Ore Geology Reviews 62 (2014) 191–198

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Spectral characteristics of minerals in alteration zones associated with porphyry copper deposits in the middle part of Kerman copper belt, SE Iran

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ARTICLE INFO

Article history:
Received 5 July 2013
Received in revised form 14 March 2014
Accepted 21 March 2014
Available online 30 March 2014

Keywords:
Spectroscopy
Analytical spectral device (ASD)
Porphyry copper deposits (PCDs)
Alteration
Mineral exploration

ABSTRACT

Visible near infrared and shortwave infrared (VNIR-SWIR, 350 to 2500 nm) reflectance spectra obtained from an analytical spectral device (ASD) have been used to define alteration zones adjacent to porphyry copper deposits (PCDs), in the central part of Kerman magmatic arc, SE Iran. The spectral analysis identified sericite, illite, halloysite, montmorillonite, dickite, kaolinite, pyrophyllite, biotite, chlorite, epidote, calcite, jarosite, and iron oxyhydroxides (e.g. hematite, goethite) of hydrothermal and supergene origin. Identified alteration zones are classified into six principal types namely phyllic, phyllic/propylitic, propylitic, potassic, argillic and advanced argillic. The iron oxide minerals in the oxidized zone were also identified using spectral analysis. Results of spectral analyses of samples are consistent with mineralogical data obtained from X-ray diffraction (XRD) and petrographic studies. Spectroscopic studies by ASD demonstrate that this tool is very useful for semi-quantitative and cost effective identification of different types of alteration mineral assemblages. Furthermore, it can provide a valuable tool for evaluating aerial distribution of alteration minerals while coupled with remote sensing data analysis.

1. Introduction

One of the most important characteristics of porphyry copper deposits (PCDs) is the type and distribution pattern of alteration zones which could be used for screening and recognizing these deposits. Conventionally, characterization of alteration minerals is done by laboratory-based analytical techniques such as petrographic microscopy, X-ray diffraction (XRD), scanning electron microscope (SEM), and electron microprobe (EMP) (Bishop et al., 2004; Cathelineau et al., 1985; Ducart et al., 2006). These techniques are costly and time consuming, require sample preparation and more labor force. Conversely, spectroscopic measurements which could be implemented in the laboratory or in the field and via the aircrafts and satellites provide information about mineral composition of altered rocks with lower costs and shorter times. They can easily and rapidly identify many of the alteration minerals that are keys for identification of porphyry copper deposits (PCDs). Infrared spectroscopy is a long established analytical technique for identification and quantitative analysis of the complex mineral composites present in various rocks and for analyzing different sampling media including outcrops, hand specimens, and core and drill chips, all with little or no sample preparation (Calvin et al., 2005, 2010; Clark, 2004; Hunt and Ashley, 1979; Huston et al., 1997; Kerr et al., 2011; Longhi et al., 2001; Salisbury et al., 1991; Schaepman et al., 2009; Thompson et al., 1999; Velasco et al., 2005; Yang and Huntington, 1996). Despite this ability field spectroscopy was generally not used as a standard tool for mineral exploration and scientists had to clearly demonstrate its practical applicability in meeting the demands of exploration projects. In order to prove the utility of spectroscopy a number of successful case studies with documented XRD and petrographic studies, combined with accurate field context should be carried out.

One of the important areas for exploration of porphyry copper deposits in the world is situated in the Central Iranian Volcanic Belt (CIVB). Although many of the known porphyry Cu deposits like Sarcheshmeh (Waterman and Hamilton, 1975), which is one of the largest porphyry copper deposits in the world, are situated in this belt, rare publications are available on characteristics of alteration minerals at this area using spectroscopic study. Different methods have been used previously to identify the distribution of hydrothermal alteration minerals in this belt at the regional and local scales; particularly useful are the published works on the applications of remote sensing spaceborne

