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# GEOHAZARDS IN THE SEABED OF MEJILLONES AND RIO CARIBE GAS FIELDS. PROYECTO MARISCAL SUCRE. NORTE DE PARIA – VENEZUELA.

# RIESGOS GEOMORFOLÓGICOS DEL LECHO MARINO DE LOS CAMPOS MEJILLONES Y RÍO CARIBE. PROYECTO MARISCAL SUCRE. NORTE DE PARIA – VENEZUELA.

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## ABSTRACT

Mariscal Sucre Project is the first offshore gas development to PDVSA own efforts, and is responsible for developing four non-associated gas fields: Dragon, Patao, Mejillones and Rio Caribe. In this regard, a survey of shallow marine geophysical was performed in order to characterize and describe the seabed geohazards that could interfere in the activities of development, design and installation of structures. The survey was performed using sub bottom profilers, side scan sonar, multibeam echo sounder and magnetometer through an efficient pre-plot design that ensured full coverage of the area of interest. The multibeam bathymetry data shown depths ranging between -74 m and -110 m referring to MSL. A highlight feature found throughout the study area is the presence of craters or pockmarks, which could be associated with the escape of gas, however, no clear evidence was found in the sub bottom profilers. Other interesting feature on the seabed, especially in the Mejillones field, is the presence of steep slopes that were defined as pinnacles that in some cases reach elevations of up to 10 meters above the bottom. These geomorphologic features were identified using sub bottom profilers to read the first line or horizon reflector. According to the reflectivity values shown in the mosaic of side scan sonar with correlations between geotechnical drilling and sub bottom profiling line, could define two possible types of materials that make up the seabed: fine and recent sediments associated with the areas low reflectivity and sandy carbonate- content material associated with areas of high reflectivity. Finally, all these geological features are defined and mapped, according to the preliminary location of structures, to serve as support for future decision making during detailed engineering design and the installation of the production estructures.

Keywords: geohazards, pockmarks, pinnacles.

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**ABBREVIATIONS**
Centimeter [cm]
Common Reference Point [CRP]
Difference Global Position System [DGPS]
Global Position System [GPS]
Kilo Hertz [kHz]
Kilometer [$Km^2$]
Meter [m]
Millimeter [mm]
Mid Sea Level [MSL]
Motion Remote Unit [MRU]
Nanotesla [nT]
Local Astronomical Tide [LAT]
Million Barrels Day [MBD]
Million Cubic Feet per Day [MMPCGD]
Mariscal Sucre Project [PMS]
Side Scan Sonar [SBL]

**INTRODUCTION**
The north of the Paria Peninsula, which forms part of the gas offshore belt, has undergone several exploration campaigns since the seventies, gain high economic interest for the nation by the discovery of large deposits of gas and condensate in the area.
The Mariscal Sucre (PMS) project is the first offshore development executed by own effort PDVSA, and is responsible for planning the exploration and exploitation of four (04) gas fields not associated, located 40 km north of the Peninsula Paria: Dragon, Patao, Mejillones and Rio Caribe. It is planned to develop the Mejillones and Rio Caribe fields during phase II of PMS, with the aim of producing 600 MMPCGD gas and between 15 to 28 MBD of condensate. To meet these goals safely and profitably, conducting detailed technical studies to support future decision-making during the early stages of basic and detailed engineering is required as well as the phases of installation and development of production facilities and offshore structures.
In this respect, a geophysical survey was conducted in order to characterize the seabed, identify geohazards (faults, rocky areas, pockmarks, etc.), locate underwater obstacles (cables, pipelines, wrecks, debris surface, etc.) or other relevant peculiarities or abnormalities that could interfere with the activities associated with marine operations and represent potential hazards in the location and installation of structures. These structures had a distribution according to the basic engineering follows:
<u>Río Caribe Field:</u> an area of platforms (drilling and processing), two vertically drilled locations, a unit of production, storage and transport (FPSO) and their connecting routes.
<u>Mejillones Field</u>: a platform area (reception), three drill centers and their respective flow lines for interconnection.

