Geological studies on Uranium, Thorium, Potassium based on airborne radiometric geophysical data in Harsin (the south of Ahar – eastern Azarbayjan)

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Abstract- Airborne radiometric geophysical operations provide information which is particularly important in the exploration of radioactive elements. In fact, this kind of information is the basis for the exploration of uranium in different regions. In the present article, areas where radioactive elements may be found have been determined after the analysis of resulting data from airborne geophysical in 1:50000 sheet of Harsin zone in the northwest of Iran. In this paper, radiometric data derived from the region was first analyzed. Then, the accuracy of geophysical data was assessed through ground control of data in Harsin and some samples of the surface of all promising areas. In addition, the geology of anomaly areas on this sheet was studied. Results have shown that volcanic rocks and lacustrine deposits are found in the northeast of Harsin. This means high levels of uranium in volcanic rocks of structural control type as well as richness of uranium in lacustrine deposits and alluvium in order to explore uranium of type sedimentary. This research first seeks to determine alterations with the aid of satellite images and microscopic sections. Then, the geology and tectonic of the region is studies so as to determine the terrene of uranium and to distinguish important factors for the host rock.

Keywords- Sedimentary uranium type, Structural control, radioactive elements, Alteration

I. Introduction

Statistic comparisons of known uranium ore deposits have shown that the most definite and reasonable estimated source belongs to uranium ore deposits of sandstone type with 29.9 %. After ore deposits of unconformity type, 26.6 percent of uranium is obtained from ore deposits of these types. This figure represents the high importance of ore deposits of sandstone type [1]. Sandstone ore deposits have several advantages including simple process of extraction and easy processing of uranium. Thanks to their simple process of exploitation through in-cite leaching, they are regarded economic ore deposit sat the present time. Results show that the most of these ore deposits have remained from Mesozoic and Cenozoic and were formed by Cimmerian and Alpine phases which were very active in Iran [1]. Several factors are considered Significant in the genesis of ore deposits including permeable layers, the availability of source rock, appropriate host rock and hydraulic system [1]. Uranium normally exists pegmatite, acid tuffs and alkaline and alkaigranits because it is a rich source of uranium (volcanic ashes) and creates conditions for the circulation of surface water in places where ore deposits of sedimentary type are formed [1]. Therefore, volcanic – sedimentary rocks of the region are known as the source rock of uranium. These rocks are made up of a lot of tuff breccias and acid ignimbrite to the extent of riodacite(potassium felspat) and a little Andesitic pyroxene and traciandesit which were formed in the east and north of lacustrine deposits and alluvium. The fact that there is intrusion dating back to Oligocene volcanic rocks of the region is of value in terms of uranium concentration in the source rock.

The present paper tries to study the relation between the tectonic of the region and volcanic- sedimentary rocks in Harsin. Volcanic – sedimentary rocks are considered an appropriate source of uranium in this study because of the richness of host sandstone units.

II. Geographic location

Harsin 1:50000 sheet is one of the four 1:100000 sheet on 1:100000 geological map of Ahar(it is located on the northwest of Iran in eastern Azerbayjan Province between latitude of 38-38,15' north and longitude of 47-47,15' east. The area of the region under study is approximately 614 km^2. Thanks to the abundant sources of water and fertility of soil [8], the region has changing climate. In order to get to Harsin, one has to take the main road of Tabriz – Bostan Abad to sarab Road until he gets to Douzdouzan. Then, he should take Mehraban-Harsin way.

