

Smithsonian Microbeam Standards Datasheets

National Museum of Natural History

Department of Mineral Sciences

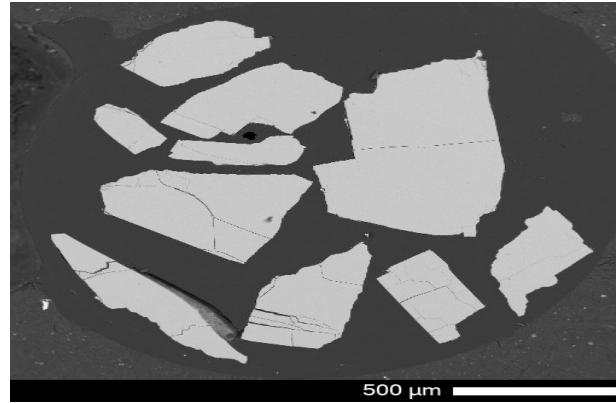
Updated 8 Apr 2025

Anorthite

NMNH 137041

Oxide	Composition (wt %)
SiO ₂	44.00
Al ₂ O ₃	36.03
FeO	0.62
MgO	<0.02
CaO	19.09
Na ₂ O	0.53
K ₂ O	0.03
TiO ₂	0.03
Total	100.33

- **Analyst:** E. Jarosewich



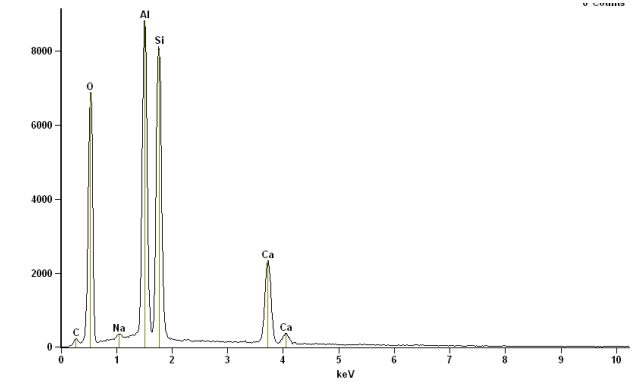
Backscatter SEM image

Locality

Great Sitkin Island, Alaska, USA

Size fractions available

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



EDS spectrum

References

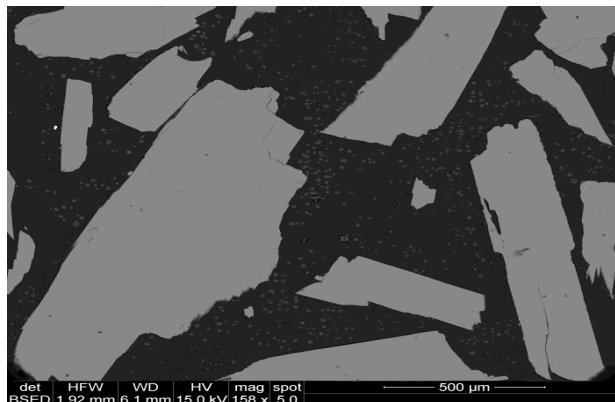
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Anorthoclase

NMNH 133868

Oxide	Composition (wt %)
SiO ₂	66.44
Al ₂ O ₃	20.12
FeO	0.20
CaO	0.87
Na ₂ O	9.31
K ₂ O	2.35
H ₂ O	<0.05
Total	99.29

- Analyst: J. Norberg



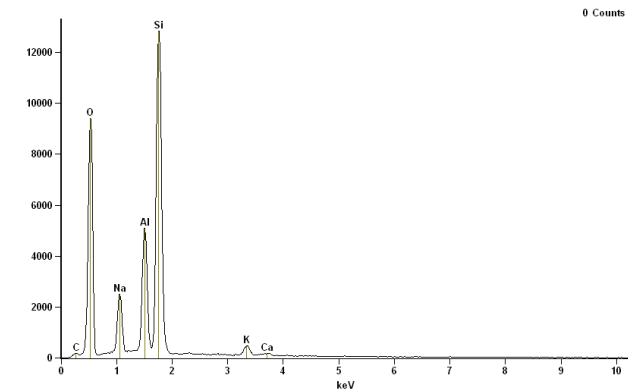
Backscatter SEM image

Locality

Kakanui, New Zealand

Size fractions available

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



EDS spectrum

References

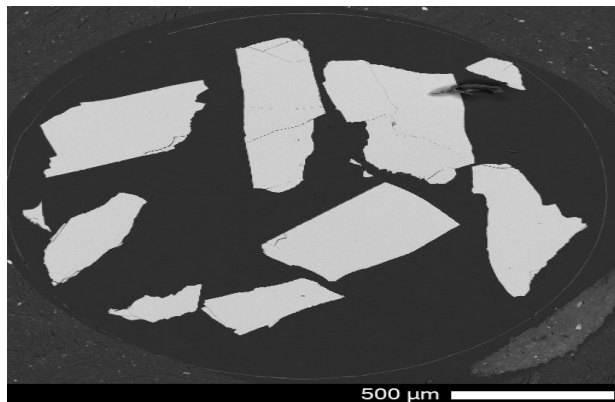
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Chromium augite

NMNH 164905

Oxide	Composition (wt %)
SiO ₂	50.48
Al ₂ O ₃	8.03
Fe ₂ O ₃	1.04
FeO	3.77
MgO	17.32
CaO	17.30
Na ₂ O	0.84
K ₂ O	<0.01
MnO	0.12
TiO ₂	0.51
P ₂ O ₅	0.00
Cr ₂ O ₃	0.85
H ₂ O-	<0.10
Total	100.26

- **Analyst:** Jarosewich et al.



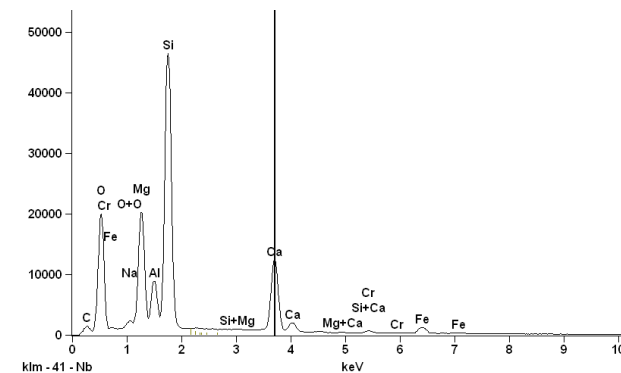
Backscatter SEM image

Locality

Nye County, Nevada, USA

Size fractions available

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



EDS spectrum

References

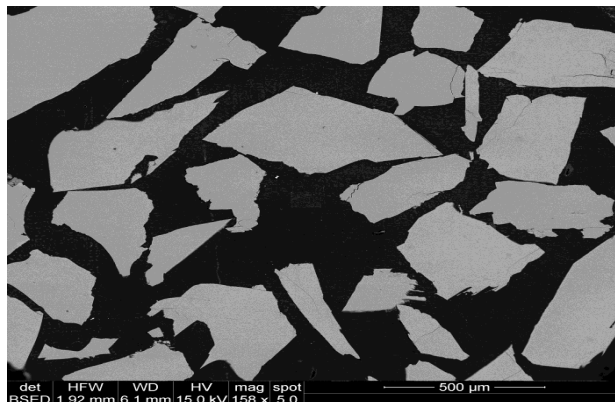
Jarosewich, E. et. al., (1987) Chromium Augite - A New Microprobe Reference Sample. *Geostandards Newsletter*, 11, p. 197-198

Kakanui augite

NMNH 122142

Oxide	Composition (wt %)	Preferred (wt %)
SiO ₂	50.73	50.73
Al ₂ O ₃	7.86	8.73
Fe ₂ O ₃	3.69	1.08
FeO	3.45	5.37
MgO	16.65	16.65
CaO	15.82	15.82
Na ₂ O	1.27	1.27
K ₂ O	0.00	0.00
TiO ₂	0.74	0.74
MnO	0.13	0.13
H ₂ O	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

Locality

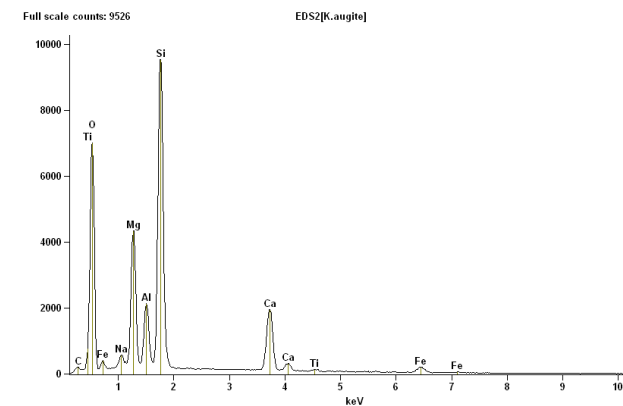
Kakanui, New Zealand

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



EDS spectrum

References

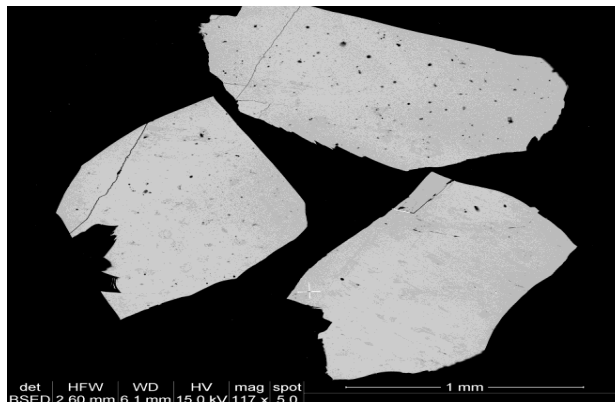
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47
- Mason, B. (1966) Pyrope, augite and hornblende from Kakanui, New Zealand. J. Geol. Geophys. 9 (4), p. 474-480
- Mason, B. and Allen, R.O. (1973) Minor and 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

Locality

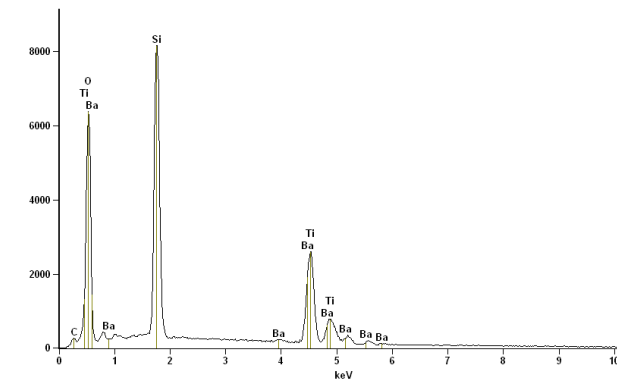
San Benito Co., California, USA

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



EDS spectrum

References

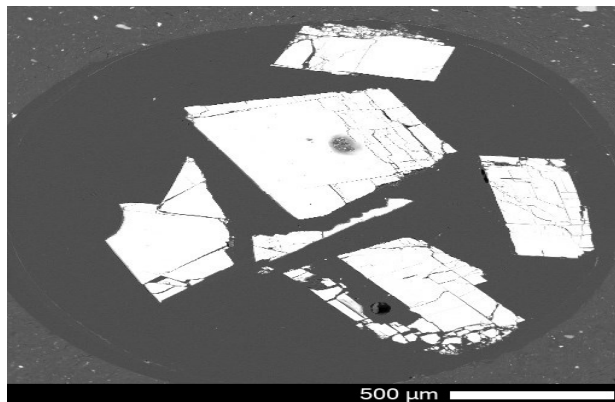
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Calcite

NMNH 136321

Oxide	Composition (wt %)
CaO	56.10
CO ₂	44.01
Total	100.11

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



Backscatter SEM image

Locality

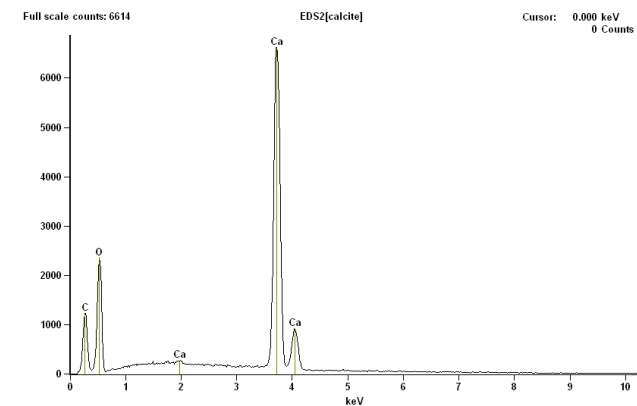
Unknown

Size fractions available

- 0.42 mm - 0.25 mm

Notes

- Preliminary cathodoluminescence study reveals peaks at 370 and 615 nm



EDS spectrum

References

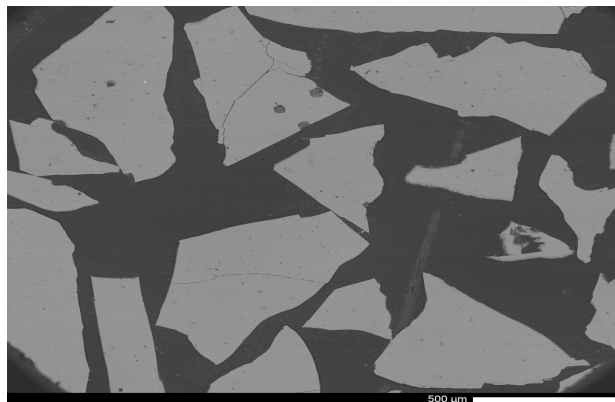
Jarosewich, E. and MacIntyre, I. G. (1983) Carbonate reference samples for electron microprobe and scanning electron microscope analyses. *J. of Sedimentary Petrol.* 52 (2), p. 677-678

