**Traveltime Tomography, Early arrival Waveform Inversion, and Surface Wave Inversion to Image Near-surface geology**

*Sherif M. Hanafy, King Fahd University of Petroleum and Minerals, Dhaharan, KSA*

*Yicheng Zhou, King Fahd University of Petroleum and Minerals, Dhaharan, KSA*

In this work we discuss, using a field example, the inversion techniques used to generate velocity models for the near-surface applications. The most commonly used techniques are the travel time tomography (TTT), the early arrival travel times inversion (EWI), and surface wave inversion (SWI). Each of these three inversion techniques has its advantages and limitations. The TTT is easy, fast, and robust, however, it suffers from raypath’s smearing problem which decreases the final resolution. The EWI has better resolution when compared to TTT, however, it is time consuming and the inversion may stick in a local minimum, moreover, the source wavelet is required, which is not always available. Finally, the SWI is based on inverting ground rolls to generate S-wave velocity tomograms, chances of getting stuck in a local minimum is high, however, the final tomogram could give a better image in case of high-heterogeneous subsurface.

In this work we used all three inversion techniques to get a better subsurface image of an area located at the eastern side of Saudi Arabia. We recorded one seismic profile with a length of 1080 m long, 180 3C wireless receivers, and 6m receiver interval. The seismic source was a 200lb accelerated weightdrop, where we recorded one shot at each receiver point. Each shot gather is recorded using 8 stacks to enhance the signal to noise ratio. The first arrival travel times of the recorded data is manually picked and then inverted to generate the TTT. The final tomogram shows 4 subsurface layers with a possibility of a fault between offsets 500m and 600m. To confirm the existence of the fault and enhance the resolution of the tomogram, EWI is used, where the TTT tomogram is used as initial velocity guess for the EWI. The pre-processing steps of the EWI included muting around the first two periods, applying a band-pass filter, and extracting the source wavelet from the recorded data. The data is then inverted to generate the final EWI tomogram. The location of the subsurface fault is confirmed to be between offsets 480m and 520m. A low velocity zone corresponding to the colluvial wedge associated with the subsurface normal fault is also detected between offsets 520m and 650 m. Both TTT and EWI generate P-wave tomogram, hence, we inverted the surface waves to generate the S-wave tomogram. Here, we muted around the surface waves, then generated the dispersion curves of each shot gather. The dispersion curves are then inverted to generate the 1D S-wave velocity curves, which is then merged together to generate the 2D S-wave tomogram. The S-wave tomogram shows more details in the shallow parts of the velocity model and confirm the existence of the fault, however, its depth of penetration (~ 150 m) was shallower than the P-wave tomograms (~ 250 m).

In this field example both TTT and EWI are used to generate the P-wave velocity tomograms, while the SWI is used to generate the S-wave velocity tomogram. The integration between both tomograms gave a better understanding of the subsurface velocity model. Resistivity and micro-gravity data are also recorded at the same site to confirm our conclusions. Their results are in a very good agreement with the seismic results.