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Geological map of Sulaimaniyah quadrangle, at scale of 1: 250 000

Varoujan K. Sissakian [1] and Saffa F. Fouad [2]

[1] Private Consultant Geologist, Erbil, Ainkawa-108. e-mail: varoujan49@yahoo.com
[2] Director General, Iraq Geological Survey, Baghdad, Iraq. e-mail: saffa.fouad1957@gmail.com

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Abstract

The geological map of Sulaimaniyah Quadrangle at scale of 1: 250 000 was first compiled by Iraq Geological Survey (GEOSURV) during 2007 depending; mainly on the available geological maps at scale of 1: 100 000, which were compiled from interpretation of aerial photographs, besides some other maps quoted from Kurdistan Series of geological maps and small parts mapped by GEOSURV during 1972 – 1974. The present geological map (2nd edition) also prepared by GEOSURV; however, includes a lot of updated data acquired from detailed geological mapping carried out during 2008 – 2009, and data acquired during systematic checking trips executed during 2007 – 2013 by the current authors. The updated geological map of Sulaimaniyah Quadrangle is attached by a geological report that describes the: Geomorphology, Structural Geology and Tectonics, Stratigraphy, Hydrogeology and Mineral Resources. Within all these subjects a lot of update data is presented, especially in Stratigraphy, and Structural Geology and Tectonics. The most updated parts of the Geological Map of Sulaimaniyah Quadrangle at scale of 1: 250 000 are those which are covered by Geological Maps of Sulaimaniyah, Qara Dagh and Halabja Quadrangles at scale of 1: 100 000, and more precisely the Sulaimaniyah Quadrangle, which is totally updated. The stratigraphic units are more accurately mapped and presented on the map, especially in the vicinity of Sulaimaniyah – Pera Magroon – Surdash – Haladin – Mawat – Azmir. The Quaternary sediments are more precisely presented on the map. Concerning the structural and tectonics, the structural elements; including anticlinal and synclinal axis and different types of faults are also more precisely presented on the current map too. However, still there are some parts that need updating within the current map, especially in areas where igneous and metamorphic rocks are exposed and in the extreme northeastern and northern parts of the map.

Introduction

The Iraqi territory is covered by 39 sheets of topographic maps at scale of 1: 250 000 series (Figure 1); among them is Sulaimaniyah Quadrangle, which has serial sheet No. NI – 38 – 3. It is located in the extreme northeastern part of Iraq, within the Kurdistan Region. Each topographic map at scale of 1: 250 000 consists of six topographic maps at scale of 1: 100 000. The Sulaimaniyah Quadrangle; at scale of 1: 250 000 consists of the following six topographic maps: Sulaimaniyah, Penjween, Mishaw, Qara Dagh, Halabja and Khurmal (Figure 2).