Chromite

NMNH 117075

Oxide	Composition (wt %)
Al ₂ O ₃	9.92
FeO	13.04
MgO	15.20
MnO	0.11
Cr ₂ O ₃	60.50
Total	98.77

- Analyst: J. Nelen



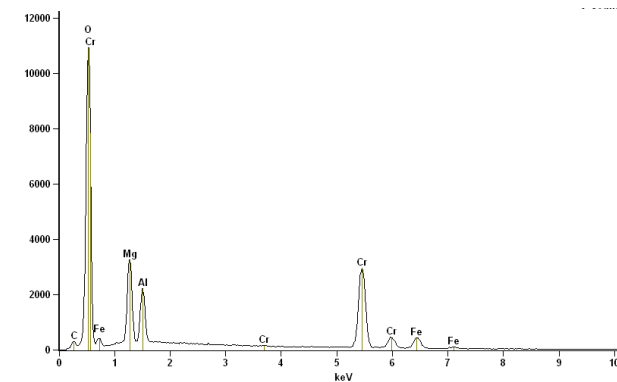
Backscatter SEM image

Locality

Tiebaghi Mine, New Caledonia

Size fractions available

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



EDS spectrum

References

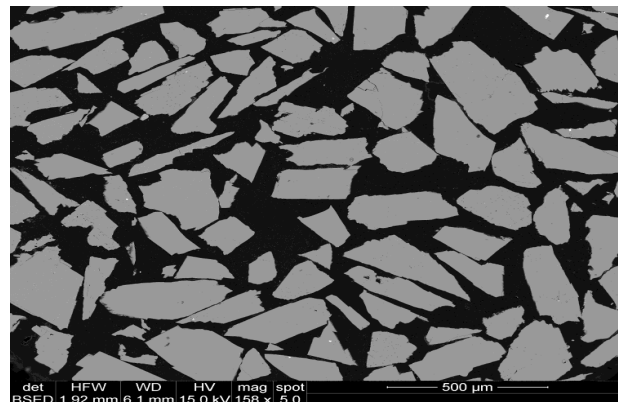
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Diopside

NMNH 117733

Oxide	Composition (wt %)	Preferred (wt %)
SiO ₂	54.87	55.81
Al ₂ O ₃	0.11	0.11
FeO	0.24	0.25
MgO	18.30	17.79
CaO	25.63	25.28
Na ₂ O	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

Locality

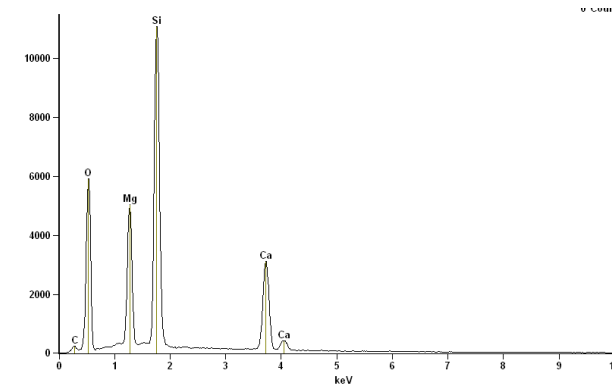
Natural Bridge, New York, USA

Size fractions available

- > 1.0 mm
- 1.0 mm - 0.42 mm

Impurities

- **Rare:** Apatite and pyrite



EDS spectrum

References

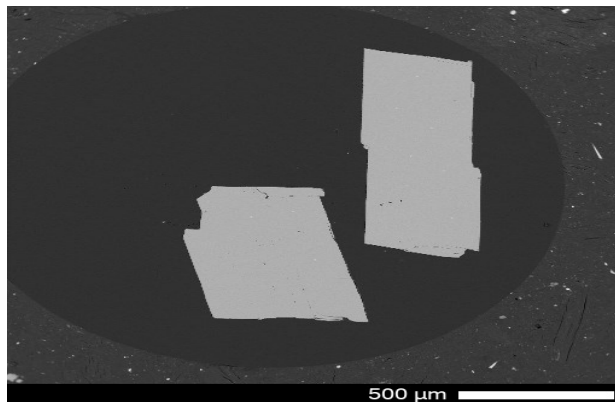
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Dolomite

NMNH R10057

Oxide	Composition (wt %)
CaO	30.56
MgO	22.04
CO ₂	46.93
Total	99.53

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



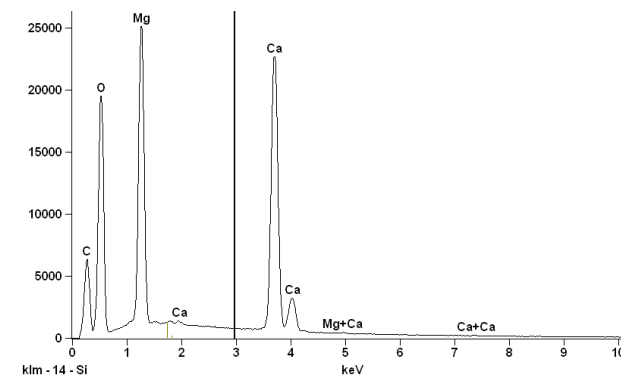
Backscatter SEM image

Locality

Oberdorf, Austria

Size fractions available

- 0.42 mm - 0.25 mm



EDS spectrum

References

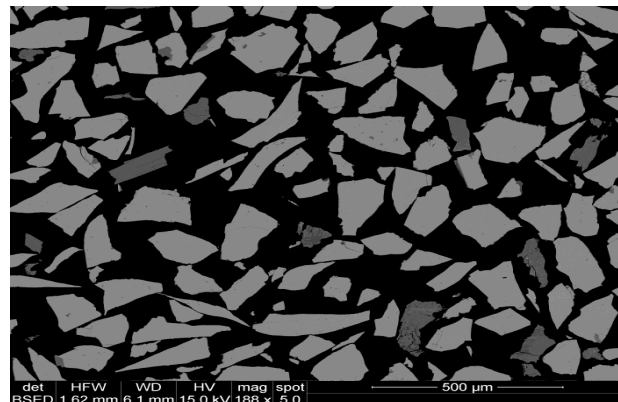
Jarosewich, E. and MacIntyre, I. G. (1983) Carbonate reference samples for electron microprobe and scanning electron microscope analyses. *J. of Sedimentary Petrol.* 52 (2), p. 677-678

Fayalite

NMNH 85276

Oxide	Composition (wt %)
SiO ₂	29.22
Fe ₂ O ₃	1.32
FeO	66.36
TiO ₂	0.04
MnO	2.14
H ₂ O	0.10
Total	99.18

- Analyst: J. Nelen



Backscatter SEM image

Locality

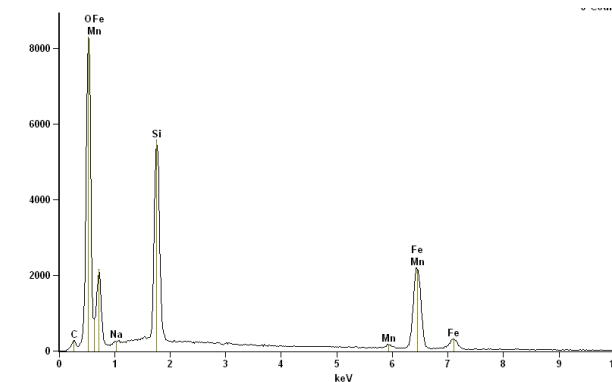
Rockport, Massachusetts, USA

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.



EDS spectrum

References

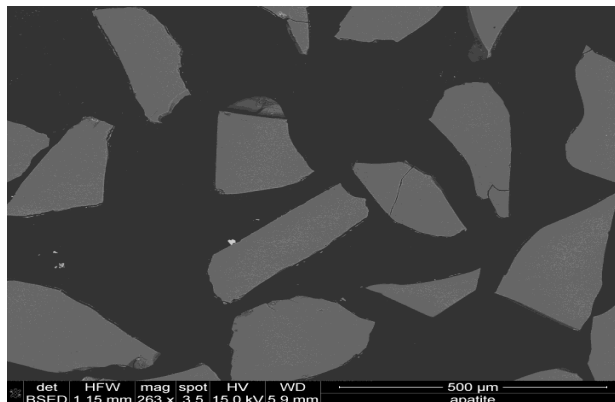
- Bowen, I. L. and Schairer, J. F. (1935) Grunerite from Rockport, Massachusetts and a Series of Synthetic Fluor-Amphiboles. *Am. Min.*, 20, p. 543- 551
- Bozhilov, K. N. and Evans, B. W. (2001) Ferroanthophyllite in Rockport grunerite: A transmission electron microscopy study. *Am. Min.*, 86, p. 1252- 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 ₂ O ₃	0.07
Fe ₂ O ₃	0.06
FeO	0.00
MgO	0.01
CaO	54.02
Na ₂ O	0.23
K ₂ O	0.01
P ₂ O ₅	40.78
MnO	0.01
SrO	0.07
REE ₂ O ₃	1.43
ThO ₂	0.02
As ₂ O ₃	0.09
V ₂ O ₅	0.01
Co ₂	0.05
SO ₃	0.37
F	3.53
Cl	0.41
H ₂ O	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

Locality

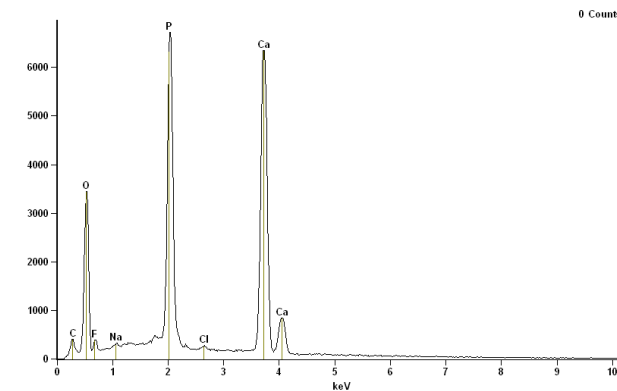
Durango, Mexico

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



EDS spectrum

References

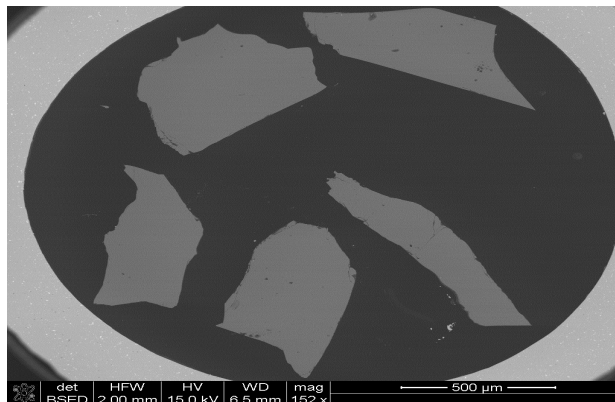
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47
- Young, E.J., Myers, A.T., Munson, E.L., Conklin, N.M. (1969) Mineralogy and geochemistry of fluorapatite from Cerro de Mercado, Durango, Mexico; USGS Professional Paper 650D, 84-93

Gahnite

NMNH 145883

Oxide	Composition (wt %)
Al ₂ O ₃	55.32
FeO	1.97
MnO	0.34
ZnO	42.50
Total	100.13

- Analyst: J. Nelen



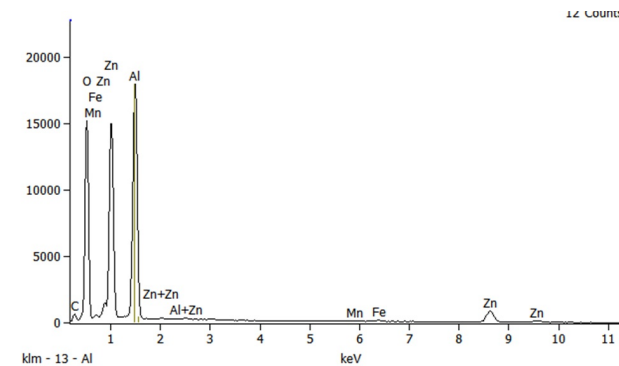
Backscatter SEM image

Locality

Brazil

Size fractions available

- > 0.25 mm
- 0.25 mm - 0.177 mm



EDS spectrum

References

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

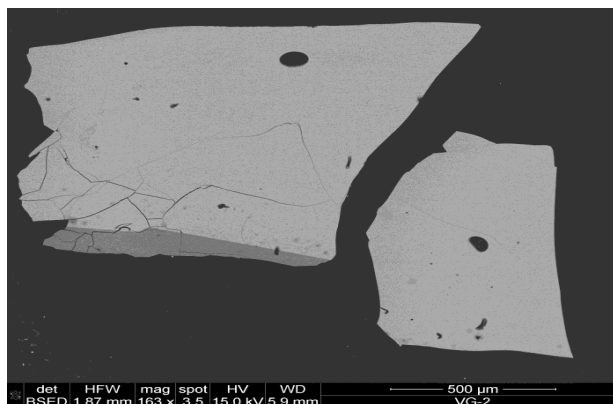
Basaltic glass

NMNH 111240-52, VG-2

Oxide	Composition (wt %)	Preferred (wt %)
SiO ₂	50.81	50.81
Al ₂ O ₃	14.06	14.06
Fe ₂ O ₃	2.23	2.23
FeO	9.83	9.83
MgO	6.71	6.95
CaO	11.12	11.12
Na ₂ O	2.62	2.62
K ₂ O	0.19	0.19
TiO ₂	1.85	1.85
P ₂ O ₅	0.20	0.20
MnO	0.22	0.22
H ₂ O-	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

