

Lineament Tectonics and Mineralization in Tarom Area, North Iran

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Abstract

The study area that is part of Tarom volcano-plutonic zone which host many hydrothermal base metal deposits located in Zanjan, NW Iran. Understanding the tectonic events that can cause mineralization and hydrothermal alteration are significant factor in assessing the exploration potential of different structures. In this research, hydrothermal alteration such as Iron oxide, argillic, phyllic, and propylitic zones were determined by Spectral Angle Method (SAM) and also lineaments identified by high pass filters and hill-shade DEM techniques on Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) data. Field studies revealed most alteration and mineralization occurred in NE-SW fractures and control mineralization.

Keywords

Lineament, Alteration, Hydrothermal, Tarom, Iran

1. Introduction

The use of satellite images for mineral exploration has been very successful in pointing out the presence of minerals such as alunite, pyrophyllite, kaolinite, sericite, illite, muscovite, smectite, and carbonate which are important in the identification of hydrothermal alterations [1]. In addition, satellite remote sensing provides synoptic view, which is helpful in identification and delineation of various land forms, linear features and structural elements [2] [3]. Hence, in primary stages, mapping geologic lineaments is important for mineral exploration, because of their potentials for harboring ore bodies that are carried and deposited by ascending hydrothermal fluids [4] [5]. Iran is located in the Alpine-Himalayan orogenic and metallogenic belt and has high potentials for gold and copper and other base metal deposits. Satellite images have been used by many Iranian geologist researchers as cheapest method for interpretation of the structural features and exploration purposes [6] [7]. The aim of the

present study is tectonic control on distribution of hydrothermal alteration zones and mineralization in Tarom Area Based on Remote Sensing Data, NW Iran.

2. Materials and Methods

2.1. Geologic Setting

Tarom area (**Figure 1**) is located between longitudes $48^{\circ}52'30''\text{E}$ - $49^{\circ}00'00''\text{E}$ and latitudes $36^{\circ}41'28''\text{N}$ - $36^{\circ}49'00''\text{N}$ in the eastern Zanzan Province, NW Iran.

