CHAPTER 12

Geological maps

Key words: Mapping geology, scale, key, cross section.

Introduction

We can study the geology of an area either in the field **and**/**or** using a geological map. Geologists record in the field the variety of geological features and rock and deposit types present, often representing many millions of years of geological evolution, and interpret them, presenting the results as a geological map. By reading this map, people can learn about the geological history of the mapped area. This map shows the distribution of rocks, deposits and geological structures at the Earth's surface – the geological foundation of the mapped area.

12.1. Know how geologists present geological information as a map

By reading a geological map we can be learn about:

- The age of the rocks present and, sometimes even the fossils and minerals they contain.
- The distribution of the rock types present and the position of structures such as faults, folds and unconformities.
- The relationship between older and younger rocks.
- The mineral deposits that rocks may contain.
- The location of many physical features, such as landslides, quarries, springs, caves, **waste-dumps** etc.

12.2. Know about topography and relief

Geological mapping is normally presented as an overlay to a topographical map of the study area. The construction of every geological map, therefore, follows the same basic rules as for the use of a topographical background, including inclusion of a scale and a key (sometimes known as a 'Legend'). The scale of the map is the ratio of the distance between two points on a map and the real distance between the corresponding points on the Earth's surface. For example, a scale of 1/50,000 means that 1 cm on the map represents 50,000 cm – or 500m – on the Earth's surface.

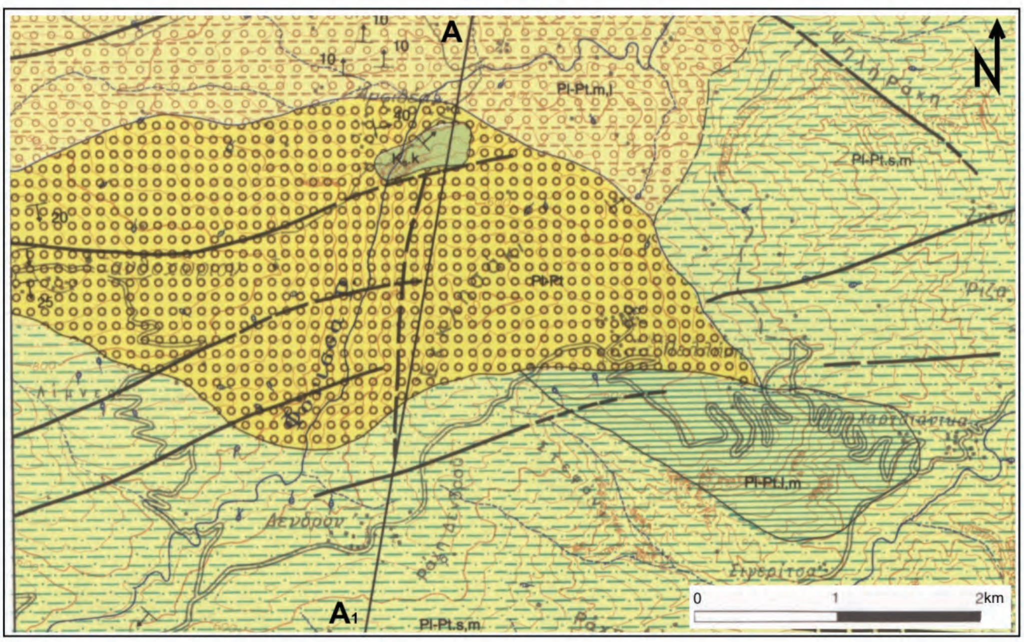
12.3. National and international geological maps

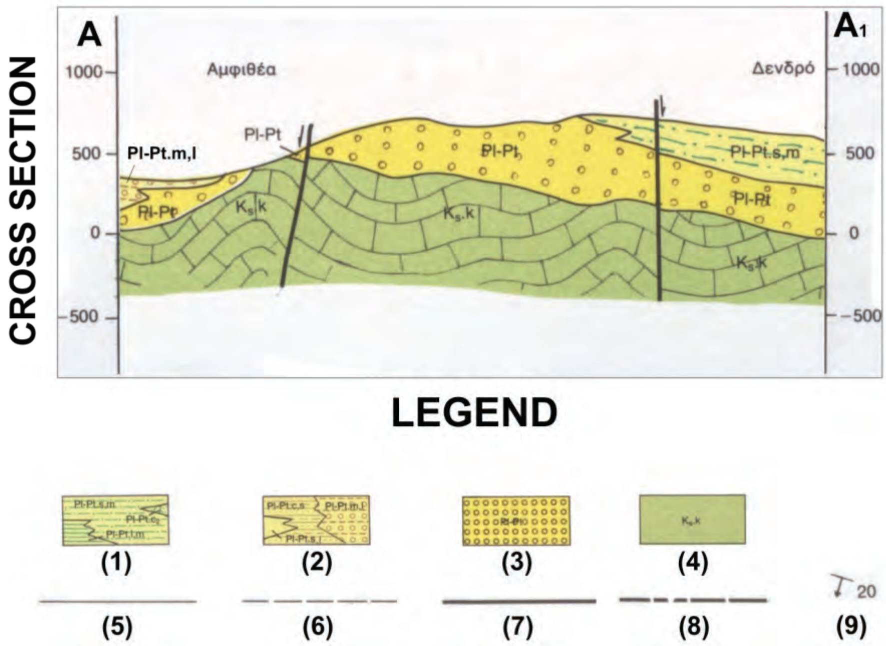
Many countries have national Geological Survey's, often producing local maps at a scale of between 1/50,000 and 1/100,000. This mapping can be compiled together to produce a national map, often at a scale between 1/500,000 and 1/1,000,000 depending on the size of the country. For international or global geological mapping, the scale will be smaller - for instance an International Geological Map of Europe has been produced at 1/1,500,000 and the World Quaternary Map (i.e. recording the distribution of rocks formed during the last 1.8 million years) has a scale of 1/5,000,000. Larger scales of 1/25,000, 1/10,000, 1/5.000, 1/1.000 and even 1/500 are very useful in applied geological studies, where greater detail is needed (e.g. for the construction of roads, dams, landslip monitoring, etc.).

