

HEADS-UP DIGITIZATION OF GEOLOGIC MAPS USING AN INDEPENDENT USER INTERFACE AND CONVERTING INTO THE GIS

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ABSTRACT:

Digitization of the geologic maps is confusing and time consuming process. If the same person is digitizing the data and converting it into the GIS, the way is not so important, but the result is. However, for parallel digitization, which means digitization of two or more geological maps by different users at the same time, user intervention brings confusion problems while converting digitized data into the GIS. For this reason, before initiating the project, the standards of geological map digitization should be well performed. A geological map can contain limited number of common features such as faults, folds, types of formation boundaries and dip-strike measurements. They should be represented with common attributes in all maps. For that reason a task bar is prepared for use in any digitization software that standardizes the attributes of digitized data. This task bar provides the attributes of common geological features. While digitizing, user finds the icon of the feature on the task bar and pushes that button. The attribute is copied into the PC's ram and user pastes it into the necessary field. One advantage of this method is to simplify the digitization process and so it is much faster than non standardized and unorganized digitization. Another advantage is the digitizing may be done by people having no geological background. Using this method, 80 pieces of 1/50,000 scaled geological map are converted into the GIS for about 4 months with two digitizing person.

1. INTRODUCTION

Today Technology forced companies a transition from paper maps to digital maps. That is why the paper maps need to be converted to GIS for many purposes. Some organizations developed their own digitization software and standards. For example, U.S. Geological Survey (USGS) has converted their maps via GSMAP or GSMCAD (Lane et al, 1999).

The digitization of geological maps and converting them into the GIS is a time consuming process which begins with converting the paper maps into raster format of digital world by scanning them.

The stage after scanning geological maps is the digitization via mouse or equivalent hardware in suitable software. In this stage, digital pictures of geological maps having only visual significance is converted into digital, smart, geological maps.

Digitizing geological maps of a wide area including tens of map sheets is a time consuming effort for a person. On the other hand the resultant errors would be consistent and personal. If digitization and converting into the GIS were done by same person, it would even not be necessary to follow a stable procedure.

The digitization of many sheets of geological maps with two or more people (parallel digitization) will reduce the digitization time. However, the variety of errors will increase and the time of converting data into GIS will increase also.

Standardization of digitization will decrease or remove many resultant errors. For this reason, before digitization, all geological features on maps are determined and grouped. Geological maps are including limited amount of features such

as faults, folds, formation boundaries, dip and strike measurements. In order to decrease the time of converting digitized data into GIS, all digitizing people should state those features identically.

2. PREREQUISITS AND METHODOLOGY

Before digitization of geological maps, the information in them was divided into two main groups. Attribute of formations were expressed by points that were placed into the formation polygon. Dips and strikes should have been expressed by points also. However they were initially digitized as straight lines having two vertices. All other features in the geological maps were digitized as lines. Polygons were constructed at the time of conversion of digitized lines into the GIS.

NDS – NeuroMap was the digitization software in this study. Nevertheless any other digitization software might have been used.

2.1 Point Data

2.1.1 Formation Attributes

A point was digitized within the polygon of the formation in order to enter the name or attributes of the formation into the related fields.

2.2 Line Data

2.2.1 Formation Boundaries

Four types of formation boundaries exist in the geological maps of the project area (Fig. 1). "Definite" formation boundaries are boundaries that the geologist observed in the field and

expressed this boundary with a continuous line on the map. Second type of formation boundaries defined as dashed lines on the map. Those are “probable” boundaries and they represent the expected place of the boundary which can not directly be observed in the field. Sometimes geologists do not finish the formation polygons because of the field conditions or because they are out of area of interest. Those types of unfinished formation polygons which are the third type of boundaries are problem while converting digitized data into the GIS. In order to define the formation as a polygon, those types of boundaries were digitized also and expressed as “Not Exist” in the attribute table. The last type of formation boundaries in our geological maps are “Faults”.

