A NEW PERSPECTIVE OF THE DEEP TECTONICS OF CENTRAL AND SOUTHERN IRAQ FROM GEOPHYSICAL EVIDENCE

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ABSTRACT

The basement magnetic anomalies or anomaly sets of the central and southern Iraq are mostly characterized by clear right lateral distortions zones (coupling stress). If this coupling stress had acted during the closure of the Tythian Sea, significant structures within the sedimentary cover should be developed along these zones.

منظور جديد حول البنيوية العميقة لوسط وجنوب العراق من المعلومات الجيوفيزيائية

جاسم محمد البديوي

المستخلص

تم استعراض الاهمية التركيبية للانحرافات التي تظهر على شواذ القاعدة البلورية المغناطيسية لوسط وجنوب العراق والتي من الممكن ان تترك أثرها الفعال على نمط تشوهات الغطاء الرسوبي بمستوياته المختلفة والتي يمكن الاستفادة منها في التحريات الهيدروكربونية.

INTRODUCTION

The study concerns scientific comments about the structural impact upon the sedimentary cover of the stress distortion that could be marked in the basement's magnetic anomalies of central and southern regions of Iraq.

Three major fault systems were identified by Jassim and Goff (2006). These systems, whose distribution is shown in Fig.1, are interpreted mainly from total horizontal derivative of the gravity field. These systems are the N – S Nabita (Idsas) System, the NW – SE Najd System and the NE – SW or E – W Transversal System. No specific lateral displacements were mentioned by Jassim and Buday along most of these zones.

The Late Precambrian Transversal System was reactivated from Late Jurassic time onwards resulting in the formation of transversal blocks. Some faults of this system underwent sinistral strike slip movement in the Quaternary time. The transversal system controlled the position of transform fault during Neo-Tethyan Ocean spreading, and during the opening of the Red Sea, (Jassim and Buday, in Jassim and Goff, 2006). Three main Transversal Fault Zones run within the study area; these are Al-Batin, Takhadid, Qurna and Kut, Dezful Fault Systems, all being defined on gravity gradients map.

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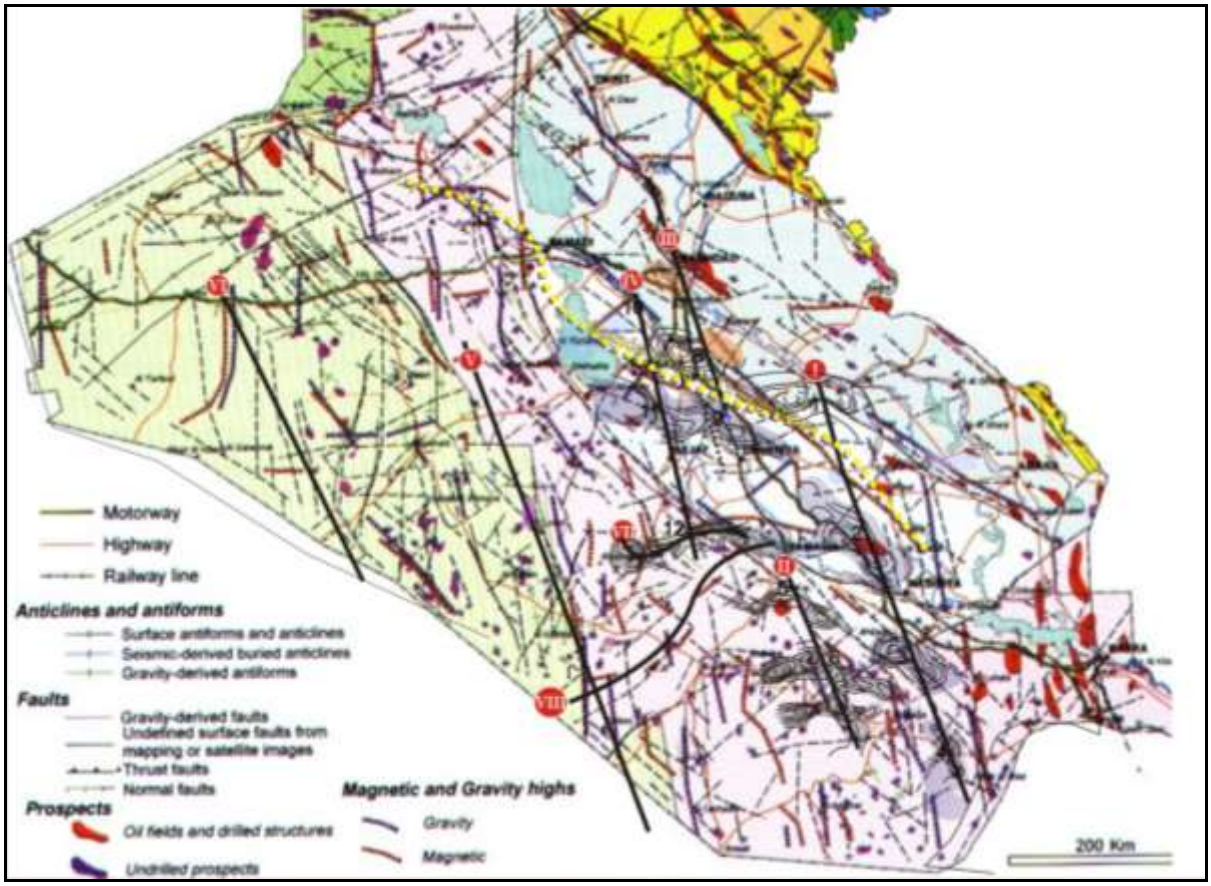