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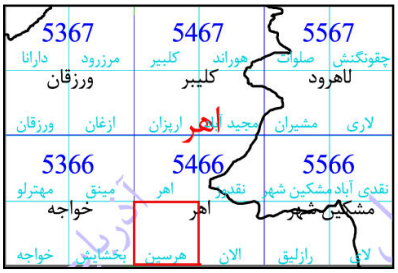

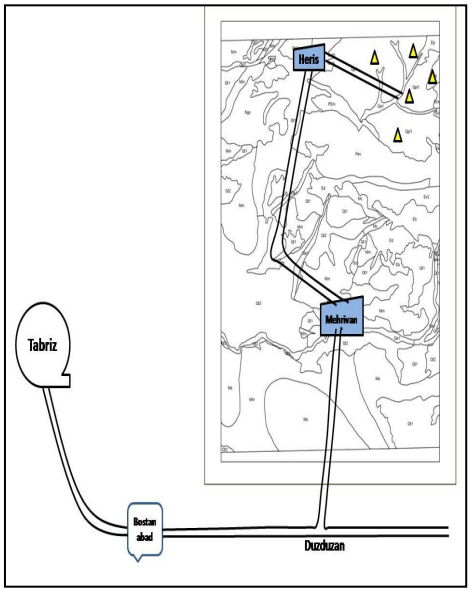

Fig .1 shows the geographic location of Harsin 1:50000 sheet and the routes to the city.

III. Geology of Harsin

Exploration area of Harsin with the number 54660 in 1:100000 Ahar sheet is situated on the southwest of Ahar and is a part of structural zone of western Alborz – Azerbayjan in eastern Azarbayjan province. rocks in Harsin were formed in Cenozoic.

IV. Structural geology of Harsin and related rock units

Tectonic phase related to Austrian event which was itself a consequence of post Cambrian folding created post cretaceous deposits. These deposits are the oldest rock unit of Ahar but none of its outcrops were found in the exploration zone. Then, a tectonic event happened and Laramian folding emerged. Meanwhile, Tertiary or Cenozoic started. Forces of tectonic event are mostly compressional and are followed by an expanding phase. The latter phase caused some fractures on the earth's crust (also known as rift or graben) through which lava came out. That most lava consists of alkaline is a proof that supports the above claim. These rocks are mostly made deep in sea or in pyroclastic environment. When lava encounters sea water along faults or fractures, it's fortified so that pieces are spread on water. Eocene deposits are affected by tectonic movements of middle Alpine phase (Pireneh).They are then folded and come out of water. The oldest rock unit of Harsin exploration zone is in the north-east and stretches to the east and the center of the city. These rocks which have remained from Eocene and Paleocene era range from intermediate to acid (volcanic – sedimentary). rock s in the north-east of Harsin ate the terrene of uranium of the region and include a lot of tuffbreccias and ignimbrite, and a little pyroxene andesit and trachiandesite (potassium feldspar). Tuffs often consist of acid with a ranging degree from riodacite to dacite (figures 2 and 3). According to geological studies, the faults of the region in this rock unit are normal or strike-slip. Lava is rich in lithophile(LEL) elements. Uranium, thorium, barium and rubidium anomalies are positive [4]. The spread of this rock unit strengthens its explosive property [2]. Toward eastern end of Harsin, most andesites are prophyritic. Finally, in the east and center, sedimentary – volcanic rocks are basaltic lava and tuffs are extremely siliceous and welded.

Fig .2 Andesitic rocks in Hayaq village.

Fig .3 Tuffs in Hayaq village.

Volcanic activities continue to have internal magmatic processes so that alkaline intrusion was lastly created. This intrusion dates back to Oligocene and has the rock compound of alkali-granite to hornblende biotit (abundant biotitic and hornblende minerals represent the high pressure of water steam). Both volcanic alkaline rocks and intrusion means that the generator magma of rocks in the region was probably the same. Following Pearce diagram (1984) and considering tectono-magmatic location of the intrusion, granites of the region are known as type (A). Following Bachelor and Bowden diagram (1985), the intrusion is located in the collision zone. This means that intrusion is related with Alpine phase [6]. (Thus, it can be said that the intrusion of the region is intraplate granites type (A) which embedded in the source rock in a tension environment related to the rift. The intrusion grouting produced heat fluids in the region followed by argillite, proplitic, potassic and fillic alterations in volcanic rocks (source rock) (figures 4, 5, 6) [4].

