Hydrocarbon Exploration Using Thermal Images West Baghdad

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ABSTRACT

This study is based on thermal anomaly of hydrocarbon materials phenomenon. This phenomena has been used as a result from the leakage of these substances from the oil trap on the earth's surface through faults and cracks in the earth's crust over the oil trap, that affect the emission of heat and temperature in the area above the oil trap. The thermal band scene (Landsat ETM+ in central Iraq-west of Baghdad) has been used to the region located between longitudes 43 ^{o} 62' 7.20" East to 44 ^{o} 61' 14.48" East and latitudes 32 ^{o} 94 '12.99" North to 34 ^{o} 0' 49.53" North. The thermal anomaly (ΔT) was estimated in relation to the change in temperature compared to the temperature anomalies in the surrounding areas. After studying several areas in central of Iraq, it is found that the thermal anomaly lies "between" (1-5) K^{o} which indicates the presence of Hydrocarbon in those areas.

Keywords: Hydrocarbon exploration, thermal image, thermal anomaly, west Baghdad.

استخدام الهيدروكاربون بأستخدام الصور الحرارية غرب بغداد

الخلاصة:

تستند هذه الدراسة على ظاهرة الشذوذ الحراري للمواد الهيدروكاربونية. استخدمت هذه الظاهرة نتيجة للتسرب غير المحسوس للمواد الهيدروكاربونية من المصيدة النفطية الى سطح الأرض، من خلال العيوب والتشققات في القشرة الارضية فوق المصيدة النفطية التي تؤثر على درجات الحرارة والانبعاث الحراري في المنطقة فوق المصيدة النفطية. قد استخدمت الفرقة الحرارية لمشهد (+Landsat ETM في وسط العراق غرب بغداد) للمنطقة المحصورة بين خطي طول "7.20 '62 ^{o} 43 شرقاً الى "14.48 '61 ^{o} 44 شرقاً ودائرتي عرض "12.99' 94 ^{o} 32 شمالاً الى "49.53 '0 ^{o} 34 شمالاً. تم تخمين الشذوذ الحراري (ΔT) نسبة الى قياس التغير في درجات الحرارة لمنطقة الشذوذ مقارنة بدرجات الحرارة في المناطق المحيطة بها. بعد دراسة عدة مناطق في وسط العراق وجدنا ان الشذوذ الحراري يقع بين (1-5) كلفن. مما يدل على وجود مواد هايدروكاربونية في تلك المناطق.

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INTRODUCTION

Hydrocarbon exploration is a systematic analytical procedure of various scientific surveys such as geological, geophysical, geochemical, etc. All these scientific methods investigate origin, occurrence, migration, trap etc. [1]. Surface expressions of oil and gas seeps have been observed for thousands of years. Some of these indications have led to discoveries of many commercially important petroleum reservoirs. Even where the presence of surface anomalies does not lead to the detection of large oil and/or gas deposits, it can establish the hydrocarbon presence in the area. Over the past 70 years, many geophysical and geochemical techniques were developed with a goal to make petroleum detection and evaluation easier and more precise [2].

As a result of hydrocarbon macroseepage and microseepage, the surface expression of hydrocarbon-induced alteration of soils and sediments can take many forms [3], including (1) microbiological anomalies and the formation of "paraffin dirt"; (2) mineralogical changes such as formation of calcite, pyrite, uranium, elemental sulfur, and certain magnetic iron oxides and sulfides; (3) bleaching of red beds; (4) clay mineral alteration; (5) electrochemical changes; (6) radiation anomalies; and (7) biogeochemical and geobotanical anomalies. (Figure 1). The hydrocarbon microseepage and alteration of soil and sediments can take thermal anomalies on the surface [3].

Hydrocarbon microseepage is the surface expression of a migration pathway, along which petroleum is currently flowing, driven by buoyancy from a sub-surface origin [4]. These surface features are evidence of the presence of oil and/or gas reservoirs below [5, 6].

The energy of particles of matter in random motion is called kinetic heat (also referred to as internal, real, or true heat). It is possible to measure the true kinetic temperature (Tkin) or concentration of this heat using a Spectroradiometer. As well as, the true kinetic internal temperature of soil or water can be measured by physically touching them with a Spectroradiometer. When these particles (have kinetic heat) collide, they change their energy state and emit electromagnetic radiation called radiant flux (watts).