Fig.1: Tectonic map of Iraq, modified from Buday and Jassim (1984), published by the GEOSURV. Magnetic contours of the related anomalies are superimposed with the shearing zones trace for comparison

According to (Jassim and Buday, in Jassim and Goff, 2006), the N – S trending system is prominent in southern and western Iraq; it affects the thickness of the Infracambrian, the Palaeozoic section and, to a lesser extent, the Triassic section. Within the Arabian Shield, the aeromagnetic map shows that the Nabitah System is offset by the sinistral shear zone of the NW – SE Najd System. Similar features are seen in Central Iraq along the Euphrates River where the N – S trending horizontal gradient gravity-defined structures are dragged and bent along the NW – SE trending Najd faults (Fig.2a and 2b); a sinistral transpressional shear along the Najd System in Iraq. Neotectonic movements may have occurred along some structures of this system, including the Abu Jir and Tharthar faults in central and N Iraq and the Nukhaib Graben in SW Iraq.

The interesting data, concerns the Total Magnetic Intensity Map (Fig.3, CGG, 1974) where the positive parts of the anomalies and negative anomalies are colored to distinguish the different anomaly sets.

In southern Iraq, the magnetic anomalies reflect the present basement fabric as well as the original Precambrian fabric. A discrimination of a later distortion zones that could be detected within these anomalies should be seriously taken in consideration; such changes, which reflect serious tectonic episodes, should leave some sort of deformation on the overlying sedimentary cover at the time of these tectonic activation processes. The epigram of the present work is to attract attention to this specific phenomenon (magnetic anomaly distortion)

that characterizes the majority of the magnetic anomalies of the southern part of Iraq and to its economic importance; hydrocarbon trapping expectation and as a guide in seismic exploration.

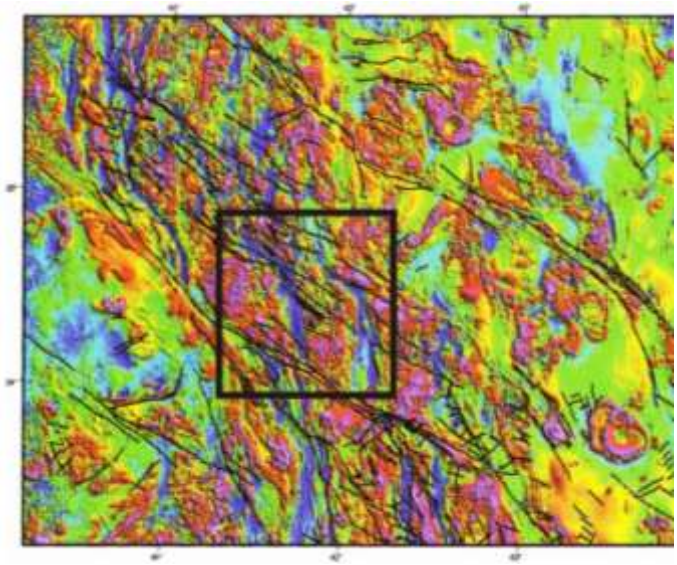

Fig.2a: RTP map of the central part of the Arabian Shield. Red is a magnetic high, blue is a magnetic low and faults in black
(after Jassim and Buday in Jassim and Goff, 2006)