**PROCCEDURES**
The study of shallow marine geophysical survey had the following objectives:

- Mapping the morphological characteristics of the seabed.
- Identify and map potential geological events that may present a risk to the structures to be designed and installed in the study area.
- Generate geophysical maps and drawings that serve as support for subsequent engineering decisions.

**Study Area**
This study was conducted in Mejillones and Rio Caribe fields, which are located in the west of the PMS, presenting extensions of 278 km2 and 206 km2. They are located about 40 Km from the Paria Peninsula, Edo. Sucre, Venezuela.

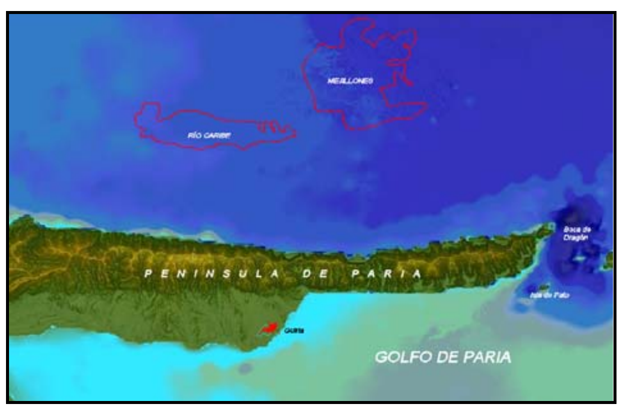

Figure 1. Location of the study area.

## Geological Context

The region covers the area of PMS is located on part of the Venezuelan mainland, specifically in Carupano Basin. Carupano Basin (PDVSA - Intevep, 1997) consists of several domains or structural features relevant to this study which are the basin of Caracolito, the high of Patao, the basin of Paria and high of Bocas (Figure 2).

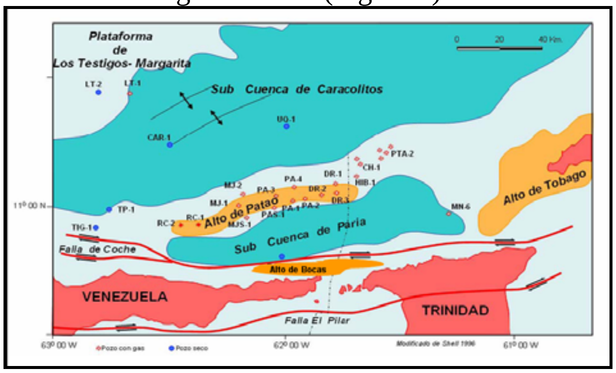


Figure 2. Patao High location and main geomorphologic adjacent provinces.

The High of Patao, a major structural expression in the area, it is considered of interest by the gas fields that are associated to it. It is a Cretaceous basement horst that separates the basin of Paria (south) of basin Caracolito (north). It was formed during the Oligocene-Miocene tectonic early Eocene transcurrent regime (Código Geológico de Venezuela, 2007), beginning to be submerged as a result of greater transgression.

## Equipment

This geophysical study covered the following equipment:

- DGPS System Position
- Multibeam
- Side Scan Sonar
- Sub-bottom Profilers
- Magnetometer

## Position of the equipment in the vessel

All equipments were placed with respect to a common reference point (CRP) that corresponds to the point where the MRU (motion reference unit), an instrument whose function is to correct the satellite positioning due to movement of the vessel respect to the three axes, which together with DGPS signal corrects the position of all instruments. In Table 1 the relative positions of instruments showing respect to CRP.

Table 1. Position of equipments in the Vessel.

| Position of the equipments in the Vesssel | | | |
|---|---|---|---|
| Reference Point | X (m) | Y (m) | Z (m) |
| Pos MV MRU (CRP) | 0 | 0 | 0 |
| C-Nav 3050 (Babor) | -3,24 | 13,85 | 17,19 |
| C-Nav 3050 (Estribor) | 3,49 | 13,72 | 17,2 |
| Reson 7125 Multihaz | 0 | 17,97 | -5,29 |
| IXSEA GAPS Head Unit (SSS/MAG Fish Tracking) | 0,72 | 6,27 | -6,07 |
| POS MV 320 (Babor) Antena | -6,17 | -15,23 | 10,8 |
| POS MV 320 (Estribor) Antena | -3,22 | -15,16 | 10,8 |
| Sparker CDP | 1,58 | -68,83 | 0 |

## RESULTS AND ANALYSIS

After developing stages of acquisition, processing and interpretation of data from different equipments used in this work different product were obtained, that characterizes the geological features of the seabed and identifies those that may be hazardous to facilities and / or structures to be designed and installed.

