SUPPLEMENTAL TABLE 1. Pixel counts per sample used to produce average spectra in the VNIR and SWIR ranges

Mineral	Sample	VNIR Pixels	SWIR Pixels
Cerite	Bastnas	9459	1853
Mosandrite	Kipawa CMN F92–23	2977	1228
Kainosite	Long Lake	175	22
Zircon	Green River	4391	497
	Mudtank	7424	2365
	North Burgess	12172	2110
	Mt. Malosa	701	40
	St. Peters Dome	948	195
Eudialyte	MSH CMN 72–24	9414	222
	MSH CMN 88–79 (Pinch Collection)	5890	476
	MSH CMNOC 2045	11171	730
	MSH CMNOC 37104	7141	2867
	MSH CMNOC 478	11324	986
	MSH CMNOC 476	5856	178
	Kipawa UofA Fragment	2416	227
	Kipawa Mariano	4070	3186
	Kipawa CMN F92–23	12305	1313

SUPPLEMENTAL TABLE 2. Chemical variation relevant to reflectance spectroscopy, as well as probable ages and geological settings for the zircon samples

Sample	U and Th	REE	Analytical Total (wt%)	Age	Geological Setting	Reference
Mudtank	Below detection	Very Low	98.24	732 Ma	Carbonatite	Currie et al. (1992)
St. Peters Dome	Below detection	Low	96.04	~1 Ga	Pegmatites of A-type granite suite	Smith et al. (1999)
Mt. Malosa	Below detection	High	95.82	~113 Ma	Pegmatites of A-type granite suite	Eby et al. (1995, Guastoni et al. (2009)
North Burgess	Moderate	Very Low	98.63	1 Ga?	Pegmatite-related metasomatic skarn?	Currie (1951)
Green River	High	Moderate	98.37	329 Ma	Syenitic pegmatite	Braun et al. (2009)

*Analytical Total is given as a rough proxy for degree of metamictization.

Supplemental Table 3. Prominent absorption features of cerite in the VNIR and SWIR ranges

Cerite	Cluster	λ (nm)	Shape	Probable Origin
VNIR Range 1		**523**	**MIN**	**Nd**
	2	**583**	**MIN - st**	**Nd, Pr**
		627	SH - n	Nd
		642	SH - n	Nd
		661	SH - n	Nd
	3	**681**	**MIN**	**Nd**
	4	**737**	**MIN**	**Nd**
		746	**MIN - st**	**Nd**
		753	SH	Nd
	5	**797**	**MIN**	**Nd**
		803	**MIN - st**	**Nd**
		811	SH	Nd
		825	SH	Nd
	6	**864**	**MIN - st**	**Nd**
		876	**MIN - st**	**Nd**
		888	SH	Nd
		898	SH	Nd
		945	MIN - w, n	Sm
		961	MIN - w, n	Sm
SWIR Range	7	1010	SH	Pr
		1080	**MIN - st**	**Sm**
		1112	SH	Sm
	8	**1232**	**MIN - st**	**Sm**
		1263	SH	Sm
	9	1383	MIN	Sm
		1408	SH	H_2O/OH
		1452	MIN	Pr
		1540	**MIN - st**	**Pr > Sm**
		1578	SH	Pr, Sm Nd
		1622	SH	Pr, Sm Nd
		1710	**MIN**	**Nd**
	10	**1968**	**MIN - st**	**Pr, Sm, H_2O**
		2030	SH	Pr > Eu
	11	**2193**	**MIN**	**OH/REE/Mg-Fe**
	*	**2243**	**MIN - w**	**OH/REE/Mg-Fe**
	*	**2312**	**MIN**	**OH/REE/Mg-Fe**
	*	2330	MIN	OH/REE/Mg-Fe
		2355	SH	OH/REE/Mg-Fe
		2380	SH	OH/REE/Mg-Fe
		2424	**MIN - st**	**OH/REE/Mg-Fe**
		2487	MIN	OH/REE/Mg-Fe
		2518	SH	OH/REE/Mg-Fe

Note: Absorption bands marked with * share distinct wavelength positions with bastnaesite.

