Repeatability of time-lapse measurements using ACROSS in Saudi Arabia

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Introduction

To do the time lapse for monitoring of injected CO_2 in CCS (carbon capture and storage) and EOR, we have used the ACROSS (Accurately Controlled and Routinely Operated Signal System) methodology to monitor the change of subsurface (Kasahara *et al.,* 2010; Kasahara and Hasada, 2016). To evaluate the true subsurface change, it is necessary to clarify the repeatability of the measurement system including instrumental parts of seismic source and receivers. Many factors contribute to repeatability of observation; seismic source signature, ground coupling of source and/or receivers, fixing accuracy of source and/or receiver locations, media along paths, and true subsurface changes (Kasahara and Hasada, 2016). In this presentation, we will examine the repeatability of our measurements by the field data in Saudi Arabia.

We used data obtained by 30 seismic stations in Al Wasse field in 2013–2014 and 2015. In addition, we carried out the refraction survey using the ACROSS seismic source. In the source-gather records the first arrivals decayed at the offset distance further than 700 m. This is thought to be caused by velocity inversion just below the top layer. The characteristics of weak first arrivals at the distance around 500–700 m might affect the repeatability

NRMS Repeatability

Kragh and Christie (2002) proposed NRMS for the repeatability between two traces. If two traces are uncorrelated, the NRMS error is 200%. If one of the traces has half amplitude of the other, the NRMS is 66.7%. In the case of the Gulf of Mexico, the best values were 18–30% (Kragh and Christie, 2002). Eiken *et al.* (2003) obtained approximately 40% NRMS by two surveys with 25 m lateral offset. For most of 4D survey, 10–30% is thought to be a typical good value (Johnston, 2013).

Results of repeatability estimation

We examined the NRMS repeatability using a geophone in the ACROSS source room. Though the analyzed duration is short, the NRMS during 12 days were less than 2%. We can clearly identify daily variations in this source room data possibly caused by housing deformation due to the large variation of outside temperature. The source was in the desert area in winter and the outside temperature was so low during nighttime.

Next, we calculated the travel time variation (dT) and the amplitude variation (dA) for the field stations using the cross-correlation of P-wave portion. The dT and the dA in some stations show small temporal variation during two periods with about two-years interval. We also calculated NRMS using the same P-wave portions. NRMS variation of the stations #33 and #53 were smaller than 5% in the first and the second periods, and it is similar results seen in dT and dA.

Considering the NRMS at ACROSS source room, the NRMS of source itself is small (< 2%) and the environmental changes affect the NRMSs of the field stations showing very large variations. Because the field geophones were located at the surface and the test field has more than 64 water-pumping stations, the apparent NRMSs observed at the grid stations show great temporal variation, which are considered time lapse itself. In addition, the weakening of first-arrivals mentioned above could affect the NRMS variation.

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