Geophysical Radioactive Environmental Anomalyin WadiShatti area South Central LIBYA

Bashir M Youshah *

Abstract:

Airborne gamma-ray spectrometric and magnetic survey was carried out in the late 70's of the last century, in, WadiShatti area, south central Libya. The area is previously known for its holding lenses of iron ore deposits. The survey objective was oriented mainly to the exploration of the mineral potentiality of the area. Samples from the area of some of the radioactive anomalies were analyzed in the laboratory by gamma ray spectrometry to determine the eU, eTh, and eK of these anomalies. Surprisingly some of these anomalies which are considered of no importance in the sense of mineral exploration were located in some sabkhas and swamps that feed by artesian springs. One of the anomaly showed as high total count Scintillometric measurement as 15000 c/s. the source of this radioactivity is debatable. It could be attributed to lithology of the aquifer formations, disequilibrium in radioactivity decay series, phosphatic beds or fertilizer and more. Whatever is the source some of the artesian springs are used as a domestic and irrigation supply to the population. Accordingly even thoughthese anomalies are located in remote desert villages they should be considered as environmental

* Geophysics Department, Faculty of Sciences -University of Tripoli LIBYA.

geophysical anomalies and should be followed by more detailed studies including health follow up and records of the population.

Introduction:

In 1977 and 1978 the Department of Geological Researches and Mining of the Industrial Research Centre of LIBYA carried out an airborne gamma-ray spectrometric and magnetic survey of the WadiShatti area (Figure-1). The survey covered an area of approximately 10,700 sq. km., and had two main objectives: 1) to define possible extensions of the known iron deposits at WadiShatti, and 2) to evaluate the potential of the area for other types of mineral deposits. Engagement of the gamma ray spectrometry in the survey was with no drought is to explore the radioactive mineral potentiality of the surveyed area. Pacific Aero Survey Co., Ltd., Tokyo, Japan collected the data, and QEB, Inc., Hayward, California, U.S.A. computer processed and interpreted the data (QEB, 1979) .

Figure-1 location map showing the location of WadiShatti area

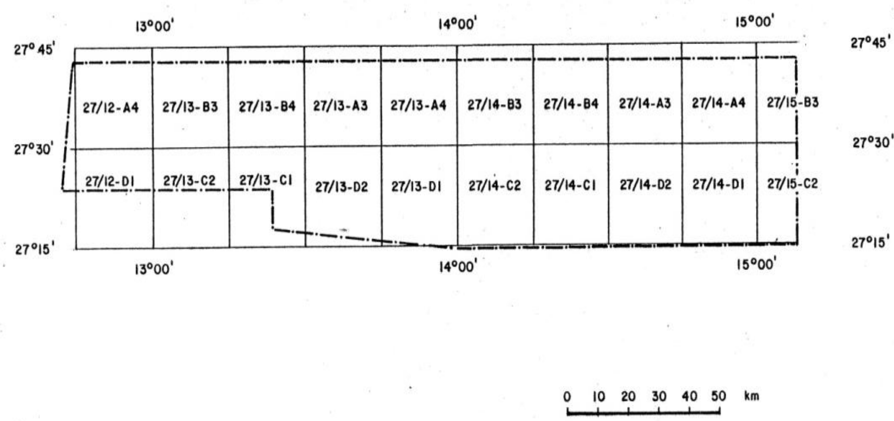

Figure-2 location map of WadiShatti Airborne Geophysical Survey (QEB, 1979)

Flight-lines of the survey were spaced at 0.5 km. intervals, were oriented north-south; tie-lines, spaced at 3 km. intervals, were oriented east-west. The surveys were flown at a nominal ground clearance of 122 metres above mean ground level.

An Exploranium DiGRS 3001 digital four channel differential gamma ray spectrometer with a NaI detector array (16,662 cm3) was employed to sense the gamma ray count rates for the 4 spectrometric channels:

Integral count (0.8 MeV – 3.0 MeV)

K^{40} $E_0 = 1.46$ MeV

Bi^{214} $E_0 = 1.76$ MeV

Tl^{208} $E_0 = 2.62$ MeV

In this paper attention was not paid here to those anomalies that may be correlated to geological, structural, or mineralogical provinces but to those radioactive anomalies that located in populated a or cultivated areas and accordingly will be of conspicuous environmental impact .

