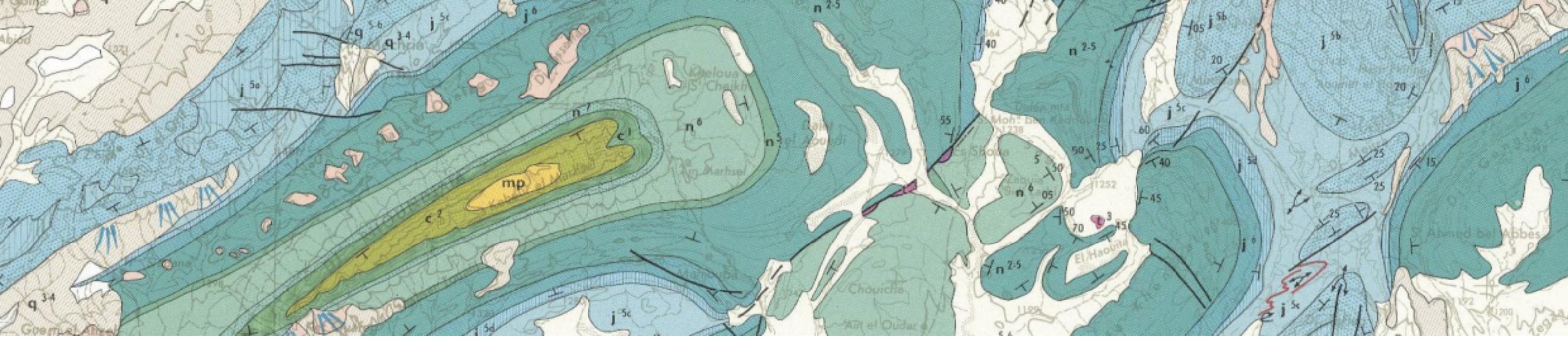


University 8 May 1945 – Guelma (Algeria)

Geology L1 - Tutorials

(Natural and Life Science Specialty)

Geologic map and cross-section

(Mrs. DJERRAB)

Table of content

1. Reminders

1.1. The different types of rocks

There are three types of rocks:

1. **Sedimentary rocks** *(ex: limestone, conglomerate, sandstone, marl, claystone…)*: they are composed of **sediments**[1], which settle in a sedimentary basin. These sediments are mainly the result of **weathering and erosion processes**. They transform into rock under the effect of different processes called **diagenesis**. Sedimentary rocks are arranged in **layers/strata/beds**[2], of varying thickness (from a few centimeters to a few hundred meters). They are **very common at the surface of the Earth** (they cover around 75% of the continental areas).
2. **Igneous (or Magmatic) rocks** *(ex: basalt, granite)*: these rocks are **derived from magma** (= molten rocks). **Volcanic** rocks form during volcanic eruptions (ex: *basalt*), whereas **plutonic** rocks cool slowly inside the Earth (ex: *granite*).
3. **Metamorphic rocks** *(ex: gneiss, shale, marble)*: they **come from the transformation of pre-existing rocks** (of sedimentary, magmatic or metamorphic type); under the effect of the increase in pressure and/or temperature.

1.2. The principles of stratigraphy

The study of strata and their relationship is called **stratigraphy**.
Several fundamental principles are **used in the interpretation of geological maps and in establishing the relative ages of rocks**.
Four of these principles are presented here (although additional ones also exist) :

1. **Original Horizontality**: Sedimentary rocks are originally deposited in flat horizontal layers (and may later be tilted by faults and folding).

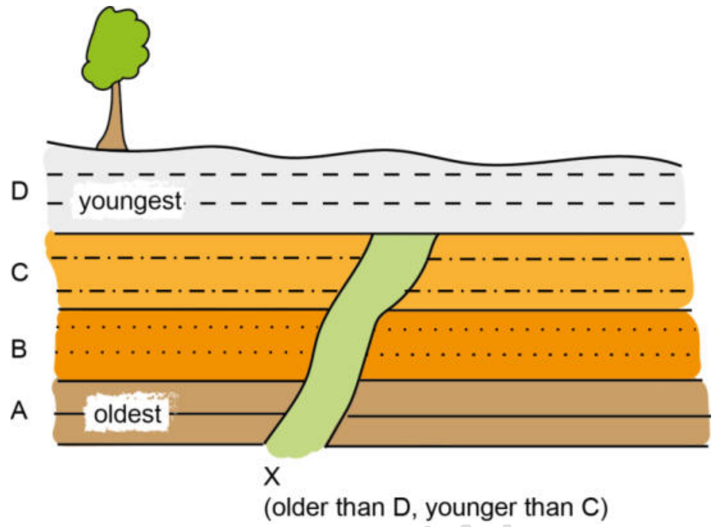
2. **Superposition:** Any sedimentary layer or bed can be assigned an "older" or "younger" age relative to the layers below and above it.

3. **Lateral Continuity:** Layers are originally deposited as continuous layers. So, a layer generally has the same age and the same facies over its entire extent, for example over a geological map (= the same thickness, the same type of rock). The layers may be faulted or removed by erosion after their deposition.

4. **Cross-Cutting Relations**: If a layer or fault cuts across a stratum, then it must have formed <u>after</u> that stratum.

[1] A SEDIMENT is composed of particles of variable size (e.g. sand grains, clay particles, gravels, etc.) that are mainly produced by weathering and erosion processes and subsequently transported, for example, by wind or water. Some sediments may also be of organic origin.
[2] A STRATUM (plur. STRATA) corresponds to a sedimentation unit, with a thickness greater than 1 cm. It can be easily observed on the field (the presence of strata is an important criterion used to identify sedimentary rocks). Synonyms of this word include the terms layer, bed or level.

Figure 1: Illustration of the principles of original horizontality, superposition, and cross-cutting relations.



1.3. Folds and faults

Folds and faults are **deformational structures**, also called **tectonic structures**:

- **Folds** are structures where layering is deformed without breaking so that the layering surfaces are curved but continuous: a fold is defined as **"a curved arrangement of originally parallel surfaces".** There are two main types of folds: **anticlines** (figure below) and **synclines**, which is the opposite shape**.**
- **Faults** represent a different type of response by rocks to the stresses imposed on them. Faults are **fracture surfaces** along which **appreciable displacement** of the layering has taken place: Faults are surfaces in the Earth along which one side moves or has moved with respect to the other. There are three main types of faults according to the type of movement that take place: **normal faults** (observed when there is an extension, of divergence movement), **reverse faults** (when there is a compression, or convergence movement: see figure below) and **strike-slip faults** (when there is a lateral movement).

