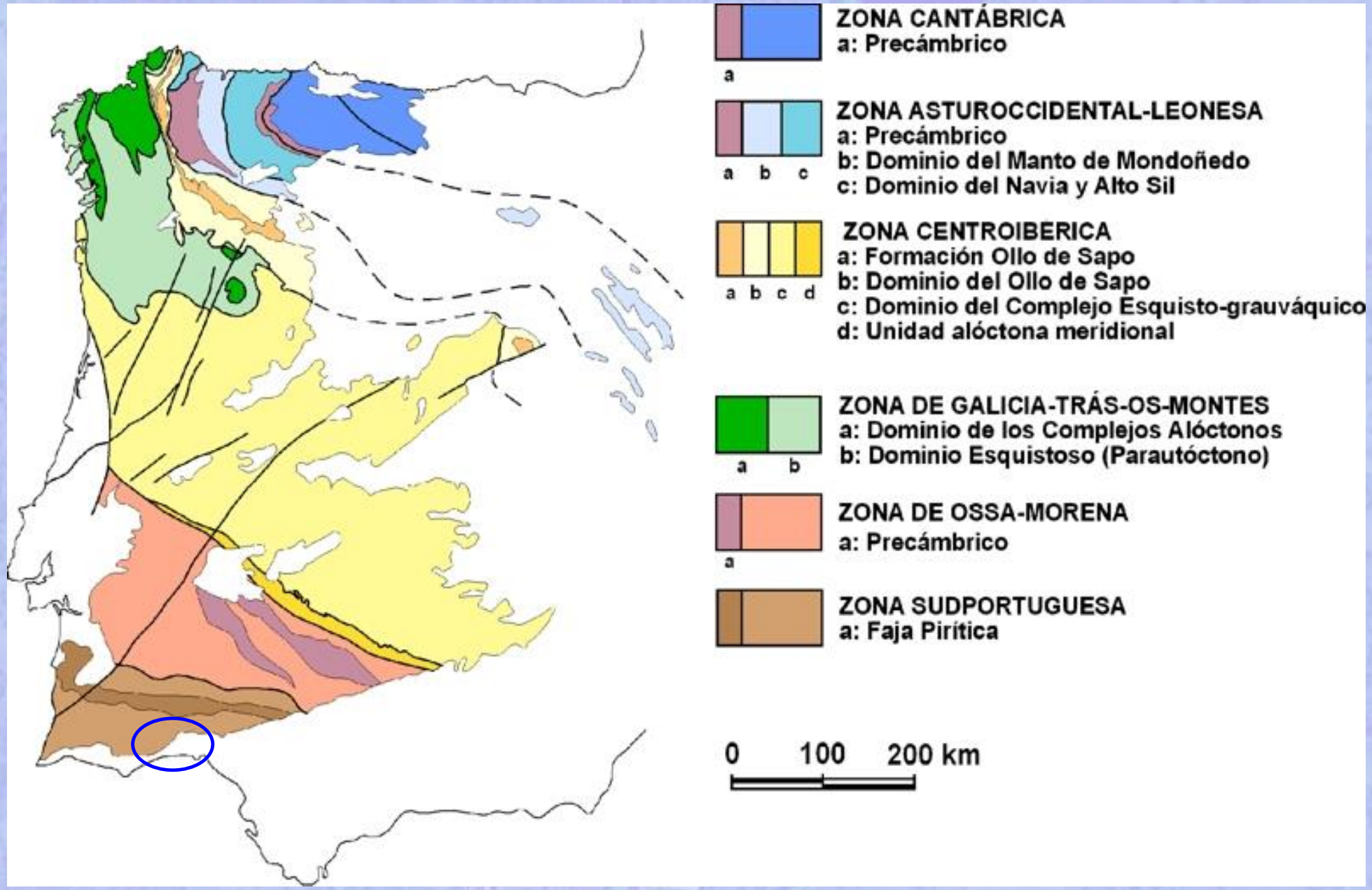
IRON SULPHIDE MINEWASTE CONTAMINATION MAPPING USING HYPERSPECTRAL DATA

J.BUZZI[1], A.RIAZA[2], E.GARCIA-MELÉNDEZ[3]

[1]IGME/LNEG/Impulso. Parque Científico de León. Av Real 1, edif. 1. 24006 León, Spain. jorge.buzzi@uteplanageo.com
[2]Geological Survey of Spain (IGME), La Calera 1, 28760 Tres Cantos, Madrid, Spain. a.riaza@igme.es
[3]Universidad de León, Facultad de Ciencias Ambientales, Campus de Vegazana s/n, León, España. egarm@unileon.es

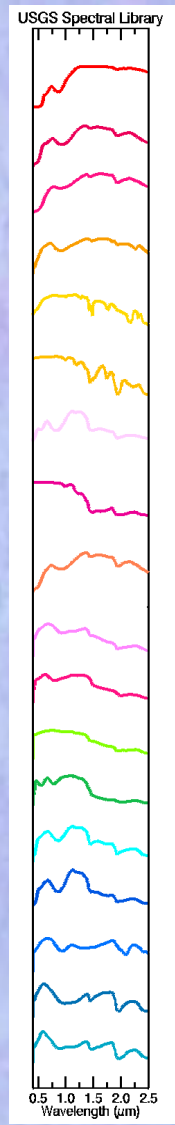
Protocolos y Librerías espectrales en Espectroscopía de Campo: de las buenas prácticas a una mayor utilidad de los datos, 7 de Marzo 2019, Instituto Nacional de Técnica Aeroespacial (INTA) en Torrejón de Ardoz (Madrid)


ZONA CANTÁBRICA
a: Precámbrico
a
ZONA ASTUROCCIDENTAL-LEONESA
a: Precámbrico
b: Dominio del Manto de Mondoñedo
c: Dominio del Navia y Alto Sil
a b c
ZONA CENTROIBERICA
a: Formación Ollo de Sapo
b: Dominio del Ollo de Sapo
c: Dominio del Complejo Esquisto-grauváquico
d: Unidad alóctona meridional
a b c d
ZONA DE GALICIA-TRÁS-OS-MONTES
a: Dominio de los Complejos Alóctonos
b: Dominio Esquistoso (Parautóctono)
a b
ZONA DE OSSA-MORENA
a: Precámbrico
a
ZONA SUDPORTUGUESA
a: Faja Pirítica
0 100 200 km

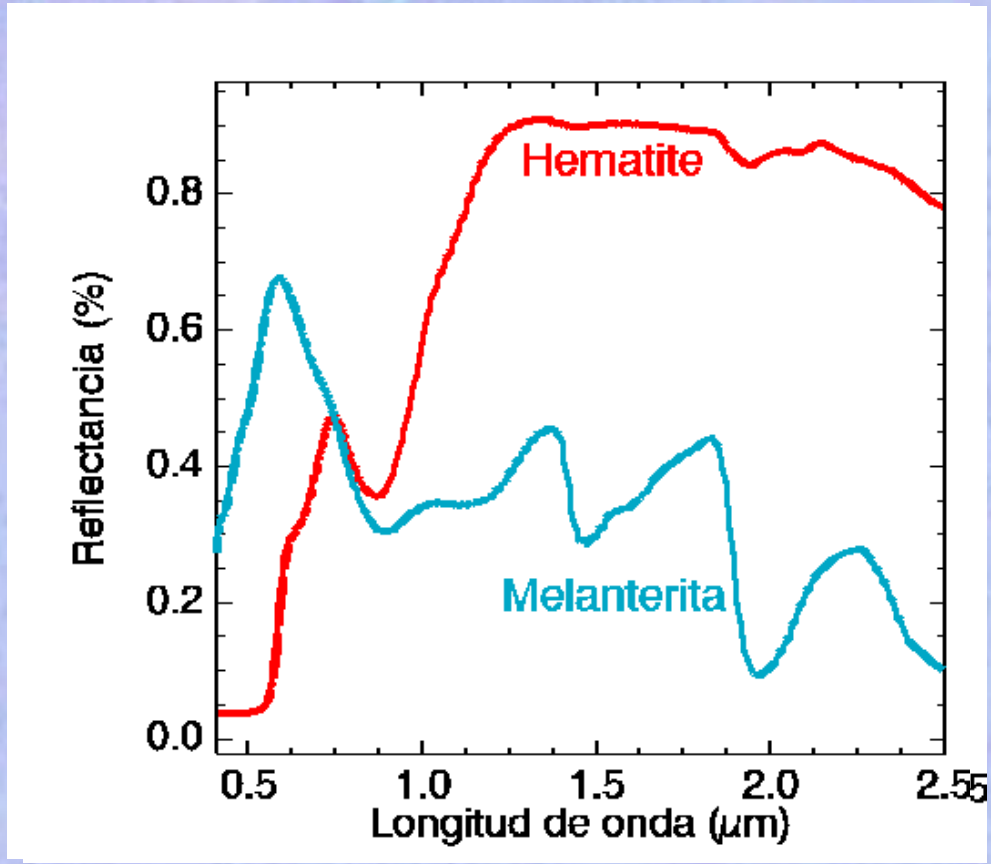
BUZZI, J., 2012, Imaging spectroscopy to evaluate the contamination from sulphide mine waste in the Iberian Pyrite Belt using hyperspectral sensors (Huelva, Spain), Tesis Doctoral Universidad de León, 212 p.

