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Low-frequency shadow (LFS) as a tool for CO₂ sequestration of Sleipner field North Sea

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Seismic low-frequency shadow (LFS) is a zone in the seismic data that is characterized by strong anomalously low-frequency energy compared to its surroundings and it occurs beneath a body that strongly attenuates the energy of the propagating seismic waves. LFS can be used as a tool to monitor the migration of CO₂ in a reservoir. To demonstrate this on the Sleipner field, North Sea, where a large amount of CO₂ is being sequestered in the deep saline Utsira Formation. A spectral decomposition analysis of time-lapse 3D seismic data of the Sleipner field, North Sea, was carried out using the continuous wavelet transform. We examined the common frequency stacks corresponding to frequencies 10 Hz, 14 Hz, 30 Hz, and 40 Hz for the occurrence of LFS in the pre- and post-CO₂ injection cases data. We did not find any signatures corresponding to LFS in the pre-CO₂ injection

scenario. In the post-CO₂ injection cases, LFSs were detected below the reservoir base at frequencies lower than 30 Hz. It is shown that the seismic low-frequency shadows are not artefacts but occur due to attenuation of the high-frequency components of the propagating seismic waves in the CO₂-saturated Utsira Formation. The low-frequency shadows are localized anomalies at the base of the formation; hence it can be applied to study the behaviour of CO₂ when stored in a reservoir.