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Detection of hydrothermal mineralized zones associated with listwaenites in Central Oman using ASTER data

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ABSTRACT

Listwaenites are highly altered ultramafic rocks that are potentially associated with economic mineralization and research on these is extremely important worldwide. In the present study, the classification of mineralized listwaenites developed along the serpentinite–amphibolite interface of the Semail Ophiolite, its associated lithology and the zones of alteration and mineralization in the Fanjah Saddle of the Central Oman Mountains region of the Sultanate of Oman are carried out, using Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) satellite data. The developed band ratioing, Principal Component Analysis (PCA) and the Spectral Angle Mapper (SAM) supervised classification and image processing techniques applied on the ASTER data set have proved their capability for better interpretation and identification of hydrothermally altered rocks and associated mineralization. The hyperspectral tools (Minimum Noise Fraction (MNF), Pixel Purity Index (PPI) and nD-visualizer) extracted end member spectra and SAM classification clearly show the occurrence of minerals and their spatial distributions.

The promising results are verified and confirmed in the field by identification of alteration and mineralization such as listwaenites, silicification, serpentinization and talc alteration and are validated further through laboratory analysis. The confirmation of the occurrence of base metal mineralization along the serpentinite–amphibolite interface in listwaenites suggests that detailed investigation in this and other arid regions which have similar geological conditions may locate mineral deposits. The hyperspectral tools applied on ASTER satellite data show that these can be used as a powerful tool to explore the listwaenites and the potential associated mineralization in other arid geographical regions worldwide.

1. Introduction

Mapping of listwaenites has become extremely important worldwide, because they are potentially associated with economic minerals including gold, nickel, arsenic, cobalt, wolframite and mercury mineralization (Borojević Šoštarić et al., 2011; Buisson and LeBlanc, 1986; Gabr et al., 2010; Kuleshevich, 1984; Kunov et al., 2007; Leblanc and Fischer, 1990; Leblanc and Lbouabi, 1988; Sherlock and Logan, 1995; Tsikouras et al., 2006; Uçurum, 1998, 2000; Uçurum and Larson, 1999). Listwaenite typically contains quartz, carbonate minerals (magnesite, dolomite and ankerite) as well as mica such as fuchsite, together with sulfides (pyrite, galena) and oxides (hematite, magnetite), cobalt minerals and chromite relicts. It is formed by intermediate-to-low temperature hydrothermal alteration of serpentinized ultramafic rocks and commonly located within or near major thrust faults and shear zones (Buisson and LeBlanc, 1986; Nasir et al., 2007; Tsikouras et al., 2006). A detailed study on the mineralogy and geochemical characterization of listwaenites from different regions of the Semail Ophiolite of Oman was carried out by Nasir et al. (2007). Listwaenites and associated mineralization have provoked constant interest by researchers for the study of their spatial distribution, association, occurrence, origin, conditions of formation, peculiarities and relation to economic deposits of ore minerals (Buisson and LeBlanc, 1985).

Remote sensing techniques play a vital role in exploration of mineral deposits, and its capability in mapping lithology and associated hydrothermal mineralization has been documented by a number of studies (Abdelsalam et al., 2000; Crósta and Filho, 2003; Crósta and Moore, 1989; Ferrier et al., 2002; Gabr et al., 2010; Kusky and Ramadan, 2002; Liu et al., 2007; Loughlin, 1991; Madani et al., 2003; Ramadan and Kontny, 2004; Ramadan et al., 2001; Rokos et al., 2000; Sultan and Arvidson, 1986; Zhang et al., 2007). The technique is particularly useful in regions that have extremely rugged topography, where it is impossible to do exhaustive sampling and detailed mapping and thus

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difficult to do conventional geological mapping. The mineral potential of mafic and ultramafic rocks in Oman has recently become the objective of a number of research studies involving primarily government and university workers. This paper aims to classify the occurrence and spatial distribution of listwaenites and associated hydrothermal mineralized zones of the Fanjah Saddle of the Central Mountains region of the Sultanate of Oman (Fig. 1) using multispectral ASTER satellite data since many studies from around the world proved that listwaenites are associated with base metal bearing ore occurrences, and regions similar to this warrant new exploration projects. Oman has no previous remote sensing studies reported on listwaenites concerning alteration/mineralization mapping.