RIAZA, J. BUZZI, E. GARCÍA-MELÉNDEZ , V. CARRÈRE and A. MÜLLER, 2011, Monitoring the extent of contamination from acid mine drainage in the Iberian Pyrite Belt (SW Spain) using hyperspectral imagery, Remote Sensing, 2011, *3*, 2166-2186; doi:10.3390/rs3102166.

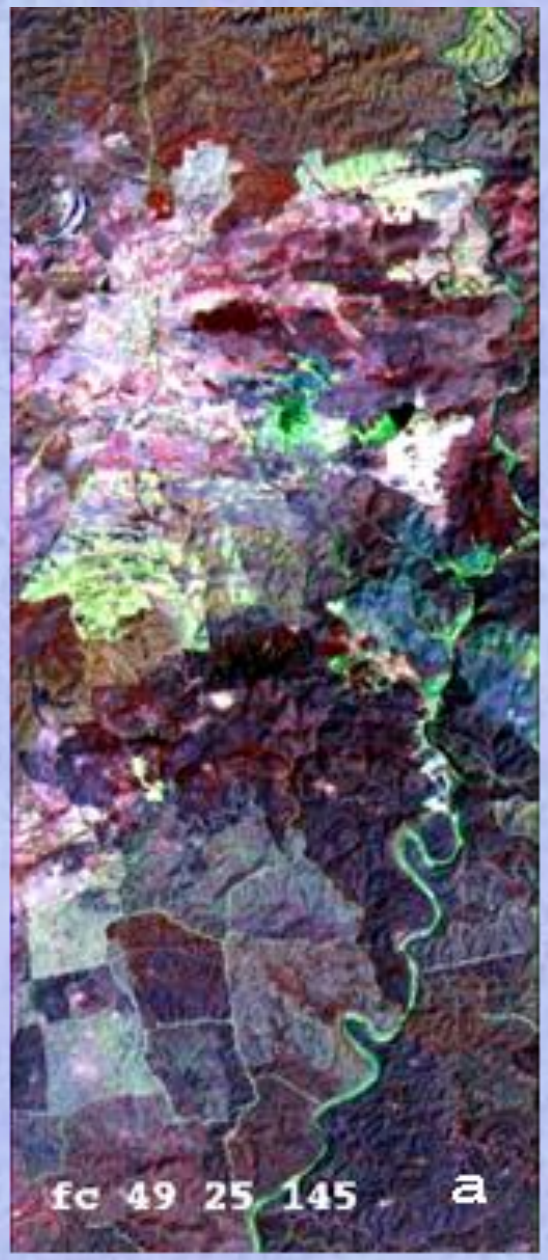
SPECTRAL LIBRARY OF MINERALS PRODUCT OF IRON SULPHIDE WEATHERING (Crowley et al, 2003)

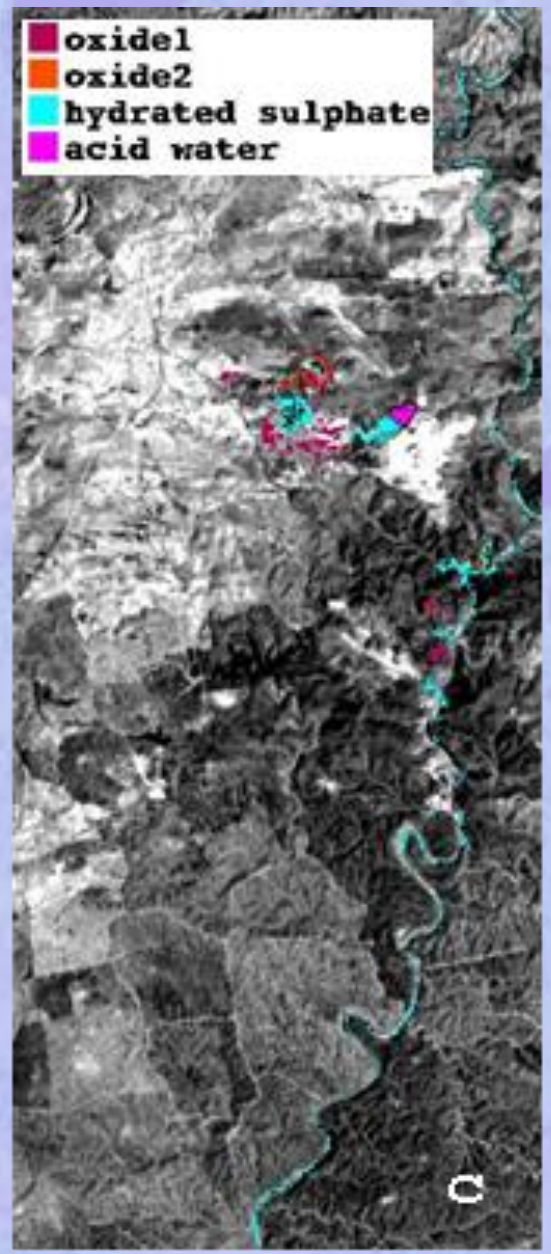


Hematite	Fe_2O_3
Goethita	$FeO(OH)$
Ferrihydrita	$Fe^{3+}{}_2O_3 \cdot 0.5(H_2O)$
Jarosita	$KFe_3(SO_4)_2(OH)_6$
Alunita	$KAl_3(SO_4)_2(OH)_6$
Yeso	$CaSO_4 \cdot 2H_2O$
Fibroferrita	$Fe^{3+}(SO_4)(OH) \cdot 5(H_2O)$
Epsomita	$MgSO_4 \cdot 7H_2O$
Schwertmannita	$Fe^{3+}{}_{16}O_{16}(OH)_{12}(SO_4)_2$
Halotrichita	$Fe^{2+}Al_2(SO_4)_4 \cdot 22(H_2O)$
Rhomboclasa	$HFe^{3+}(SO_4)_2 \cdot 4(H_2O)$
Pickeringita	$MgAl_2(SO_4)_4 \cdot 22(H_2O)$
Paracoquimbita	$Fe^{3+}{}_2(SO_4)_3 \cdot 9(H_2O)$
Copiapita	$Fe^{2+}Fe^{3+}{}_4(SO_4)_6(OH)_2 \cdot 20(H_2O)$
Ferricopiapita	$Fe^{3+}{}_{0.6}Fe^{3+}{}_4(SO_4)_6(OH)_2 \cdot 20(H_2O)$
Szmolnokita	$Fe(SO_4) \cdot H_2O$
Rozenita	$Fe^{2+}(SO_4) \cdot 4(H_2O)$
Melanterita	$Fe^{2+}(SO_4) \cdot 7(H_2O)$



