Mapping of Volcanogenic Massive Sulphide (VMS) deposits zone using satellite data

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Volcanogenic Massive Sulphide (VMS)

- Volcanogenic Massive Sulphide (VMS) deposits are typical Cyprus-type and occur in the in the Oman Ophiolite as clusters of pyritic copper-rich mounds with gold bearing gossans.

- The occurrence of deposits is abundant in Sohar –Shinas region of East Al-Batina coast region of the Sultanate of Oman.

- This work describes the spectral absorption characters of the minerals of the deposits and demonstrates the methods to map the deposit.

Volcanogenic Massive Sulphide (VMS)

Economic importance:

- Porphyry copper deposits presently provide nearly three-quarters of world's Cu, half the world's Mo, perhaps one-fifth of the world's Au, most of the world's Re, and minor amount of other metals such as Ag, Pd, Te, Se, Bi, Zn, and Pb (Sillitoe, 2010).
- Porphyry copper deposits typically occur in association with hydrothermal alteration mineral zones such as argillic, propylitic, phyllic, and potassic (Fig. 1; Lowell and Guilbert, 1970).

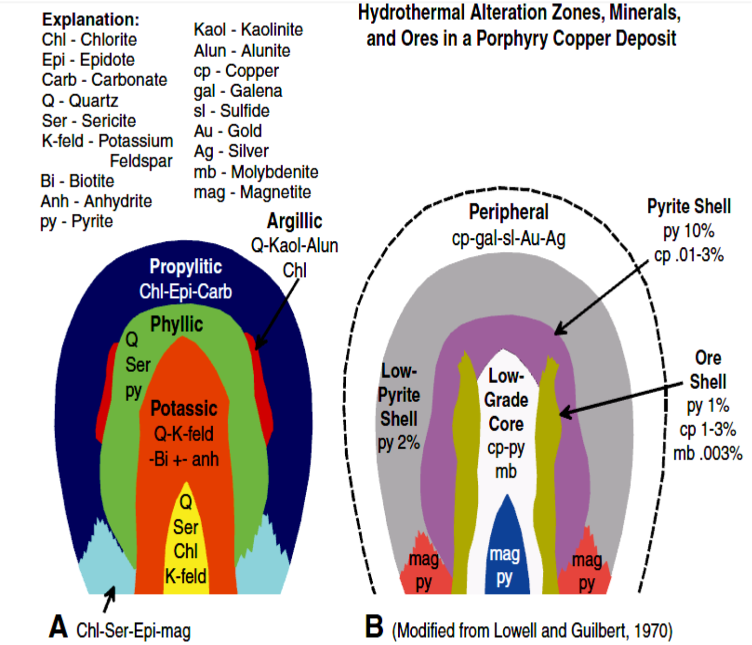


Fig.1. Illustrated deposit model of a porphyry copper deposit (modified from Lowell and Guilbert, 1970). (A) Schematic cross section of hydrothermal alteration minerals and types, which include propylitic, phyllic, argillic, and potassic alteration. (B) Schematic cross section of ores associated with each alteration type. (Mars and Rowan, 2006) , Pour and Hasim, (2012)

Remote sensing applicaion

- VMS deposit is a core of quartz and potassium-bearing minerals is surrounded by multiple zones that contain clay and other hydroxyl-bearing minerals have diagnostic spectral absorption properties in the visible and near infrared through the shortwave length infrared portions of the electromagnetic spectrum.
- The differentiation between the three hydrothermal alteration zones and especially targeted identification of the phyllic zone are important in the exploration of porphyry copper mineralization, because phyllic zone is an indicator of high-economic potential for copper mineralization within the central shell of mineralization.
- Hydrothermal alteration minerals with diagnostic spectral absorption properties in the visible and near infrared through the shortwave length infrared regions can be identified by multispectral and hyperspectral remote sensing data as a tool for the initial stages of porphyry copper and epithermal gold exploration (Bedini et al., 2009; Gabr et al., 2010; Mars and Rowan, 2006;).

