Investigation of catchment areas migrations through a sinstral and dextral strike slip faults: the case study of Zerka Ma'in and Al Hasa catchment areas, east of the Dead Sea in Jordan.

TALEB ODEH[1 2], RICHARD GLOAGUEN[2], MARIO SCHIRMER[3], STEFAN GEYER[1], TINO RÖDIGER[1], CHRISTIAN SIEBERT[1]

1Helmholtz Centre for Environmental Research – UFZ, Department of Hydrogeology, Theodor-Lieser-Strasse 4 / 06120 Halle, GERMANY

2 TU Mining Academy Freiberg, Institute for Geology / Remote sensing group, Bernhard-von-Cotta-Strasse 2 / 09596 Freiberg, GERMANY

3 Eawag - Swiss Federal Institute of Aquatic Science and Technology, Department Water Resources and Drinking Water, Überlandstrasse 133, 8600 Dübendorf, SWITZERLAND

taleb.odeh@ufz.de http://www.ufz.de/index.php?en=17682, http://www.rsg.tu-freiberg.de/

Abstract

Three major catchment areas discharge surface water directly into the eastern side of the Dead Sea namely: 1) Wadi Al Hasa catchment area, 2) Wadi Al Mujib catchment area and 3) Wadi Zerka Ma'in catchment area. They have areas of about 6596, 2520 and 272 km², respectively. Digital elevation models (DEMs), of 30 m and 5m resolutions, within a geographical information system (GIS) were used to extract the drainage network of the catchment areas. The northern part of Wadi Al Mujib catchment area has a similar drainage network as Wadi Zerka Ma'in that runs from the north to the west while the southern part of Wadi Al Mujib has a drainage network similar as Wadi Al Hasa that runs from the south to the west. The surface deformation of the border areas, between Al Mujib and the other two catchment areas, indicates a W - E dextral strike slip fault with a displacement reaching up to 12 km in the Wadi Zerka Ma'in side and a NW- SE sinstral strike slip fault with a displacement reaching 24 km into Wadi Al Hasa side. The displacements were estimated through measuring the drainage network shifting. The age is Pleistocene for the dextral fault and middle Miocene for the sinstral one. However, the two catchment areas were drainage network branches from the Wadi Al Mujib catchment area and split throw the strike slip faults that led to migrate the drainage network and formed independent catchment areas. A simplified geomorphological model is described how the previous process was carried out by using the capacity of GIS to manipulate, subset the DEMs and converting it to vectors.

Key words: DEM; Dead Sea; Strike slip fault; Surface deformation; Catchment area migration

1 Introduction

Dead Sea is a hypersaline endorheic lake and located at the border between Jordan and Israel [1] (Fig.1). Geologically, it represents a pull apart in the middle of the Dead Sea lateral strike slip fault and has an age of 15 Ma. BP [2].

The development of the structural setting of the area has a great impact on the catchment areas' generation and migration. The development of the catchment areas in the eastern shore of the Dead Sea has not been adequately studied. Therefore, the objective of this research is to evaluate how the structures developed the catchment areas migrations by using spatial analysis of DEMs within a GIS system.

