Volcano

A volcano can be defined as a relief feature where the molten magma has reached the earth’s crust, either on land or under the sea. This relief feature can take the form of a more or less conical hill of very variable size, or of a depression in cases where there is only a crater or a caldera. According to the type of magma (fluidity and homogeneity of composition vary), and according to whether it is under the sea or on land (and in the latter case depending on presence or absence of surface water), the arrival of the magma at the surface can cause either an accumulation of lava (lava eruption) or an explosion (explosive eruption, leading to the deposit of pyroclastics or tephra). An active volcano is one for which there are records of an eruption in historical times. According to the Smithsonian Institute Global Volcanology Programme, 550 volcanoes are thought to correspond to this definition, and this does not include sub-marine activity. However the example of the Pinatubo volcano in the Philippines shows the limitations of the definition: the volcano was considered as inactive until the eruption in 1991 which was one of the largest in the 20th century in terms of the volume of matter produced.

Localisation.
Worldwide, localisation of volcanoes is determined by plate tectonics. The main volcanoes are situated in subduction zones (island arcs and the Pacific "ring of fire") and along ocean ridges (Iceland). Certain volcanoes also occur at intra-plate locations, in connection with the formation of rifts or the existence of hot spots, or again in situations of collision (the Caucasus). On a larger scale, the frequently observed alignment of volcanic formations along preferential axes (for instance the ChaÃ®ne dePuys in Auvergne, France) also demonstrates the role of the tectonic plates in channelling the magma to the surface.

In the Western world, volcanoes have been documented since Antiquity, and numerous eruptions in the Mediterranean area have been described by the classical authors. The most famous of these descriptions is probably that provided by Pliny the Younger who observed the eruption of Vesuvius in 79 AD which destroyed Herculaneum and Pompei. However the geological explanation for volcanic activity remained the subject of debate for centuries.

From the 18th century there were two opposing theories for the origins of volcanoes. According to neptunism, volcanic activity was a superficial phenomenon that had no relationship with the deep regions of the earth. In contrast, plutonism held that volcanic rocks originated from the deep magma. As early as 1752, J.E. Guettard recognised deep volcanic origins for the Puy de DÃ´me (Auvergne, France) and the local stone known as "la pierre de Volvic". Plutonism gradually gained ground, in particular from the middle of the 19th century with the progress in methods of analysis, both physical (polarising microscope) and chemical.
Modern volcanology progressed fast, using the major eruptions to analyse volcanic processes and associated formations. Thus in the 20th century two large eruptions, among others, contributed to the advancement of knowledge: the eruption in Martinique of Mount PelÃ©e (1902) and that of Mount St Helens, USA (1980).

Classically, four types of volcanic activity have been distinguished, on the basis of the viscosity of the lava and the explosive phenomena: Hawaiian, Strombolian, Vulcanian and Pelean. This typology has been dropped today because
-i) it does not account for the full diversity of types of volcano and volcanic activity (such as maars, phreato-magmatic eruptions, lava volcanoes or under-sea volcanic activity), and
-ii) in the course of its history a polygenic volcanic feature can exhibit several types of activity.
It is usual today to distinguish between monogenic volcanic formations (Strombolian cone, maar dome) and polygenic formations (composite volcanoes, shield volcanoes). These two categories can at least partially be distinguished by the spatial and temporal scales of their activity. Monogenic formations are "small" features formed over a "short" period of time, and, in theory, in the course of a single eruptive episode characterised by a single eruptive mode. In contrast, polygenic formations are large, they remain active over thousand of years and exhibit a wide variety of eruptive modes. Phases of volcanic activity are followed by phases of remission, and likewise "edification" phases are followed by destruction phases (explosive activity, emission of pyroclastic material, formation of caldera).

Man and volcanoes.
In a work published in 1958 L’homme et les volcans, (coll. GÃ©ographie humaine, Gallimard), E. Aubert de la Rue was the first French geographer to offer a synthetic review of volcanic zones. After describing the wide diversity of volcanic eruptions and the resulting formations, and the different volcanic areas worldwide, the author entitled the sixth and last chapter of his book "Le volcan utile" (the useful volcano).