Spectral absorption characters of the mineralized zone

- The phyllic zone is characterized by illite/muscovite (sericite) which yields an intense Al-OH absorption feature centered at 2.20 µm, coinciding with ASTER band 6.
- The narrower argillic zone includes kaolinite and alunite, which collectively displays a secondary Al-OH absorption feature at 2.17 µm that corresponds with ASTER band 5.
- The mineral assemblages of the outer propylitic zone include epidote, chlorite, and calcite which all exhibit absorption features situated at 2.35 µm, which coincide with ASTER band 8 (Clark et al., 1990; Mars and Rowan, 2006;).
- Iron oxide/hydroxide minerals such as limonite, jarosite, and hematite tend to have low reflectance in visible and higher reflectance in near infrared wavelength region (Hunt, 1977; Hunt and Salisbury, 1974).
- Electronic processes produce absorption features in the visible and near infrared radiation (0.4 to 1.1 µm) due to the presence of transition elements such as Fe2+, Fe3+ and often substituted by Mn, Cr, and Ni in the crystal structure of the minerals (Hunt, 1977; Hunt and Ashley, 1979).

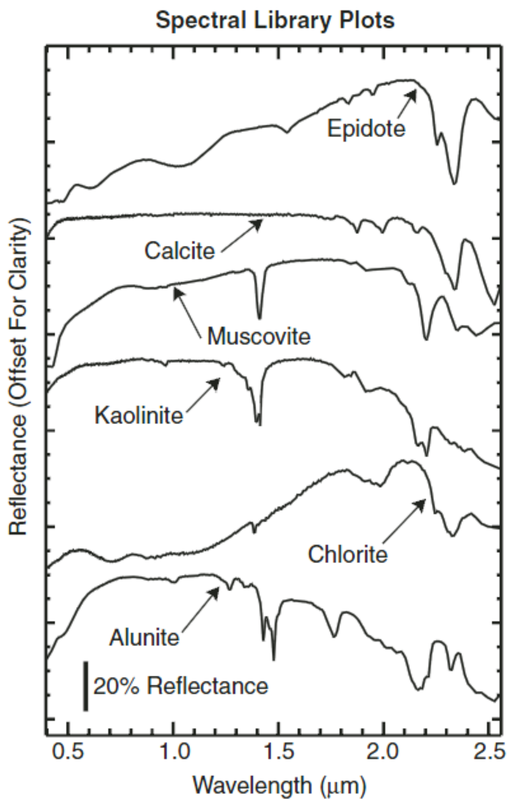


Fig.2 Laboratory spectra of epidote, calcite, muscovite, kaolinite, chlorite, and alunite, which are common hydrothermal alteration minerals (Clark et al., 1993b). Alunite and kaolinite have Al-O-H absorption features at 2.17 and 2.20 µm. Muscovite has a prominent Al-O-H 2.20 µm absorption feature and a secondary 2.35 µm absorption feature. Chlorite and epidote have an Fe-Mg-O-H 2.32 µm absorption feature and a broad Fe2+ feature from 1.65 to 0.6 µm. Calcite has a prominent 2.33 µm CO3 absorption feature. (Mars and Rowan, 2012)

Objectives of the present study

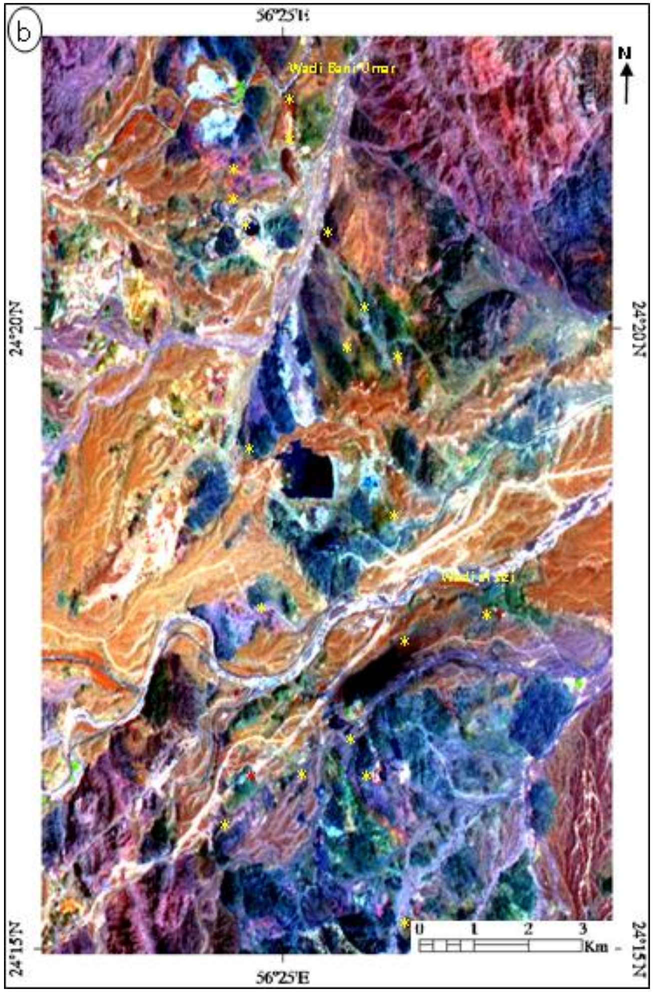
- ✓ This study shows the capability of ASTER sensor for mapping of such hydrothermal alteration mineral zones associated with porphyry copper and epithermal gold mineralization and related host-rock lithology using the most recently developed image processing methods.