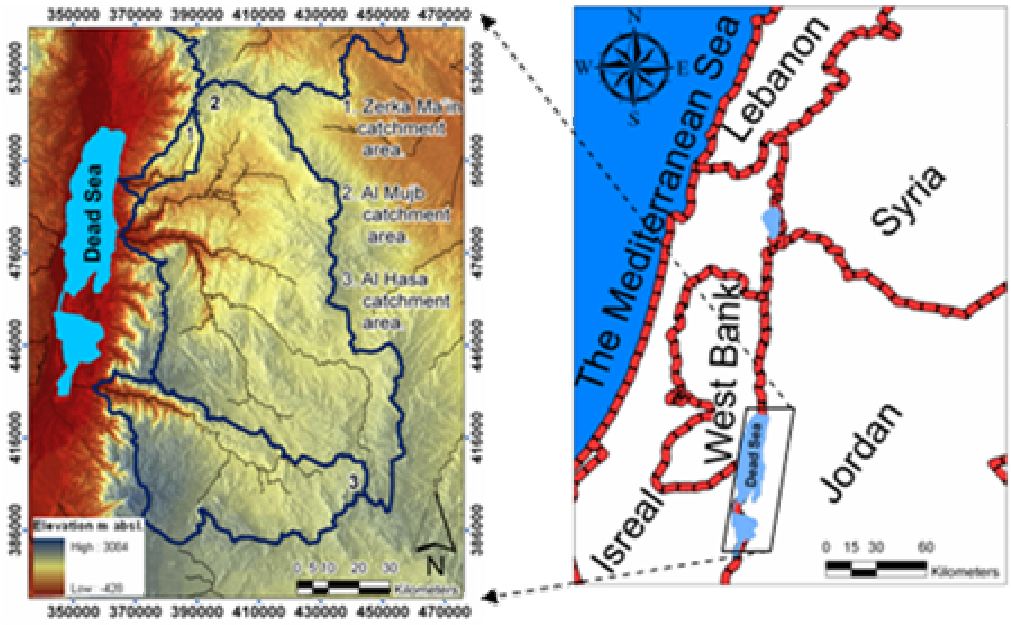

Fig.1: Location of the study area. at the Eastern side of the Dead Sea shore, three major catchment areas discharge directly into the Dead Sea

2 Geology

The rocks of the studied area are mostly sedimentary rocks of the Cambrian to Quaternary periods (Fig.2). However, basaltic rock are copping out in the middle west of the case study and have ages ranging from 3.4 to 0.4 Ma BP [3].

There are two major faults systems in the studied area that belong to regional faults systems (Fig.3) as follow:

1) NW – SE fault which is the oldest fault system and generated as a result of the spreading of the Red Sea. The age of this fault system is the middle of the Miocene.

2) WNW - ESE fault system. This fault system is assigned with volcanic activity and younger than the pervious fault system. The age of this fault system is the Pleistocene [4].

3 Methodology

Extracting drainage networks from DEMs is one of the most important digital terrain analyses [5]. DEMs in tow level of resolutions:

A) 15m DEM extracted from ASTER Image.

B) 5m DEM extracted from aerial photos.

were analyzed [6]. We used ArcGIS 9.3 to do the spatial analysis, manipulating and subset the raster and extracting the drainage network (Fig.4). GIS-software provides a powerful tool for analysis and controls the spatial datasets such as DEMs (Fig.5) [7].

