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Geomorphologic Map of Nineveh Governorate, Northwestern Iraq Using Visual Image Interpretation

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ABSTRACT

For academic and practical purposes, this map project had the following components:

1-Compiling a geomorphic map as the basis for establishing a database and publishing a full-view map at a scale of 1: 250,000 using visual image interpretation

2-Classification and mapping of basic landform units, landform types that are relatively uniform in genesis and relief forms.

The study area consists of three main genetic groups of landforms based on units of tectonic, fluvial and denudation landform types, subdivided into 14 subunits. Each landform assemblage reflects a different balance between the various endogenic and exogenic processes of landscape evolutions in northern Iraq since late Miocene.

These data were utilized to draw a regional geomorphologic map for the Nineveh Governorate, showing the relationship between landform units and various geomorphic processes. The contents of this map were produced following the scheme devised by the ITC textbook. This map was finalized in 2006 at the Remote Sensing Center, in Mosul University.

الخارطة الجيومورفولوجية لمحافظة نينوى، شمال غرب العراق باستخدام التفسير البصري للمرئيات الفضائية

الملخص

لأجل الاغراض الاكاديمية والعلمية، فقد أحتوى مشروع هذه الخارطة على العناصر التالية:

1- تجميع خارطة جيومورفولوجية لتكون الاساس في تثبيت قاعدة المعلومات عليها، الى جانب نشر خارطة متكاملة بمقياس 1:250000 بأستخدام التفسير البصري للمرئيات الفضائية.

2- تصنيف ومسح الوحدات الاساسية لأشكال سطح الارض وتحديد أنواعها، والتي تكون متجانسة نسبياً في منشأها التكويني وطبيعة تضاريسها الارضية.

تألفت منطقة الدراسة من ثلاثة وحدات رئيسة من أشكال سطح الارض، تكتونية، نهرية وتعروية، وقد تم تقسيم هذه الوحدات الى اربعة عشرة وحدة ثانوية. ان كل مجموعة من اشكال سطح الارض تعكس توازن متباين بين مختلف العمليات الباطنية والظاهرية مع طبيعة اسلوب نشوء وتطور تضاريس سطح الارض في شمال العراق منذ نهاية حقبة المايوسين المتاخر.

أستخدمت هذه المعلومات في اعداد ورسم خارطة جيومورفولوجية شاملة لمحافظة نينوى تعكـس العلاقة بين وحدات اشكال سطح الارض ومختلف العمليات الجيومورفولوجية. اتبع في اخراج محتويـات هذه الخارطة نظام المسح الجيومورفولوجي الخاص بالمعهد الدولي لمسوحات الفضاء وعلوم الاراضـي في هولندا، وقد تم انجازها في عام 2006 في مركز التحسس النائي في جامعة الموصل.

INTRDUCTION

Remote sensing is intensively being used in nearly all sections of science and technology (Lillesand and Kiefer, 2000). In the geosciences, remote sensing data, mainly in the form of images and aerial photographs, is a very important method of documentation and a source of information particulary in thematic mapping and classification of basic landform units (Zhou and Hui, 2004).

Nineveh is one of the largest governorate of Iraq and has the most varied and complex geomorphic landscapes (Fig. 1). With the aim of satisfying the demands of various readers and users, the study is concerned with the classification and mapping of basic landform units, including morphotectonic, fluvial, denudation and accumulation landform types.

The data-base map can be used not only for assessing the adaptability of landuse and or the sensitivity of geomorphic conditions to the related environmental hazards, but also for the studying of the relationship between geomorphic regions and economic exploitation (Al-Daghastani et al., 2002). A preliminary analysis map was made for the relationship between morphotectonics and seismic activity in Nineveh Governorate showing the relationship between earthquake epicenters and geological features (Al-Daghastani and Daood, 2005). The combination of geophysical data and remote sensing information is a promising approach to obtain quantitative evidence of the relative activity of neotectonic movements throughout the study area.

While digital image classification techniques, supervised and unsupervised manipulation modes are now accepted as an alternative to visual image interpretation for remote sensing image classification being faster and more accurate, the visual approach adopted in this study present both unique challenges and abilities as inputs into the accuracy of geomorphic landscape classifications.

