

## CHAPTER 8

# Creating an engineering geological data base

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### Summary

There are several methods that can be applied for the construction of an engineering geological data-base. The most used method is to interpolate between existing boreholes in an area. However, when boreholes are scarce, or the terrain is very heterogeneous, this is not a good solution. In such situations use could be made of geomorphologic information, and an engineering geological data base can be constructed by logical reasoning. The material map is calculated according to the so-called sequence method.

### Getting started

The data for this case study are stored on the ILWIS 2.1 CD-ROM in the directory d:\appguide\chap08. If you have already installed the data on your hard-disk, you should start up ILWIS and change to the subdirectory where the data files for this chapter are stored, c:\ilwis21\data\appguide\chap08. If you did not install the data for this case study yet, please run the ILWIS installation program (see ILWIS Installation Guide).



- Double-click the ILWIS program icon in the ILWIS program group.
- Change the working drive and the working directory until you are in the directory c:\ilwis21\data\appguide\chap08.

Now you are ready to start the exercises of this case study.

## 8.1 Introduction

The *sequence method* considers all the material sequences in the area as standard sequences. The standard sequences are a result of the statistical analysis of the sampling points, which have been obtained during field work. The eight sequences occurring in the area around the city of Manizales, in central Colombia (South America) are given in Table 8.1.

Table 8.1: Standard sequences of materials (\*) This can also be followed by residual soil, depending on the terrain characteristics

Sequence	Layer1: Mat1	Layer2: Mat2	Layer3: Mat3	Layer4: Mat4
1	Volcanic ash	Residual soil	Weathered rock	Fresh rock
2	Residual soil	Weathered rock	Fresh rock	fresh rock
3	Weathered rock	Fresh rock	Fresh rock	Fresh rock
4	Fresh rock	Fresh rock	Fresh rock	Fresh rock
5	Colluvium	Residual soil	Weathered rock	Fresh rock
6	Alluvial material	Weathered rock	Fresh rock	Fresh rock
7	Normal fill	Volcanic ash (*)	Residual soil	Weathered rock
8	Hydraulic fill	Volcanic ash (*)	Residual soil	Weathered rock

In this exercise you are going to construct four different maps, displaying the layers 1 to 4. The material in each of the layers is obtained by combining five input maps: a geomorphological map, a fill thickness map, a colluvial thickness map, an ash thickness map and a slope map, and by taking into account the material in the layer above (figure 8.1).

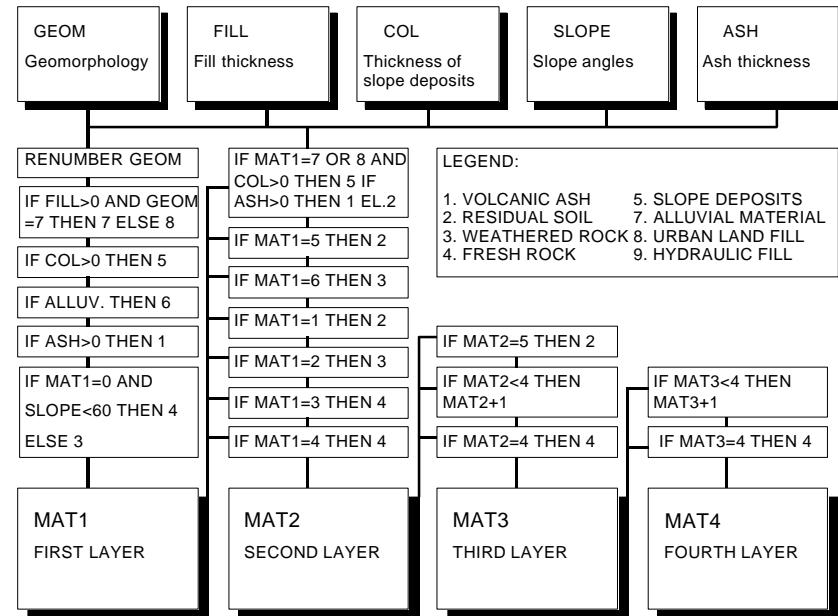


Figure 8.1: Scheme of the analysis

## 8.2 Visualization of the input data

The maps are from the city of Manizales in the Caldas department in Central Colombia (figure 8.2). The following maps are available:

Mani3d1	Three dimensional view of the city of Manizales.
Manigeom	Geomorphologic map (with accompanying table).
Slope89	Slope angles derived from a DTM, based on a topomap of 1989.
Bound89	Boundary of the area covered by topomaps from 1989.
Colt	Thickness of slope deposits in meters. This map is made by map modeling using multitemporal landslide maps and the geomorphologic map.
Fillt	Thickness of fill material. Manizales contains a large number of landfills, some of which are very thick. The thickness was calculated by overlaying two DTM's. An old one from 1949 and a recent one from 1989.
Asht	Thickness of volcanic ash deposits in the area. This map was also derived by map modeling, from field observations and several input maps.
Mzgeol	Raster maps with the geological units.