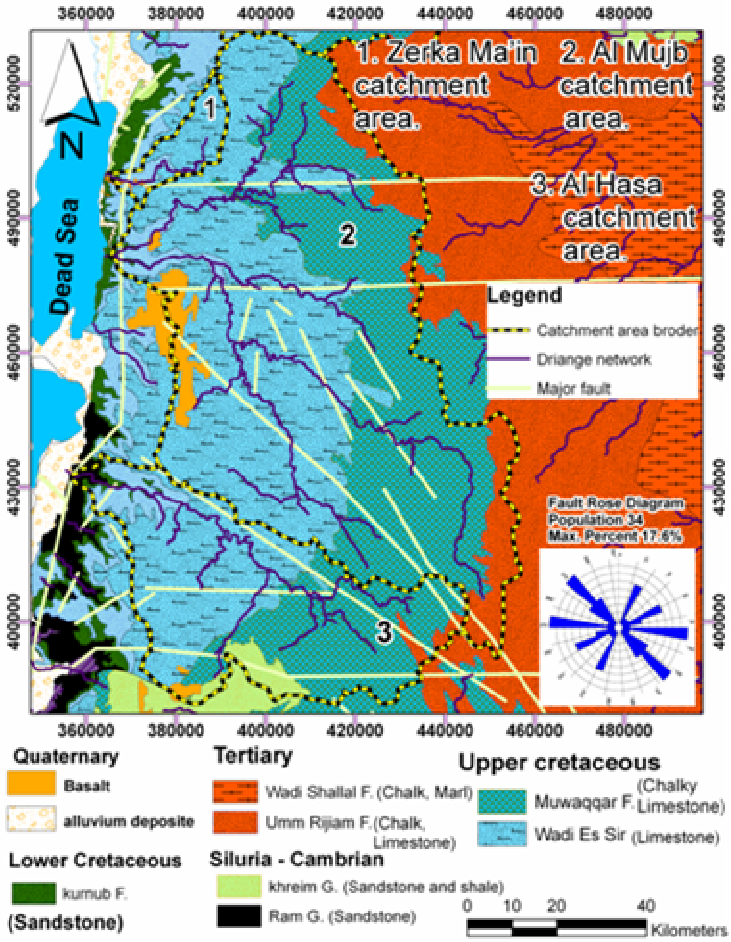

Fig.2: Geological map shows the major fault direction in the studied area. The border between the catchment areas is located on faults.

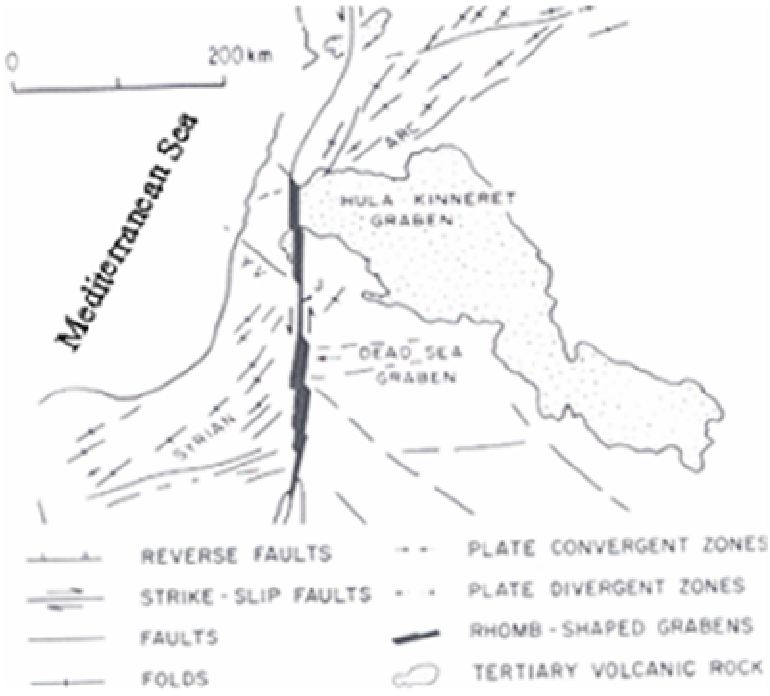

Fig.3: Regional tectonic setting of the Dead Sea (after Garfunkel et al., 1981). The major regional faults are in two directions NW-SE and W- E.

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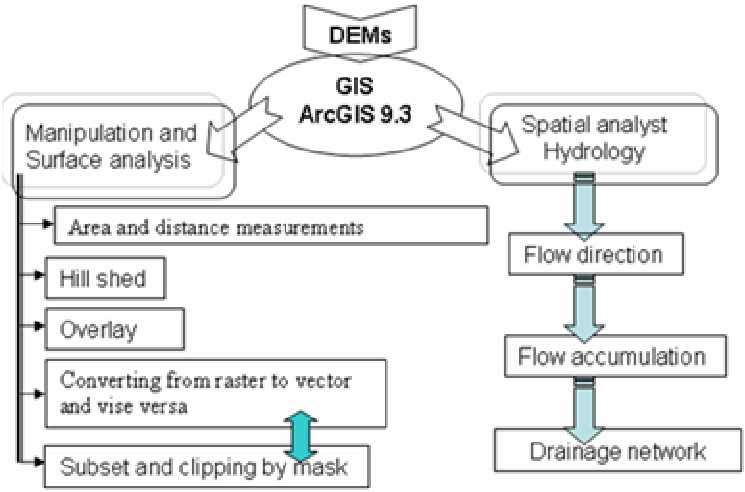

Fig.4: Simplified flow chart for using GIS. GIS has a strong capacity for manipulating and analyzing the surface data.

