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MORPHOLOGICAL FORMS IN THE DOLLUGE BASIN, AIN SIFINE AREA (KURDISTAN OF IRAQ)

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Abstract

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The Dolluge valley is located in the Ain Sifine area in northern Iraq. The DEM Module, Map Module, TIN Module, and Hydrologic Module were used to analyze the physical characteristics of the Dolluge valley. The integration of these models opened up new avenues for constructing digital maps representing the upstream and downstream portions of the valley along with corresponding elevations. The sinuosity and the shape of the valley have always been affected by the direction of the main fault, the axis of the Ain Sifine anticline, and the limb of the Maqlub anticline. Average slope variances were 0.12, 0.7, and 0.6 in the Dolluge, Moskain, and Doshivan valleys, respectively. The calculated sediment yield was 65,128, 18,436, and 62,053 (t cm^{-2} a-1) in the upstream area and 16,074, 8,322, and 8,425 (t cm^{-2} a-1) in the downstream area.

Key words: GIS, average slope , Digital elevation , drainage pattren , geomorphic & morph tectonic map and sediment yield

Introduction

Fluvial geomorphology is the study of landform evolution related to stream systems and the geological and hydrological factors that affect sediment transport (Booth, 1991). Drainage basin boundaries are defined by polygon-shaped icons and the direction of water flowing across the terrain can be identified using a DEM module in the Watershed Modeling System (Brigham Young University). The resulting flow lines can be used to calculate channel erosion (Tucker et al., 2001). Slope changes affected by the hydrology of the channel with higher water levels and aggradation can result in flooding across the plain area. A past uplift had warped the valley profile and the slope had become smaller above the uplift and larger below it (Schumm et al., 2002). In this paper, the study area has been divided into two parts (upstream and downstream) in order to help understand the changes affecting the slopes of interest as well as the sediment yield. The aim of this study is to accomplish the following goals:

1. to define the physical characteristics of the Dolluge basin using average variance analysis,
2. to classify streams, based on elevation, into upstream and downstream portions,
3. to measure sediment yield (input and outflow).

Study area

The Dolluge stream flows from Gali Qeer Mountain and from both the Moskain andDoshivan streams from Ain Sifine Mountain during the winter season and it flows into the Gomel river. The area represents the southbound runoff zone from the Gali Qeer Anticline, the Ain Sefni Anticline, and the Maqlub Anticline (Fig. 1). These three drainage basins feed the Gomel river north of the Mindan Anticline. The total area of the combined drainage basin is 17.2 km^2, with an average annual rainfall between 300 and 600 mm.

The study area is part of the Low Folded Zone in northern Iraq. The following seven anticlines can be found in this drainage basin.; The Mindan, Maqlub, Bashiqa, Walley, Kand, Ain Sifne, and Gali Qeer. Field notes and satellite image analysis revealed the effect of the prominent fault axis of the Ain Sifne anticline, the axis of the Maqlubanticline, the eastern plunges of the Walley and Kand anticlines, and the northern limb of the Bashiqa anticline which affect the direction of the valley and its morphology to the east, as it connects with the Gomel river, and does not proceed south (Fig. 2).

The geological formations in this region are called Pilaspi, Fatha, Injana, Mukdadiya, and Bai Hassan (Burwary, 1983).

Data set

A topographic map (scale: 1:50 000), satellite images (scale: 1:50 000), and meteorological data were used in this study. Fieldwork was carried out in order to support theoretical work. The fieldwork involved notes and land-truth checking of satellite images as well as measurements of the width and depth of streams. The topographic map was then digitized by using contour intervals of 10 m on a grid of 5 m x 5 m cells (i.e. 5x5 mm). Each cell included an elevation grid, and a flow direction grid was then constructed. Finally, a flow accumulation grid was derived based on the above by counting the number of upstream cells within a given cell. On the DEM, streams are identified as lines of cells whose flow accumulation exceeds a specified stream number of cells, and thus a specified upstream drainage area.

