Multi-parameter low enthalpy geothermal mapping of Cantone Ticino

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Low enthalpy geothermal energy is a type of renewable energy that is continuously growing in terms of exploitation within Europe, especially through the use of closed-loop systems. Currently the authorisation process for closed-loop systems in Cantone Ticino is based on maps taking into account the presence of restrictions arising from the enforcement of the water protection act and ordinance. It states that new closed-loop systems can not be installed within S groundwater protection zones, while they are always allowed in üB("übriger Bereich"= remaining territory) sectors. Within the Au (usable groundwater) sector, a "sacrifice area" approach is adopted, allowing the installations of such systems in specific areas where the presence of conflicts precludes groundwater exploitation for drinking purposes.The described procedure, however, does not consider the subsurface potential. Therefore developing a multi-parameter geothermal mapping could give precious planning indications from both an energetic and socio-economic standpoint while fulfilling environmental protection requirements. Furthermore, an overall estimate of shallow geothermal potential in Canton Ticino is important due to the progressive diffusion of these kind of systems in the next years, since at least the 20% of energy requirements for new buildings will have to be provided from renewables (RUEn, 2008).The mapping procedure started with the realization of a ground surface temperature (GST) map using mean annual air temperature (MAAT) data retrieved by MeteoSwiss stations and a 25m DEM. Firstly we correlated MAAT measured in different stations with altitude in order to find a regression equation, then we applied it to the DEM to create a MAAT map.The GST map was then obtained by applying the formulas contained in SIA 384/6 regulation:

$GST = Mean\ Annual\ Air\ Temperature + 1.55$ for altitude < 1000 m.a.s.l.

$GST = Mean\ Annual\ Air\ Temperature + 1.55 + \frac{(Altitude - 1000)}{800} * 2.45$ for altitude > 1000 m.a.s.l.

Results were compared with real measured data of ground temperature coming both from IDAWEB database and undisturbed ground temperature values obtained by TRT tests executed in 6 spots. A digitalized geological map (Geologische Karte der Schweiz 1:500000, 2005) was used in order to define the main outcrop lithologies, while part of the sedimentary portion of the Canton Ticino region was characterized using hydraulic conductivity values extracted from pumping tests, interpolated using ordinary kriging and classified accordingly into gravels, sands and clays. A reference set of thermal properties was then assigned to each lithological unit (both rocky and sedimentary)

according to SIA 384/6 regulation and a thermal conductivity map (for outcrops and equivalent Quaternary deposits) was realized. 128 simulations with EED varying λ, GST, heat flux and volumetric heat capacity were performed in order to calculate the total borehole length required to satisfy a hypothesized annual heat demand of 30 MWh/year. This value was estimated taking into account a residential unit composed of 5 flats of 100 m^2 each, with an equivalent operating annual time of 1200 hours, a heat pump peak power of 25 kW and an energetic index of 60 kWh/m^2 year (MINERGIE® standard for refurbished buildings). Maps of required borehole length and estimated extraction rate (W/m) were developed for Canton Ticino. Usually the most suitable areas match the most densely populated ones however, within Au sectors, most of the areas where closed-loops are authorised show lower potential as they are placed in alluvial fans, where the higher depth to the groundwater table results in lower λ values.

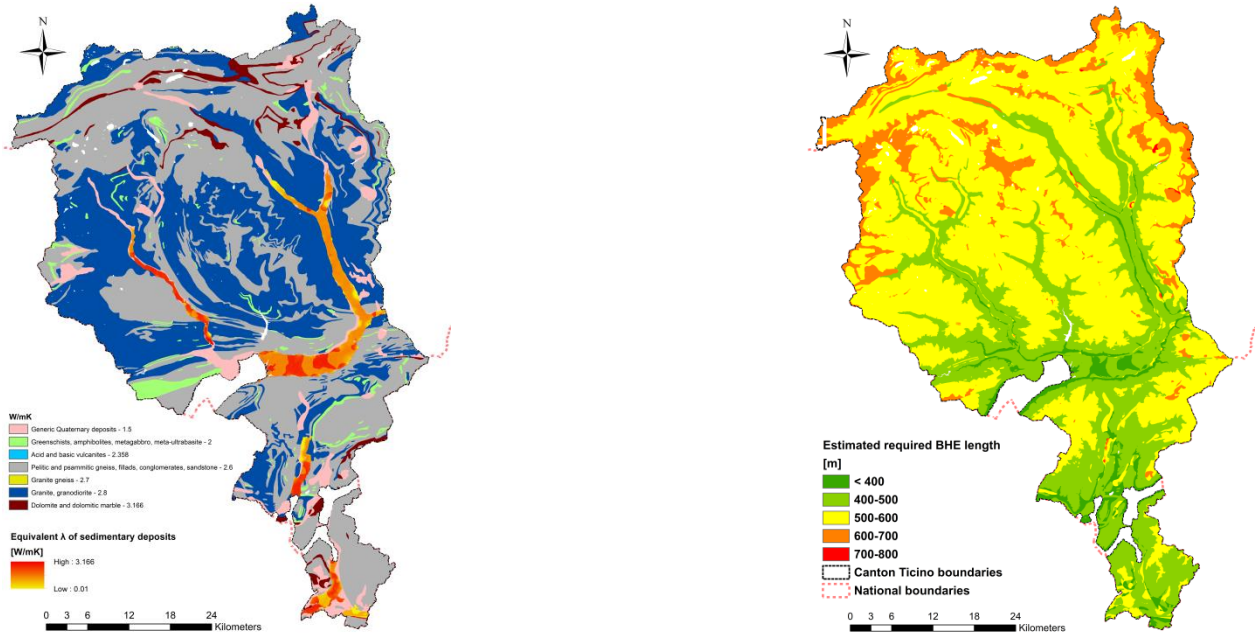

Figure 1 - Left) λ map for Cantone Ticino. The orange portion represents the equivalent λ of Quaternary deposits within monitored aquifers. Right) Estimated BHE length to satisfy the assigned annual heat demand for a reference residential unit

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