Radiometric analysis of surface samples:

Radiometric data provides specific information on the chemical composition of the upper 30-50 cm of the earth's surface materials a clear description of the surface martial of the sampled data is an important factor in understanding and better interpretation of the obtained data (DARNLEY and GRASTY, 1971). Counts rates collected in the Uranium and Thorium spectral channels are then converted to the concentrations of these elements on the earth's surface, after the appropriate corrections and processing . However the estimation of U and Th in this manner assumes that the daughter products in Th and U decay series are in equilibrium.U and Th are usually expressed in equivalent parts per million (eU and eTh), which indicates that their concentrations are inferred from daughter elements in their decay chain, whereas, because of its higher crustal abundance, K is typically expressed as a percentage (K%) (Wilford*et. al.*, 1997)
Twelve samples of surface geological materials were collected and subjected to laboratory radiometric analysis for K ($K_{40)}$, U ($Bi_{214)}$ and Th(Tl_{208}). Table-1 gives the radiometric analyses of the 12 sampled data.

Out of the twelve samples given in table-1 two of them described (sample 1 and 6-1) as samples in "Cultivation" areas. The other (ten) samples are of rock units exposed in the different areas were these rocks are exposed. The radioactivity of the rock units is not the concern of this paper and are given her only for the sake of comparison. Surprisingly, the two cultivated areas anomalies are the highest, so they worth some attention. Sample 1 and 6-1contained also anomalous concentrations of uranium and potassium and each had high U/Th counts ratio. If these cultivation areas have been fertilized by inorganic fertilizers, it is possible that the high uranium and potassium concentrations find in the soils might have originated from the fertilizer (QEB Inc, 1979). But this is assumption is debatable, for the simple reason that in WadiShatti area one can count hundreds of fertilized farms that covered by the mentioned airborne gamma ray survey and do not show any radioactive anomaly.

Table-1 Gamma ray spectrometric and equivalent radioactive concentrations of Potassium, uranium and Thorium of samples from WadiShatti survey

Sample	**Gamma Ray Spectrometric data (Counts per Second)**			**Calculated Equivalent Concentrations (ppm)**		
	U	Th	K	U	Th	K
1	1944.0	7.66	46.9	158	1.9	
2	54.7	3.87	18.5	4.4	0.96	13.8
3	43.2	3.62	4.70	3.5	0.90	3.5
4	13.8	7.05	19.4	1.1	1.75	14.5
5	5.72	7.79	19.4	0.47	1.93	14.5
6-1	1114.0	7.64	23.8	90.6	1089	17.8
6-2	828.0	8.35	41.3	75.4	2.07	30.8
7	49.5	2.36	23.6	4.0	0.58	17.6
8	280.0	4.66	31.4	22.8	1.16	23.4
9	17.6	13.50	90.9	1.43	3.35	67.8
10	2.72	0.86	34.3	0.22	0.21	25.6
11	1.81	5.35	19.8	0.81	0.81	14.8

Hydrology of the area:

WadiShatti area belongs to an extensive hydrogeological system defined by Pallas (1980) as Murzuq basin system, by Jones (1969) as the Murzuq basin groundwater province.

Based on the stratigraphic sequence developed in the Murzuq Basin, the following formations, from top to bottom, can be considered to be water-bearing formations (El-Barouni and El-Futaisi, 2012):

- Nubian sandstone (Jurassic-Lower Cretaceous)
- Post-Tassilian sandstone (Triassic)

- Dembaba and Assedjefar limestone and dolomite (Carboniferous)
- AwaynatWanin and Akakus sandstone (Silurian-Devonian)
- Hawaz, Ash Shabiat and Hasawnah sandstone (Cambro-Ordovician)

This water –bearing formations are composed mainly of continental sandstone and can be broadly classified into two major aquifer system (DUBAY, 1980):

The lower groundwater aquifer composed of Cambrian, Ordovician, and Devonian sandstones. In Wadi ash Shati the maximum penetration depth of this aquifer was 420 m. the groundwater from this aquifer are fundamental for the supply of the population with drink water as well as for other purposes and are indispensable for the irrigation of agricultural land throughout Wadi ash Shati area. Numerous artesian springs exist on the northern side of Wadi ash Shati were the surface declines below the ground water table, probably in tectonically predisposed places. A good part of them are no more effective but some of them most probably still supply sabkhas. The population is supplied through private wells or municipal mains from drilled wells, of which a number have unregulated artesian overflow in the villages of: (Al Hatiyat, Bargan, Quttah, Al Qardah, Aqar, Brak)

The upper aquifer formed in permeable sediments of Triassic, Jurassic and early cretaceous.