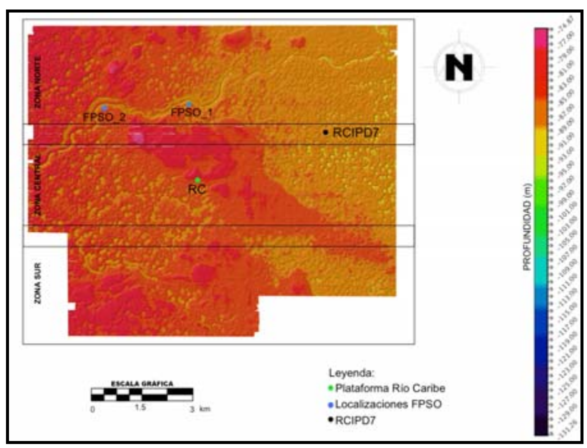


Figure 3. DTM of Rio Caribe Field.

The digital model obtained with multibeam echo sounder, can observe the average depths of both fields. The Rio Caribe field has depths ranging between -74 m. and -94 m. relative to mean sea level (MSL), with an increasing trend from west to east (Figure 3). The characteristic feature of the bathymetric surface of this field is the presence of craters or "pockmarks" (Figure 4) that range in size from 80 to 300 m, with depths between 2 and 6.5 m, whose slopes are between 15% and 30%, also is possible to observe an increase in the central area of the block with NW-SE trend in which the water depth increases. Also, a “canaliforme” structure is observed that crosses the block north trending ENE-WSW.

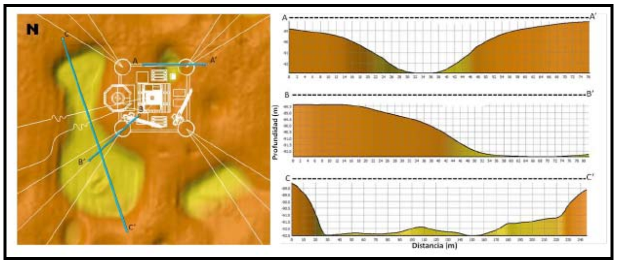

Figure 4. Pockmark close to the structures.

In the Mejillones field, the digital terrain model presented depths increase in NE direction and varies between -82 m. and -110 m. referred to M.S.L. The most striking feature of this bathymetric surface is the presence of steep slopes, which were called pinnacles (Figure 5), which reach up to 15 m. of altitude with respect to the average surface.

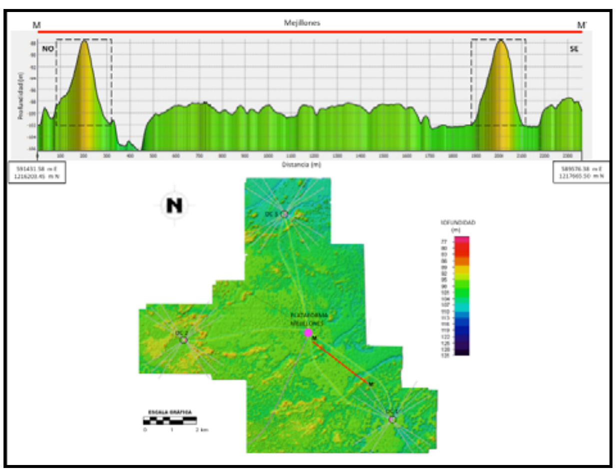

Figure 5. Bathymetric profile showing the pinnacles structure.

Another feature identified with multibeam was the presence of a sunken vessel (Figure 6), which has 28 m wide and 140 m long, approximately. The maximum elevation of the wreck on the ocean floor is about 17 m and it is located close to the route of the proposed pipeline engineering design, specifically to 183 meters from the flow line which connecting a center of perforation (north) to the platform area.