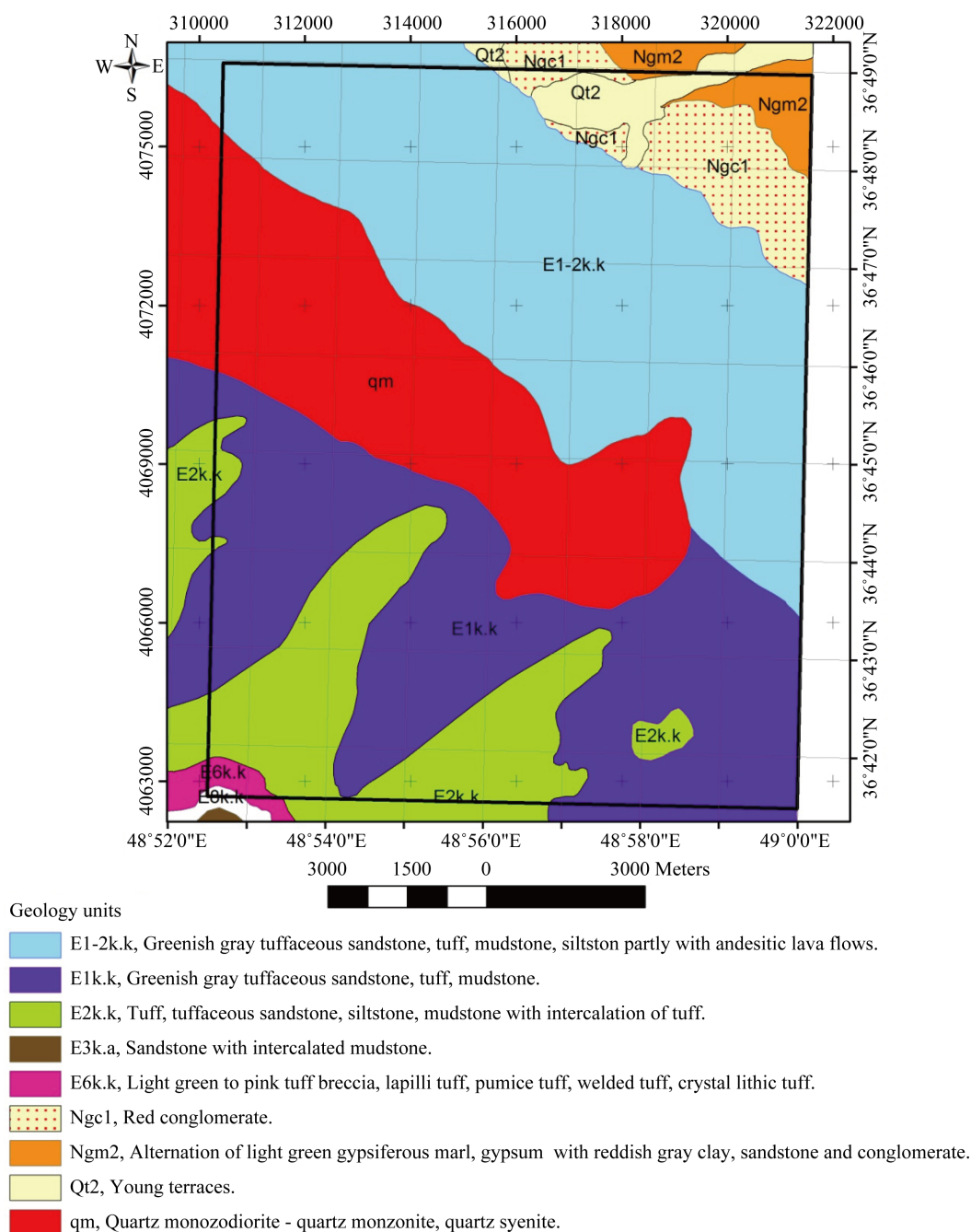


Figure 1. Geological map of studied area based on 1:100,000 geological map of Tarom. This area has shown in **Figure 2** by a black rectangle.

This area belongs to West-Central Alborz and lesser Caucasus hinterland [8] [9] that formed on the inverted back arc intra-continental rift since Oligocene. Dominant structural trend in West-Central Alborz and lesser Caucasus province is NW-SE (Figure 2). From tectonics view, it contains deformed zone (fold and thrust belt) of Cimmerian miniplate that formed in northern active margin until late Triassic. Then it has rifted by tension in a back arc basin of Neotethyan subduction zone in the south margin of Cimmerian miniplate. Development of that rift stopped in the late Cretaceous and then, renewed in the Eocene by spreading in submarine arc basin of Neotethyan subduction zone. In the other word, this hinterland is result of a magmatic arc system spreading in the evolutionary back arc basin. After that, this region has converted to back arc regim again and West-Central Alborz and lesser Caucasus hinterland has formed by its deformation and regional uplift from SW part of Caspian Sea to Black sea. Recently, Damavand and Sebalan cones have formed by late volcanism that related to final subduction of oceanic slab (Neotethys) toward north and northeast [10].

This area has an active tectonics regim [11]-[24] in compared to the Central Iran [25]-[33], Zagros in the southern Iran [34]-[40] and salt diapiric areas in Iran [41] [42]. Also, some concept of its metal mineralization, have investigated by [43]-[46]. Tarom volcanic rocks are changing from rhyodacite, dacite to basalt. Lava rocks such as tuff and tuffite, andesite-basalt, andesite, trachyte, latite, trachyandesitic, dacite, rhyodacite, ignimbrite and moderate acidic tuff volcanic rocks in the Tarom zone have been observed. Also, in the Tarom zone, sericite,