Supplemental Table 4. Prominent absorption features of mosandrite in the VNIR and SWIR ranges

Mosandrite	Cluster	λ (nm)	Shape	Probable Origin
VNIR Range	1	**527**	**MIN**	**Nd**
		547	SH - n	Nd
	2	**574**	**MIN - st**	**Nd, Pr**
		586	**MIN - st**	**Nd, Pr**
		615	SH	Nd
		627	SH - n	Nd
		651	SH - b, n	Er
	3	**681**	**MIN**	**Nd**
	4	736	MIN	Nd
		740	**MIN - st**	**Nd > Dy**
		745	MIN	Nd > Dy
	5	772	SH	Nd > Dy
		795	SH	Nd > Dy
		804	**MIN - st**	**Nd > Dy**
		811	SH	Nd > Dy
	6	864	SH	Nd
		874	**MIN - st**	**Nd**
		880	SH	Nd
		919	SH - n	Dy
		945	MIN - w, n	Sm > Dy
	7	**976**	**MIN - st**	**Er, Yb**
SWIR Range	8	**1074**	**MIN - st**	**Sm**
		1093	SH	Sm
	9	1232	SH	Sm
		1257	**MIN - st**	**Sm**
	10	1377	SH	Sm
		1440	SH	H_2O/OH
		1471	**MIN - st**	**Pr**
		1528	**MIN**	**Sm > Pr, Er**
		1585	SH	Sm > Pr, Nd
	11	1729	SH	Nd, Dy
		1817	SH	Nd, Dy
		1930	**MIN - st**	**H_2O**
	12	**2318**	**MIN**	**OH/REE/Ti**
		2393	SH	OH/REE/Ti
		2418	SH	OH/REE/Ti
		2462	**MIN**	**OH/REE/Ti**

Supplemental Table 5. Prominent absorption features of kainosite in the VNIR and SWIR ranges

Kainosite	Cluster	λ (nm)	Shape	Probable Origin
VNIR Range	1	**576**	**MIN - n**	**Nd**
		585	MIN - n	Nd
		596	SH - n	Nd
	2	**651**	**MIN - n**	**Ho, Er**
	3	**737**	**MIN**	**Nd, Dy**
		743	SH - n	Nd, Dy
		745	SH - n	Nd, Dy
		750	**MIN - st**	**Nd, Dy**
		754	**MIN**	**Nd, Dy**
	4	782	SH - n	Nd, Dy, Er
		795	MIN	Nd, Dy, Er
		805	**MIN - st**	**Nd, Dy, Er**
		814	MIN	Nd, Dy, Er
		820	SH	Nd, Dy, Er
	5	**865**	**MIN**	**Nd**
		876	**MIN**	**Nd**
		887	MIN - n	Nd, Ho, Dy
		896	MIN - n	Dy, Nd
	6	**978**	**MIN**	**Er, Yb**
SWIR Range	7	**1080**	**MIN**	**Sm**
		1105	SH	Dy, U?
		1156	SH	Dy, Ho
	8	**1232**	**MIN**	**Dy, Sm**
		1263	**MIN**	**Dy, Sm**
		1288	SH	Dy
	9	**1377**	**MIN**	**Sm**
	10	1415	SH	H_2O/OH
		1484	**MIN - st**	**Er, Pr**
		1528	**MIN**	**Er > Sm**
	11	1653	SH - w	Dy, Nd
		1723	MIN - w	Dy, Nd, Tb
	12	**1961**	**MIN - st**	**H_2O, Eu, Pr, Ho**
		2055	**MIN - st**	**U?, Sm, Pr, Ho, Tb**
		2105	SH	Sm, Pr, Ho
	13	2199	MIN - w	CO_3/OH/REE
		2243	SH	CO_3/OH/REE
		2268	SH	CO_3/OH/REE
		2318	SH	CO_3/OH/REE
		2387	**MIN - st**	**CO_3/OH/REE**
		2474	**MIN**	**CO_3/OH/REE**
		2505	SH	CO_3/OH/REE

SUPPLEMENTAL TABLE 6. Prominent absorption features of zircon samples in the VNIR range

		Zircon	St Peters Dome		Mudtank		North Burgess		Green River		Mt Malosa	
Cluster	U		λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape
1		Nd									575	SH
		Nd									**576**	**MIN**
		Nd									**582**	**MIN**
		Nd							589	SH - w, n	585	SH
		Nd									594	MIN
2	A	U^{4+} and Er					653	MIN - w	654	MIN	651	MIN - n
		Er							661	SH	660	SH - n
		Nd							683	SH - w	681	MIN - n, w
	B	U^{4+}					691	SH - w	690	MIN		
3		**Nd > Dy**							**738**	**MIN - w**	**739**	**MIN - st**
		Nd > Dy							**750**	**MIN**	**750**	**MIN - st**
		Nd							756	SH - w	757	MIN
		Nd							760	SH - w	769	SH
		Nd									774	SH
4		Nd > Er,Dy							781	MIN - w	781	MIN
		Nd > Er,Dy							797	SH	796	SH
		Nd > Er,Dy							803	MIN	802	SH
		Nd > Er,Dy							**808**	**MIN - st**	**808**	**MIN - st**
		Nd > Er,Dy									819	SH
		Er									835	MIN - n
		Er									844	MIN - n
	C	U^{4+}?							849	MIN - n b		
5		**Nd**									**870**	**MIN - st**
		Nd							**882**	**SH**	**880**	**MIN - st**
		Dy	**892**	**MIN - w**			**892**	**MIN - w**	**894**	**MIN**	**893**	**MIN**
	D	U^{4+}			916	MIN - n, w	916	MIN - n, w	916	MIN - st	915	MIN - w
	E	U^{4+}					961	MIN - n, w	961	SH - b		
6		**Er, Yb**							**978**	**MIN - st**	**978**	**MIN**

