Rock mass discontinuities

We will confine ourselves here to sedimentary rocks. These are formed from the deposit, for the most part on the seabed, of a variety of materials known as sediments. These sediments are either carried by rivers from the continent (sands, clays), or created chemically by living creatures (molluscs, corals, echinoderms) using substances (carbonate, silica) in solution to form their shells, or tests. When the organism dies, these tests are deposited on the seabed and are gradually cemented together by lime muds (figure 1).

Figure 1. Fossil corals. The branches of the coral bush can be made out in the centre fossil. The white areas are other fossils of the same type. The brown area is the partly altered calcareous cement. These fossils can be seen during the tour of the Cave of Lorette, in the Chamber of the Cataclysm.

Little by little, these sediments build up in successive layers, or **strata**, separated by the first family of discontinuities: **bedding planes**. As they are buried, these sediments are transformed into consolidated rock. These strata are made up of sedimentary rocks formed from sediments. The series of strata is known as a sedimentary series. It may be made up of rocks of the same kind, as in the Resteigne quarry, where limestone predominates (figure 2), or of different kinds, such as alternating sandstone and shale, for example (figure 3). Theses stratified masses, originally horizontal, may have been disrupted by later tectonic events that caused the formation of mountain ranges.

In the early stages of diagenesis (the process by which soft sediment is transformed into hard rock), fractures form in the sediment as it hardens: these are known as **joints**, as opposed to any other discontinuity. They run perpendicular to the stratification (figure 4) and are often confined to a single stratum.

Figure 2. Limestone strata tilted to the vertical. Abandoned quarry in Wellin.

Figure 3. Alternating strata of sandstone strata (massive and light colored) and shale strata.

Figure 4. Alternating sandstone and shale strata. This wall forms part of the rocky outcrop on which the Citadel of Namur is built. The two parallel red lines mark out the two bedding planes delineating a stratum of sandstone. The green lines indicate a number of joints.

The tectonic stresses acting on the rock mass may cause other types of discontinuities. **Stylolitic joints** are highly complex surfaces, parallel to the stratification, caused by a mechanism of pressure dissolution (figure 5). **Tension gashes** are almond-shaped fissures filled with minerals (calcite in the case of a limestone mass) following each other. These, too, are generated under pressure (figure 6). In most instances, these discontinuities form at great depths, sometime as much as several kilometres beneath the earth's surface.

Faults are the best-known types of fracture. They occur between blocks that have shifted in relation to one another. We can recognize normal faults that form in extensional regime and inverse and strike-slip faults that form in compression regime (figure 7). The movement of a fault is one of its main characteristics. It is caused by the movement of tectonic plates or by mechanical stresses in the earth's crust that reactivate earlier faults. The initial result of such stresses is earthquakes, on faults that are still active. Subsequently, this movement causes striations (slicken sides) on the fault planes as a result of abrasion (figures 8 & 9).