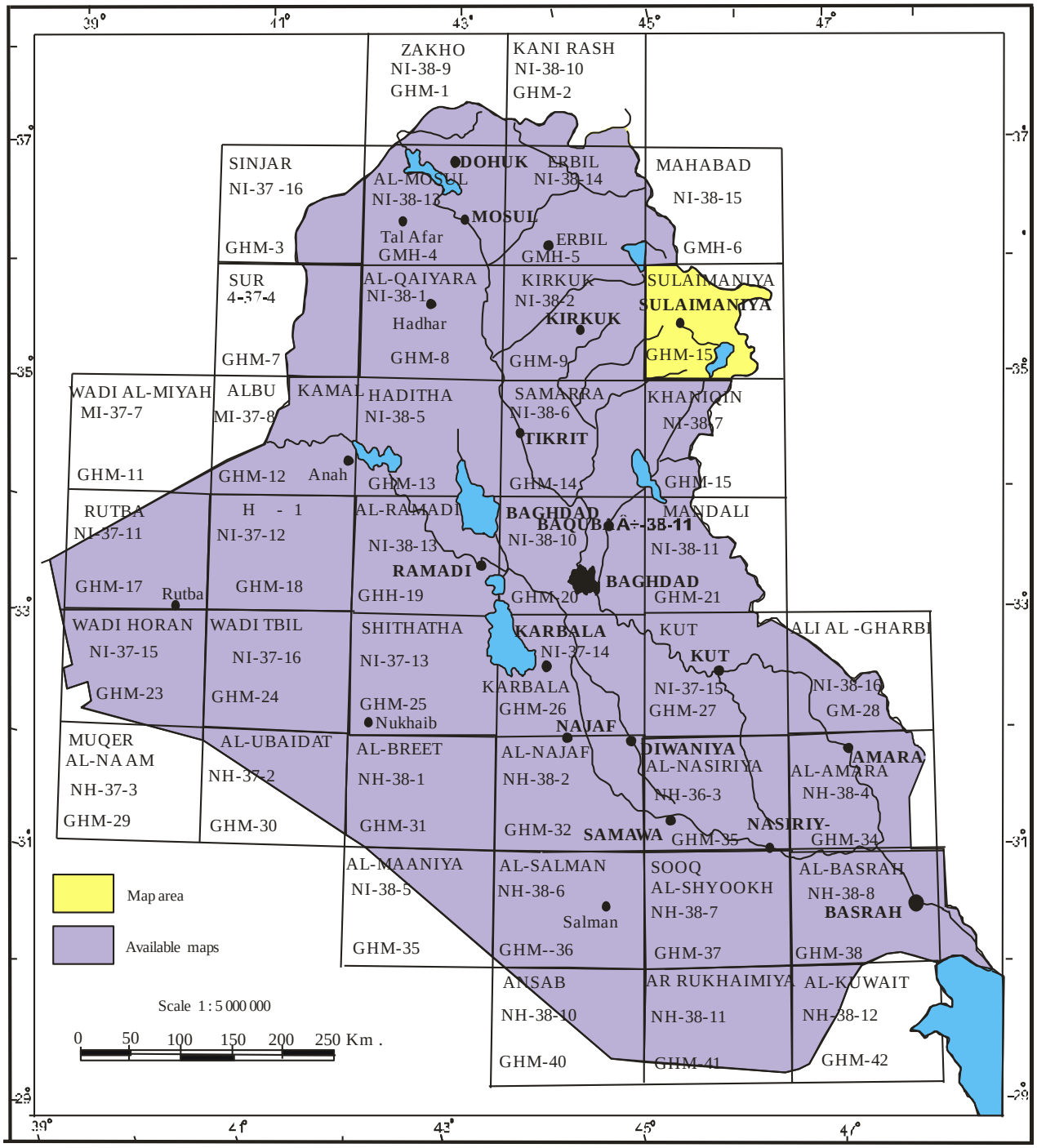

Figure 1: Index map of topographic maps at scale of 1: 250 000 in Iraq

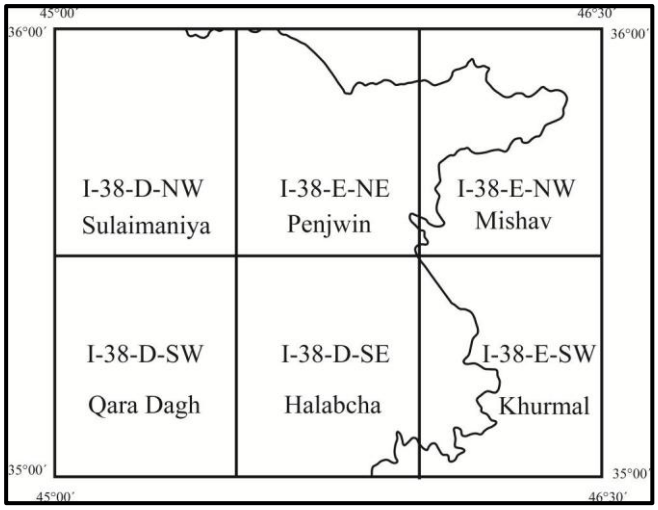

Figure 2: Index map of the six topographic maps (at scale of 1: 100 000) of Sulaimaniyah Quadrangle, at scale of 1: 250 000

The coverage area of each topographic map at scale of 1: 250 00 is about 15000 Km^2, whereas those at scale of 1: 100 000 is about 2500 Km^2, and each one consists of 16 topographic maps at scale of 1: 25 000, which covers about 155 Km^2, or consists of 25 topographic maps at scale of 1: 20 000, which covers 100 Km^2. In case of Sulaimaniyah Quadrangle at scale of 1: 250 000, it consists of 150 topographic maps at scale of 1: 20 000.

The aim of this article is to shed light on the updated Geological Map of Sulaimaniyah Quadrangle; at scale of 1: 250 000 [1], and to compare it with the first version [2] of the current map. Also to show the main differences between the two concerned versions in the geographic distribution of the exposed formations, anticlinal and synclinal axes, faults, Quaternary sediments, besides the updating and compilation techniques.

Materials and Methods

A. Study area

The study area is limited to the coverage area of Sulaimaniyah Quadrangle at scale of 1: 250000 (Figure 1), which is about 15000 Km^2. It is located in the extreme northeastern part of Iraq; within the Kurdistan Region.

B. Materials

To update the first version of the geological map of Sulaimaniyah Quadrangle at scale of 1: 250000 [2], the following materials were used:

- Geological and topographical maps that forms the Geological Map of Sulaimaniyah Quadrangle,
- Landsat and Quick bird images of different scales of high quality that cover the concerned map,
- Google Earth images of different scales that cover the concerned map,
- Aerial photographs at scale of 1: 42000, for certain parts of the concerned map,
- Ph.D. thesis that cover significant parts of the concerned map [3],
- Different published scientific articles that dealt with different aspects within the concerned map,
- The surrounding geological maps at scale of 1: 250000 to Sulaimaniyah Quadrangle, which are: Erbil and Mahabad, Kirkuk and Khanaqeen (Figure 1).

