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The Castel Giorgio and Torre Alfina geothermal pilot projects with no gas emission into atmosphere

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Geothermal pilot projects

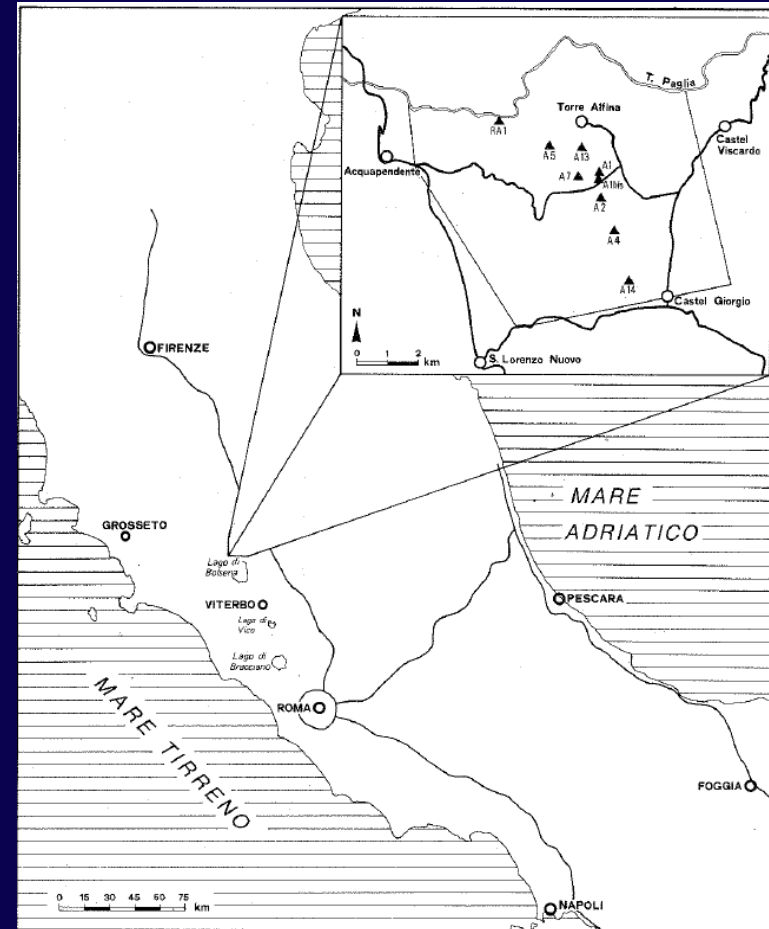
- introduced by D.lgs. 03/03/2011 n. 28 to promote geothermal energy production with very low environmental impact
- electrical energy production up to 5 Mwe per plant for a total 50 Mwe at national level
- zero emission into atmosphere and total reinjection of the extracted fluids into the provenance reservoir
- limit of 3 pilot plants per operator
- competence on authorization, permits and controls under Ministry of Economic Development (MISE) with agreement of the interested Region

Reasons for selecting Torre Alfina geothermal field for pilot projects

This geothermal field is very well known thanks to geological, geochemical, hydrogeological and geophysical studies and the results of 10 deep exploratory wells

