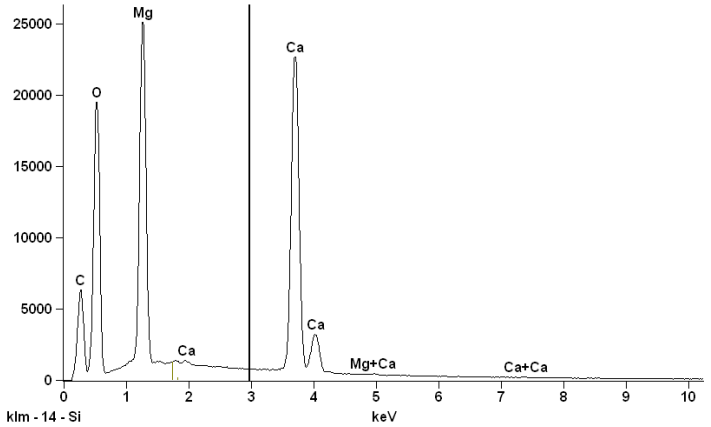
NMNH R10057

Oxide	Composition (wt %)
CaO	30.56
MgO	22.04
Co_2	46.93
Total	99.53

- **Analyst:** Jarosewich et al. (1980)



Backscatter SEM image



EDS spectrum

Locality

Oberdorf, Austria

Size fractions available

- 0.42 mm - 0.25 mm

References

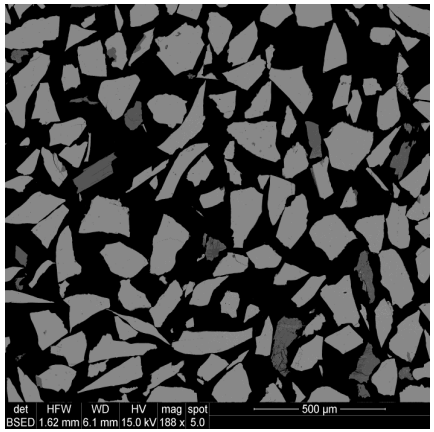
Jarosewich, E. and MacIntyre, I. G. (1983) Carbonate reference samples for electron microprobe and scanning electron microscope analyses. J. of Sedimentary Petrol. 52 (2), p. 677-678

Fayalite

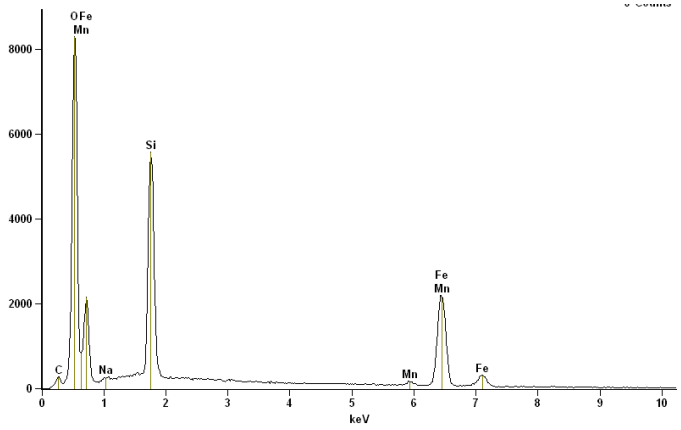
NMNH 85276

Oxide	Composition (wt %)
SiO_2	29.22
Fe_2O_3	1.32
FeO	66.36
TiO_2	0.04
MnO	2.14
H_2O	0.10
Total	99.18

- **Analyst:** J. Nelen



Backscatter SEM image



EDS spectrum

Locality

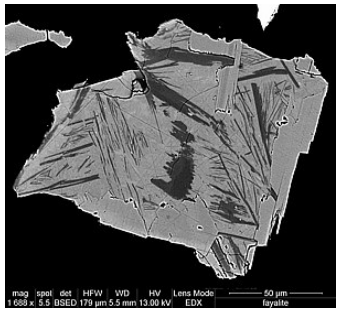
Rockport, Massachusetts, USA

Size fractions available

- Tiny grains (see image)

Impurities

- **Common:** This material is known to contain approximately 10% amphibole, probably grunerite, commonly associated with the fayalite from this locality (visible in image above). Some fayalite grains are intergrown with impurities. Other complex grains like that above remain largely unstudied.



Impurities in standard

References

Bowen, I. L. and Schairer, J. F. (1935) Grunerite from Rockport, Massachusetts and a Series of Synthetic Fluor-Amphiboles. Am. Min., 20, p. 543- 551

Bozhilov, K. N. and Evans, B. W. (2001) Ferroanthophyllite in Rockport grunerite: A transmission electron microscopy study. Am. Min., 86, p. 1252- 1260

Dyar, M. D. et. al. (1988) Fe3+ distribution in oxidized olivine: A Synchrontron micro-XANES study. Am. Min., 83, p. 1361-1365

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Palache, C. (1950) Fayalite from Rockport, Mass. Am. J. Sci., 4th Ser, 1, p. 134-135

Schaefer, M. W. (1985) Site occupancy and two-phase character of "ferrifayalite." Am. Min., 70, p. 729-736.

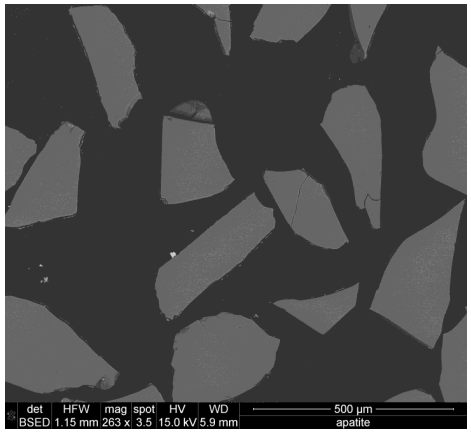
Warren, C. H. (1903) Anthophyllite with fayalite from Rockport. Am. J. of Sci., 16, p. 339.

Fluorapatite

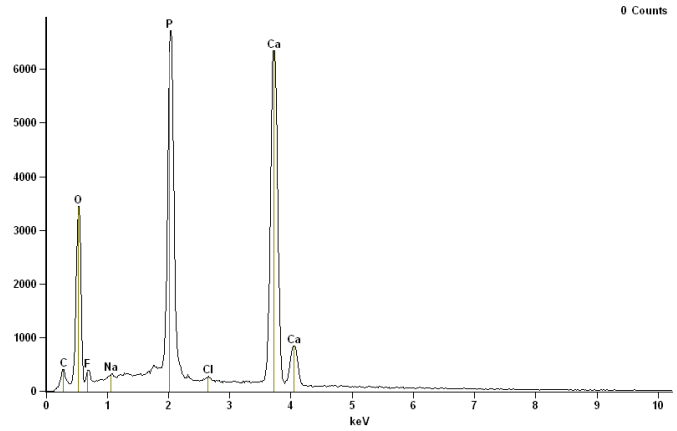
NMNH 104021

Oxide	Composition (wt %)
SiO_2	0.34
Al_2O_3	0.07
Fe_2O_3	0.06
FeO	0.00
MgO	0.01
CaO	54.02
Na_2O	0.23
K_2O	0.01
P_2O_5	40.78
MnO	0.01
SrO	0.07
REE_2O_3	1.43
ThO_2	0.02
As_2O_3	0.09
V_2O_5	0.01
Co_2	0.05
SO_3	0.37
F	3.53
Cl	0.41
H_2O	0.01
Subtotal	101.52
Total	99.94

- **Analyst:** E L. Munson et al.
- **Notes:** O equivalent to Cl, F = 1.58



Backscatter SEM image



EDS spectrum

Locality

Durango, Mexico

Size fractions available

- 0.250 mm - 0.177 mm
- 0.177 mm - 0.149 mm

Notes

- Cathodoluminescence: peaks at: 370, 410, 450, 480, 580, 610, 650 nm

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

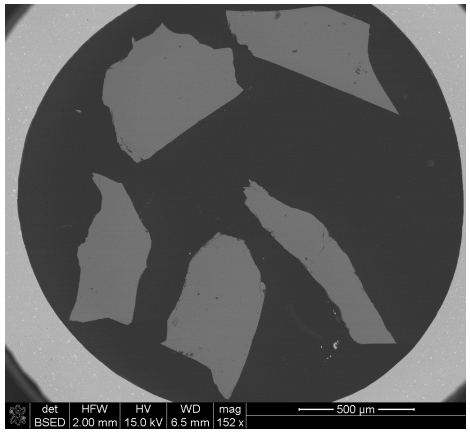
Young, E.J., Myers, A.T., Munson, E.L., Conklin, N.M. (1969) Mineralogy and geochemistry of fluorapatite from Cerro de Mercado, Durango, Mexico; USGS Professional Paper 650D, 84-93

Gahnite

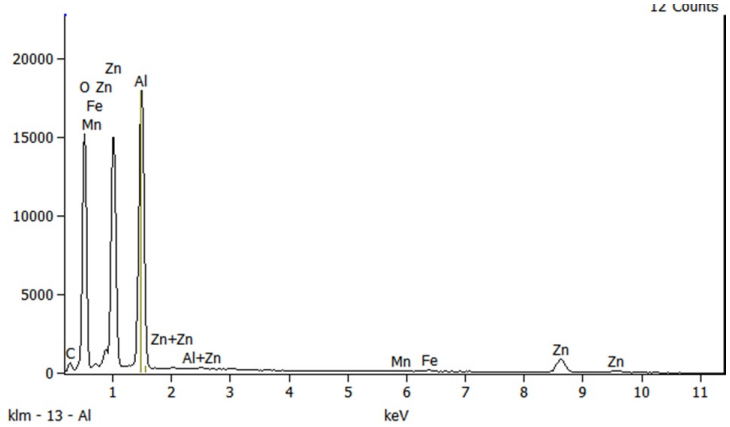
NMNH 145883

Oxide	Composition (wt %)
Al_2O_3	55.32
FeO	1.97
MnO	0.34
ZnO	42.50
Total	100.13

- **Analyst:** J. Nelen



Backscatter SEM image



EDS spectrum

Locality

Brazil

Size fractions available

- > 0.25 mm
- 0.25 mm - 0.177 mm

References

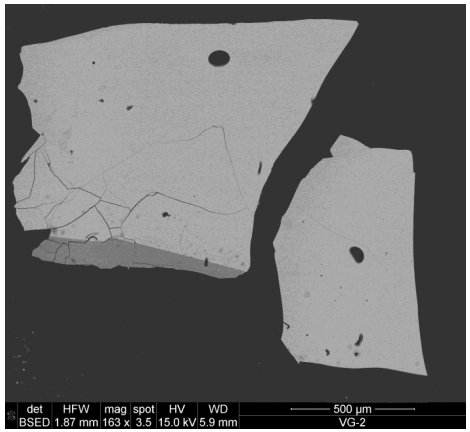
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Basaltic glass

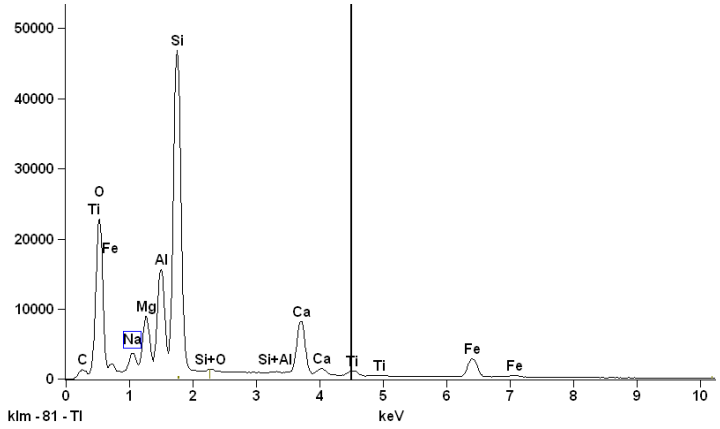
NMNH 111240-52, VG-2

Oxide	Composition (wt %)	Preferred (wt %)
SiO_2	50.81	50.81
Al_2O_3	14.06	14.06
Fe_2O_3	2.23	2.23
FeO	9.83	9.83
MgO	6.71	6.95
CaO	11.12	11.12
Na_2O	2.62	2.62
K_2O	0.19	0.19
TiO_2	1.85	1.85
P_2O_5	0.20	0.20
MnO	0.22	0.22
H_2O-	0.02	0.02
Total	99.86	100.10

- **Analyst:** E. Jarosewich
- **Notes:** The published MgO value for VG-2 is widely known to be low. We suggest 6.95 wt.% is a better working value based on hundreds of analyses of numerous grains from the original material. See Helz et al (2014).