Indeed, volcanoes can provide Â«resourcesÂ» (energy and raw materials). Different types of lava have been used in architecture (for instance Clermont Ferrand cathedral, France, in Volvic stone), or at earlier dates, lava is noted in prehistoric artefacts. Obsidian was thus a much sought-after resource in Palaeolithic and Neolithic human groups, and trading in obsidian was active across the whole of the Middle East (Cauvin et al (dir), 1998). On the slopes of volcanoes agriculture often draws benefit from fertile soils, in particular those forming on basic lavas. Likewise, volcanic ash enriches soils in nutrient substances (nitrogen, potassium, etc) that contribute to the fertility of these regions. In tropical areas, the high population densities in rural Indonesia or the Philippines are an indication of the richness of many of the soils that form on volcano slopes. Today certain volcanic rocks, such as perlite (hydrated obsidian) or pumice are used in industry.

Volcanoes carry mystery and myth, and numerous legends are associated with them, often in connection with divinities, as can be seen in the places of worship often perched on volcanic features. Myths and legends associating volcanoes with divinities can be found in a wide range of societies, from Mediterranean Antiquity to New Zealand and pre-Columbian South America (De Wever, 2003). Today, volcanic landscapes often have a positive popular image and attract certain forms of tourism to island destinations (from the Aeolian (Lipari) Islands to Reunion Island and Pacific archipelagos), or to inland sites (such as Yellowstone).

Resources provided by volcanoes thus explain why high densities of population tend to accumulate around them, despite the Â«risks Â» associated with volcanic activity. It is usual to distinguish seven volcanic risks: lava flows, fallout of ash and rock, pyroclastic flows, gases, lahars, avalanches of debris and tsunamis. The management of volcanic risk is based on the identification of warning signs (gas emissions, steam eruptions, seismic activity etc) that are characteristic of rising magma in the vent, and also on recognition of the different types of eruption. The Armero disaster when Nevado del Ruyz erupted in 1985, which led to lahars that caused more than 20 000 deaths, is the perfect counter-example. While the early warning signs were indeed spotted by scientists (the melting of the ice cap at the summit of the volcano) the information issued to the population was both imprecise and inadequate. The population stayed shut up in their homes, which would have been appropriate in case of a Plinian eruption, while the lahar risk, on the contrary, required an evacuation of the population to interfluvial zones. The disorganisation of the Columbian authorities was largely responsible for this inadequate information process (Voight, 1990).

Volcanic eruptions are momentary phenomena, the products of which fossilise both paleo-topographies and former human occupation. Tephra are therefore frequently used for the purpose of geo-morphological, paleo-environmental or (geo)-archaeolgical reconstitutions, in particular in cases where dating is possible using radiometric techniques (Â«geo-chronologyÂ»). In geomorphology, lava flows that have been eroded on either side by river valleys to form plateaus, or planÃ¨zes, are used to retrace the evolution of different regions, (the Limagne area, for instance, in Auvergne, France). Numerous archaeological sites have been dated by way of the pyroclastics associated with the fossils. For instance the site at Dmanissi (Georgia) has yielded the oldest European Homo fossils, which were dated 1.81 MY on the basis of a layer of volcanic ash (De Lumley et al, 2002). In addition, certain particularly well-known tephra are sought in marine or continental sedimentary sequences to serve as chrono-stratigraphic markers. The Laacher See tephra (derived from the eruption of maar from the Eiffel volcano, Germany, around 12900 years BP) serve in all reconstructions for the European Late Glacial period from the west of Italy to Scandinavia. Likewise Santorini tephra (the Santorini eruption occurred around 1645 BC, putting an end to the Minoan civilisation and generating the Atlantis myth), form a reference level in the eastern Mediterranean zone, the Black Sea and western Anatolia.

Bibliographie