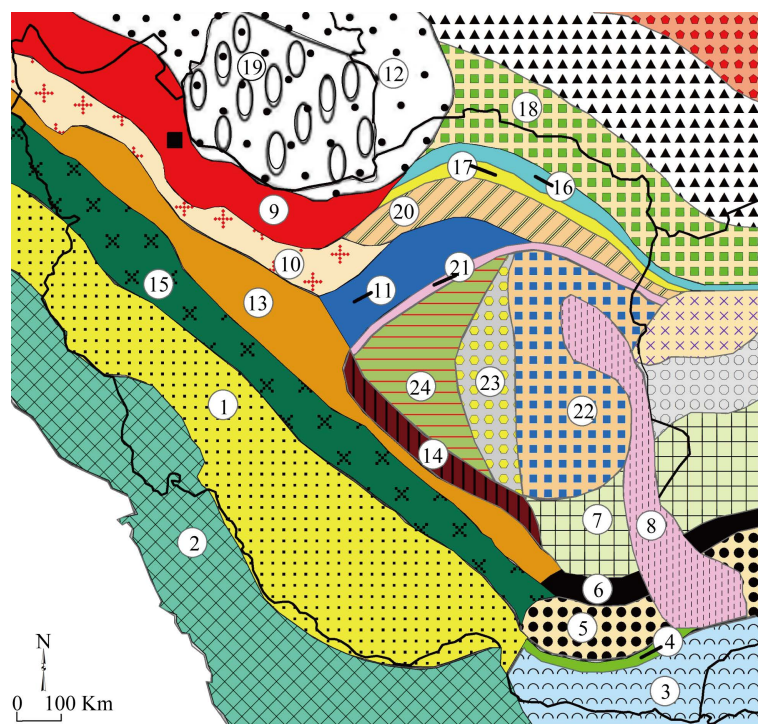


Figure 2. Physiographic-tectonic zoning map of Iran's sedimentary basins Iran, modified from [10]. Numbers in this figure are, 1: Zagros-East Taurus hinterland, 2: Persian Gulf-Mesopotamian foreland basin, 3: Makran accretionary prism, 4: Bashagard Mountains, 5: Jazmorian-Mashkel fore arc basin, 6: Shabsavar-Soltan magmatic arc, 7: South Lut-South Helmand back arc basin, 8: East Iran Mountain belt, 9: West-Central Alborz and lesser Caucasus hinterland, 10: Great Kavir-Northern Urmieh lake foreland basin, 11: South Great Kavir fold and thrust belt, 12: South Caspian-Black sea foreland basin, 13: Urmieh-Dokhtar Magmatic Arc, 14: Naïen-Kerman retro arc foreland basin, 15: Sanandaj-Sirjan overthrust belts, 16: East Alborz or Binalod hinterland, 17: Torbat-e am-Neyshabour retro arc foreland basin, 18: KopetDagh hinterland, 19: South Caspian remnant basin, 20: Maiamay-Taibad Inverted back arc basin, 21: Khaf-Kavir Plain Magmatic Arc, 22: Lut Plain-Gonabad back arc basin, 23: Tabas hinterland, 24: Yazd-Khour Piggy back basin. The study area is shown in the black rectangle.

propylitic, silica, chlorite, alunitic, zeolite alteration zones have been identified. Zanzan province has a particular mineral resource position among the structural domains of Iran. All kinds of metamorphic basement rocks, ophiolites (ancient oceanic lithosphere), and magmatic arcs can be observed in this province.

As a result, various types of mineral resources exist in this territory, which have made this province a high-potential mineral resource domain in Iran [47]. Based on 1:100,000 geological map of Tarom, the most impressive geological feature in studied area is the Eocene sequences which composite of quartz-monzonite that spread northwest to southeast of investigated area. Sandstone, tuffaceous sandstone, and andesite lava flows formed other part of studied area. The conglomerate, gypsiferous marl and young terraces are in the north west of investigated area [48].

2.2. ASTER Data

The ASTER is an advanced optical sensor comprised of 14 spectral channels ranging from the visible to thermal infrared region. It will provide scientific and also practical data regarding various field related to the study of the earth [49]. Various factors affect the signal measured at the sensor, such as drift of the sensor radiometric calibration, atmospheric and topographical effects. For accurate analysis, all of these corrections are necessary for remote sensing imagery.

To this end, at the beginning of the path, data set AST_L1B_010_8200745110108311331 in hierarchical data format (HDF) was used for this research and radiance correlation such as wavelength, dark subtract and log residual by ENVI4.4 software which is essential for multispectral images, were implemented.