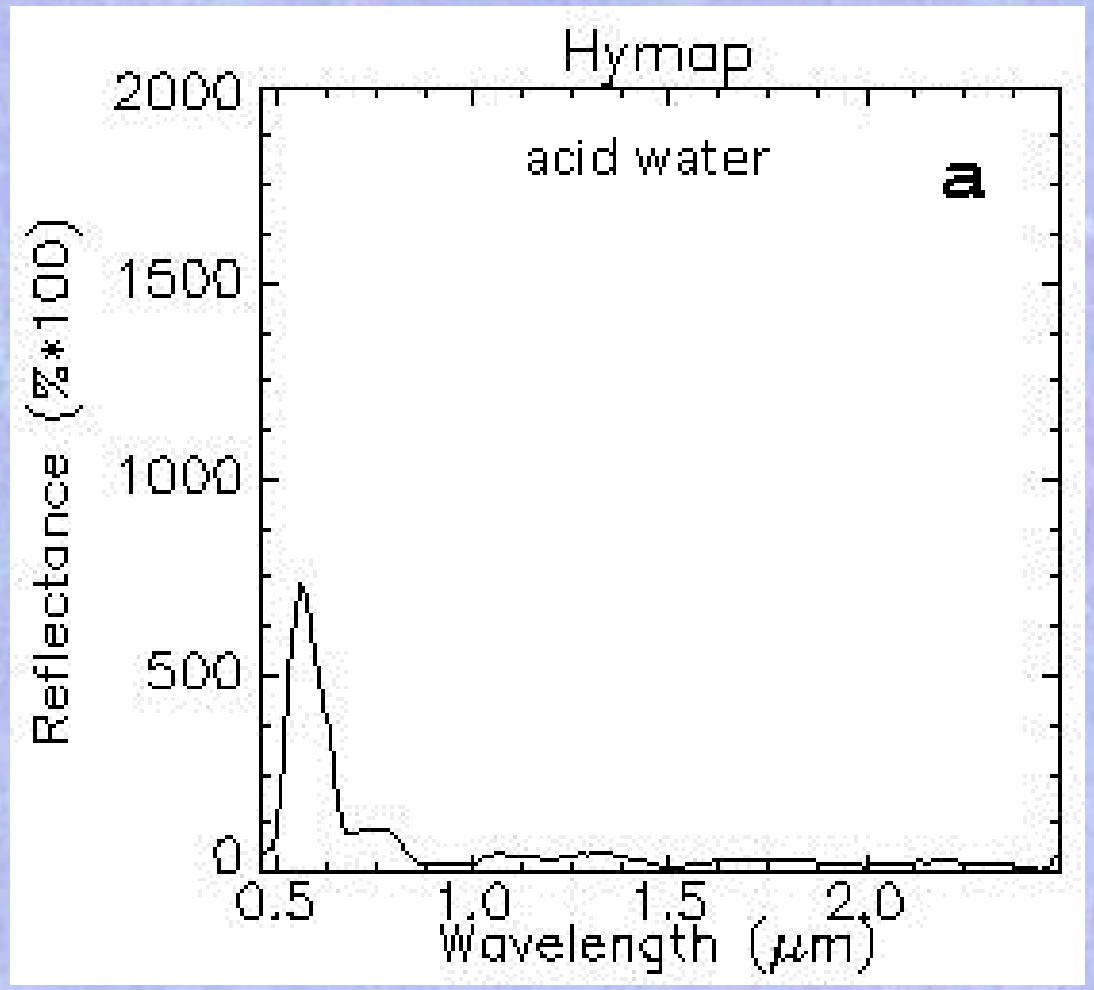
CROWLEY, J.K., WILLIAMS, D.E., HAMMARSTROM, J.M., PIATAK, N., CHOU, I-M., MARS, J.C., 2003, Spectral reflectance properties (0.4–2.5 µm) of secondary Fe-oxide, Fe-hydroxide, and Fe-sulphate-hydrate minerals associated with sulphide-bearing mine wastes. *Geochemistry: Exploration, Environment, Analysis, 3-3*, 219-228(10).

