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Thermal anomalies associated with groundwater circulation in the southern part of the Po Plain

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The Po Plain, located in northern Italy between the Alpine and Apennine mountain ranges, is a wide subsiding depression filled by Plio-Quaternary terrains sometimes exceeding a thickness of 6000 m. The deep morphology of the Mesozoic carbonatic bedrock, which is of geothermal interest particularly when it becomes shallower (like e.g. in the Ferrara ridge), is controlled by several anticlines and synclinals also affecting the overlying Plio-Quaternary sediments. From the hydro-geothermal point of view, the younger terrains form the cover of thick reservoirs of fluids located in the underlying carbonatic formations.

We processed temperature data from oil wells drilled in the southern part of the plain and analysed them in relation to water circulation. These data show more or less evident thermal anomalies. The temperature at the cover base represents that of the top of the reservoirs containing low enthalpy fluids, while the low thermal gradient within the Mesozoic carbonatic formations indicates water movements at depth. Many thermal anomalies can be ascribed to sub-vertical circulation of water, which moving downward (recharge areas) yields a very low thermal gradient.

The study of subhorizontal aquifers required a complex approach based on numerical calculations. For an undulated aquifer with relatively large water velocity, the change in temperature increases when the aquifer deepens, whereas it decreases when water moves upward. Moreover, there is no proportionality between temperature and depth.

With the exception of the Emilia area, characterised by some local thermal minima, most of the investigated area shows anomalously high temperatures, which can be

accounted for by groundwater movements. Unfortunately, due to the uneven distribution of the available thermal data, it is not possible to define precisely the shape and extension of such anomalies.

A strong contribution originated by convective heat transfer was put into evidence for some areas of Romagna. At the recharge areas, underground fluids generally move downward and their average velocity is of the order of a few centimetres per year. In the Emilia area, there is upward fluid flow at a rate decidedly larger than the average.

Alpine and Apenninic chains at the edges of the sedimentary basin form recharge areas. The supplies are larger in the eastern sectors because of carbonatic outcrops that facilitate the deep leakage. However, there are also supplies from the moraine deposits occurring along the Alpine arc. In the south-Piedmont basin, there is a relatively shallow circulation of fluids, whose origin is from recharge areas formed by clastic rocks located in the western Alps, and with temperatures of about 30 ˚C at 1000 m depth.

In the western side of the Po Plain, we inferred areas characterised by clastic rocks with fluids flowing in aquifers extending down to 2000 m depth in Messinian terrains, with temperatures of about 60 ˚C. The portion of Quaternary cover affected by cold shallow aquifers is wider in the southern sector, close to the Apennine recharge zone. The highest geothermal potential seems to occur along a relatively narrow belt, which affects the Ferrara district. In this area, a Mesozoic carbonatic ridge rises to about 1000 depth, and aquifers, albeit of low enthalpy, are of relevant importance for direct energetic use. A demonstration is the current exploitation for district heating of the hot fluids (about 100 ˚C) circulating at depth.