საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 9, №2, 2015
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 9, no. 2, 2015

Geology

Structural Control on the Distribution of Hydrothermal Alteration Zones and Mineralization in Dastjerdeh Area Based on Remote Sensing Data, NW Iran

Reza Nouri* **and Mehran Arian****

* *Young Researchers and Elite Club, North Tehran Branch, Islamic Azad University, Tehran, Iran*
***Department of Geology, Science and Research Branch, Islamic Azad University, Tehran, Iran*

(Presented by Academy Member Irakli Gamkrelidze)

ABSTRACT. The Dastjerdeh area is a part of Tarom volcano-plutonic zone which hosts many hydrothermal base metal deposits located in Zanjan, NW Iran. Understanding the tectonic events that can cause mineralization and hydrothermal alteration is a significant factor in assessing the exploration potential of different structures. In this research, hydrothermal alteration such as iron oxide, argillic, phyllitic, 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 that most alteration and mineralization occurred in NE-SW fractures. *© 2015 Bull. Georg. Natl. Acad. Sci.*

Key words: *lineament, structure, mineralization, remote sensing, Dastjerdeh, Iran.*

Introduction

The use of satellite images for mineral exploration is very successful in pointing out the presence of some minerals [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 metalogenic belt and has high potentials for gold and copper and other base metal deposits. Satellite images are used by many Iranian geologist researchers as the 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 Dastjerdeh Area Based on Remote Sensing Data, NW Iran.