Locality

Juan de Fuca Ridge

Size fractions available

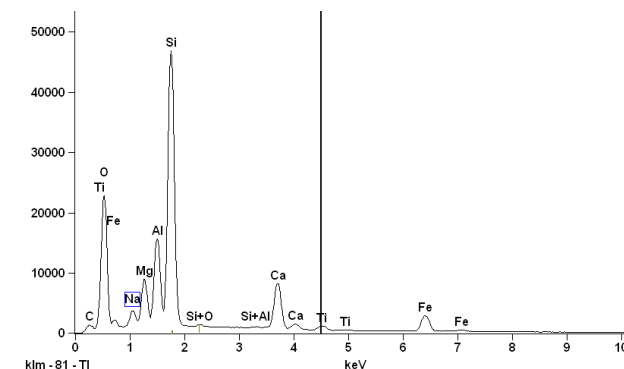
- 1.0 mm - 2.0 mm
- > 0.350 mm

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



EDS spectrum

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

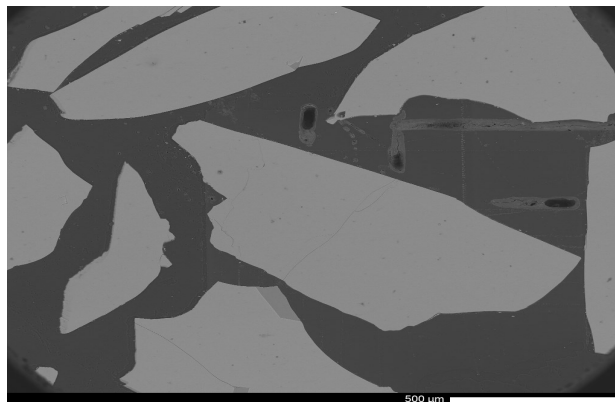
- Helz, R.T., Clague, D.A., Mastin, L.G., and Rose, T.R., 2014, Electron microprobe analyses of glasses from Kīlauea Tephra Units, Kīlauea Volcano, Hawaii: U.S. Geological Survey Open-File Report 2014–1090, 24 p., plus 2 appendixes in separate files, <http://dx.doi.org/10.3133/ofr20141090>
- Sun, W.D., 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 Kīlauea 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 ₂ O ₃	12.49
Fe ₂ O ₃	1.87
FeO	11.62
MgO	5.08
CaO	9.30
Na ₂ O	2.66
K ₂ O	0.82
TiO ₂	4.06
P ₂ O ₅	0.38
MnO	0.15
H ₂ O	0.02
Total	99.39

- **Analyst:** J. Norberg



Backscatter SEM image

Locality

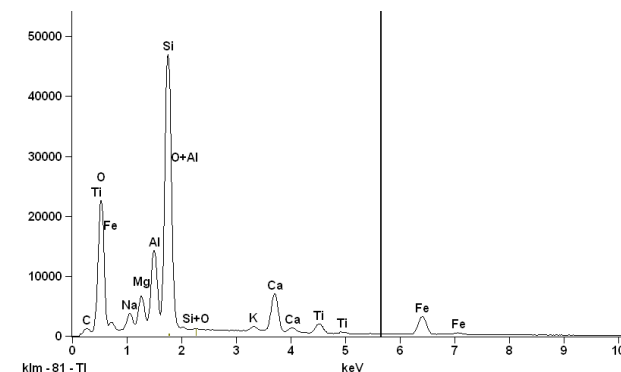
Makaopuhi Lava Lake, Hawaii, USA

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



EDS spectrum

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

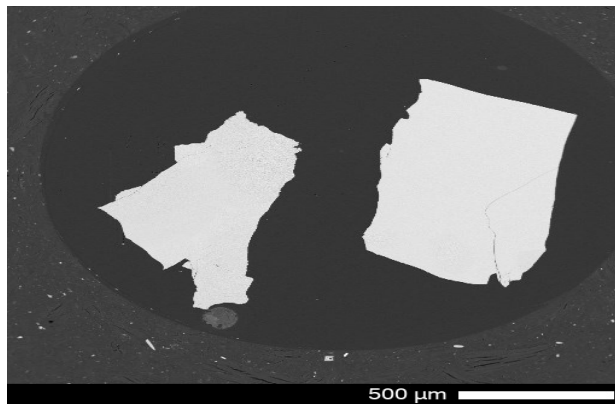
Witter et al. (2005)

Basaltic glass

NMNH 113716-1

Oxide	Composition (wt %)
SiO ₂	51.52
Al ₂ O ₃	15.39
Fe ₂ O ₃	1.12
FeO	8.12
MgO	8.21
CaO	11.31
Na ₂ O	2.48
K ₂ O	0.09
TiO ₂	1.30
P ₂ O ₅	0.12
MnO	0.17
H ₂ O	0.18
S	0.12
Subtotal	100.13
Total	100.07

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



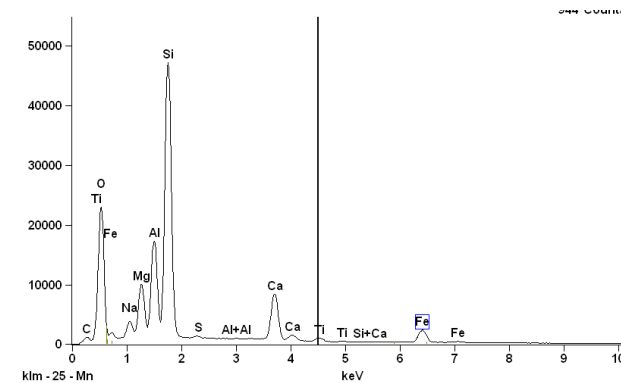
Backscatter SEM image

Locality

Indian Ocean

Size fractions available

- 1.0 mm - 0.5 mm



EDS spectrum

References

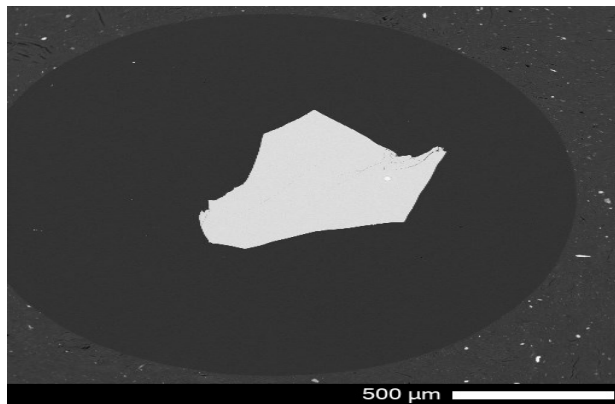
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Corrections. Geostandards Newsletter 4, p. 257-258

Corning Glass A

NMNH 117218-4

Oxide	Composition (wt %)
SiO ₂	66.56
Al ₂ O ₃	1.00
Fe ₂ O ₃	1.09
MgO	2.66
CaO	5.03
Na ₂ O	14.30
K ₂ O	2.87
MnO	1.00
P ₂ O ₅	0.13
TiO ₂	0.79
Sb ₂ O 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 ₂ O ₃	0.20
Li ₂ O	0.01
Cl	0.10
SO ₃	0.10
Rb ₂ O	0.01
V ₂ O ₅	0.006
Cr ₂ O ₃	0.001
NiO	0.02
ZrO ₂	0.005
Ag ₂ O	0.002
Bi ₂ O 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

Locality

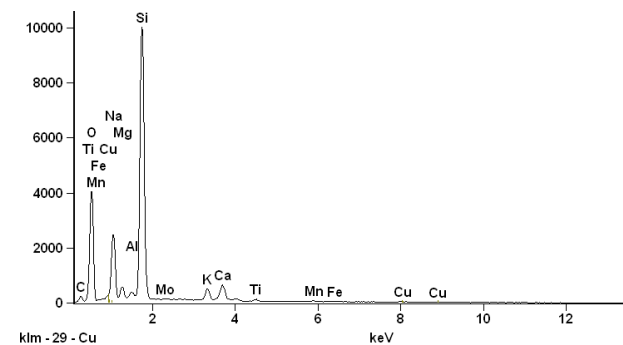
None (synthetic)

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



EDS spectrum

References

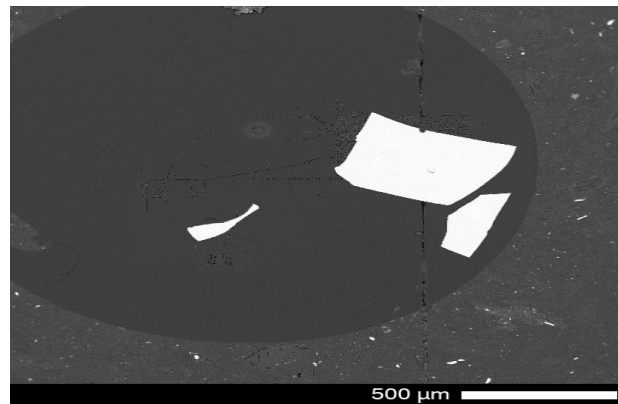
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. *J. of Res. NIST*, 107, p. 719-727.

Corning Glass B

NMNH 117218-1

Oxide	Composition (wt %)
SiO ₂	61.55
Al ₂ O ₃	4.36
Fe ₂ O ₃	0.34
MgO	1.03
CaO	8.56
Na ₂ O	17.00
K ₂ O	1.00
MnO	0.25
P ₂ O ₅	0.82
TiO ₂	0.089
Sb ₂ O 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 ₂ O ₃	0.02
Li ₂ O	0.001
Cl	0.20
SO ₃	0.50
Rb ₂ O	0.001
V ₂ O ₅	0.03
Cr ₂ O ₃	0.005
NiO	0.10
ZrO ₂	0.025
Ag ₂ O	0.01
Bi ₂ O 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

Locality

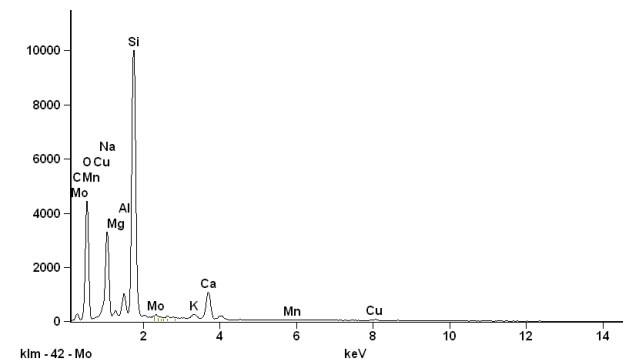
None (synthetic)

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



EDS spectrum

References

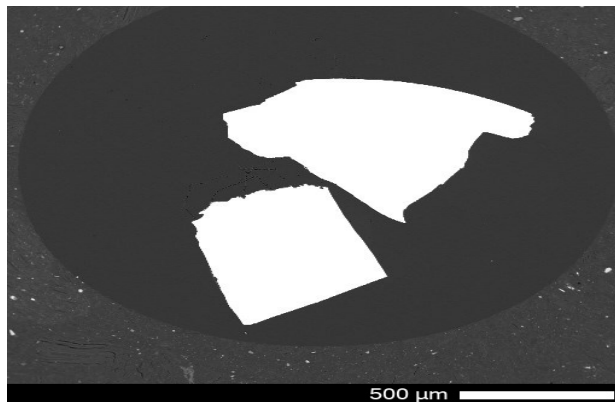
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. J. of Res. NIST, 107, p. 719-727.

Corning Glass C

NMNH 117218-2

Oxide	Composition (wt %)
SiO ₂	34.87
Al ₂ O ₃	0.87
Fe ₂ O ₃	0.34
MgO	2.76
CaO	5.07
Na ₂ O	1.07
K ₂ O	2.84
MnO	0.82
P ₂ O ₅	0.14
TiO ₂	0.79
Sb ₂ O 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 ₂ O ₃	0.20
Li ₂ O	0.01
Cl	0.10
SO ₃	0.10
Rb ₂ O	0.01
V ₂ O ₅	0.006
Cr ₂ O ₃	0.001
NiO	0.02
ZrO ₂	0.005
Ag ₂ O	0.002
Bi ₂ O 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

Locality

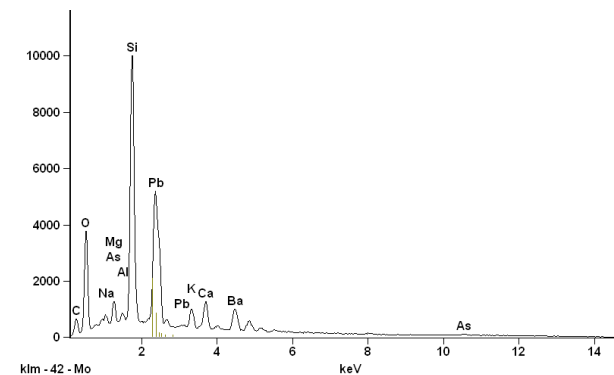
None (synthetic)

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.



EDS spectrum

References

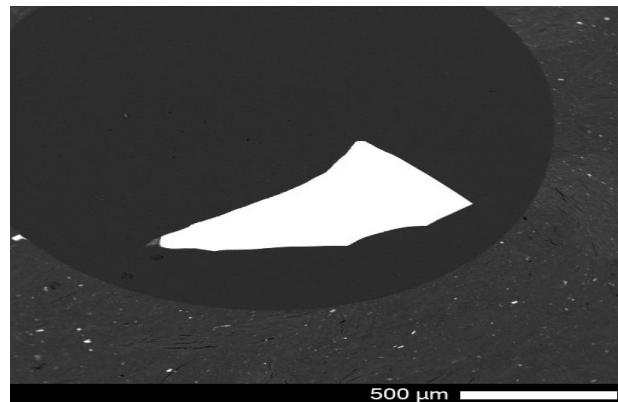
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. J. of Res. NIST, 107, p. 719-727.