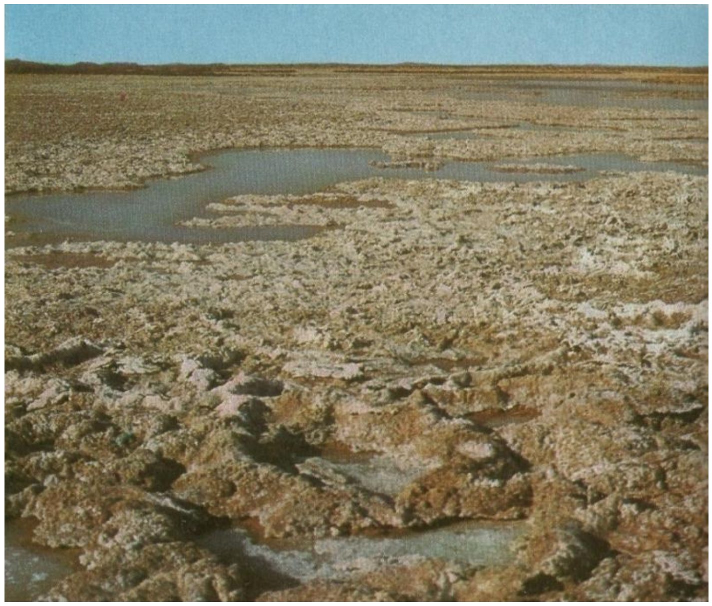

Figure-3 photograph showing artesian feed sebkhawich show some high radioactivity levels

Radioactivity of surface flowed water:

Measurements of radioactivity in one of these springs (AinGolmaya) showed high radioactive value of 15000 counts per second as being measured by SPP2 Gamma Ray Scintillometer. These correspond to an activity of 30mR/hr, which is environmentally a quite considerable activity. The area belongs to the lower ground water aquifer province system with main aquifer composed of Cambrian, Ordovician, and Devonian sandstones. Groundwater from this aquifer are fundamental for the supply of the population with drink water as well as for other purposes and are indispensable for the irrigation of agricultural land. Numerous artesian springs feed from this aquifer exist on the northern side of Wadi ash Shati were the surface declines below the ground water table, probably in tectonically predisposed places. The source of radioactivity could be attributed to the basement granites at the base of the Cambrian aquifer or to the thin phosphate beds known to be locally exist in the FrasnianDabab Formation as been exposed in outcrops.

Possible source of the Environmental Radioactive Anomaly The Triassic Zarzatine Formation exposed in the southwestern flanks of MurzuqBasin (Figure-4) is known for the occurrence of radioactive mineralization [1,2]. Uraniferous mineralization in the area occurred as irregularly distributed concentration of secondary minerals forming yellow coating on detrital fragments [12].

