P538 ACOUSTIC EMISSION MONITORING AND HYDROFRAC EXPERIMENTS

The development of tight oil and gas reservoirs, waterflooding, waste fluid disposal, geothermal recovery, salt leaching at great depth to name but a few, are instances where fractures are hydraulically induced and propagated. The knowledge of the direction of propagation of the created fracture is always important and some times critical. In fact, in every case hydraulic fracture orientation can be seen as a method which yield information about the orientation of the in-situ stress. The monitoring of acoustic activity associated with propagation and/or closure of a hydraulic fracture is a method which can provide unambiguously the fracture direction and gives information on the geometry of the fracture.

Because of well spacing often encountered and low magnitude of the seismicity expected in most of the case, we considered that to be efficient the downhole seismic monitoring must be carried out directly in the treatment well. To that end , a SEIS-FRAC ^{R} system was jointly developed by IFP and géostock. It allows to record and analyse acoustic emission detected from a treatment well. It is based on a wireline operated tool SIMFRAC ^{R} (figure 1) equipped with a 3-component geophone, a 3 component accelerometer, a pressure/temperature gauge and a pendulum to determine the absolute orientation of the tool. The tool is lowered in the well using a conventional heptacable and is coupled to the casing or formation below the perforations. The tool is connected to a real time PC-based surface acquisition system that records seismic events and downhole pressure and temperature. The recording of acoustic data is done in trigger mode and full wave form is recorded. Then, knowing the orientation of the tool, the absolute direction (azimuth and inclination) of incoming signals can be determined from the polarisation analysis carried out on the 3 component records. Orientation of the fracture propagation direction will then be derived from the analysis of all the acoustic events for which an orientation has been obtained. A first estimate of the orientation is obtained on site.

The major drawback in these circumstances is that acoustic emission can not be easily recorded during pumping phases of the treatment (i.e. during the propagation of the fracture), because of the noise generated by the fluid flow past the tool. The monitoring periods are then often restricted to fall-off periods. The recorded data therefore correspond to the signals produced during the closure of the fracture. The monitoring is possible during some injection phases but requires low flow rate.

The poster will present results obtained during acoustic monitoring operations carried out to determine the orientation of a fracture created by hydraulic stimulation treatment. Two cases will be presented. In both cases, the overall results derived from seismic polarisation analysis show unambiguously a preferred orientation of seismicity (figure 2). In both cases there is evidences that the major direction of seismicity is the direction of the hydraulic fracture. The results come in close agreement with wider scale tectonic studies or geological indicators. The first case deals with the stimulation of a gas well in a tight sandstone reservoir. The objective of this test was the determination of the optimum azimuth for a horizontal well planned in a neighbouring reservoir block. The second case is totally different, it deals with hydraulic treatment carried out to connect two wells in order to initiate the leaching of a salt layer (production of brine). The objective of this test was the determination of the direction of the fluid injected from the treatment well, which is a critical information to optimise the design of the second well (horizontal well).

The objectives of these tests were convincingly met, in that the direction of "fractures" were unambiguously determined and the information was obtained on site.

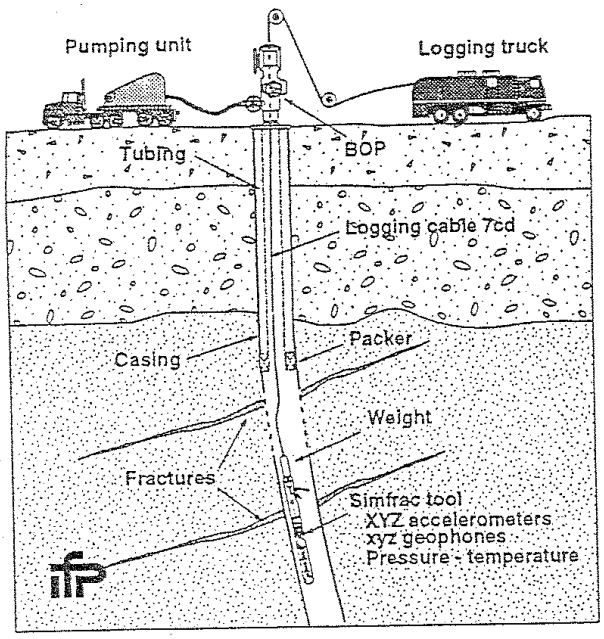

Figure 1 - Synoptic of a SEIS-FRAC [R] operation - Slim SIMFRAC [R] tool 2" max. OD can be used through tubing and packer in cased hole only.

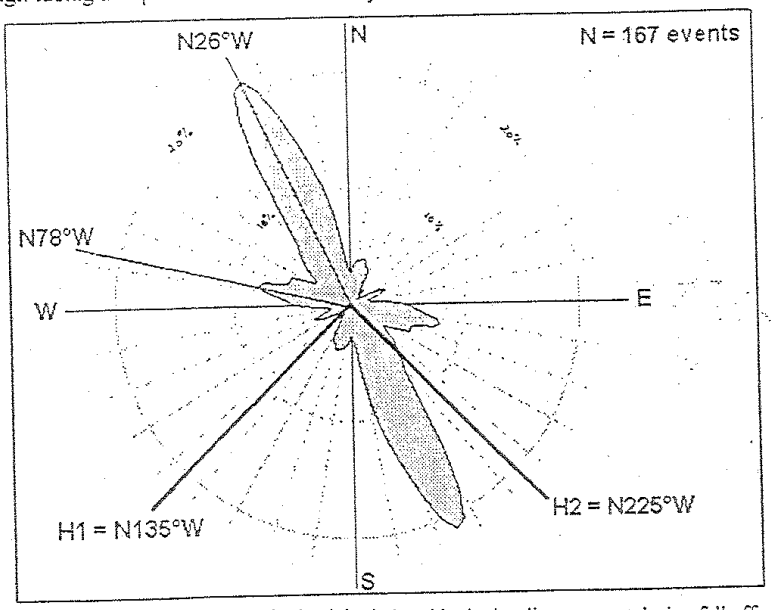

Figure 2 - Rose diagram of the azimuth of seismicity induced by hydraulic treatment during fall off periods. The rose diagram presents a smoothed presentation of the frequency of the events analysed (percentage of events per class interval of 5°).