The purpose of the digital map was to divide the study area into two parts: 1) the upstream part and 2) the downstream part. The use of the Watershed Modeling System involved four steps (modules): 1. digital elevation model, 2. map module, 3. triangular irregular network module, 4. hydrologic module (Fig. 3). A DEM was derived from the TIN used, featuring a 250x250 m cell size. The DEM was then used to determine hydrological parameters of the drainage basin such as slope, flow accumulation, flow direction, drainage area delineation and stream network.

Triangulated Irregular Networks (TIN) was derived from the digital map.

Formula 1 was used to calculate the average variance of the Dolluge, Moskain and Doshivan valleys:-

$$\text{Average variance} = \{\sum_{i=l}^{nu} (SU - \overline{SU})^2 + \sum_{j=l}^{nl} (Sl - \overline{Sl})^2\} / (nu + nl),$$

where:

Su is the slope angle of an upper slope pixel, Su is the mean slope angle of the upper slope. S1 is the angle of the lower slope pixel S1 is the mean slope angle of the lower slope nu is the number of upper slope pixels and n1 is the number of lower slope pixels (Dymond et al., 1995).

Formula 2 was used to calculate sediment yield:

Qss=0.02(Q x Sx Ps),

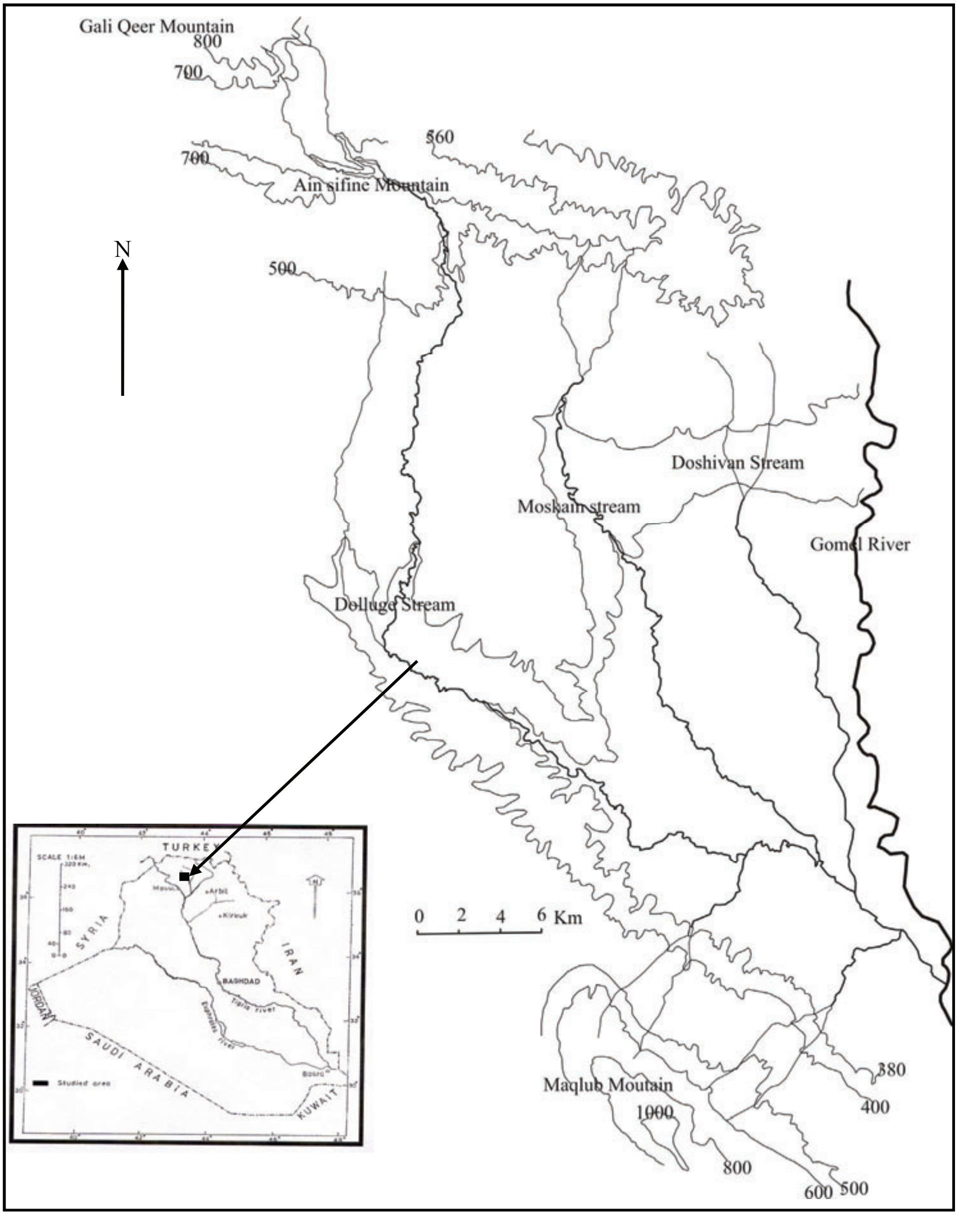

Fig. 1. Location of the Dolluge basin.

