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Near-seafloor Geohazards Analysis of the Western Patraikos Block, offshore western Greece

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Extended Abstract

Western Patraikos Block (WPB) was awarded to Hellenic Petroleum in 2012 for Hydrocarbon exploration activities. Extensive geological and geophysical analysis resulted in the identification of multiple potential leads, and one of them is planned to be tested by an exploration well in 2020. As a consequence, several environmental, oceanographic, and geological studies have been conducted in the region in order to ensure negligible impact on the marine environment and safe drilling procedures, namely: 1) side-scan-sonar images and multibeam bathymetry for the identification and mapping of seafloor characteristics (e.g. slope gradients, sedimentary structures), benthic biocommunities, and shipwrecks, cables and other human made objects, 2) analysis of ultra-high-resolution seismic-reflection data (sparker and chirp sub bottom profiles) for the identification and mapping of recent landslides and shallow faults, and 3) examination of a high-resolution 3D PSDM (pre-stack depth migration) seismic cube in order to define lithostratigraphy, fault mapping, and potential drilling hazards in the upper 1000 m of the sedimentary column. This work aims to present the key results from the various studies with ultimate goal to define areas of environmental, archeological, and geohazards risk, which should be treated with caution during drilling activities.

The bathymetry of the broader WPG was derived from the PSDM volume (Fig. 1A) and it was complemented by high-resolution (15 m grid) multibeam bathymetric data in selected areas of interest (AOI). Two major morphological settings comprise the WPB. An extensive shelf zone to the east, which represented a delta plain depositional setting during the low sea-level stand (~ 120 m below present sea level) of the last glacial maximum (LGM) (18 – 27 ka B.P.) (Fig. 1A). The lithology of such a depositional setting is anticipated to range from thick (> 1 m), paralic and river sand packages to lagoonal and flooding plain mud deposits. Shallow marine mud deposits characterize this area during high sea-level stands. The transition to the basin floor to the west occurs through a steep (5° - 15° and only locally up to 32°) delta slope (Fig 1D, E). Parallel, continuous to semi-continuous reflections in ultra-high and high-resolution seismic-reflection profiles indicate that mud-dominated sediments characterize late Quaternary deposits on the basin floor (Fig 1C).

A deep-tow system (DEEP-TOW 2000, Geoacoustics /Kongsberg), flying 30 m above the seafloor was used in selected areas of interest (AOI) for the acquisition of ultra-high resolution data (side scan sonar and chirp sub bottom profiler), in order to identify and map in detail on the seafloor structures and/or objects with dimensions down to 0.3 m. Through this dataset was possible to examine the presence of benthic biocommunities (e.g. corals), shipwrecks and archeological artifacts, cables, and sedimentary structures (e.g. sediment waves, expulsion features) that might impose issues on safe drilling procedures with respect to the environment. The seafloor in the AOI is smooth in the vast majority of its extension, with no benthic biocommunities or man-made structures and objects. However, the presence of extensive and widespread NW – SE and SW – NE lineations on the side-scan-sonar images reveal intense scouring of the seafloor through intense trawling activity in the area (Fig 1B).

Ultra-high resolution seismic-reflection profiles and sediment cores indicate that Holocene (high sea-level stand during the last 10 ka), sediment failures on the delta slope, although common, are of local-scale with limited run off distances (a few hundred meters) with a recurrence time interval of a few to several hundred years. On the other hand, sediment failures and gravity flow deposits during the LGM were abundant and of larger run off (a few to several km). This discrepancy is attributed to the direct river-sourced sediment discharge at the shelf edge during this low sea-level stand, resulting in the formation of thick, loose and easy to fail piles of sediment at a high gradient slope setting. Two large, mass-transport complexes at the southern and northern part of the basin floor are dated to have occurred during the LGM, based on their burial by a 10 – 20 m thick cover of hemipelagic mud. On the contrary, the entrapment of most river-sourced sediments at the shallower parts of the shelf to the east during the Holocene high sea-level stand resulted in lower sedimentation rates at the slope, and thus in more resilient to failure sediment packages.

The seismic-reflection profile in Figure 1C, extracted from the available 3D PSDM seismic cube, shows the existence of a major unconformity at the base of the Pliocene – Pleistocene section, which is interpreted to represent the areal exposure of the area during the Messinian Salinity Crisis, during which the sea-level had dropped over 1 km below the present sea level. Clastic sedimentation dominates in the overlying Pliocene – Pleistocene section, which consists of two seismic sequences, named as lower marine sequence (LMS) and upper progradational wedge sequence (UPWS). The LMS consists of continuous to semi-continuous, mid to high-amplitude seismic reflections, and it is interpreted to represent mud-dominated hemipelagic deposits interbedded in places by a few turbiditic channel sand packages. The UPWS comprises several foreset packages in the eastern part of the WPB. Those foreset geometries are interpreted as delta complexes of the Achelous River during low sea-level stands. Foreset packages transit westwards to bottom set packages, these being interpreted to comprise mud-dominated prodeltaic and marine depositional settings.

Given the current 3D seismic survey, faulting within the Pliocene – Pleistocene section is not common, and, where present, are of low displacement and occur within deformed strata by Late Neogene diapirism (Fig 1A, C). It is interesting that diapirism has absolutely no surface expression at the eastern part of the WPB, whereas it has a distinct seafloor expression, in the form of elongated bulges, at the western basinal part of the WPB. This discrepancy on the seafloor imprint of the diapiric activity is attributed to much higher sedimentation rates and more efficient burial at the eastern parts of the WPB due to their proximity to the mouth of the Achelous River. Seafloor bulges at the basin floor related to diapirism are commonly characterized by steep flanks (2.5° – 10°), whereas Neogene faulting might also have in places seafloor expression. Ultra-high- and high-resolution seismic-reflection profiles indicate that infrequent (recurrence e period of 100s of years), local-scale (a few to several hundred meters long) failures occur along the flanks of the seafloor bulges formed by the uplifted diapirs at the western part of the WPB.