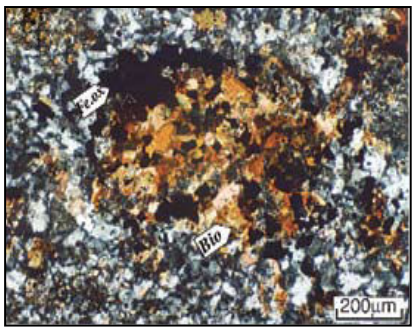

Fig .4 the concentration small biotite by alteration ferromagnesian mineral in potassic zone.

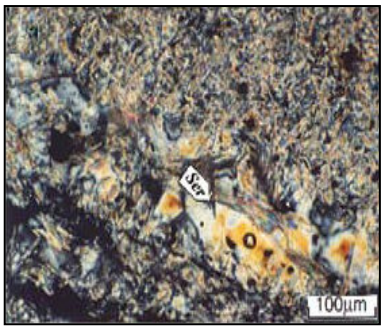

Fig .5 the conversion of a major part of rock to sericite in fillic zone.

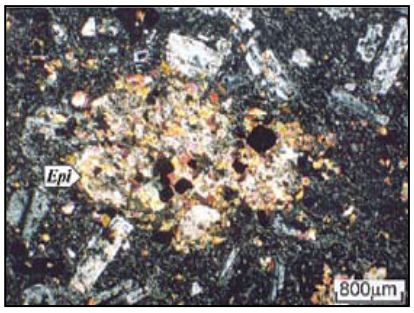

Fig .6 the formation of epidot and opaque minerals as a result of alterations of ferromagnesian minerals in prophilic zone.

Some iron oxide vein lets (hematite) were observed in crashed pieces of intrusion and volcanic rocks. These vein lets become visible using GIS software and field observation iron is altered (figures 7, 8, 9).

Fig .7 Jasb accompanied by quartz veins.

Fig .8 Andesite covered by iron oxide (hematite).

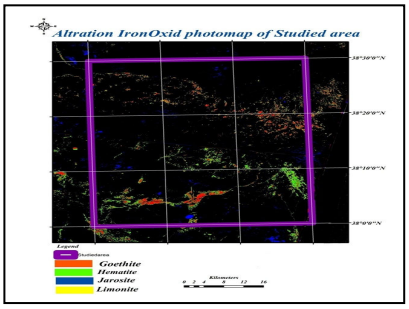

Fig .9 the separation of iron oxide alteration using SAM method.

Marl, sandstones and conglomerate sediments dating back to Oligocene – Miocene which were predominant in shallow sedimentary basin in the continent folded by the effect of post Alpine phase and came out of water. They shaped anticlines and synclines in the south, which were in fact sediments created in Neogene in Harsin. Currently, MS unit of these sediments can be found in the form of a syncline in the south of Harsin near Mehraban city. The last stage of sedimentation occurred in Pliocene when sedimentary basin was closed and sediments mostly exhibit lacustral environment. Sediments of up to 100 m thick have been reported. These deposits which were formed in Neogene-quaternary are now observable in the north of Harsin and stretches to the north – east of the city. They have high anomalies and are as uranium source rock of the region. quaternary volcanic phase, later, caused some volcanic eruptions which sent tremendous amount of basaltic materials out. The materials are presently visible as horizontal lava flows in highlands of GushehDaq and Hayaq. Lava can be seen on volcanic rocks (probable source rock) in Hayaq village in Harsin. Later as differentiation continued and volcanic rocks and intrusion appeared, lava penetrated volcanic rocks so that it's now observable at the bottom of intrusion. The intrusion, alterations, volcanic rocks in Harsin and finally the performance of faults until quaternary [7], all, show that Harsin is a proper area for uranium mineralization.