The concentration of the amount of radiant flux emitted from an object represents its radiant temperature (Trad). There is usually a high positive correlation between the true kinetic temperature of an object (Tkin) and the amount of radiant flux radiated from the object (Trad). Therefore, radiometers can be used by placing them at some distance from the object to measure its radiant temperature which hopefully correlates well with the object's true kinetic temperature. This is the basis of thermal infrared spectral sensing.

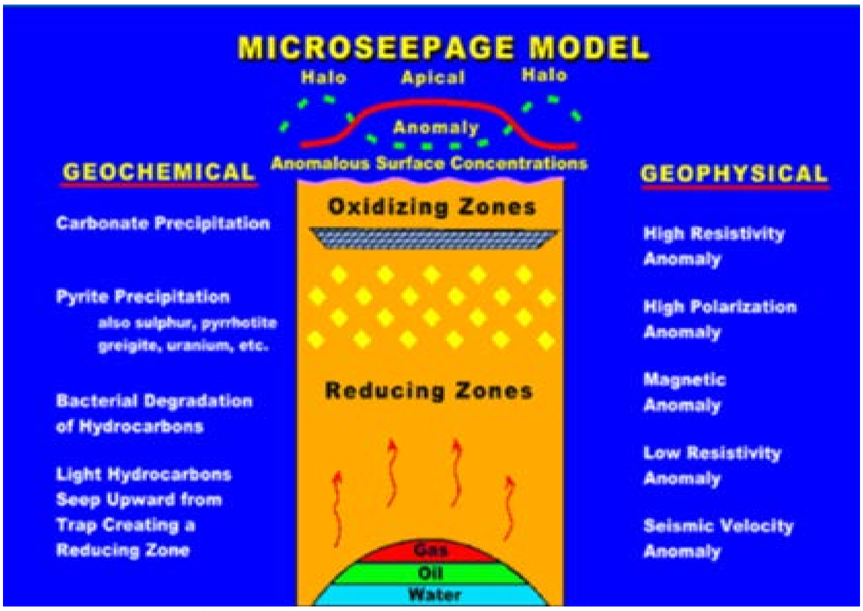

Figure (1) The Surface and Subsurface Expression of Hydrocarbon Alteration Zone [3].

Spectral emissivity and spectral emittance are optical properties of materials. The difference between the two terms, emissivity and emittance, used to be a source of arguments between scientists and engineers, but in practice, they have come to mean essentially the same thing. The VNIR, SWIR, and TIR regions are most useful for mapping surface mineralogy because these wavelengths are sensitive to a wide range of diagnostic electromagnetic radiation-material interactions [7].Radiance is the amount of radiated electromagnetic power emitted per unit surface area per unit wavelength of an object that is due to the motion of molecules within the object. This coefficient is the fraction of the ideal blackbody spectrum energy which a real body actually emits [8].

If we are interested in soil, water, and rock with ambient temperatures on the earth's surface of 300 ˚K and a dominant wavelength of 9.66 µm, then a thermal infrared detector operating in the 8 - 14 µm region might be most appropriate: Landsat image thermal band (6) is in 10.4-12.5 µm, ASTER band 12 and 13 are in 8 - 14 µm, and MODIS band 29-30 and 31-32 are in 8 - 14 µm. The use of infrared spectroscopy in detecting hydrocarbons is well known. The absorption wavelengths in the regions 1700 to 1730 nm and 2300 to 2600 nm of electromagnetic spectrum are the best intervals for detecting various hydrocarbon absorption bands [9, 10].

ENVI Software has three techniques that are used to separate the emissivity and temperature information in radiance data measured with thermal infrared sensors. Both the Reference Channel and Emissivity Normalization techniques assume a fixed emissivity value and produce emissivity, minerals signature, and temperature output.

Location of Study Area:

The study area located in middle Iraq western of Baghdad between longitudes 43^{o} 26' 7.20" E to 44^{o} 16' 14.48" E and latitudes 32^{o} 49' 12.99" N to 34^{o} 0' 49.53" N, with area approximately 6239.50 km².