3. Results and Discussion

3.1. Hydrothermal Alteration Detection

By using of spectral angle mapper method alteration zones were determined. SAM method is a classification technique that permits rapid mapping by calculating the spectral similarity between the image spectrums to reference reflectance spectra. SAM measures the spectral similarity by calculating the angle between the two spectra, treating them as vectors in n-dimensional space [50] [51]. The image spectra were compared with USGS Digital Spectral Library (Minerals) [52]. **Figure 3** show selected minerals spectral library plots that related to iron oxide, argillic, phyllic and propylitic alterations.

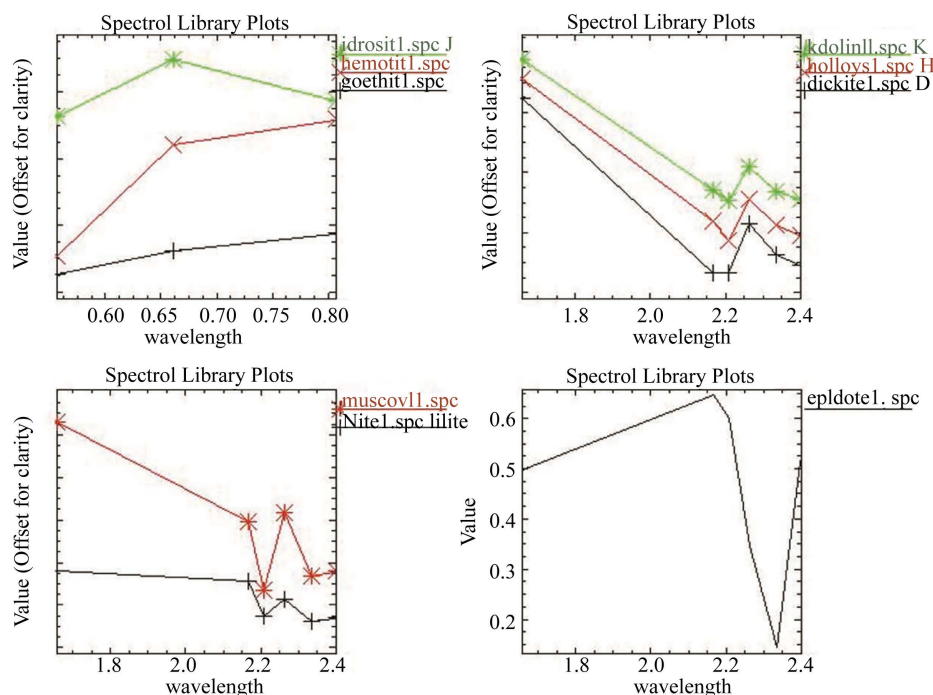


Figure 3. Spectral library plots from USGS library.

Three mineral spectral representative of iron oxide include jarosite, hematite, goethite, three mineral spectral representative of argillic zone include kaolinite, dickite and halloysite, three minerals spectral representative of phyllic alteration consist of illite and muscovite and epidote representative of propylitic zone were selected (Figure 4).