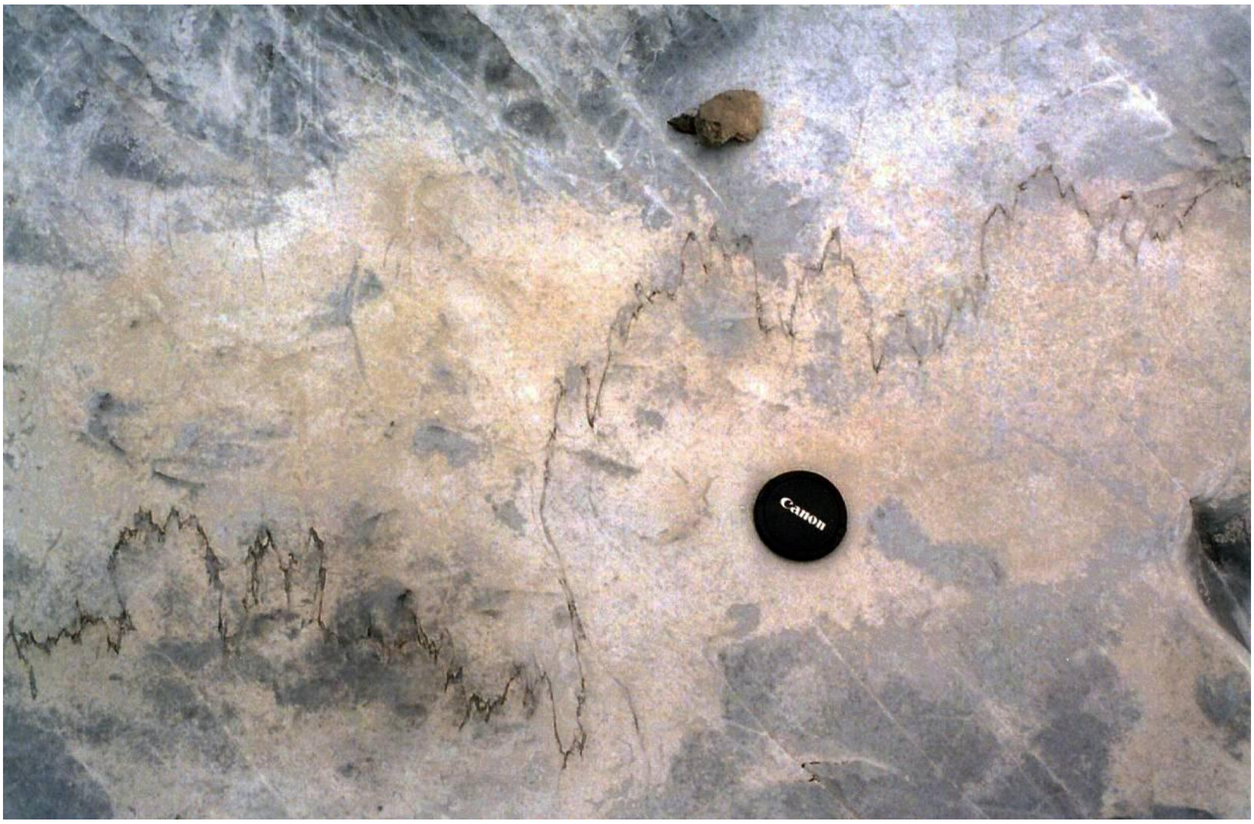
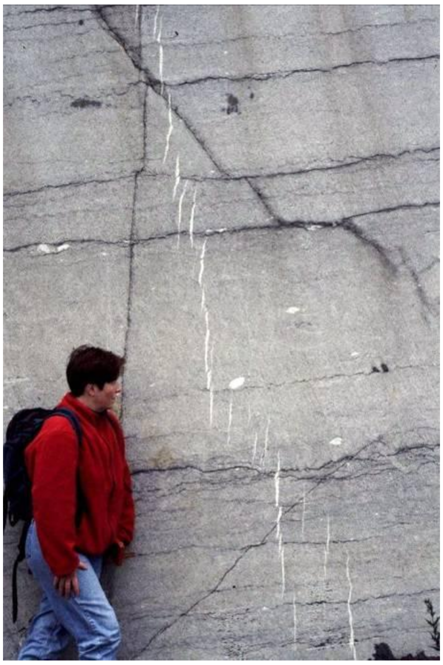


Figure 5. Stylolitic joint. Generated under compression, the secant to the knee of the curve indicates the direction of the shortening, which in this case is vertical.



Figures 6. Tension gashes. Left, they can be seen following en echelon on the cutting face of the bluestone quarry in Clypot, near Soignies. Right, this close-up shows them in relief in a limestone slab in the Milieu quarry, near Tournai.

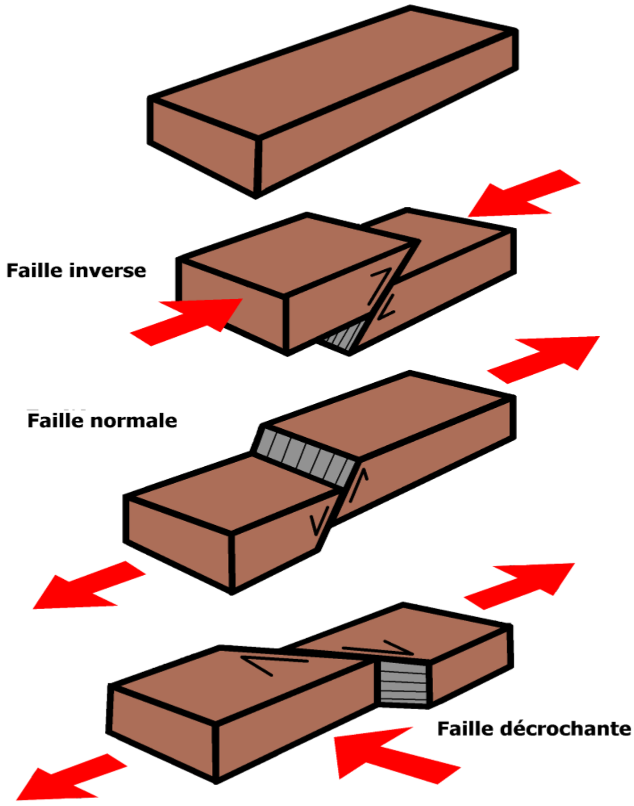


Figure 7. Fault types. The red arrows show the stresses acting on a block of the earth's crust (in brown). The line markings on the fault planes are the slicken sides caused by abrasion between the two rock faces.

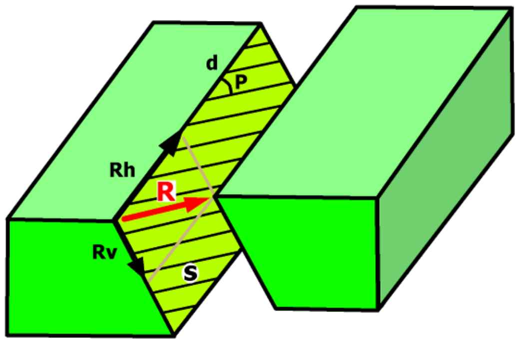


Figure 8. Components of a fault. R: net slip vector; Rh: strike slip; Rv: dip slip; d: fault direction; s: slicken sides on the fault plane; P: pitch.