Backscatter SEM image



EDS spectrum

Locality

Juan de Fuca Ridge

Size fractions available

- 1.0 mm - 2.0 mm
- > 0.350 mm

Impurities

- **Common:** Tiny olivine crystals
- **Rare:** Plagioclase (large crystal on one grain)

Notes

- Jenner and O'Neill (2012) analyzed this sample for a large suite of trace elements

References

Dixon, J.E., and Clague, D.A., 2001. Volatiles in basaltic glasses from Loihi Seamount,Hawaii: evidence for a relatively dry plume component. J. Petrol., 42:627–654

Dixon, J.E., Clague, D.A., and Stolper, E.M. (1991) Degassing history of water, sulfur and carbon in submarine lavas from Kilauea volcano, Hawaii, J. Geol., 99 (1991), pp. 371–394

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Jarosewich, E., et. al. (1979) Microprobe Analyses of Four Natural Glasses and One Mineral: An Interlaboratory Study of Precision and Accuracy. Smith Contr. Ear. Sci. 22, p. 53-67

Jego and Dasgupta (2014) The Fate of Sulfur During Fluid-Present Melting of Subducting Basaltic Crust at Variable Oxygen Fugacity. Journal of Petrology, 55, No. 6, 1019-1050

Jenner, F. E., and H. St. C. O'Neill (2012), Analysis of 60 elements in 616 ocean floor basaltic glasses, Geochem. Geophys. Geosyst., 13, Q02005, doi: 10.1029/2011GC004009

Gale, A. et. al. (2013) The Mean Composition of Ocean Ridge Basalts. Geochem. Geophys. Geosyst. 14, no 3, p. 489-518

Sulfur and chlorine content

Reference	S (wt %)	Cl (wt %)
Dixon et al. (1991)	0.1340	
Wallace and Carmichael (1992)	0.1320	
Thordarson (1996)	0.1348	
Thordarson (1996)	0.1365	
Metrich et al. (1998)	0.1430	
Dixon and Clague (2001)	0.127 ± 0.008	0.031
De Hoog (2001)	0.1416	
Wallace (2002)	0.1370	
Thornber et al. (2002)	0.1305	
M. Davis (pers. comm. ca. 2002)	0.1497 ± 0.0026 (2σ)	0.0315 ± 0.0025 (2σ)
Wallace and Roberge (2004)	0.147	
Sun et al. (2007)		0.029 ± 0.007
Self et al (2008) (MgO = 6.92)	0.141	
Bell et al. (2009)	0.1300	
Kamensky et al (2010)	0.140	
Jego and Dasgupta (2014)	0.161	
M. LeVoyer (pers. comm, 2014) n => 300, IONPROBE	0.1486 + 0.0056 (2σ)	
F. Jenner (2014, pers. comm. to E. Bullock) EPMA at ANU	0.1415 + 0.0068	

Additional references

Helz, R.T., Clague, D.A., Mastin, L.G., and Rose, T.R., 2014, Electron microprobe analyses of glasses from Kīlauea Tephra Units, Kīlauea Volcano, Hawaii: U.S. Geological Survey Open-File Report 2014–1090, 24 p., plus 2 appendixes in separate files, http://dx.doi.org/10.3133/ofr20141090

Sun, W.D., Binns, R.A., Fan, A.C., Kamenetsky, V.S., Wysoczanski, R., Wei, G.J., Hu, Y.H., and Arculus, R.J. (2007) Chlorine in submarine volcanic glasses from the eastern Manus basin. Geochimica et Cosmochimica Acta 71 (2007) 1542–1552

Thornber, C.R., Sherrod, D.R., Siems, D.F., Heliker, C.C., Meeker, G.P., Oscarson, R.L., and Kauahikaua, J.P., 2002, Whole-rock and glass major-element geochemistry of Kilauea Volcano, Hawaii, near-vent eruptive products; September 1994 through September 2001: U.S. Geological Survey, v. OF 02-0017

Kamenetsky, V.S., Gurenko, A.A., and Kerr, A.C. (2010) Composition and temperature of komatiite melts from Gorgona Island constrained from olivine-hosted melt inclusions. GSA Data Repository item 2010279

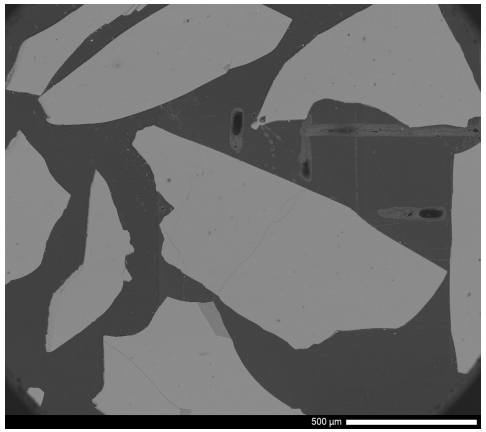
Wallace, P., and Carmichael, I.S.E., 1992. Sulfur in basaltic magmas. Geochim. Cosmochim. Acta, 56:1863–1874

Basaltic glass

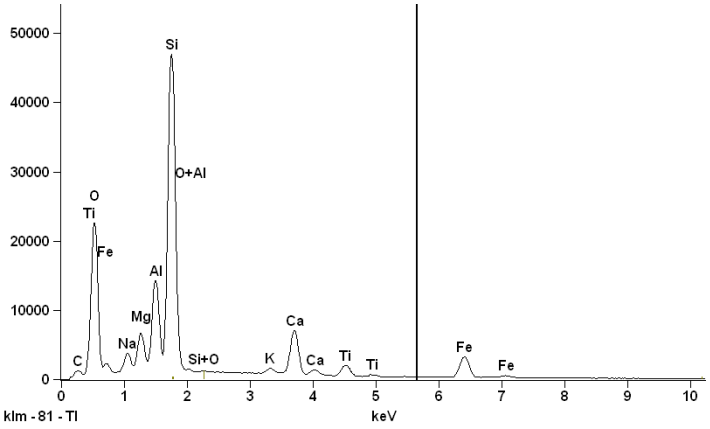
NMNH 113498-1, A-99

Oxide	Composition (wt %)
SiO_2	50.94
Al_2O_3	12.49
Fe_2O_3	1.87
FeO	11.62
MgO	5.08
CaO	9.30
Na_2O	2.66
K_2O	0.82
TiO_2	4.06
P_2O_5	0.38
MnO	0.15
H_2O	0.02
Total	99.39

- **Analyst:** J. Norberg



Backscatter SEM image



EDS spectrum

Locality

Makaopuhi Lava Lake, Hawaii, USA

Size fractions available

- 2.0 mm - 0.841 mm
- 1.0 mm - 0.5 mm
- 0.840 mm - 0.42 mm

Impurities

- **Common:** Tiny plagioclase crystals
- **Rare:** Tiny clinopyroxene crystals

References

Bell et al. (2009)

De Hoog (2001)

Dixon, J.E., Clague, D.A., and Stolper, E.M. (1991) Degassing history of water, sulfur and carbon in submarine lavas from Kilauea volcano, Hawaii, J. Geol., 99 (1991), pp. 371–394

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Jarosewich, E., et. al. (1979) Microprobe Analyses of Four Natural Glasses and One Mineral: An Interlaboratory Study of Precision and Accuracy. Smith Contr. Ear. Sci. 22, p. 53-67

Jego and Dasgupta (2014) The Fate of Sulfur During Fluid-Present Melting of Subducting Basaltic Crust at Variable Oxygen Fugacity. Journal of Petrology, 55, No. 6, 1019-1050

Thordarson (1996)

Sulfur content

Reference	S (wt%)
Dixon et al. (1991)	0.0170
Thordarson (1996)	0.0135
Thordarson (1996)	0.0220
De Hoog (2001)	0.0177
Thornber et al. (2002)	0.0096
Witter et al. (2005)	0.0138
Bell et al. (2009)	0.0155
Jego and Dasgupta (2014)	0.016
M. LeVoyer (pers. comm., 2014) n => 300, IONPROBE	0.0143 ± 0.0010 (2σ)

Additional references

Thornber, C.R., Sherrod, D.R., Siems, D.F., Heliker, C.C., Meeker, G.P., Oscarson, R.L., and Kauahikaua, J.P., 2002, Whole-rock and glass major-element geochemistry of Kilauea Volcano, Hawaii, near-vent eruptive products; September 1994 through September 2001: U.S. Geological Survey, v. OF 02-0017

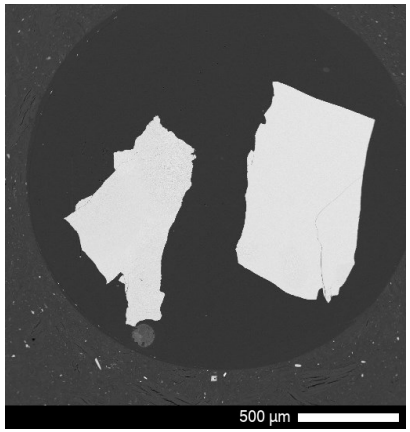
Witter et al. (2005)

Basaltic glass

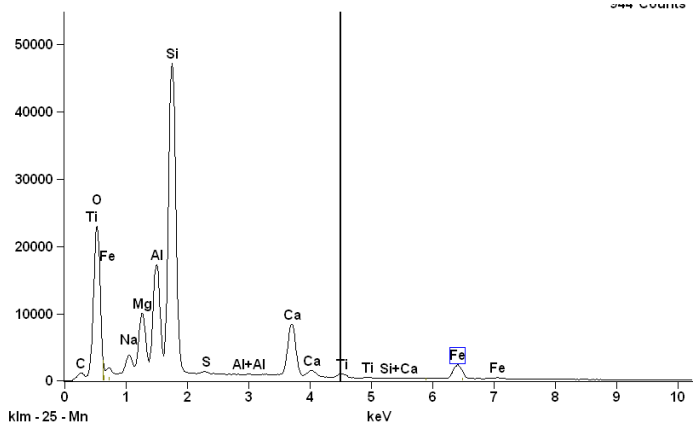
NMNH 113716-1

Oxide	Composition (wt %)
SiO_2	51.52
Al_2O_3	15.39
Fe_2O_3	1.12
FeO	8.12
MgO	8.21
CaO	11.31
Na_2O	2.48
K_2O	0.09
TiO_2	1.30
P_2O_5	0.12
MnO	0.17
H_2O	0.18
S	0.12
Subtotal	100.13
Total	100.07

- **Analyst:** J. Norberg
- **Notes:** O equivalent to S = 0.06



Backscatter SEM image



EDS spectrum

Locality

Indian Ocean

Size fractions available

- 1.0 mm - 0.5 mm

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

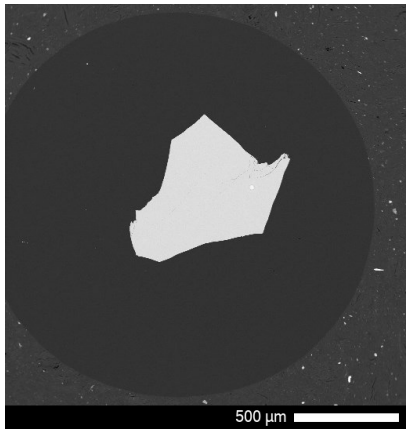
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Corning Glass A

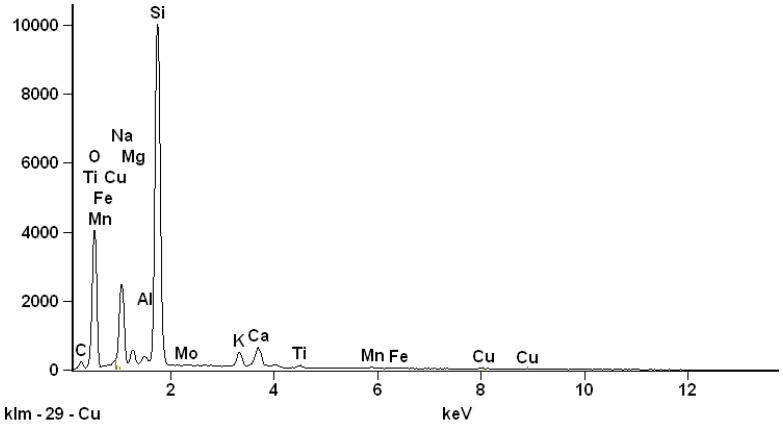
NMNH 117218-4

Oxide	Composition (wt %)
SiO_2	66.56
Al_2O_3	1.00
Fe_2O_3	1.09
MgO	2.66
CaO	5.03
Na_2O	14.30
K_2O	2.87
MnO	1.00
P_2O_5	0.13
TiO_2	0.79
Sb_2O_5	1.75
CuO	1.17
PbO	0.12
CoO	0.17
BaO	0.56
SnO_2	0.19
SrO	0.10
ZnO	0.044
B_2O_3	0.20
Li_2O	0.01
Cl	0.10
SO_3	0.10
Rb_2O	0.01
V_2O_5	0.006
Cr_2O_3	0.001
NiO	0.02
ZrO_2	0.005
Ag_2O	0.002
Bi_2O_3	0.001
Total	99.99

- **Analyst:** Vicenzi et al. (2002)
- **Notes:** Vicenzi et al (2002) gives the total as 99.94



Backscatter SEM image



EDS spectrum

Locality

None (synthetic)

Size fractions available

- 1.0 mm - 2 mm
- 1.0 mm - 0.5 mm
- 0.50 mm - 0.25 mm

Notes

- Large grains and a significant quantity make this material suitable for large area destructive techniques

References

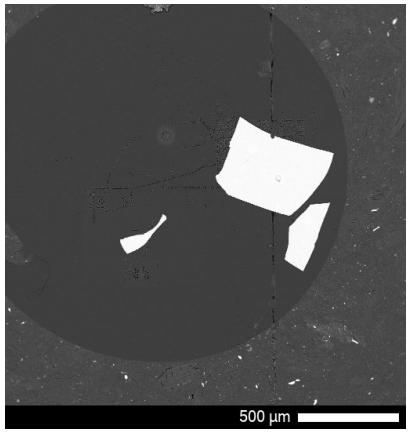
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. J. of Res. NIST, 107, p. 719-727.

