DISTRIBUTION OF FREE GAS AND IMAGE STRUCTURES BENEATH SEVASTOPOL MUD VOLCANO, BLACK SEA, FROM A 3D STUDY OF A HIGH RESOLUTION WIDE-ANGLE SEISMIC DATASET

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Abstract
Combined geophysical, geological, and geochemical analyses were conducted to investigate gas-hydrate occurrence in the Sorokin Trough, Black Sea. This study concentrates on a 3D high resolution seismic grid recorded with 13 ocean bottom stations on Sevastopol mud volcano. The 3D nature of the experiment results from the geometry of densely spaced profiles as well as the cubical configuration of the densely spaced receivers on the seafloor (~300 m station spacing). Correlation of a 3D mirror image of the seismic records in addition with 2D velocity-depth inversions of several seismic profiles gives a quasi 3D image of the subsurface. The Kirchhoff mirror image time migration reveals the reflective structure of the sub-seafloor beneath the ocean bottom stations. The traveltime inversion reveals the seismic velocities along the profiles.

Keywords: Geophysics, Black Sea, Sorokin Trough, Seismics, Mud volcanoes

The goal of this study is to image the sub-seafloor structure beneath the Sevastopol mud volcano (SMV) with the focus on structures of/within the feeder channel, the distribution of gas and gas hydrates and their relation to fluid migration zones in sediments. SMV lies in the Sorokin Trough and is located southeast of the Crimean peninsula in the Black Sea.

To achieve the goals, the main focus of this study lies in the interpretation of seismic data recorded with ocean bottom stations. Four ocean bottom hydrophones (OBH) [1] and 9 ocean bottom seismometers (OBS) [2] were deployed in a 3D grid for high resolution wide-angle seismic measurements. The high density of the seismic profiles is the pre-requisite of the 3D investigation of the dataset. Two 1.7 l GI-guns generated the seismic signal at a shooting rate of 10 s. The extent of the 3D study area is 7 km x 2.5 km, comprising 113 profiles, recorded at a distance of 25 m in the central region and 50 m distance in the peripheral region. The seismic profiles are typically longer than 6 km which results in large offsets for the reflections of the OBH/S section. This enables the study of the seismic velocities of the sub-seafloor sediments and additionally large offset incident analysis.

Seismic data quality is improved by frequency-wavenumber and bandpass-frequency filters with the main frequencies lying between 16 Hz and 400 Hz. This means i.e. to reduce the low frequency content of the strong bubble signal from the direct wave, which interferes with the uppermost sediment reflections, and therefore allow for a better identification of reflections originating from the uppermost sediment reflectors.

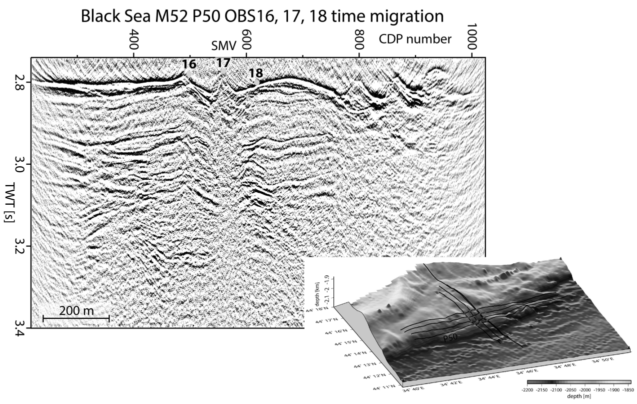

Fig. 1. Bathymetry of region of SMV showing major seismic lines and OBH/S positions. Mirror image of OBH 16, 17, and 18 on profile 50 across SMV.

The 3D Kirchhoff mirror image [3] time migration, applied to all OBH/S sections including all shots from all profiles, leads to a spatial image of the sub-seafloor. Here, the migration was applied with the velocity distribution of 1.49 km/s in the water column and 1.5 km/s below the seafloor (bsf) increasing to 2 km/s for the deeper sedimentary layers at ~2 s bsf. Acoustic blanking occurs beneath the south-easterly located OBH/S and is associated with the feeder channel of the mud volcano. There, gas from depth can vertically migrate to the seafloor and on its way to the surface horizontally distribute patchily within sedimentary layers. High amplitude reflections are not observed as continuous reflections, but in a patchy distribution. They are associated with accumulations of gas. Also structures exist within the feeder channel of the SMV.

The velocity depth structures for the seismic profiles of the 2D traveltime inversion (RayInvr [4]), show reduced seismic velocity zones correlating with the zones where gas is indicated from the time migration and assumed fluid-migration paths.

Mirror imaging proves to be a good tool to seismically image structures, especially steep dipping reflectors and structures which are otherwise obscured by signal scattering, i.e structures associated with fluid migration paths.

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