C. Methods

The first version of the Geological Map of Sulaimaniyah Quadrangle at scale of 1: 250000 [2] was compiled using the available geological maps, especially [4, 5, 6, 7 and 8] without any field check or using remote sensing technique via interpretation of Landsat and/ or Quick bird images or aerial photographs; therefore, the compiled map is like a mosaic work by matching parts of the available maps together, consequently different controversies are present in the map [2].

The second version [1] of the current map; however, is compiled by the following steps: **1)** the first version of the current map [2] was used as a base map, **2)** data acquired through detailed geological mapping for considerable parts of the current map area, which was carried out by GEOSURV during 2007 and 2008 [9] was used in the updating, **3)** data acquired through field checks for tens of exposed sequences in different parts of the current map (Figure 3); using high quality Landsat and Quick bird images of high resolutions for interpretation uses, besides using Google Earth images and aerial photographs; occasionally from which the distribution of the exposed formations and different types of Quaternary sediments were amended and the structural elements were more precisely drawn, **4)** the surrounding geological maps (Figure 1) of Sulaimaniyah Quadrangle at scale of 1: 250000 were also checked and updated, especially the edges of the maps to be sure that all geological boundaries and structural elements coincide with each other, the maps are: Erbil – Mahabad Geological Map [10], Kirkuk Geological Map [11] and Khanaqeen Geological Map [12]. All those maps with many others were used to update the Geological Map of Iraq [13], and **5)** the attached geological report was amended to be in harmony with the updated geological map of Sulaimaniyah Quadrangle. In the extreme northeastern parts of the map area; however, where igneous rocks are exposed, no changes were performed on the current map; except amendment of the extensions of faults, structural axes and Quaternary cover.

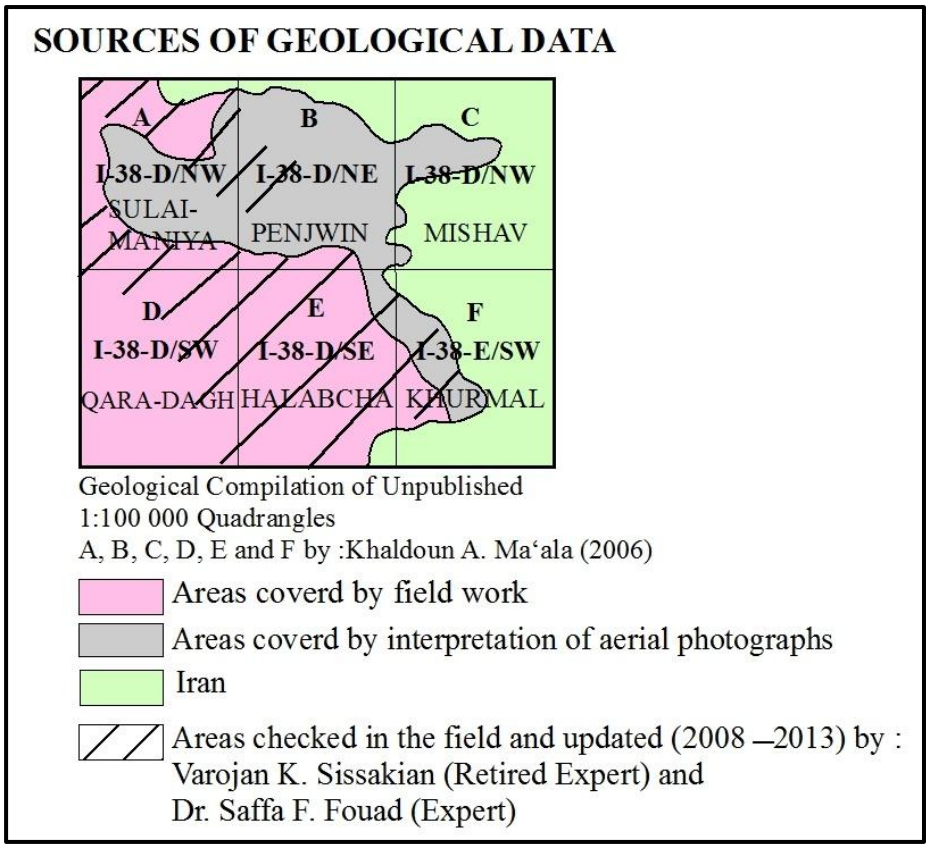

Figure 3: Index map of the used data in compilation of the current map

The Geological Map of Sulaimaniyah (1; 250000)

The new version of the Geological Map of Sulaimaniyah Quadrangle at scale of 1: 250000 [1] (Figure 4) has better presentation for the exposed stratigraphic sequence; including different types of the Quaternary sediments as well the structural elements; such as anticlinal and synclinal axes, faults and their types. The updated aspects will be discussed in details hereinafter.

Stratigraphy

Although there is no large changes in the exposed stratigraphic sequence within the map area; apart from the recently discovered Late Jurassic rocks in Pera Magroon anticline [9]; however, the geographical distribution of the exposed formations is quite different in different parts of the map area. Many examples are selected from different parts of the map area, these are presented hereinafter.