Corning Glass B

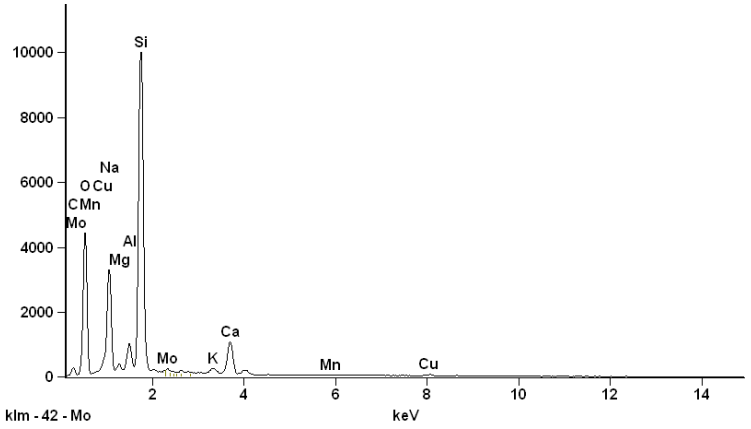
NMNH 117218-1

Oxide	Composition (wt %)
SiO_2	61.55
Al_2O_3	4.36
Fe_2O_3	0.34
MgO	1.03
CaO	8.56
Na_2O	17.00
K_2O	1.00
MnO	0.25
P_2O_5	0.82
TiO_2	0.089
Sb_2O_5	0.46
CuO	2.66
PbO	0.61
CoO	0.046
BaO	0.12
SnO_2	0.04
SrO	0.019
ZnO	0.19
B_2O_3	0.02
Li_2O	0.001
Cl	0.20
SO_3	0.50
Rb_2O	0.001
V_2O_5	0.03
Cr_2O_3	0.005
NiO	0.10
ZrO_2	0.025
Ag_2O	0.01
Bi_2O_3	0.005
Total	100.04

- **Analyst:** Vicenzi et al. (2002)
- **Notes:** Vicenzi et al (2002) gives the total as 99.87



Backscatter SEM image



EDS spectrum

Locality

None (synthetic)

Size fractions available

- Cubes that can be chipped
- 2.0 mm - 1.0 mm
- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm

Notes

- In addition to sizes above, small bricks of this material greater than 1 cm in thickness along with a large quantity make this material suitable for large area destructive techniques

References

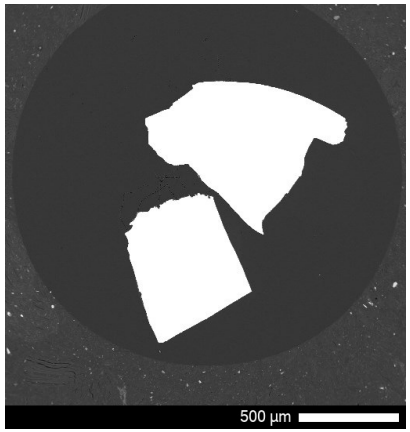
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. J. of Res. NIST, 107, p. 719-727.

Corning Glass C

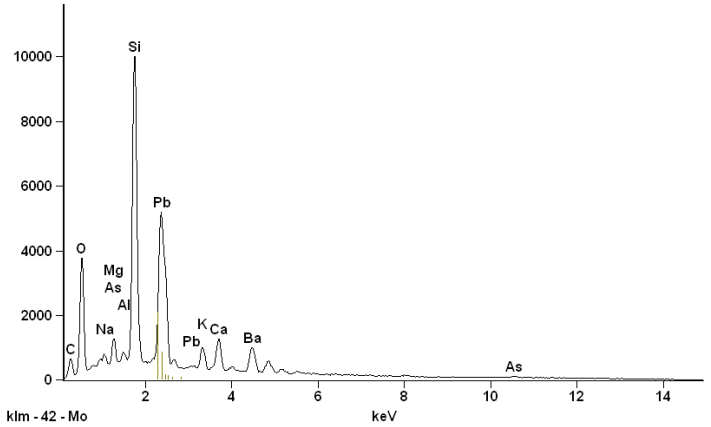
NMNH 117218-2

Oxide	Composition (wt %)
SiO_2	34.87
Al_2O_3	0.87
Fe_2O_3	0.34
MgO	2.76
CaO	5.07
Na_2O	1.07
K_2O	2.84
MnO	0.82
P_2O_5	0.14
TiO_2	0.79
Sb_2O_5	0.03
CuO	1.13
PbO	36.70
CoO	0.18
BaO	11.40
SnO_2	0.19
SrO	0.29
ZnO	0.052
B_2O_3	0.20
Li_2O	0.01
Cl	0.10
SO_3	0.10
Rb_2O	0.01
V_2O_5	0.006
Cr_2O_3	0.001
NiO	0.02
ZrO_2	0.005
Ag_2O	0.002
Bi_2O_3	0.001
Total	100.00

- **Analyst:** Vicenzi et al. (2002)
- **Notes:** Vicenzi et al (2002) gives the total as 99.95



Backscatter SEM image



EDS spectrum

Locality

None (synthetic)

Size fractions available

- Cubes that can be chipped
- 2.0 mm - 1.0 mm
- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm

Notes

- In addition to sizes above, small bricks of this material greater than 1 cm in thickness along with a large quantity make this material suitable for large area destructive techniques.

References

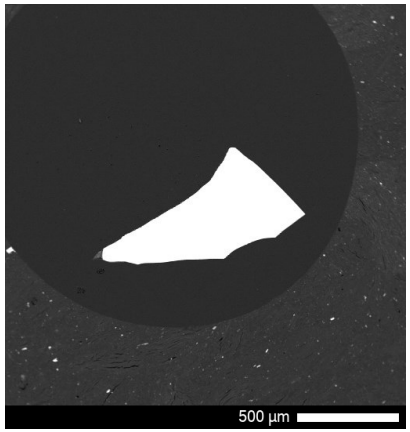
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. J. of Res. NIST, 107, p. 719-727.

Corning Glass D

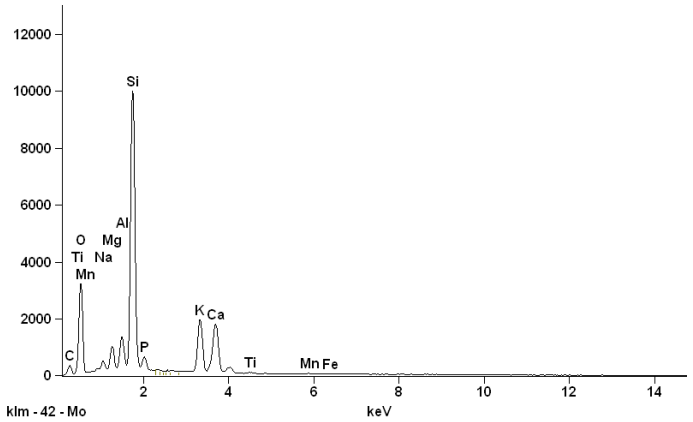
NMNH 117218-3

Oxide	Composition (wt %)
SiO_2	55.24
Al_2O_3	5.30
Fe_2O_3	0.52
MgO	3.94
CaO	14.80
Na_2O	1.20
K_2O	11.30
MnO	0.55
P_2O_5	3.93
TiO_2	0.38
Sb_2O_5	0.97
CuO	0.38
PbO	0.48
CoO	0.023
BaO	0.51
SnO_2	0.10
SrO	0.057
ZnO	0.10
B_2O_3	0.10
Li_2O	0.005
Cl	0.40
SO_3	0.30
Rb_2O	0.005
V_2O_5	0.015
Cr_2O_3	0.0025
NiO	0.05
ZrO_2	0.0125
Ag_2O	0.005
Bi_2O_3	0.0025
Total	100.68

- **Analyst:** Vicenzi et al. (2002)
- **Notes:** Vicenzi et al (2002) gives the total as 100.59



Backscatter SEM image



EDS spectrum

Locality

None (synthetic)

Size fractions available

- Cubes that can be chipped
- 2.0 mm - 1.0 mm
- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm

Notes

- In addition to sizes above, small bricks of this material greater than 1 cm in thickness along with a large quantity make this material suitable for large area destructive techniques

References

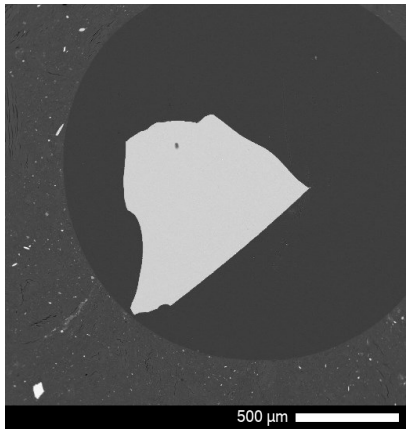
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. J. of Res. NIST, 107, p. 719-727.

Corning Glass IR-V

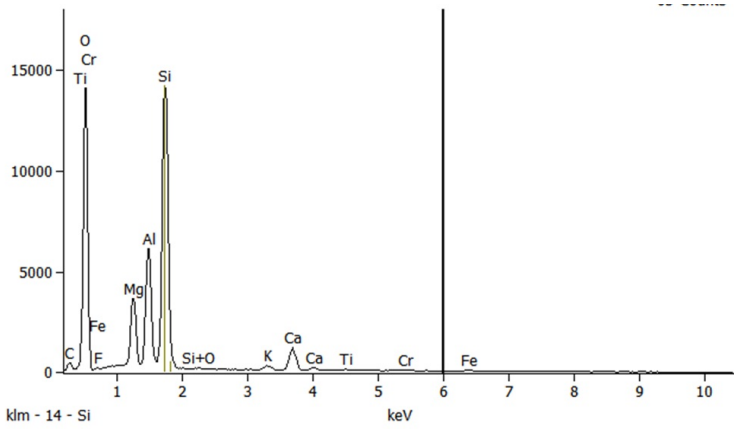
NMNH 117083

Oxide	Composition (wt %)
B_2O_3	4.44
Na_2O	0.018
MgO	8.82
Al_2O_3	18.46
SiO_2	57.49
K_2O	0.792
CaO	6.41
TiO_2	0.787
V_2O_3	0.001
Cr_2O_3	0.747
MnO	0.005
FeO	0.744
CoO	0.001
NiO	0.011
CuO	0.002
ZnO	0.004
SrO	0.080
Y_2O_3	0.007
ZrO_2	0.027
BaO	0.016
La_2O_3	0.002
Ce_2O_3	0.760
HfO_2	0.744
PbO	0.007
ThO_2	0.012
Total	100.39

- **Analyst:** Carpenter et al. (2002)



Backscatter SEM image



EDS spectrum

Locality

None (synthetic)

Size fractions available

- 1.68 mm - 0.707 mm
- 0.710 mm - 0.500 mm

Notes

- A large quantity of this material exists in 6.5 mm diameter rods making it suitable for large area destructive analysis.

References

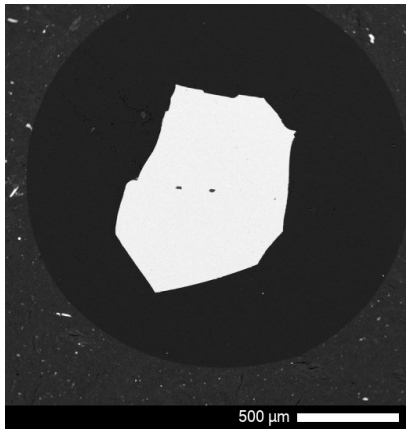
Carpenter, P. et. al. (2002) Characterization of Corning EPMA Standard Glasses 95IRV, 95IRW, and 95IRX. J. of Res. NIST, 107, p. 703-718

Corning Glass IR-W

NMNH 117084

Oxide	Composition (wt %)
B_2O_3	4.39
Na_2O	<0.003
MgO	8.71
Al_2O_3	18.12
SiO_2	56.68
P_2O_5	<0.005
K_2O	0.004
CaO	6.39
TiO_2	0.008
V_2O_3	0.638
Cr_2O_3	0.002
MnO	0.637
FeO	0.084
CoO	0.734
NiO	0.005
CuO	0.700
ZnO	0.008
SrO	0.044
Y_2O_3	0.009
ZrO_2	0.007
Cs_2O	0.710
BaO	0.776
La_2O_3	0.783
HfO_2	0.003
PbO	0.006
ThO_2	0.838
UO_2	0.001
Total	100.295

- **Analyst:** Carpenter et al. (2002)
- **Notes:** Total in Carpenter is 100.32



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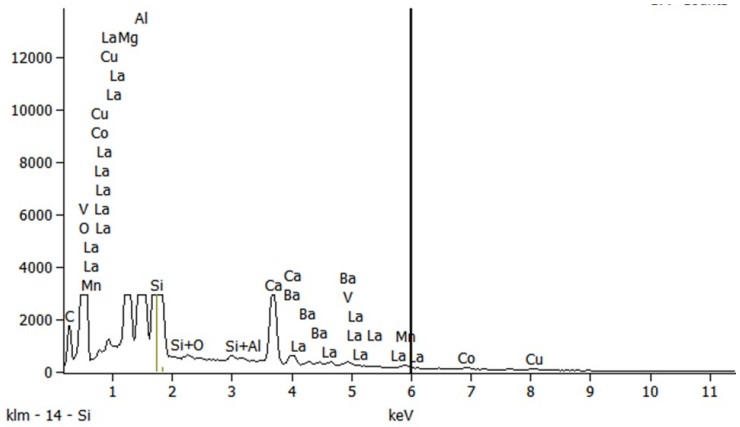


EDS spectrum

Locality

None (synthetic)

Size fractions available

- Rods that can be chipped
- 1.00 mm - 0.710 mm
- 0.710 mm - 0.500 mm

Notes

- A large quantity of this material exists in 6.5 mm diameter rods making it suitable for large area destructive analysis.