The study of these structures and deformations is called **Tectonics**.

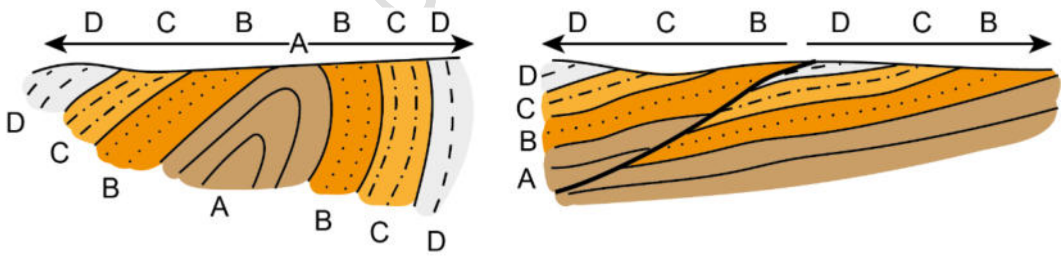


Figure 2: Anticline fold (to the left) and reverse fault (to the right).

1.4. The geologic (or stratigraphic) time scale

The stratigraphic time scale is **a division of geological time based on the study of sedimentary strata** that were deposited successively over time. It can be viewed as a **geological calendar of the Earth**.

The stratigraphic scale is **international and used worldwide**.

It is subdivided into several hierarchical units: **eons** (the longest units), **eras**, **periods** (also called systems), **epochs** (also called series), and **stages** (see figure 3).

The stage is the fundamental unit of the stratigraphic scale. The major divisions of the scale were established primarily through the study of fossils.

Eons	Eras	Periods	Numerical ages (Ma)
Phanerozoic	**Cenozoic** (Tertiary)	Quaternary	
		Neogene	
		Paleogene	66
	Mesozoic (Secondary)	Cretaceous	
		Jurassic	
		Triassic	251
	Paleozoic (Primary)	Permian	
		Carboniferous	
		Devonian	
		Silurian	
		Ordovician	
		Cambrian	538.8
Precambrian – Proterozoic			2500
Precambrian – Archean			4000
Precambrian – Hadean			4600

Figure 3 : Simplified stratigraphic time scale (with major divisions). Ages given in millions of years.

The most widely used standard charts showing the relationships between the various intervals of geologic time is the International Chronostratigraphic Chart, which is maintained by the International Commission on Stratigraphy (ICS): https://stratigraphy.org/

2. Geologic maps

2.1. Definition

Geologic maps represent the **distribution of different types of rock and surficial deposits**[3], as well as **locations of geologic structures such as faults and folds**.

Rock types or unconsolidated materials are depicted **using different colors**. Maps are based on detailed fieldwork in a variety of terrains.
Measurements taken at the surface are used to predict the location of geologic units and structures at depth and these **predictions are shown on cross-sections** (see below).

Why are we using geologic maps?
Geologic maps are **suited to solve problems involving Earth resources, hazards, and environments**.
Geologic maps are the primary source of information for various aspects of land-use planning, including the siting of buildings and transportation systems. Thus, a geologic map is a major tool for communicating geologic information to other geologists, various professionals and also to the public.

2.2. Description

On the map and around the map, lots of information are available, both topographical and geological:

2.2.1. General information

To give the map reader an indication of where features on the map are located in the real world, geologic maps display the geology overlain on a representation of the land surface that is known as a **base map** (it's a topographic map). **Base maps may show streams, roads, and other cultural features,**

[3] Exposures of the bedrock surface are called **outcrops**.

and may also include elevation contour lines that show land surface topography. Base maps all have the goal of getting you oriented and situated on the map.
So, on the map (and its margin), we will find the **same type of information as those present on the topographic map**; for example: the title and number of the map, type of projection used, contour lines and contour interval, geographical grid, scale, magnetic declination, meridians and parallels…

2.2.2. Geologic information

Colors and code

Geologic maps use color to represent various types of geologic features or units (a particular type of rock with a known age range). Geologic units are indicated by colors that can range from yellows and reds to purples and greys. These colors are **standards**, which means that the same colors are always used for the same stratigraphic unit (but you should always refer to the legend to be sure of the meaning of a color):
For example: purple is used for Triassic layers, blue for Jurassic and green for Cretaceous.

In addition to colors, each geological unit is also designated by an abbreviated identifier code.

This is a letter, sometimes accompanied by a superscript or subscript, but the conventions used can differ from map to map.

- **For sedimentary formations,** a letter (from the Latin alphabet) is used to designate the periods, indicating the age of the layer. Each letter may be accompanied by a superscript or a subscript, which allows for further subdivision of the units designated by the letters.
  Ex: k = Cambrian, t = Triassic, j = Middle to Upper Jurassic / j^5 *= Oxfordian,* j^6 *= Kimmeridgian (stages of the Jurassic period, by convention* j^5 *is older than* j^6*)*
- **For recent superficial formations** (Quaternary): *F = alluvial deposits, G = glacial deposits…*
- **For volcanic, plutonic and metamorphic rocks**, we use Greek letters: *β (beta): basalt, ρ (rho): rhyolite, γ (gamma): granite, ξ (ksi) = micaschist, ζ (dzeta) = gneiss …*

Contact and fault lines

When **two geologic units are located next to each other**, the place where they meet is called a **contact**. The two main types of contacts are depositional contacts and faults:

- **Depositional contacts** are indicated by a **thin line**, and correspond to the place where the two units meet. We use dotted lines when the contact is not directly visible on the surface.
- **A fault line** is indicated by a **thick line** (dotted thick lines if the fault is not directly visible on the surface).

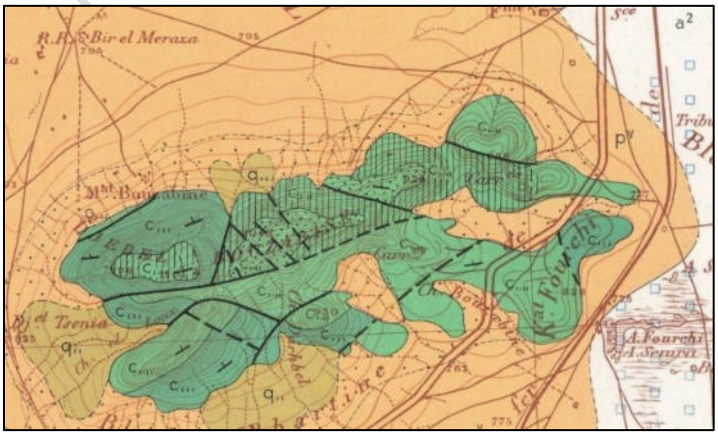


Figure 4 : Extract from a geological map showing the boundaries of different geological layers (thin solid or dashed lines), as well as exposed and concealed faults (thick solid or dashed lines).