A- Derbendi Khan Area

The exposed geological formations and structural elements in surroundings of Derbendi Khan Lake (Figure 5) are quite different from the first version [2]. The Jurassic formations; north of the lake are presented in more details. The Cretaceous, Paleogene and Neogene formations within the whole involved area are presented in more details. The Quaternary sediments are also presented more accurately and in details. The structural elements, which are present around the lake are amended and more accurately presented.

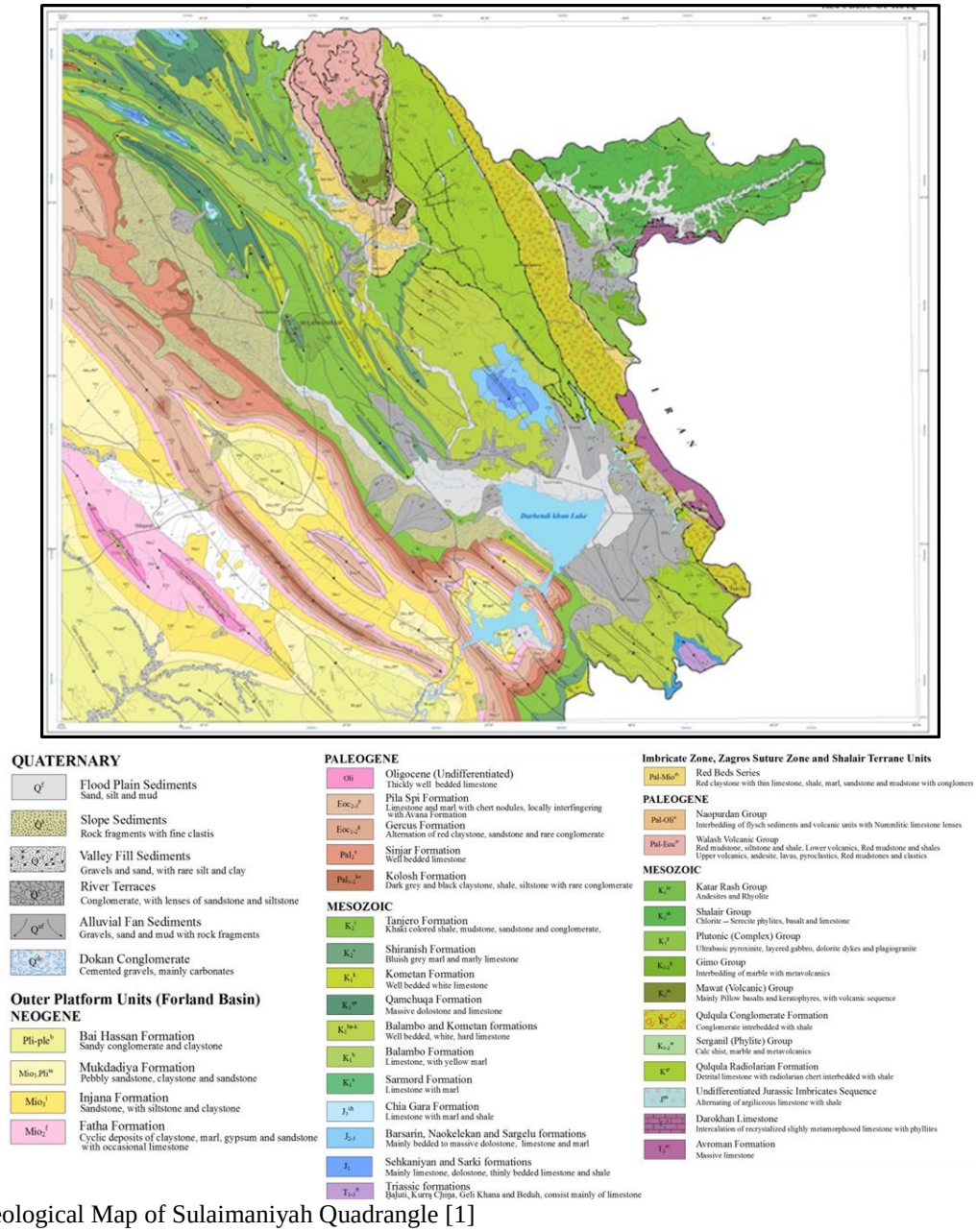

Figure 4: Geological Map of Sulaimaniyah Quadrangle [1]