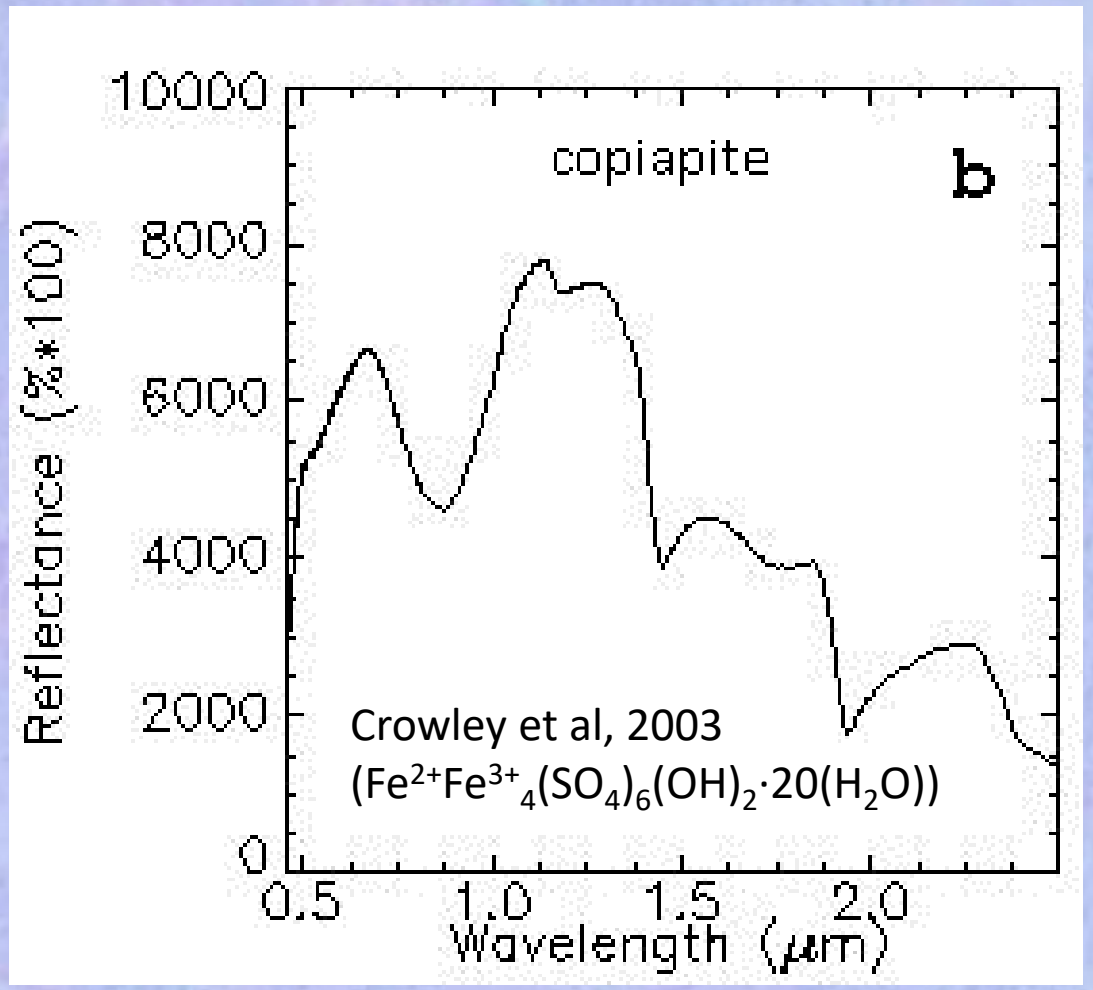




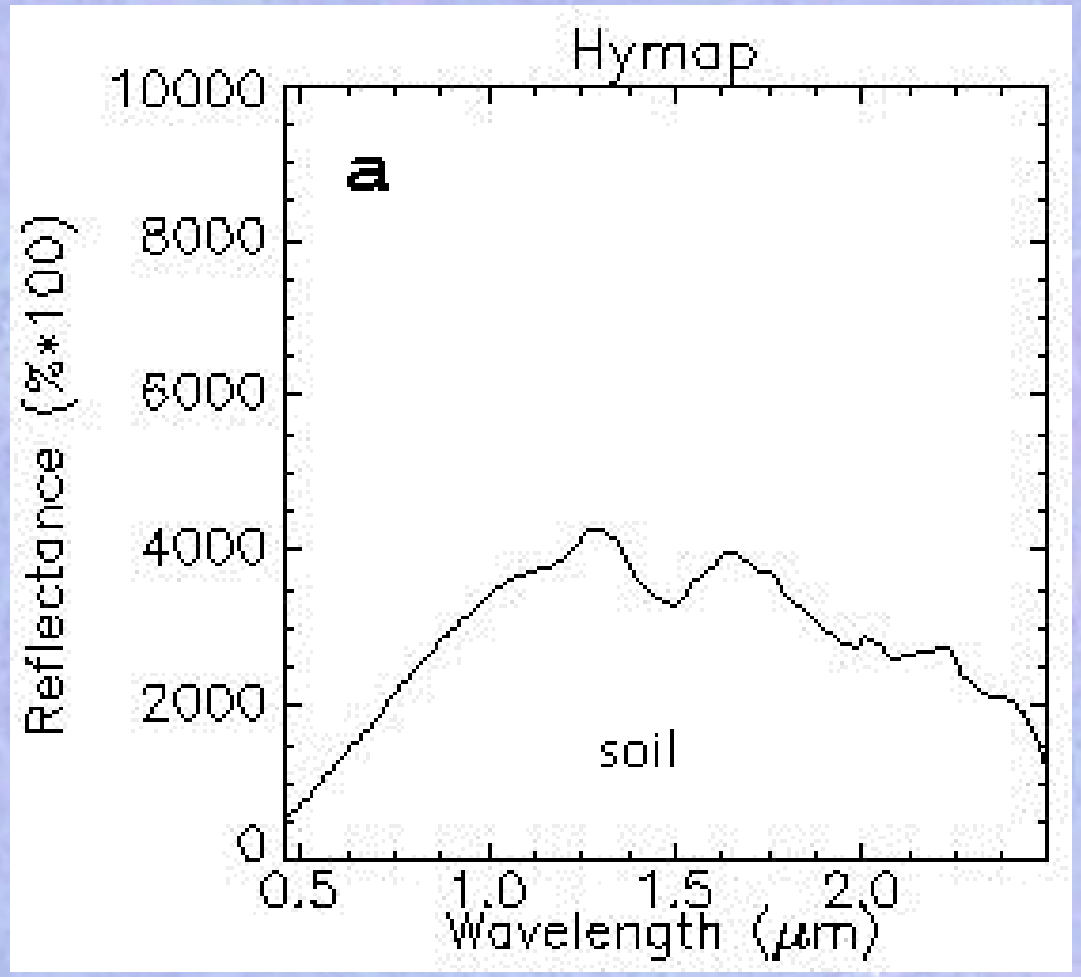
HYPERION 2005

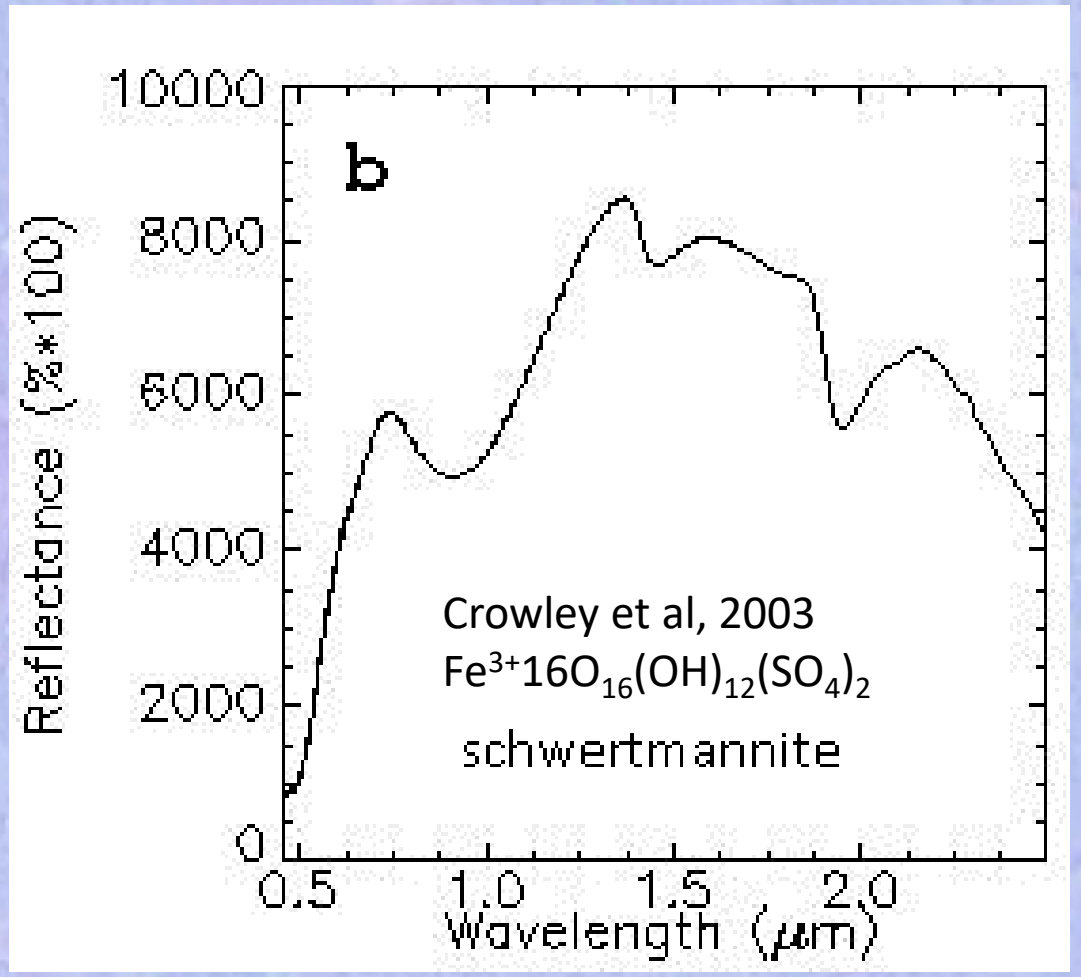
SPECTRAL ANALYST WITH REFERENCE SPECTRAL LIBRARIES