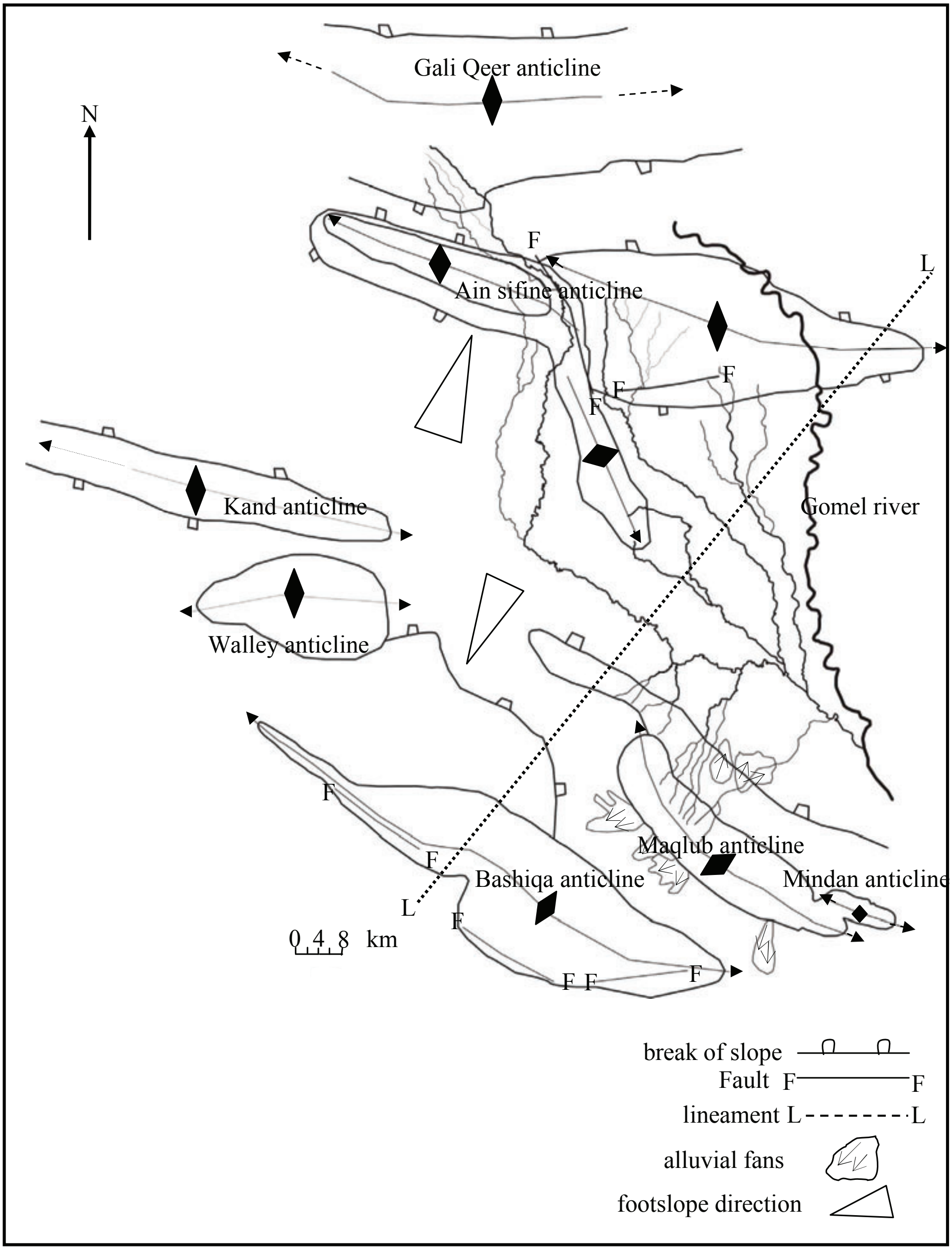

Fig. 2. Geomorphologic and morphotectonic map.

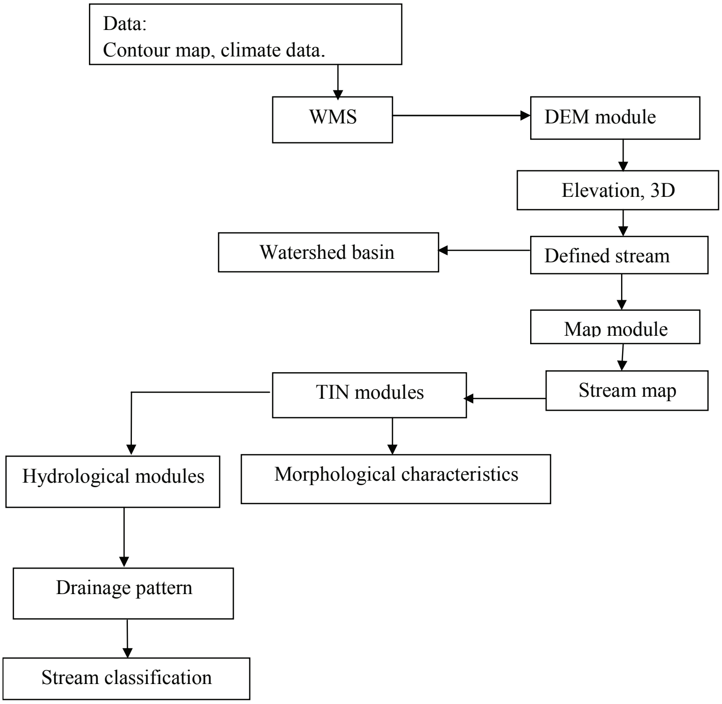

Fig. 3. WMS flow chart.

where:

Qss is the total suspended sediment yield (t cm^{-2} a-1) Q is the mean annual runoff (mm) S is the average basin slope and Ps is the seasonal precipitation variability (mm) (Finlayson, Montgomery, 2003).

Stream classification

The study area can be divided into two geomorphological types: 1) mountains (anticlines) and 2) plains. The average variance of the Dolluge valley is 0.12, while that for the Moskain valley is 0.7 and the Doshivan valley is 0.6. This indicates that the Dolluge valley (starting at 840 m) is located at a higher elevation than the Moskain and Doshivan valleys which both start at 630 m. The elevation of the water divide in the Dolluge valley is 840m on Galie Qeer Mt., while water divides in the Moskain and Doshivan valleys are found at 630m (Ain Sifine Mt.).

The upstream portion is found at an elevation of (560–840 m) in a mountainous area and the dividing line between the upstream portion and the downstream portion is located at an elevation of 490m. All local streams flow from an elevation of 490 m down to the plain area in the south at (420–350 m).