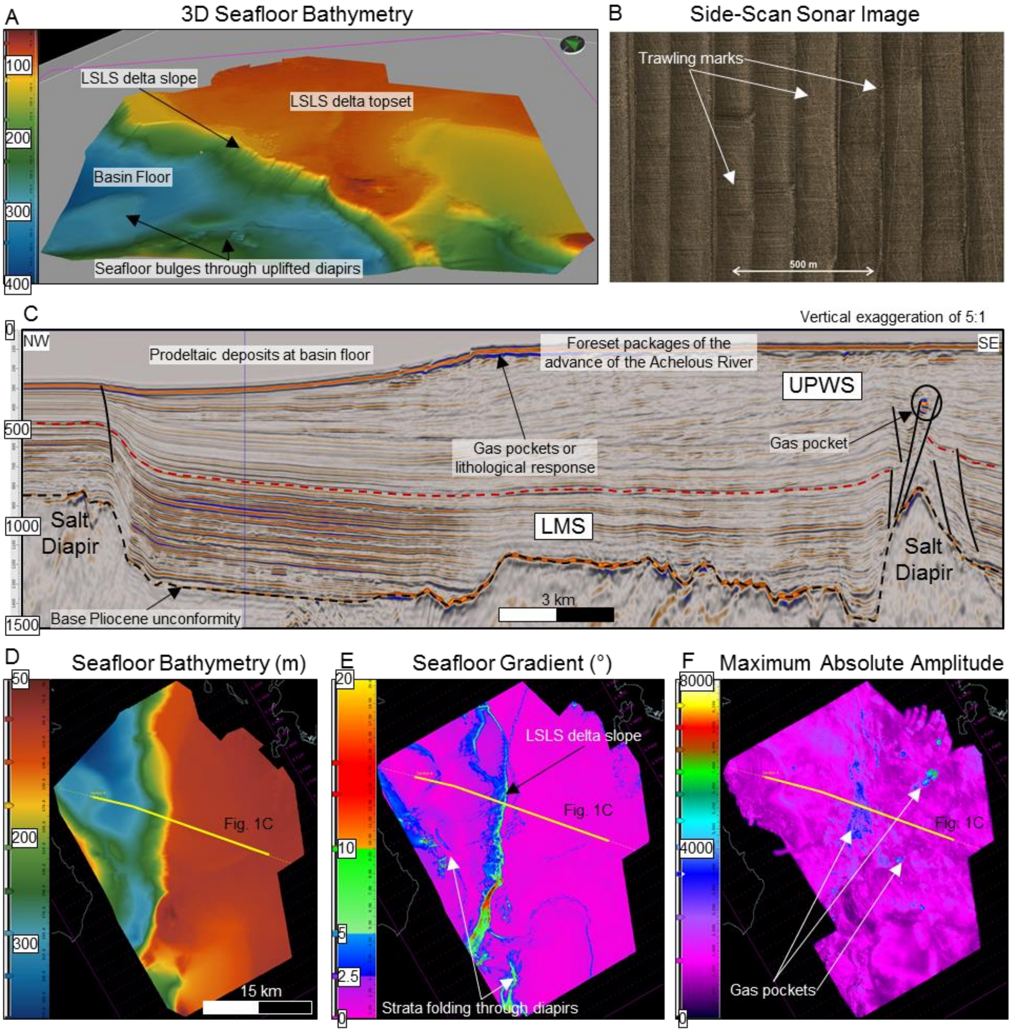

Figure 1. (A) Three dimensional representation of the bathymetry of the area of interest, showing key morphological characteristics. (B) Side-scan image showing a very smooth seafloor, which has been significantly scoured by trawling activities. (C) Seismic-reflection profile reveals that the Pliocene – Pleistocene section consists of a lower marine (LMS) and an upper progradational wedge sequence (UPWS). (D – F) maps of bathymetry, seafloor dip-angle, and maximum absolute amplitude from the UPWS showing areas of steep slopes (> 5°) and potential gas pockets, which have to be avoided during drilling. Steep slopes occur mostly at low sea-level stand (LSLS) delta slopes of the last glacial maximum (18 – 27 ka BP) and locally around areas of diapirism.

The presence and extension of shallow gas pockets in the Pleistocene section of the WPB was investigated through the generation of amplitude maps from the UPWS. Extremely high amplitude values are commonly associated to the presence of shallow gas accumulations, whose distribution and dimensions can be variable (Fig. 1C, F). In this manner, areas of high probability of encountering shallow gas pockets have been identified and mapped. The presence of (small <10 m in diameter and 1 – 2 m deep), circular depressions above such a zone of amplitude anomalies suggests the development of expulsion features (pockmarks), and thus, supports their interpretation as shallow gas pockets.

In conclusion, it is evident that through such a detailed and extensive work the WPB region has been properly evaluated, resulting in the identification and mapping of areas which either for potential geohazards issues (e.g. seafloor gradient, Neogene faults, slope stability, gas pockets), or environmental aspects (benthic biocommunities, shipwrecks, cables) have to be treated with caution and respect.

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