Visible layers: Cretaceous (green), Pliocene (orange), Quaternary (white and beige).

Symbols

Various symbols may appear on geological maps, including strike and dip symbols, or folding symbols (Figure 5). Other symbols may be given on the map, such as the location of mineral or fossil deposits, or the location of quarries and mines. Detailed information on dip symbols[4] will be provided later.

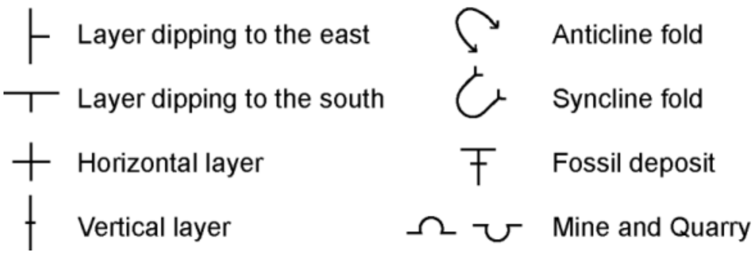


Figure 5 : Examples of symbols found on geological maps (left: dip symbols).

Map key (or legend)

To help the user interpret the map, a legend is always provided. It compiles both general information, previously discussed, and geology-specific information. The legend **explains the meaning of all the symbols used on the map**.

The legend also **includes the list of the geological units present, in the form of small boxes**. Each box represents a unit of a given geological age, with its identifier code and color, and is accompanied by a brief description of the rock type and its age. The boxes are **arranged in stratigraphic order**, with the youngest units at the top and the oldest at the bottom.

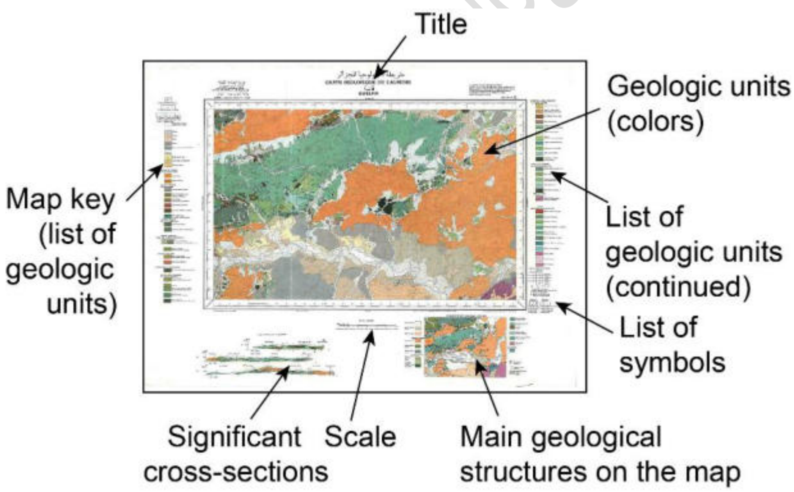


Figure 6 : Main features on a geologic map.

[4] Dip symbols in particular provide information on the inclination of strata relative to a horizontal plane.

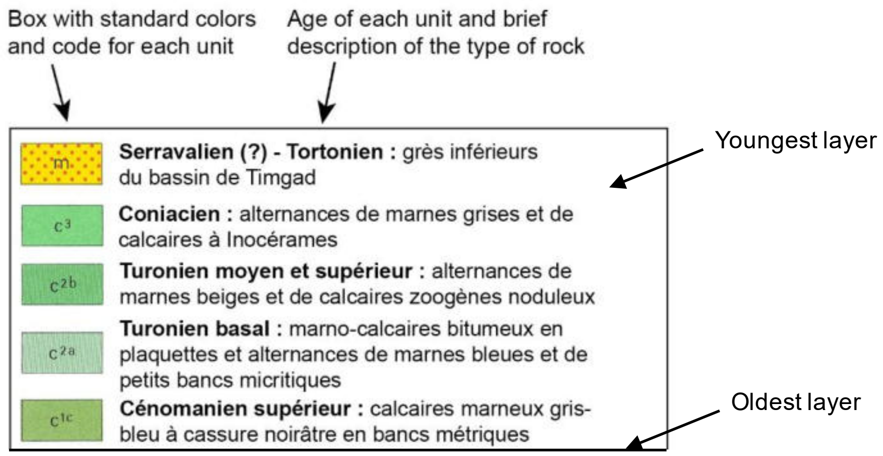


Figure 7 : Legend of a geological map showing the list of the geological units.

Explanatory note

Geological maps are generally **accompanied by a booklet known as an explanatory note**, which **provides information that is often essential but cannot be represented graphically on the map**. This booklet includes, for example, information related to geography (e.g. relief and drainage), the age and thickness of geological layers, the fossils they contain, as well as economically useful materials such as petroleum, coal, and mineral resources.

3. Geological cross-section

3.1. Definition

In geology, a cross-section (or cross section) is a **diagram representing the geologic features intersecting a vertical plane**, and is **used to illustrate an area's structure and stratigraphy** that would otherwise be hidden underground.

The features described in a cross section can include **rock units, faults, topography**, and more. They often accompany geologic maps.
Cross sections are **made by interpreting and extrapolating** a broad range of information about a region's geological characteristics (data from the surface, geologic maps). A lot of information cannot be directly observed, so there is always an **amount of uncertainty about the accuracy** of the final product.
Differences between the topographic profile and the geological cross-section:

- ***For the topographic profile***: no extrapolation / every point is pick off from the map.
- ***For the geological cross-section***: lot of extrapolations / only outcrops visible, hidden strata organization should be understood. It is therefore necessary to understand and interpret.

3.2. Useful information

3.2.1. Strike and dip

The strike and dip of geological layers are **measured in the field using a special compass**. This information is then indicated on geological maps using specific symbols. Knowledge of the dip of layers is essential for constructing a geological cross-section.

The line of strike is the intersection between the bedding plane and the horizontal plane (figure 8). It is measured with reference to north.