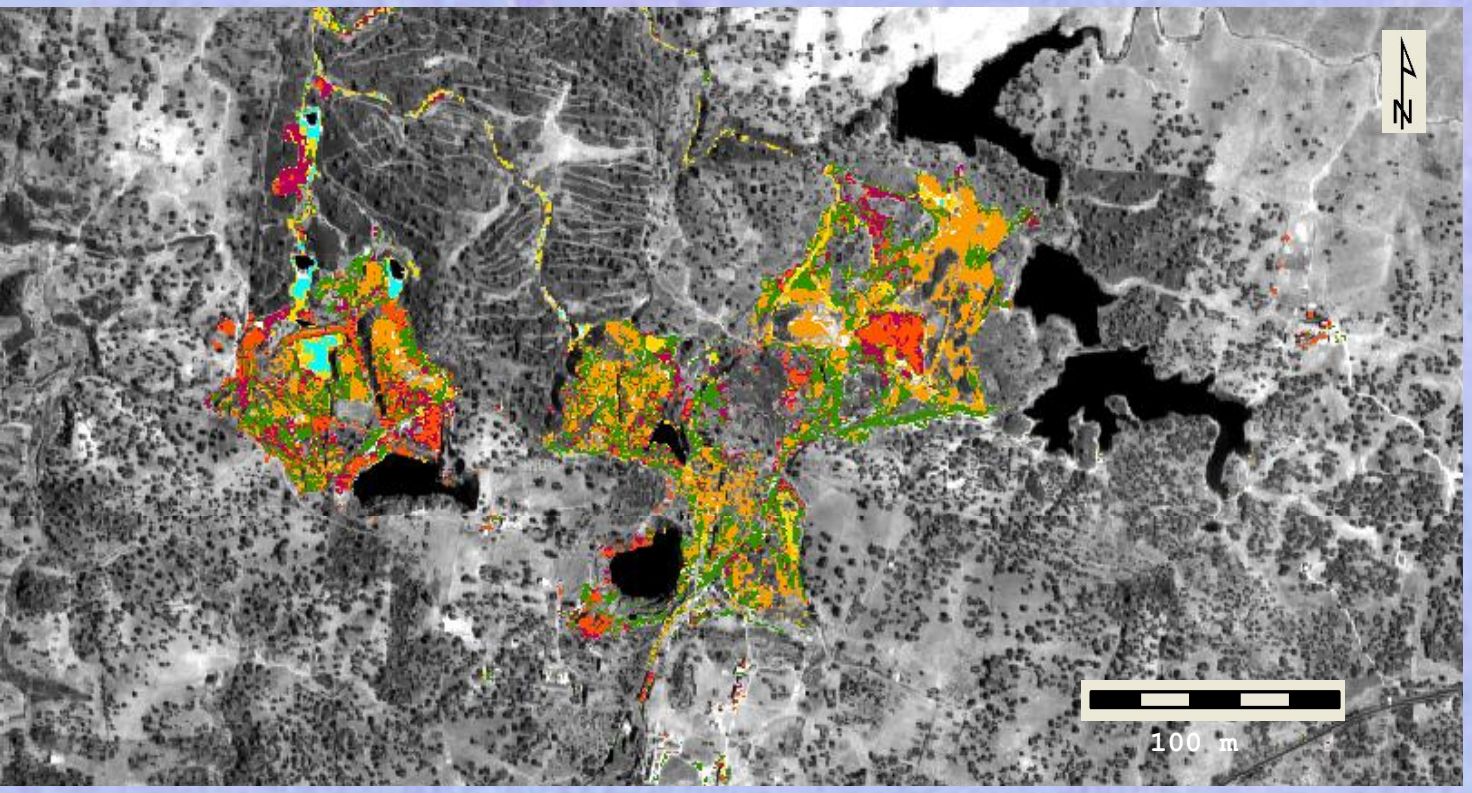


SPECTRAL ANALYST WITH REFERENCE SPECTRAL LIBRARIES





HYMAP August 2009



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Goethite	$FeO(OH)$
Ferrihydrite	$Fe^{3+}{}_2O_3{\cdot}0.5(H_2O)$
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Alunite	$KAl_3(SO_4)_2(OH)_6$
Gypsum	$SO_4Ca.2H_2O$
Fibroferrite	$Fe^{3+}(SO_4)(OH){\cdot}5(H_2O)$
Epsomite	$MgSO_4{\cdot}7(H_2O)$
Schwertmannite	$Fe^{3+}16O_{16}(OH)_{12}(SO_4)_2$