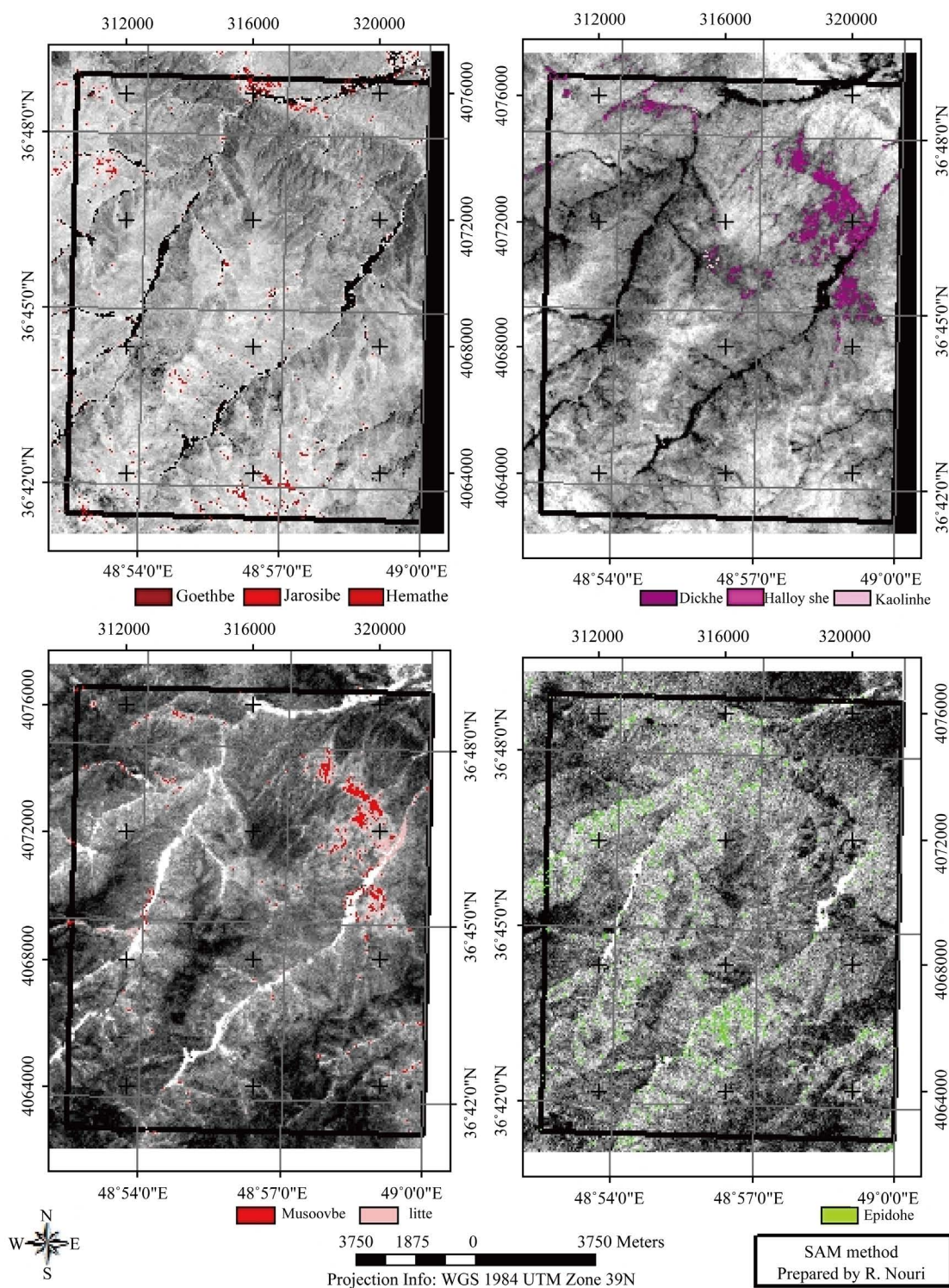


Figure 4. The iron oxide, argillic, phyllic, and propylitic images prepared based on SAM method.

3.2. Lineament Extraction

Lineament extraction in this study is performed in Manual method. In manual extraction method, the lineaments are extracted from satellite image by using visual interpretation. The lineaments usually appear as straight lines or “edges” on the satellite images which in all cases contributed by the tonal differences within the surface material. The knowledge and the experience of the user is the key point in the identification of the lineaments particularly to connect broken segments into a longer lineament [53].

False color images are produced for manual lineament extraction because they increase the interpretability of the data. Different combinations of three bands are examined and the best visual quality is obtained with a false color image utilizing three 7, 4, and 2 (in blue, green and red respectively).

This false color combination made it easier to identify linear patterns of vegetation, geologic formation boundaries, river channels, geological weakness zones. Moreover, filtering operations are used to emphasize or deemphasize spatial frequency in the image. The filtering operation will sharpen the boundary that exists between adjacent units. Furthermore, standard GIS techniques have been carried out to help in the evaluation of the lineaments detected. Digital Elevation Model (DEM) has the advantage of representing the vertical extension of the earth's surface by assigning height values for every pixel [54].

Also, hill-shade DEM technique is effective in creating images that enhance geomorphologic features. Therefore, Hill-shades DEM with different azimuth direction and sun angle were used in this study (Figure 5). Integration of alteration and lineament with accordance to geology map of studied area is shown in Figure 6.

