The deep reservoir of the Travale geothermal area: mineralogical, geochemical and resistivity data

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The aim of the present multidisciplinary study is to explain the changes in resistivity observed in the deep reservoir of the Travale area taking into account the lithology and alteration affecting the reservoir rocks, with particular regard to conductive and clay minerals, the physico-chemical characteristics of the fluids, and their distribution and evolution with time. The study is also directed at calibrating petrophysical experiments in order to reproduce realistic physical conditions on a small scale.

**DEEP RESERVOIR**

The deep reservoir consists of metamorphic Paleozoic units and younger granite. The metamorphic units include: i) the Phyllitic Quartzitic Complex (metagreywacke with minor metafelsite and locally carbonate-silicilastic metasediments); ii) the Micacicchot Complex (almandine-bearing albite micaceous with minor amphibolite); and iii) the Gneiss Complex (gneisses with minor amphibolite layers and rare calc-silicate rocks). Deep drillings have encountered Pliocene-Quaternary granites at depths between -2 and 4 km below ground level (b.g.l.). All the crystalline units are interbedded by contact and hydrothermal metamorphism originated by the granite intrusions.

**SAMPLE DESCRIPTION**

The well-1 sample is characterised by a lens of quartz folded inside the phyllites affected by thermo-metamorphism (a granitic body is suggested at 3 km of depth). The sample is located between two fracture zones and it is roughly coincident with H-horizon location.

Four types of fluid inclusions occur in the sample: polyphase (LVHS), three-phase (VL-c), biphase (LV- NaCa) and monophase (V-c) inclusions. The fluid inclusion chronology was reconstructed taking into account the relative relationship between fluid inclusions trails and microthermometric data.

**FLUID INCLUSIONS**

Four types of fluid inclusions have been recognised:

- polyphase (LVHS)
- threephase (VL-c)
- biphase (LV-NaCa)
- monophase (V-c)

**polyphase inclusions (LVHS): liquid + vapour + halite (H) + an unknown solid (S) that does not dissolve on heating.

**three-phase inclusions (V-c):** carbonic gas + carbonic liquid + liquid water. Microthermometry shows the presence of CO₂ and an anhydrous gas (presumably CH₄).

**monophase inclusions (V-c):** vapour, but in a few cases may contain small amounts of liquid.

**XRD**

X-ray diffraction was carried out on one well in the Travale area (63 cutting samples in 2400 m of drilled depth). We focused to identify the types of minerals present, their relative abundance and to compare the mineral characterisation with resistivity values.

The Phyllitic-Quartzitic Complex is characterised by clay minerals (chlorite and mica types), quartz, plagioclase, calcite, epidote and rare dolomite. The relative abundance of these minerals is not homogeneously throughout the complex.

A clear correlation between the abundance of clay minerals and a change in resistivity was not observed.

**GEOTHERMAL FLUIDS**

The present-day geothermal fluid is superheated steam with similar gassteam ratios (4.9±0.7 % wt.).

CO₂ is the main gas compound (91.0–94.8 % vol.), followed by CH₄ (1.3–3.0 % vol.), H₂S (1.6–2.9 % vol.), H₂O (0.7–2.2 % vol.) and N₂ (0.8–1.3 % vol.). He, Ar, O₂ and CO are always lower than 0.1 % vol.

The steam condensates are characterised by high amounts of HCO₃⁻, NH₄⁻ and B (up to 439, 145 and 101 mg/kg, respectively).

**CONCLUSIONS**

Since the state of the geothermal fluid produced cannot explain the observed reduction in resistivity, the latter could be related to the abundance and type of i) heterogeneities in the reservoir rocks, ii) the abundance and type of alteration minerals, and iii) the presence of brines similar to those evidenced by the fluid inclusion study, whose interconnection would be sufficient to produce electrolytic conduction.

In order to reproduce realistic physical conditions on a small scale, we propose petro-physical measurements, whose interconnection would be sufficient to produce electrolytic conduction.

- i) the present-day reservoir conditions (H-horizon): one- and two-salinity
- ii) the K-horizon condition represents a potential deep-seated reservoir hosting a fluid in a superheated state (Berti et al., 2008):

**REFERENCES**