The dip is the slope of a geological surface. There are two aspects to the dip of a plane:

- **The direction of dip** is perpendicular to the strike: it is a line at the intersection of a vertical plane and the horizontal plane. It's the direction in which the rock dips: if you were to tilt a bottle of water over the outcrop surface, the little stream of water would run downhill in the direction of dip.
- **The angle of dip (α)** is the angle of inclination, measured from horizontal down to the bedding plane. The angle of dip is an angle between 0° (for horizontal planes) and 90° (for vertical planes). It is not always marked on the map.

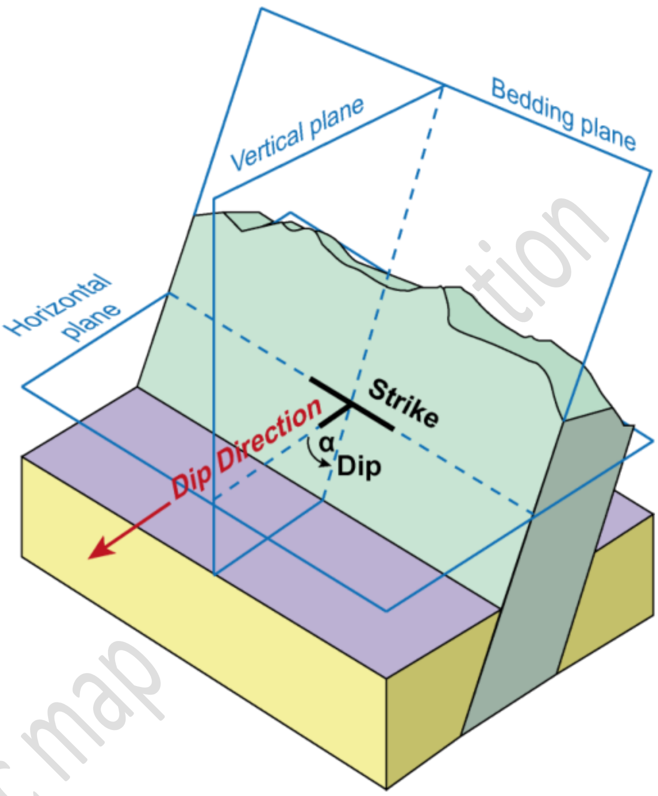


Figure 8 : Measuring the strike and dip (diagram redrawn from (1)).

A T-shaped symbol is used on geological maps to represent dip measurements (Figure 9). The horizontal bar (the longest) of the "T" represents the strike of the layer, and the vertical bar indicates the dip direction (or line of greatest slope). The T-shaped symbol is oriented on the map according to field measurements. The dip angle (α) may be indicated next to the symbol, but this is not systematic. Depending on the maps, these symbols may vary slightly (check the legend).

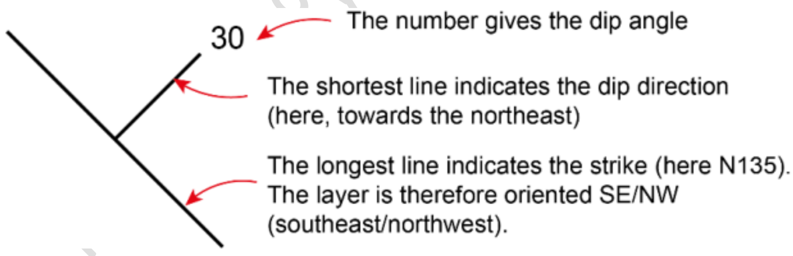


Figure 9 : Explanation of the dip symbol.

If the dip is not indicated, it can be easily estimated by observing the shape of the geological boundaries as they cross the valleys. **This is the 'V' rule**.

- **For horizontal strata** (figure 10.c), the **outcrop trace is parallel** to the topographic contours.
- **For vertical strata** (figure 10.b), the outcrop trace is a **straight line** parallel to the strike; it ignores topographic contours.

- **For dipping strata,** the outcrop traces show **V-shapes as they cross valleys**; these regions are particularly useful in determining strike and dip.
  - In general, the **V-shape points in the direction of dip** (This is the “rule of V”) (see figures 10.a and d). The angle of dip can be estimated from the opening of the ‘V’: the more open it is, the steeper the slope.
  - **The only exception occurs when the dip is in the same direction as the slope of the valley, but gentler than the gradient** of the river; then the V-shapes point up-dip. For planar surfaces with shallow dip (gentler than the typical hill slopes of topography in the region) the outcrop trace will generally follow topographic contours quite closely, crossing them at widely spaced intervals (see figure 10.e).

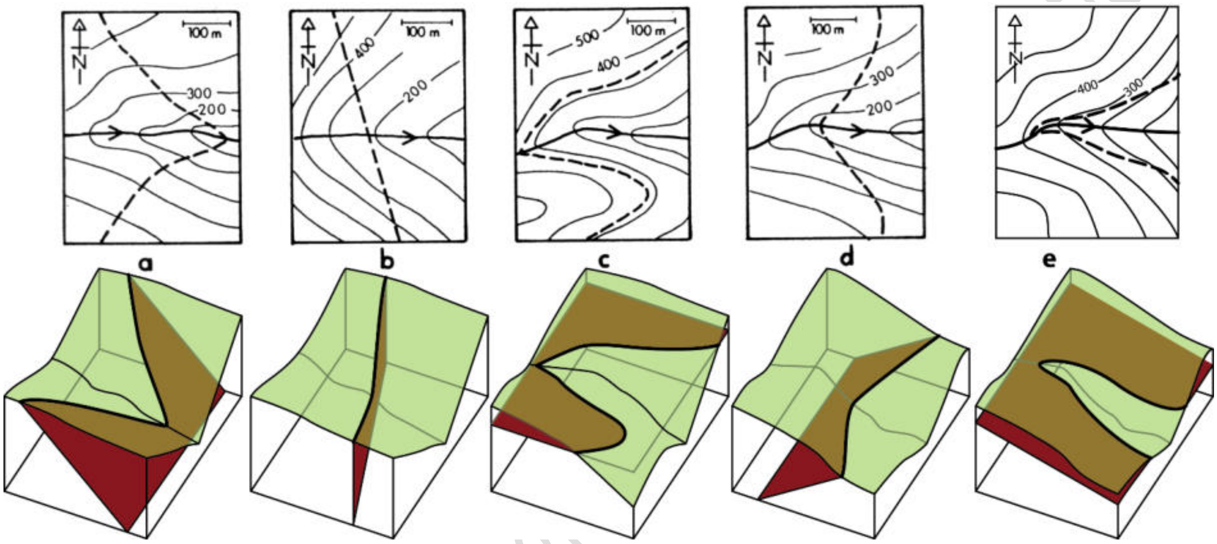


Figure 10 : Sketch maps and block diagrams showing the outcrop traces (dashed lines) of geological surfaces of different orientation: (a) Dip to the east; (b) Vertical; (c) Horizontal; (d) Dip to the west; (e) Dip to the east but less steep than valley (2).