4. Ground-Truth Verification

To evaluate the ASTER satellite data, discriminate alteration zones and lineaments, field-checks have been verified. In almost all cases, our fieldwork confirmed in showing real alteration and detection of area of lineament by the interpreted remote sensing imagery. The field photographs of the hydrothermally altered rocks are shown in Figure 7. Microscopic photographs of the study areas are shown in Figure 8.

5. Conclusion

The use of remote sensing data in the early stages of mineral exploration was very successful for recognition of

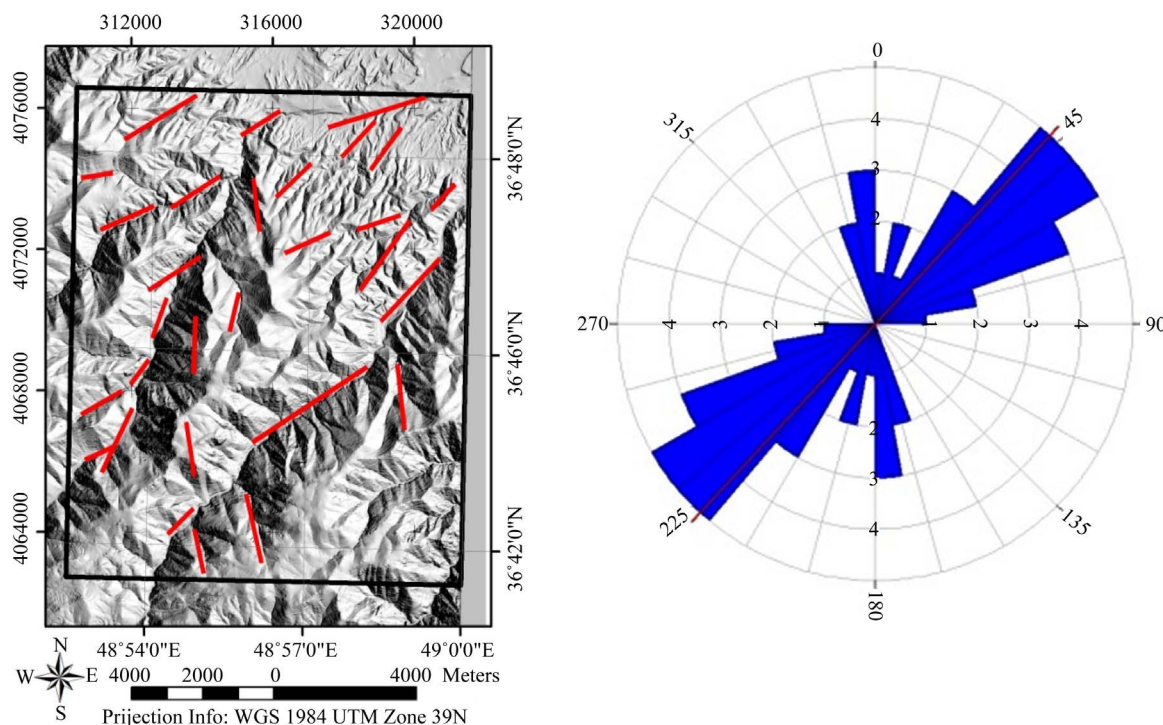


Figure 5. Lineament and rose diagram of studied area.