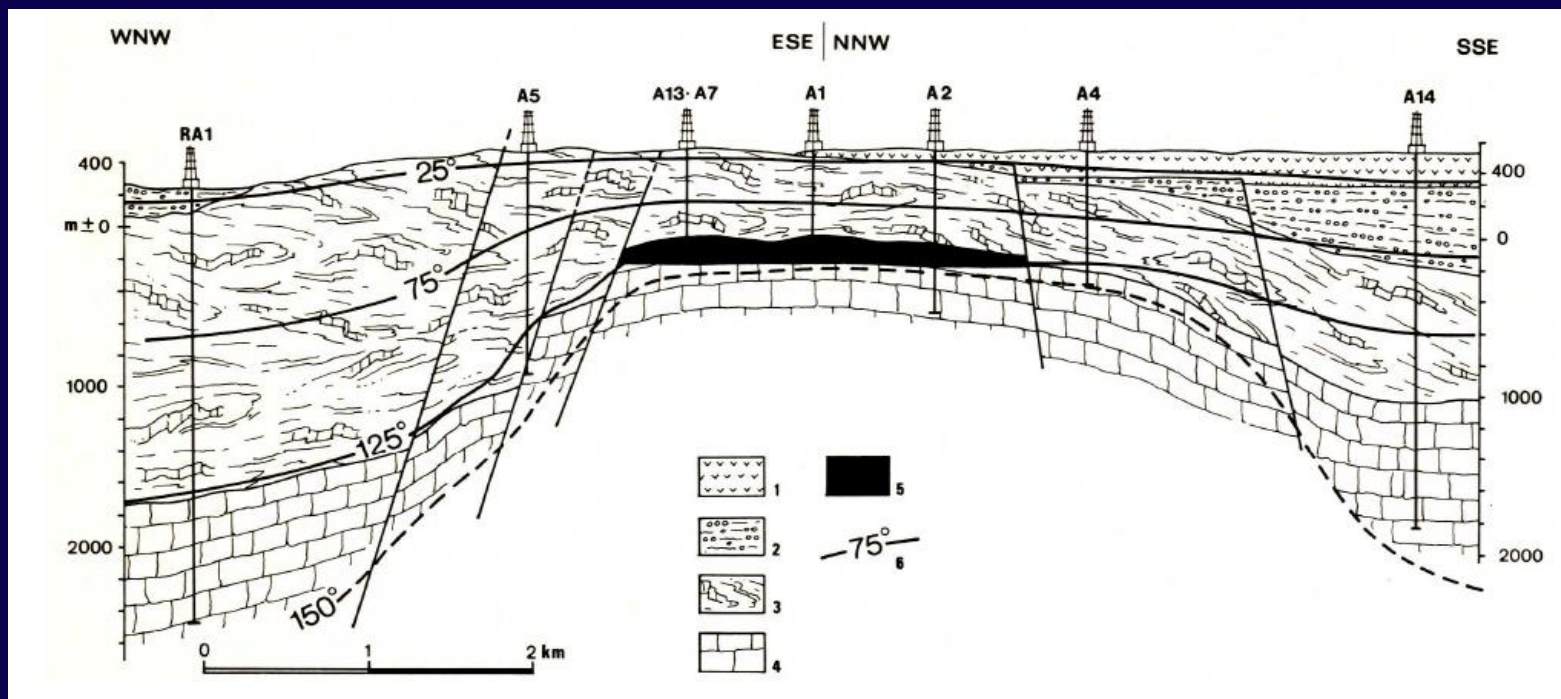
Immediate possibility of executive projects with very low exploration risk