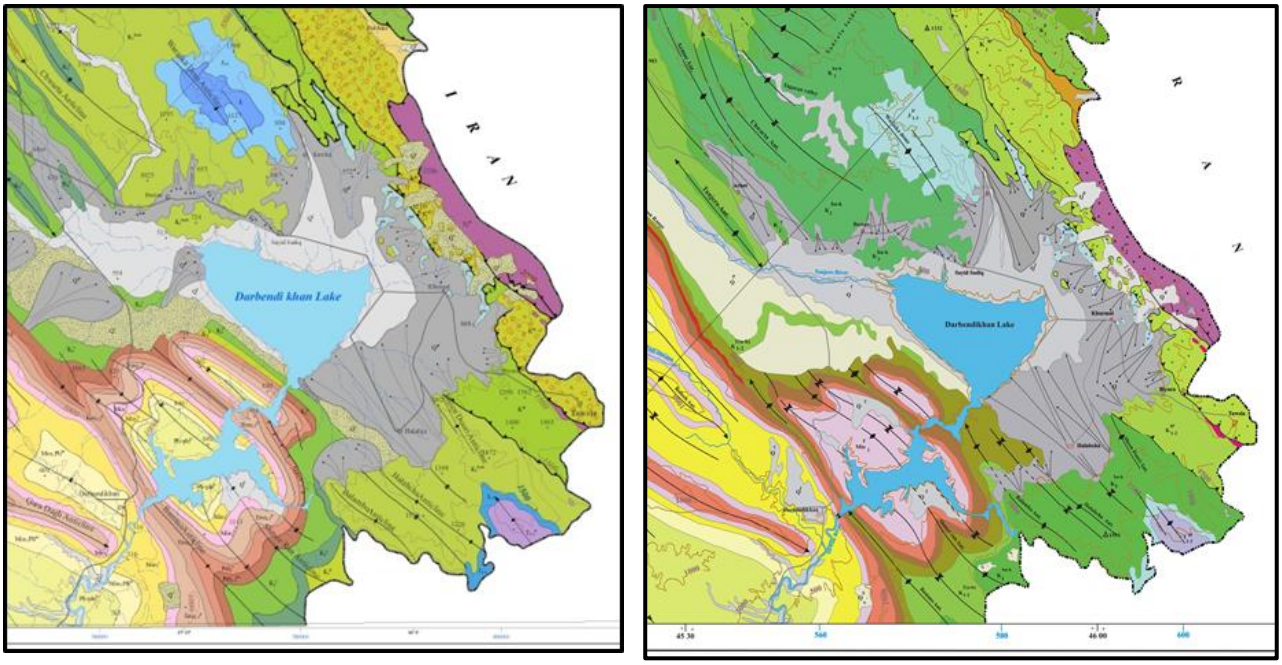

Figure 5: Surroundings of Derbendi Khan Lake, **Left)** Current map [1], **Right)** First version [2]

B- Qara Dagh and Aj Dagh Anticlines Area

The exposed geological formations and structural elements in Qara Dagh and Aj Dagh anticlines' (Figure 6) are quite different from the first version [2]. The Eocene and Oligocene formations in the core of Qara Dagh and Aj Dagh anticlines are presented more accurately and the Oligocene rocks are presented for the first time. The Miocene - Pleistocene formations within the whole involved area are presented in more details, which manifested the forms of both anticlines and synclines more clearly.

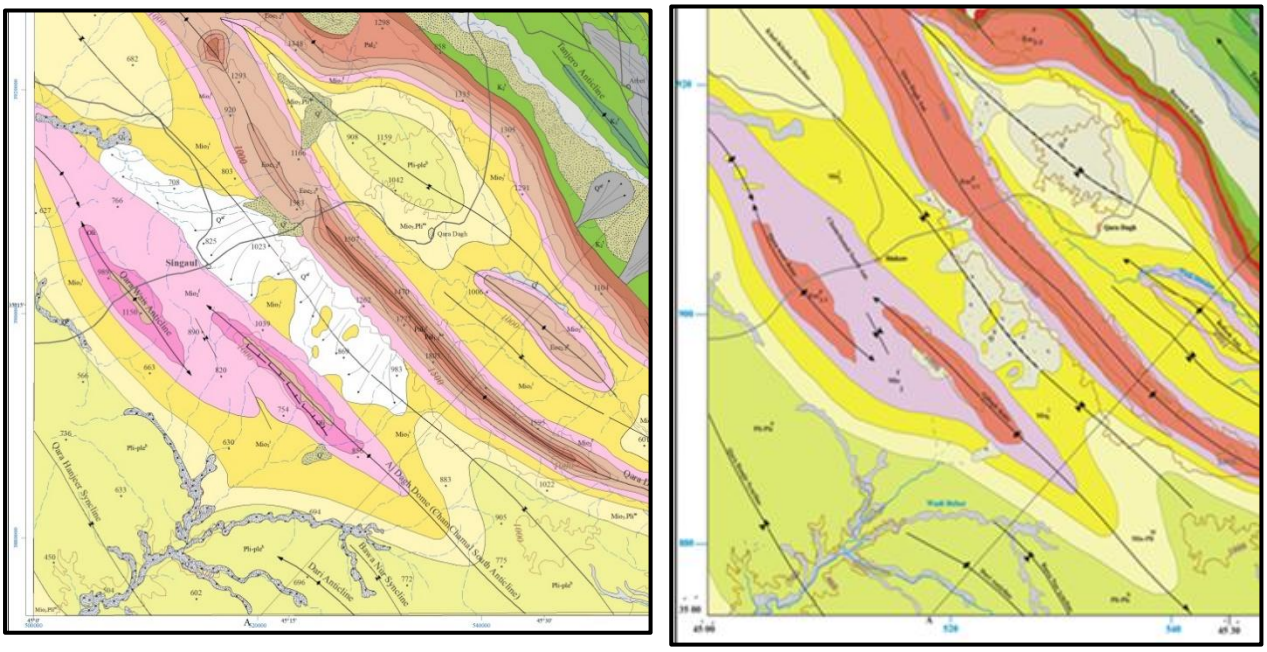

Figure 6: Qara Dagh and Aj Dagh anticlines' area, **Left)** Current map [1], **Right)** First version [2] (For legend refer to Figure 4).