3.2.2. Colors or patterns ?

On the map, the different rocks are identified by colors and letters.
On the cross-section, colors as well as patterns could be used, but:

- **Colors are generally used for a numerical work** (using a computer): they could be combined or not with patterns. But whatever you choose, there are some conventions to respect (standard colors).
- **Patterns (or symbols) are preferred for a traditional work** (using a sheet of paper); indeed, colors are difficult to clearly reproduce.

Which pattern for which rock?

Each kind of rock is represented by a special pattern, usually quite the same all around the world. Different patterns could also be mixed for intermediate rocks.
But keep in mind that:

- **The pattern type should be correctly chosen:** it generally reminds the aspect of the rock (for example small dots for sand, small dashes for clay),

And

- **The pattern disposition on your cross-section should always follow the dip** (see figure below).

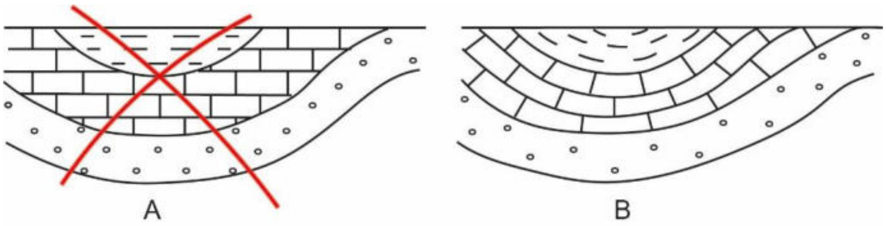


Figure 11 : Pattern disposition.
A : Incorrect. B : Correct.

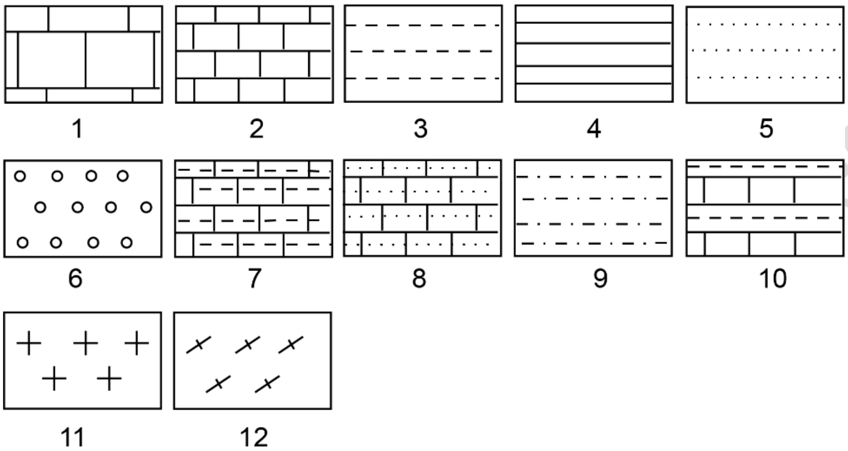


Figure 12 : Examples of geological patterns or symbols.
1 and 2: Limestone (thick or thin beds), 3 and 4: Clay or marl, 5: Sand or sandstone, 6: Gravels or conglomerate, 7: Argillaceous (or shaly) limestone, 8: Sandy limestone, 9: Sandy marl (or argillaceous sand), 10: Interbedded limestone and marl, 11: Granite (magmatic rock), 12: Gneiss (metamorphic rock).

3.2.3. Difference between thickness and width of a layer

On a geologic map, **the thickness of a layer stays the same (according to lateral continuity principle), but its width on the map can vary a lot**.

It **depends on three factors**: the **true thickness** (TT), the **topographic slope** and the **dip**:

- The true or stratigraphic thickness of a unit is the distance between its bounding surfaces measured in a direction perpendicular to these surfaces (see 'TT' on the figure below)
- The width of outcrop ("W") of this unit is usually different from TT. In some case, the width can be equal to TT, but it can be much greater.

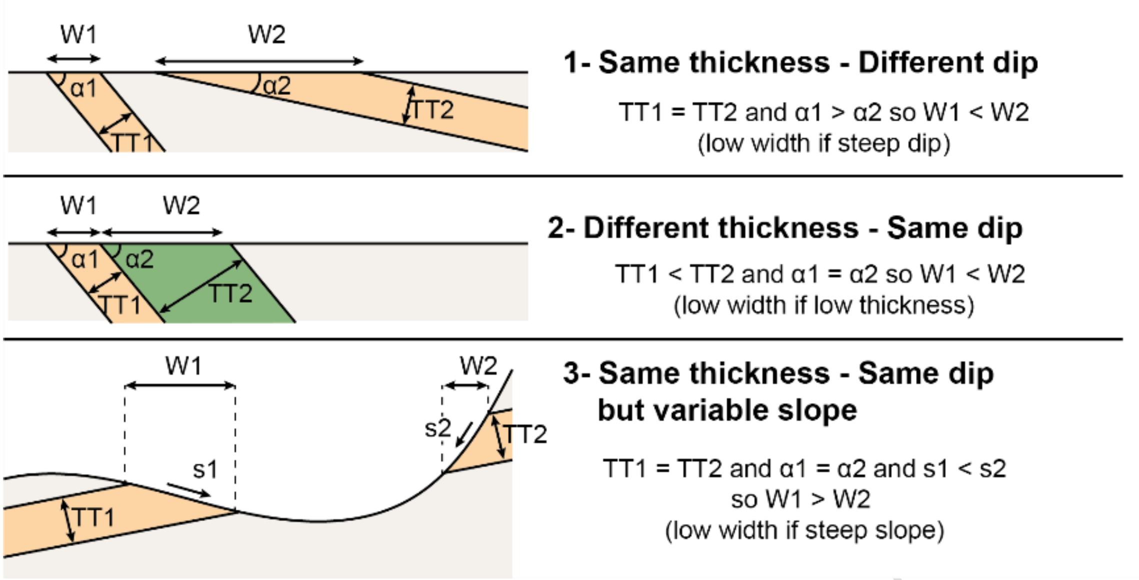


Figure 13 : Different explanation for the width variation.