Two regions involved:
Umbria for Castel Giorgio
Lazio for Torre Alfina



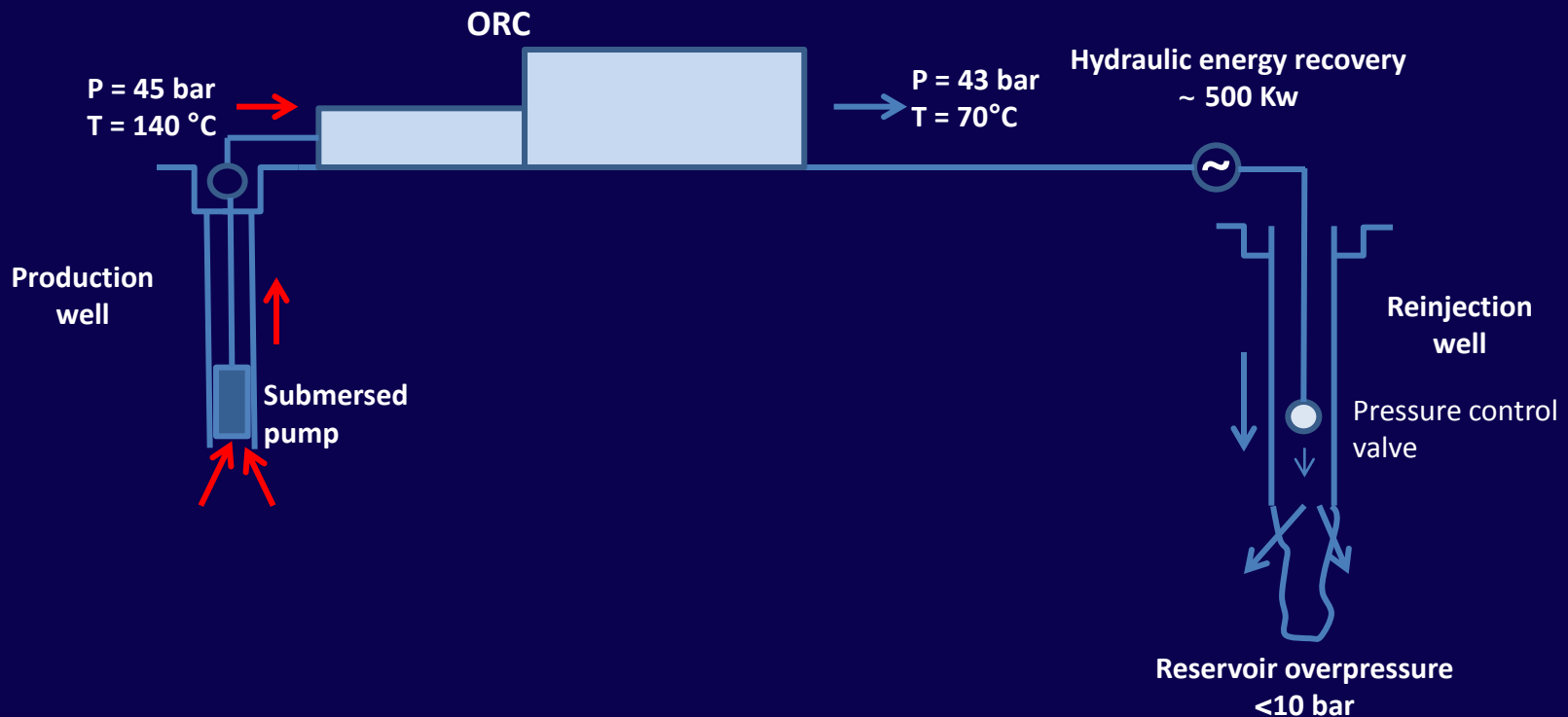
Characteristics of the geothermal field

- Geothermal reservoir hosted in a structural high of Mesozoic carbonatic rocks highly permeable by fracturation
- Cap rock provided by impervious flyschoid formation
- Gas (CO₂) cap at the reservoir top (~45 bar, 100m thickness)
- Reservoir Temperature 140°C (medium enthalpy)
- Water salinity 5000ppm
- 2wt% CO₂ dissolved in the water