* REE related absorption clusters are labeled with numbers while U-related absorptions are labeled with letters.

SUPPLEMENTAL TABLE 7. Prominent absorption features of zircon samples in the SWIR range

Cluster	U	Zircon	St Peters Dome		Mudtank		North Burgess		Green River		Mt Malosa	
			λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape
	F	U^{4+}	1010	SH - w	1010	SH	1010	MIN - w	1010	SH		
	F	U^{4+}	1061	SH - w	1055	SH	1055	MIN	1061	MIN		
7		**Sm**	**1086**	**SH - w**							**1086**	**MIN**
		Sm									1105	MIN
	G	U^{5+}	1118	SH - w	1112	MIN	1112	MIN	1118	MIN	1112	SH
	G	U^{4+}	1137	SH - w	1149	SH	1149	SH	1143	SH - w	1143	SH
8		Sm?									1200	SH
		Sm									**1244**	**MIN**
		Sm, Dy							**1263**	**SH**	**1263**	**MIN**
		Dy							1288	MIN - w	1288	SH
	H	U^{4+}			1326	MIN	1326	MIN	1326	MIN		
	H	U^{4+}			1345	MIN - w	1345	SH	1345	SH	1332	SH
9		**Sm**							**1389**	**SH**	**1389**	**MIN**
		H_2O/OH	**1415**	**MIN**					**1415**	**MIN - w**	**1415**	**MIN - w**
10	I	U^{4+}, Er	1478	MIN - w	1478	SH	1478	SH	1478	SH	1427	SH - w
	I	U^{5+}	1503	MIN - w	1503	MIN - st	1503	MIN - st	1503	MIN - st	1503	MIN - st
	I	U^{4+}, Er, Sm	1522	SH - w	1534	SH	1534	SH	1534	SH	1528	SH
		Er, Sm									**1560**	**MIN**
		Sm	1616	SH - w							1616	MIN - w
	J	U^{4+}	1654	MIN - w	1660	MIN	1660	MIN	1660	MIN	1660	MIN
11		Dy									1691	MIN - w
	J	U^{4+}			1704	MIN	1704	MIN	1704	MIN - w		
		Nd?	1729	MIN - w, b	1742	SH - w	1742	SH - w	1729	MIN - w, b	1729	MIN
	K	U^{4+}			1792	SH - w	1792	SH - w	1792	SH - w		
12		**H_2O**	**1924**	**MIN - st**	**1924**	**SH**	**1917**	**MIN - b**	**1930**	**MIN**	**1917**	**SH**
		Sm									**1943**	**MIN**
	L	U^{4+}	2068	MIN - w	2068	MIN - st	2068	MIN - st	2074	MIN - st	2074	SH - w
	M	U^{4+}			2187	SH	2187	SH				
13		**Comb & Overt**	**2206**	**MIN - st**	**2206**	**SH**			**2206**	**MIN**		
		Comb & Overt	2256	SH	2268	MIN - w	2262	SH	2262	SH		
		Comb & Overt	**2312**	**SH**	**2306**	**SH**	**2306**	**MIN**	**2305**	**MIN**	**2312**	**MIN**
		Comb & Overt	2355	MIN	2362	SH	2349	SH	2355	MIN	2349	MIN
		Comb & Overt	2387	MIN			2393	SH	2393	MIN	2474	MIN
		Comb & Overt	2443	SH	2462	MIN						
		Comb & Overt	2499	MIN							2499	MIN
		Comb & Overt	2511	MIN - w								

* REE related absorption clusters are labeled with numbers while U-related absorptions are labeled with letters.