References

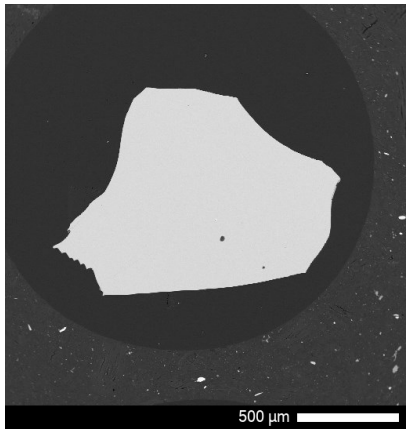
Carpenter, P. et. al. (2002) Characterization of Corning EPMA Standard Glasses 95IRV, 95IRW, and 95IRX. J. of Res. NIST, 107, p. 703-718

Corning Glass IR-X

NMNH 117085

Oxide	Composition (wt %)
B_2O_3	4.35
MgO	8.57
Al_2O_3	18.04
SiO_2	57.23
P_2O_5	<0.006
K_2O	0.028
CaO	6.34
TiO_2	0.006
V_2O_3	0.003
Cr_2O_3	0.001
MnO	0.005
FeO	0.063
CoO	0.004
NiO	0.730
CuO	0.005
ZnO	0.787
Rb_2O	0.494
SrO	0.762
Y_2O_3	0.851
ZrO_2	0.789
BaO	0.017
La_2O_3	0.004
HfO_2	0.019
PbO	0.754
ThO_2	0.016
UO_2	0.754
Total	100.628

- **Analyst:** Carpenter et al. (2002)
- **Notes:** Published total is 100.60. B2O3 value of 4.35 wt. % was left out of Table 7 in reference paper (personal communication with P. Carpenter, 2013).



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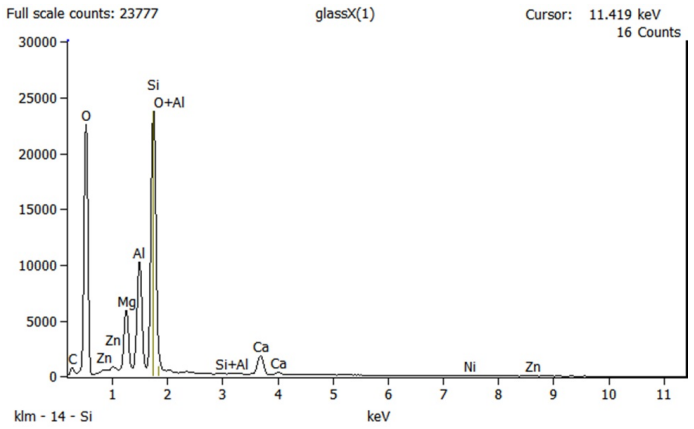


EDS spectrum

Locality

None (synthetic)

Size fractions available

- Rods that can be chipped
- 1.68 mm - 0.710 mm
- 0.710 mm - 0.500 mm

Notes

- A large quantity of this material exists in 6.5 mm diameter rods making it suitable for large area destructive analysis.

References

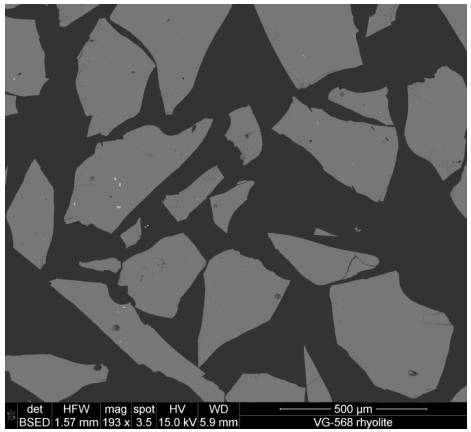
Carpenter, P. et. al. (2002) Characterization of Corning EPMA Standard Glasses 95IRV, 95IRW, and 95IRX. J. of Res. NIST, 107, p. 703-718

Rhyolitic glass

NMNH 72854, VG 568

Oxide	Composition (wt %)
SiO_2	76.71
Al_2O_3	12.06
Fe_2O_3	0.48
FeO	0.80
MgO	<0.10
CaO	0.50
Na_2O	3.75
K_2O	4.89
TiO_2	0.12
P_2O_5	<0.01
MnO	0.03
H_2O	0.12
Cl	0.13
Subtotal	99.59
Total	99.56

- **Analyst:** J. Norberg
- **Notes:** O equivalent to Cl = 0.03



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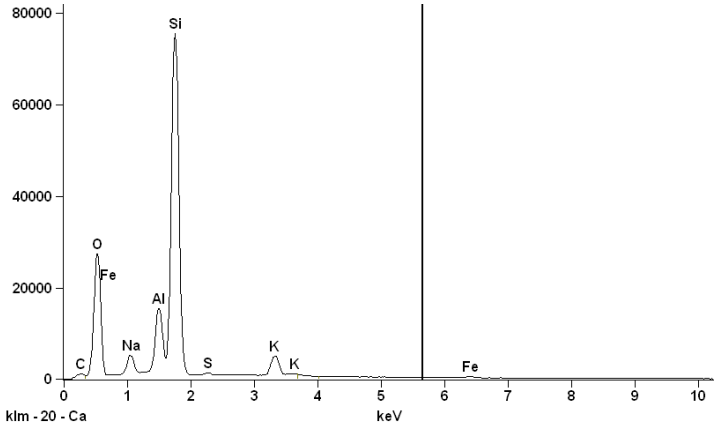


EDS spectrum

Locality

Yellowstone National Park, Wyoming, USA

Size fractions available

- 1.0 mm - 2.0 mm
- 0.42 mm - 0.25 mm
- 0.25 mm - 0.149 mm

Impurities

- **Common:** 5 µm crystals of iron oxide

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

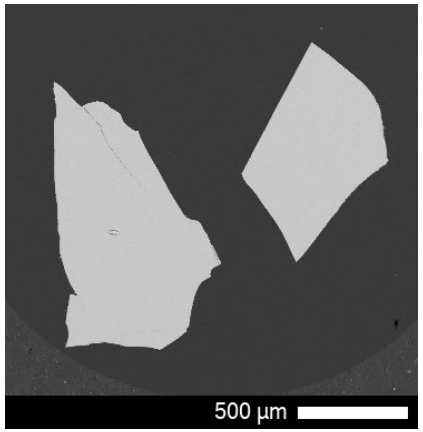
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Tektite glass

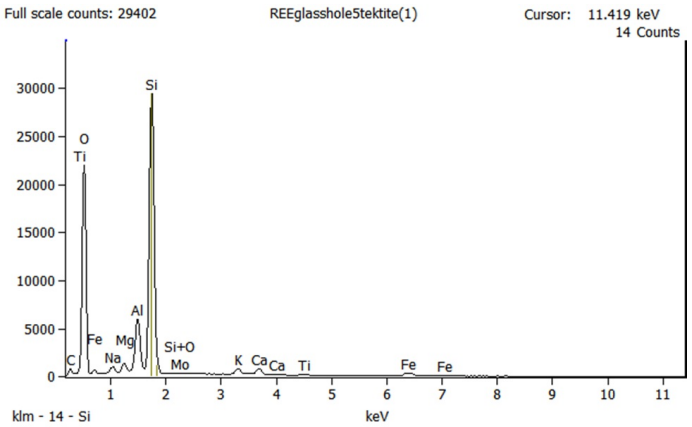
USNM 2213

Oxide	Composition (wt %)
SiO_2	75.75
Al_2O_3	11.34
Fe_2O_3	0.64
FeO	4.32
MgO	1.51
CaO	2.66
Na_2O	1.06
K_2O	1.88
TiO_2	0.50
P_2O_5	0.00
MnO	0.11
H_2O	0.10
Cl	0.00
F	0.01
Total	99.88

- **Analyst:** USGS Geochemistry and Petrology Branch



Backscatter SEM image



EDS spectrum

Locality

None (synthetic)

Size fractions available

- 1.00 - 0.5 mm
- 0.50 - 0.25 mm

Notes

- Prepared by Corning Labs

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

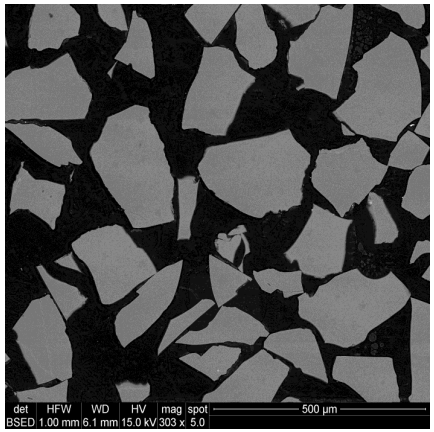
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Grossular garnet

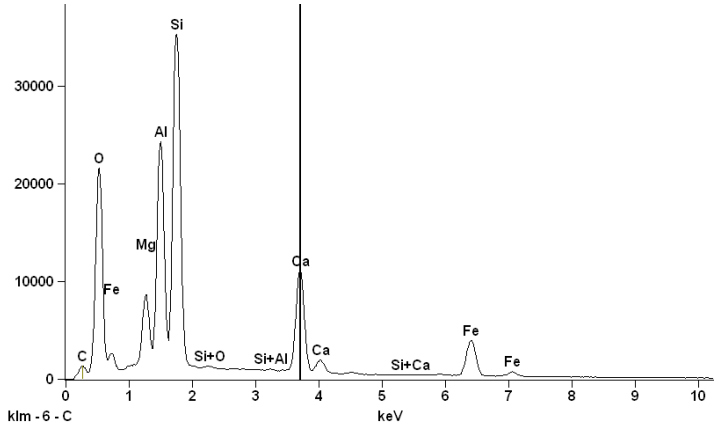
NMNH 87375

Oxide	Composition (wt %)
SiO_2	39.47
Al_2O_3	22.27
Fe_2O_3	2.77
FeO	13.76
MgO	6.55
CaO	14.39
TiO_2	0.39
MnO	0.59
H_2O	<0.01
Total	100.19

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Roberts Victor Mine, South Africa

Size fractions available

- 0.125 mm - ~0.088 mm

Notes

- The amount of this material remaining is very small. We are now distributing material from a vial labeled "small impurities." There are rare black grains visible under the microscope that have yet to be identified.