ASTER mapping

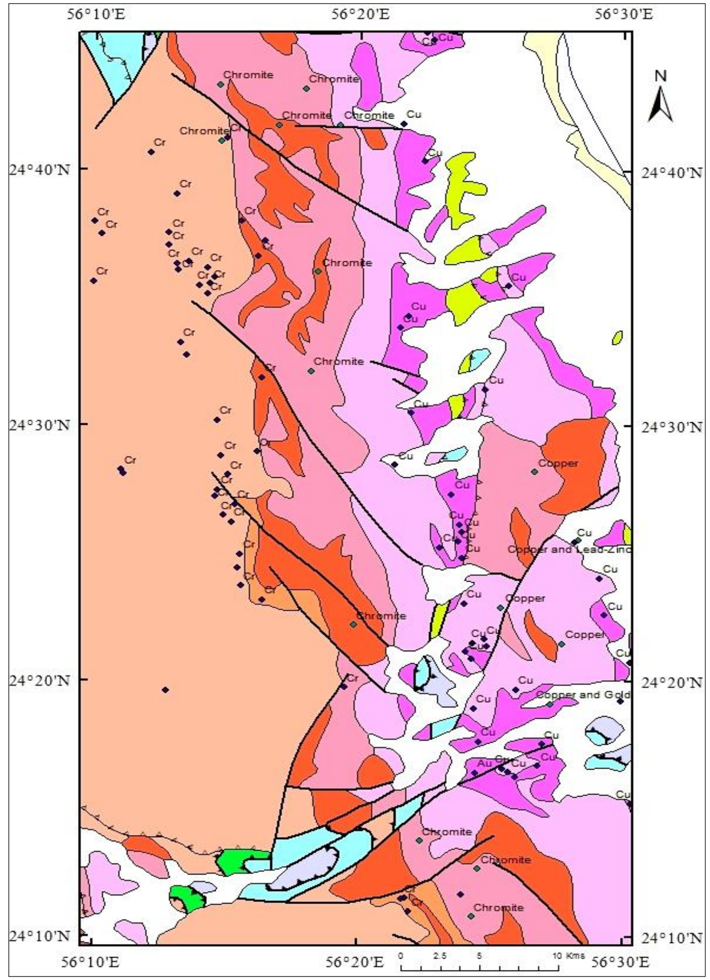
- The image processing methods namely band ratios, principal component analysis (PCA), spectral angle mapper, linear spectral unmixing (LSU) and spectral feature fitting (SFF) were applied to map and discriminate the minerals and rocks of the deposits using Landsat 8 and ASTER data.

- The results of study evaluated in the field to show the sensor capability potential of the image processing methods.

Geology



- Occurrence of copper deposits are at the extrusive.



Map showing the regional geology and mineral occurrences of the study area.