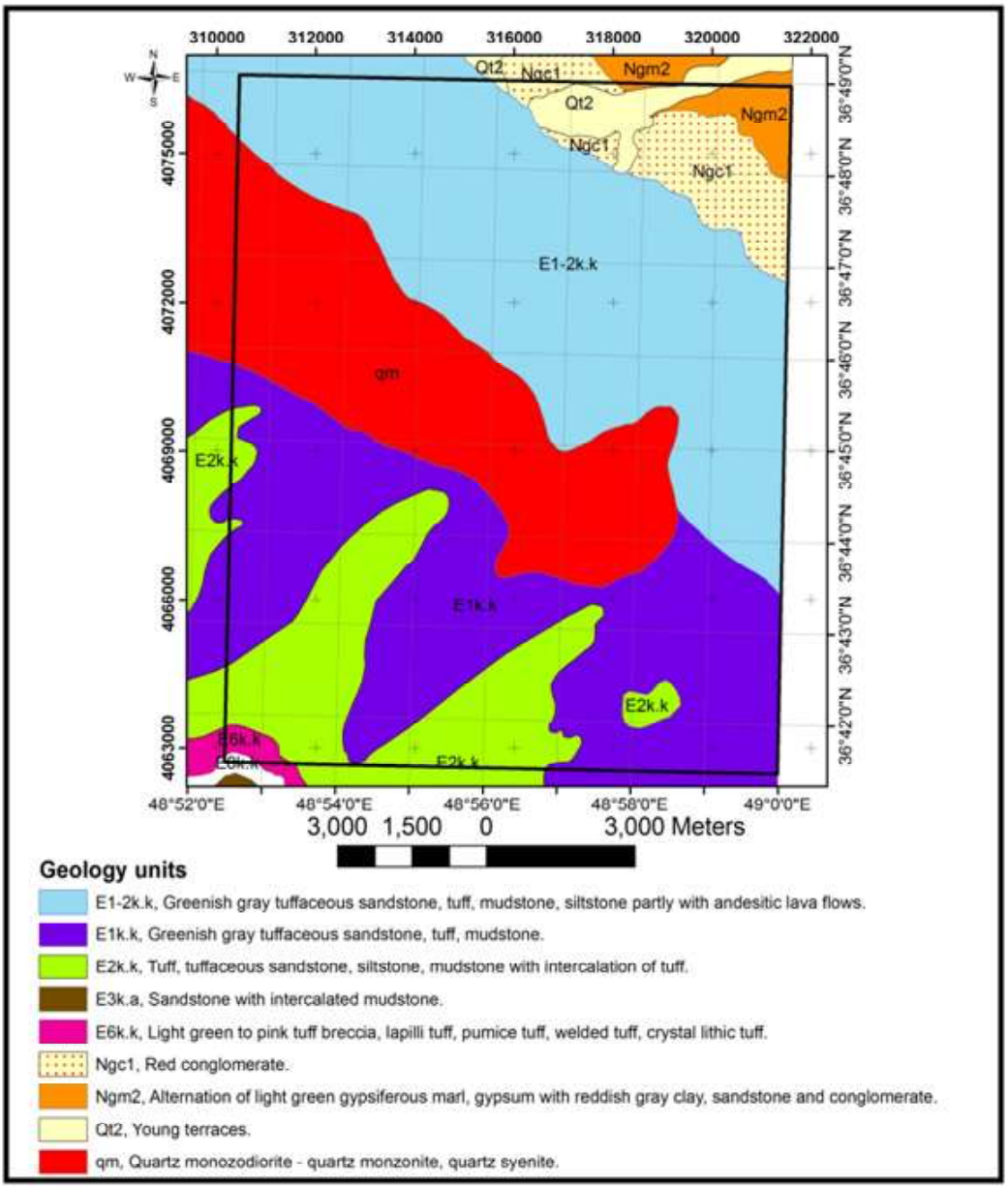

Fig. 1. Geological map of studied area based on 1:100000 geological map of Tarom. This area has shown in Figure 2 by a black rectangle.

Materials and Methods

Geologic setting

Dastjerdeh area (Fig. 1) is located between longitudes E48°52'30"– 49°00'00" and latitudes N36°41'28"– 36°49'00" in the eastern Zanjan Province, NW Iran.

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 (Fig. 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 rifted by tension in a back arc basin of Neotethyian 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