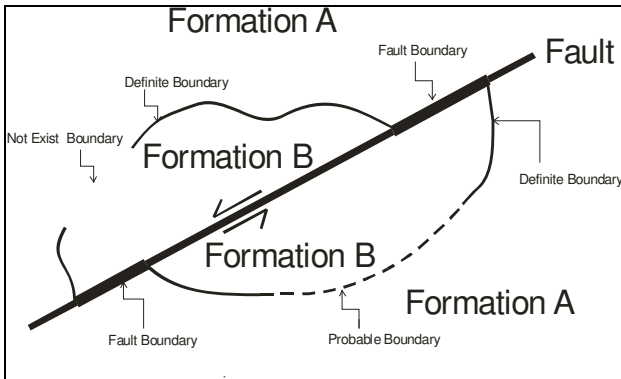


Figure 1. Types of formation boundaries

As a result all of the formation boundary types are shown in table 1.

| | |
|--------------------|--|
| Table Name | Baoundary |
| Field Name | Status |
| Entered Attributes | Definite Probable Not Exist Fault |

Table 1. Attributes of formation boundaries entered during digitization

2.2.2 Structural Features

Structural features of the geological maps were expressed in three items. Those are faults, folds and dip-strike measurements.

The direction of lines expressing structural features contains information. For that reason, direction of the lines is also considered during digitization. For example, a right lateral strike-slip fault is always digitized from left to right. By this way, cartographical symbols can be placed by scripts within GIS.

2.2.2.1 Faults

The faults (Fig. 2) that were indicated as straight lines on the map are observed in the field. Those types of faults are named as “Definite Fault”. Faults indicated with dashed-lines are named as “Probable Faults”.

| Definite | Probable |
|---------------------------|---------------------------|
| Right Lateral Strike-Slip | Right Lateral Strike-Slip |
| Left Lateral Strike-Slip | Left Lateral Strike-Slip |
| Low Angle Thrust | Low Angle Thrust |
| High Angle Thrust | High Angle Thrust |
| Normal | Normal |
| Normal | Normal |
| Normal | Normal |

Figure 2. The symbols of faults represented on the geological maps and their meanings.

2.2.2.2 Folds

Folds are structural features which are represented on geological maps by their axis. If a fold is observed in the field and/or using other geological properties it is named as “Definite” and represented by a straight line on the map. On the other hand if the axis is not definite at the field, it is represented by dashed line on the map and it is named as “Probable” (Fig 3).

| Definite | Probable |
|----------------------|----------------------|
| Anticlinal | Anticlinal |
| Synclinal | Synclinal |
| Overtuned Anticlinal | Overtuned Anticlinal |
| Overtuned Synclinal | Overtuned Synclinal |

Figure 3. Symbols of fold axis represented on the geological maps and their meanings.

As a result while digitization of structural features all of the entered attributes are shown in table 2.

| NAME | STRUCTURE | PROPERTY | STATUS | SIGN | RESULT |
|-------|-----------|---------------|----------|------|--------|
| FAULT | FAULT | | DEFINITE | NO | |
| FAULT | FAULT | | PROBABLE | NO | |
| FAULT | FAULT | RIGHT LATERAL | DEFINITE | YES | |
| FAULT | FAULT | RIGHT LATERAL | PROBABLE | YES | |
| FAULT | FAULT | LEFT LATERAL | DEFINITE | YES | |
| FAULT | FAULT | LEFT LATERAL | PROBABLE | YES | |
| FAULT | FAULT | NORMAL | DEFINITE | YES | |
| FAULT | FAULT | NORMAL | PROBABLE | YES | |
| FAULT | FAULT | AY | DEFINITE | YES | |
| FAULT | FAULT | AY | PROBABLE | YES | |
| FAULT | FAULT | + | DEFINITE | YES | |
| FAULT | FAULT | + | PROBABLE | YES | |
| FAULT | FAULT | LA THRUST | DEFINITE | YES | |
| FAULT | FAULT | LA THRUST | PROBABLE | YES | |
| FAULT | FAULT | HA THRUST | DEFINITE | YES | |
| FAULT | FAULT | HA THRUST | PROBABLE | YES | |
| FOLD | FOLD | | DEFINITE | NO | |
| FOLD | FOLD | | PROBABLE | NO | |
| FOLD | FOLD | ANTICLINAL | DEFINITE | YES | |
| FOLD | FOLD | ANTICLINAL | PROBABLE | YES | |
| FOLD | FOLD | SYNCLINAL | DEFINITE | YES | |