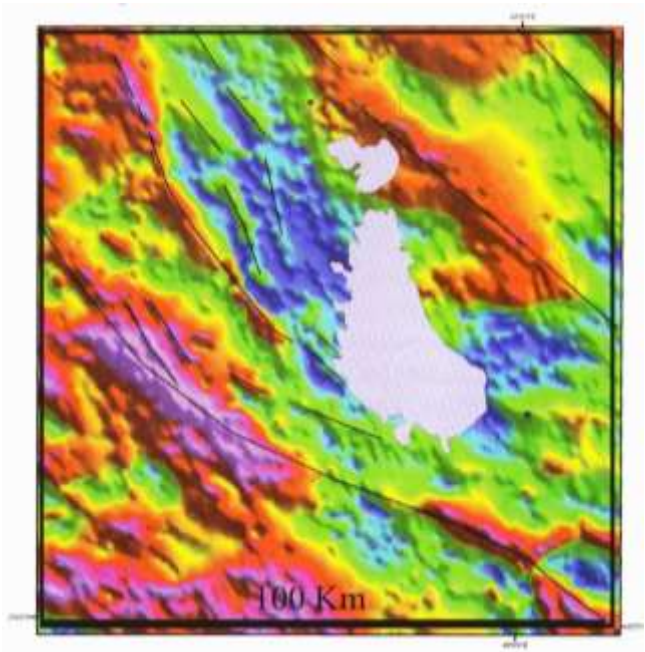

Fig.2b: Gravity horizontal gradient of central Iraq showing bending of N – S structures along the NW – SE Euphrates Boundary Faults
(after Jassim and Buday in Jassim and Goff, 2006)