C- Sulaimaniyah City and Northwards Area

The exposed geological formations and structural elements in Sulaimaniyah city and northwards area (Figure 7) are quite different from the first version [2]. The Jurassic formations in the core of Pera Magroon anticline are discovered [9] and presented on the map for the first time. The Cretaceous, Paleogene and Neogene formations within the whole involved area are presented in more details, which manifested the forms of the anticlines more clearly, especially Pera Magroon, Surdash and Khalikan anticlines. The Quaternary sediments are also presented more accurately and in details, besides presentation of Dokan Conglomerate [14] for the first time along the southern banks of Dokan Lake; instead of Pila Spi, Fatha, Injana, Mukdadiya and Bai Hassan formation; as was presented there [15]. The structural elements in different parts of the involved area are amended and more accurately presented.

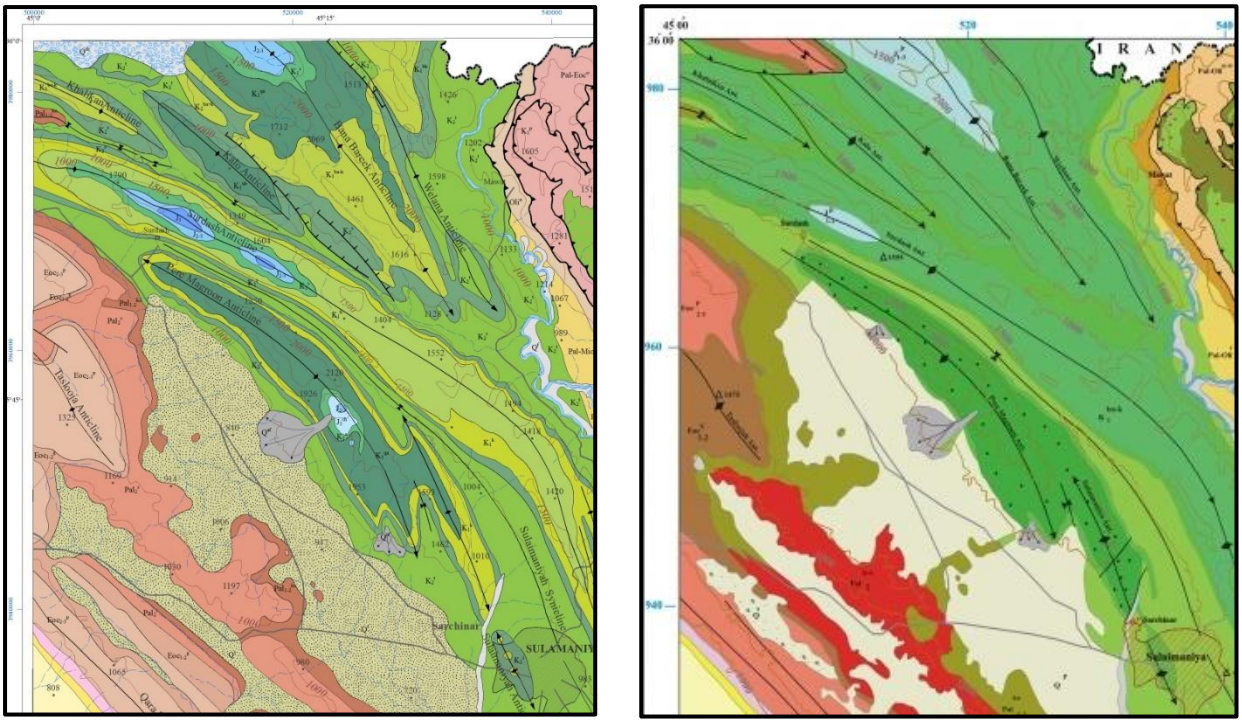

Figure 7: Sulaimaniyah city and northwards, **Left)** Current map [1], **Right)** First version [2] (for legend refer to Figure 4)

Structural Elements

Although there is no large changes in the structural elements within the map area; however, the extension of the anticlinal and synclinal axes are quite different in different parts of the map area. Many examples are selected from different parts of the map area, these are presented hereinafter.

A-Sulaimaniyah City and Northwestern Part of the Map Area

Many anticlines are present in this area, among them are: Pera Magroon, Surdash, Khalikan, Kalo, Bana Bareek, Welana (Figure 7), in all of them the axis is more precisely traced and presented on the map. The plunges, synclinal axes and reverse faults are also more precisely presented on the map. The Tasloojah anticline; in the extreme western part of the involved area is also more precisely mapped with the associated fault and presented on the map. The axes of Sulaimaniyah anticline and syncline are also more precisely mapped and presented (Figure 7).