V. Geological map

Exploration region is to a large extent covered by such sedimentary rocks as conglomerate, sandstones, old terraces and marl. Sediments and faults identified on geological map have been digitized by ARC GIS software so that an informational layer was finally prepared. Figures 10 and 11 show the digitized sub layers of geological units.

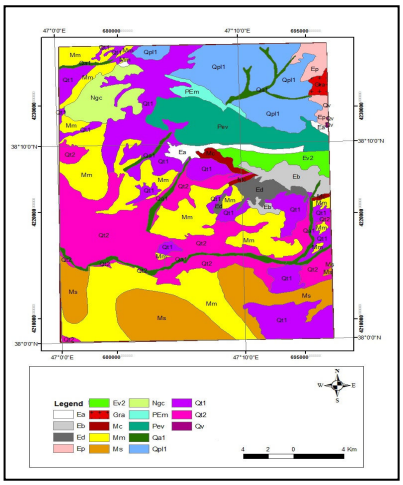

Fig .10 Digitized map of rock units based on the geological map.

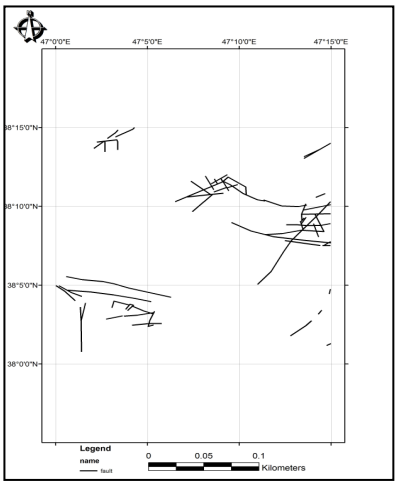

Fig .11 Digitized map of faults and lineation based on geological map.

VI. Radiometric data of uranium, thorium and potassium

In order to determine the spread of radioactive materials, information about geophysical airborne radiometric surveys from the exploration zone is considered to be the most important set of data, after geological informational layer. This information plus measurements of radiations from radioactive materials are highly required for the identification and assessment of the spread of radioactive materials. Information obtained from the exploration of uranium, thorium and potassium was entered in GIS software. Next, IDW operations were done on the data for interpolation and determination of isointensity radioactive elements concentration. Finally, each of them was used as an informational layer for exploration. Figures 12, 13 and 14 show the informational layers of uranium, thorium and potassium in the exploration zone.

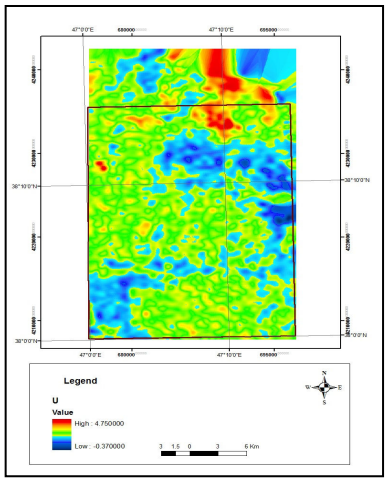

Fig .12 IDW map of uranium data in the exploration zone.

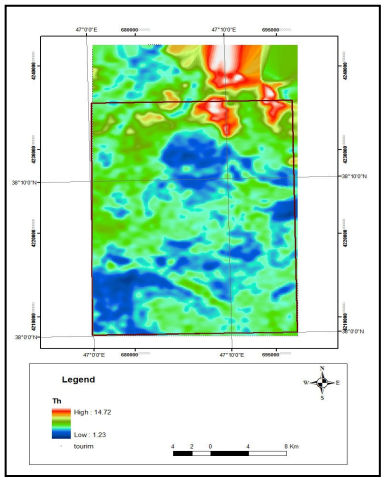

Fig .13 IDW map of thorium data in the exploration zone.