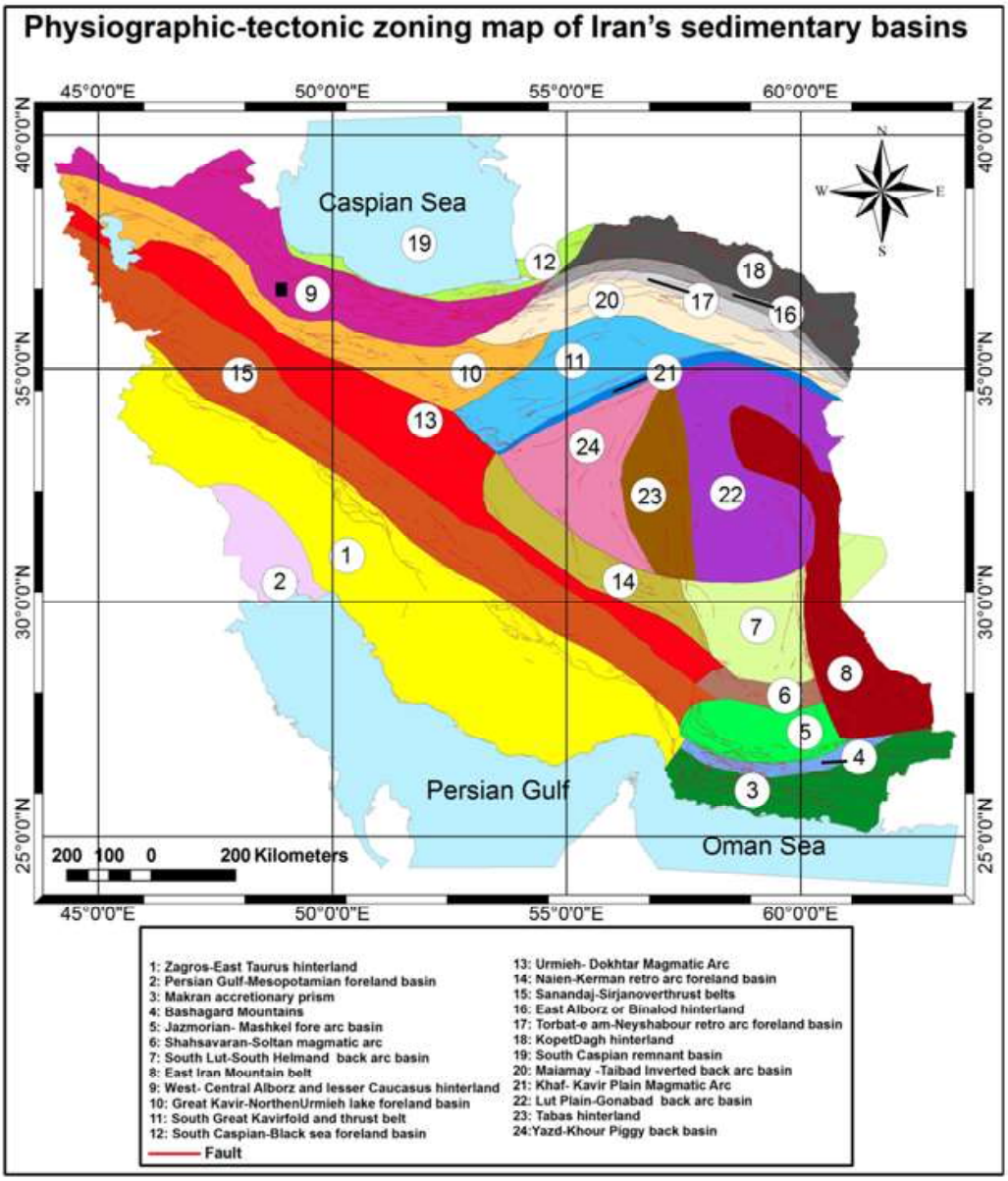

Fig. 2. Physiographic-tectonic zoning map of Iran's sedimentary basins, modified from [10]. The study area is shown in the black rectangle.

Neotethyian subduction zone. In the other word, this hinterland is the result of a magmatic arc system spreading in the evolutional back arc basin. After that, this region converted to back arc regime again and West-Central Alborz and lesser Caucasus hinterland is formed by its deformation and regional uplift from SW part of Caspian Sea to Black sea. Recently, Damavand and Sebalan cones were formed by late volcanism that related to final subduction of oceanic slab (Neotethys) toward the north and northeast [10].

This area has an active tectonics regime [11-24] compared to the Central Iran[25- 33] and Zagros in the southern Iran[34-40].Also, some concept of its metal mineralization, investigated by [41-44] Tarom volcanic rocks are changing from rhyodacite, dacite to basalt.