3.2.4. Determination of the thickness of a layer

To produce a detailed geological cross-section, it is necessary to know the thickness of the layers. Several scenarios are possible:

- The thickness of the layers may simply be indicated **in the map legend or in the accompanying explanatory notes.**
- **When the layers are horizontal** (see Figure 14), their thickness can be determined using contour lines (in this case, it will be necessary to know the contour interval of the map). The thickness of the most recent layer (located on the surface) cannot be determined because erosion may have caused part of it to disappear.
- **When the layers are vertical** (Figure 15A), the thickness can be determined using the map scale (this simply involves calculating the distance between the base and the top of the layer).
- **When the layers are tilted** (Figures 15B and 16), we can use a formula to calculate the thickness. The calculated value depends on two parameters:

TT = W.sin(α), with TT = true thickness, W = outcrop width and α = dip

The dip (α) can be given directly on the map (it can also be calculated), and the outcrop width (W) varies according to the three parameters mentioned in the previous paragraph (dip, layer thickness and topographic slope).

Consequently, this calculation formula can only be used if the terrain is flat (the boundaries of the layer under study must be at the same altitude).

3.2.5. Disposition of the strata

a) Horizontal strata

When sediment is initially deposited, it is laid down in horizontal layers (= strata).

Horizontal bedding usually indicates that **little or no structural deformation** has occurred to a sedimentary succession after deposit. Horizontal bedding may give rise to **very simple geological maps**.

Recognize horizontal strata on a map

- **Depositional contacts are parallel to the contour lines**: their projection on a map **never intersects** the contour lines,
- When the ground is flat (plateau or plain), **only the youngest layer outcrops** and is therefore represented on a geological map,
- The **dip symbols are all identical** (**+**),
- The **oldest layers are visible at the bottom of the valleys**.

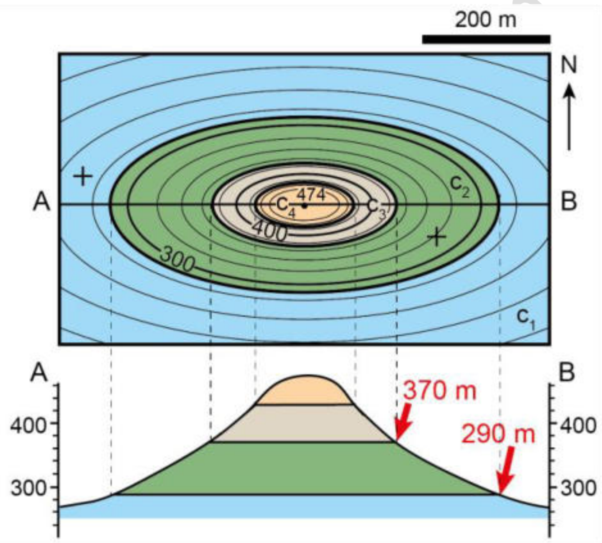


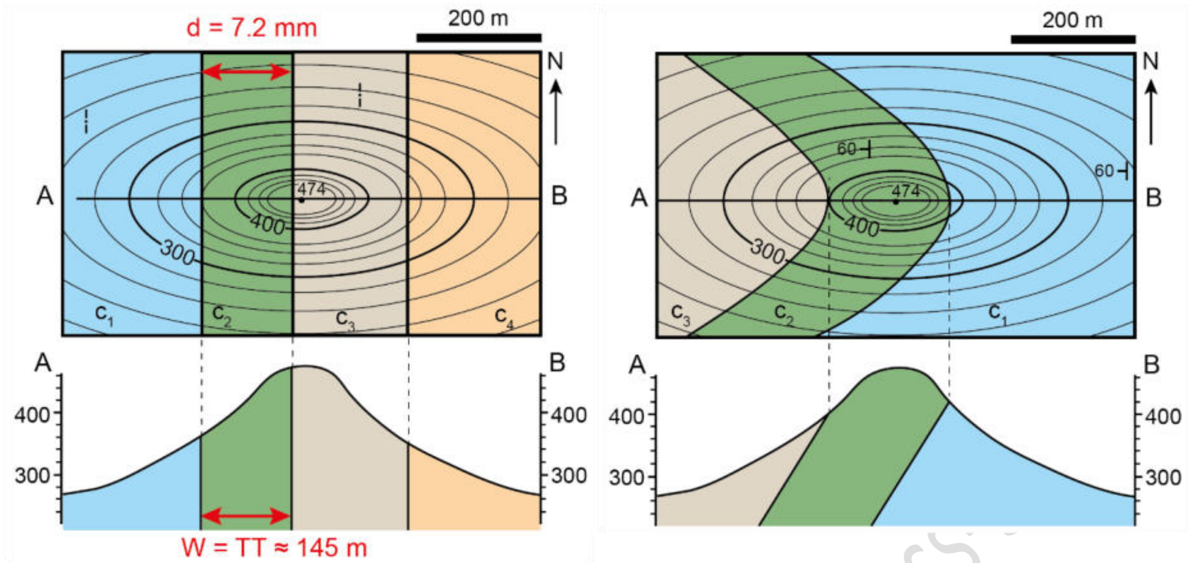
Figure 14 : Horizontal strata, on a map (top) and cross-section (bottom).
The thickness of layer C_2 (in green) is determined using contour lines. It is equal to 80 m.

b) Inclined strata (uniformly dipping beds)

Inclined bedding is the simplest form of rock deformation: strata become tilted relative to their original (horizontal) disposition. In this case, **the orientation of the inclination is the same for all strata**.

Recognize inclined strata on a map

- **The bedding planes are inclined** (could also be **vertical**): their projection on a map **always intersects** the contour lines
- **The dip symbols are all identical** (⊢ or ┼ ╎)
- **When depositional contacts cross valleys**, the contacts are bent, or deflected. The direction and amount of bending depend on the slope of the valley and the dip of the beds. **The Rule of "V"** is helpful for **determining the general dip** of a bed on a geological map or block diagram if it is not shown by a symbol (see figure 10).



A - Vertical strata **B - Inclined strata**

Figure 15 : Inclined strata, on a map (top) and cross-section (bottom).
On the left, the thickness of layer C_2 (in green) is determined using the scale. The distance on the map (d) corresponds to a width (W) of 145 m (and in this case the width is equal to the thickness 'TT').

c) Folded strata

A geological surface which is curved is said to be folded. In case of folding, strata can have different direction of inclination.