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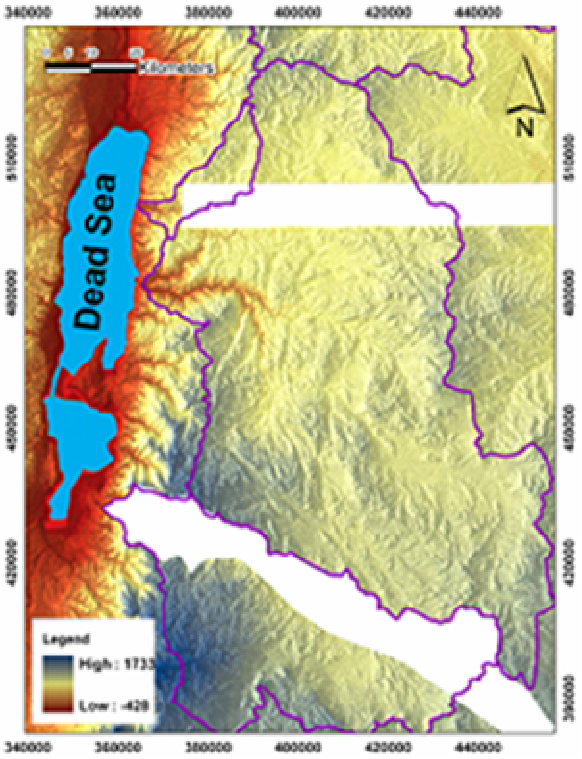
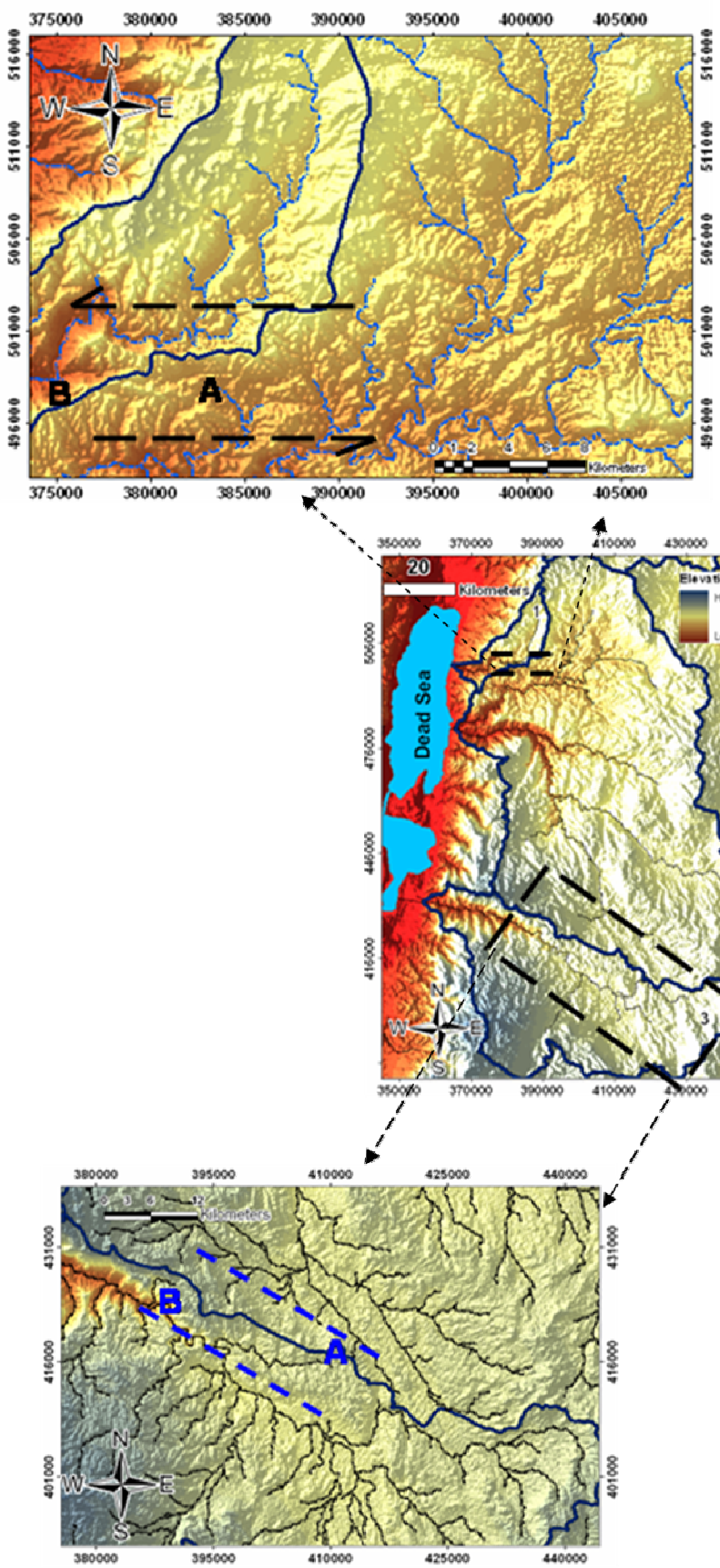