The study area includes the northern part of the East Baghdad oil field, the southern part of the Balad oil field and the areas which are located to the west of them between the Tigris and Euphrates rivers. See figure (2)

Geology of The Study Area:

The study area is part of the Arabian Basin in a regional extent and specifically within Mesopotamian Fore deep Basin. Locating this studied area in the Arabian Peninsula Basins map prepared by the U.S.Geological Survey [11] with special emphasis on Iraqi region of northeastern Arabian Peninsula figure (2), The study area could be grading tectonically northeastward toward the Zagross Fold Belt and westward toward the boundary with the Widian Basin of Interior Platform while its southward extensions is the Mesopotamian Fore deep Basin that contain deposits of the Tethys ocean during the Jurassic and Cretaceous Periods. Tethys ocean was of mainly dysoxic– anoxic palaeo environments along the equator and of tectonically unrest [12] that permitted preservation of high organic matters and development of highest world oil and gas reserve in the Arabian Region. See figure (3)

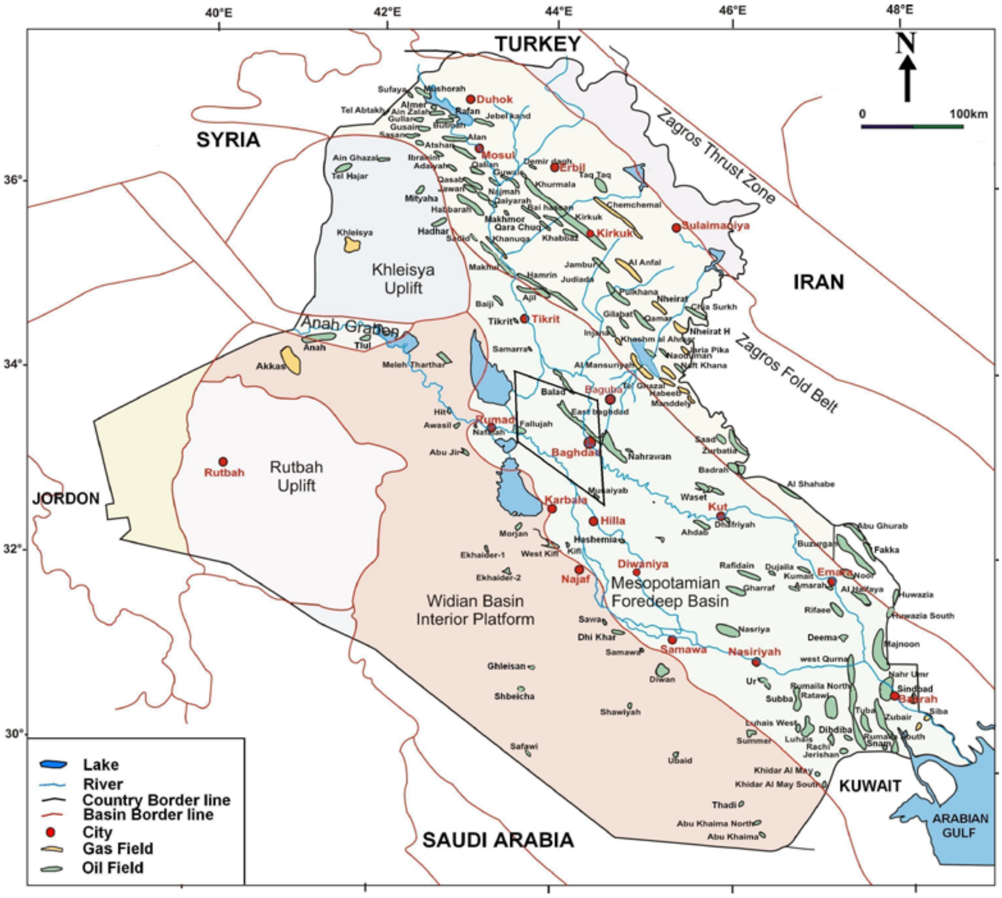

Figure (2). Location map of Iraq showing a northeast Arabian Peninsula of the region Iraq with locations of basins and oil fields [Iraqi Geological Survey and Mining, 2010]