Different average slope variances can be found across the study area due to neotectonic effects, which have shaped stream channel patterns between the slopes (Table 1). The Dolluge stream catchment develops over a surface area of about 17.2 km^2, ranging from 6.97 km^2 from the steep slopes of the headwaters to the hilly middle course to the low-gradient coastal plain which covers 10.23 km (Fig. 4).

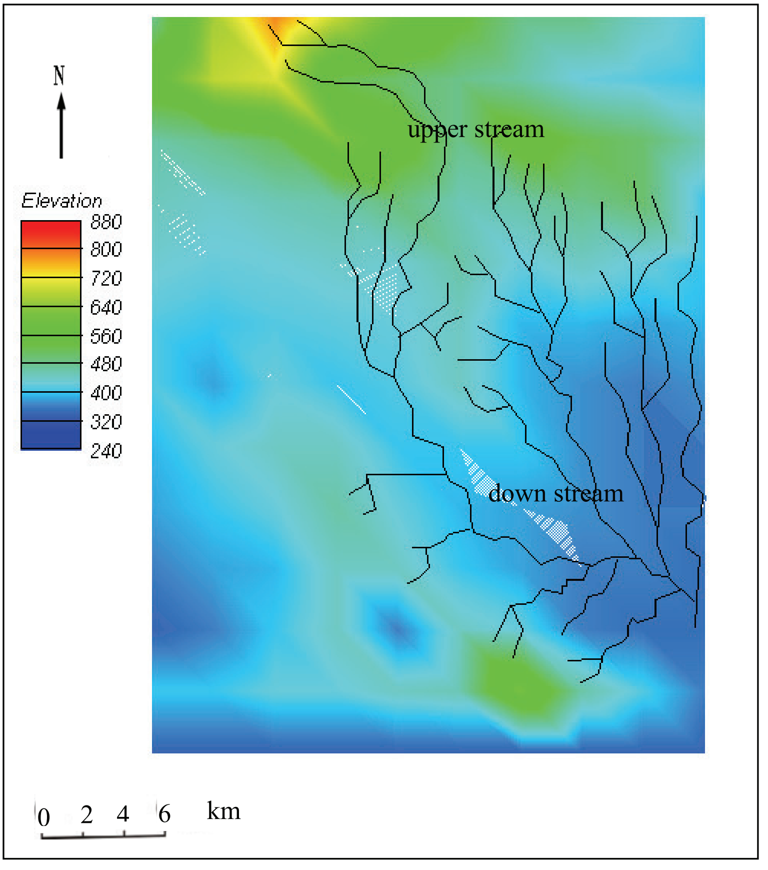

Fig. 4. Elevations and stream classification.

T a b l e 1. Morphological characteristics of the combined drainage basin.

	Dolluge		Moskain		Doshivan	
	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream
Area (km^2)	4.49	4.55	1.37	3.71	1.11	1.97
Basin slope (M)	0.98	0.06	0.11	0.06	0.16	0.06
Shape Factor(MI^2)	26.56	19.70	10.11	19.70	7.21	27.67
Sinuosity (MSL/L)	5.89	1.21	2.04	1.07	1.69	1.16
Mean elevation (M)	2530.71	413.90	992.09	411.63	999.72	403.21
Length (M)	10759.21	12306.65	3495.32	8546.95	3635.61	7392.15
Average variance	0.8	0.4	0.4	0.3	0.4	0.2

Discussion

Channel morphology yields to the effects of neotectonics and the flow of water, which moves sediments through the drainage basin. The processes by which water flowing through drainage networks acts to erode, transport, and deposit sediment are called stream processes. The sinuosity and the shape of the valley have always been affected by the direction of the main fault, the axis of the Ain Sifine anticline, and the limb of the Bashiqa anticline. A change in flow direction will cause a change in channel morphology. However, this type of change will depend on the proximity of channel parameters to a locally relevant threshold value (Watson et al., 1983). Maximum flow distance and average overland flow are important factors in erosion rates.