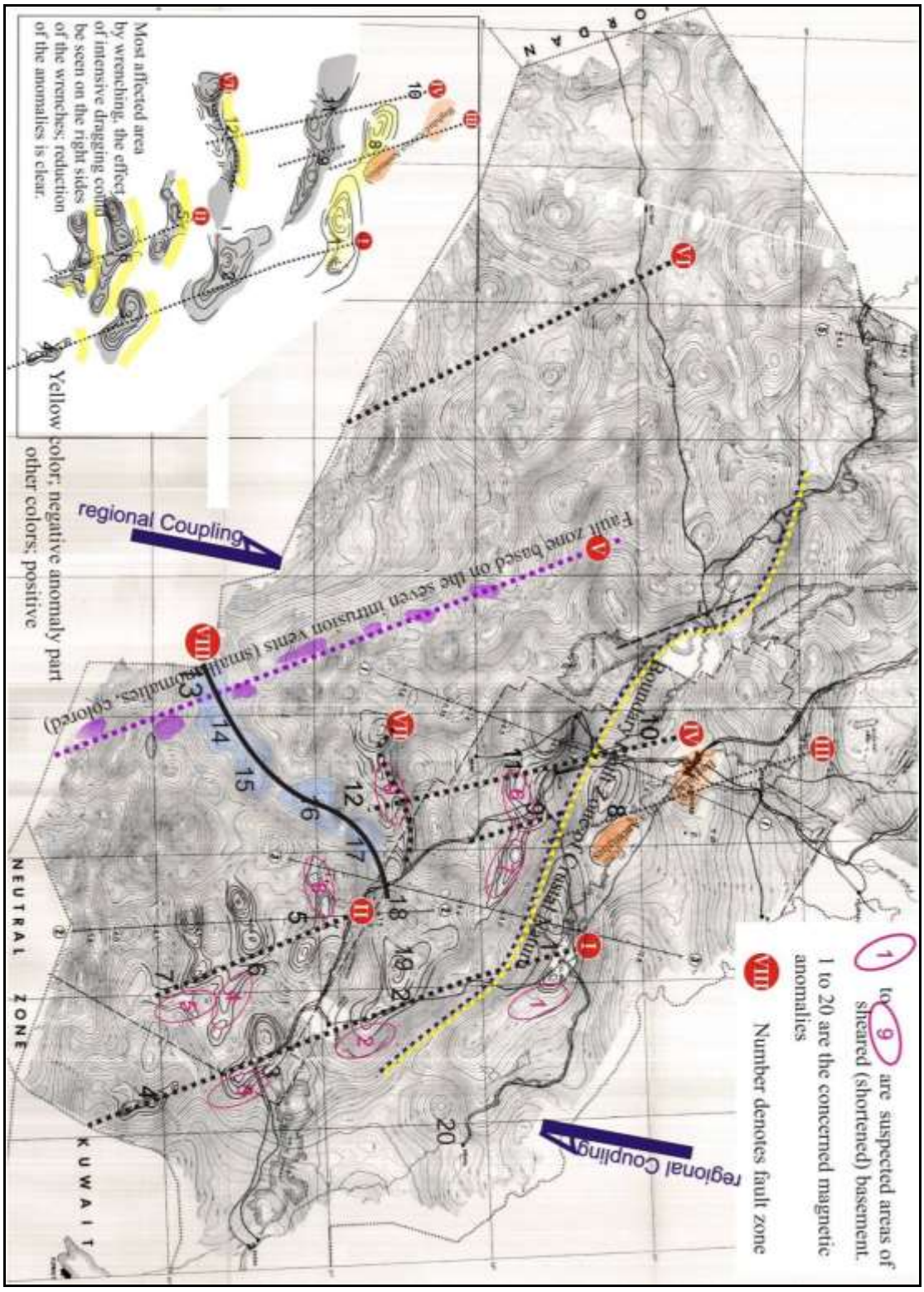

Fig.3: Total magnetic anomaly map, colors discrimination of anomaly groups. Dotted lines are suspected basement shearing zones, note that all of same trend and shearing sense; zone of suspected en echelon deformation within the sedimentary column

- **The Configuration of the Magnetic Anomalies in Central and Southern Iraq, the Basement Shearing Zones**

The considered anomalies are inclusively related to the old basement intrusions and structures. Generally, extensional tectonic activity is one of the most favorable medium for magmatization process – emplacement of magmatic intrusions along linear fractures. Such activity creates segmented (not tectonically shifted) linear intrusions. When these intrusions have considerable positive magnetic susceptibility contrast (basic intrusions) relative to the basement country rocks, they possibly give intensive uniformly elongated magnetic anomalies; the great depth to the basement in Iraq deteriorates the details of the intrusions (anomalies). Later, when these uniform linear segments are effectively (tectonically) sheared and distorted, the shearing and the distortion should be expressed by the magnetic contour configuration of the intrusion; magnetic intensity degradation and contours bending respectively. In the present work we draw attention to these particular characteristics of the magnetic anomalies in central and southern Iraq, (Fig.3). The following could be seen in this figure:

1. A very clear right lateral distortion (bending) is a diagnostic character of the magnetic anomalies of the Precambrian basement basic intrusions in these areas (some bended anomalies are shown, Nos.1 – 12).
2. A second diagnostic character of the concerned areas is that the distortions along anomalies (Nos. 1 – 12) display aligned grouping of anomaly distortions; group No. (I) comprises anomaly distortion Nos. 1 – 4; group No. (II) comprises anomaly distortion Nos. 5 – 7; group No. (III) comprises anomaly distortion No. 8 and 9 and group No. (IV) comprises anomaly distortion Nos. 10 – 12.
3. A third diagnostic character of the effect of the distortion phenomenon is that all anomalies except anomaly No. 5 show eastern side lower magnetic intensity part relative to the left anomaly side, anomaly No. 5 shows western side degraded anomaly; a clear diminution in the magnetic intensity could be seen along the eastern part of each single anomaly due to shearing effect. Within each anomaly group, these diminations are spacially harmonic.

DISCUSSION AND CONCLUSION

As a starting point, the perfect unified trend of all lines connecting each distorted anomaly group is a diagnostic feature of shear zones affecting each group separately. All these shear zones show effective right lateral magnetic anomaly bending which naturally implies considerable right lateral faulting within the basement. Along fault line No.II alone, a total lateral displacement of about 20 Km could be estimated.