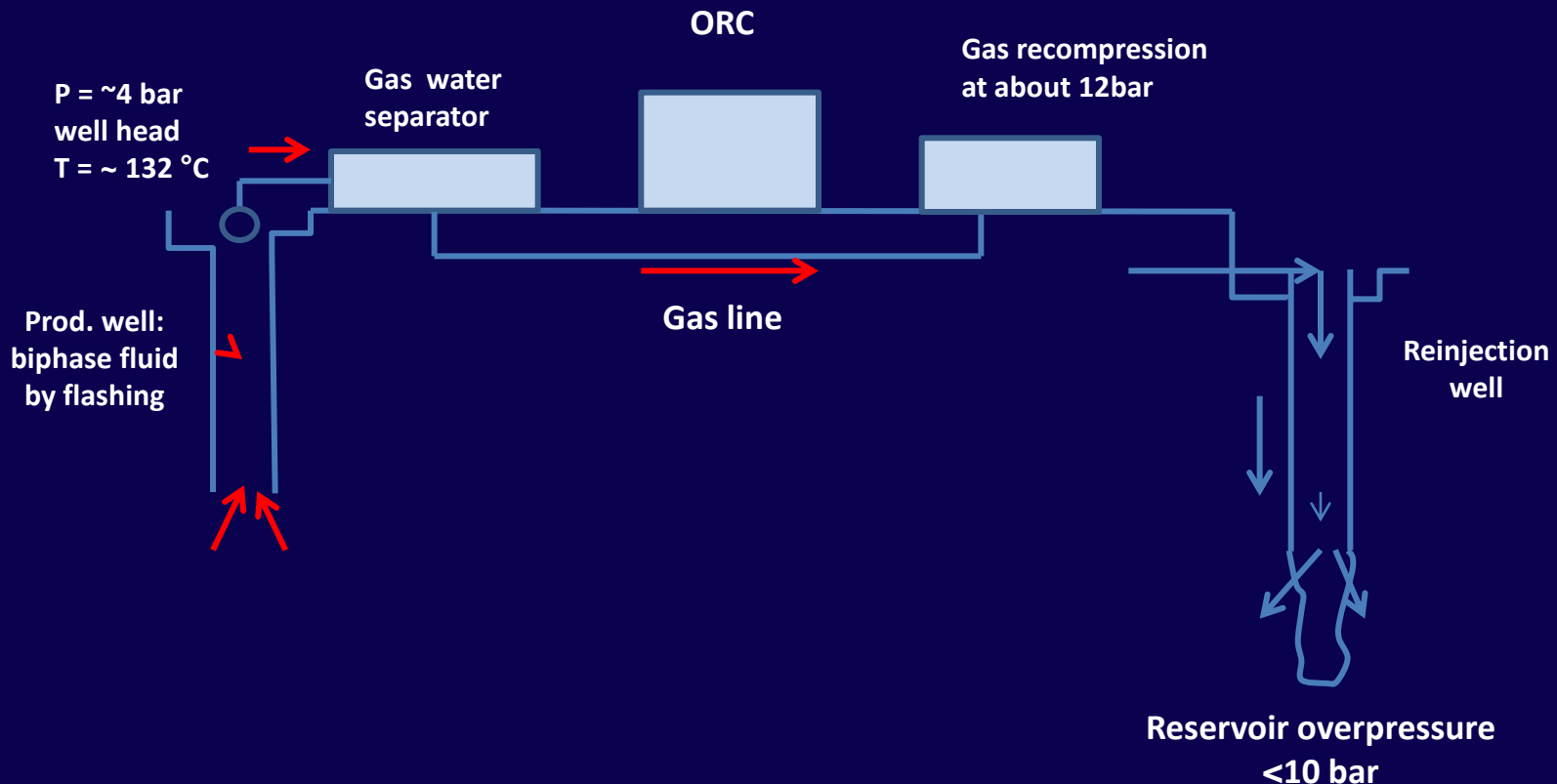
Technical solution to prevent gas emission into atmosphere at Castel Giorgio

Utilization of Electrical Submersed Pumps for water production and maintaining a pressure value >40 bar into the entire circuit to prevent CO_2 bubble formation and CaCO_3 scaling

