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# Field methodologies aimed at geomechanical and geophysical characterization of faults zones in geothermal areas

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During March 2018 field works were conducted in the Acoculco and Las Minas areas for both geomechanical and geophysical surveys at the outcrop scale. In particular, were performed: classical ISRM scanlines, photo acquisition for no-contact geomechanical surveys, Electrical Resistivity Tomography, Ultrasonic Pulse Velocity measurements. Moreover, samples were collected for some sites.
Unito team reached the field sites previously selected thanks to Domenico Liotta and Walter Wheeler descriptions and suggestions.
During field trip, the attention was dedicated to find situations (outcrops) permitting to find explanation to the problem of the fluid paths. Field geologist suggested us some (a dozen) interesting outcrops but, already from preliminary descriptions, only a few of them suited the necessity of standard methodology for rock mass characterization. Main problems were: the dimension and continuity of the outcrops, the meaning respect to depth circuits, the practical accessibility at instruments in certain places. Anyway, some consideration can be done, especially about rock mass behaviour after faulting and related hydraulic conductivity. Interesting was to couple geomechanical surveys (both field measurements and no-contact photogrammetric elaboration) to geophysical lines (high resolution electrical topographies).
In the report of each studied outcrop, hydraulic conductivity was estimated. As a matter of fact, most depends on joint opening and infilling, parameter very difficult to determine with precision in surface and subjected to meaningful variation with depth. It is possible to give some general consideration and in particular:
• Limestone range between 10-3 and 10-5 m/s, depending to joint density (faulting);
• Andesite show a brittle behaviour and consequently higher values (10-3 m/s);
• Fault and the surroundings can reach also 10-2 m/s.
Only in one site was possible to study a well-developed discontinuity and the related damage zone: the Rinconda fault. In this was possible to directly measure discontinuities only on one side of the fault, but the other part was investigated by geoelecrical survey. Results are the following:
• there is an evident decrease in fracturation moving away from the fault core: from more that 20 j/m near the fault to less than 5 in the sounding rock mass;
• this passage is not progressive but there is core of about 5 m of the fault characterized with more than 10 j/m, than there is a slightly deformed zone (about 5 j/m) of 6-8 m followed by a more fractured one that pass again to a less jointed “sounding”rock mass;
• the same situation is highlighted by geoelectric that “see”the same order of changes;
• due to these differences, also hydraulic conductivity changes from very high in the core (about 10-2 m/s, the orange box in the picture) to a less permeable zone (green, 10-5) to an increase for a couple of m (blue again) to the permeability typical for intact rock mass (usually very low, 10-6 m/s).
From a geothermal point of view, this situation depicts a zone damaged by a meaningful fault of about 30-40 m in which the permeability is definitely higher (orders of magnitude) than to rest of the rock mass.
Strong emphasis we would like to give also to the very good agreement between physical and geophysical results: geoelectric, even if qualitative, couple very well direct observation and ca be used when field observation are not possible.

Also where there are only indirect observation of subsoil fluids emission, like near the Acoculco wells, near surface geophysics is able to give information about the origin of gas and/o brine: in that case, gas emission alignment well fit the resistivity anomaly highlighted by electrical topographies. Interpretation seem to give the idea that fluids came thought a fault strong dipping towards SW going towards the pass the road came into the valley.
Field surveys were useful to understand the technical characteristic of the rock mass outcropping in the geothermal area or in similar geological context (Las Minas). Traditional and no-contact methodology produced date usually well-fitting each other and permitting to do estimation about mechanical and hydrogeological properties. Moreover, was possible to give information about dimension of fault and related damaged zone. Meaningful information aimed at identifying geological structures came from geoelectrical tomography's. By the way, field measurements confirm that the fluid circulation is leaded by fragile structures where permeability is orders of magnitude higher than intact rock masses.

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