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## Full-wave inversion results for offset VSP data in geothermal GGR5 well

Christophe Barnes\* (CYU), Charles Naville (IFPEN).

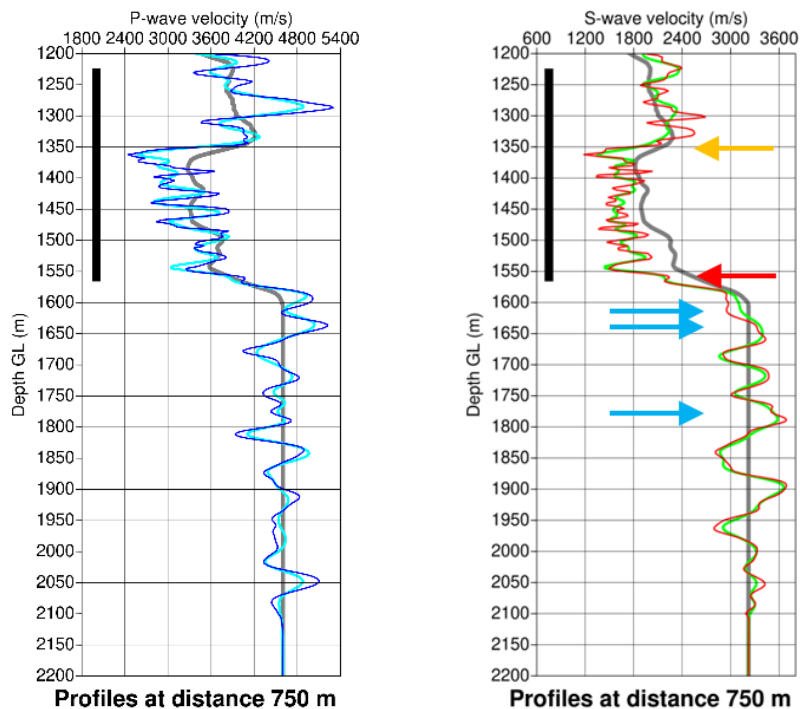
### Abstract:

Borehole seismic is supposed to provide better image of the subsurface near the well, with better resolution, and more precise location of structures than surface seismic. However, the wavefield is often complex and difficult to exploit when using standard imaging techniques. The full-wave inversion (FWI) method applied to such well seismic data can extract a lot of information from the data, allowing both a thin image of structures and an estimate of physical parameters like the P- and S-wave velocities or the density of the rocks.

The goal of the present study is to verify that the FWI can detect very thin porous reservoir beds below the geophone antenna from an offset VSP dataset with an expected thickness of 5-10 m. The data are from the HF/HR look ahead VSP survey recorded in the deviated section of a geothermal production well GGR5 drilled down to the top of the carbonate Dogger aquifer in the Paris basin.

The FWI approach is based on the seismic modeling of the wave equation through numerical methods. In the present study, the seismic modeling is achieved for a viscoelastic rheology, and we invert for the P- and S-wave velocities and density. Full-wave seismic modeling allows to reproduce the data with the correct geometrical spreading, the correct decay of seismic amplitude due to attenuation and all elastic effects.

The results show that we can detect the thin porous reservoir in the upper part of the Dogger (see figure 1). These results are reproducible when modifying the FWI algorithm parameters, reinforcing their reliability.



**Figure 1:** P- and S-wave velocity profiles at 750 m from the source. The blue/cyan and green/red lines are the results for 10-80 Hz and 10-120 Hz frequency bands respectively, the gray line is the initial profile and the thick black line the antenna. The Argovian and Bathonian tops, clearly marked, are indicated respectively by the orange and the red arrows. The thin layer with a lower velocity indicated by the blue arrow at 1615 m vertical depth coincides with the targeted porous thin bed.

### Speaker short Bio:

Christophe Barnes: Mines de Paris 1989; PhD in geophysics, IPGP, 1997. Associate professor at CYU and GIM-labs company CEO. Borehole seismic, traveltime/full-wave modeling and inversion, numerical methods, inverse problems.