Corning Glass D

NMNH 117218-3

Oxide	Composition (wt %)
SiO ₂	55.24
Al ₂ O ₃	5.30
Fe ₂ O ₃	0.52
MgO	3.94
CaO	14.80
Na ₂ O	1.20
K ₂ O	11.30
MnO	0.55
P ₂ O ₅	3.93
TiO ₂	0.38
Sb ₂ O 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 ₂ O ₃	0.10
Li ₂ O	0.005
Cl	0.40
SO ₃	0.30
Rb ₂ O	0.005
V ₂ O ₅	0.015
Cr ₂ O ₃	0.0025
NiO	0.05
ZrO ₂	0.0125
Ag ₂ O	0.005
Bi ₂ O 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

Locality

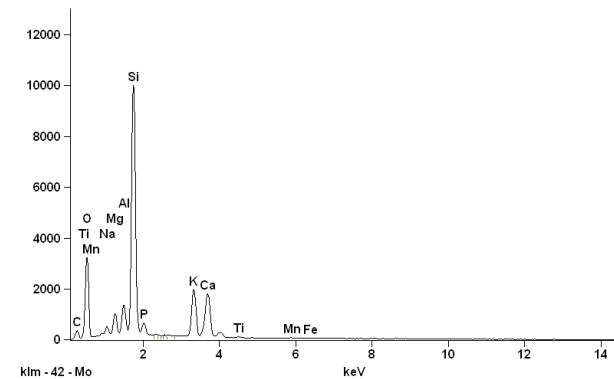
None (synthetic)

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



EDS spectrum

References

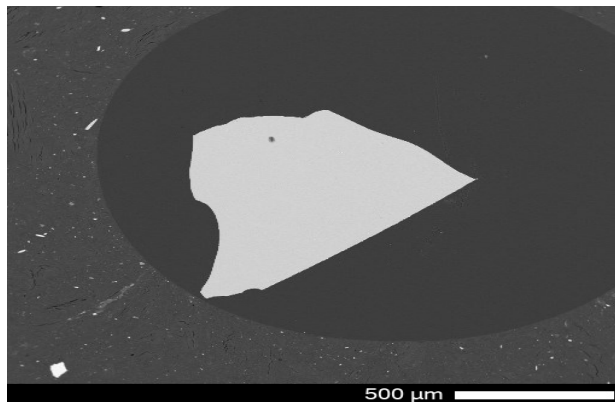
Vicenzi, E. P. et. al. (2002) Microbeam Characterization of Corning Archeological Reference Glasses: New Additions to the Smithsonian Microbeam Standard Collection. *J. of Res. NIST*, 107, p. 719-727.

Corning Glass IR-V

NMNH 117083

Oxide	Composition (wt %)
B ₂ O ₃	4.44
Na ₂ O	0.018
MgO	8.82
Al ₂ O ₃	18.46
SiO ₂	57.49
K ₂ O	0.792
CaO	6.41
TiO ₂	0.787
V ₂ O ₃	0.001
Cr ₂ O 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 ₂ O ₃	0.007
ZrO ₂	0.027
BaO	0.016
La ₂ O ₃	0.002
Ce ₂ O 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

Locality

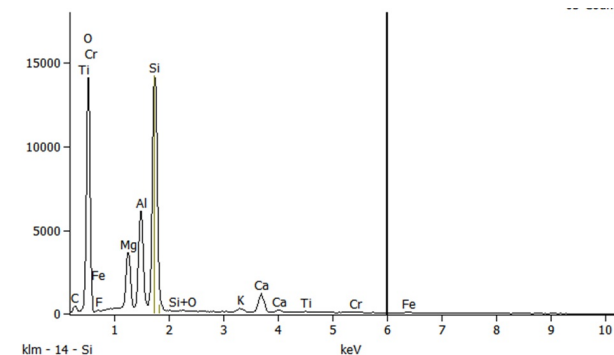
None (synthetic)

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.



EDS spectrum

References

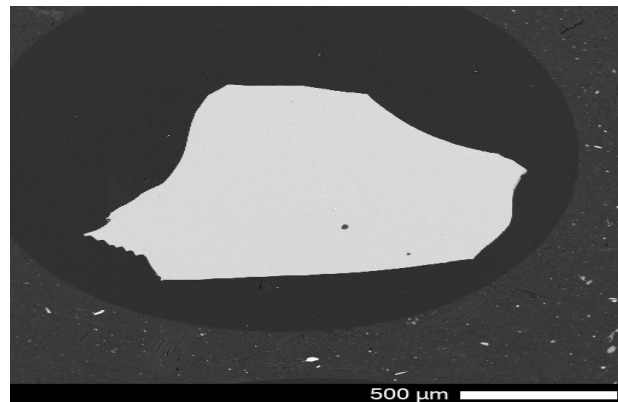
Carpenter, P. et. al. (2002) Characterization of Corning EPMA Standard Glasses 95IRV, 95IRW, and 95IRX. J. of Res. NIST, 107, p. 703-718

Corning Glass IR-X

NMNH 117085

Oxide	Composition (wt %)
B ₂ O ₃	4.35
MgO	8.57
Al ₂ O ₃	18.04
SiO ₂	57.23
P ₂ O ₅	<0.006
K ₂ O	0.028
CaO	6.34
TiO ₂	0.006
V ₂ O ₃	0.003
Cr ₂ O ₃	0.001
MnO	0.005
FeO	0.063
CoO	0.004
NiO	0.730
CuO	0.005
ZnO	0.787
Rb ₂ O	0.494
SrO	0.762
Y ₂ O ₃	0.851
ZrO ₂	0.789
BaO	0.017
La ₂ O 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).



Backscatter SEM image

Locality

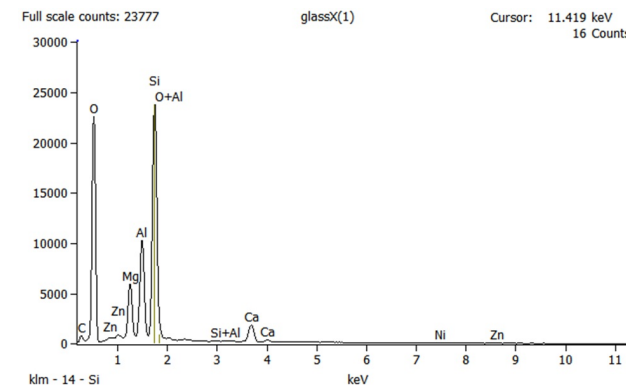
None (synthetic)

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.



EDS spectrum

References

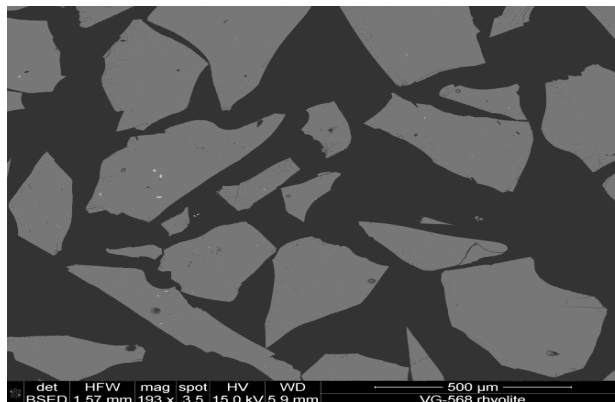
Carpenter, P. et. al. (2002) Characterization of Corning EPMA Standard Glasses 95IRV, 95IRW, and 95IRX. J. of Res. NIST, 107, p. 703-718

Rhyolitic glass

NMNH 72854, VG 568

Oxide	Composition (wt %)
SiO ₂	76.71
Al ₂ O ₃	12.06
Fe ₂ O ₃	0.48
FeO	0.80
MgO	<0.10
CaO	0.50
Na ₂ O	3.75
K ₂ O	4.89
TiO ₂	0.12
P ₂ O ₅	<0.01
MnO	0.03
H ₂ O	0.12
Cl	0.13
Subtotal	99.59
Total	99.56

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



Backscatter SEM image

Locality

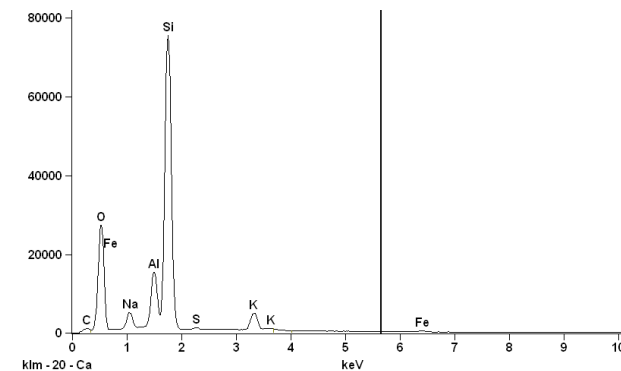
Yellowstone National Park, Wyoming, USA

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



EDS spectrum

References

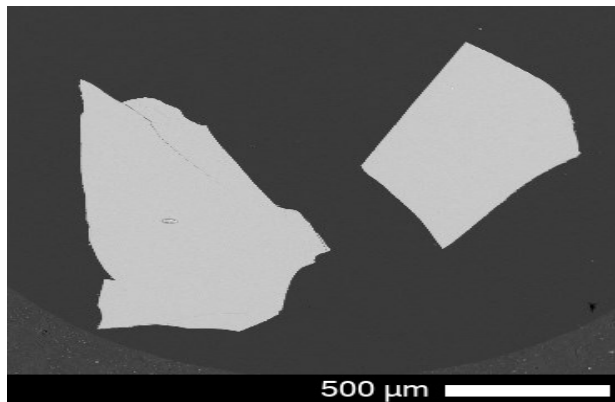
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Tektite glass

USNM 2213

Oxide	Composition (wt %)
SiO ₂	75.75
Al ₂ O ₃	11.34
Fe ₂ O ₃	0.64
FeO	4.32
MgO	1.51
CaO	2.66
Na ₂ O	1.06
K ₂ O	1.88
TiO ₂	0.50
P ₂ O ₅	0.00
MnO	0.11
H ₂ O	0.10
Cl	0.00
F	0.01
Total	99.88

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



Backscatter SEM image

Locality

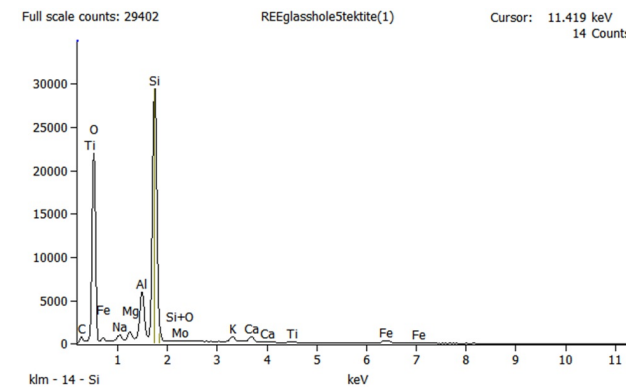
None (synthetic)

Size fractions available

- 1.00 - 0.5 mm
- 0.50 - 0.25 mm

Notes

- Prepared by Corning Labs



EDS spectrum

References

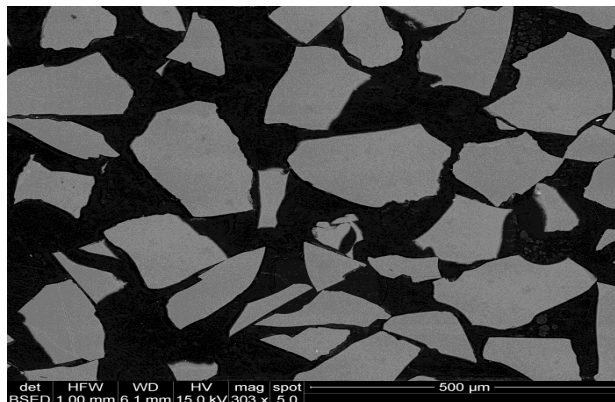
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Grossular garnet

NMNH 87375

Oxide	Composition (wt %)
SiO ₂	39.47
Al ₂ O ₃	22.27
Fe ₂ O ₃	2.77
FeO	13.76
MgO	6.55
CaO	14.39
TiO ₂	0.39
MnO	0.59
H ₂ O	<0.01
Total	100.19

- **Analyst:** E. Jarosewich



Backscatter SEM image

Locality

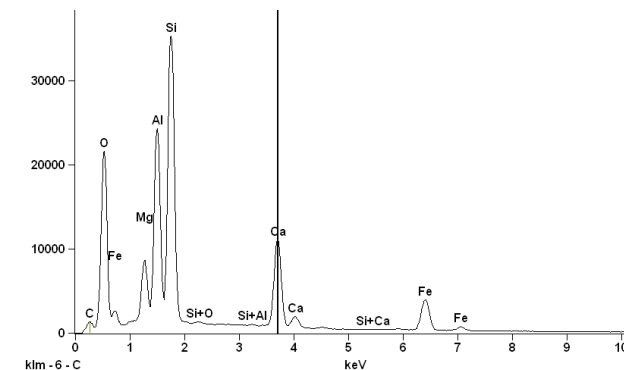
Roberts Victor Mine, South Africa

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.