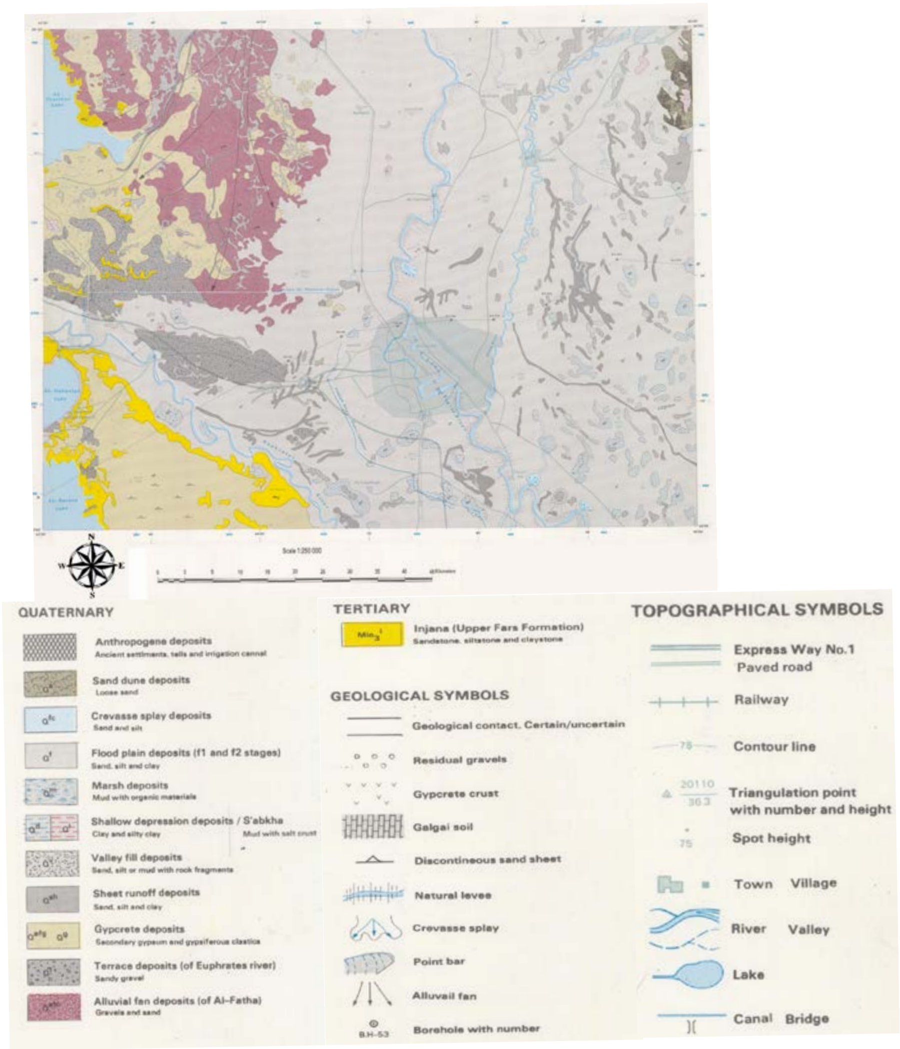

Figure (3) Baghdad geological map [Iraqi Geological Survey andMining, 1994]

Methodology:

The radiation emitted from a surface in the thermal infrared wavelengths is a function of both the surface temperature and emissivity. The emissivity relates to composition of the surface and is often used for surface constituent mapping.

The Landsat Enhancement Thematic Mapper plus (ETM+) is recorded tow channel thermal multi-spectral scanner covering the wavelength 11.45µm: band 6 low and band 6 high. The spatial resolution of two band is 60m on the ground and acquisition data; 2001-03-18 [Landsat metadata file].

The radiation emitted from the study area surface (Min-Max-radiance); band 6L (0-17.04 w/m ²/µm/sr) and band 6h (3.2-12.65 w/m ²/µm/sr) but image data (Min-Max-pixel value) between 0 to 255 [Landsat metadata file]. To convert Min-Max-pixel value, see figures (4-a & 4-b) to Min-Max-radiance used mathematical function within ENVI processing software; R=b6L/x, when X=255/17.04, see figures (5- a & 5- b) and (b6h/x) +3.2 when X=255/ (12.65-3.2).