Halotrichite	$Fe^{2+}Al_2(SO4)_4{\cdot}22(H_2O)$
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Copiapite	$Fe^{2+}Fe^{3+}{}_4(SO_4)_6(OH)_2{\cdot}20(H_2O)$
Ferricopiapite	$Fe^{3+}{}_{0.6666}{}^{Fe3+}{}_4(SO_4)_6(OH)_2{\cdot}20(H_2O)$
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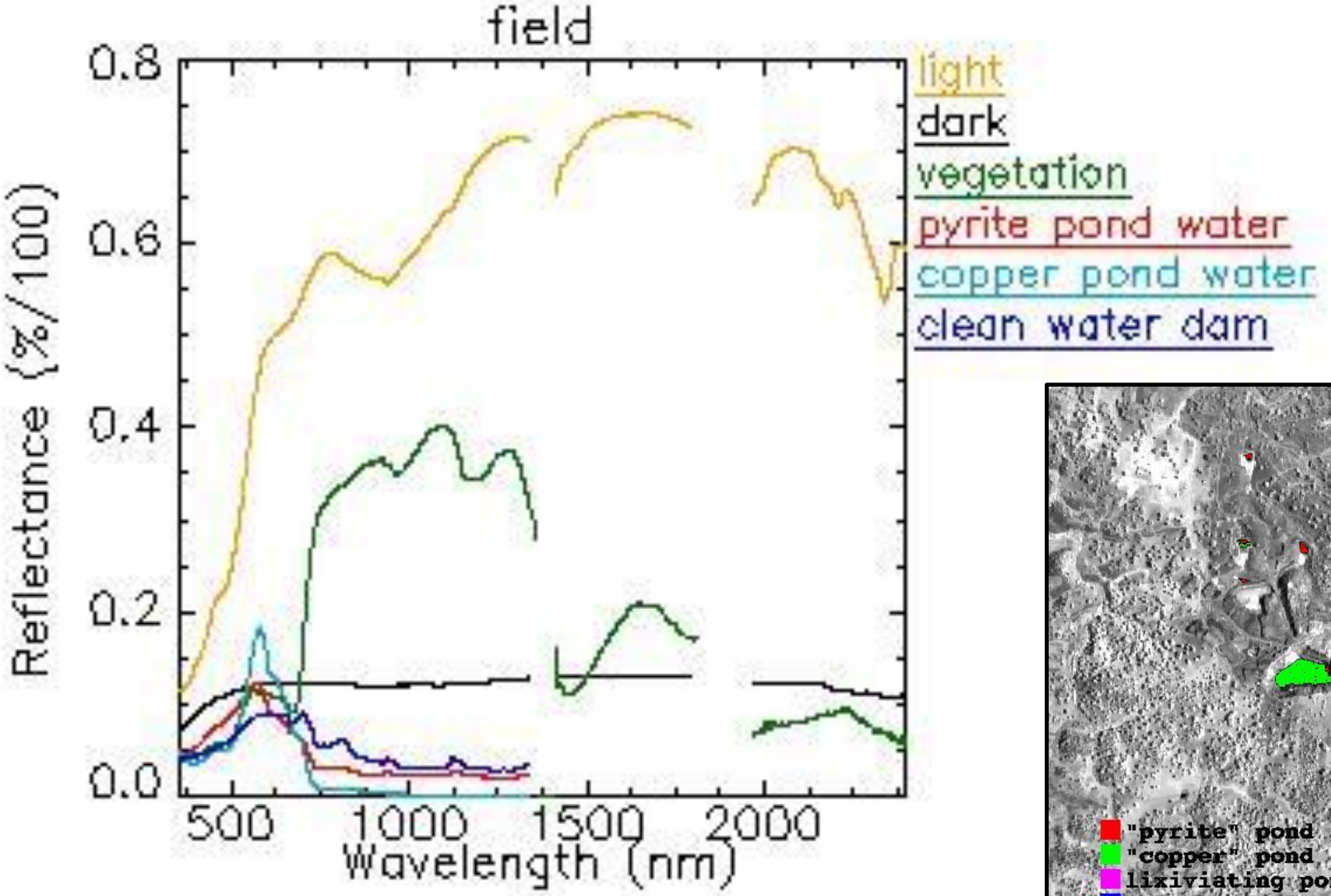
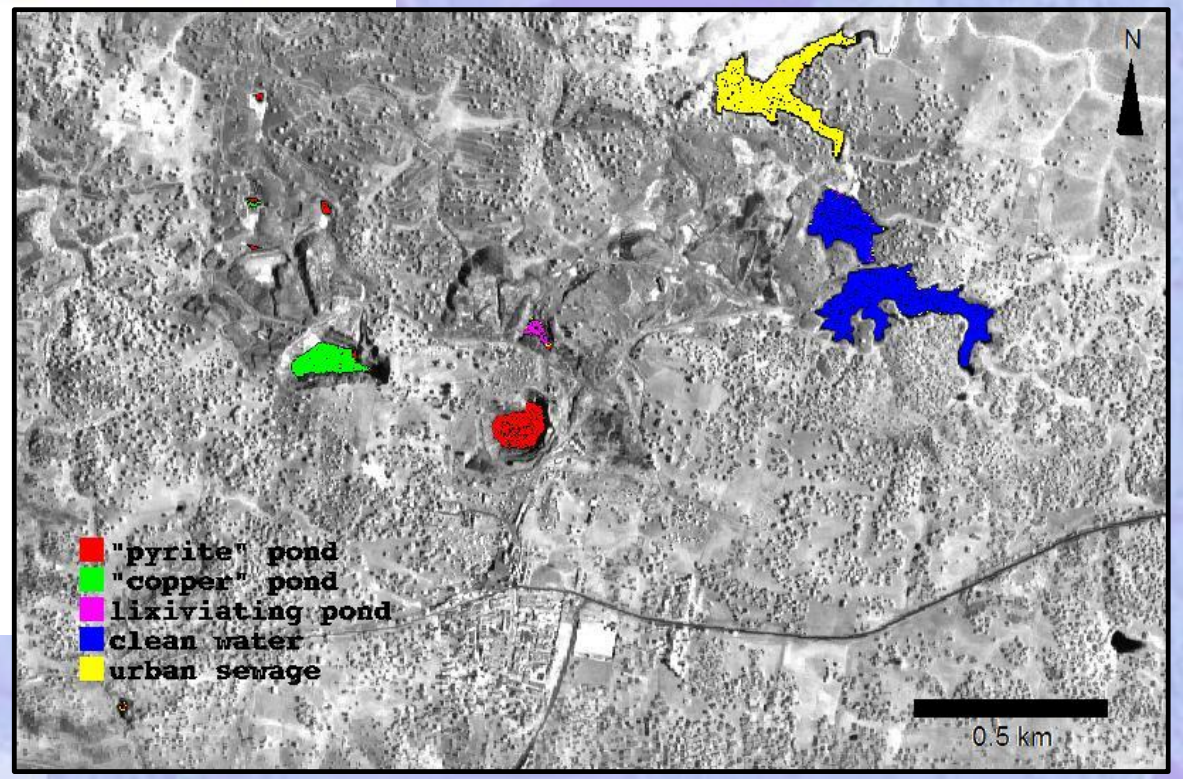
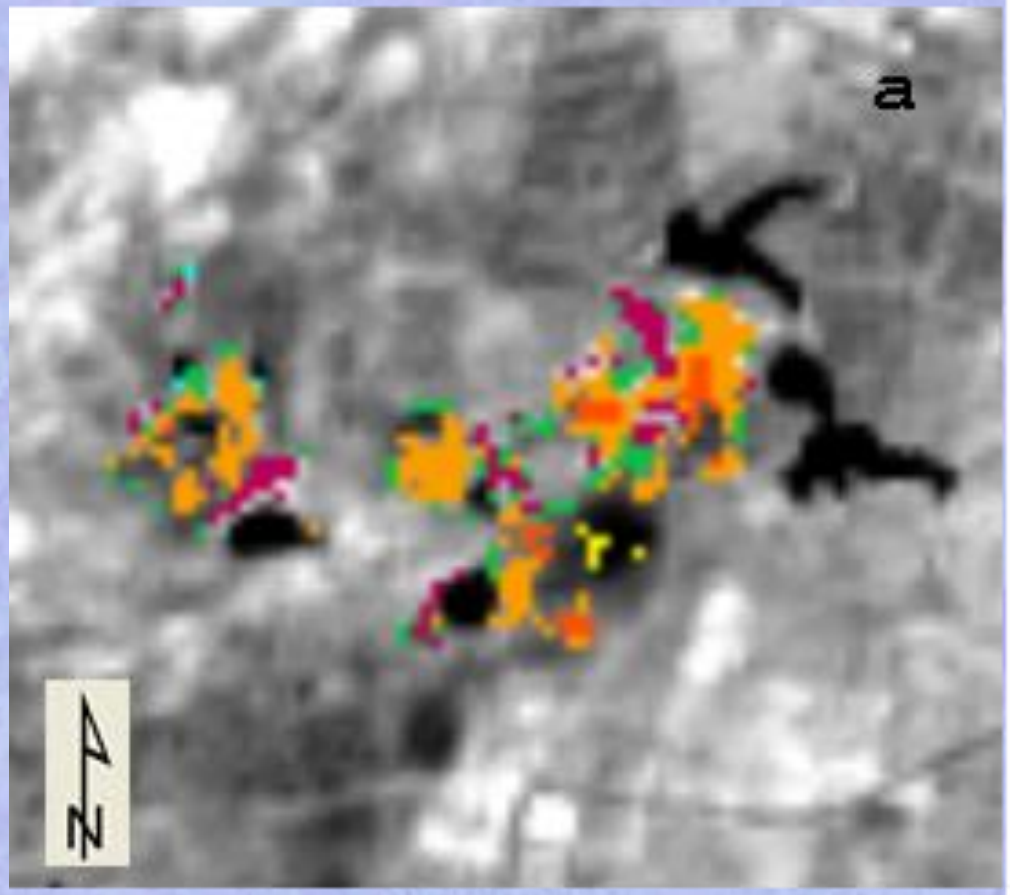
Rozenite	$Fe^{2+}(SO_4){\cdot}4(H_2O)$
Melanterite	$Fe^{2+}(SO_4){\cdot}7(H_2O)$