References

Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. Smithsonian Contributions to the Earth Sciences 9, 83-84

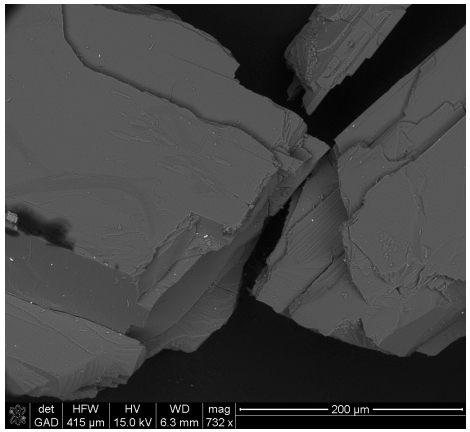
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Arenal hornblende

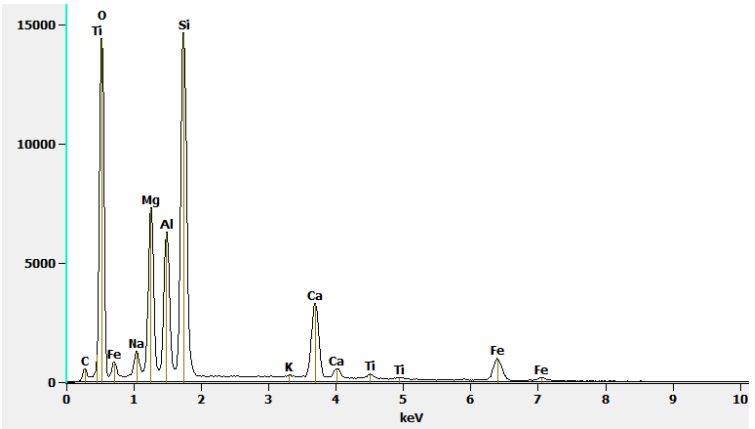
NMNH 111356

Oxide	Composition (wt %)
SiO_2	41.46
Al_2O_3	15.47
Fe_2O_3	5.60
FeO	6.43
MgO	14.24
CaO	11.55
Na_2O	1.91
K_2O	0.21
TiO_2	1.41
P_2O_5	<0.01
MnO	0.15
H_2O	1.21
Total	99.64

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Arenal Volcano, Costa Rica

Size fractions available

- 0.5 mm - 0.25 mm
- 0.25 mm - 0.149 mm
- 0.149 mm - 0.074 mm

Notes

- This note was distributed by Gene Jarosewich with a number of reference materials:

> Based on our experience the oxides in the standards listed below may give inferior results. Other oxides in the same standards give excellent results. Al2O3 hornblende, Arenal volcano

References

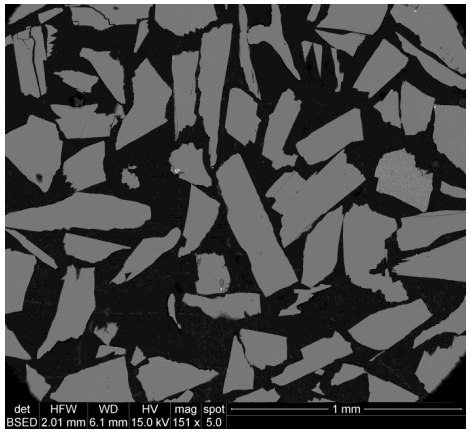
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Kakanui hornblende

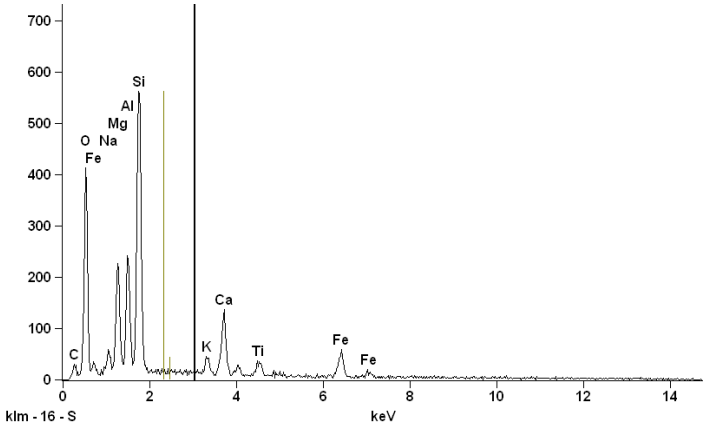
NMNH 143965

Oxide	Composition (wt %)
SiO_2	40.37
Al_2O_3	14.90
Fe_2O_3	3.30
FeO	7.95
MgO	12.80
CaO	10.30
Na_2O	2.60
K_2O	2.05
TiO_2	4.72
P_2O_5	0.00
MnO	0.09
H_2O	0.94
Total	100.02

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Kakanui, New Zealand

Size fractions available

- 0.590 mm - 0.420 mm
- > 0.420 mm
- 0.420 mm - 0.297 mm
- 0.420 mm - 0.250 mm
- 0.297 mm - 0.177 mm
- 0.250 mm - 0.177 mm
- 0.177 mm - 0.125 mm

Impurities

- **Abundant:** FeTi oxide (complex melt(?) inclusions with tiny oxide crystals)
- **Rare:** FeTi oxide (larger individual crystals)

References

Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. Smithsonian Contributions to the Earth Sciences 9, 83-84

Jarosewich, E., et. al. (1979) Microprobe Analyses of Four Natural Glasses and One Mineral: An Interlaboratory Study of Precision and Accuracy. Smith Contr. Ear. Sci. 22, p. 53-67

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

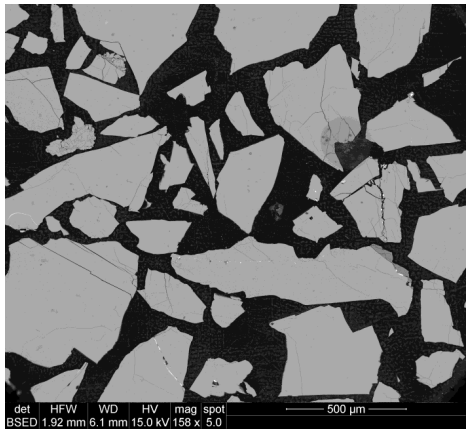
Mason, B. (1966) Pyrope, augite and hornblende from Kakanui, New Zealand. J. Geol. Geophys. 9 (4), p. 474-480

Hypersthene

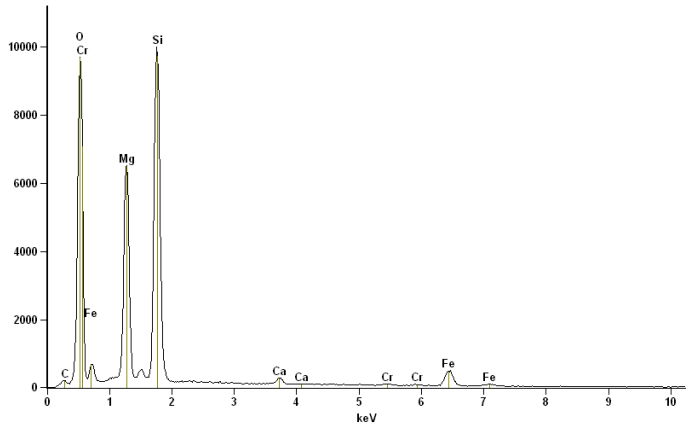
USNM 746

Oxide	Composition (wt %)
SiO_2	54.09
Al_2O_3	1.23
FeO	15.22
MgO	26.79
CaO	1.52
Na_2O	<0.05
K_2O	<0.05
TiO_2	0.16
Cr_2O_3	0.75
MnO	0.49
H_2O	0.00
Total	100.25

- **Analyst:** J. Norberg



Backscatter SEM image



EDS spectrum

Locality

Johnstown (meteorite)

Size fractions available

- Unsized crushed material

Impurities

- **Common:** Chromite veins and included crystals

Notes

- This material is no longer available
- This note was distributed by Gene Jarosewich with a number of reference materials:

> Based on our experience the oxides in the standards listed below may give inferior results. Other oxides in the same standards give excellent results. Al2O3, CaO Johnstown Hypersthene

References

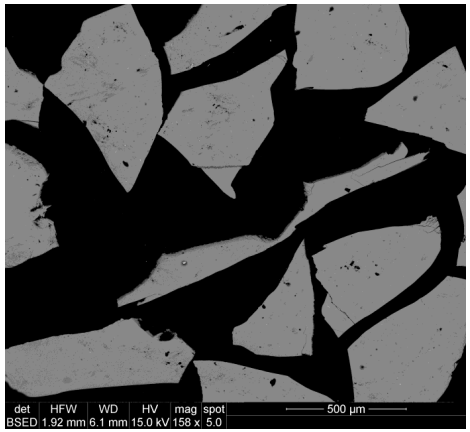
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Ilmenite

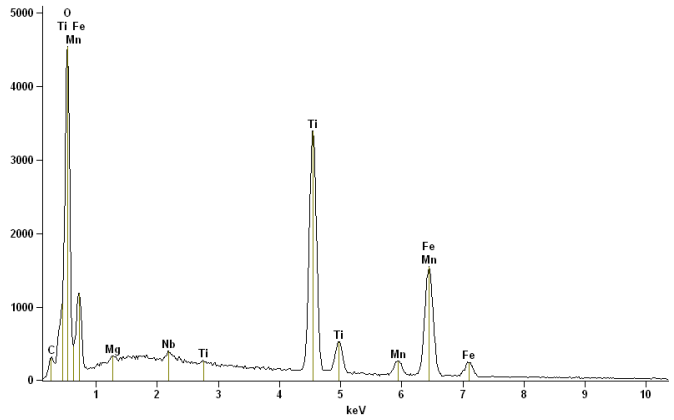
NMNH 96189

Oxide	Composition (wt %)
Fe_2O_3	11.60
FeO	36.10
MgO	0.31
TiO_2	45.70
MnO	4.77
nB_2O_5	0.92
Total	99.40

- **Analysts:** D. Mills, J. Nelen, and J. Norberg



Backscatter SEM image



EDS spectrum

Locality

Ilmen Mountains, Russia

Size fractions available

- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm
- 0.25 mm - 0.177 mm

Impurities

- **Common:** NbFeTi oxide (tiny)
- **Rare:** Nb and Zn phases

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

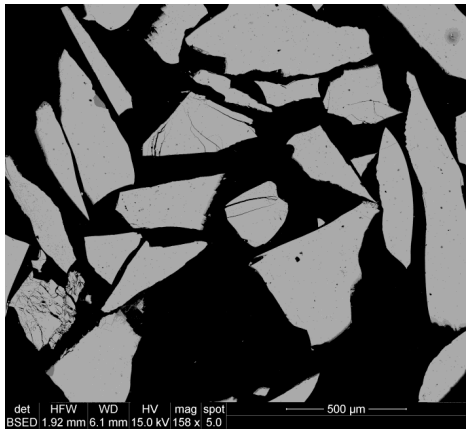
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Magnetite

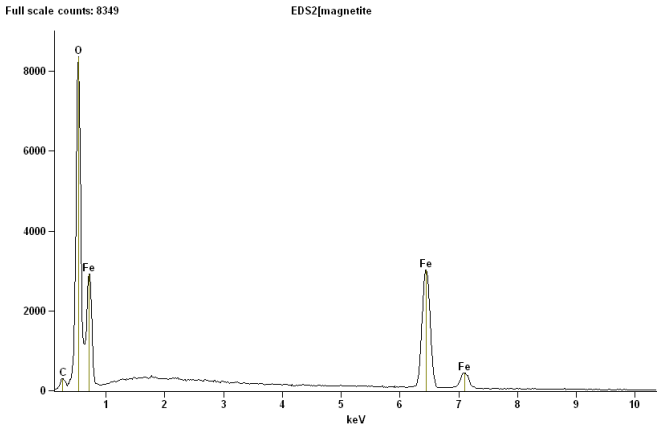
NMNH 114887

Oxide	Composition (wt %)
Fe_2O_3	67.50
FeO	30.20
MgO	0.05
TiO_2	0.16
MnO	<0.01
Cr_2O_3	0.25
Total	98.16

- **Analyst:** J. Norberg



Backscatter SEM image



EDS spectrum

Locality

Minas Gerais, Brazil

Size fractions available

- 1.0 mm - 0.5 mm
- 0.5 mm - 0.25 mm
- 0.25 mm - 0.177 mm
- < 0.177 mm

Impurities

- **Rare:** Ilmenite

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

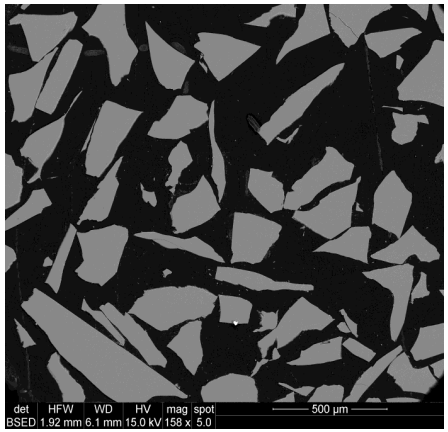
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Meionite

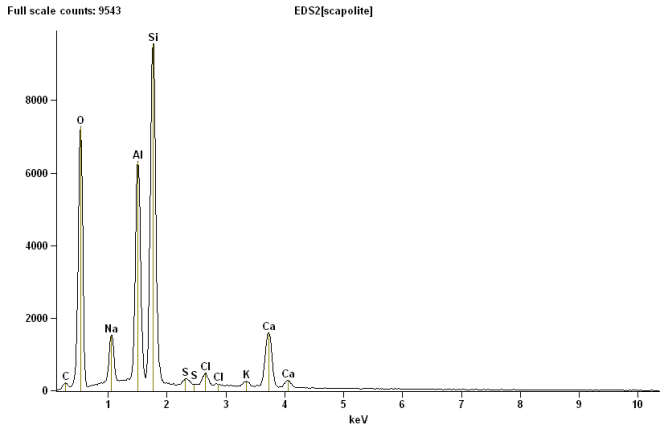
NMNH R6600

Oxide	Composition (wt %)
SiO_2	49.78
Al_2O_3	25.05
FeO	0.17
CaO	13.58
Na_2O	5.20
K_2O	0.94
H_2O	0.21
Co_2	2.50
SO_3	1.32
Cl	1.43
Subtotal	100.18
Total	99.86