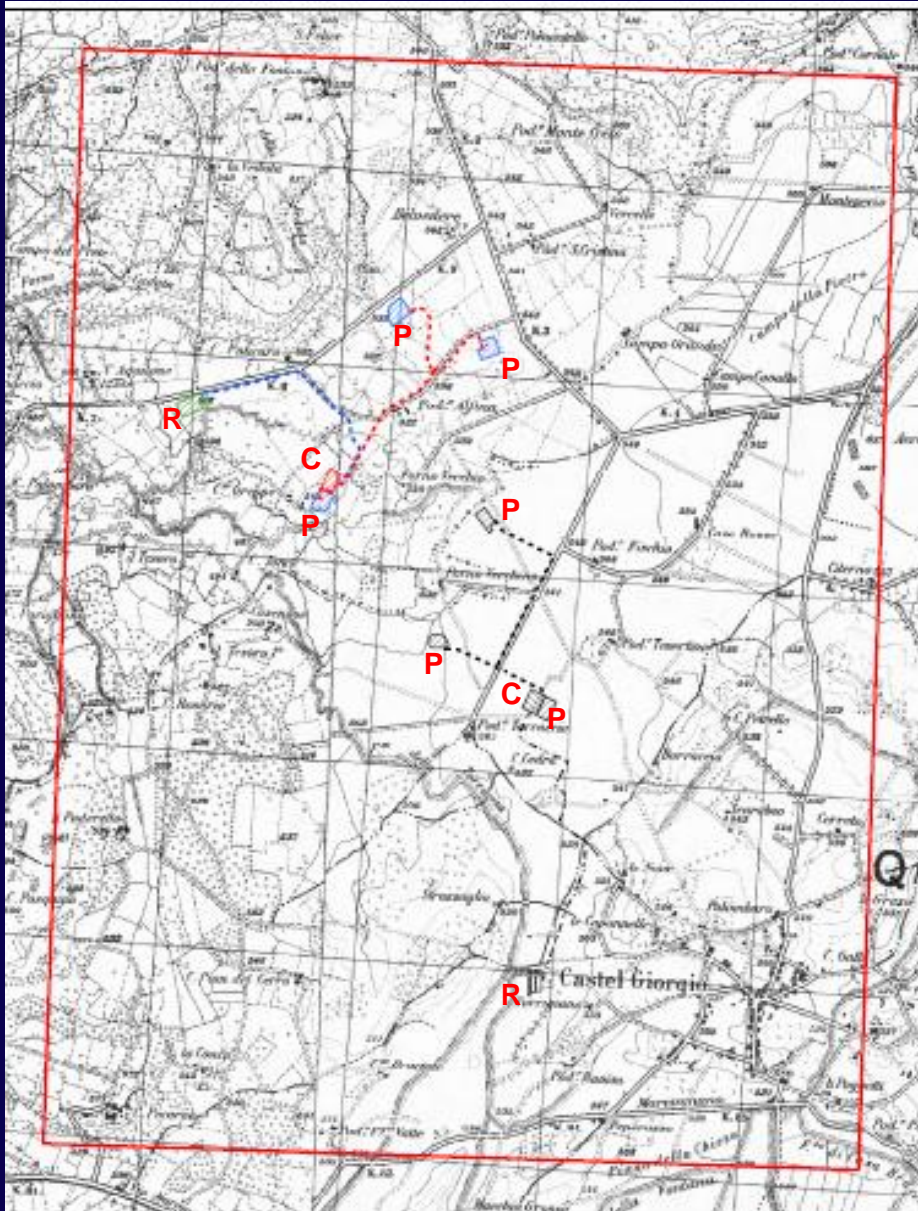


Technical solution to prevent gas emission into atmosphere at Torre Alfina

Geothermal fluid production by flashing with inhibitor injection into the well to prevent carbonate scaling



Main works of Castel Giorgio and Torre Alfina geothermal projects



C = ORC plant

P = production well pad

R = reinjection well pad

For each project:

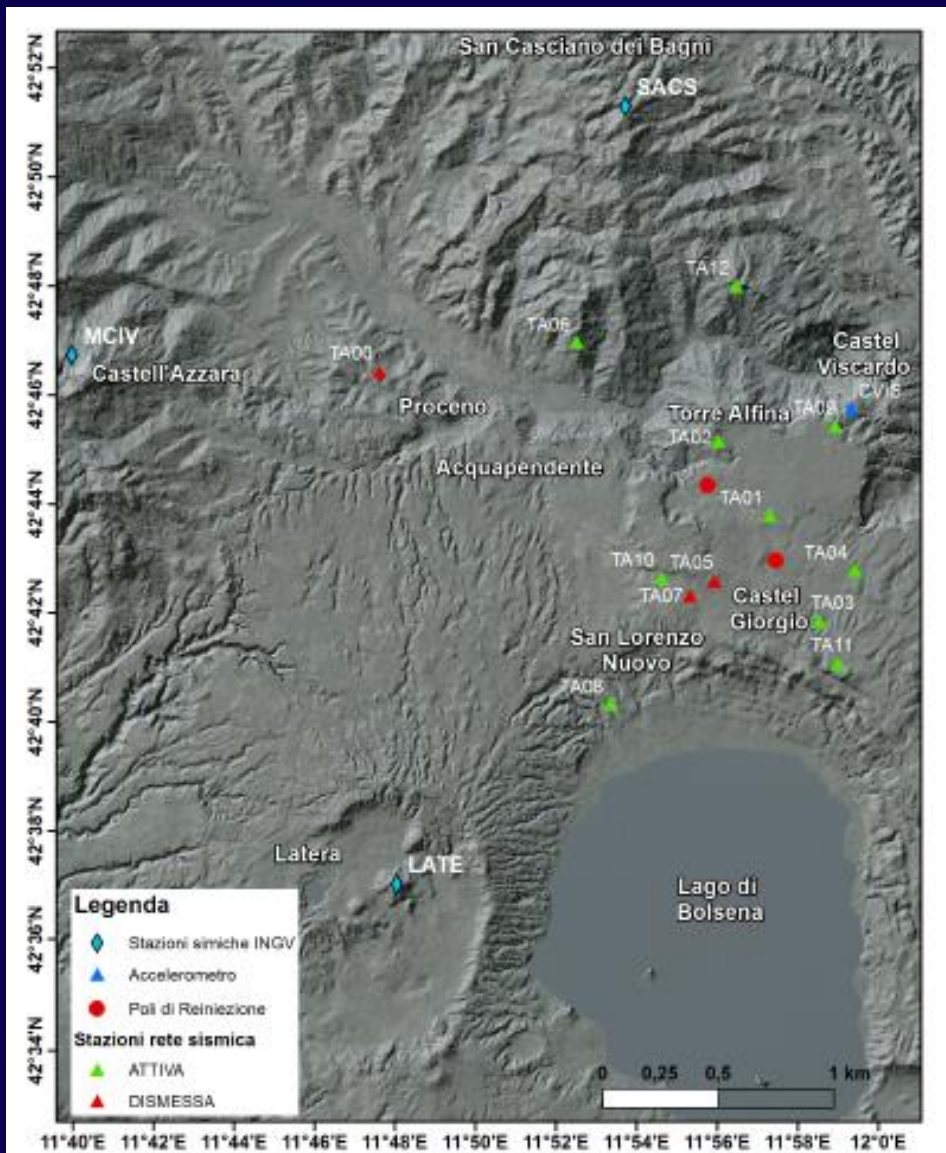
- n. 5 production wells
- n. 4 reinjection wells (vertical and directional)

depth from 1000m to 2500 m

Main results of reservoir simulation by TOUGH 2

- The field may sustain the fluid production needed for the two plants (~1900t/h) for at least 30 years
- The reservoir P - reduction at production wells is about 7.5bar and increases gradually up to 11bar after 30 years
- The reservoir overpressure at reinjection wells is about 4.5bar and increases gradually up to 7 bar after 30 years
- These variations have a limited extension in the reservoir and seem too small to induce subsidence and seismicity, respectively
- Simulation will be repeated when new well data will be available

Geophysical and geochemical monitoring



In the CG and TA area a local microseismic network, consisting of ten 3C stations, operates since June 2014

Seismicity is monitored also by 4 stations belonging to the INGV national network and by an accelerometer of Umbria region

This network will be completed by broad band stations and data teletransmission when the geothermal permit will be obtained

Subsidence will be monitored by a GPS network and a satellite InSar system

Since 2013 soil gas emission is regularly monitored in the zones where production and reinjection wells will be drilled

Economic aspects

- The investment needed for each pilot project is about 40M€
- No public funding is foreseen by the law for geothermal pilot plants
- The law only foresees a special fare for sold KWh
- The economic risk is then totally at the operator charge

Present situation of the projects

- Work program presented to MISE in 2011 and approved in 2012
- Environmental Impact Study presented to the Environment Ministry in 2013 for CG and in 2015 for TA
- Interministerial (MATTEM e MIBACT) decree of environmental compatibility released for CG on 3 April 2015 and still awaited for TA
- Umbria and Lazio regions participated to the entire procedure and they never expressed contrariety to the projects
- Today, after 6 years, the permit for CG has not been yet released as the Ministry is still waiting for the final agreement of Umbria region