12.4. Know about geological structure

A geological map always has an accompanying key, which explains the abbreviations, symbols, patterns and colours shown on the map. Every marked outcrop of rocks will usually have a special symbol or abbreviation that will usually combine the rock type and geological age, for instance: Mc = 'Miocene conglomerate', Jm = 'Jurassic marble' or CPS = 'Creedy Park Sandstone Formation'. These keys also usually show an idealized geological succession or 'column' for the area, with the rocks and deposits present in chronological order, i.e. with the oldest at the bottom of the column and the younger in their correct order above. The different rock-types shown on the legend are usually marked by a number on the map.

GEOLOGICAL MAP





Excerpt from the "Xylokastron Sheet": part of the geological map of Greece

Key: 1. Sandy marls (Lower Pleistocene), 2. Sandstones and conglomerates (Upper Pliocene), 3. Conglomerates (Upper Pliocene), 4. Limestones (Cretaceous), 5. Geological boundary (observed) 6. geological boundary (inferred, i.e. covered), 7. Fault, 8. Fault (inferred), 9. Dip and strike of beds (i.e. the angle of slope and direction of the geological layers).

Although a conventional printed or digital geological map shows a two dimensional view of the surface of the mapped area, a third, or vertical dimension is provided by geological cross-sections. These cross sections are constructed from the mapped geological information between two points on the map, including information about the shape of the land surface (i.e. the topography), the types of rocks present and their thickness and dip direction, as well as faults and other geological structures.

To construct a cross-section two scales are used - a horizontal scale which is usually the same as the map's scale and a vertical scale that can vary depending on requirements. Typically, however, this latter scale is expanded relative to the horizontal scale to allow more detail to be included, for instance the inclusion of relatively thin but important geological units.

By reading a geological map it can be easy to interpret the past history of the area, by determining 1) the geological events or processes that are recorded and 2) the sequence through time in which these events or processes happened. Three very important principles can help users work out this sequence:

- *The Law of Superposition:* i.e. The rock that lies above another is expected to be younger than the one below (this is always true for sedimentary rocks which have not been overturned by major tectonic events).
- *The Law of Cross Cutting Relationships:* A rock or structure is older than the rock or structure that cuts it across.
- *The law of Inclusions:* A rock *fragment* included in another rock is always older than the host rock.

Geological maps are the main archive of knowledge about the surface of the terrestrial Earth and a fundamental tool for further research and exploration. One of the first true national geological maps published in Europe – with rocks types ordered by their relative geological age – was produced by the canal engineer William Smith for England, Wales and southern Scotland and published in 1815.

Geological Maps are very useful to the our society for applications such as:

- Searching for ground water resources
- Prospecting for mineral or energy resources
- Assessing natural risks
- Looking for building materials
- Locating sites suitable for waste disposal
- Assessing soil quality for agriculture
- Informing dam, road and other major construction projects.

12.5. See the geology of a region from the air

In areas where access might be difficult, geological mapping can be carried out using aerial photographs. Historically these have been taken from aircraft flying at a fixed height in a series of parallel transects. The first aerial photographs, however, date from 1860 and were taken of the city of Paris from a balloon. Today, in addition to aeriel photographs, satellite images are also used, including the well-known ”Landsat” images. Interpretation of satellite images, however, requires special computer processing techniques. Some images are produced by governmental organisations, although commercial companies are also involved. As with aeriel photographs, the early use of satellite imagery was often military, but now they are also used for meteorological, geophysical, telecommunication, landuse and natural resources studies.
This type of survey is known as ‘remote-sensing’ and both aircraft and satellites are still used. Images are recorded with photographic cameras, polyspectral and thermal scanners and radar (microwaves). In geology Landsat and other comparable images can be very useful, for instance for:

- Research into and prospecting for natural resources (e.g. metalliferous and other mineral deposits, hydrographic systems, etc.).
- Identification of fault-zones and landslides areas.
- The selection of sites for major constructions such as dams, bridges, harbours, etc.
- Investigating and monitoring landscape scale change.

Classically, a field geologist would use a simple range of tools to make a geological map, for instance a topographic base map of the region, a notebook, some coloured pencils, a geological hammer, a combined compass and inclinometer for measuring slope angles, magnifying lenses and occasionally an altimeter. Today, however, some of these tools have been replaced or at least supplemented by laptops or netbooks for note taking, GPS devices for determining precise locations and GIS (i.e. Geographic Information System) applications for plotting locations and records. Despite all this technology, however, it is the experience and accuracy of the field mapper that remains the key determining factor as to whether the geological map produced will be reliable, even credible.

Intended learning outcomes:

- Understand the underlying principles of geological mapping.
- Recognise the importance of time and scale in geology.
- Visualize geological data in two and three dimensions (including using cross-sections).
- Recognize the importance of different types of geological maps.
- Describe the basic steps needed to compile a geological map.

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