The aim of this project is mainly to construct a geomorphic map for Nineveh Governorate based on visual image interpretation, to provide concise and systematic information about landforms and related phenomena to satisfy the needs of various users.

MATERIALS AND METHODS OF INVESTIGATION

Complete coverage of the Nineveh Governorate by the Landsat imagery taken in January (2004) has been analyzed, to determine major geomorphic landscapes. In general, these landscape such as mountain, hills, plains, rivers and terraces …etc, were most readily observed on color composite prints of Landsat imagery (Plate 1a). The most positive use of this imagery has been the mapping changes of wide range of image brightness (colours) values and slope forms. While classifying the major landscapes, the present study has taken into consideration both terrain analysis and evaluation, in addition to the genetic descriptions.

Fig. 1: Geomorphology of Iraq, (Modified after Al-Daghastani 1987).

AL-Shumam (2001) built an integrate software to classify the data of remote sensing which included all classical and network methods. The main benefit of this program is its generalization of classification of any kind of images with any number of bands. The present study applied this program to demonstrate its validity. Therefore, in this research the unsupervised classification method is used which requires no prior knowledge about the study area. Seven major geomorphic landscapes can be identified, as shown on (plate 1b) as follows:

Class 1: Structurally controlled low folded topography.
Class 2: Structurally controlled denudational hills and river terraces.
Class 3 : Structurally controlled high folded topography.
Class 4: Basin of Mosul Dam lake and playa lake.
Class 5: Active erosional glacis on gently sloping surfaces .
Class 6: Mixed erosional glacis on sloping foothills surfaces.
Class 7: Stable accumulation glacis on sloping foothills surfaces.

Unfortunately, the use of multi-date Landsat coverage of the Nineveh Governorate (Plate 1a) has caused serious problems in adopting this classification software. For example, the spectral signature of the vegetation south of the Mosul Dam shows clear differences on both side of the sub scenes, as shown on class2 (Plate 1b). On the contrarily, no such differences have seen in the southern Al-Jezira area due to the similar spectral signature of Gypsies soil and the scarce of the vegetation covers.

Consequently, the traditional visual interpretation of images (photo interpretation) remains the predominant method of evaluation as shown below. A detailed description of the method used to create the geomorphic database map was given by (Verstappen and Zuidam, 1975; Yousif ,1988).

Owing to the scale restrictions (1: 250,000), the genesis of geomorphic landscapes shows mainly the endogenic force, i.e. the various morphotectonic types under the denudation of different exogenic forces (Huggett, 2003). In this project map, the landscapes have been divided into three main genetic groups, subdivided into 14 subunits (Plate 2).

This map was finalized and different geomorphic units were classified following the scheme devised by the ITC textbook (Zuidam and Zuidam, 1979). This classification can be explained as follows:

First: Landforms of Tectonic Origin:

These are structural landforms which, after folding, are clearly dislocated and uplifted. They generally occur in the Folded Belt or the Unstable Shelf of northwestern Iraq (AL-Kadhimi, 1996). Comparison of the geomorphic map of the study area with the geologic interpretation map shows that topography is controlled by geologic structure. The fundamental framework of the structure and stratigraphy of northern Iraq is strongly influenced by the positioning of the country within the main tectonic units of the Middle East (Daly, 1989; Numan, 2001), arrising from the progression of continual plate collision between the Arabian Plate and Turkish and Iranian plates (Eurasian Plate), forming an en echelon or linear folded structural landforms of different types since late Miocene. Some major faults and lineaments trend parallel to the fold axis and others cut

صورة ملونة

Plate 2: Geomorphic map of Nineveh Governorate as interpreted from Landsat Imagery :

Geomorphic Units

First: Landdforms of Tectonic Origin

1- Structurally controlled high folded topography
2- Structurally controlled low folded topography
3- Structurally controlled denudational hills

Second: Landforms of Fluvial Origin

4- Tigris River valley and its tributaries
5- Seasonal dry valleys
6- Fluvial river terraces at low levels
7- Fluvial river terraces at high levels
8- Basin of Mosul Dam lake
9- Depression salt areas and playa lakes (Sebkra).