EDS spectrum

References

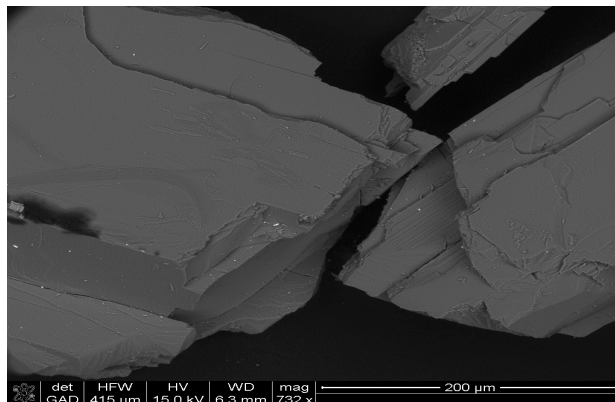
- Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. *Smithsonian Contributions to the Earth Sciences* 9, 83-84
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. *Geostandards Newsletter* 4, p. 43-47

Arenal hornblende

NMNH 111356

Oxide	Composition (wt %)
SiO ₂	41.46
Al ₂ O ₃	15.47
Fe ₂ O ₃	5.60
FeO	6.43
MgO	14.24
CaO	11.55
Na ₂ O	1.91
K ₂ O	0.21
TiO ₂	1.41
P ₂ O ₅	<0.01
MnO	0.15
H ₂ O	1.21
Total	99.64

- **Analyst:** E. Jarosewich



Backscatter SEM image

Locality

Arenal Volcano, Costa Rica

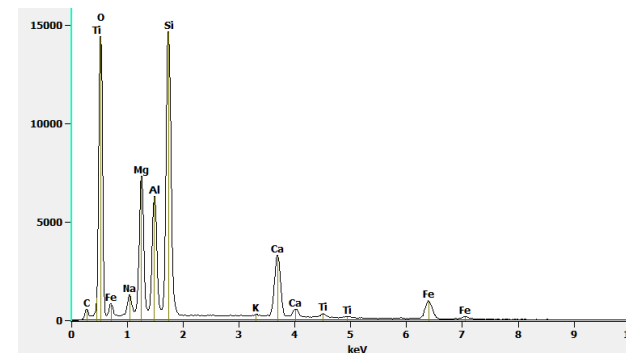
Size fractions available

- 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



EDS spectrum

References

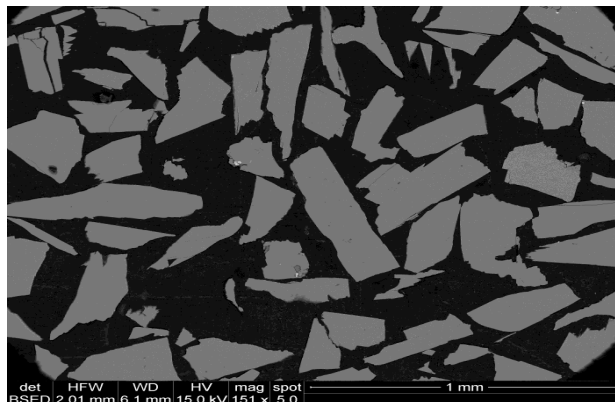
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Kakanui hornblende

NMNH 143965

Oxide	Composition (wt %)
SiO ₂	40.37
Al ₂ O ₃	14.90
Fe ₂ O ₃	3.30
FeO	7.95
MgO	12.80
CaO	10.30
Na ₂ O	2.60
K ₂ O	2.05
TiO ₂	4.72
P ₂ O ₅	0.00
MnO	0.09
H ₂ O	0.94
Total	100.02

- **Analyst:** E. Jarosewich



Backscatter SEM image

Locality

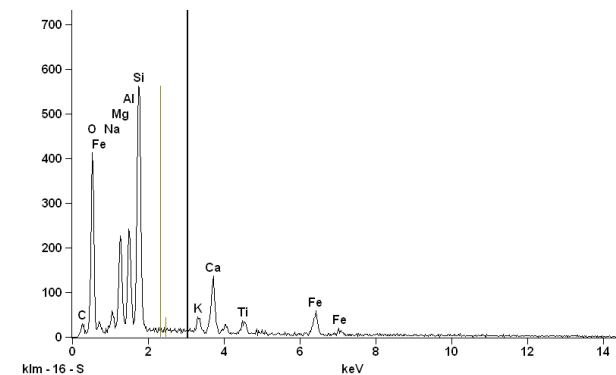
Kakanui, New Zealand

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)



EDS spectrum

References

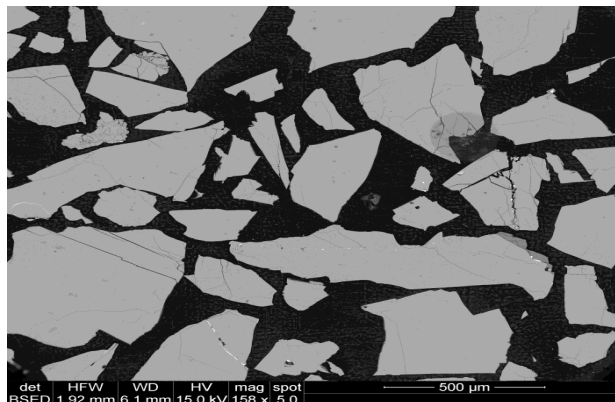
- Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. *Smithsonian Contributions to the Earth Sciences* 9, 83-84
- Jarosewich, E., et. al. (1979) Microprobe Analyses of Four Natural Glasses and One Mineral: An Interlaboratory Study of Precision and Accuracy. *Smith Contr. 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 ₂ O ₃	1.23
FeO	15.22
MgO	26.79
CaO	1.52
Na ₂ O	<0.05
K ₂ O	<0.05
TiO ₂	0.16
Cr ₂ O ₃	0.75
MnO	0.49
H ₂ O	0.00
Total	100.25

- **Analyst:** J. Norberg



Backscatter SEM image

Locality

Johnstown (meteorite)

Size fractions available

- Unsized crushed material

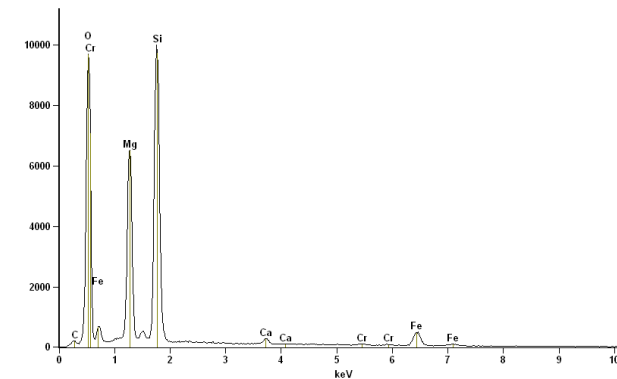
Impurities

- **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



EDS spectrum

References

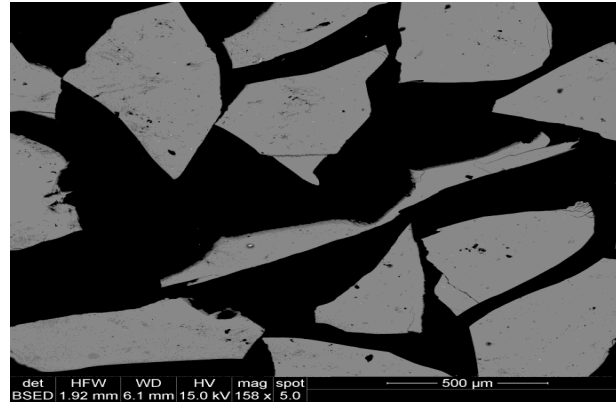
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Ilmenite

NMNH 96189

Oxide	Composition (wt %)
Fe ₂ O ₃	11.60
FeO	36.10
MgO	0.31
TiO ₂	45.70
MnO	4.77
nB ₂ O ₅	0.92
Total	99.40

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



Backscatter SEM image

Locality

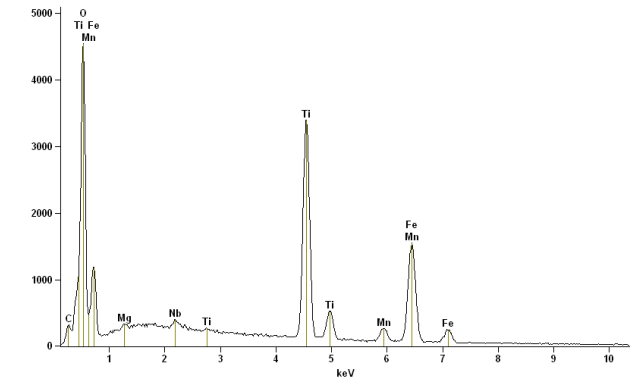
Ilmen Mountains, Russia

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



EDS spectrum

References

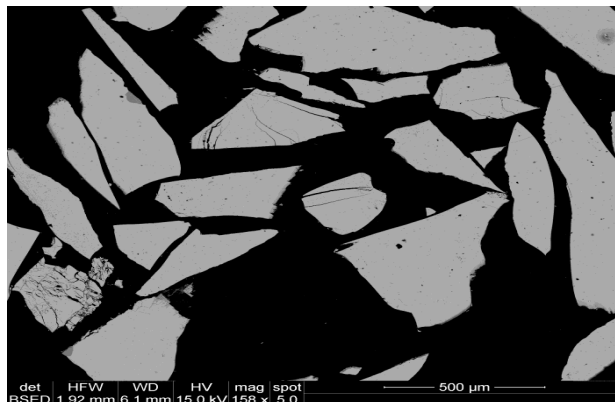
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. *Geostandards Newsletter* 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. *Geostandards Newsletter* 4, p. 257-258

Magnetite

NMNH 114887

Oxide	Composition (wt %)
Fe ₂ O ₃	67.50
FeO	30.20
MgO	0.05
TiO ₂	0.16
MnO	<0.01
Cr ₂ O ₃	0.25
Total	98.16

- **Analyst:** J. Norberg



Backscatter SEM image

Locality

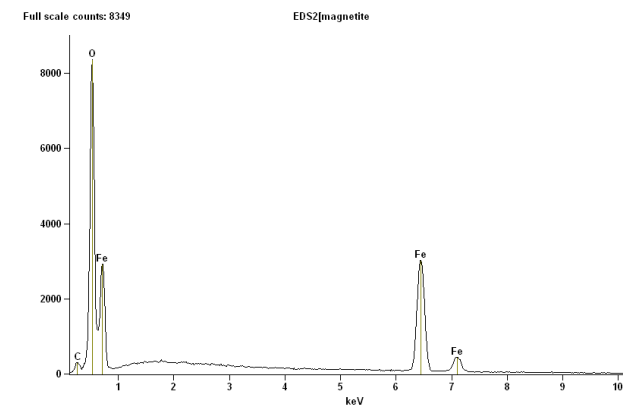
Minas Gerais, Brazil

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



EDS spectrum

References

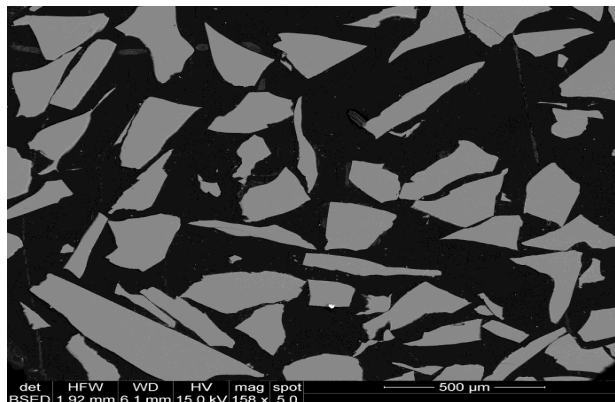
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Corrections. Geostandards Newsletter 4, p. 257-258

Meionite

NMNH R6600

Oxide	Composition (wt %)
SiO ₂	49.78
Al ₂ O ₃	25.05
FeO	0.17
CaO	13.58
Na ₂ O	5.20
K ₂ O	0.94
H ₂ O	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



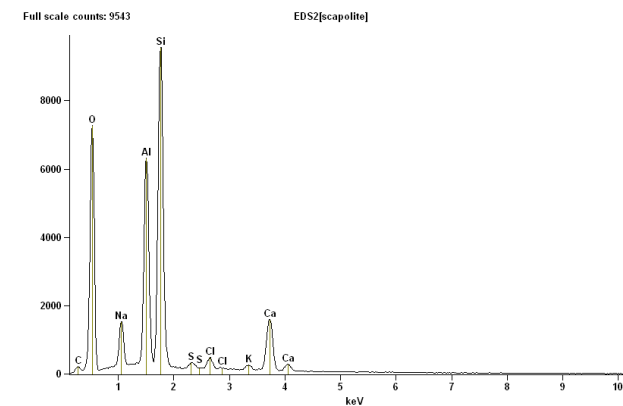
Backscatter SEM image

Locality

Brazil

Size fractions available

- 0.25 mm - 0.177 mm
- > 0.177 mm



EDS spectrum

References

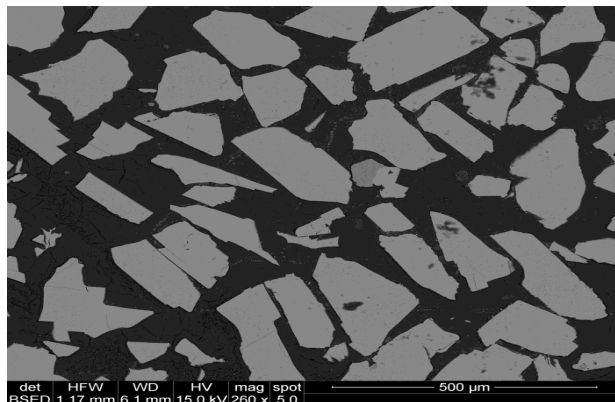
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. Geostandards Newsletter 4, p. 257-258

Microcline

NMNH 143966

Oxide	Composition (wt %)
SiO ₂	64.24
Al ₂ O ₃	18.30
Fe ₂ O ₃	0.00
FeO	0.04
MgO	0.03
CaO	0.02
Na ₂ O	1.30
K ₂ O	15.14
TiO ₂	0.01
MnO	0.04
Total	99.12