The degradation in the magnetic intensity could be inclusively explained in terms of shearing of one side of the faulted block relative to the other side; the shearing (mylonitization) affects a narrow zone along the right side or along left side of the faults of the zones causing partial destruction of the magnetic minerals of the intrusions. The narrow zone of shearing implies a possible zone of basement slight shortening. Again, along fault zone No.II, the shortening on the left side could be seen along anomaly No.5 in contrast to the shortening along anomalies Nos.6 and 7, which show shortening on the right side of the fault zone. On fault line No.I, the shearing is restricted to the right side of the fault zone only. The age of shearing and shortening is of prime importance in the sedimentary cover structuring (folding).

Anomaly lines Nos.VII and VIII show clear S-shape distortion and/ or en echelon configuration. Out of these anomalies, anomaly set No. VII is the most conclusive in this

respect, it has a very clear S – shape configuration. This anomaly has a nature which could be interpreted as a reverse fault dipping due south, its incurvate western side due north points to the western end of the reverse fault; a reasonable clue to an additional basement shortening. The linear zones of wrenching, the S – shape configuration together with the en echelon one are conclusive criteria for effective right lateral regional coupling prevailing over central and southern Iraq. Lines Nos.I to V, could represent basement specific zone of more intensive linear shearing (wrenching) affecting the crystalline basement. This specific zone as (interpreted from magnetic and gravity data) is bordered from NE by NW – SE trending great boundary fault zone of a crustal nature (Haditha – West Amara – West Kuwait Boundary Fault Zone, Al-Bdaiwi, 2010). Along the entire length of the HWAWKBFZ segmenting right, lateral faults could be seen. From the west, it is bounded by the more rigid part of the Arabian Plate. A specific tectonic sub-block could be introduced on the bases of tectonic criteria of effective wrenching intensity.

It is believed that the original old configuration of the basement's basic intrusion systems of the concerned area, which are naturally the principal cause of the expressive magnetic anomalies, have been effectively distorted by later tectonic coupling stress. The two known major processes, which encountered the northern margin of the Arabian Plate, are those which caused the development of the Tythian Sea (Triassic rifting stage) and the stage of the sea closure at the beginning of the Cretaceous. The emphasis here is on the later stage, since the former stage was acted on a passive margin, which was inclusively restricted to the block faulting of the pre Triassic crust. This stage, which prevailed over a wide zone of the northern part of the Arabian Plate, is culminated in the formation of the Alpine Orogeny. This great tectonic process causes wrenching, as well as block faulting of a crustal scale. The Mesopotamian Foredeep with the Crustal Flexure Zone (Salman Zone) Al-Bdaiwi (2014), which include the block of the right lateral shearing, are the main tectonic components of the Orogeny. Accordingly, it is most probable that the same orogenic stress, which developed the Mesopotamian Foredeep and the Crustal Flexure Zone, is responsible for the formation of the concentrated wrenching of the area in "post Miocene". Economic wise (structures), the age of formation of the wrenches is of the main point of the present work; if the age of the wrenches is Precambrian or even Palaeozoic, no economic significance could be expected from this tectonic process.

The proposed right lateral shearing zones are coincident with gravity gradients, which could indicate normal displacement too (Fig.4). On the ground surface, the geological mapping of the region shows no sign for the existence of these faults; they have so far been unobserved. The preferred interpretation for this problem is that these fault zones have never reached the surface; their lateral displacement could be consumed in building diagonal short anticlines and complimentary short lateral faulting along the wrench traces. Systematic structural correlation with the available seismic data (interpreted structures) could serve in a better discrimination of the details of the later regional stress modifications which should have impacts on the structural style of deformation at different levels of the sedimentary cover that could be separated by decoupling surfaces, such as salt or other incompetent horizons. Thus for the time being, the "the proposed basement distortion model and its role in structuring the sedimentary cover" could represent a locus of an insight.