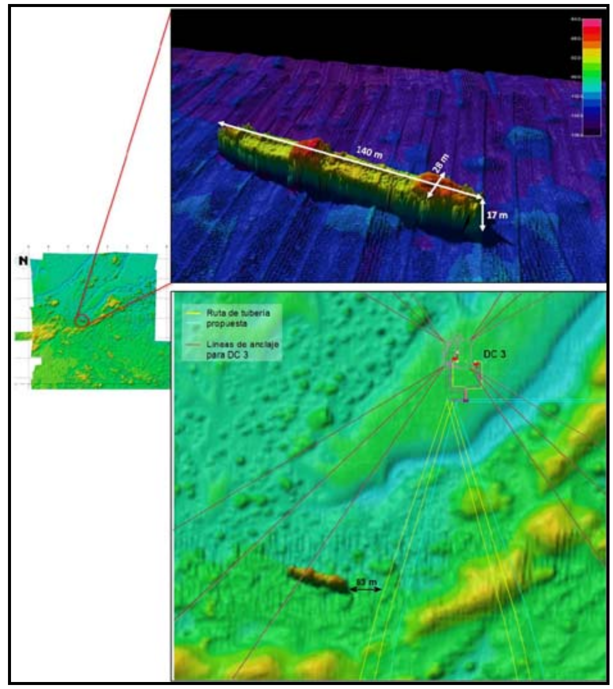

Figure 6. Wreck in Mejillones field.

Now, discrimination of variations in the acoustic response or levels of relative reflectivity of side scan sonar and the existence of geotechnical drilling in the area, allowed us to identify two areas on the seafloor (A and B). The area A, characterized by showing low values of reflectivity, was related to the presence of unconsolidated material or low compaction and / or fine sediment, while area B was related to the possible presence of carbonatic material content higher density of the adjacent areas (Figure 7). This sector has few affectations or irregularities in the sea floor (pockmarks), unlike the area A, where this feature is characteristic.
In the specific case of Mejillones field, the wreck was observed again with this tool.

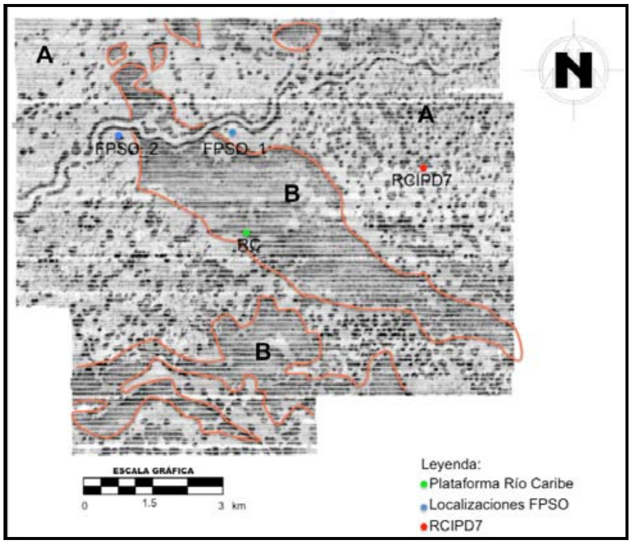


Figure 7. Mosaic f side scan sonar.

Sub bottom profilers (Figure 8) used were interpreted in order to identify patterns of stratification, being defined horizon, the possible boundary between two units with different stratigraphic characteristics, so that a strong reflector could mark the top or base of a stratigraphic sequence.

Records obtained with the Pinger showed on average a signal range of 280 ms equivalent to 203 m. approx. Useful information on this equipment occurred between the first 100-120 ms, i.e., 30 m below the seafloor. The Sparker showed greater signal range than Pinger, recording information up to 400 ms or 290 m on average. Useful information from this profiler reported among the first 200 ms or 145 m approximately, counting from the seabed. The interpretation of the different horizons allowed us to achieve the generation of structural drawings and isopach maps (Figure 9), which allowed us to characterize the thickness of the different units, especially in the shallower units where the structures (platform legs, pipes, flow lines) will be installed.

