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Long-Wavelength Oscillations at a Mud Volcano in the West Nile Delta

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An Ocean Bottom Seismometer (OBS) Network was installed for a period of 8 months at North Alex Mud Volcano (NAMV) in the West Nile Delta. The six OBS stations operated at ~500m water depth and were equipped with both a hydrophone and a 3-component geophone.
Local seismicity, i.e. micro-earthquakes from NAMV, were recorded, but in addition several clear observations of large earthquakes that occurred in the Mediterranean, e.g. a Mw=6.7 event that took place offshore Crete at the 1st of July 2009 were found in the data traces. Waveforms of these large earthquakes vary significantly depending on the location of the OBS station:
Stations that were located in the center of the Mud Volcano's conduit, differ markedly from records of the stations positioned outside of the mud volcano. Meanwhile onset and waveform of P- and S-wave are comparable everywhere, a long-wavelength ground movement can be observed exclusively at stations in the NAMV's center.
This movement lasts for several minutes after P- and S-wave signals have died at any other station. Spectral analysis shows distinguished peaks for this movement at periods of 11.1s; 5.6s; 2.8s and 1.9s, which implies a harmonic oscillation in resonance of the entire conduit. Thus, large seismic events seem to be able to stimulate mud volcanoes to all natural oscillations, comparable to the 1s – 5d modes of a stimulated membrane.
Seafloor bathymetry and 3-D seismic images made it possible to derive the dimensions of the central NAMV conduit. If dimension is known, modeling of the resonance wavelength might allow constructing depth and seismic velocities within it. In turn, seismic velocities could be related to gas content.
Further, when oscillating in resonance, the slow movement of the NAMV surface means a pressure change in the upper sedimentary layers. We present evidence that this causes degassing of the conduit. Gas pressures in the conduit are expected to be in equilibrium with the surrounding pressure. Lowering the surrounding pressure causes the mentioned effect, in agreement with Henry's law. We show that in case of a harmonic oscillation, large amplitude noise in the high-frequency spectra of hydrophone traces from OBS stations on top of the NAMV conduit are best explained by gas bubbles around the station.
In addition to the seismic investigations, five MT-stations (magnetotelluric) were also installed on the central conduit of the NAMV at the beginning of the project for a period of three weeks. Electric fields at these stations frequently show harmonic signals with periods of about 3s, 6s, and 12s, thus, closely resembling the spectrum found in the seismic records. We will further investigate and discuss the implications of this finding in conjunction with the interpretation of the seismological measurements.