Figure 8.2: Location of the city of Manizales



- Display all maps, look at the meaning of the different units, and use the pixel information window to consult more maps at the same time.

### 8.3 Creating 4 material maps

In the following section the different steps indicated in figure 8.1 are followed exactly. Four material maps are made, using conditional statements and the input maps Manigeom, Asht, Fillt, and Colt.

#### 8.3.1 Creating the upper layer: Mat1

First the map displaying surface material is made: Mat1. Follow the steps taken from figure 8.1, left column leading to Mat1.

##### Step 1: Renumbering the map Manigeom

The table Manigeom contains a column called Material. This column contains the most probable material type for each geomorphologic unit.



- Renumber the map Manigeom with the column Material. The output map name should be Mat1a.

##### Step 2: If there is fill material, then select whether it is normal or hydraulic fill

The map Fillt contains the thickness of landfill in the city. There are two types of landfill in Manizales: “normal fill”, made by bulldozers, and “hydraulic fill”, which is made by washing down soil into a dammed valley, which gets filled up. The two types of fill behave very different in geotechnical sense, and should therefore be separated in the engineering geological map. The information on the type of fill can be obtained from the geomorphologic map (column Material). In the previous step you have created a map showing the material types: Mat1a

If there is fill material ( $\text{Fillt} > 0$ ) and the geomorphologic map indicates that it is hydraulic fill, ( $\text{Mat1a} = \text{“Hydraulic fill”}$ ) then the resulting map unit should be named “Hydraulic fill”. If there is fill material, but the geomorphologic map indicates it is normal fill ( $\text{Mat1a} = \text{“Normal fill”}$ ), then the resulting map unit should be named “Normal fill”.

If there is no fill material ( $\text{Fillt} = 0$ ) then the resulting map unit should be named “Unknown”.



- Design the map calculation formula yourself to do this. The output map name should be Mat1b.

**Step 3:**

If there are slope deposits, as can be found from the map Colt (containing the thickness of slope deposits) and the result of the previous step is “Unknown”, then the map Mat1b is renumbered to “Slope deposits”, otherwise no change is made.



- Design the map calculation formula yourself to do this. The output map name should be Mat1c.

**Step 4:**

If there is alluvial material, as can be found from the column material, linked to the map Manigeom and the result of the previous step is “Unknown” then the output is “Alluvial”, otherwise no change is made.



- Design the map calculation formula yourself to do this. The output map name should be Mat1d.

**Step 5:**

If there is a cover of volcanic ashes, which can be found from the map Asht, and the result of the previous step is “Unknown” then the output is “Volcanic ash”, otherwise no change is made.



- Design the map calculation formula yourself to do this. The output map name should be Mat1e.

**Step 6:**

If the area is outside of the boundary of 1989, then the output is “Unknown”. If not, and the result of the previous step is “Unknown”, then we look whether the slope is lower than 60 degrees (map: Slope89). If that is so, the output is

“Residual soil”, and otherwise “Weathered rock”. If the result of the previous step is not “Unknown”, no change is made.



- Design the map calculation formula yourself to do this. The output map name should be Mat1.

The first map, displaying the surface materials is finished now.

### 8.3.2 Creating the second layer: Mat

Now the map displaying the material below the surface material is made: Mat2. Follow the steps taken from figure 8.1, second left column leading to Mat2.

#### Step 1:

If the first layer is either “Normal fill” or “Hydraulic fill”, then we look whether there are “Slope deposits”. This we evaluate from the map colt. If so then the second layer is assigned “Slope deposits”. If not, then we look whether there are “Volcanic ash”. We do that from the map Asht. If there are volcanic ashes then the second layer assigned as “Volcanic ash”, otherwise it is assigned as “Residual soil”. If there is no fill, the result is assigned “Unknown”.



- Design the map calculation formula yourself to do this. The output map name should be Mat2a.

#### Step 2:

If the first layer is “Slope deposits”, then the second one is “Residual soil”. If not, nothing is changed.



- Design the map calculation formula yourself to do this. The output map name should be Mat2b.

#### Step 3:

If the first layer is “Alluvial”, then the second one is “Weathered rock”. If not, no change.



- Design the map calculation formula yourself to do this. The output map name should be Mat2c.

**Step 4:**

If the first layer is “Weathered rock”, then the second one is “Fresh rock”. If not, no change.



- Design the map calculation formula yourself to do this. The output map name should be Mat2d.

**Step 5:**

If the first layer is “Residual soil”, then the second one is “Weathered rock”. If not, no change.



- Design the map calculation formula yourself to do this. The output map name should be Mat2e.

**Step 6:**

If the first layer is “Volcanic ash”, then the second one is “Residual soil”. If not, no change.



- Design the map calculation formula yourself to do this. The output map name should be Mat2f.