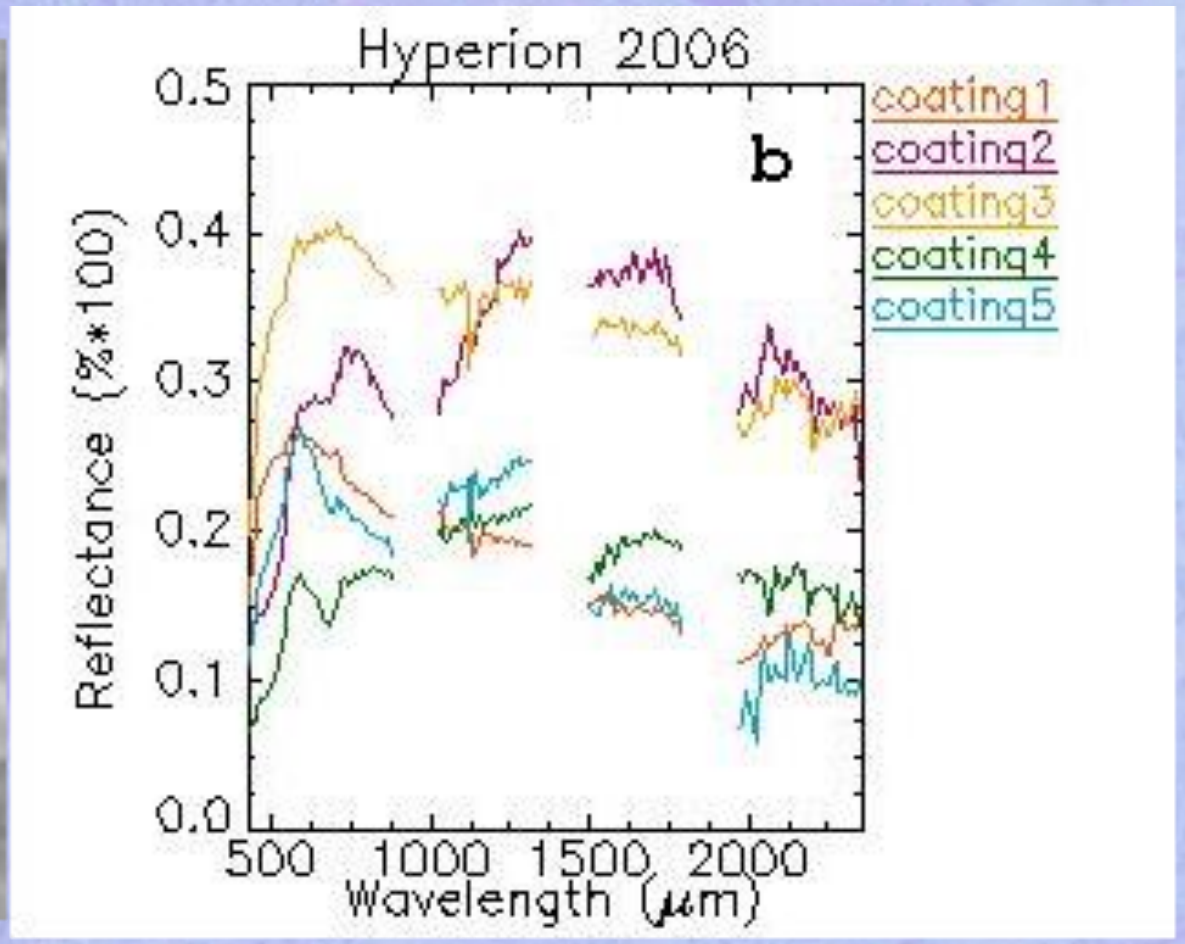


SPECTRA FOR ATMOSPHERIC CORRECTION

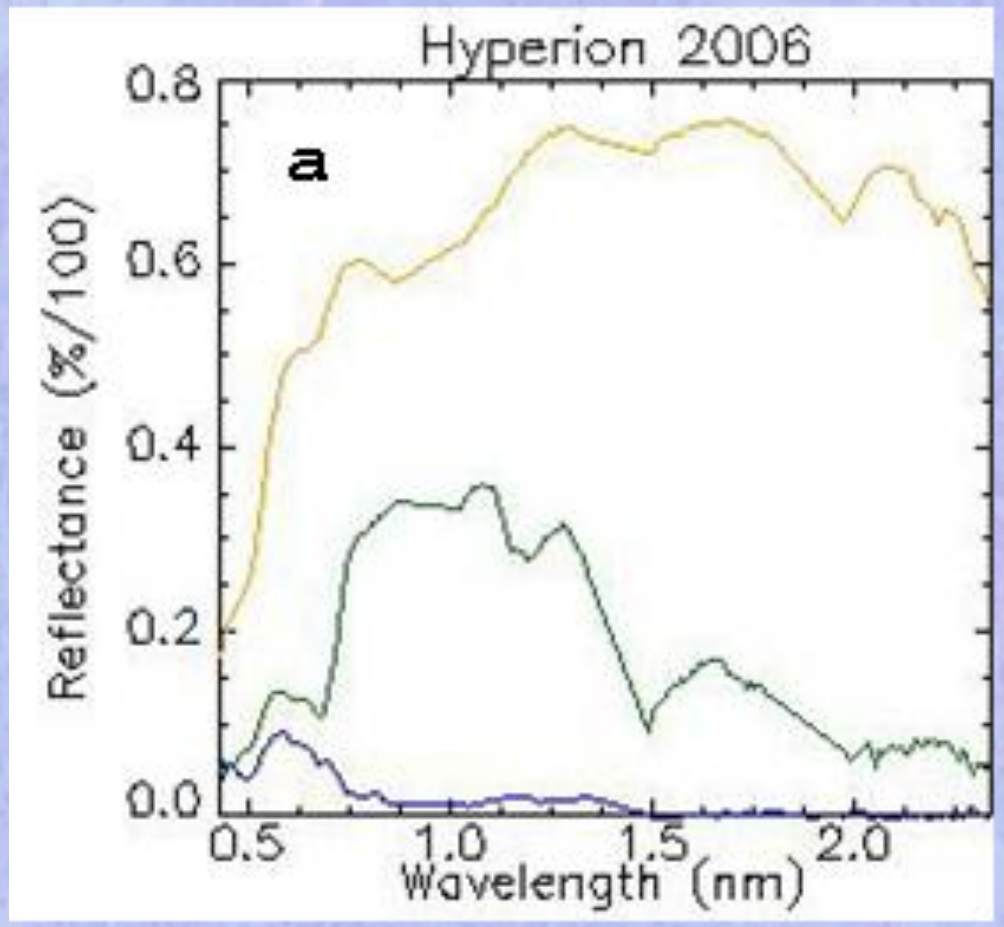
HYMAP

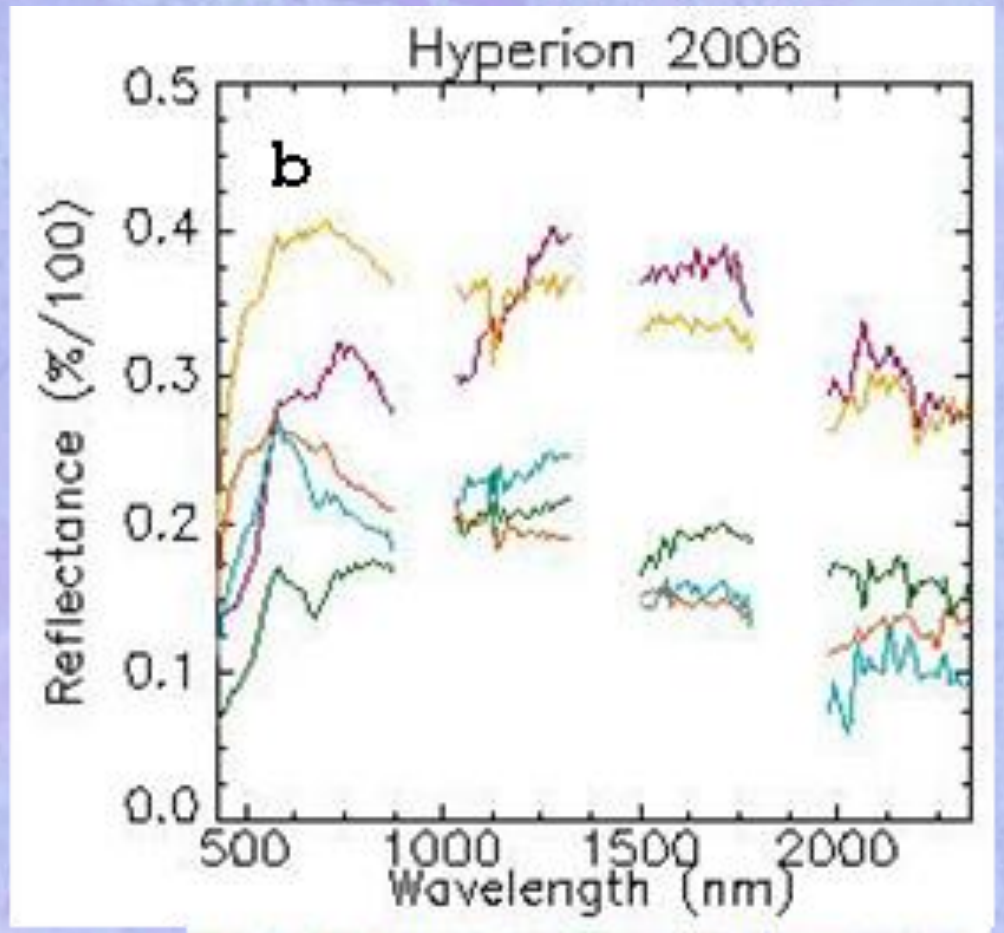



a
N
200 m


Hyperion 2006
b
Reflectance (%*100)
0.0
0.1
0.2
0.3
0.4
0.5
500
1000
1500
2000
Wavelength (μm)
coating1
coating2
coating3
coating4
coating5

SPECTRAL ANALYST WITH REFERENCE SPECTRAL LIBRARIES (Atmospheric correction Empirical Line)