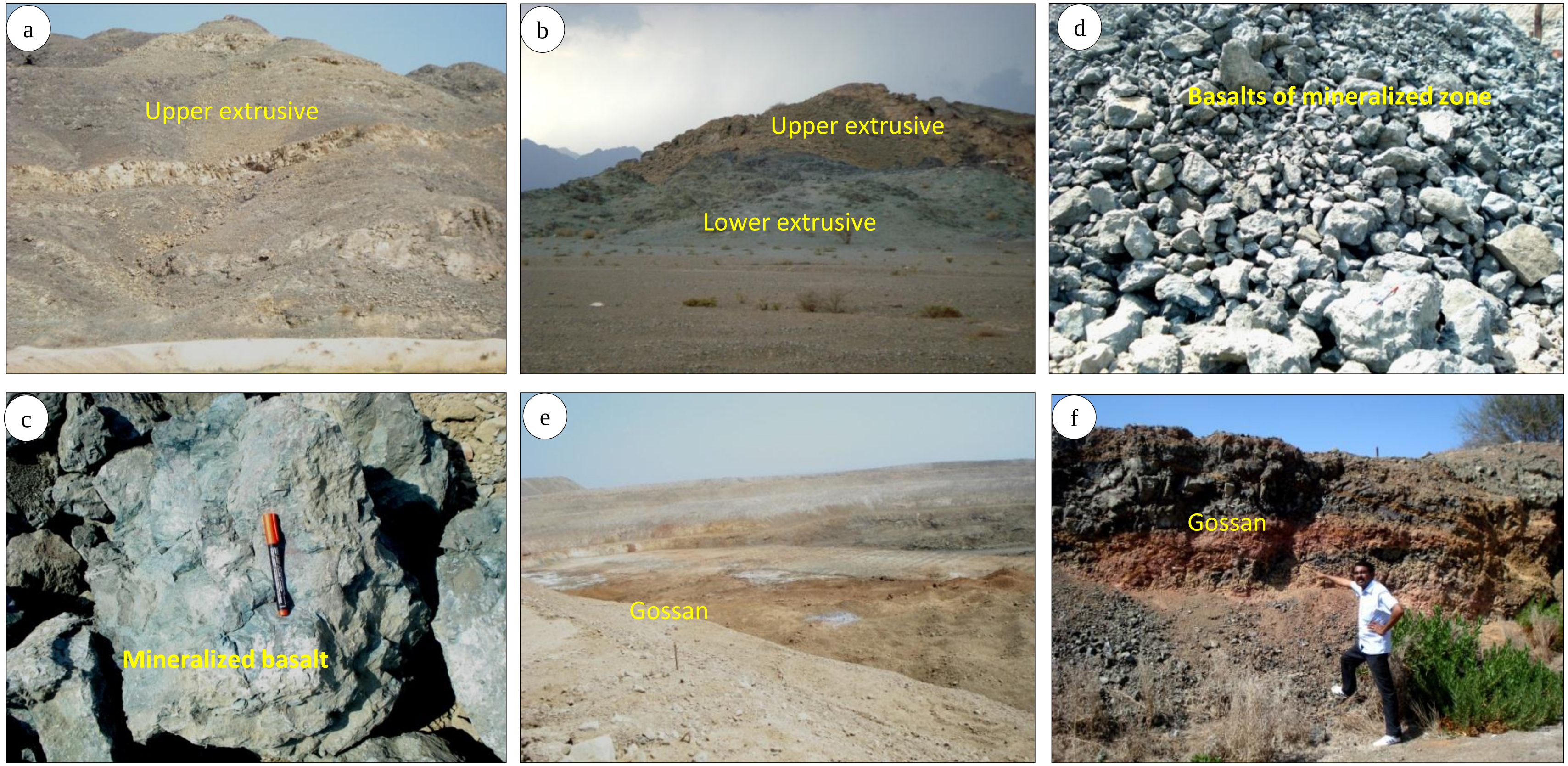
LEGEND

- Alluvial deposits
- Quaternary surficial deposits
- KAM – Aruma Group
- Volcanic Rocks
- Upper Extrusive
- Lower Extrusive sheeted dyke
- Cumulate and High level Gabbro
- Peridotite Gabbro
- Dunite
- Tectonized Harzburgite

Cr, Cu, Pb, Zn and Au Mineral occurrences

- ◆ Points of economic interest
- ◆ Points of minerals occurrence

Field evidences



Field photographs show the occurrence of **a.** upper extrusive basalt; **b. c.** and **d.** lower extrusive basalts (basaltic to andesitic pillow lava) and **e.** and **f.** the gossan (altered pyrite zone).

Conclusion

- The spectral absorption character of minerals namely epidote, chlorite, pyrophyllite, illite, calcite, dolomite, pyrite, siderite and hematite are studied.

- The image processing methods namely band ratios, principal component analysis (PCA), spectral angle mapper, linear spectral unmixing (LSU) and spectral feature fitting (SFF) were applied to map and discriminate the minerals and rocks of the deposits using Landsat 8 and ASTER data.

- The results of study evaluated in the field to show the sensor capability potential of the image processing methods.

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Thank you