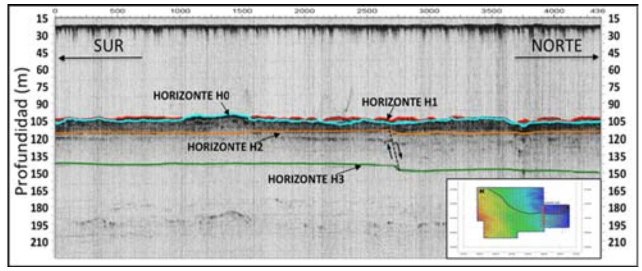


Figure 8. Sub bottom profiler.

It is noteworthy that the elevated structure with NW-SE which is in the central part of Rio Caribe field agrees with the area of greatest relative reflectivity in the SSS mosaic (defined as area B). These features allow inferring that the structure is made of materials resistant to erosion compared to the surrounding sea floor. Also, the regions most influenced by the depressions coincide with the areas of lower reflectivity in the SSS mosaic (defined as A) and also are consistent with the sectors where recent sediment deposition was observed in the isopach map of the first unit (Figure 9).

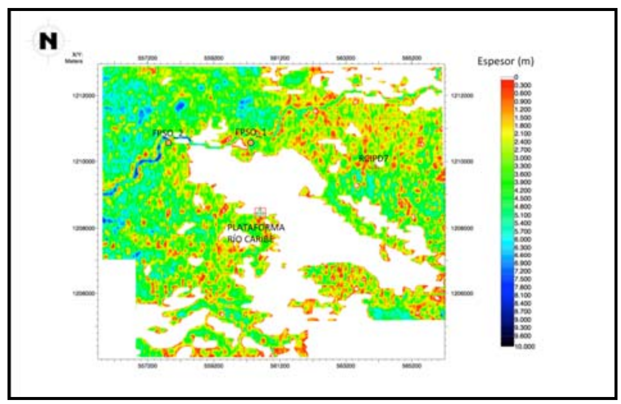


Figure 9. Isopach map of Unit 1.

Finally, these geomorphic features were identified according to the structures designed to optimize the design of them and alert the engineering team of the potential risks and threats present in the study area.

## CONCLUSIONS

The relative reflectivity exhibited by SSS mosaic with correlations between records of SBP, available geotechnical drilling and isopach map of unit 1, allowed to define the presence of at least 2 types of materials constituting the sea floor of the study area: recent sediments, mainly soft clays (less reflective responses in mosaic - zone A) and carbonate-content sands (zone B - more reflective response). These variations could generate local differences in hardness and competitiveness of the material found at the level of the surface of the seabed.

From the sub bottom profilers (Pinger profiler and Sparker type) it failed to detect risks associated with gas accumulation and / or shallow fluids. Both bathymetry as SSS mosaic records show that the morphology of the seafloor is rugged. Morphological accidents present in these blocks consist to pockmarks and borings, which do not exhibit a definite pattern of occurrence. Similarly steep slopes areas, some type of pinnacle, coincide with the response more reflective areas shown (zone B) of the tile.

The high plasticity clay sediments present in some areas of the seabed could pose a risk because the water content and workability of such materials, receiving loads or be under pressure tend to deform causing subsidence or instability of pipes that were installed on sedimentary material

In the bathymetry, mosaic and sub bottom profilers was interpreted one “canaliforme” structure near the possible location for the floating structure proposed FPSO in Rio Caribe field. Also, it was identified an elevated structure with NW-SE direction, whose surface is composed mainly of carbonate sands (according to the correlation with existing geotechnical drilling), on which is designed as part of a route connecting pipe.

Failed to detect pipes, obstacles, or metal objects on the seabed with the SSS mosaic nor magnetometer that could endanger the structures that form part of the engineering design proposed for the Rio Caribe field, however, in the vicinity of the proposed route for the pipeline from the Mejillones platform to a drill center (north), the presence of a shipwreck about 83 m away was detected, which may affect the safety of lying and / or installation of the same.

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