B- Derbendi Khan Lake Area

The area of Derbendi Khan Lake and surroundings is characterized by the presence of many anticlines and synclines, which act as a closed folded basin form (Figure 8), beside the other anticlines near Derbendi Khan and Halabja towns. A long reverse fault runs parallel to the anticlinal and synclinal axes has complicated the succession of the exposed rocks that range in age from Paleocene to Pleistocene (Kolosh, Sinjar, Gercus, Pila Spi, Fatha, Injana, Mukdadiya and Bai Hassan formations). These axes were not accurately presented on previous map [2]. A long syncline with the Mukdadiya Formation in the trough is present near Derbendi Khan town; it was not presented on the previous map [2] too. The axes of Bammo and Derbendi Khan anticlines are more precisely mapped and presented on the current map [1].

C- Qara Dagh and Aj Dagh Anticlines Area

The axes of Qara Dagh, Aj Dagh as well Kolos anticlines and associated synclinal axes are more precisely mapped and presented on the current map [1]. The Qara Dagh anticline was mapped as one single anticline on the previous map [2], whereas on the current map, two axes in en-echelon form are mapped and presented on the current map [2] (Figure 6).

- ***Geological Cross Section***

On the First version of the geological map of Sulaimaniyah [2], a geological cross section was constructed perpendicular on the strike of the exposed formation to include almost all the exposed rocks. The same cross section was reconstructed and presented on the current geological map [1] (Figure 9). The main differences are: **1)** the Triassic rocks were presented in Waraska anticline to be near surface instead of the Lower Jurassic rocks, **2)** three faults were presented in the cross section without having sufficient surface and/ or subsurface data for their presence, and **3)** the thickness of the Jurassic rocks is estimated less than the true thickness; because no Lower Jurassic rocks were presented in Waraska anticline.

- ***Compilation and Presentation Techniques***

The first version of the Geological Map of Sulaimaniyah Quadrangle; at scale of 1: 250000 [2] is compiled by matching of the six geological maps at scale of 1: 100000 (Figure 3) without any interpretation or extrapolation of the geological features. It was presented using Coral programme. The current map [1]; however, is compiled using field data for about 1000 Km^2 in Pera Magroon and Surdash anticlines and more northwards [9]; besides field checking for tens of exposed sections and doubtful area, which were indicated during interpretation of Landsat, Quick bird and Google Earth images. The current map is presented using GIS programme; therefore, it can be more easily updated; in future and can be matched with the Geological Map of Iraq [15] and the data base in Iraq Geological Survey. Moreover, the used colors chart in the map for different ages (formations) depends on the Stratigraphic Chart prepared by the International Commission on Stratigraphy [16].

