Geophysical evidence for gas hydrate/free gas associated with mud volcanism in the western Ross Sea (Antarctica)

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Geophysical evidence of gas hydrates associated with mud volcanism has been found in the western Ross Sea (Geletti & Busetti, 2011, 2022; Busetti et al., 2024). The location of the mud volcanoes appears to be closely related to the tectonic structures in this area (Sauli et al., 2021) and the fluid releases, with the zone where Bottom Simulating Reflectors (BSRs) are strongly pronounced in the seismic profiles. These BSRs describe the transition between gas hydrate and free gas. The presence of the reservoir appears to be associated with morpho-structural high zones that may act as traps for the gas, which is present in both the solid and gaseous phases. Mud volcanism is generally involving voluminous generation and emission of methane and carbon dioxide, which means that most mud volcanoes serve as an efficient, natural source of greenhouse gasses and consequently play an important role in global climate dynamics (Judd, 2005). The system of mud volcanoes and gas-bearing sediments in the western Ross Sea could therefore be a source of methane flux from the lithosphere to the hydrosphere and atmosphere, as recent studies along the coastal margin have also shown (Seabrook et al., 2023), and thus impact on the greenhouse effect and climate change.

We present a reprocessing of multichannel seismic profiles that provides evidence for a plumbing system feeding the mud volcanoes, with gas leaking from the seafloor in the western Ross Sea (Geletti and Busetti, 2011, 2022, Busetti et al., 2024). In pre-stack analysis, BSRs in the seismic records are characterized by several anomalies in amplitude, velocity and frequency compared to the normal adjacent seismo-stratigraphic reflectors (Geletti & Busetti, 2011, 2022): (a) the amplitude of the reflection varies with offset, with its negative value increasing with distance (or incidence angle) and absolute values comparable to those of the seafloor reflection; (b) the velocity function at the level of the BSR decreases drastically, going from about 2000 m/s to less than 1400 m/s in the underlying layer; (c) the dominant frequency of the BSR is below 25 Hz of the seismostratigraphic reflectors at the same time twt. On the stacking profiles, the BSRs appear with events of strongly negative amplitude, simulating the trend of seafloor deepening with increasing bathymetric depth, cutting the horizons in some areas regardless of stratigraphy. These BSRs are discontinuous and are interrupted near some active faults in the Lee Arch (acoustic gap), at the top of which morpho-bathymetric reliefs and depressions such as mud volcanoes and pockmarks can be recognized.

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