- **Analyst:** J. Nelen
- **Notes:** O equivalent to Cl = 0.32



Backscatter SEM image



EDS spectrum

Locality

Brazil

Size fractions available

- 0.25 mm - 0.177 mm
- > 0.177 mm

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

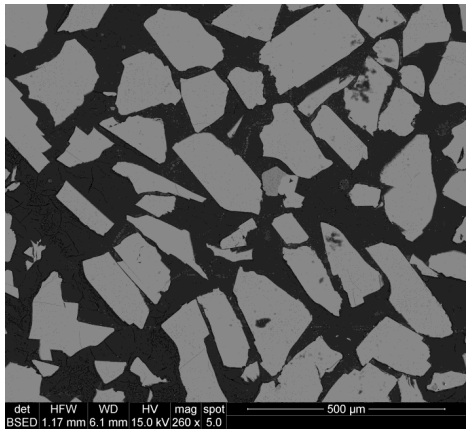
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Microcline

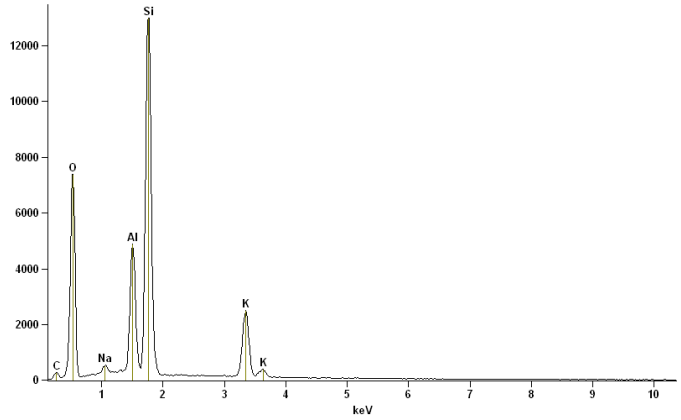
NMNH 143966

Oxide	Composition (wt %)
SiO_2	64.24
Al_2O_3	18.30
Fe_2O_3	0.00
FeO	0.04
MgO	0.03
CaO	0.02
Na_2O	1.30
K_2O	15.14
TiO_2	0.01
MnO	0.04
Total	99.12

- **Analyst:** E. Kiss



Backscatter SEM image



EDS spectrum

Locality

Unknown

Size fractions available

- 0.177 mm - 0.125 mm
- 0.125 mm - 0.066 mm

Impurities

- **Rare:** Albite inclusions

References

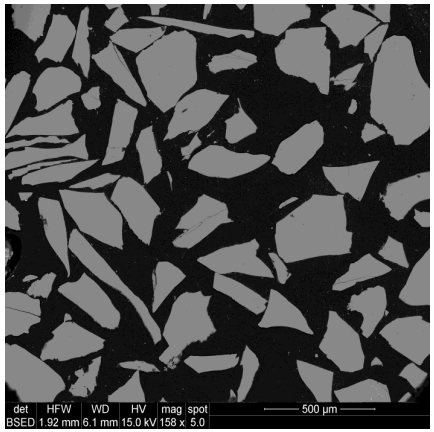
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

San Carlos olivine

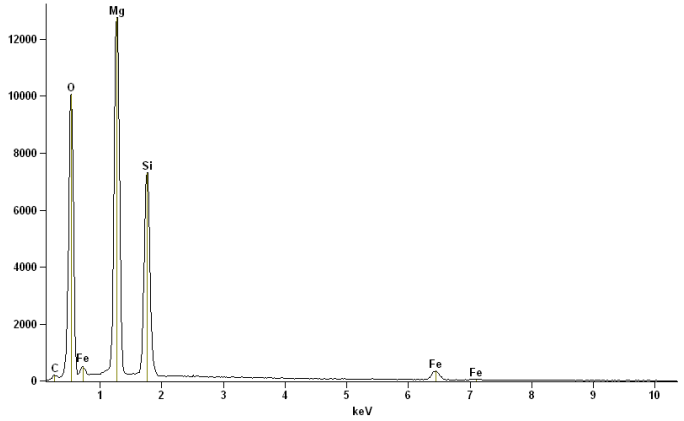
NMNH 111312-44

Oxide	Composition (wt %)
SiO_2	40.81
FeO	9.55
MgO	49.42
CaO	<0.05
P_2O_5	0.00
MnO	0.14
NiO	0.37
Total	100.29

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

San Carlos, Arizona, USA

Size fractions available

- 0.25 mm - 0.177 mm

Notes

- See Fournelle (2011) for detailed compositional variability
- This standard has been published widely under incorrect catalog numbers, including NMNH 11312-44, NMNH 111312-444, and NMNH 1113122-444. The correct catalog number is NMNH 111312-44.

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

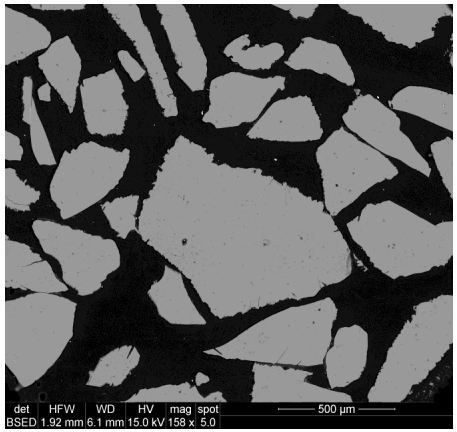
Fournelle, John H. (2011) An Investigation of "San Carlos Olivine": Comparing USNM-distributed Material with Commercially Available Material. Microsc. Microanal. 17 (Suppl 2), pp. 842-843. (doi:10.1017/S1431927611005083)

Springwater olivine

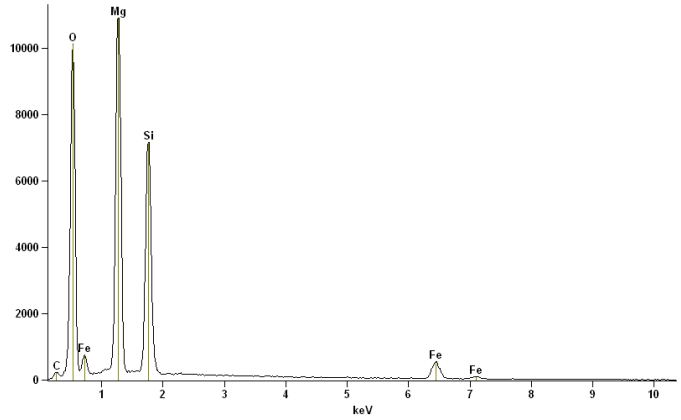
USNM 2566

Oxide	Composition (wt %)
SiO_2	38.95
FeO	16.62
MgO	43.58
MnO	0.30
Cr_2O_3	0.02
H_2O	<0.05
Total	99.47

- **Analyst:** J. Norberg



Backscatter SEM image



EDS spectrum

Locality

Springwater (meteorite)

Size fractions available

- 0.42 mm - 0.25 mm
- > 0.25 mm

Notes

- This note was distributed by Gene Jarosewich with a number of reference materials:

  > Based on our experience the oxides in the standards listed below may give inferior results. Other oxides in the same standards give excellent results. SiO2: Springwater Olivine

- Recently a phosphorus-rich portion of a grain was found in a Smithsonian mount. The phosphorus rich area has a sharp boundary with the rest of the grain and contains approximately 8 wt. % P2O5.

References

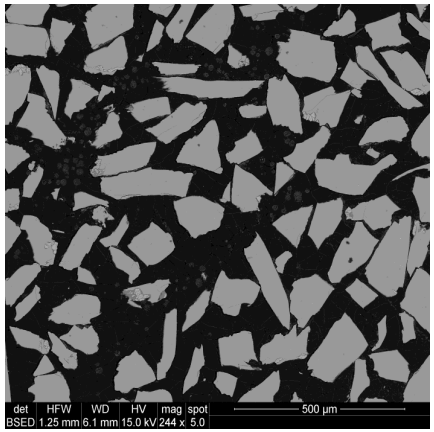
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Omphacite

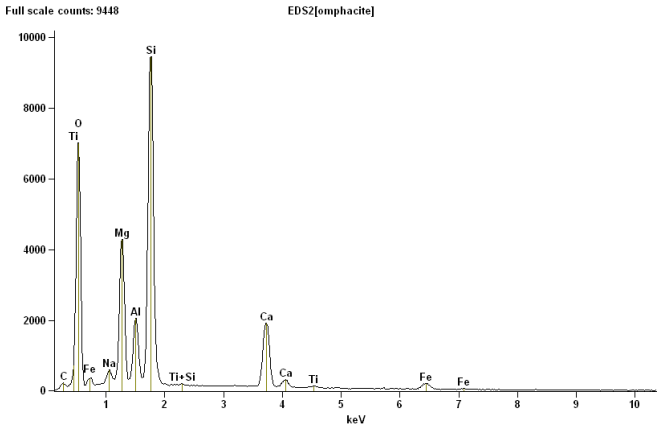
NMNH 110607

Oxide	Composition (wt %)
SiO_2	55.42
Al_2O_3	8.89
Fe_2O_3	1.35
FeO	3.41
MgO	11.57
CaO	13.75
Na_2O	5.00
K_2O	0.15
TiO_2	0.37
MnO	0.10
H_2O	0.02
Total	100.03

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Roberts Victor Mine, South Africa

Size fractions available

- Fragments of variable size

Impurities

- **Common:** Different CaNaMgAl silicate enclosed in jadeite

References

Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. Smithsonian Contributions to the Earth Sciences 9, 83-84

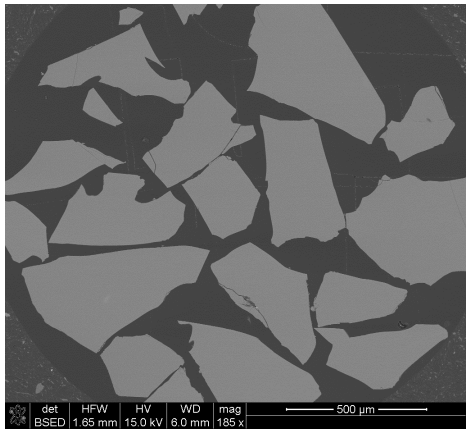
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Osumulite

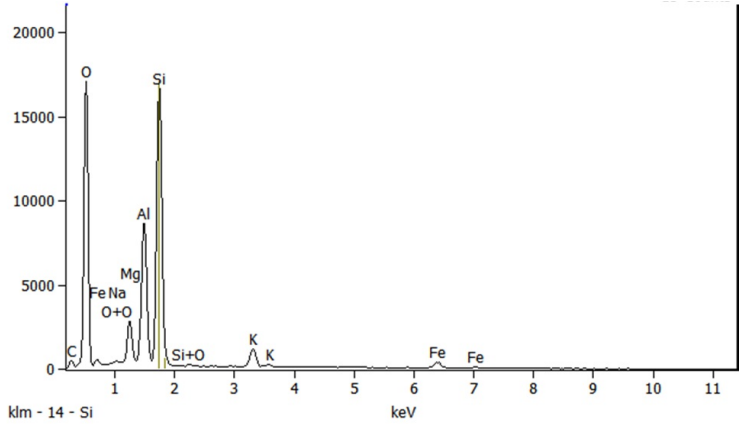
NMNH 143967

Oxide	Composition (wt %)
SiO_2	60.20
Al_2O_3	22.60
FeO	6.38
MgO	5.83
CaO	<0.03
Na_2O	0.39
K_2O	4.00
TiO_2	0.18
H_2O	0.02
Total	99.60

- **Analyst:** Jarosewich et al. (1980)



Backscatter SEM image



EDS spectrum

Locality

Nain, Newfoundland and Labrador, Canada

Size fractions available

- fragments of unknown size

References

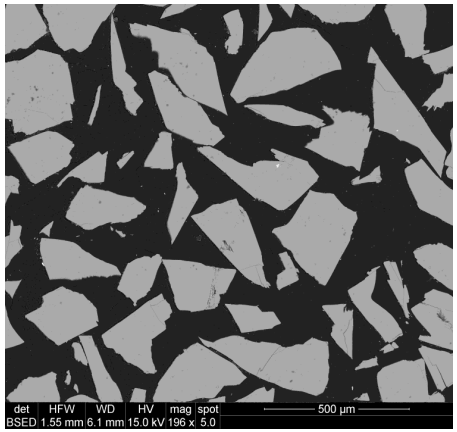
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Plagioclase

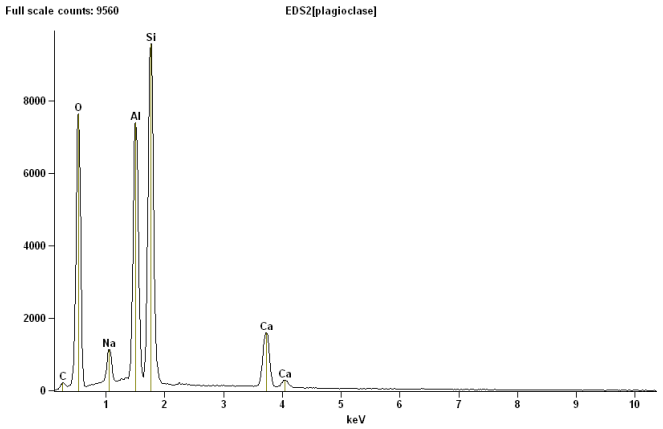
NMNH 115900

Oxide	Composition (wt %)
SiO_2	51.25
Al_2O_3	30.91
Fe_2O_3	0.34
FeO	0.15
MgO	0.14
CaO	13.64
Na_2O	3.45
K_2O	0.18
TiO_2	0.05
MnO	0.01
H_2O	0.05
Total	100.17