Third: Landforms of denudational Origin

10- Stable accumulation glacis on sloping foothills surfaces
11- Mixed erosional glacis on sloping foothills surfaces
12- Active erosional glacis on gently sloping surfaces
13- Karstic landforms with sinkholes and subsurface valley
14- Aeolian sand deposits without distinct dune forms

Geomorphic Symbols

Plate 2: Geomorphic map of Nineveh Governorate as interpreted from Landsat Imagery. diagonally across the axes are also shown on this map.

These landforms cauld be subdivided into three subunits as shown on (Plate 2) as follows:

1. Structurally controlled high folded topography.
2. Structurally controlled low folded topography.
3. Structurally controlled denudational hills.

Second: Landforms of Fluvial Origin:

These are landforms of fluvial processes with a slope angle of less than 5º. Genesis such as those influenced by fluvial processes together with relief types constitute the basic landform units of fluvial regions. Tigris River and its tributaries took their present courses in an ongoing cycle of erosion introduced by gentle uplift and make their way across warping anticlines during the ongoing phases of deformation to which the present relief is due. Fluvial terraces, resulting from changes in mode of stream operation, provide isochronous features that can be applied to tectonic analysis of the study region (Al-Daghastani and Salih, 1992). As in traditional geomorphic mapping, these landform can be sub divided into six subunits as shown on (Plate 2) as follows:

1. Tigris River valley and its tributaries.
2. Seasonal dry valleys.
3. Fluvial river terraces at low levels.
4. Fluvial river terraces at high levels.
5. Basin of Mosul Dam lake.
6. Depression salt areas and playa lakes (Sebkra).

Third: Landforms of Denudational Origin:

These are landforms of denudational processes, with a slope angle of less than 10°, and occur in both Stable and Unstable Shelf northwestern Iraq. The basic units of denuded accumulation landforms are composed of genesis (sedimentary facies) and relief (forms). They include both fluvial (surface and subsurface), soil (residual and slope) and aeolian deposits. Fundamental underlying geological features such as bedding and lithological composition show up well in the denuded landform and enable readly recognition of the dominant structural characteristics. The relief types in these landforms are sloping, undulating plains and finally karstic region. Two karst systems were identified, an active karst is located at the core and flanks of the anticlines located in the zone of low folded topography. The fossil karstic features are found on elevated land surface in the inter drainage areas at the south and southwestern margin of the study area (Jassim et al., 1997). These landform can be subdivided into five subunits as shown on (Plate 2) as follows:

1. Stable accumulation glacis on sloping foothills surfaces.
2. Mixed erosional glacis on sloping foothills surfaces.
3. Active erosional glacis on gently sloping surfaces.
4. Karstic landforms with sinkholes and subsurface valley.
5. Aeolian sand deposits without distinct dune forms.

CONCLUSIONS

The present landscape of the Nineveh Governorate is viewed as the product of a series of interactions between fluvial and denuded processes operating on the underlying geology that has been subjected to both past and ongoing endogenic deformation by folding and faulting, arrising from the progression of continual plate collision between the Arabian and Eurasian plates scince the Miocene onwords.

Detailed study of individual geomorphic units and landforms from dynamic, tectonic and morphochronologic aspects have been studied by mapping the distribution of the various geomorphic landscapes. These are important in developing a regional geomorphology and promoting regional exploitation and environmental management throughout the study area.

The classification of the basic landform units has been greatly improved through the study and mapping of the landscapes of Nineveh Governorate, using several visual interpretation criteria, that have been employed in interpreting Landsat imagery.

Each landform assemblage reflects a different balance between the various processes of landscape evolutions. Three main genetic landforms were identified, namely tectonic, fluvial and denudation, subdivided into 14 subunits. These are composed of genesis and relief forms, separately displayed by basic color tones and symbols in the final map produced at scale of 1:250,000. The final print of these map at this scale is available at the auther and in the remote sensing center. This map is an important step forward in geomorphological management, because it allows the identification and quantitative assessment of several landform characteristics throughout the study area, although further research is necessary to refine this approach.

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