FLUID-ESCAPE STRUCTURES ON THE CENTRAL NILE DEEP-SEA FAN: RESULTS FROM INTEGRATED SWATH BATHYMETRY AND 3D SEISMIC DATA

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Abstract
Fluid seepages are observed on almost every continental margin where detailed surveys have been conducted. They exhibit different morphologies at the seafloor, but pockmarks, mounds, and mud volcanoes are predominant. In the Central Nile Deep-Sea Fan (NDSF), an integrated approach, based on bathymetry and seismic investigations of the seafloor and of the sedimentary column reveal that pockmarks fields, mud volcanoes and shallow networks of cracks are associated with various geological features such as normal faults, faulted anticline, buried turbidite channels and mass-transport deposits.

Keywords: South-Eastern Mediterranean, Nile Delta, Bathymetry, Seismics, Mud volcanoes

Fluid emissions at the seafloor of continental margins have been recognized in a large range of settings. The most commonly described expression of fluid seepages are commonly pockmarks, carbonate mounds, mud volcanoes (MV) and/or gas chimneys; they may result from migration of thermogenic fluids along tectonic conduits, dissociation of gas hydrates and dewatering of turbidite channels or of mass-transport deposits (MTDs). Fluid seepages constitute thus a potential window on deep reservoirs and constitute part of geohazards affecting continental-slope environments. A great variety of fluid seepages have already been described over the NDSF. They are also recorded by patches of high acoustic backscatter indicating pockmarks and/or small carbonate mounds [1; 2]. Submersible observations have shown the high-backscatter patches to coincide with authigenic carbonate pavements [3]. Some of them were thought to be active during the Holocene. A new dataset used in this study includes multibeam bathymetry and backscatter data, as well as Chirp and seismic-reflection profiles (Géoazur laboratory) mixed together with the upper section of 3D seismic data (Total Company); it helps to better constrain the characteristics of already-known structures and to identify new ones within the central NDSF. Some 200 additional pockmarks, identified between 300-1300 m water depths, appear either isolated or grouped in clusters. On seismic data, they are expressed at the seafloor as concave-up high-amplitude reflections lying on top of vertical pipes with incoherent facies at depth. Seven MV (conical, flat, circular in shape; 1.5-4 km in diameter; up to 70 m high) already identified between 100-1100 m water depths, are imaged in better details. The new observations reveal abundant mud flows at the seafloor, suggesting recent fluid activity. Newly identified emission centers consist of either low-elevation domes, with concentric ridges, or chimney-like structures merging in a large caldera. Such morphological differences may indicate variations in both nature and viscosity of fluid emissions. Radiating networks of lineaments, interpreted as small-scale fractures, are seen on the seafloor and at depth around some MVs and may indicate fluid intrusion processes within the pre-existing deposits. On seismic data, MVs exhibit either a “christmas-tree” pattern up to 300 ms penetration below the seafloor, or thinner construction lying at the seafloor, suggesting different fluid/mud emission cyclicity scales and initiation ages. Dendritic networks of curved cracks (0.1-3 km long, 5-10 m deep) are present at various locations between 800-1400 m water depths. They affect the first 50 ms below the seafloor and appear anchored on top of sub-vertical conduits with concave-up reflections. Over the studied area the spatial organization of pockmarks, MVs and cracks is constrained by several types of structures identified on the seafloor and at depth. In most cases, MVs are associated with networks of normal deep faults that in some case affect the present-day seafloor, for example Rosetta fault, as already indicated and which is therefore an active fault. Pockmark fields are superimposed to buried normal faults and on a faulted anticline, but can also be observed at the base of fault scarp affecting the seafloor. More surprisingly, some pockmark fields mimic relatively deeply buried turbidite channels and MTDs located up to 550 ms below the seafloor; and they likely result from dewatering processes strong enough to impact the seafloor; similar relationships were established in the Congo basin and on the Niger submarine delta [4]. Finally, shallow networks of cracks are located on top of buried MTDs. Their origin is still unclear but their orientation is nearly similar to the organization of MTDs internal thrust faults as shown on 3D seismic time slices. It is thus believed that dewatering of MTDs, guided by thrust faults, could generate overpressures within the overlying deposits and then extensional structures that propagate upward to the seafloor.

References