Recognize folded strata on a map

- As for inclined strata, the depositional contacts always intersect the contour lines
- The dip symbols are different (for example '┤ ', '+', or ' ├').
- Folded strata are characterized by elongated **concentric outcrops** (see figure below):
    - **The oldest strata are found in the centre of anticlines. Anticlines are folds that close up (think Λnticline),**
    - On the contrary, **youngest strata** can be found in the **center of the synclines. Synclines are folds that open up (**think sVncline).

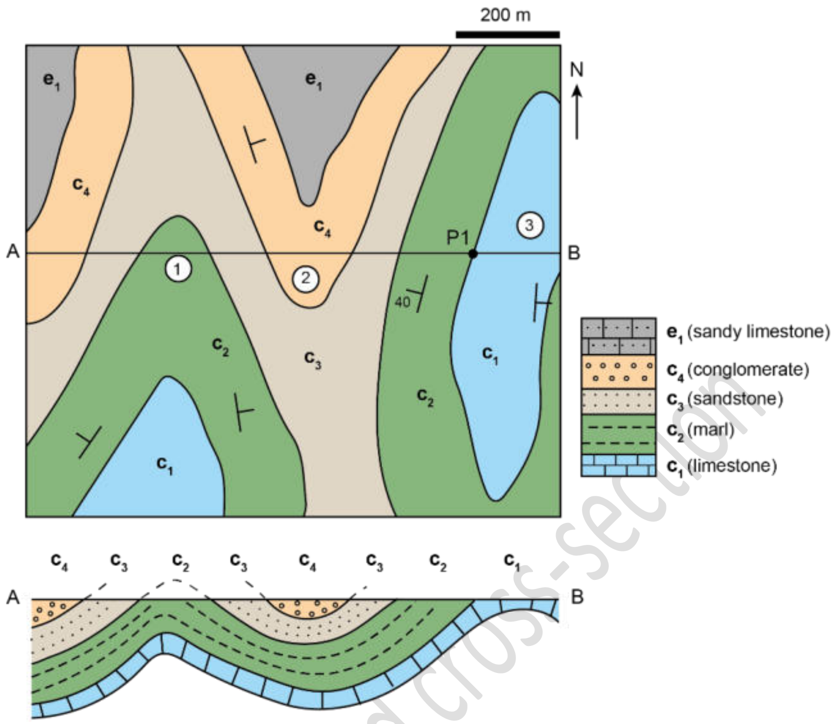
Figure 16 : Folded strata, on a map (top) and cross-section (bottom). (The topography has not been shown in this figure).

The cross-section drawing uses the colors shown on the map, as well as the standard symbols for each type of rock.

Structures 1 and 3 are anticlines. Layer c_1, the oldest, is visible in the center.

Structure 2 is a syncline. Layer e_1, the most recent, is visible in the center.

Right: stratigraphic column with thicknesses to scale.



Calculating the thickness for layer c_2 at point P1 gives us:

- **The dip (α) is equal to 40°**
- **The outcrop width (W) at this location is 150 m**
- **The thickness of the layer is therefore equal to: $TT = W.\sin\alpha \approx 96$ m.**

Depending on the inclination of the axial plane, we can have different types of folds (see next figure).

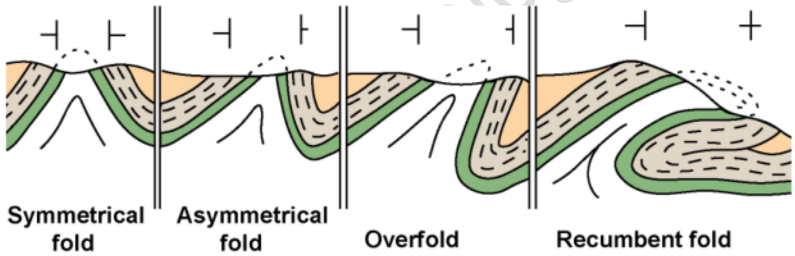


Figure 17 : Different types of folds

d) Other Structures

In a faulted structure, rocks have been subjected to tectonic stresses that caused them to fracture. When displacement occurs along such a fracture, it is referred to as a fault. On geological maps, faults are represented by thick lines, which are dashed when their location is uncertain.

When there is an unconformity, sedimentation has been interrupted, resulting in the formation of an unconformity surface. This surface separates a set of concordant layers at the base—deposited continuously and without interruption—from a set of discordant layers above. The discordant layers are commonly identified by differences in dip and/or strike relative to the older layers (see figure below).

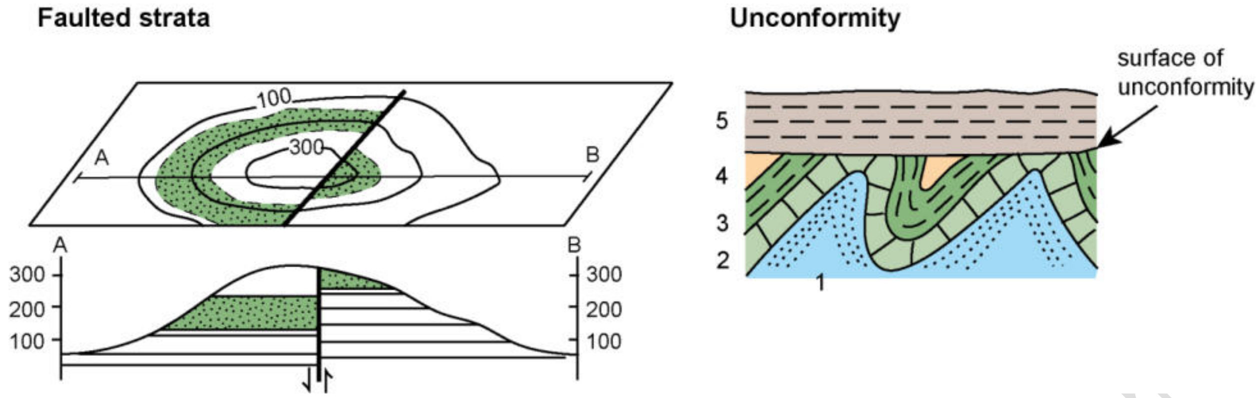


Figure 18 : Example of faulted strata and unconformity.
(Layer 5 is unconformable on layers 1 to 4, which were folded and eroded prior to its deposition.)

3.3. How to construct a geological cross-section?

Unlike a topographic profile, **constructing a geological cross-section is often more delicate**, because it **requires constantly formulating hypotheses** in order to understand the appearance of geological layers at depth. Interpretation is therefore necessary.