Fig.5: Clipped DEM using ArcGIS.

4 Discussion and conclusion

There are three major catchment areas at the eastern side of the Dead Sea. Wadi Al Mujb catchment area is the largest one with an extent of about 6596 km². Wadi Zerk Ma'in is the smallest with an area of about 272 km² while Wadi Al Hasa has an area of about 2520 km². Before middle Miocene, all the three catchment areas were unified in one large catchment area with an extent of about 8781 km². In the middle Miocene, a sinstal strike slip fault with displacement reach up to 24 km was generated as a result of the shear stress in the south of the large catchment area. . The sinstal movement has a direction of NW – SE that was specified through the direction of the drainage network shifting. The spilt drainage network formed an independent catchment area that is called Wadi Al Hasa catchment area. Through this migration process, the size of that large catchment area was reduced from 8781 to 6958 km².

In Pleistocene, with other shear stress, a WSW – ENE dextral strike slip fault with displacement reach up to12 Km was generated in the north of that large catchment area (Fig.6). The drainage network was spelt and Wadi Zerka Ma'in migrated and formed an independence catchment area. The final size of the large catchment area is about 6596 Km² (Fig. 7).



Case number 1:

Dextral strike-slip fault.

The displacement is 12 km from A to B.

The age is Pleistocene.

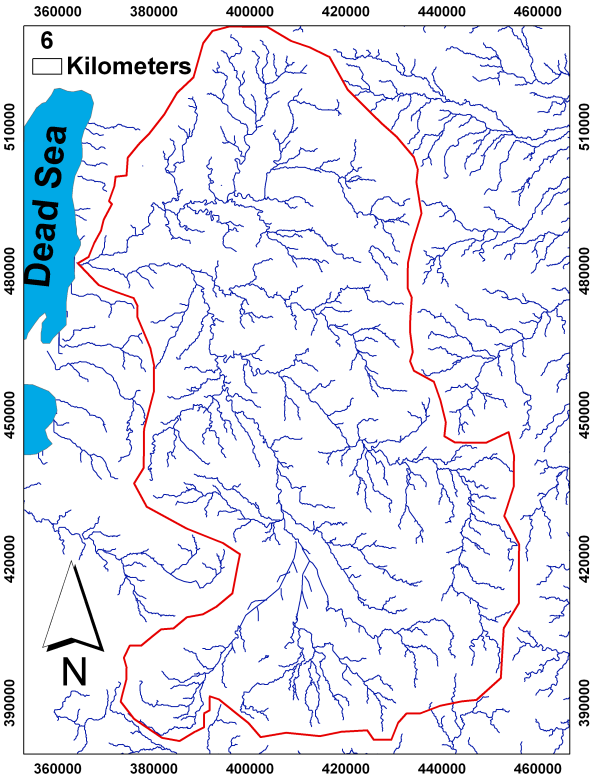
Case number 2:

Sinstral strike-slip fault.