- **Analyst:** E. Kiss



Backscatter SEM image

Locality

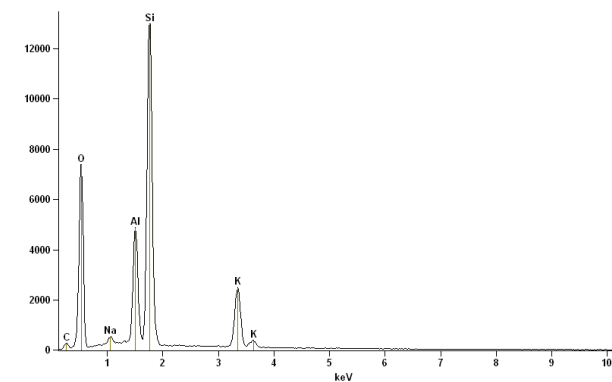
Unknown

Size fractions available

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

Impurities

- **Rare:** Albite inclusions



EDS spectrum

References

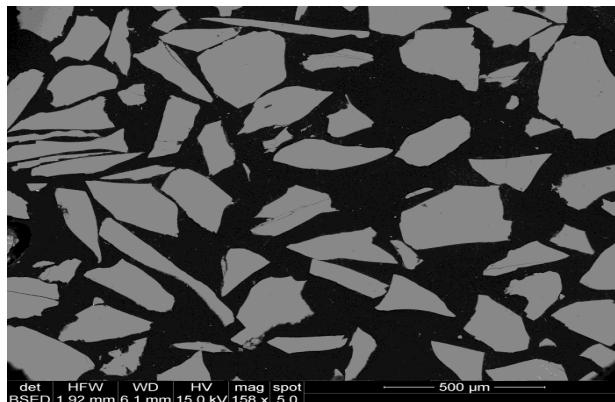
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

San Carlos olivine

NMNH 111312-44

Oxide	Composition (wt %)
SiO ₂	40.81
FeO	9.55
MgO	49.42
CaO	<0.05
P ₂ O ₅	0.00
MnO	0.14
NiO	0.37
Total	100.29

- **Analyst:** E. Jarosewich



Backscatter SEM image

Locality

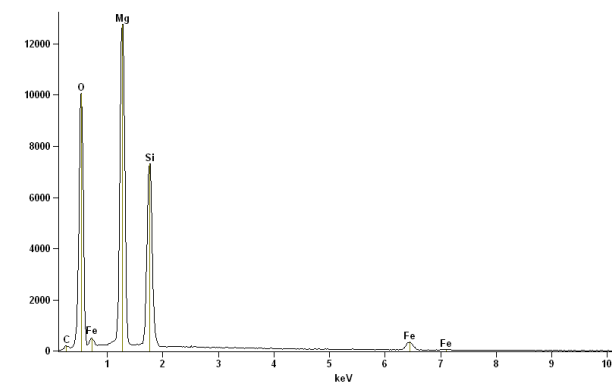
San Carlos, Arizona, USA

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.



EDS spectrum

References

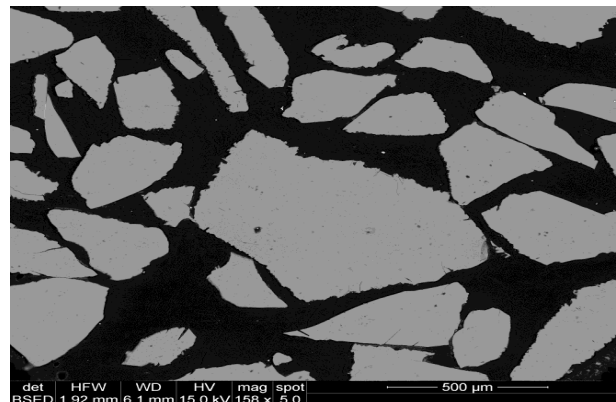
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. *Geostandards Newsletter* 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Corrections. *Geostandards Newsletter* 4, p. 257-258
- Fournelle, John H. (2011) An Investigation 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 ₂ O ₃	0.02
H ₂ O	<0.05
Total	99.47

- Analyst: J. Norberg



Backscatter SEM image

Locality

Springwater (meteorite)

Size fractions available

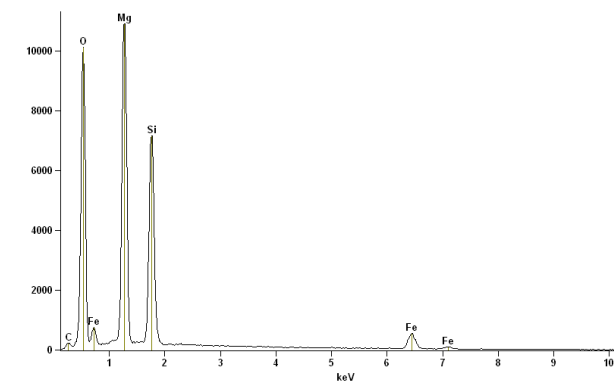
- 0.42 mm - 0.25 mm
- > 0.25 mm

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.



EDS spectrum

References

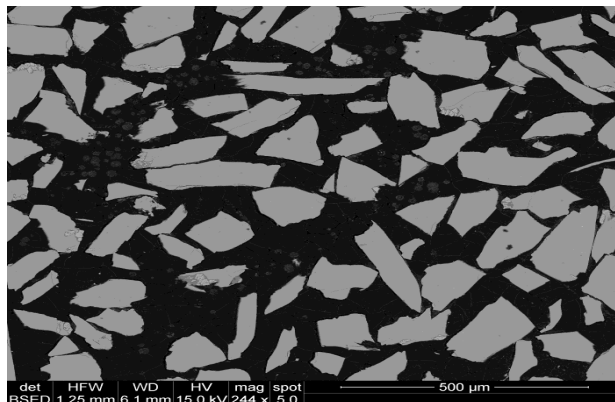
Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. Geostandards Newsletter 4, p. 43-47

Omphacite

NMNH 110607

Oxide	Composition (wt %)
SiO ₂	55.42
Al ₂ O ₃	8.89
Fe ₂ O ₃	1.35
FeO	3.41
MgO	11.57
CaO	13.75
Na ₂ O	5.00
K ₂ O	0.15
TiO ₂	0.37
MnO	0.10
H ₂ O	0.02
Total	100.03

- **Analyst:** E. Jarosewich



Backscatter SEM image

Locality

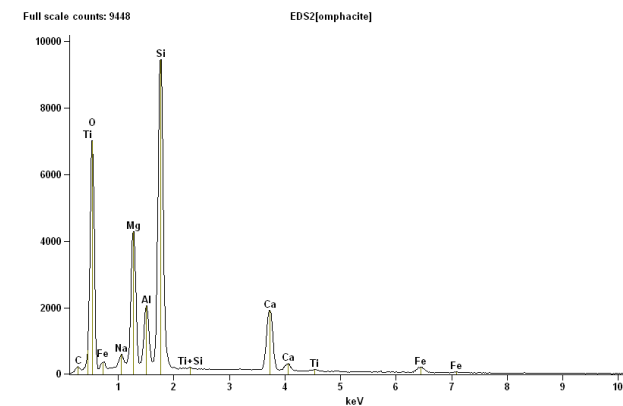
Roberts Victor Mine, South Africa

Size fractions available

- Fragments of variable size

Impurities

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



EDS spectrum

References

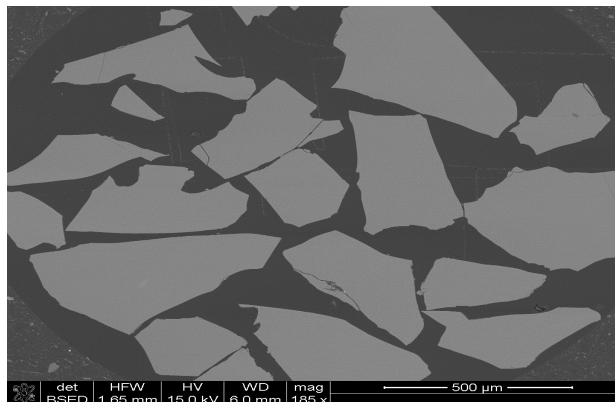
- Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. *Smithsonian Contributions to the Earth Sciences* 9, 83-84
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. *Geostandards Newsletter* 4, p. 43-47

Osumulite

NMNH 143967

Oxide	Composition (wt %)
SiO ₂	60.20
Al ₂ O ₃	22.60
FeO	6.38
MgO	5.83
CaO	<0.03
Na ₂ O	0.39
K ₂ O	4.00
TiO ₂	0.18
H ₂ O	0.02
Total	99.60

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



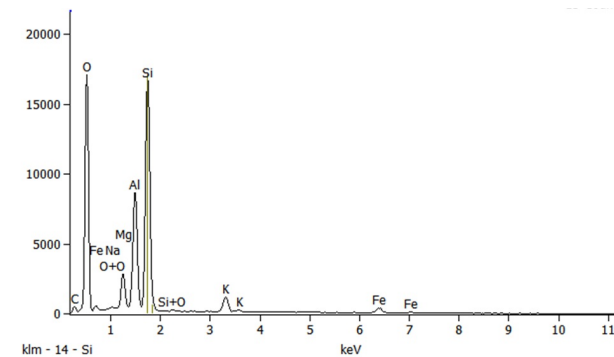
Backscatter SEM image

Locality

Nain, Newfoundland and Labrador, Canada

Size fractions available

- fragments of unknown size



EDS spectrum

References

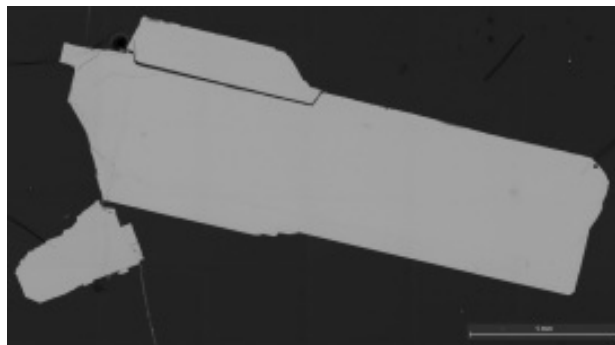
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Periclase

NMNH 118585

Oxide	Composition (wt %)
Mg	99.80
CaO	0.160
MnO	0.026
FeO	0.010
Total	100.00

- **Analyst:** Chris Sheedy (CSIRO)
- **Notes:** Trace element concentrations by ICP-OES:
 - Ca: 1150 mg/kg
 - Mn: 200 mg/kg
 - Fe: 79 mg/kg



Backscatter SEM image

Locality

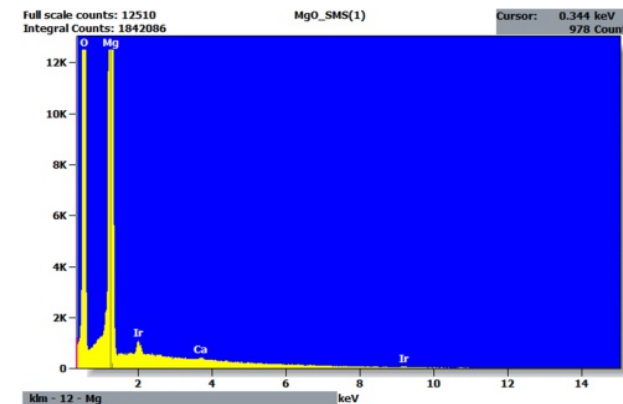
None (synthetic)

Size fractions available

- Grains to chunks

Notes

- This material was created at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and a >100gm piece was kindly provided by Colin M. MacRae.
- Phase identification as periclase by M. Wise using x-ray diffraction.



EDS spectrum

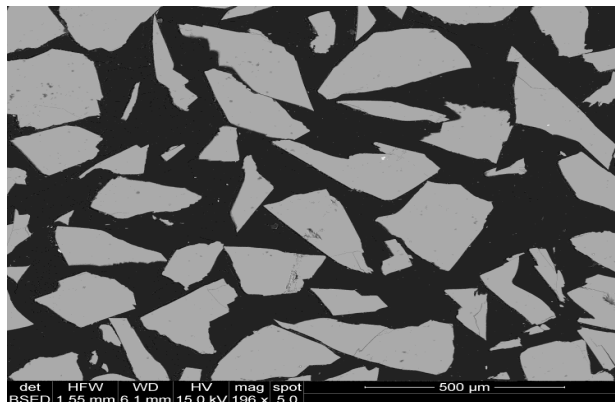
References

Plagioclase

NMNH 115900

Oxide	Composition (wt %)
SiO ₂	51.25
Al ₂ O ₃	30.91
Fe ₂ O ₃	0.34
FeO	0.15
MgO	0.14
CaO	13.64
Na ₂ O	3.45
K ₂ O	0.18
TiO ₂	0.05
MnO	0.01
H ₂ O	0.05
Total	100.17

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



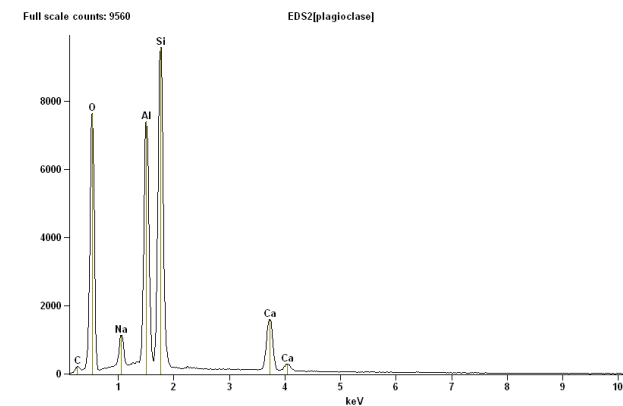
Backscatter SEM image

Locality

Lake County, Oregon, United States

Size fractions available

- > 0.149 mm



EDS spectrum

References

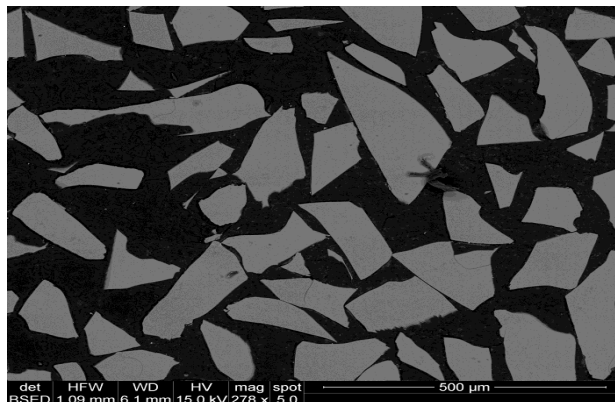
- Stewart, D.B., Walker, G.W., Wright, T.L., Fahey, J.J.(1966)
Physical Properties of calcic Labradorite from Lake County,
Oregon; American Mineralogist 51, 177-197
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