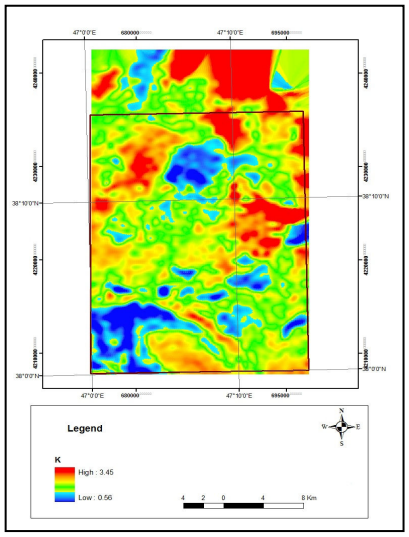

Fig .14 IDW map potassium data in the exploratory zone.

VII. Data analysis

Airborne radiometric data and interpolation by GIS software represent anomalies of radioactive elements in the north-east of Harsin. Combining layers leads us to the conclusion that anomalies exist in volcanic – sedimentary rocks, contemporary lacustrine deposits as well as alluvium. This indicates a probable source rock, tuffbreccias of type acid and its host rock, sandstones in deposits and alluvium. The following positive factors confirm the conclusion:

Volcanic- sedimentary rocks (a probable source rock) were generated by active tectonic in a graben environment during a tensional phase. This indicated that the tectonic resulted from an older orogenic belt was suitable for the formation of uranium source rock. In addition, anomalies in the probable source rock along with the faults in the region means that there is the concentration of uranium of structural control type in empty places of tuffbreccias in the mineralized area [1]. (ignimbrite and acid tuffs which are deposited in subsiding grabens as a series of volcanic- sedimentary rocks are of high importance). Besides, that intrusion in the probable source rock represent a fluid skin is considered both a positive factor and very worthwhile in studies. Alternation in the region produces clay minerals such as kaolinite and montmorionite. These minerals are frequently found in the probable source rock (volcanic rocks) and are a positive factor, too [1]. Therefore, the excess of acid rocks and lava over the average rate, faulting in the region, frequent structural performances(the performance of faults until quaternary), geological evolution (the existence of a fluid crust), the development of alteration phenomenon and its relation with the importance of mineralization, all, show that the volcanic basin is an appropriate host of uranium.

Sediment basin of the area (the host rock) is confined from the sides by volcano-platonic body and highlands. It needs to be mentioned that a brief uplift in the environment of these ore deposits is essential so as conditions for the oxidation are provided and reduced for the formation of deposits [1]. Accordingly, exotic Sandstone (source rock) made tuffs rich of uranium in surface water oxidize and move in the direction of topographic steep of the region. The processes of erosion and sedimentation are performed by the river results in an increase of organic materials in sediments. When the conditions of oxidation in the environment change and organic materials move, uranium is left as uraninite in the reduced environment. If channels move along faults, uranium is left in channels and deposits in a shorter time. Absorbing materials such as iron oxide and clay minerals of deposits and reducing conditions like organic materials (plants) play an important part in the creation of supply. They are also necessary in the accumulation of uranium [1]. Small gradation of source rock shows its low permeability and porosity while source rock's low hardening indicates high permeability for ore- forming solutions [3]. Sandstone unit is confined from bottom by marlic lithology. Given that marlic lithology has low permeability, this closure can act as a damp and prevent uranium escape from the source rock. This phenomenon is itself regarded a positive factor [3]. According to tectonic environment of sediment basin (graben and tension basin), it can be said that ore deposit is shaped like a plate [1]. Overall, we can conclude from the properties of the host sand stone, mentioned in this section, that this host rock has provided proper circumstances for uranium mineralization type sand stone.

Figure 15 is an overview of the probable source rock and uranium host rock shown by an arrow. This overview can be viewed as a similar pattern for Harsin exploration zone.