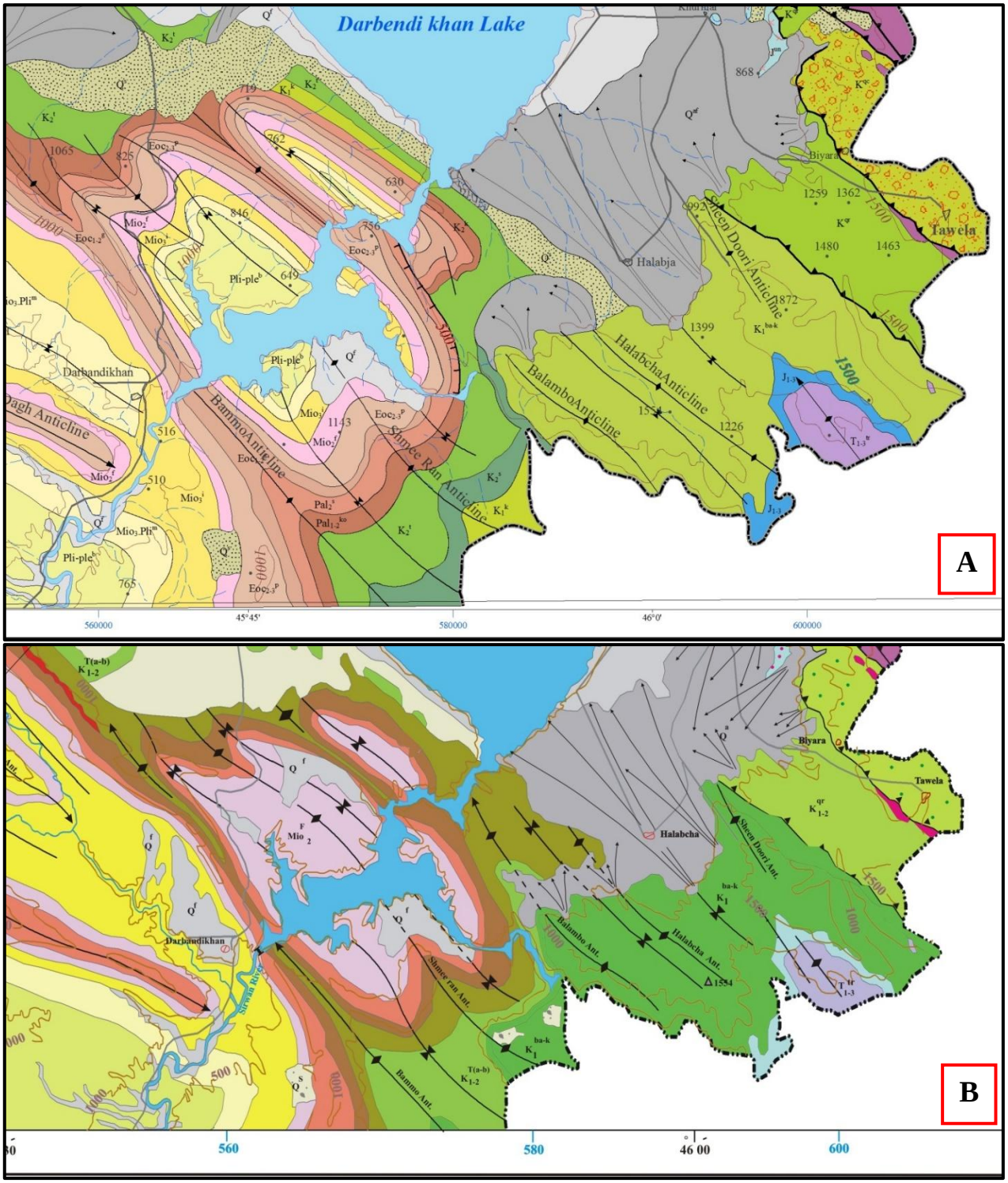

Figure 8: Derbendi Khan Lake Area, **A)** Current map [1], **B)** First version of the map [2] (For legend refer to Figure 4).

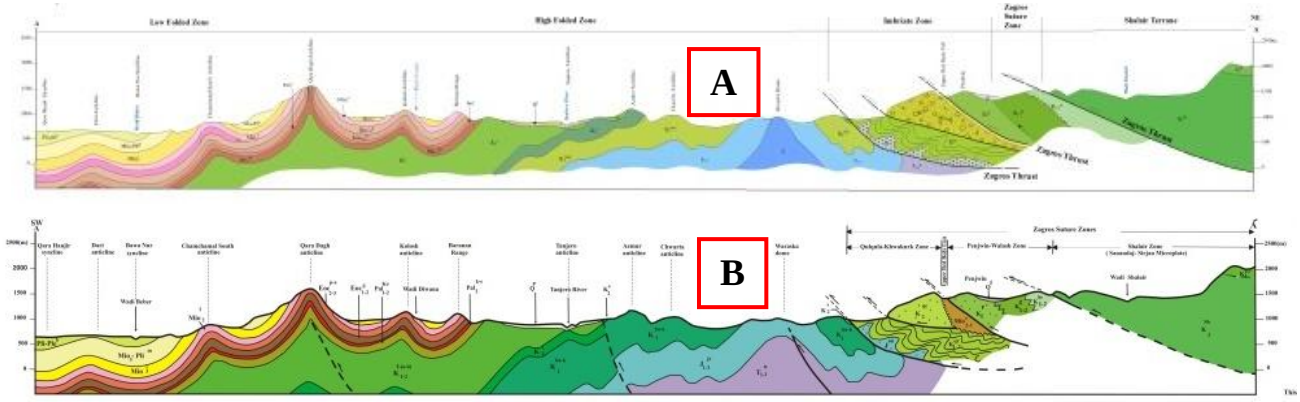

Figure 9: Geological cross section in Sulaaimaniyah Geological Map, **A)** Current map, **B)** First version of the map [2] (For legend refer to Figure 4).

The Enclosed Geological Report

The written report of the first version of the Geological Map of Sulaimaniyah Quadrangle at scale of 1: 250000 [2] is amended during the updating of the map [1]. The report is amended according to the new stratigraphic findings at different parts of the map area, corrected structural elements; such as anticlinal and synclinal axes, faults of different types, and acquired new geomorphological and hydrogeological data. Moreover, a lot of linguistic corrections were conducted in the new version of the report.

The names of the authors of the current map, names of approvers and reviewers and the names of GIS presentation are according to [17]. The current map is available in both digital and hard format.

Conclusions

This article has the following conclusions concerning many aspects; as compared with the first version:

- The geographic distribution of the exposed formations in the current map is more accurate,
- The extensions and locations of anticlinal and synclinal axes; as well different types of faults are more accurate,
- The legend and the columnar geological section are presented in more details,
- The geological cross sections is more reliable,
- The compilation of the current map depends on field data, field checking data and interpretation of high quality Landsat, Quick bird, and Google Earth images, as well aerial photographs,
- The current map is presented using GIS technique; therefore, it can be easily updated in future or retrieve different files, which represent different layers,
- Data from many published scientific articles as well Ph.D. thesis is used in compilation of the current map, and
- The enclosed geological report is written more precisely, as the scientific aspects and linguistic amendment are concerned, following GEOSURV's Work Procedure, Part 2, Report Formatting.

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