SUPPLEMENTAL TABLE 8. Prominent absorption features of HREE-enriched eudialyte samples in the VNIR and SWIR ranges

Eudialyte	Kipawa-Mariano		Kipawa - UofA		Kipawa F92-23		CMNOC 478		Probable Origin
LREE/HREE	0.4		0.4		0.5		2.7		
Cluster	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	
1					576	SH - n	576	MIN - n	Nd
					584	**SH - n**	**584**	**MIN - n**	**Nd**
2	**651**	**MIN - w**	**651**	**MIN - w**	**651**	**MIN - w**			**Er, U?**
	661	MIN - w, n	661	MIN - w, n	661	MIN - w, n			Er
	680	SH	680	SH	680	SH			Er
3	733	SH	735	MIN	734	MIN	735	MIN - w	Dy, Nd
	741	**MIN - st**	**745**	**MIN - st**	**745**	**MIN - st**	**745**	**MIN - w**	**Dy, Nd**
	750	MIN	752	MIN	752	MIN	754	MIN - w	Dy, Nd
	760	SH							Dy
4	**800**	**MIN - st**	**800**	**MIN - st**	**800**	**MIN - st**	**800**	**MIN**	**Nd, Dy, Er**
	808	MIN	809	SH	809	SH	804	MIN - w	Nd, Dy, Er
	824	SH							Nd, Dy, Er
5	865	SH	865	SH	865	SH	865	SH - w	Nd, Dy
	873	**MIN**	**872**	**MIN**	**872**	**MIN**	**872**	**SH - w**	**Nd, Dy**
	880	MIN							Nd, Dy
	888	SH - b	888	SH - b	888	SH - b			Dy
	910	**MIN**	**910**	**MIN - b**	**910**	**MIN - b**			**Dy**
6	**974**	**MIN - st**	**974**	**MIN**	**975**	**MIN**			**Er, Yb**
$^{V}Fe^{2+}$	–	–	914	MIN - b	914	MIN - b	914	MIN - b	$^{V}Fe^{2+}$
7	**1061**	**MIN**	**1067**	**SH**	**1067**	**SH**			**Dy, Sm, U?**
	1099	SH	1105	SH - w					Dy
8	1168	SH	1168	SH	1168	SH			Dy, U?
	1213	SH	1213	SH	1213	SH	1200	SH - w	Dy, Sm
	1276	**MIN**	**1276**	**MIN**	**1276**	**MIN**	**1263**	**SH**	**Dy, Sm**
	1358	SH	1358	SH	1358	SH			Dy, U^{4+}?
	1408	**MIN**	**1408**	**MIN**	**1408**	**MIN**			**H_2O/OH, Sm**
	1433	**MIN - st**	**1440**	**MIN - st**	**1433**	**MIN - st**	**1433**	**MIN - st**	**H_2O/OH**
	1478	SH	1478	SH	1478	SH	1471	MIN	Pr, Er, U^{4+}?
	1534	**MIN**	**1534**	**MIN**	**1534**	**MIN**	**1540**	**SH**	**Er, Sm, U^{4+}?**
	1566	SH - w	1566	SH - w	1566	SH - w			Er
9									Nd
	1811	SH	1811	SH	1811	SH	1792	SH	U^{4+}?
	1930	**MIN - st**	**1930**	**MIN - st**	**1930**	**MIN - st**	**1924**	**MIN - st**	**Pr, Sm, H_2O**
			2074	SH - w, b	2093	SH - w, b	2080	SH - w, b	U^{4+}?
10	2193	SH	2193	SH	2193	SH	2193	SH	OH/REE/Mn-Fe
									OH/REE/Mn-Fe
									OH/REE/Mn-Fe
	2312	SH	2312	SH	2318	MIN - w	2312	MIN - w	OH/REE/Mn-Fe
									OH/REE/Mn-Fe
	2437	**MIN**	**2443**	**MIN**	**2437**	**MIN**	**2437**	**SH**	**OH/REE/Mn-Fe**
									OH/REE/Mn-Fe
	2493	**SH**	**2493**	**SH**	**2493**	**SH**	**2474**	**MIN**	**OH/REE/Mn-Fe**
Refl. Peak	1118		1156		1143		1320		

Supplemental Table 9. Prominent absorption features of LREE-enriched eudialyte samples in the VNIR and SWIR ranges