ENVI Software has three techniques that are used to separate the emissivity and temperature information in radiance data measured with thermal infrared sensors. Both the Reference Channel and Emissivity Normalization techniques assume a fixed emissivity value and produce emissivity and temperature output. The Alpha Residuals technique does not provide temperature information. Emissivity Normalization function is used to calculate emissivity and temperature values for the radiance data. The Emissivity Normalization technique calculates the temperature for every pixel and band in the data using a fixed emissivity value. The emissivity value relates to composition of oil equal 0.972 [13,14]. The highest temperature for each pixel is used to calculate the emissivity values using the Planck Function. Figure (6) shows the temperature image of thermal high band 6. The temperature is calculated between 288.54K° to 306.242K° (14.46C° to 22.76C°).

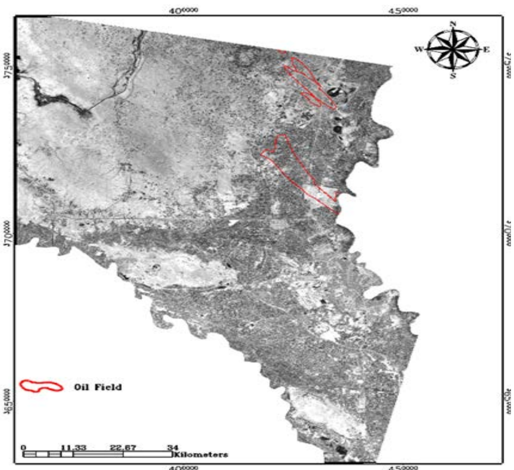

Figure (4-a) Gray Scale Thermal Low Band (ETM+).

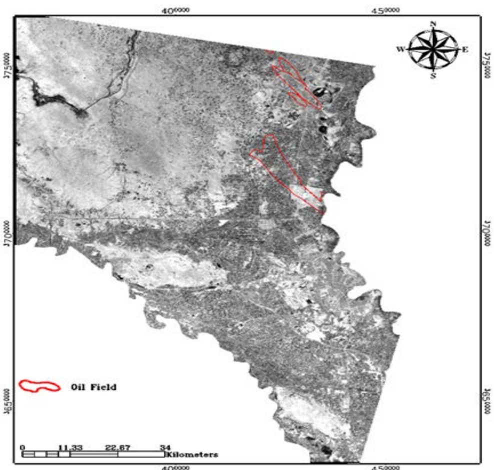

Figure (4-b) Gray Scale Thermal High Band (ETM+).

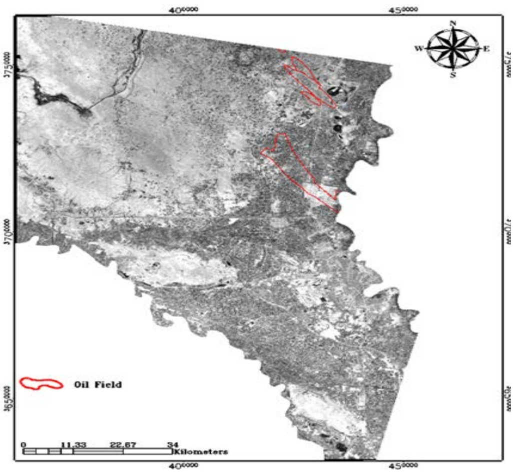

Figure (5-a) Radiation Data Thermal Low Band (ETM+).

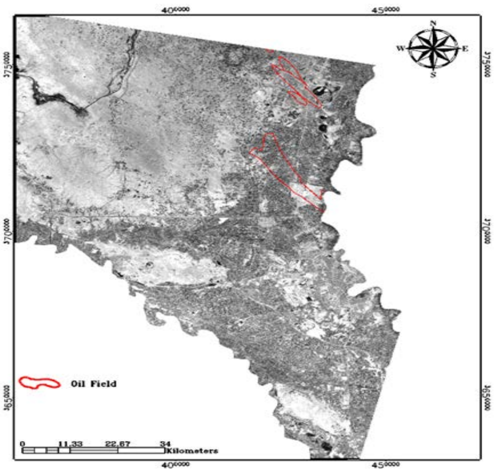

Figure (5-b) Radiation Data Thermal High Band (ETM+).