Pyrope

NMNH 143968

Oxide	Composition (wt %)
SiO ₂	41.46
Al ₂ O ₃	23.73
FeO	10.68
MgO	18.51
CaO	5.17
TiO ₂	0.47
MnO	0.28
H ₂ O	<0.01
Total	100.30

- **Analyst:** E. Jarosewich



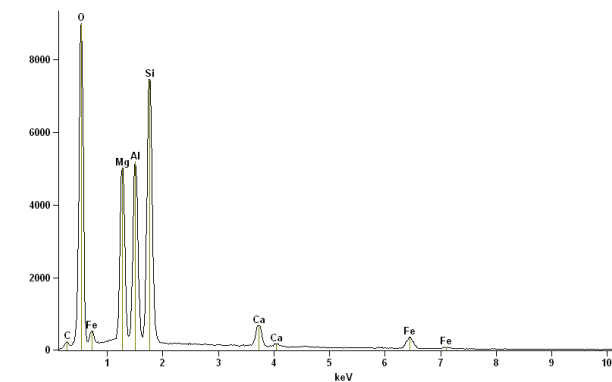
Backscatter SEM image

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



EDS spectrum

References

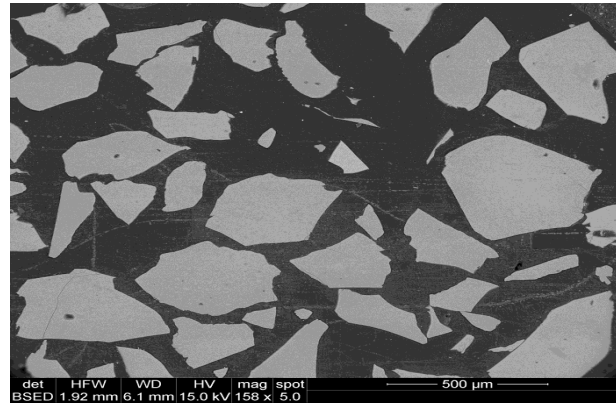
- Jarosewich, E. (1972) Chemical analysis of five minerals for microprobe standards. *Smithsonian Contributions to the Earth Sciences* 9, 83-84
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980) Reference Samples for Electron Microprobe Analysis. *Geostandards Newsletter* 4, p. 43-47

Quartz

NMNH R17701

Oxide	Composition (wt %)
SiO ₂	99.99
Total	99.99

- **Analyst:** E. Jarosewich



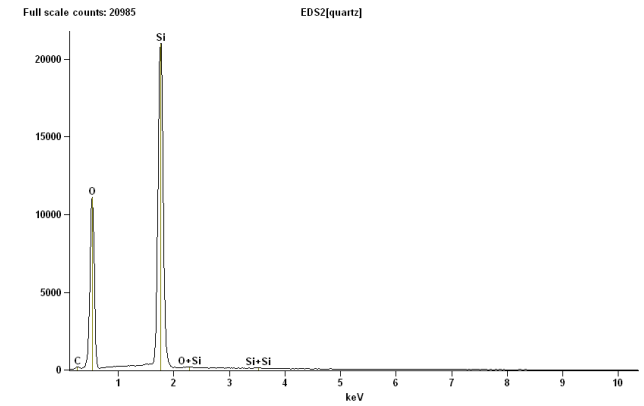
Backscatter SEM image

Locality

Hot Springs, Arkansas, USA

Size fractions available

- 0.25 mm - 0.177 mm



EDS spectrum

References

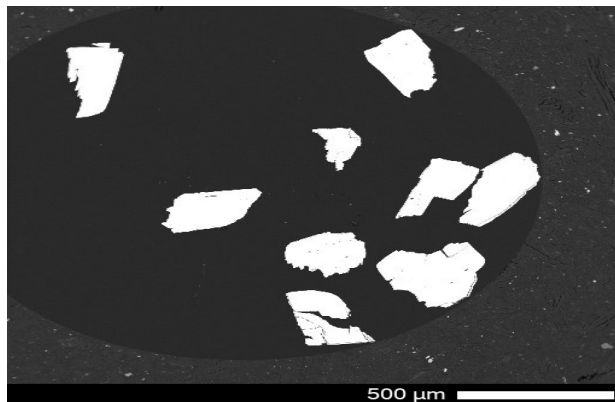
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Corrections. Geostandards Newsletter 4, p. 257-258

Siderite

NMNH R2460

Oxide	Composition (wt %)
FeO	59.08
MnO	2.95
CO ₂	37.88
Total	99.91

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



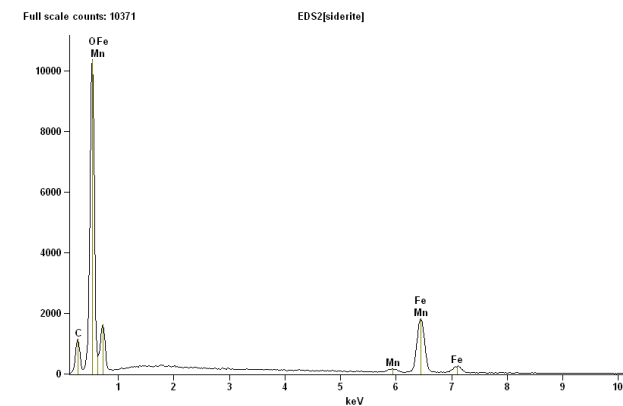
Backscatter SEM image

Locality

Ivigtut, Greenland

Size fractions available

- 0.42 - 0.25 mm



EDS spectrum

References

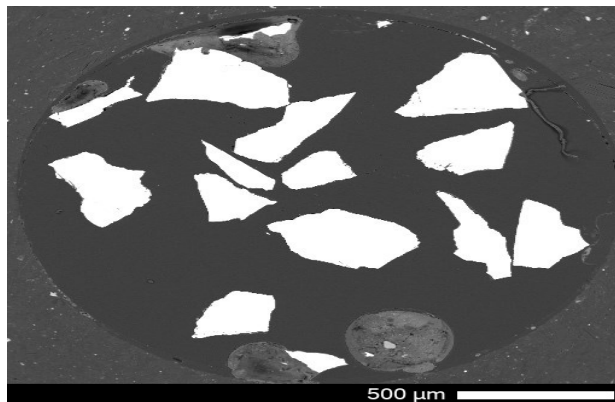
Jarosewich, E. et. al. (1983) Carbonate reference samples for electron microprobe and scanning electron microscope analyses. *J. of Sedimentary Petrol.* 52 (2), p. 677-678.

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

Locality

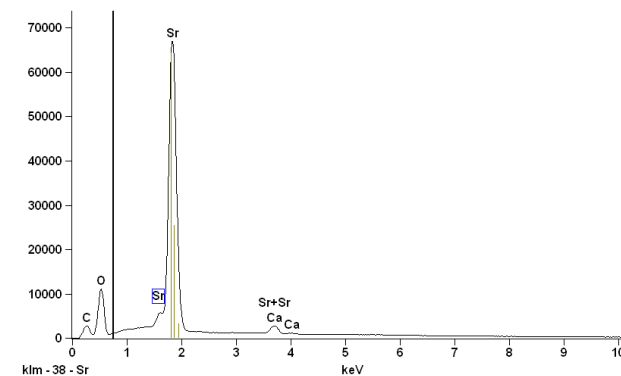
Oberdorf, Austria

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



EDS spectrum

References

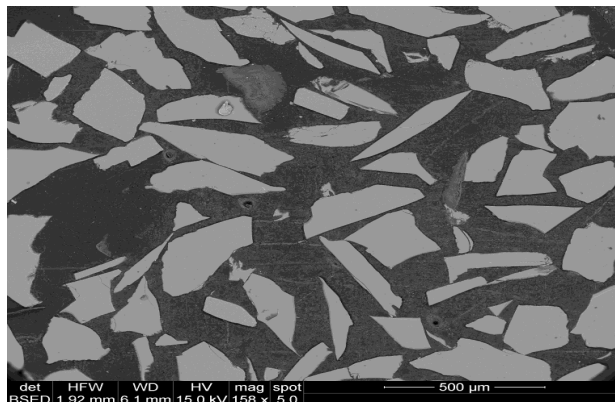
Jarosewich, E. and White, J. S. (1987) Strontianite reference sample for electron microprobe and SEM analyses. *J. Sedimentary Petrol.* 57 (4), p. 762-763

Synthetic corundum

NMNH 135602

Oxide	Composition (wt %)
Al ₂ O ₃	99.99
Total	99.99

- **Analyst:** E. Jarosewich
- **Notes:** Emission spectrometric analysis:
 - Si: 0.03
 - Fe: 0.003
 - Mg: 0.007
 - Ca: 0.003
 - Na: 0.005
 - K: 0.005



Backscatter SEM image

Locality

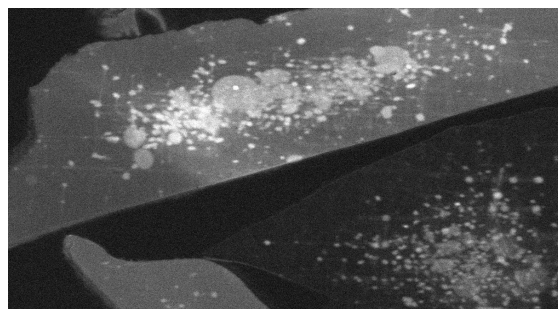
None (synthetic)

Size fractions available

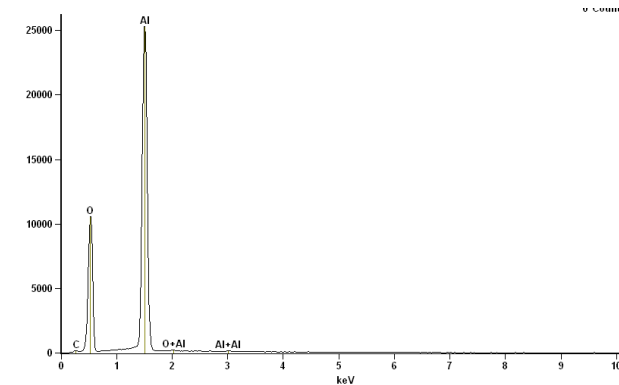
- 0.250 mm - ~0.177 mm

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



EDS spectrum

References

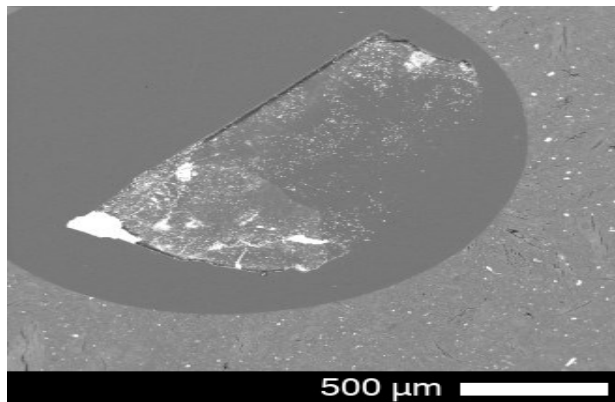
- Jarosewich, E., Nelen, J. A., and Norberg, J. A. (1980)
Reference Samples for Electron Microprobe Analysis.
Geostandards Newsletter 4, p. 43-47

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

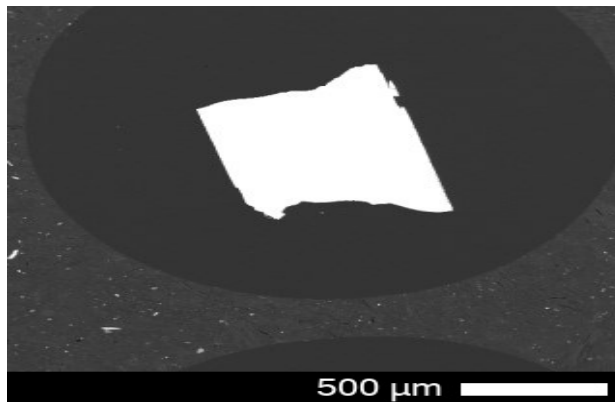
- Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. *J. of Research of NIST*, 107, p. 693-701
- Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. *Can. Min.* 41, pp. 221-232
- 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

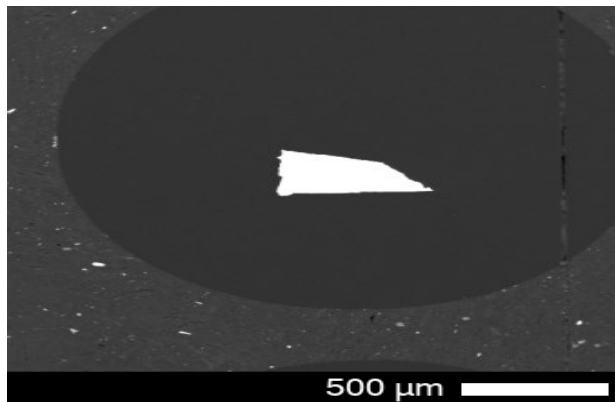
- Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. *J. of Research of NIST*, 107, p. 693-701
- Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. *Can. Min.* 41, pp. 221-232
- 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