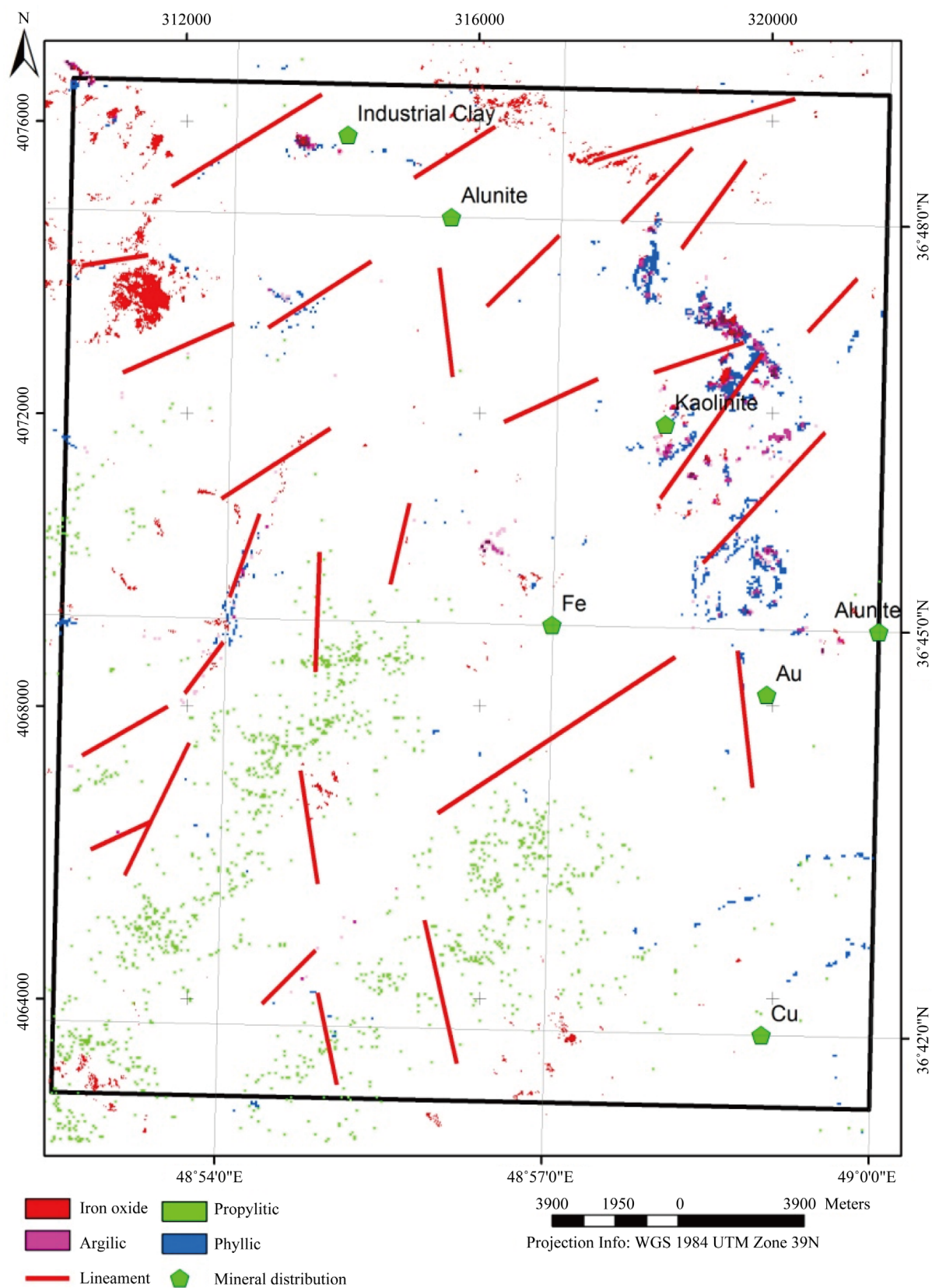


Figure 6. Integration of alteration and lineament.