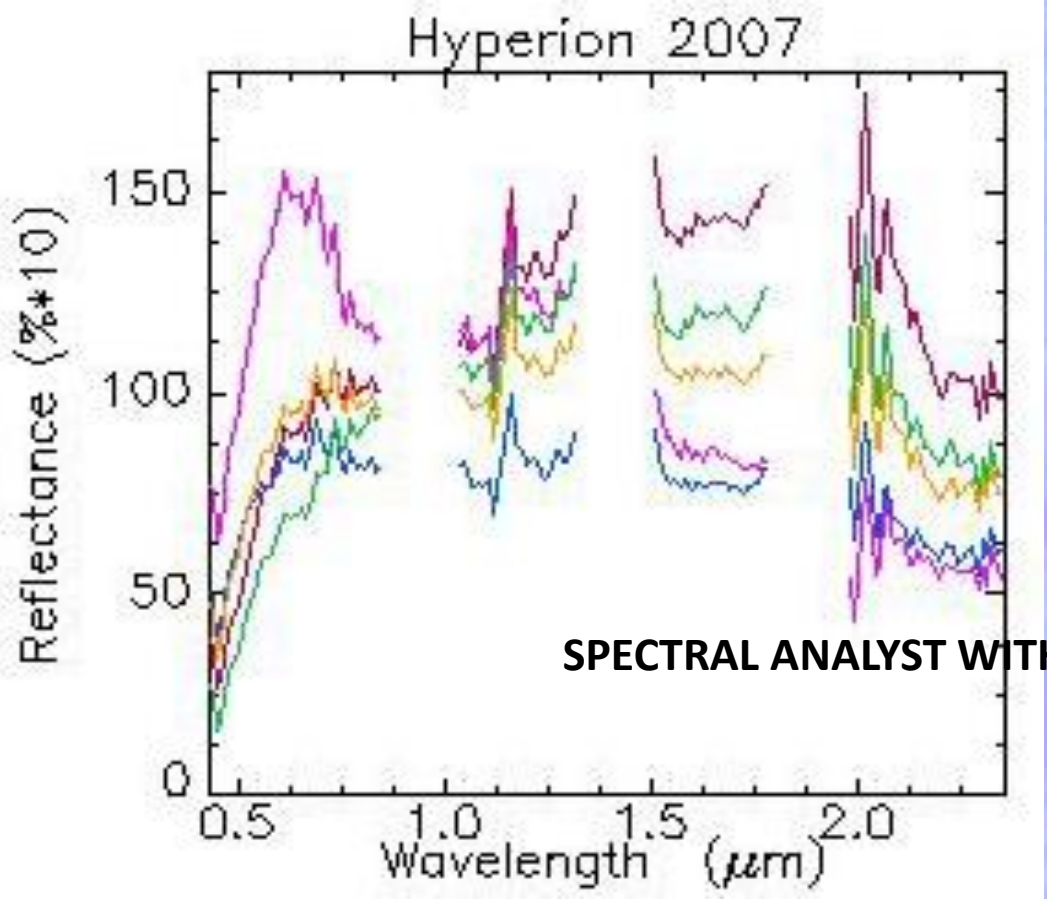




soil
vegetation
acid water

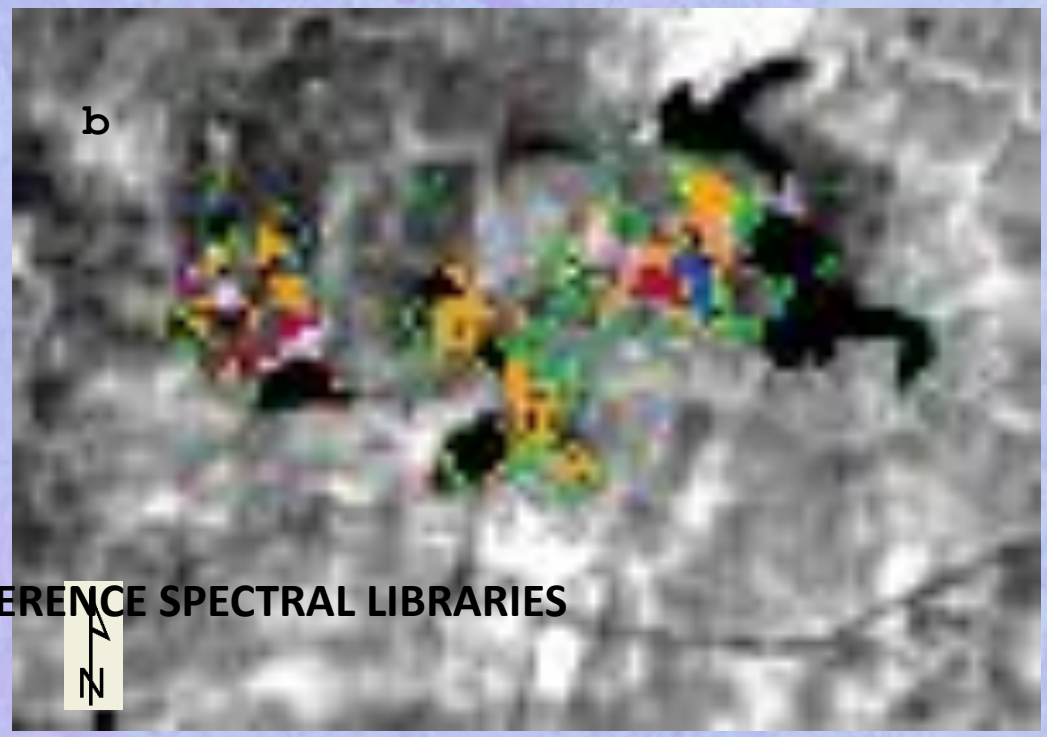
pickeringite halotrichite ferricopiapite
pickeringite halotrichite ferricopiapite
pickeringite halotrichite ferricopiapite
pickeringite halotrichite ferricopiapite
pickeringite halotrichite ferricopiapite

SPECTRAL ANALYST WITH REFERENCE SPECTRAL LIBRARIES (ATCOR4)



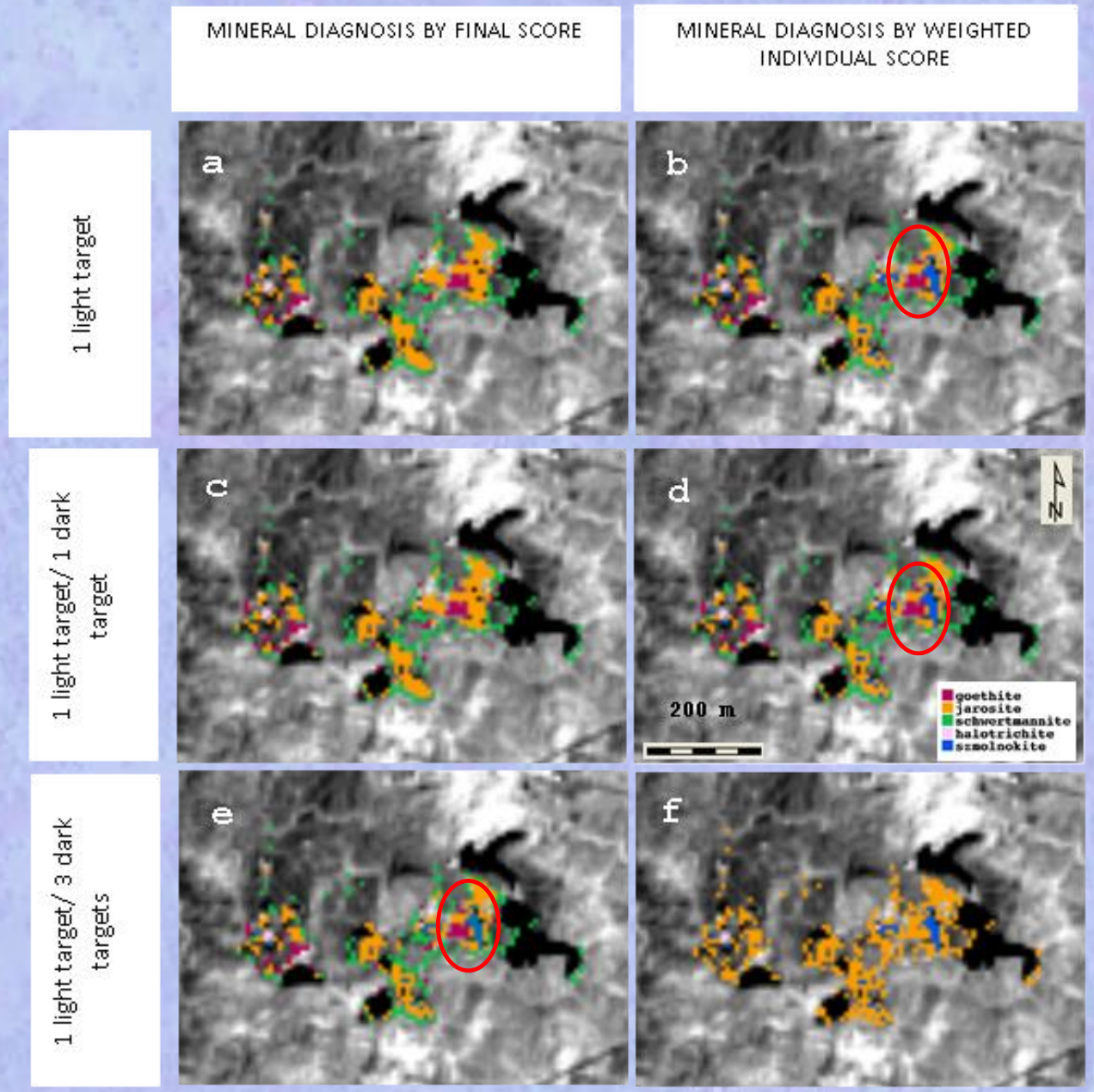
SPECTRAL ANALYST WITH REFERENCE SPECTRAL LIBRARIES

szmolnokite jarosite rozenite
goethite jarosite schwertmannite
jarosite alunite schwertmannite
halotrichite copiapite rhomboclase
schwertmannite goethite jarosite



goethite
jarosite
schwertmannite
halotrichite
szmolnokite

Atmospheric correction



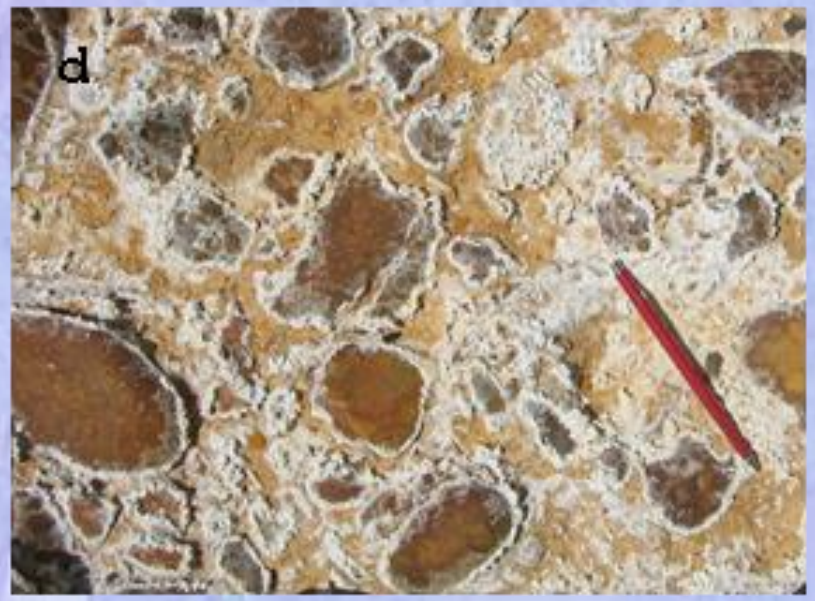
SPECTRAL ANALYST WITH REFERENCE SPECTRAL LIBRARIES (ATCOR4)

HYPERION August 2007


a


b


c


d

CONCLUSIONES

Image processing should be tailored per scene and per domain within a mine site. Maps which are derived from individual subscenes, and processed using independent processing procedures, broadly agree with each other with respect to changes in oxidation and dehydration mineral phases.

Reference spectral libraries are useful to assess the oxidation or hydration stage of a mineral mixture. In addition, they help establish statistical evaluations of scores produced by mineralogical diagnoses, which are established by the spectral library using various algorithms. Variations in these scores can be used to improve our understanding of contaminant patterns.

The atmospheric correction method has a strong influence on mineralogical diagnoses of spectra derived from hyperspectral imagery. However, calibration targets have to be carefully established to adjust spectral features of the substances to the map, in addition to general landcover features, such as soil, vegetation or water.

Although all geological interpretation is based on a reference spectral library, which only includes a small number of minerals, reality is far more complex. Hence, the maps provided in this study must be understood as simplified images of mineralogical trends in a closed geological context.