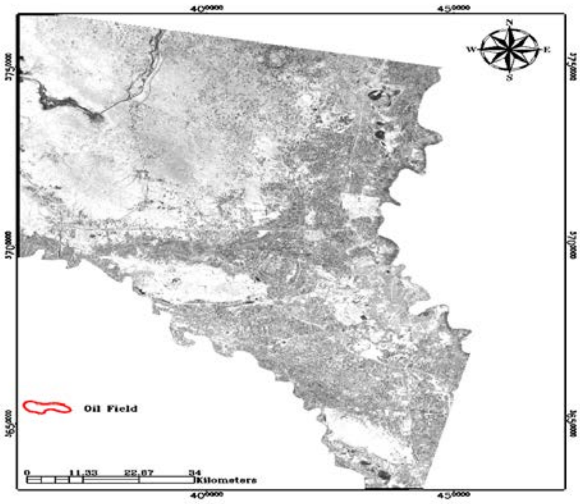

Figure (6) Temperature High Data Image

According to Sabin (1987) [5], Thermal IR image records the radiant temperature of materials. Radiant temperature is determined by a materials kinetic temperature and its emissivity, which is a measure of its ability to radiate and to absorb thermal energy. Daytime images record the deferential solar heating and shadowing of topographic features but geological and other interpretation require nighttime images. The diurnal temperature rang (ΔT) is a function of thermal inertia, which is directly related to density of materials.

Color Mapping of Temperature Image:

The density slice technique was used to temperature data range of thermal IR image and colors for highlighting area in gray scale image. Figure (7) shows density slice with color scaling data of thermal low band IR image. The figure shows five gradient temperature styles coincide with different locations of study area as follows:

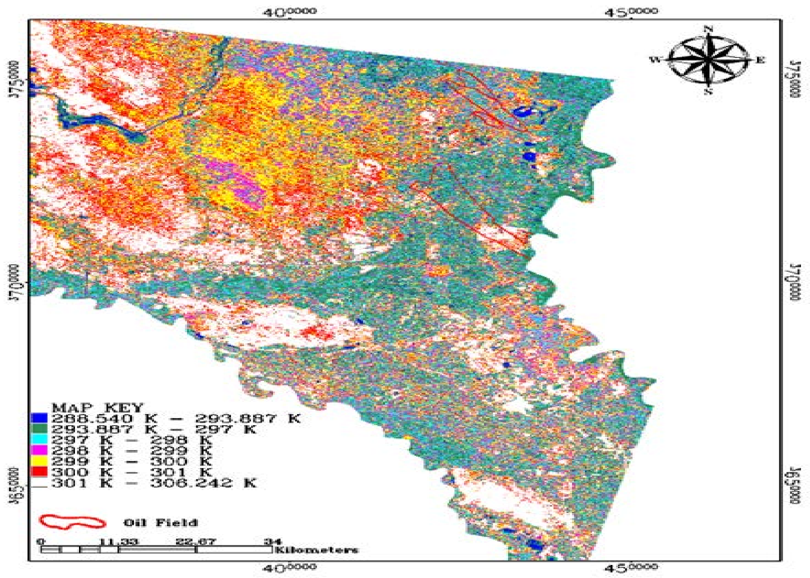

Figure (7) Temperature density slice map of study area

1- Al-Fallujah area (terrace deposits), is located to the east of Euphrates and to the west of Baghdad. The temperature gradient is high presented by white color (high temperature value; 301 K° to 306.242 K°), red color (300 K° - 301°K), yellow color (299 K° -300 K°), and magenta color (298 K ° -299 K °), see Figure (8 & 8-#1). The thermal anomaly, as a function (ΔT) between anomaly and surrounding area, is roughly around 5 K°.