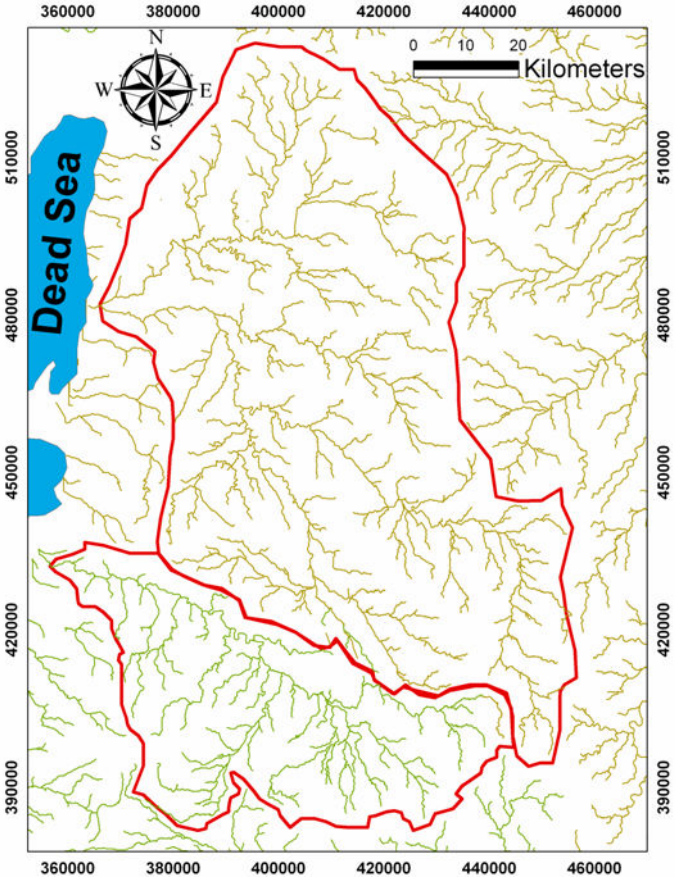
The displacement is 24 Km from B to A.

The age is Middle Miocene.

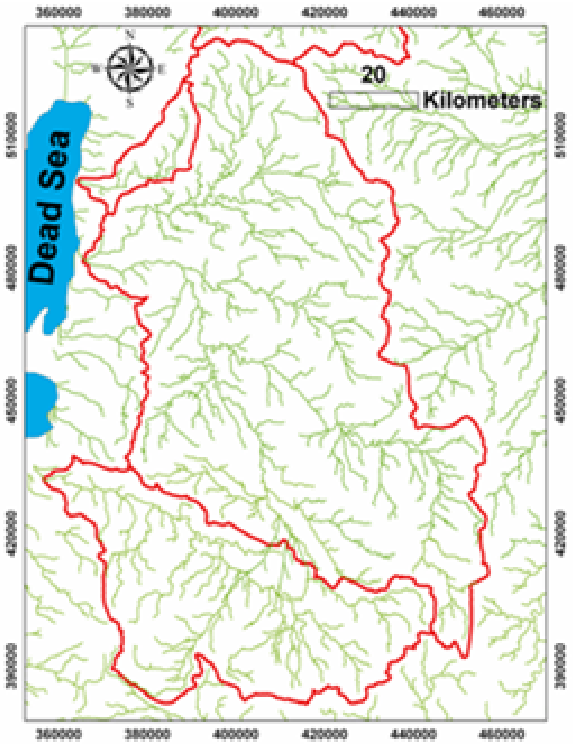
Fig.6: The border area between Wadi Al Mujb and the other tow catchment area has strike slip fault. Case number 1 is between Wadi Almujb and Wadi Zerka Ma'in while case number 2 is between Al Mujb and Wadi Al Hasa.



1) The large catchment area before the middle of the Miocene.



2) The large catchment area after the middle of the Miocene (after the sinsteral strike slip fault).



3) The large catchment area after Pleistocene ,after the sinsteral and the dextral strike slip fault, became three catchement areas.

Fig.7: Simplified model for the catchments area shape and size as a result of the strike slip faults.

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