In conclusion, the structural configuration of the basement of the region which could be inferred from the magnetic field data is of first order guidance in developing an acceptable knowledge on the regional stress field configuration of the latest stages of deformation. The assigned basement zones of right lateral shearing could be of special importance in localizing

flexural folding zones over the incompetent known horizons within the sedimentary cover. More sophisticated study of the discussed basement magnetic phenomena could well be useful in hydrocarbon exploration. Integration of the discussed wrenches with the main Basement Fault Systems of Jassim and Buday in Jassim and Goff (2006) is not a simple task especially because, hitherto, there are no sophisticated tectonic models based on analyzing all the huge available tectonic elements; there is an actual need to study the stress configuration of all ages.

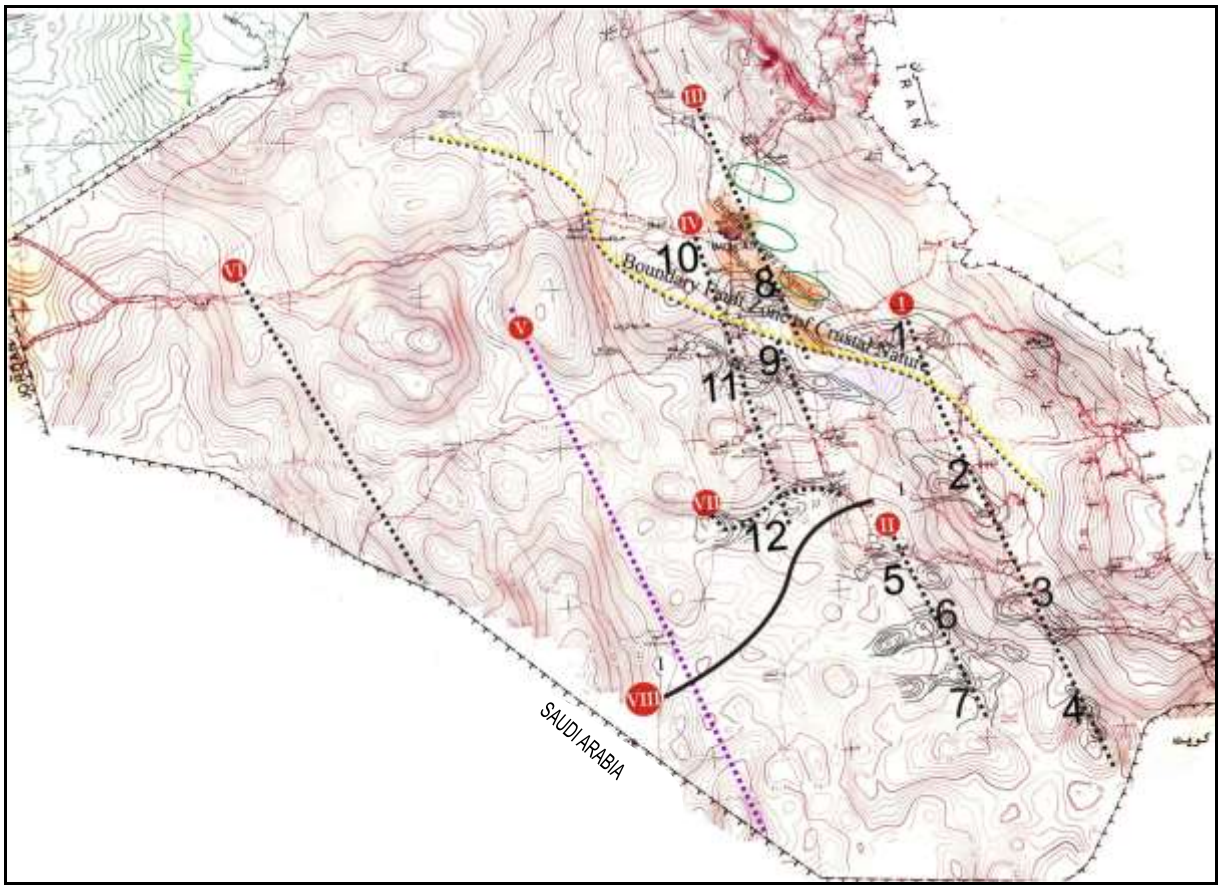

Fig.4: Bouguer gravity of southern Iraq, the superimposed contours and lines are the related magnetic anomalies and zones of lateral shearing. Note that most of the shearing zones coincide with gravity gradients. The magnetic en echelon configuration is less reflected gravimetrically, although, the green three oval shapes could reflects this configuration

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