**Step 7:**

If the area is within the boundary of 1989, then the result of the previous step is taken. Otherwise a value of “Unknown” is assigned.



- Design the map calculation formula yourself to do this. The output

map name should be Mat2.

Now also the second layer map is finished.

### 8.3.3 Creating the third layer map: Mat3

Now the map displaying the third material below the surface is made: Mat3. Follow the steps taken from figure 8.1, second right column leading to Mat2.

#### Steps 1, 2 and 3 combined (Figure 8.1):

If the second layer is “Volcanic ash”, the third is “Residual soil”. If the second layer is “Residual soil”, the third layer is “Weathered rock”. If the second layer is “Weathered rock”, the third is “Fresh rock”. If the second layer is “Fresh rock”, the third one as well. If the second layer is “Slope deposits”, the third is “Residual soil”.



- Design the map calculation formula yourself to do this. You can do it either with one formula, or in a few steps. The output map name should be Mat3.

### 8.3.4 Creating the forth layer map: Mat4

Now the map displaying the fourth material below the surface is made: Mat4. Follow the steps taken from figure 8.1, first right column leading to Mat4.

#### Steps 1 and 2 combined (Figure 8.1):

If the third layer is “Volcanic ash”, the fourth is “Residual soil”. If the third layer is “Residual soil”, the fourth layer is “Weathered rock”. If the third layer is “Weathered rock”, the fourth is “Fresh rock”. If the third layer is “Fresh rock”, the fourth one as well.



- Design the map calculation formula yourself to do this. You can do it either in one step, with a complicated formula, or in a several steps. The output map name should be Mat4.

Now the four maps are ready and we can read the results.

### 8.3.5 Evaluating the result

Now that the four maps have been created, display the results.



- Display the maps Mat1, Mat2, Mat3 and Mat4 in four different windows on your screen.
- Use the PixelInfo to read the four maps together with the input. Check the result.

## 8.4 Differentiating material types according to geology

When you were reading the maps and tables, many times the name "Residual soil", "Weathered rock", "Fresh rock" and "Slope deposits" appeared, without a specification of which lithology they are. To include the information on the lithology, we will have to combine the geological information with the Mat1 - Mat4 maps, so that we can also evaluate that it is "Residual soil from lavas", for example.

The geological units present in the area are displayed Table 8.2. This table is connected to the map Mzgeol. As you can see there are 10 geological units.

Table 8.2: Geological units

Mzgeol	Description
Alluvial	Recent alluvial sediments
Casabianc	Casabianca formation: Tertiary fluvio-volcanic sediments
Gabbro	Metamorphic gabbros in the North of Manizales
Manistrong	Manizales formation: cemented Tertiary debris flows
Manizales	Manizales formation: Tertiary fluvio-volcanic sediments
Manizcol	Colluvial material derived from the Manizales formation
Quebradagran	Quebradagrande formation: Cherts, grauwackes, sandstones, black shales etc.
Sancancio	Quaternary andesitic lavas in the San Cancio dome
Terracechin	Quaternary debris flow deposits in terraces along Chinchina river
Terracemini	Quaternary debris flow deposits in terraces along Chinchina river



- Display the maps Mzgeol and find out the names of the units.
- Open the pixel information window and read the map Mzgeol.

The following observations are important:

- If the material type is "Volcanic ash" than it does not matter which lithology is below, since the volcanic ash cover is not related to the underlying lithology, but comes from a distant volcano. Therefore the combination of Mat= "Volcanic ash" and Mzgeol always obtains the same value:

“Volcanic ash”.

- The same is true for the “Alluvial materials”. They will not be differentiated according to geological type.
- Also the “Normal fills” and the “Hydraulic fills” are not very much related to the underlying lithology. They are mostly consist of removed volcanic ash, with a minor addition of residual soil.
- For the “Residual soils”, “Weathered rocks”, “Fresh rocks”, and “Colluvial materials”, it is important from which lithological units they are.



- Design a method for including the above statements in the construction of four final material maps: Mater1, Mater2, Mater3, and Mater4.  
(Hint: This can be done using a 2-dimensional table or via crossing).
- Open the pixel information window and read the final maps: Mater1, Mater2, Mater3, and Mater4.

### Additional exercise



- Create the analysis as a script.

### References

- Van Westen, C.J., Van Duren, I., Kruse, H.M.G. and Terlien, M.T.J. (1993). *GISSIZ: training package for Geographic Information Systems in Slope Instability Zonation*. ITC-Publication Number 15, ITC, Enschede, The Netherlands. Volume 1: Theory, 245 pp. Volume 2: Exercises, 359 pp. 10 diskettes.
- Van Westen, C.J., Rengers, N., Soeters, R. and Terlien, M.T.J. (1994). An engineering geological data base for mountainous terrain. *Proceedings 7th International IAEG Congress*, Balkema, Rotterdam. pp. 4467-4475.