2. Listwaenites

The emplacement of Semail Ophiolite massifs in the northern mountain region of Oman onto the Arabian plate during the Late Cretaceous is now well documented and generally agreed upon (Boudier et al., 1985; Coleman, 1981; Glennie et al., 1973, 1974; Lippard et al., 1986; Searle and Malpas, 1980). Numerous studies that detail the igneous and structural history of the Semail Ophiolite as well as the stratigraphy of the Oman continental margin have clarified the evolution and passive nature of this margin between the Permian to Late Cretaceous period. The geometry and nature of the continental margin bounding the Arabian carbonate platform in the area of the Oman Mountains were

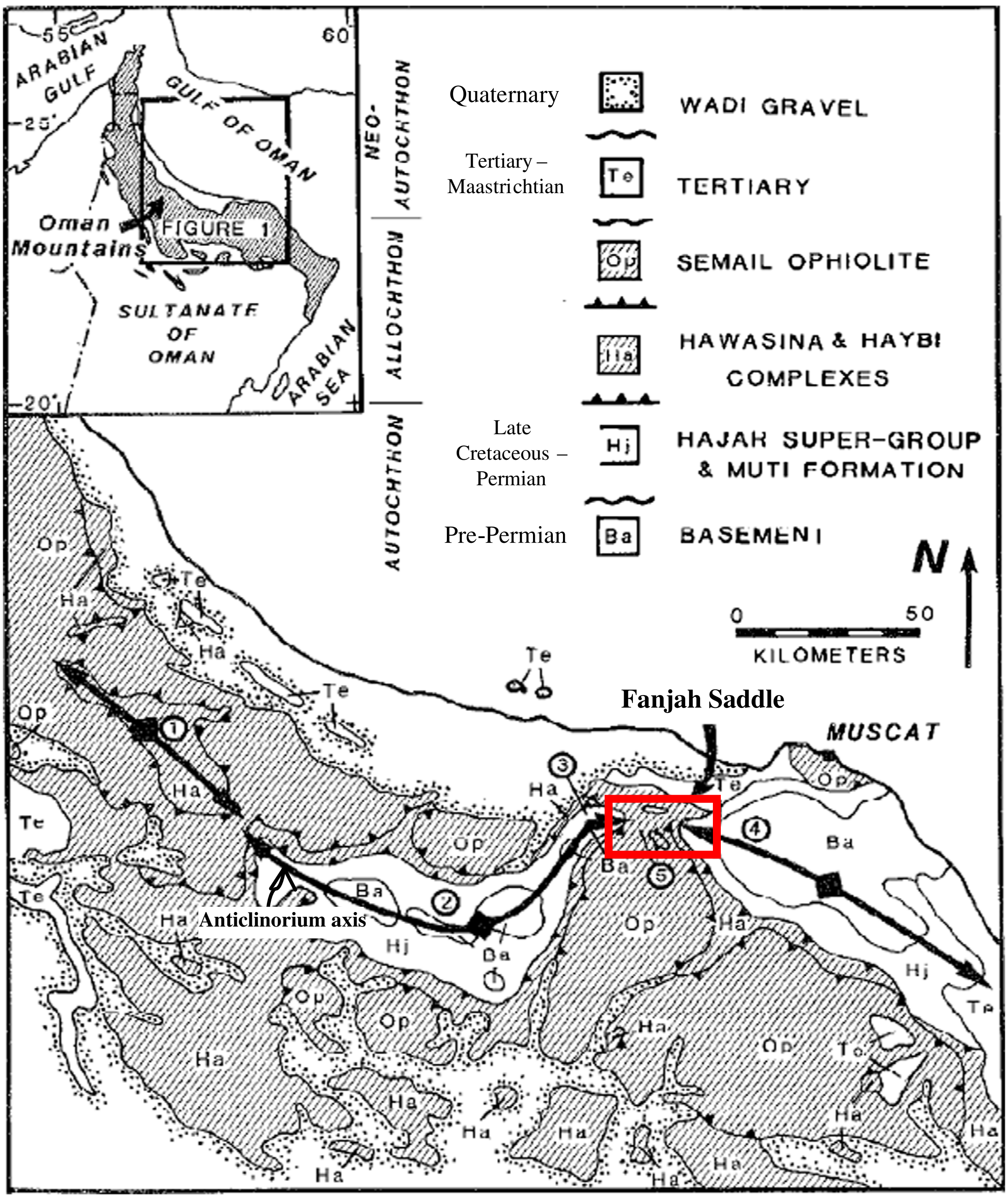

Fig. 1. Location map showing the simplified geology of the Oman Mountains and 1, Hawasina Window; 2, Jebel Akhdar culmination; 3, Jebel Nakhl culmination; 4, Saih Hatat culmination; and 5, Fanjah Saddle.
After Coffield (1990).