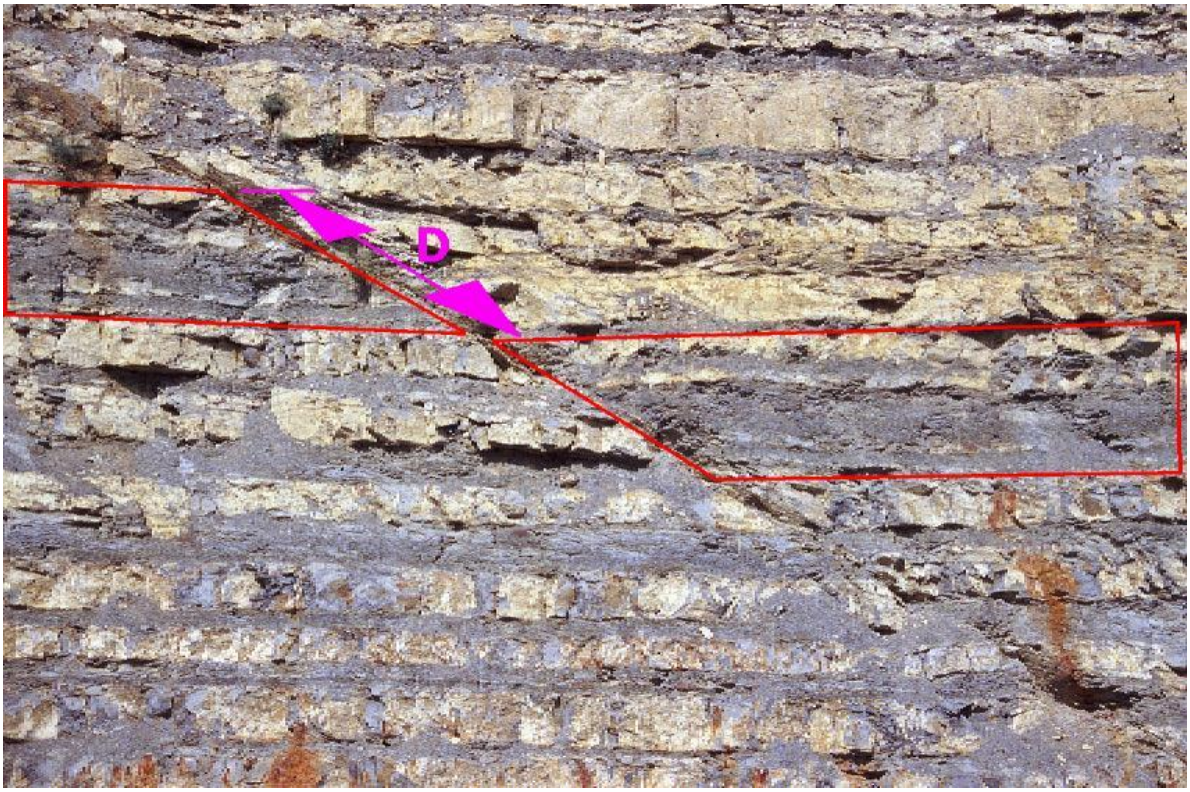


Figure 8. Normal fault. The fracture cuts diagonally across a sedimentary series consisting of irregular alternating strata of marls (argillaceous limestone) and limestone (lighter in color). The two surfaces outlined in red highlight a series of characteristic strata serving as a baseline. They have visibly been displaced by a distance D by the fault. The panel on the right has dipped below the panel on the left . The movement corresponds to an extension of the rock mass, thus, this is therefore a normal fault.

Figure 9. Strike-slip fault. This example is visible in the limestone of the Gauthier-Wincqz quarry in Soignies. The slicken sides are horizontal, attesting to the strike-slip movement.

Tectonic stresses can also cause fractures in which there is no visible movement by the rock masses on either side. Such fractures are known as **joints**. They may be either perpendicular or at an angle to the stratification (figures 10). They are of particular importance, since they play a fundamental role in channelling underground water in consolidated rock such as limestone.

Figures 10. Simple vertical, non-karstified tectonic joints in the Carrière du Milieu quarry in Gaurain-Ramecroix.

Figure 11. Vertical joints at the temporary swallow-hole on the River Lesse in the Han massif. These joints cut through several strata and are not perpendicular to the stratification, which is inclined here. These joints have been widened by karstification to become metric galleries in which the river is lost in floods.

Lastly, these tectonic stresses give rise to other rock deformations such as folds, anticlines and synclines (figures 12). Fissures may form at the point where layers are stretched by folding (upwards for an anticline, downwards for a syncline).

Figure 12a. Anticline at Durbuy.

Figure 12b. Syncline at Anseremme.

Figure 12c. Anticline in the Thure quarry.