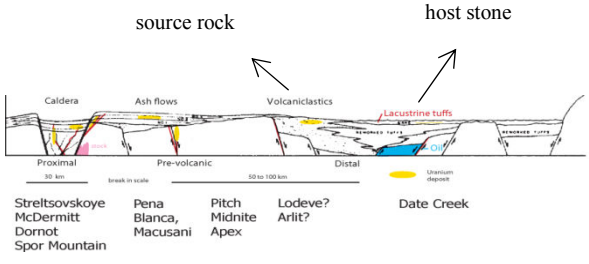

Fig .15 Probable source rocks and uranium host rocks (Base for section is from Sherborne and others, 1979).

III. Ground radiometric survey of Harsin

Another stage of exploration of radioactive elements involves ground control operations. Such operations include sampling of the domain radioactive rock units. The samples are used in chemical analysis experiments in order to confirm the accuracy and precision of results produced from airborne radiometric data.Thus, 6 surveys of different locations of anomalous zones in Harsin were measured by spectrometer. The measurements were later recorded as shown in table 1.

Table 1: measurements of Gama ray by a spectrometer and its separation in uranium, thorium, rubidium and niobium in Harsin

	Sample No.	U ppm	Th ppm	Rb ppm	Nb ppm	K2O %
1	B-031	19	31	184	24	6.7
2	B-015	24	31	202	118	9.8
3	B-025	21	22	146	21	4.7
4	B-029	16	19	198	13	5.2
5	B-P19	26	43	184	99	5.5
6	B-P5	23	34	195	79	4.8

IV. Conclusion

Analysis of airborne radiometric data and field observations led us to the following conclusions about the probable terrene of uranium and its host rock.

1- The main factor of mineralization is the tension tectonic phase. This phase created some fractures through which altering and mineralizing fluids pass.
2- Mineralization occurred in porous tuff horizons, shears and wherever there was a contact with cracks.
3- The interpolation of higher areas in the exploration zone, the upward spread of anomalies of host rock and the direction of channels mean that the origin of uranium is probably volcanic rocks in upstream deposits. (epigenetic) conditions, channels of Hajilou river in the source rock and also in lacustral
4- Since the only lacustral sandstones are mineralized and are unable to form ore-deposits, it can be concluded that the exploration zone is not economically profitable.

References

[1] A., ZiyaZarifi (2010),The bases of radiometric geophysical explorations, 1st edition, Azad University press, Lahijan branch, p:308.

[2] A.,Darvishzadeh(2001), Iran Geology, Amirkabir press,2nd edition, p:901.

[3] A.,MajidiSeyyedBayglou; M.,Lotfi; M.R.Hezareh; A., ZiyaZarifi, An assessment of NeflinCinit mass in Razgah and its surrounding sediment units with the purpose of uranium explorations of type sedimentary (northern Azarbayjan), Earth and Resource research – scientific quarterly, Lahijan branch, 3rd year, no.1, spring 2010, pp: 51-58.

[4] G., Hosseinzadeh; M., Moayyed; R., Esfehanipour, supergenic processes in copper ore deposits in PourfiriSonajiil, Iran Geological quarterly, 3rd year, no. 10, Summer 1999, pp: 85-96.

[5] G., Hosseinzadeh;M., Moayyed;A.A., Kalagary , quarternermagmatism in copper ore deposit in PourfiriSnajiil, 1995, 9th conference of Iran.

[6] H., Gadimzadeh, and M., Mehrpartou, An approach to intrusion petrology of Youseflou-Qanlou(Anzan) (East – south of Ahar), 2005, 8th annual conference of Iran Association of Geology.

[7] H., Asadzadeh; A., Ziyazarifi, A study on the spread of radioactive materials based on radiometric and satellite data in Ahar, Earth and resource research – scientific quarterly lahijan branch, 4th year, no.2, summer 2011.

[8] M., Mahdavi; A., AminiAfzal, under the supervision of AlaviTehrani, N(1988), A report of Ahar 1:100000 geological map, Iran Organization of Geology and Mineral explorations.