MEMS Sensors: Added Value For Land And Seabed Seismic Acquisitions In The Middle East

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Abstract

Objectives/Scope: OBN projects are taking an increasing market share over towed streamer surveys, including in the Middle East where the most ambitious OBN surveys are ongoing. In OBN, each node is equipped with a pressure sensor (hydrophone) and three motion sensors (typically, geophones). However, the now century old geophone technology has inherent shortcomings that alter the recorded signal. These shortcomings are not observed on MEMS sensors, with an excellent fit of theory and field observations.

Methods, Procedures, Process: Contrary to MEMS sensors, geophone technical specifications are affected by changes in temperature, sensor aging and manufacturing tolerances, the latter only yielding an amplitude/phase variation in response up to 3 dB/10° in low frequencies. These uncertainties in sensor response are particularly difficult to model in practice, and become a concern especially when operated in a point-receiver or blending context. On geophone OBN, a tiltmeter with a typical 3° precision is used. Individual MEMS can detect the gravity vector. With smart factory calibration, their orthogonality error in 3C is brought close to zero. Field experience further confirms these theoretical statements.

Results, Observations, Conclusions: A 23,000 channel MEMS-based OBN project is going on in the Middle East, and already delivering a promising dataset. While the excellent phase and amplitude response of MEMS has been demonstrated in land (Tellier, 2021), this observation is further confirmed in OBN, where MEMS outperform hydrophones and geophones in low frequencies. 3C MEMS sensors with 0 Hz sensing capability also exhibit much better accuracy in terms of verticality and vector fidelity, without prior pre-processing: the ground acceleration is measured with a very accurate separation of horizontal and vertical components, and with true amplitudes and timings. In a shallow water context, Z MEMS would e.g. not record the horizontal water breaks, and record significantly less converted wave contamination at short offsets. The high-fidelity data recorded in this way thus enables e.g. rigorous analysis of anisotropy or enhanced denoising of the Z component when compared to traditional calibration with the hydrophone, while offering the quality of low frequencies required for full-waveform inversion or imaging. Further observations and comparisons will be presented and discussed, supported by field data from the Middle East.

Novel/Additive Information: On the seabed, the sensing performances of 3C MEMS remain unrivalled. Besides the true phase an amplitude sensing capability of 1C MEMS, signal can be reconstructed with a true verticality, while the vector fidelity of the 3C axis is significantly improved. This added to other properties of MEMS, makes this sensor an awaited driver
for the development of OBN acquisitions - especially for sparse, blended or 4D acquisitions, where the sensing fidelity more than ever matters.