- **Analyst:** J. J. Fahey and L. C. Peck



Backscatter SEM image



EDS spectrum

Locality

Lake County, Oregon, United States

Size fractions available

- > 0.149 mm

References

Stewart, D.B., Walker, G.W., Wright, T.L., Fahey, J.J.(1966) Physical Properties of calcic Labradorite from Lake County, Oregon; American Mineralogist 51, 177-197

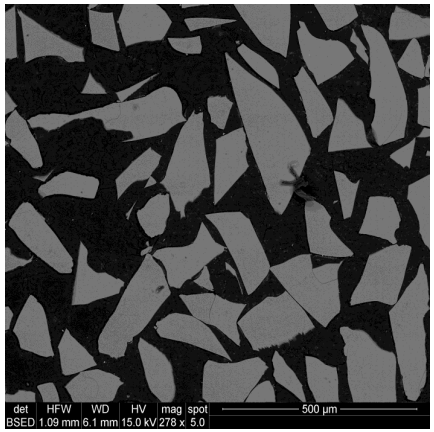
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Pyrope

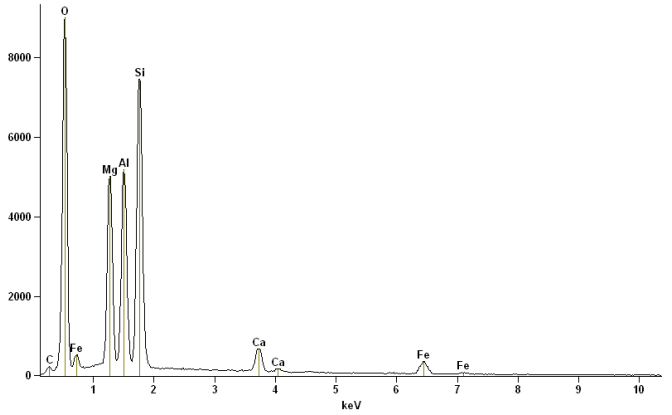
NMNH 143968

Oxide	Composition (wt %)
SiO_2	41.46
Al_2O_3	23.73
FeO	10.68
MgO	18.51
CaO	5.17
TiO_2	0.47
MnO	0.28
H_2O	<0.01
Total	100.30

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Kakanui, New Zealand

Size fractions available

- 0.840 mm - 0.590 mm
- 0.590 mm - 0.420 mm
- 0.420 mm - 0.297 mm
- 0.297 mm - 0.250 mm

References

Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. Smithsonian Contributions to the Earth Sciences 9, 83-84

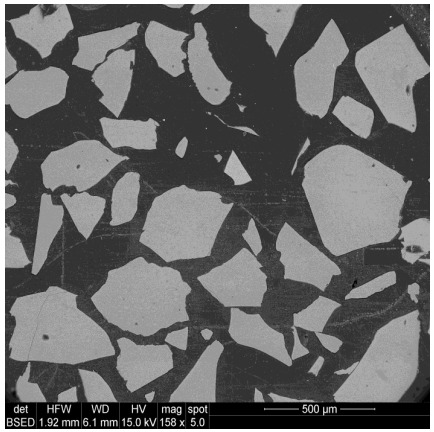
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Quartz

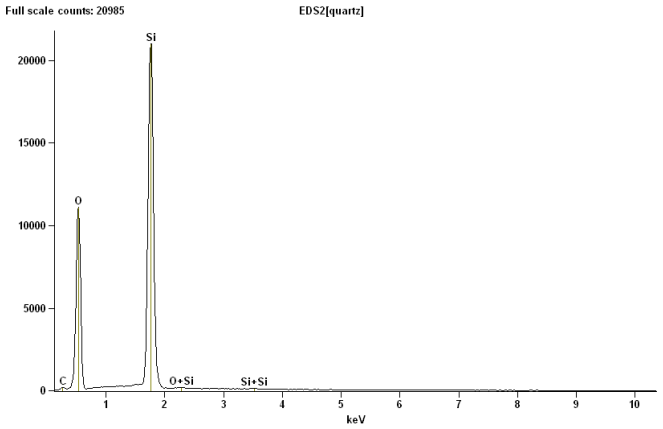
NMNH R17701

Oxide	Composition (wt %)
SiO_2	99.99
Total	99.99

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

Hot Springs, Arkansas, USA

Size fractions available

- 0.25 mm - 0.177 mm

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

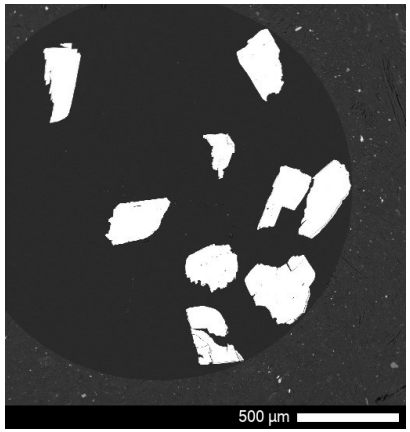
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Siderite

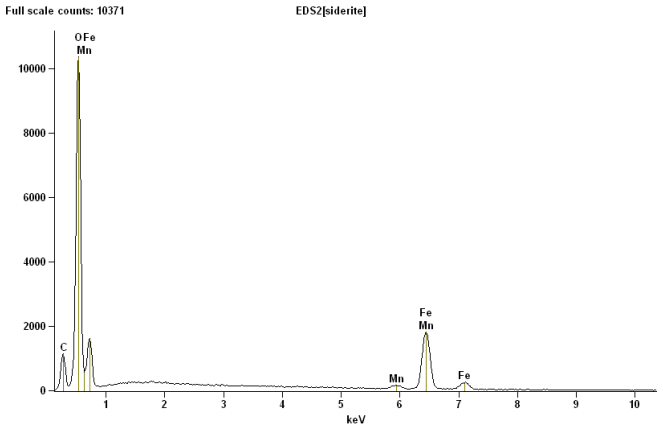
NMNH R2460

Oxide	Composition (wt %)
FeO	59.08
MnO	2.95
Co_2	37.88
Total	99.91

- **Analyst:** Jarosewich et al. (1983)



Backscatter SEM image



EDS spectrum

Locality

Ivigtut, Greenland

Size fractions available

- 0.42 - 0.25 mm

References

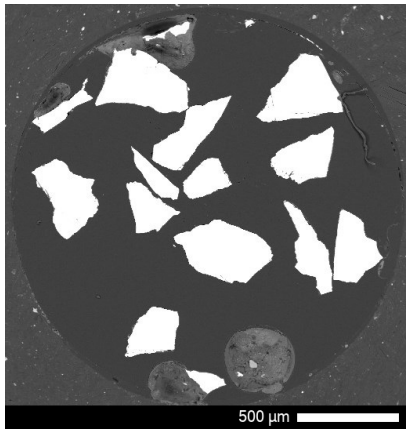
Jarosewich, E. et. al. (1983) Carbonate reference samples for electron microprobe and scanning electron microscope analyses. J. of Sedimentary Petrol. 52 (2), p. 677-678.

Strontianite

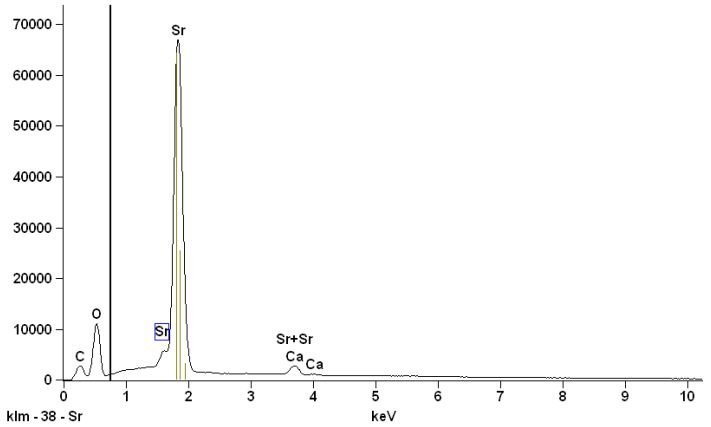
NMNH R10065

Oxide	Composition (wt %)
CaO	1.90
SrO	67.67
Co_2	30.23
Total	99.80

- **Analyst:** Jarosewich et al. (1987)



Backscatter SEM image



EDS spectrum

Locality

Oberdorf, Austria

Size fractions available

- 1.0 mm - 0.5 mm
- 0.5 mm - 0.42 mm

Notes

- Cathodoluminescence: peaks at approximately 320, 380, 520, 550, 600, 640 and 850 nm

References

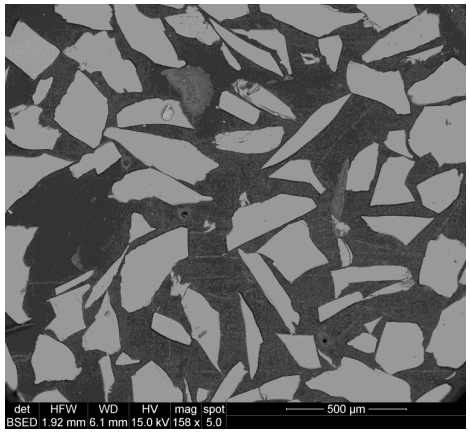
Jarosewich, E. and White, J. S. (1987) Strontianite reference sample for electron microprobe and SEM analyses. J. Sedimentary Petrol. 57 (4), p. 762-763

Synthetic corundum

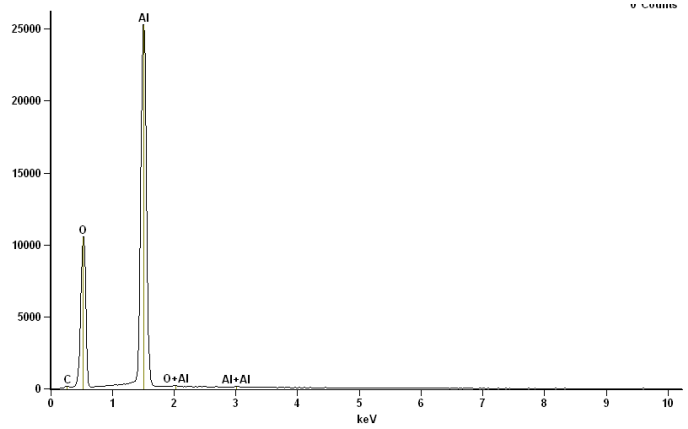
NMNH 135602

Oxide	Composition (wt %)
Al_2O_3	99.99
Total	99.99

- **Analyst:** E. Jarosewich



Backscatter SEM image



EDS spectrum

Locality

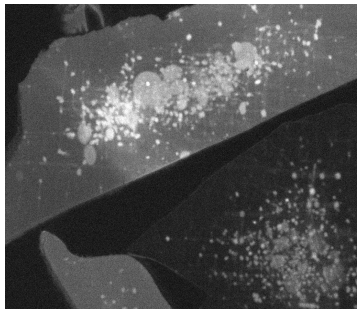
None (synthetic)

Size fractions available

- 0.250 mm - ~0.177 mm

Notes

- This material exhibits cathodoluminescence peaks at approximately 330, 575 and 728 nm. Samples exhibit permanent induced CL as can be seen in grains used as electron beam references (see above).



CL image

References

Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Emission spectrometric analysis

Element	Value
Si	0.03
Fe	0.003
Mg	0.007
Ca	0.003
Na	0.005
K	0.005

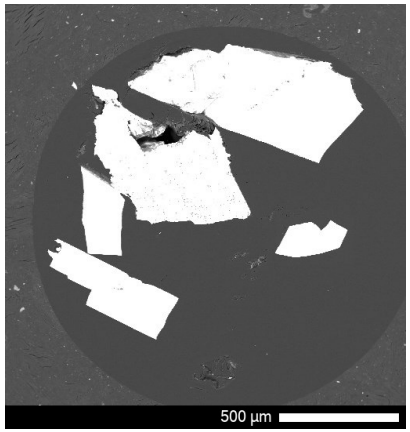
Zircon

NMNH 117288-3

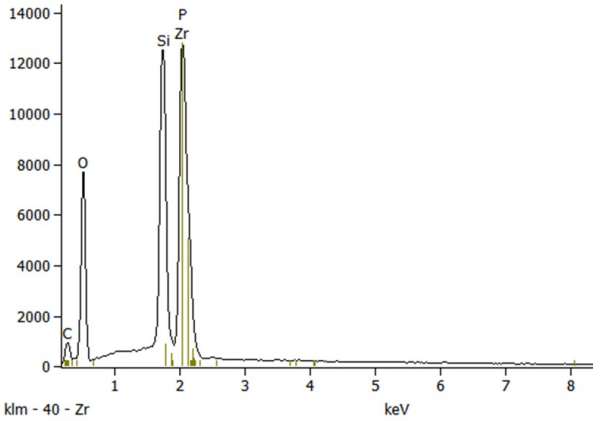
Oxide	Composition (wt %)
SiO_2	32.40
ZrO_2	66.32
HfO_2	1.06
Total	99.78

- **Analyst:** J. Nelen
- **Notes:** From J. Nelen:

> $ZrO_2$was determined from by subtracting $HfO_2$from combined ZrO_2- HfO_2analysis. $HfO_2$was determined by microprobe, corrected by modified magic.