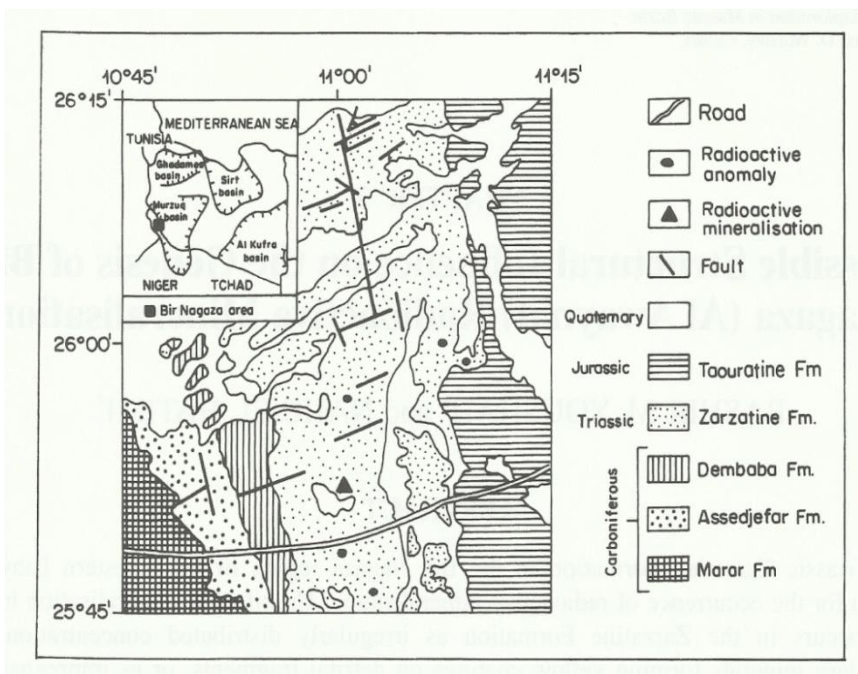

Figure-4 localized uranium mineralization in Triassic formation in the southwestern flank of Murzuq Basin (Youshah and El Hatimi, 2000).

The source of the discussed Idri Environmental Anomaly may be attributed to artesian water that comes from the Triassic upper aquifer in the area of Idri of. The localization of this anomaly in Idri and not in the other cultivation area may be explained by localization of the assumed subsurface uranium mineralization in the same analogy to those mineralization exposed in the southwestern flanks of Murzuq Basin. The source oh this high radioactivity may interpreted according to [4] that the parent radioactive element in the uranium or thorium decay series are not in equilibrium with its daughter products. Disequilibrium occurs when one or more of daughter products in the decay chain removed or concentrated [11]. For example –(as it might be the case in Idri anomaly) – in some salt lakes and ground water discharge sites, high eU and eTh values may be due to accumulation of radium isotopes that are mobile in acid saline solution.

Ignored Environmental Impact of the Radioactive Anomaly

The Airborne geophysical survey as previously mentioned was mainly oriented to mineral exploration and tone can quote from the final report of the airborne geophysical Survey of WadiShatti area:

" The radiometric anomaly occurs in the area of Idri (WadiShatti). We consider two possibilities for the enrichment of uranium in this area:

1. Concentration of uranium due to the evaporation of uranium-bearing water.
2. Precipitation of uranium-bearing salts from aqueous solution passing through permeable rocks containing organic redctants (e.g. asphalt, bitumen)."

The only recommendation given in that context is to:

"execute further exploration program to determine wither there is a sufficient amount of enriched material to constitute an ore body."

On the other hand the hydrogeological studies carried out in the area they looked to the environmental impact only in the sense of "…protect them and minimize the problems associated with over-exploitation of ground water resources".

Conclusion and Recommendations:

In conclusion the radioactive anomaly that discovered for the first time by the airborne gamma ray survey in the village of Idri (WadiShatti area), whatever its source or origin, should be considered as an environmental anomaly to which more attention should be paid. Further detailed work and follow up of these radioactive environmental issue is strongly recommended. This should include health record of the population in the area of possible radioactive contamination as well as drinking water analyses and ground radioactive survey in those areas, preferably gamma ray spectrometric survey.

شادة اشعاعية جيوفيزيائية بيئية في منطقة وادي الشاطئ في وسط الجنوب الليبي

بشير يوشع *

المستخلص:

