

Spectral Feature (MRD-140)		Major Category	Subcategory	"Minerals and Chemicals of Interest" entries
NIR (OVIRS)	TIR (OTES)			
1.0-um electronic transition	8-12, 15-20, >15 um Si-O modes	Silicates	Olivine	Forsterite Fayalite
				"Olivine"
1.0- and 2.0-um electronic transitions	8-12, 15-20, >15 um Si-O modes		Pyroxenes and Wollastonite	Augite
				Clinopyroxene
				Diopside
				Fassaite
				Enstatite
				Hedenbergite
No reliable features (LFL); weak 1.2-um feature	8-12, 15-20, >15 um Si-O modes		Feldspars	Orthopyroxene (other than enstatite)
				Wollastonite
	8-12, 15-20, >15 um Si-O modes	Albite Anorthite Orthoclase		
		Plagioclase		
			Quartz Melilite	

	>15 um Si-O modes (presumably)		Other Silicates	Nepheline Sodalite Grossular
2.74 microns	8-12, 15-20, >15 um Si-O modes (not identified as hydrated silicates in MRD-140, but relevant -- LFL)	Hydrated Phases (silicate)	Serpentines	Biotite Chlorite Mica Chrysotile Cronstedtite Greenalite Montmorillonite
			Smectites	Saponite Talc Hornblende
	Not in MRD-140	Other Hydrated Phases	Phosphate	Apatite
Fe 3+ electronic transitions, 0.35-1.0 um	metal-O vibrations, >12.5 um	Oxides		chromite corundum hematite hercynite ilmenite magnetite perovskite spinel
>1.6 microns	6.3-6.7 um C-O stretch; C-O bend 11.1-11.4 um;	Carbonates		Calcite Siderite Magnesite
Ferric pigment, 0.4-0.6 um; Fe3+ 0.44, 0.95 um; overtones of	S-O stretches, 8-12 um; S-O bends, 14-25	Sulfates		Anhydrite Epsomite Gypsum

~2.74 microns

**XRD Phases
not in
Minerals and
Chemicals of
Interest**

"Si-O"
modes, 8-12,

2.95 um O-H stret 6.15 microns
3.38, 3.42, 3.48, 3.50 um
PAH, 3.29 microns

Not in MRD-140

2.95 microns?

Not in MRD-140

Chemicals

H₂O
Aliphatics (C-C, C-H)
Aromatic hydrocarbons
C=O (aka carbonyls)

O-H (aka alcohols)
N-H (aka amines)

Specific Material (columns G-K)	Detected by PSD- XRD (or other XRD) in any meteorite?	Found >5% in any meteorite?	Found >5% in any carbonaceou s meteorite?
Forsterite (XRD)	Y ?	Y	Y
Other Olivine (Fo10-Fo90?)	Y	Y	Y
Includes all high- Ca pyroxene	Y	Y	??
		Y	?
Enstatite	Y	Y	Y
		Y	?
Other low-Ca pyroxenes	Y	Y	Y
	?	N	N
	?	?	
	Y	Y	?
	N?	N	N
Non-Endmember Plagioclase	Y	Y	N?
	N?	N	N
	N?		

	N? N? N?		
		N N N	N N N
		Y Y Y	
	~Y	N Y N N	N Y N N
		Y Y Y	
		Y	
		Y Y Y	

Mg-Serpentine	Y	Y	Y
Pyrrhotite	Y	Y	Y
Pentlandite	Y	Y	Y
Troilite	Y	Y	
Metal	Y	Y	
Amorphous Fe-Silicate	Y	Y	Y
Probably			

	N
	N
	N
See also below under "Mg-Serpentine"	N
	N
	N
	N
The major XRD phase in Murchison (58.1 vol%	Sort of
See also below under "Mg-Serpentine"	N
	N
"Saponite-serpentine" (rather than simple saponite) is the major XRD phase in Orgeuil (Bland et al. 2004)	?
	N
	N
	N
	N
	N
17% in Al Rais (PSD-XRD); 5-8% in CO chondrites	Maybe?
	N
	Y
1.2% in Murchison by PSD-XRD	Maybe
	Maybe
	N
	N
0 to 9.3% in CM chondrites (PSD-XRD, Howard et al. 2014)	N

	Sort of
5.3% in Tagish Lake, Bland et al. 2004	N
8% in Allende, Bland et al. 2004	N
1.2% in Orgueil	
	Sort of
A major XRD phase in CO 3.0 meteorites, also important in CR	N
Maybe Tagish Lake??	Y
IOM is possibly 5% of Tagish Lake?	
Do phyllosilicates count?	Y

Asteroid Notes

Further Notes

Astronomical detections not specific to Fo100, see below under "Other Olivine"

Numerous NIR detections in S-type, V-type, and A-type asteroids; at least one TIR detection in an Sa-type (Spitzer; Lim et al. DPS 2011)

NIR detections in various S-type asteroids and Vestoids, e.g. Sunshine et al. 2004

N.B. Aubrites have no VNIR spectra features but should be distinctive in the TIR

Definitively Opx asteroidal px detections are almost all basaltic; detection also claimed by e.g. Fieber-Beyer 2012 in association with spinel. Note that spectrally, Opx is hard to distinguish from low-Ca Cpx.

NIR detections in various S-type asteroids and Vestoids, e.g. Sunshine et al. 2004; low-Ca Opx and low-Ca Cpx not easy to distinguish spectrally.

Inferred in Vestoid NIR spectra (e.g. Sunshine et al. 2004) and Vesta (McCord et al. 1970). However, 1.2-micron (NIR) feature is weak.

Rivkin et al. (2006) published cronstedtite on Ceres, but a better case can probably be made for the Pallas-type asteroids by the CM-like spectral shape near 3 microns (e.g. Takir et al. 2013, 2015; Rivkin et al. 2015). It's still unclear how specific the spectral signature is to cronstedtite.

Based on the 2.8-micron spectral shape, *ammoniated* saponite is a popular candidate material for Ceres: King et al. 1992

Ed Cloutis seems to think that the negative slope in B-type asteroids is magnetite?

Spinel detections (NIR) in S-type asteroids by e.g. Burbine et al. 1992, Sunshine et al. (2008), Cellino et al. 2014

Published for Ceres by Rivkin et al. 2006
Published for Ceres by Milliken and Rivkin 2009

See also de Sanctis et al. 2015:
"Carbonates are always needed in the fit but the specific carbonate mineral is not fully constrained because dolomite, magnesite

Takir et al. (2015) say that the "sharp" (Pallas-like 3-micron feature) spectral group from Takir and Emery 2012 is consistent with a mixture of Mg-serpentine and Fe-serpentine. See also Rivkin et al. 2015. Unclear how specific the spectral feature is.

Claims have been made for 16 Psyche and a few other asteroids on the basis of radar albedo. No infrared detection, though (no features)

e.g. "ice coated pyroxene grains" in Rivkin and Emery 2010 (24 Themis); Oxo crater on 1 Ceres

The 2.7-micron OH feature is very widespread (Rivkin et al. 2015)

... but I've never heard it referred to as an alcohol