| | | | | | |
|--|------|---------------|----------|-----|--|
| | FOLD | SYNCLINAL | PROBABLE | YES | |
| | FOLD | OT ANTICLINAL | DEFINITE | YES | |
| | FOLD | OT ANTICLINAL | PROBABLE | YES | |
| | FOLD | OT SYNCLINAL | DEFINITE | YES | |
| | FOLD | OT SYNCLINAL | PROBABLE | YES | |

Table 2. Attributes of structural features entered during digitization and their meaning.

2.2.2.3 Strike-Dip Measurements

The strike-dip notations are composed of three parts. First is the strike line which is the longest one. Second indicates the direction of dip and it is the shorter line. Third one is an angle indicating the dip amount. Only strike is digitized with end points and the sequence of digitization is according to dip direction so that dip direction should always at the right hand side (Fig. 4). The angle of dip amount is then entered into the related field.

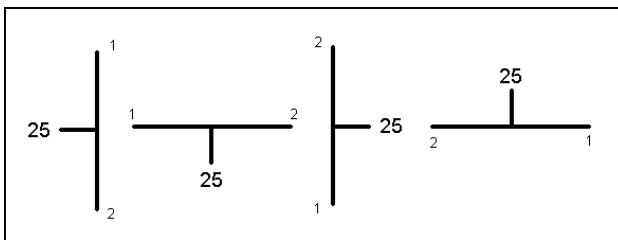


Figure 4. Digitization procedure of strikes in several positions. Numbers at end points correspond to the digitization order.

Strike and dip notations can be represented by a point feature in GIS. So during the conversion process, the centre point of strikes would be calculated. The angle of strike would also be calculated and entered to the related field.

3. GEOLOGIC FEATURE ATTRIBUTE INTERFACE (GFAI) AND APPLICATION

While digitizing the geological features stated above, GFAI is developed in order to help the digitizing person and maximize the standardization. It is independent from any other software except operating system. That is why it can be used in any digitization software (Fig. 5).

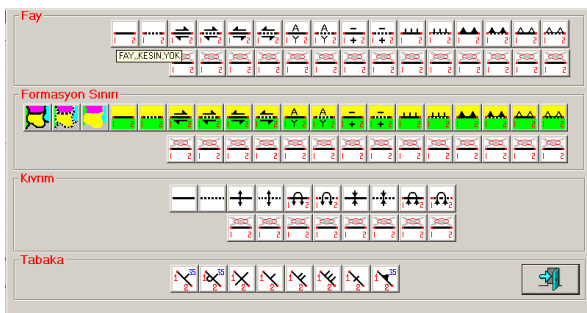


Figure 5. The geologic feature attribute interface (GFAI).

User does not see the GFAI during the digitization unless the mouse is pointed to the top of the screen (Fig. 6). The digitizing person presses the related button on the GFAI according to the geological feature that is digitized. When the button is pressed, the information about that feature is copied into the ram. Then the user pastes it into the related field at the digitizing software.