أجري في نهاية القرن الماضي مسح جيوفيزيائي جوي لقياس طيف أشعة جاما وكذلك قياس المجال المغناطيسي الأرضي وذلك في منطقة وادي الشاطئ بوسط جنوب ليبيا. عرفت المنطقة في السابق بإحتوائها لعدسات رسوبية من خام الحديد. كان الهدف الأساسي من المسح الجيوفيزيائي هو استكشاف الإمكانيات المعدنية في المنطقة. تم تحليل بعض الشادات الإشعاعية الناتجة عن المسح والتي تم تسجيلها بواسطة جهاز قياس طيف اشعة جاما وذلك لتحديد اليورانيوم المكافئ والثوريوم المكافئ و البوتاسيوم المكافئ لهذه الشادات. لقد بينت بعض من الشادات الإشعاعية وبشكل مفاجئ في انها تقع عند السبخات والمستنقعات التي يتم تغديتها من قبل عيون ارتوازية ناشئة عن تدفق المياه الجوفية. تبين وجود نشاط اشعاعي عالي عند أحد العيون الإرتوازية حيث بينت القياسات السنتلومترية نشاطا قدره 1500 عدة في الثانية الواحدة. قد يرجع هذا النشاط الإشعاعي الى التكاوين الجيولوجية الحاملة للمياه الجوفية او لعدم التوازن في انحلال السلاسل الإشعاعية المختلفة او لوجود طبقات فوسفاتية تحت سطحية او بسبب بعض الأسمدة الفوسفاتية وغيرها من الأسباب. ومهما يكن سبب هذا النشاط الإشعاعي الملفت للنظر فإن بعض من عيون المياه الطبيعية في المنطقة يتم استعمالها للتزود بمياه الشرب وفي الزراعة. على الرغم من وقوع بعض من هذه الشادات في مناطق صحراوية نائية فيجب النظر إليها على انها شادات جيوفيزيائية بيئية ويجب دراستها بشيئ من التفصيل و المتابعة ويشمل ذلك متابعة السجلات الصحية لسكان المناطق التي تقع فيه هذه الشادات.

* قسم الجيوفيزياء- كلية العلوم – جامعة طرابلس.

References:

1. Almehdi, B., Gojkovic, S., Megresi, M., Obrenovic, M., Puric, D. and Zelenka, J. (1991). Radioactive elements in sedimentary rocks of the western paert of Murzuq Basin. In: *The Geology of Libya* (M. J. Salem, M. T. Busrewil and A. M. Ben Ashour (*eds*). Elsevier, Amsterdam, VII, 2645-2658
2. Assaf, H. S., Hungary, K. M. and Baegi, M. B. (1994). Al Awaynat surface mineralization , southwestern Libya – a new approach to its origin. *Jour. African Earth Sci*., 13, 85-90.
3. Darnley and Grasty, 1971. Mapping from the air by gamma-ray spectrometry. Proceedings of the 3rd International Geochemstry Symposium, Toronto, Ontario, Canadian Institute of Mining and Metaaurgy, Special Volume II, 485-500.
4. Dickson, B. L. Radium isotopes in saline seepage, south-western Yilgarn, Western Australia. Geochimica et CosmochimicaActa, 49, 361-368
5. Dubay, L. ,1980, Ground water in Wadi ash Shati, Fezzan – A case history of resource development. *In: The Geology of Libya (eds. M. J. Salem and M. T. Busrewil).* Academic Press, London, II, 611 – 627.
6. EL-barouni S., S. and EL-futaisi R., H., 2012, Hydrogeology of the Murzuq Basin,, In: The Geology of Southern Libya (eds. M. J. Salem and Mahmoud T. Elbakai& Yousef Abutarruma) VolI, 315-342
7. Jones, J. R., 1969. Ground water in Libya. A summary of hydrogeology of the sothern Mediterranean littoral of the north central Sahara, L. A. R., U.S.G.S. *Open-file Rep.*
8. Idrotecnico, 1982, Hydrogeological study of Wadi ash Shati, Al Jufra and Jabal Fezzan. *Upubl. Rept.* Secretariat Dams and Water Resources, Tripoli .
9. Palls, P., 1980, Water resources of the Socialist People's Libyan Arab Jamahiriya , *In: The Geology of Libya (eds. M. J. Salem and M. T. Busrewil).* Academic Press, London, II, 539-594

10. Qeb Inc., 1979, Airborne Geophysical Survey, Wad is hatti area, Final Report, Unpublished report, Industrial Research Centre, Tripoli
11. Wil ford, J., R, Bierwirth, P. N., & CRAIG M. A, 1997, Application of airborne gamm-ray spectrometry in soil/regolith mapping and applied geomorphology, AGSO Journal of Australian Geology & Geophysics, 17(2), 201-216.
12. You shah, B. M. and EL hatimi N., 2000, Possible Structural Influence on the Genesis of BirNagaza (Al Awaynat) Radioactive Mineralisation. In: Geological Exploration in Murzuq Basin (eds. M.A. Sola and D. Worsley). Elsevier Science , 31-39