Lava rocks such as tuff and tuffite, andesite -

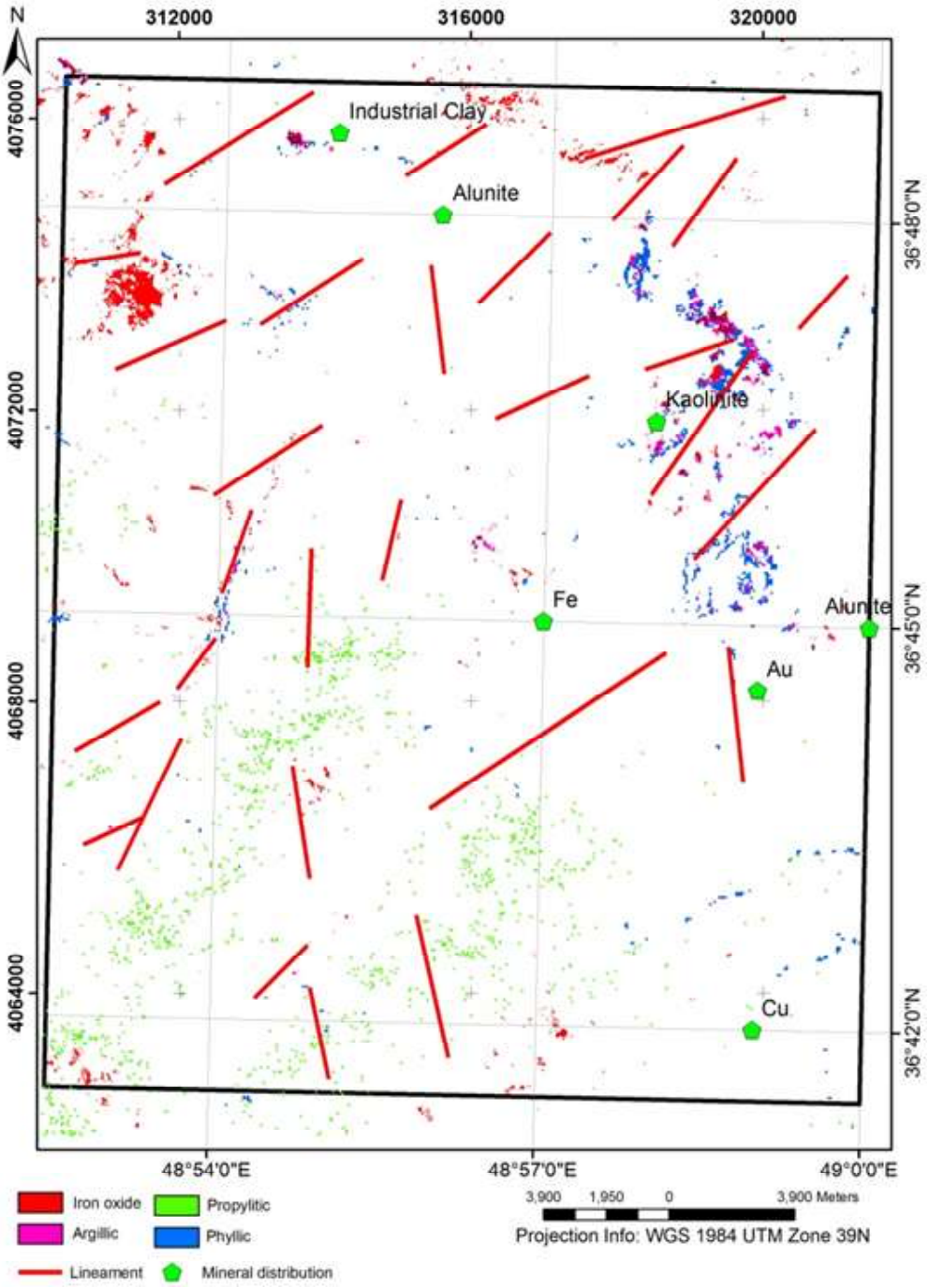

Fig. 3. Integration of alteration and lineament.

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, propylitic, silica, chlorite, alunitic, zeolite alteration zones were identified. Zanjan 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 [45]. Based on 1:100000 geological map of Tarom, the most

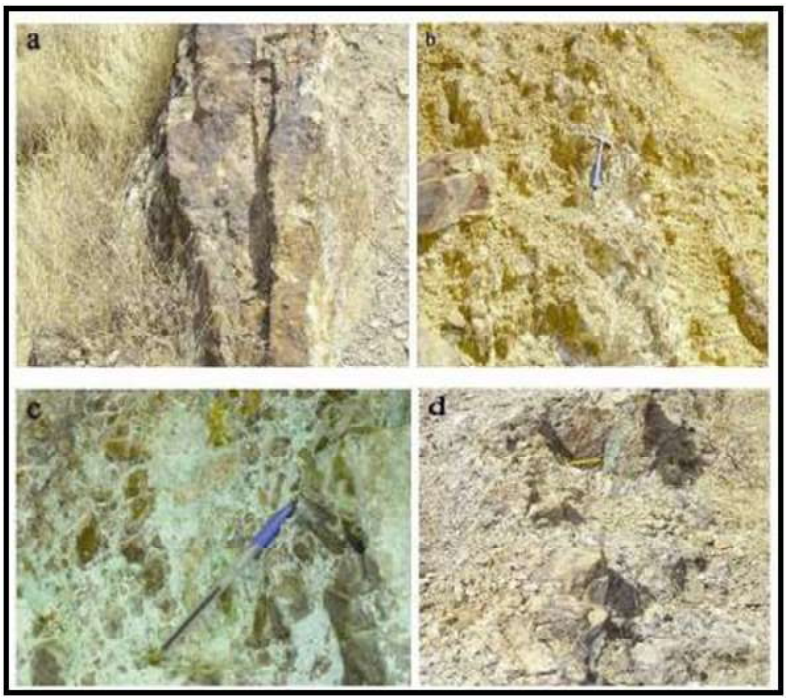

Fig. 4. Field photographs of the study area. (a) View of the iron oxide; (b) View of the silica vein- and argillic-altered rocks (c) View of the propylitic-altered rocks; (d) View of the copper and gold outcrop.

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 [46].

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 fields related to the study of the earth [47]. 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.

Results and Discussion

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 [48, 49]. The image spectra were compared with USGS Digital Spectral Library.