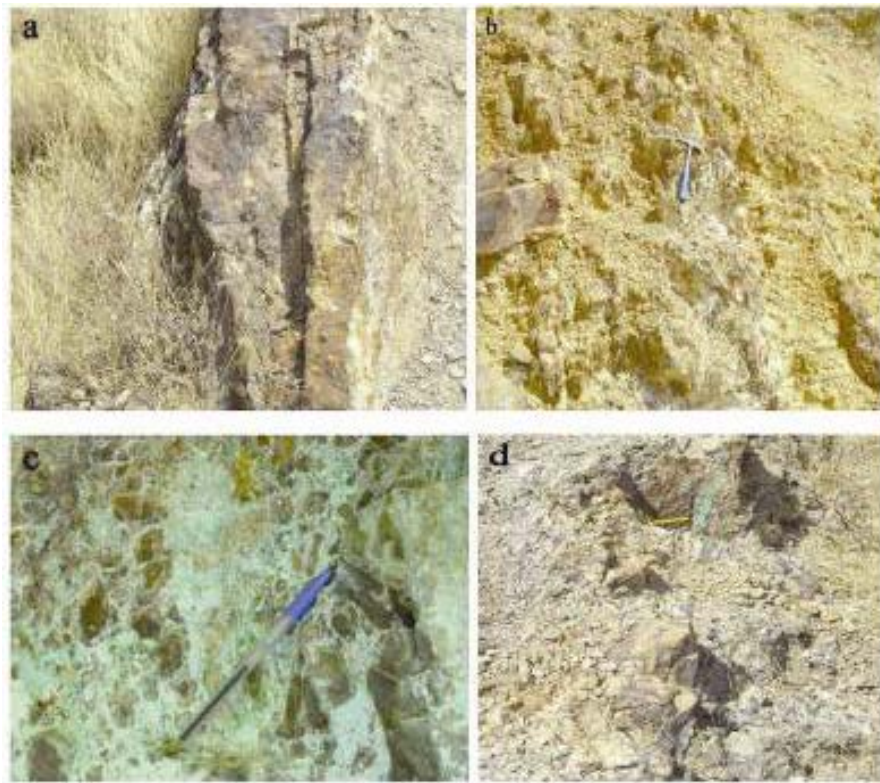


Figure 7. Field photographs of the study area. (a) View of the iron oxide; (b) View of the silica vein- and argillic-altered rocks (c) View of the propylitic-altered rocks; (d) View of the copper and gold outcrop.

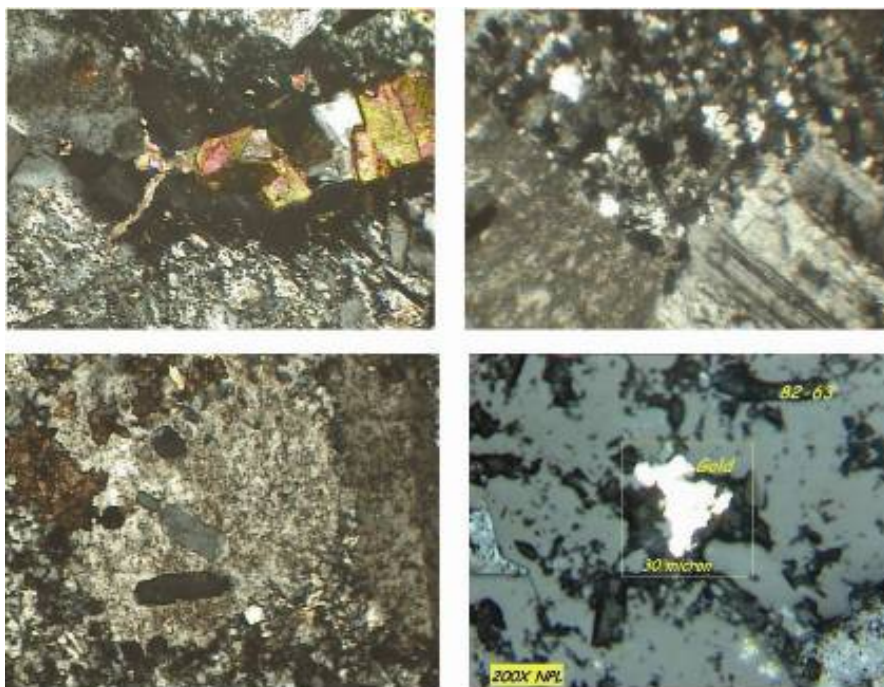


Figure 8. Microscopic photographs of the study areas. (a) Thin section of quartzmonzonite with clay minerals, 40 XPL; (b) Thin section of granite with sericite and iron oxide, 40 XPL; (c) Thin section of monzodiorite with chlorite, 40 XPL; (d) Gold in silica gangue.

the hydrothermal alterations. Moreover, ASTER multi spectral images could be used for the identification of lineaments possibly related to faults. The performance of conventional image processing techniques has been evaluated on ASTER bands. Results show that the integration of the image processing techniques has great ability to detect iron oxide, argillic, phyllic and propylitic. Field checks also confirmed in showing real alteration and detection of area of lineament by the interpreted remote sensing imagery.

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