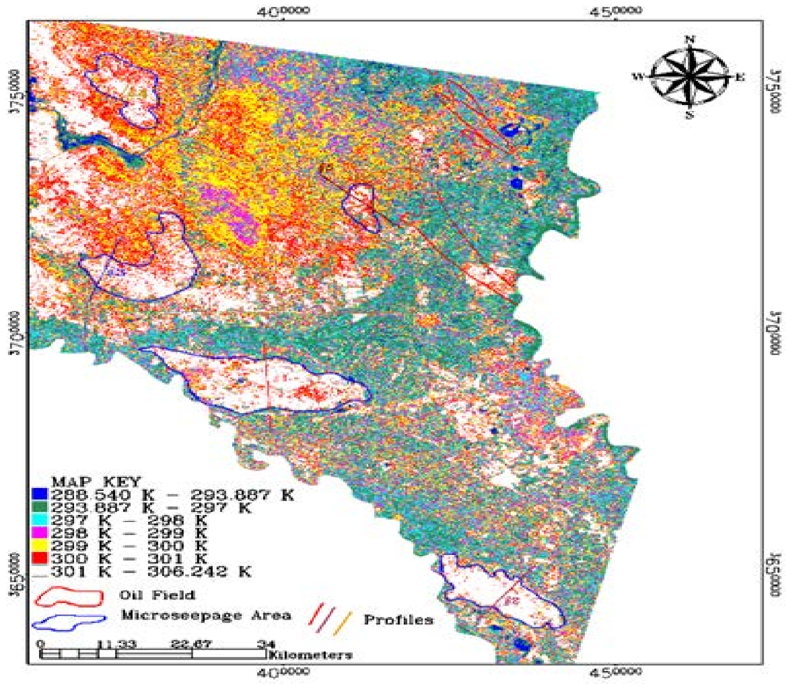

Figure (8) thermal anomaly map of study area

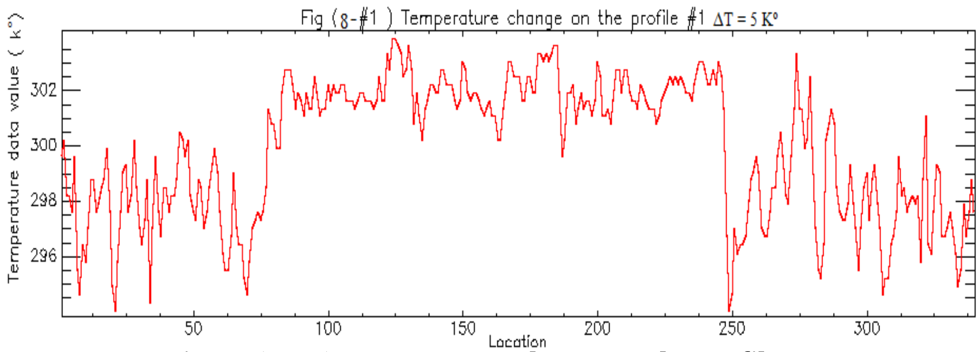

Figure (8- #1) Temperature change on the profile #1

2- North Alexandria area (terrace deposits), is located to the east of Euphrates and to the southwest of Baghdad. The temperature gradient is high presented by white color, red, magenta to yellow color, see Figures (8 & 8- #2). The thermal anomaly is roughly around 3 K°

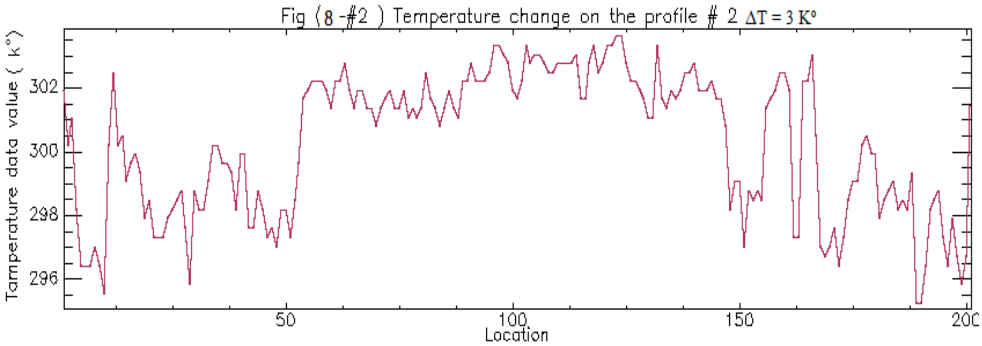

Figure (8- #2) Temperature change on the profile #2

3- Southern Al- Thirthar lake (gypcrete, terrace, valley fill, alluvial fan and authropogene deposits). The temperature gradient is high- medium presented by white color, red, magenta, yellow, cyan to sea green color, see Figures (8 & 8-#3). The thermal anomaly is roughly about 2.7 K.°