Eudialyte	CMNOC 2045		CMNOC 476		CMN 88-79 Pinch		CMN 72-24		CMNOC 37104		Probable Origin
LREE/HREE	4.6		6.2		8.5		9.5		10.6		
Cluster	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	λ (nm)	Shape	
1	576	MIN - n, w									Nd
					582	**MIN - w, n**	**581**	**MIN - w, n**	**593**	**SH - n**	**Nd**
2					656	MIN - w, n					Er, U?
											Er
											Er
3					735	SH					Dy, Nd
	737	**SH - v, w**	**739**	**MIN - st**	**740**	**MIN - st**	**740**	**MIN**	**740**	**MIN**	**Dy, Nd**
	753	**SH - v, w**	**751**	**MIN**	**752**	**MIN**	**750**	**MIN**	**751**	**MIN**	**Dy, Nd**
											Dy
4			**801**	**MIN**	**798**	**SH - n**	**796**	**MIN**	**795**	**MIN**	**Nd, Dy, Er**
			810	**MIN - st**	**807**	**MIN - st**	**808**	**MIN**	**807**	**MIN**	**Nd, Dy, Er**
			826	SH			824	SH - n			Nd, Dy, Er
5			**869**	**SH**	**866**	**MIN**	**864**	**MIN**	**863**	**MIN**	**Nd, Dy**
											Nd, Dy
			880	**MIN**	**880**	**MIN**	**880**	**MIN**	**879**	**MIN**	**Nd, Dy**
											Dy
											Dy
6											Er, Yb
$^{V}Fe^{2+}$	920	MIN - b	916	MIN - b	886	MIN - b	-	-	-	-	$^{V}Fe^{2+}$
7			1061	SH - w	1061	SH - w	1061	SH - w	1061	SH - w	Dy, Sm, U?
											Dy
8			1162	SH	1162	SH	1162	SH	1162	SH	Dy, U?
	1200	SH - w	1213	MIN - w	1206	MIN - w	1200	SH	1200	SH	Dy, Sm
			1269	SH	1263	SH	1251	SH	1251	SH	Dy, Sm
	1351	SH - w	1351	SH	1351	SH	1351	SH	1351	SH	Dy, U^{4+}?
	1408	SH	1408	SH	1408	SH					H_2O/OH, Sm
	1440	**MIN**	**1440**	**MIN - st**	**1440**	**MIN - st**	**1427**	**MIN - st**	**1433**	**MIN - st**	**H_2O/OH**
	1478	MIN - w	1478	SH -w	1478	SH	1478	SH	1478	SH	Pr, Er, U^{4+}?
					1553	SH					Er, Sm, U^{4+}?
											Er
9					1729	SH					Nd
			1817	SH	1817	SH	1805	SH	1805	SH	U^{4+}?
	1936	**MIN - st**	**1930**	**MIN - st**	**1930**	**MIN - st**	**1930**	**MIN - st**	**1930**	**MIN - st**	**Pr, Sm, H_2O**
	2087	MIN - w, b	2093	SH - w, b	2087	SH - b					U^{4+}?
10	2193	MIN - w, b			2193	SH					OH/REE/Mn-Fe
	2230	MIN - w			2237	SH	**2249**	**MIN - st**	**2256**	**MIN - st**	**OH/REE/Mn-Fe**
	2274	SH - w	2268	SH	2274	MIN - w					OH/REE/Mn-Fe
	2324	MIN - w	2312	SH	2312	MIN	2312	MIN - w	2305	SH -w	OH/REE/Mn-Fe
					2349	SH	2330	SH - w			OH/REE/Mn-Fe
			2437	**MIN - st**	**2443**	**MIN - st**					**OH/REE/Mn-Fe**
			2462	MIN							OH/REE/Mn-Fe
			2487	SH	2487	SH	**2480**	**MIN - st**	**2480**	**MIN - st**	**OH/REE/Mn-Fe**
Refl. Peak	1307		1232		1307		1307		1307		

Supplemental Table 10. Cation site parameters for Yb3+ in REE-bearing silicate minerals

	Kainosite	Zircon	Mosandrite		Eudialyte	
Cation site	*Y*	*Zr*	*M*4, *M*5	*M*3	*M*1	*Na*4
Normal occupant	Y ≈ HREE	Zr	Ca ≈ Ce	Na	Ca	Na
Normal valence charge	+3	+4	~+2.5	+1	+2	+1
Coordination no.	8 (VIII)	8 (VIII)	7 (VII)	6 (VI)	6 (VI)	9 (IX)
Ionic radius (Å)	~1.002	0.84	~1.065	1.02	1.00	1.24
Coordinated anions	8 × O	8 × O	6 × O, 1 × OH	2 × O, 4 × Mixed	6 × O	"Cavity"
Yb^{3+} Substitution						
Valence charge	+3	+3	+3	+3	+3	+3
Ionic radius (Å)	0.985	0.985	0.925	0.868	0.868	1.042
Charge imbalance						
(Yb^{3+} - M^{X+})	0	–1	+0.5	+2	+1	+2
Yb^{3+} radius/M^{X+} radius	0.98	1.17	0.87	0.85	0.87	0.84

* Ionic radii from Shannon (1976).