When Surface Waves Become our Zoom-in Lens—a Case Study from Western Desert Of Egypt

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Abstract

The Western desert of Egypt is characterized by its very complex near surface geology. Its surface is composed of hard limestone which has a lot of cavities. The cavities are usually filled with other rock types like shale or loose sand, creating a very rapid lateral lithology change within a few tens of meters. Failure to properly model and understand the first few hundred meters of the subsurface in the western desert has led to the lack of focusing of the seismic data. Imprints of the near surface anomalies and poor imaging are usually observed on seismic sections from western desert; this has led to a some surprises in exploration over the past decades. SWAMI (Surface Waves Analysis Modelling and Inversion) is a technique that has shown success in many areas in the world over the past 10 years. In this technique, the Rayleigh waves recorded on the seismic data are analyzed to determine their dispersion and propagation behavior, then they are inverted into a near surface model or used for modelling the direct and scattered ground roll on the gathers. Previous work done in nearby areas (Strobbia 2011, Yanchak 2013) shows the SWAMI has a very good potential in characterizing the near surface, however it lacked the high resolution in the first 50 meters of the subsurface which are more unpredictable. We present the SWAMI analysis modeling and inversion of the surface waves over an area in the Western Desert of Egypt where a broadband point source, point receiver seismic acquisition was carried out with a delicate sampling. SWAMI was pushed to limits that were achieved for the first time, thanks to the good sampling of the data. Ground roll was recorded with frequencies as high as 70Hz while typically its maximum frequency in other acquisitions was 20 to 30 Hz. This allowed SWAMI to detect a new level of resolution in the Western Desert. It also enabled the understanding of how the deep faults are extending up to the surface which is something that was not visible on seismic data in the area before. A detailed analysis of the sources of wave scattering in the area was possible, this explained some of the mis-understood events on the raw shot records and allowed us to properly address them. The shear velocities derived from SWAMI are typically converted them to primary velocities to be used in statics and migration; however, there were no direct sources of information about Vp to Vs ratio in the area. To overcome this challenge, the near surface model was converted to primary velocities based on correlation between the direct arrival velocities from the seismic gathers and the shear velocities from SWAMI. The model was then input to a diving wave tomography solver to get a stable near surface model for refraction statics and depth imaging. This combination helped to resolve the near surface challenges in the Western Desert and produced remarkably better results in comparison to the vintage seismic data in the area.