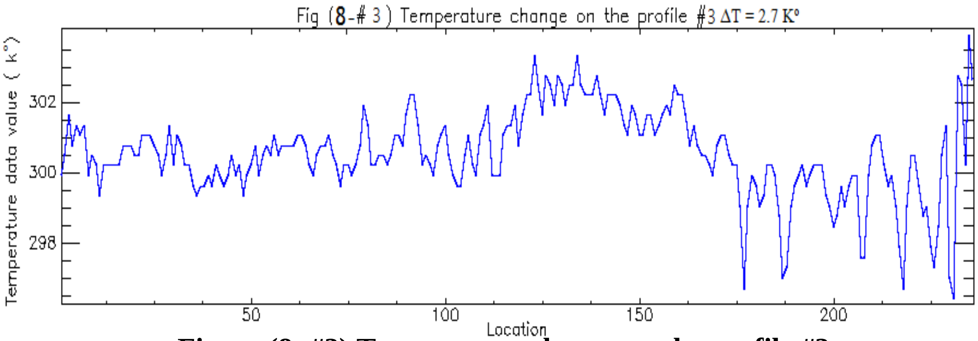

Figure (8- #3) Temperature change on the profile #3

4- The area beside Al-Thirthar Lake (gypcrete, valley fill, alluvial fan and authropogene deposits). This area is located to the east of Al-Thirthar Lake, to the west of Samara city and to the northwest of Baghdad. The temperature gradient is low presented by white color, red to yellow color. See Figures (8 & 8-#4). The thermal anomaly is roughly about 1.4 K°.

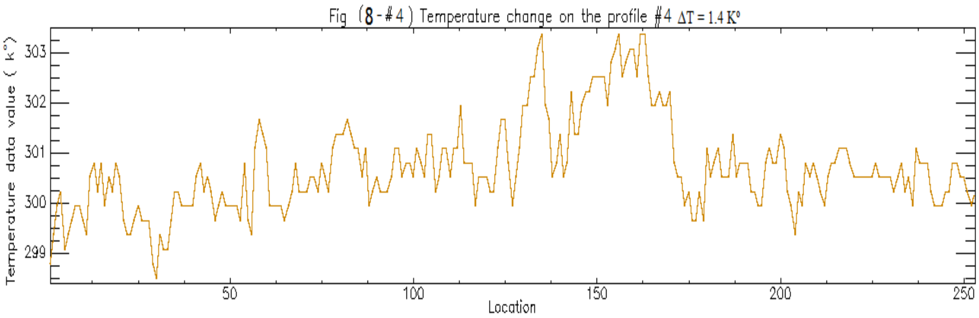

Figure (8- #4) Temperature change on the profile #4

5- Northwest east Baghdad oil field (flood plain deposits). This area is located to the west of Al-Tarmiyha area. The temperature gradient is medium presented by white color, red, magenta, yellow, cyan to sea green color, see Figures (8 & 8-#5). The thermal anomaly is roughly around 2 K°.

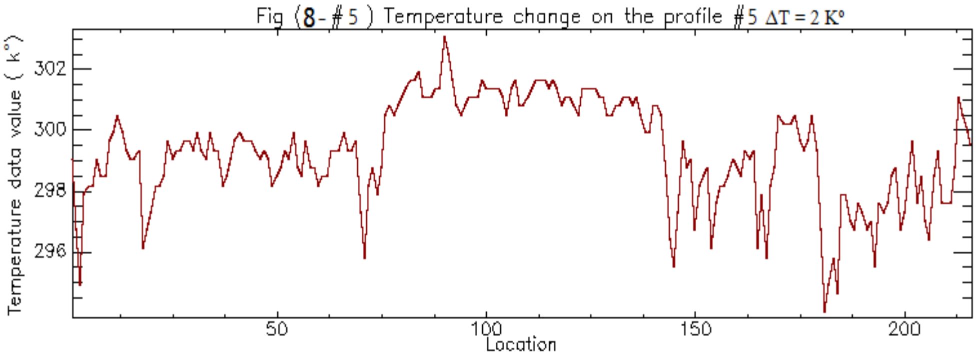

Figure (8- #5) Temperature change on the profile #5

CONCLUSION

In some areas in the middle of Iraq, the thermal anomaly, resulted from hydrocarbon detection, was estimated basically on temperature measurements upon the change of the local areas from their surrounding radiation temperature. It is found that the thermal anomaly of the studied areas is between 1-5 K^o (oil/gas detection). This technique is considered as the first step possible stages of hydrocarbon exploration before proceeding with other methods to reduce the cost of exploration.

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