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. False color images are produced for manual lineament extraction because they increase

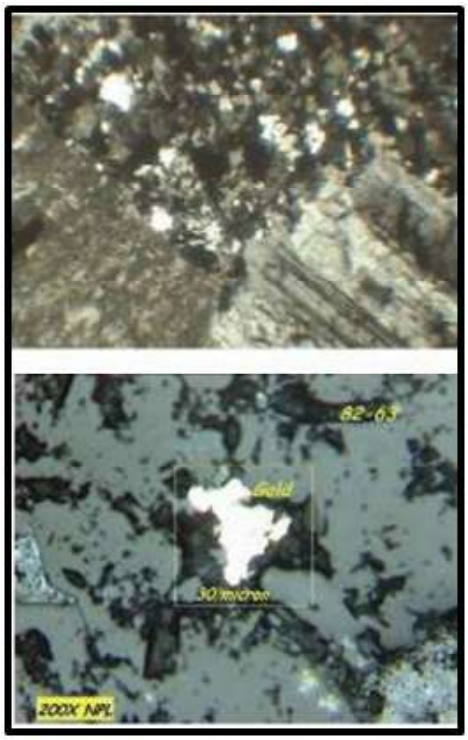

Fig. 5. Microscopic photographs of the study areas. (Up) Thin section of granite with sericite and iron oxide, 40 XPL; (Down) Gold in silica gangue, 40 XPL.

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). Integration of alteration and lineament with accordance to geology map of studied area is shown in Fig. 3.

Ground-Truth Verification

To evaluate the ASTER satellite data, discriminate alteration zones and lineaments, field-checks were 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 Fig. 4. Microscopic photographs of the study areas are shown in Fig. 5.

Conclusions

The use of remote sensing data in the early stages of mineral exploration was very successful for recognition of 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 were evaluated on ASTER bands. Results show that the integration of the image processing techniques has great ability to detect iron oxide, argillic, phyllitic and propylitic. Field checks also confirmed in showing real alteration and detection of area of lineament by the interpreted remote sensing imagery.

Acknowledgements

This work was funded by the Department of geology, Islamic Azad University, North Tehran branch, Tehran, Iran. The authors are grateful to Exploration Department of Geological Survey of Iran.

გეოლოგია

სტრუქტურული კონტროლი ჰიდროთერმულად შეცვლილი ზონების გავრცელებაზე და მინერალიზაცია ჩრდილო-დასავლეთ ირანის დასტჯერდეჰის რაიონში დისტანციური ზონდირების მონაცემებზე დაყრდნობით

რ. ნოური*, მ. არიანი**

** აზადის ისლამური უნივერსიტეტი, ჩრდილოეთ თეირანის განყოფილება, ახალგაზრდა მეცნიერთა კლუბი, თეირანი, ირანი*
***აზადის ისლამური უნივერსიტეტი, გეოლოგიის დეპარტამენტი, სამეცნიერო-კვლევითი განყოფილება, თეირანი, ირანი*

(წარმოდგენილია აკადემიის წევრის ე. გამყრელიძის მიერ)

დასტჯერდეჰის ტერიტორია არის ტარომის ვულკანურ-პლუტონური ზონის ნაწილი, სადაც განლაგებულია ზანჯანის ჰიდროთერმული არაკეთილშობილი ლითონების საბადოების უმეტესობა. ტექტონიკური მოვლენების შეცნობა, რომლებსაც შეიძლება გამოეწვია მინერალიზაცია და ჰიდროთერმული შეცვლა, არის მნიშვნელოვანი ფაქტორი სხვადასხვა სტრუქტურების საძიებო პოტენციალის შესაფასებლად. ამ კვლევაში ისეთი ჰიდროთერმული შეცვლები, როგორიცაა რკინის ჟანგის, არგილიტური, ფილიტური და პროპილიტური ზონები განსაზღვრული იყო SAM მეთოდით, ხოლო ლინეამენტები იდენტიფიცირებულ იქნა DEM მეთოდით და ASTER-ის მონაცემებით. საველე კვლევებმა გამოავლინა, რომ ძირითადი შეცვლა და მინერალიზაცია ხდება უმეტესად ჩრდილო-აღმოსავლეთი და სამხრეთ-დასავლეთი მიმართულების რღვევების ზონებში.

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Received February, 2015