To do this properly, a number of rules must be followed, in the order outlined below:

1. Select the location of the cross-section and draw the section line on the map.
2. Construct the corresponding topographic profile, indicating its orientation and scale.
3. Carefully examine the geological map to identify the main structures, any faults and folds present, as well as dip symbols.
4. Draw, to scale, the stratigraphic column of the units crossed by the section (on a separate sheet of paper).
5. Produce a quick preliminary sketch of the geological cross-section.
6. Plot the outcrops intersected by the section line onto the topographic profile, indicating the dip of each layer (the corresponding symbols may be noted in the margin of the graph paper). Where dip values are not provided, they can be estimated using the “V rule.”
7. Draw the geological cross-section properly: faults are shown first (each fault-bounded block is treated as an independent structural unit), followed by the layers, starting with the youngest units.
8. Assign each layer an appropriate pattern corresponding to the rock type.
9. Complete the cross-section by adding a legend (meaning of symbols and patterns, title and number of the map, scale, reference points…).
10. Optionally, redraw the cross-section neatly in ink to produce a clean final document.

An example of a cross-section is given here:

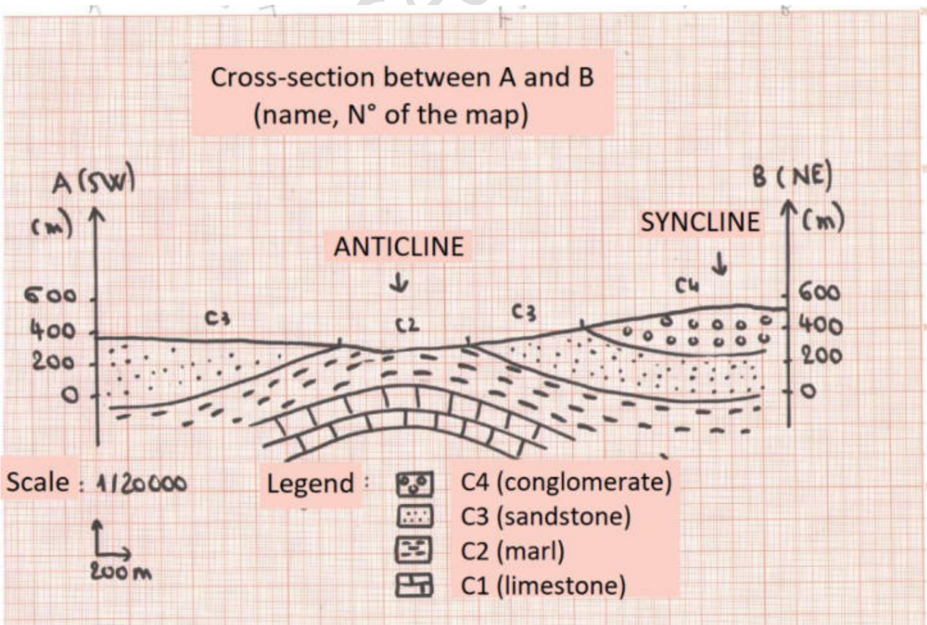


Figure 19 : Example of a cross-section.

Bibliography

Books:

FOUCAULT A. & RAOULT J.F., 1966 - *Coupes et cartes géologiques*. Travaux pratiques de Géologie de 1er et 2ème cycle. Société d'édition d'enseignement supérieur, Paris, 146 p.

LISLE R.J., 2004 - *Geological Structures and Maps. A practical guide* (3rd edition). British Library Cataloguing in Publication Data, 106 p.

SOREL D. & VERGELY P., 2018 – *Atlas d'initiation aux cartes et aux coupes géologiques* (4th edition). Dunod Edition, 128 p.

Online resources:

(1) Geological maps: https://opengeology.org/historicalgeology/tools-of-historical-geology/geologic-maps/
(2) Geological structures: a practical information: https://openeducationalberta.ca/introductorystructuralgeology/chapter/b-orientation-of-structures/
(3) Introduction to Geological Maps and Cross-Sections: https://geo.libretexts.org/Bookshelves/Geology/GEOS%3A_A_Physical_Geology_Lab_Manual_for_California_Community_Colleges_(Branciforte_and_Haddad)/16%3A_Geological_Maps_and_Cross-sections/16.01%3A_Front_Matter
(4) How can you determine the true thickness of a layer? (according to the dip angle and the outcrop width): https://sciences-paysages.fr/geologie/epaisseurCoucheGeologique.htm

And useful videos, for example:

- THE GEOLOGICAL MAP *"Drawing the Earth's skin" (9'47''): https://youtu.be/qdz9DN74ukY*
- GEOCOAST - Using Geological Compass: Measuring Strike, Dip & Dip Direction (4'17''): https://youtu.be/FbXhooadhZw
- My own youtube channel 'TP Géologie L2', where you can find many videos that can help you with the courses and tutorials of Geology. All these videos were recorded in French. Subtitles are available if needed.
  - Home page: https://www.youtube.com/@tpgeologie
  - Playlist about cartography ("TD Géologie de 1ère année SNV"): https://youtube.com/playlist?list=PLjepoOw2WVmh18Iv6bLIhYDUuqxojZIxS

English / French glossary

English	*French*
Base map	*Fond topographique*
Clay	*Argile*
Conglomerate	*Conglomérat*
Contour interval	*Equidistance*
Contour lines	*Courbes de niveau*
Cross-section (geological)	*Coupe (géologique)*
Depositional contact	*Contour géologique (contact normal)*
Deposits	*Gisements*
Dip	*Pendage*
Fault (normal, reverse, strike-slip)	*Faille (normale, inverse, décrochement)*
Fault line	*Ligne de faille (contact anormal)*
Fold (anticline, syncline, symmetrical, overfold, recumbent)	*Pli* *(anticlinal, synclinal, droit, déversé, couché)*
Geologic map	*Carte géologique*
Geologic time scale	*Echelle des temps géologiques*
Geologic unit	*Unité géologique*
Layer	*Couche*
Limestone	*Calcaire*
Map key (or legend)	*Légende*
Marl	*Marne*
Outcrop	*Affleurement*
Principles (original horizontality, superposition, lateral continuity, cross-cutting relation)	*Principes* *(horizontalité, superposition, continuité, recoupement)*
Quarry	*Carrière*
Rock (sedimentary, igneous, metamorphic)	*Roche* *(sédimentaire, magmatique, métamorphique)*
Sandstone	*Grès*
Scale	*Echelle*
Stratigraphy	*Stratigraphie*
Stratum (plur. Strata)	*Strate*
Tectonics	*Tectonique*
Unconformity	*Discordance*
Valley	*Vallée*

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