Backscatter SEM image



EDS spectrum

Locality

Strangeway Range, Australia

References

Nelen, J. (pers. comm.)

Size fractions available

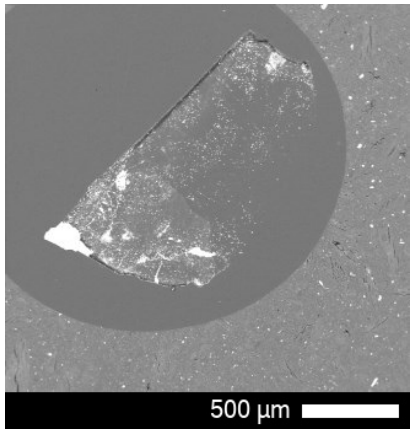
- > 0.50 mm
- > 0.297 mm
- > 0.177 mm

Cerium phosphate

NMNH 168484

Oxide	Composition (wt %)
Ce	59.60
PO_4	40.40
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

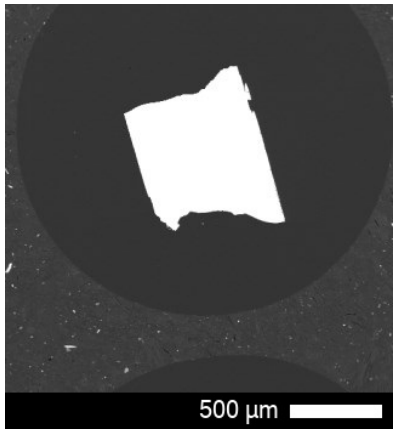
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Dysprosium phosphate

NMNH 168485

Oxide	Composition (wt %)
Dy	63.11
PO_4	36.89
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

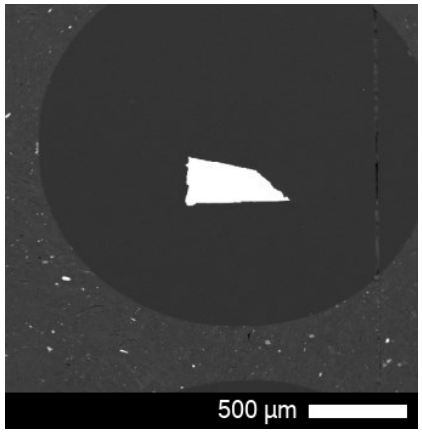
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Erbium phosphate

NMNH 168486

Oxide	Composition (wt %)
Er	63.78
PO_4	36.22
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

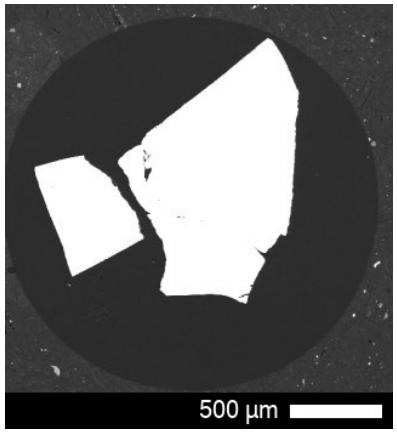
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Europium phosphate

NMNH 168487

Oxide	Composition (wt %)
Eu	61.54
PO_4	38.46
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

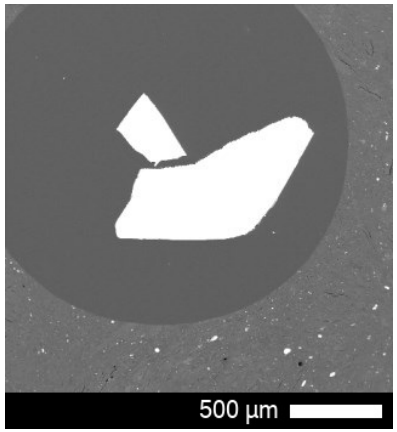
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Gadolinium phosphate

NMNH 168488

Oxide	Composition (wt %)
Gd	62.34
PO_4	37.66
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

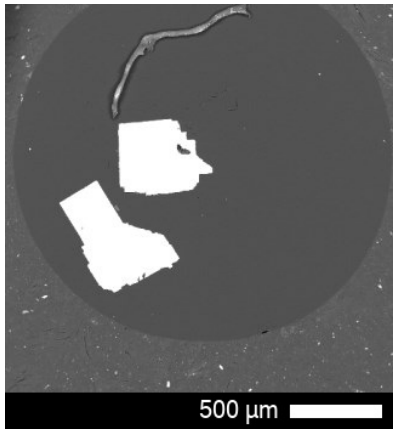
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Holmium phosphate

NMNH 168489

Oxide	Composition (wt %)
Ho	63.45
PO_4	36.55
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

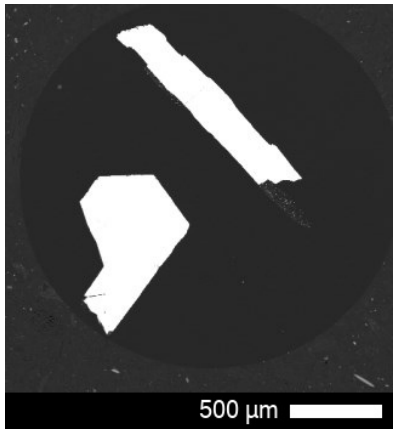
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Lanthanum phosphate

NMNH 168490

Oxide	Composition (wt %)
La	59.39
PO_4	40.61
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

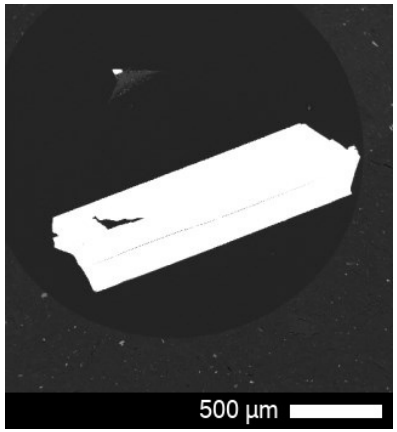
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Lutetium phosphate

NMNH 168491

Oxide	Composition (wt %)
Lu	64.81
PO_4	35.19
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

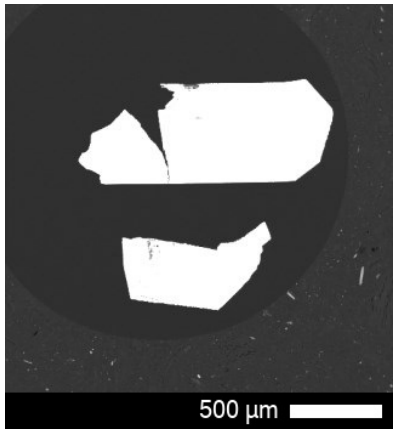
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Neodymium phosphate

NMNH 168492

Oxide	Composition (wt %)
Nd	60.30
PO_4	39.70
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

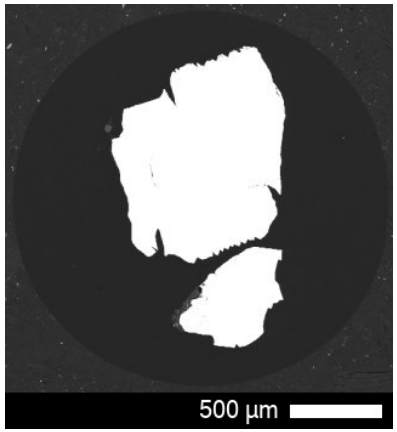
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Praseodymium phosphate

NMNH 168493

Oxide	Composition (wt %)
Pr	59.73
PO_4	40.27
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

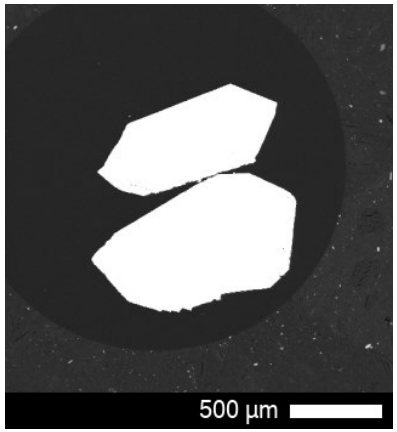
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Samarium phosphate

NMNH 168494

Oxide	Composition (wt %)
Sm	61.28
PO_4	38.72
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

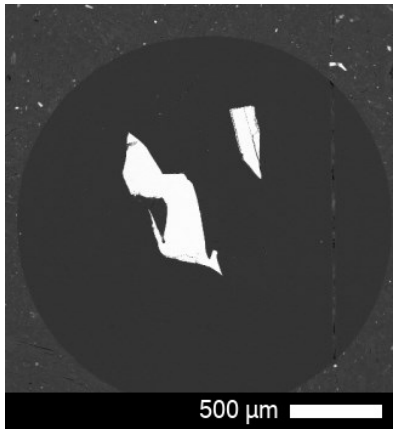
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Scandium phosphate

NMNH 168495

Oxide	Composition (wt %)
Sc	32.12
PO_4	67.88
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

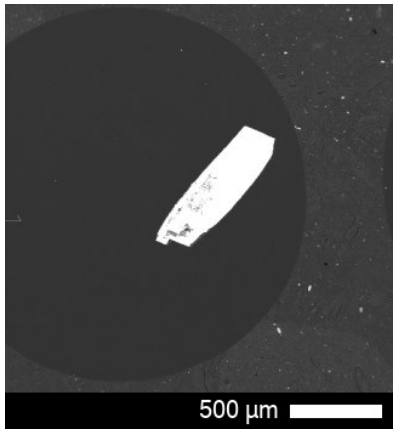
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Terbium phosphate

NMNH 168496

Oxide	Composition (wt %)
Tb	62.59
PO_4	37.41
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

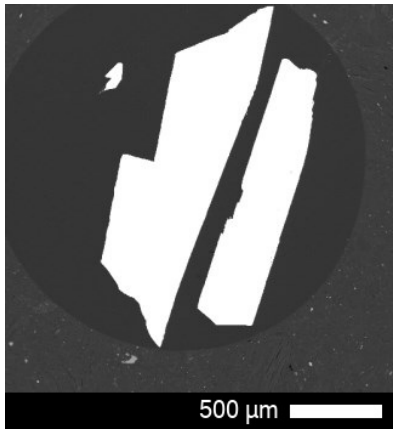
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Thulium phosphate

NMNH 168497

Oxide	Composition (wt %)
Tm	64.01
PO_4	35.99
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

None (synthetic)

Size fractions available

- Grain sizes available are highly variable as the materials are unsieved

Notes

- Many of the REE phosphates have significant lead contamination (see Donovan et al. 2002 and 2003 for details)

References

Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. J. of Research of NIST, 107, p. 693-701

Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. Can. Min. 41, pp. 221-232

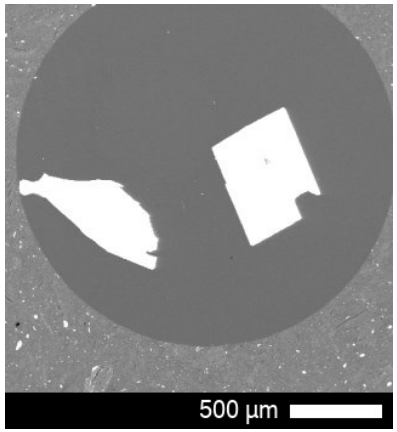
Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. Geostand. Newslett. 15 (2), p. 397-399

Ytterbium phosphate

NMNH 168498

Oxide	Composition (wt %)
Yb	64.56
PO_4	35.44
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



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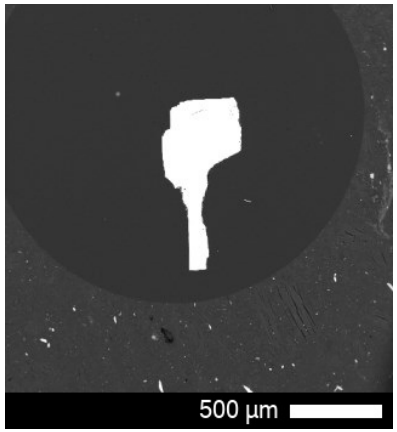
Yttrium phosphate

NMNH 168499

Oxide	Composition (wt %)
Y	48.35
PO_4	51.65
Total	100.00

- **Analyst:** Jarosewich and Boatner (1991)



Backscatter SEM image

Locality

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Size fractions available

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Notes

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