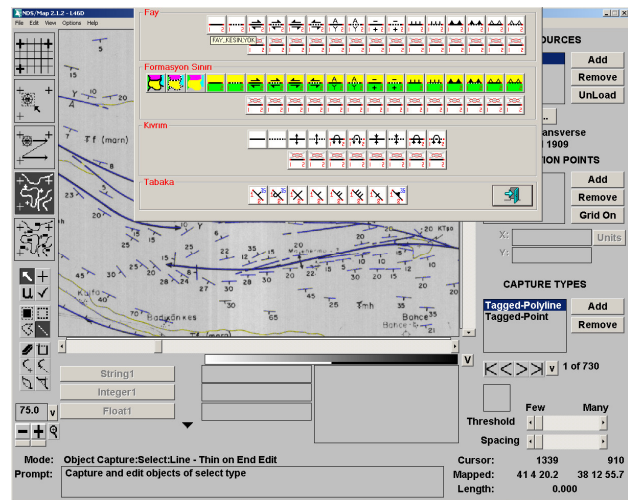
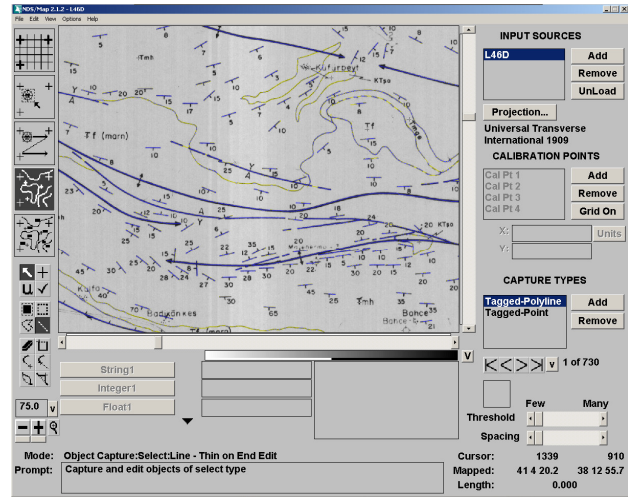


Figure 6. The screen captures during the digitization and after the GFAI appears.

For example if the captured geologic feature is a formation boundary and it is a right lateral strike slip fault at the same time, the user finds the same feature on the GFAI and presses on that button. A string such as "FORMATION BOUNDARY, FAULT, RIGHT LATERAL STRIKE-SLIP, DEFINITE, YES" is copied to the ram. User pastes it to the field of captured feature. It saves time because the user does not repeatedly write the same string every time when the same feature is met. The ability to make a mistake is also decreased with this tool.

In this project ARCVIEW shape format is used to export digitized data as NDSMap digitization software supports it.

At the end of digitization, point layer containing the name of formations and a line layer containing all other features for each map sheet is exported. The next step is to import those layers into the GIS and to pick the dip-strike measurements, tectonic features and formation boundary information to separate layers which is much simpler and easier than before because of the standardized explanation of all features.

4. CONCLUSION

To convert digitized geological map sheets into GIS is a time consuming and difficult process when there is many map sheets and more than one digitizing person. The standardization of digitization is necessary in such cases. The GFAI presented here

standardize the resultant digitized data and decrease the user intervention and hence decrease the possibility to make mistakes while digitization.

The 80 map sheets of Thrace Basin (NW of Turkey) are digitized using the GFAI and all of them were converted into GIS (Fig. 7).

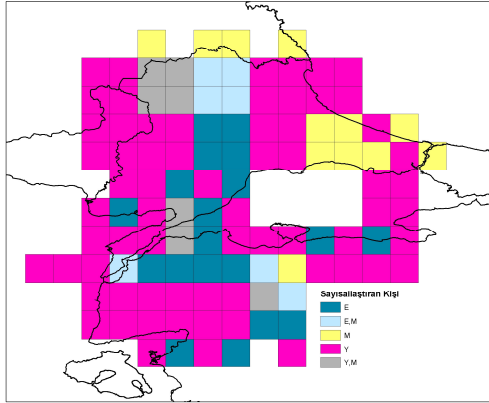


Figure 7. 80 Map sheets of Thrace Basin digitized which were digitized using the GFAI. Different colours show sheets digitized by different person.

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REFERENCES

Lane, D.E., Donatich, A., Brunstein, F.C., Shock, N.A., 1999, Digital Geological Map Production and Database Development in the Central Publications Group of Geological U.S. Geological Survey, Digital Mapping Techniques '99 – Workshop Proceedings, U.S. Geological Survey Open-File Report 99-386. <http://pubs.usgs.gov/of/of99-386/lane.html> (accessed 28 Apr. 2003)