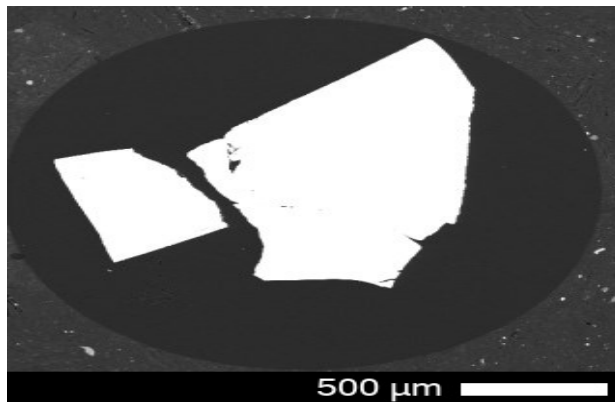
- Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. *J. of Research of NIST*, 107, p. 693-701
- Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. *Can. Min.* 41, pp. 221-232
- 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

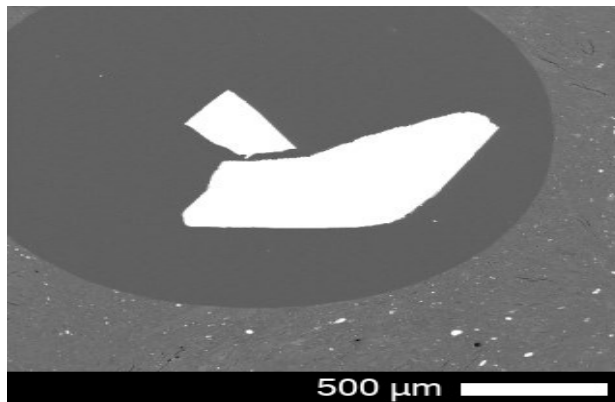
- Donovan, J. et al. (2002) Contamination in the rare-earth element orthophosphate reference samples. *J. of Research of NIST*, 107, p. 693-701
- Donovan, J. et al (2003) A Re-examination of the Rare-Earth-Element Orthophosphate Standards in Use For Electron Microprobe Analysis. *Can. Min.* 41, pp. 221-232
- 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

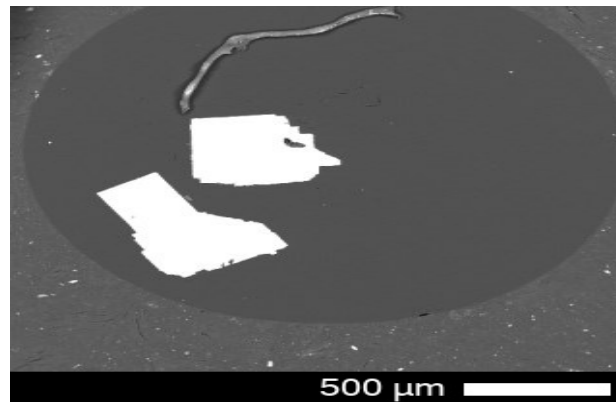
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Holmium phosphate

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

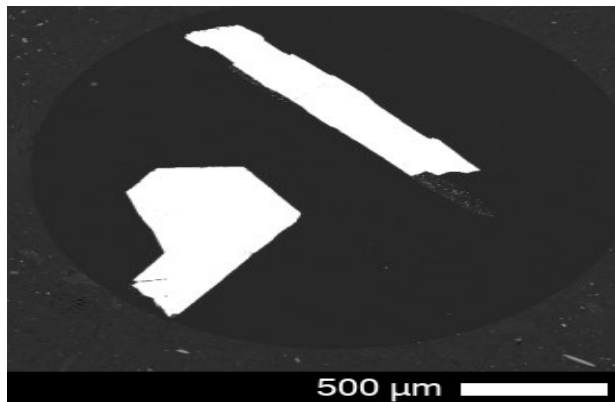
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Lanthanum phosphate

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

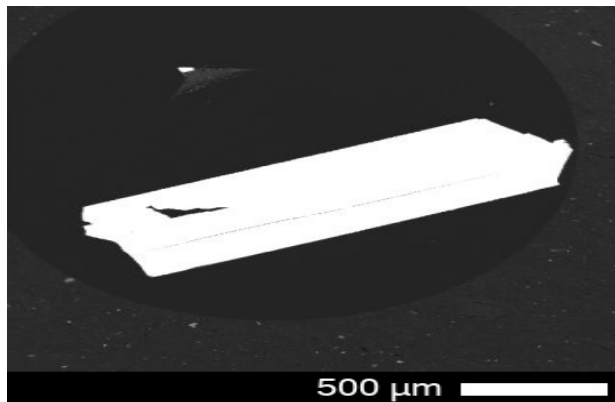
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Lutetium phosphate

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

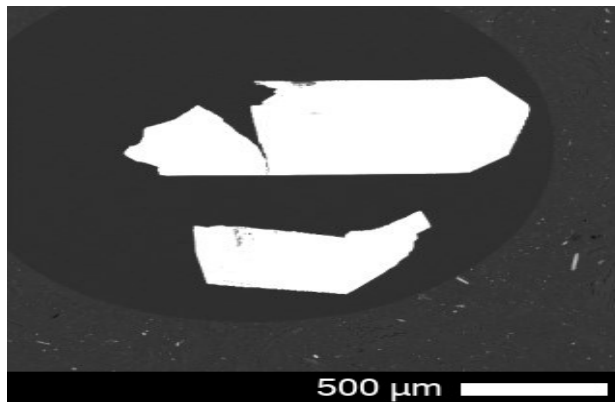
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Neodymium phosphate

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

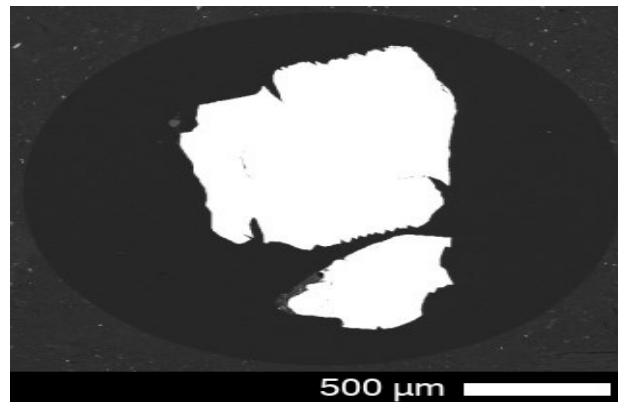
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Praseodymium phosphate

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

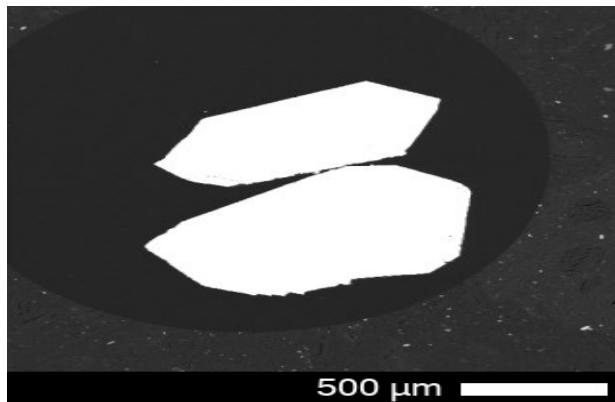
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- Jarosewich, E. and Boatner, L. (1991) Rare-earth element reference samples for electron microprobe analysis. *Geostand. Newslett.* 15 (2), p. 397-399

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

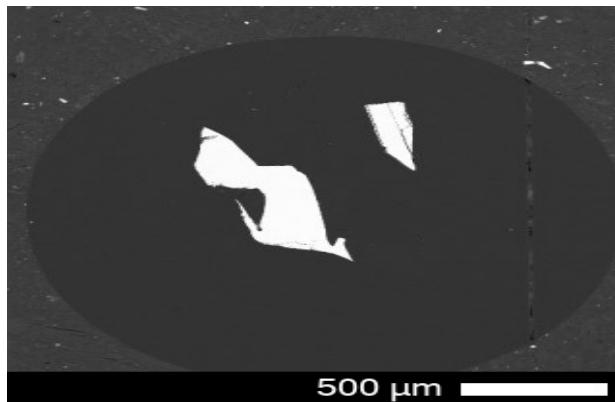
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Scandium phosphate

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

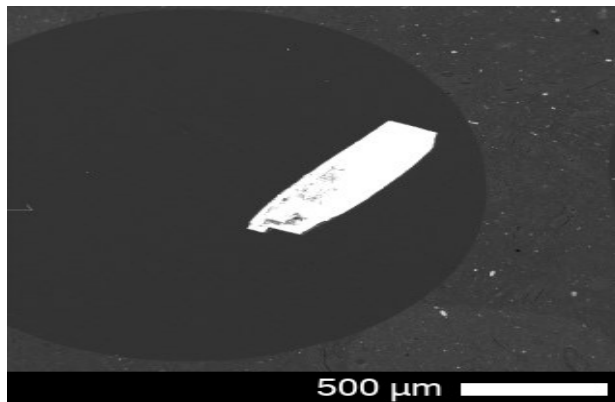
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Terbium phosphate

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

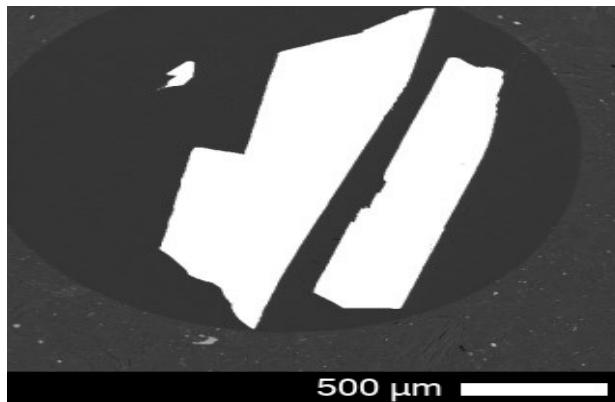
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Thulium phosphate

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

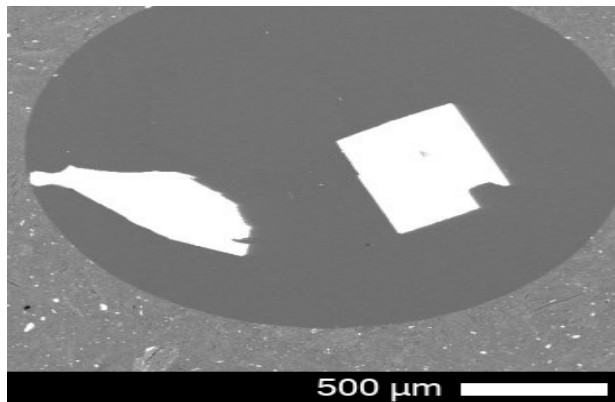
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Ytterbium phosphate

NMNH 168498

Oxide	Composition (wt %)
Yb	64.56
PO ₄	35.44
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

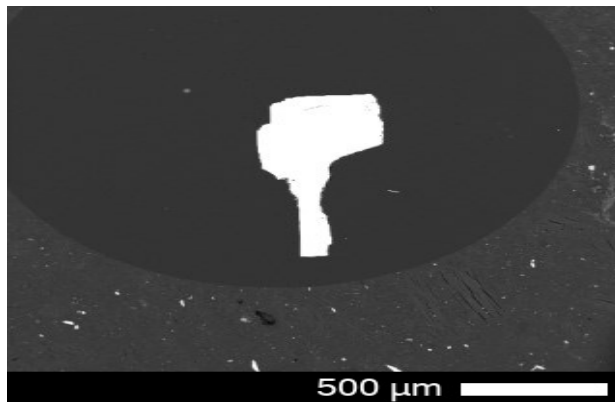
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Yttrium phosphate

NMNH 168499

Oxide	Composition (wt %)
Y	48.35
PO ₄	51.65
Total	100.00

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



Backscatter SEM image

Locality

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
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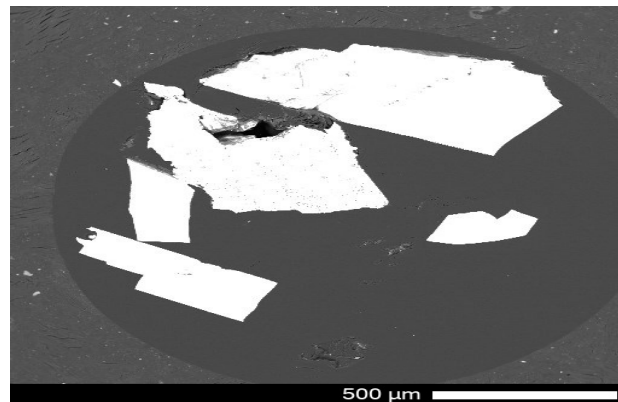
Zircon

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:

ZrO₂ was determined from by subtracting HfO₂ from combined ZrO₂- HfO₂ analysis. HfO₂ was determined by microprobe, corrected by modified magic.



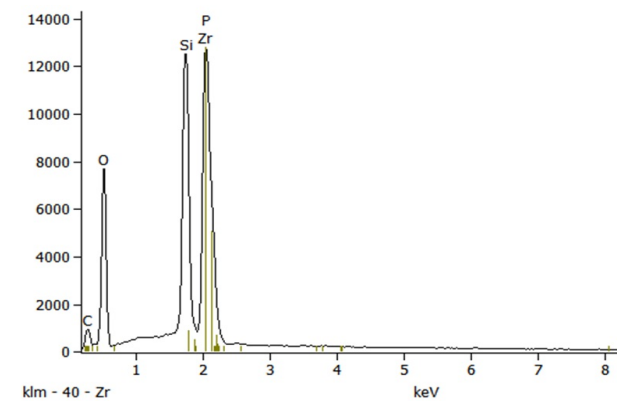
Backscatter SEM image

Locality

Strangeway Range, Australia

Size fractions available

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



EDS spectrum

References

Nelen, J. (pers. comm.)