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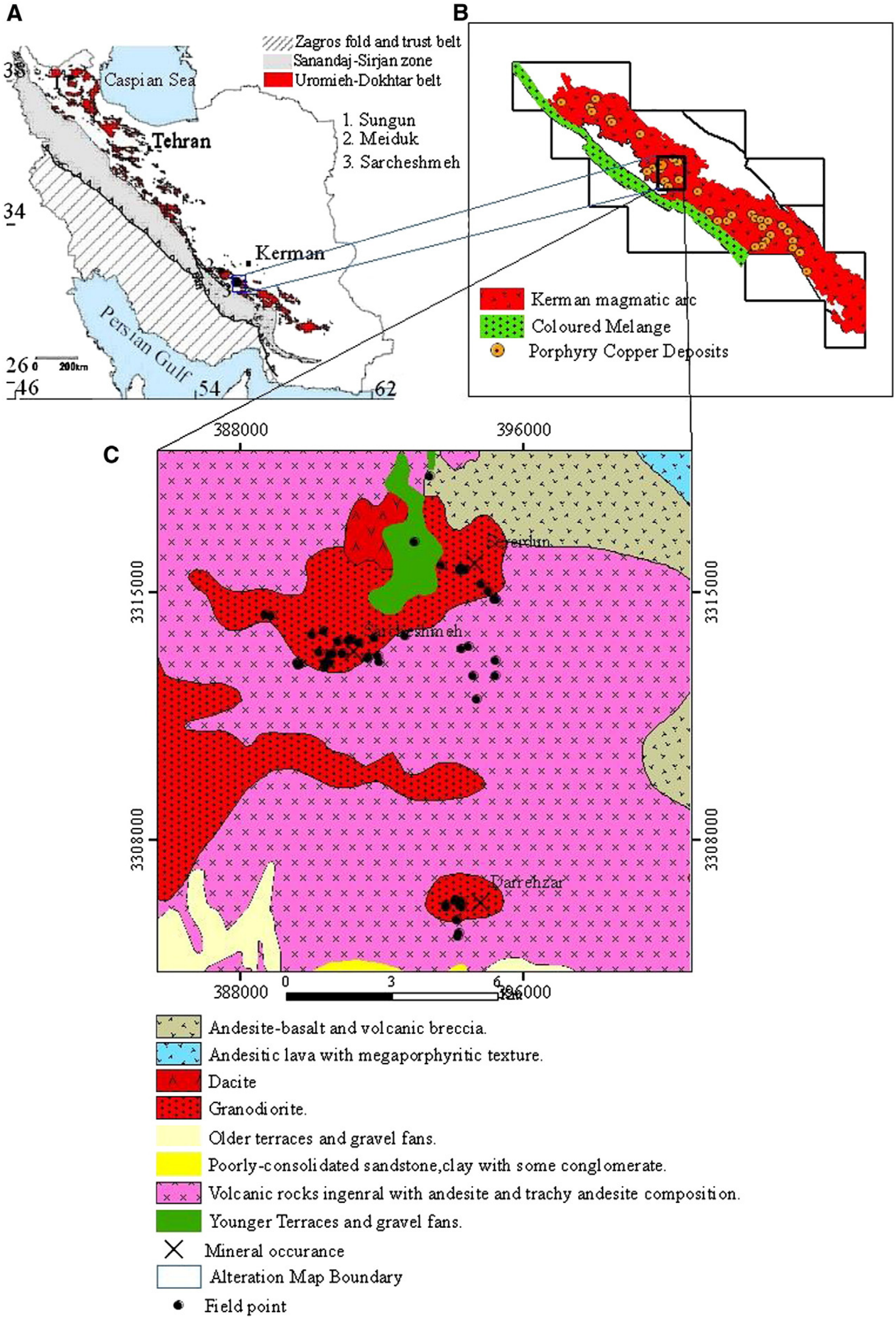
http://dx.doi.org/10.1016/j.oregeorev.2014.03.013
0169-1368/


A
Zagros fold and trust belt
Sanandaj-Sirjan zone
Uromieh-Dokhtar belt
Caspian Sea
Tehran
1. Sungun
2. Meiduk
3. Sarcheshmeh
Kerman
Persian Gulf
38
34
26
46
54
62
0
200km
B
Kerman magmatic arc
Coloured Melange
Porphyry Copper Deposits
C
388000
396000
3315000
3308000
Sarcheshmeh
Darrehzar
0
3
6
Km
Andesite-basalt and volcanic breccia.
Andesitic lava with megaporphyritic texture.
Dacite
Granodiorite.
Older terraces and gravel fans.
Poorly-consolidated sandstone,clay with some conglomerate.
Volcanic rocks ingenral with andesite and trachy andesite composition.
Younger Terraces and gravel fans.
Mineral occurance
Alteration Map Boundary
Field point