Geothermal knowledge

What it is

Our planet constantly emits energy in the form of heat, which propagates from deeper ground towards the surface. This is the so-called flow of heat or geothermal flow. The Sun heats the Earth's surface with a flow of heat that is almost 6,000 times greater than the heat from inside the Earth, however, the constant and continuous geothermal flow is an important source of heating for our Planet. With an average of 0.06 watt per sq. m, an overall amount of heat, equal to approximately 30,000 billion watts is radiated from the entire surface of the Earth.

The Earth gets hotter as we dig deeper in the ground, and this is a phenomenon that is well known to miners. Some of the deep mines and galleries reach temperatures that are near the boundary of human survival (which is not the case in caves, where the natural circulation of air and water remarkably lower the temperature, so that an increase in temperature related to depth is practically not felt). The Earth's heat, is mostly due to energy freed in the decay process of the radioactive isotopes of some elements such as potassium, thorium and uranium. Due to the different thicknesses of the Earth's crust and the different geological situations which can cause the rise of warmer materials from deeper zones, the geothermal gradient (i.e. the increase in temperature, due to greater depth) is not equal all over the World. On average, the temperature increases 2-3°C per 100 m in depth, but the increase can vary from 1° up to 5°C/100 m.

In order to measure the geothermal gradient, wells are dug at least 300 m deep (so that the effect of daily and annual variations in the temperature, due to climatic influences, is not felt). In these wells, special thermometers which record the temperature at the different depths are positioned.

The flow of heat is greater where the thickness of the lithosphere is less, as for example on the ocean ridges or in the continental rifting zones or in volcanic areas where different geological processes lead to rock melting, or in areas where there is slowly cooling magma in the subsoil.

Underground study

In order to find the most suitable areas to exploit geothermal resources, surveys are conducted both on the surface and underground. The results of the survey are used to understand what are the geological, hydro-geological, thermal characteristics and the output capacity of the geothermal system.

Surface analyses include: the exam of the underground thermal conditions and the location of possible reservoirs. First of all, the geothermal gradient is measured in various points of the area and obvious signs as smoke-holes and spas are looked for. In this respect, data provided by the chemical analysis of gas and water can be very useful.

The identification of a reservoir is the most complex part of the exploration, since it calls for the integration of the results of all the geological, volcanic, geo-chemical, geo-physical (gravimetric, geo-electric, seismic, etc.) surveys previously carried out.

The underground survey is conducted by drilling a well to verify the hypotheses that have been put forward.

Where it is

With reference to the "plate tectonics" theory (according to which the earth's crust can be divided into approximately 20 micro-areas called "plates" which every year move between zero and 18 centimetres), the hottest geothermal areas of the globe are generally positioned along the breaking and collision margins of the plates.

The breaking of a plate causes long cracks on the earth's crust, through which the magma reaches the surface (the Iceland Rift, The Red Sea/Rift Valley system, the Baikal lake).

The collision between two plates causes the compression and lifting of the margins: in the case of oceanic plates, island arches such as the Antilles and the Japanese archipelagos; in the case of an oceanic and a continental plate, continental ranges emerge such as the Andes. If both plates are continental, the lifting of the margins leads to the formation of mountain ranges such as the Alps or Himalayas.
Important geothermal areas are “hot spots” such as Hawaii, Galapagos, Canaries and the area included between Tuscany and northern Lazio in Italy.
The continental plates include large sedimentary basins with low-temperature geothermal resources such as those in France, Hungary and China.
From the geothermal viewpoint, Italy is the hottest area in Europe although the exploitation of its geothermal resources has been so far developed only in the central and northern regions.

Where it is produced

Tuscany and the northern part of the Lazio region are well-known for their production of geothermal energy and host the largest geothermal plants in Italy (and Europe), near Piancastagnaio, at the foot of the Amiata mountain, and in Civitavecchia.
The biggest plant is “The Geysers” plant, located 140 km in the north of San Francisco in California (USA), with a total power of 750 megawatts.
Near Orbetello an important aquaculture centre was created: seawater is mixed with water at a temperature between 17°C and 25°C to create the optimum environment to breed sea-bass and pandoras.
Among the direct uses of heat, the most meaningful example at European level is the urban heating system in Ferrara. It is a district heating system that supplies 14,000 flats with hot water at 102°C, coming from a location at 4 km from the city, from a well at 1,300 metres of depth that was originally drilled for oil search. By extracting 250 cubic metres of water, 12,000 tons of oil are saved each year. The water is then re-injected underground.
As well as saving fossil fuel, district heating reduces air pollution, bringing many benefits to urban centres.
In the Euganean Hills area (Abano Terme, Montegrotto, etc.) and to a lesser extent in Bormio, near the border to Switzerland, hot water is exploited for spas and household heating.
According to a recent study it was calculated that with the “vapour dominant” geothermal systems that are present in Tuscany and Lazio it would be possible to produce more than 5 billion kW per hour, a quantity that would satisfy the national demand for 70 years, while the use of “water dominant” geothermal systems would lead to a huge production of electric power, which is impossible to estimate.

A bit of history

The use of geothermal waters is a very ancient phenomenon probably dating back to the higher Palaeolithic. Nevertheless, its development from a more specifically health viewpoint originated in Japan and in Italy approximately 2000 years ago. However, although in Japan it was limited at national level, Romans disseminated it from Italy to any region of their Empire (Hungary, Germany, France, Spain, Great Britain, Turkey and Arabia).
However, spas were treated in a scientific way only starting from the Renaissance, when the book De Thermis was published by Andrea Bacci (Venice 1571). Since then, between the 17th and the 18th century, numerous spa centres are built in Europe to operate as therapeutic centres to treat mind and body. Thanks to its 170 centres, the most famous country in Europe as regards spas is Italy, but mention should be made of Hungary (the Budapest centre dates back to the Roman time) and Iceland.
The exploitation of the energy of geothermal sources developed later than spas.

The first industrial plant to produce energy was built in Tuscany in 1827. At the time, *Francesco Larderel*, the owner of a plant producing boric acid by extracting it from the water flowing underground in the area, had a brilliant idea. Instead of making the boric water evaporate by burning the woods of nearby forests, he decided to exploit the heat contained naturally in the water. The idea was successful and, up to 1875, the chemical industry in Larderello was the most important in the world with reference to the boric products sector. It was in Larderello, in 1904, that the first lights powered by geothermal energy were lit, and in 1913 the first industrial plant for the production of electricity from geothermal sources was inaugurated, with a power of 250 kW. Since then Italy has always been a leader in the production of geothermal electricity, and in time it has accumulated a unique experience on a global scale. In Italy, for example, the hotels in the thermal area around Abano Terme (Colli Eugenei, Veneto region) and almost all the municipalities where the geothermal electricity plants are located, in Tuscany , are heated with a system of teleheating for households. Research in this field has not ceased. At present there are projects to explore greater depths than the present geothermal fields, with the scope of finding supercritical fluids.
Starting from the 1920s, the geothermal industry developed also in Japan, Iceland, Hungary and, starting from the 1950s, in the rest of the world.