The streambank material in the valley is not only critical for sediment transport and hydraulic impact but it also modifies local landforms such as plains and river channels (Rosgen,1994). Increasing hydraulic shear or increasing bank erodibility should result in increased rates of bank erosion and lateral stream migration. The sediment yield includes sediment delivered via tributaries and sediments from the channel bed and those eroded from channel banks. Since sediment interacts directly with flowing water, some sediment characteristics, such as size and shape, affect channel flow (Table 2). Vegetation, both on channel banks and within channels, can play an important role in controlling morphologic adjustment of channels by altering the resistance to erosion and affecting flow hydraulics. In extreme cases, riparian vegetation can act as a primary control on channel shape (Tal et al., 2004).

Conclusion

The application of the software program "Watershed Modeling Systems" in the analysis of the study area described the physical characteristics of a combined drainage area of three sub-basins. The objective of the research study described in this paper was the analysis of sediment yield in this combined drainage basin**.** The study area was divided into two parts – an upstream part and a downstream part. It has been established that the downstream part is affected by sediment accumulation more than the upstream part an that the hydrologic

T a b l e 2. Stream erosion across the study area.

	Dolluge		Moskain		Doshivan	
	Up stream	Down stream	Up stream	Down stream	Up stream	Down stream
Maximum(m) flow distance	14059.52	16491.07	4078.24	9221.87	4469.39	9185.72
Average overlandflow (m)	876.55	157.46	274.62	168.85	252.92	253.38
Sediment yield	651228	160774	18436	8322	62053	8425

regime of this downstream portion can be characterized by increased volume and decreased flow variability.

Structural features such as plunge, faults, bedding, and drainage patterns clearly affect stream channel morphology. Sediment transport can generally be described as increasing in volume downstream but decreasing in particle size. Local variations in geological formations result in depositional patterns. The magnitude of sediment yield shapes channel morphology (sinuosity, channel width and slope). However, natural streams tend to develop a channel size and shape that accommodate and reflect the typical hydrologic regime and the quantity of sediment supplied by flowing water. A change in channel gradient will upset the equilibrium between channel slope and hydraulic properties of a given stream. Estimation of sediment yield in the watershed areas of rivers and water surface bodies is considered an important issue in the fluvial geomorphology.

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References

Booth, D.B.,1991:Urbanization and the natural drainage system – impacts, solutions, and prognoses. The Northwest Environment Journal, 7: 93–118.

Burwary, A.M., 1983: Report on the regional geological survey of the Khazir-Gomel area (unpublished special report), No.1137. Hsom Library, Baghdad.

Dymond, J.R. Derose, R.C., Garth, R.H., 1995: Automated mapping of land components from digital elevation data. Earth Surface Processes and Landforms Journal, 21: 131–137.

Finlayson, D.P., Montgomery, D.R., 2003: Modeling large-scale fluvial erosion in geographic information systems. Journal of Geomorphology, 53: 147–169.

Schumm, S.A., Dumont, J.F., Holbrook, J.M., 2002: Active tectonics and alluvial rivers. Cambridge University Press, 276 pp.

Tal, M., Gran, K., Murray, A.B., Paola, C., Hicks, D.M., 2004: Riparian vegetation as a primary control on channel characteristics in multi-thread rivers. In Bennett, S.J., Simon, A. (eds), Riparian vegetation and fluvial geomorphology. Water Sci. Appl. Ser. 8. AGU, Washington, D.C., p. 43–58.

Tucker, G.E., Stephen, T.L., Nicole, M.G., Rafeal, L.B., Scott, M.R., 2001: An object-oriented framework for distributed hydrologic and geomorphic modelling using triangulated irregular networks. Computer and Geoscience Journal, 37: 959–937.

Rosgen, D.L., 1994: A classification of natural rivers. Catena Journal, 22: 196–199.

Watson, C.C., Schumm, S.A., Harvey, M.D., 1983: Neotectonic effects on river patterns. River Meandering, 24–26: 55–65.