Keywords: M Prospect, 3D seismic interpretation, pull-down effects, seismic attributes anomalies, depth conversion

INTRODUCTION

M Prospect, located in the “A” Block, Croatian offshore, was generated and evaluated with the aid of the interpretation of the new 3D seismic volume carried out from 1997 to 1999 over the whole area of the block.

All the Croatian wells in the block, drilled during the 70ties and 80ties, were studied and correlated to several equivalent Italian wells.

Most of the fields and discoveries of the Croatian and Italian Adriatic were found in the Quaternary gas pools.

M prospect was as a combination of DHI, like bright spot, pull-down, energy absorption and frequency decrease in the Quaternary series.

The reservoirs are represented by the sandy layers of the Quaternary turbidites of the Carola Formation, thinly interbedded with shales that are the sealing and the source for biogenic gas accumulation.

The traps are mainly structural, by differential compaction, or structural-stratigraphic by pinching on the Plio-Pleistocene Santcroreno foreland ramp shales.

The same geological setting was previously studied in the Croatian offshore and in the Italian North Adriatic Quaternary reservoirs.

SEISMIC INTERPRETATION

The interpretation of the M Prospect was firstly performed on the “A” Block 3D seismic volume with the Landmark seisworks software on seven regional horizons.

A detailed and precise interpretation over the M Prospect was carried out on the Quaternary turbiditic serie, refining the regional interpretation and studying three additional seismic horizons (fig. 1), correspondent to three bright spots.

The “A” Block 3D seismic volume shows many areas with evident bright spots, pull-down and absorption effects usually generated by gas bearing levels in the uppermost Quaternary turbiditic series, like in other blocks of the Croatian offshore and in all the northern Italian Adriatic.

Three strong bright spots are clearly shown in fig. 1 between 1000 and 1200 ms in the Carola Formation (referred to the 1, 2, and 3 levels).

Strong amplitude anomalies due to the presence of gas bearing levels between 100 and 600 ms, provide both pull-down and absorption effects in the levels below.
The pull-down sagging increases with depth (almost a time delay of 80 ms at the top of the Pre-Pliocene unconformity) and the strongest absorptions occurred in the lower Carolà formation series, where also the maximum absorption is present: this is the reason why there is not clear bright spots evidence between 600 and 1000 ms.

In the prospect area, all the turbidic levels considered the main targets for the exploration, pinch on the Santerno equivalent shales.

Amplitude extractions were performed on several time intervals in order to reconstruct the possible gas bearing levels. The amplitude map of the level 2 extracted in a 24 ms window, (figure 2) shows an absorption zone, surrounded by a ring shaped amplitude anomaly area; its external limits is very clear in the eastern side, while it is affected by absorption in the western one.

It is worth noting the perfect coincidence between the absorption area in the amplitude map and the maximum pull-down zone in the twt map; the external boundaries of the amplitude anomaly (possibly indicating the gas-water contact) are also coincident with the pull-down areas.

The average instantaneous frequency map between the levels 1 and 3 displays a low frequency zone in the prospect area, coincident with the pull-down distribution.

As a result of this analysis, the well M 1 was located in the maximum pull-down zone, that was referred to the highest hydrocarbon column, coincident with the top of the depth structure.

**POST WELL APPRAISAL**

The drilling of the M1 well confirmed the presence of gas and the total net pay forecast by the 3D seismic and old wells data interpretation:

- The level 3 found 6 m net pay (with a 12 m vertical closure)
- The level 2 has 4.3 net pay (6 m vertical closure).
- The shallowest bright spot considered is the result of the contribution of the gas effects in three different reservoirs:
  - levels 1a, 1b and 1c, hydrodinamically separated, with a 4 m total net pay.
- More gas bearing levels with minor net pays were found.

The new synthetic seismogram and VSP acquired and processed show a very good well-seismic tie, with an excellent correspondence between the bright spots and the main gas bearing intervals; minor levels don't show strong amplitudes, because of the strong absorption effects.

**Depth Conversion Method**

The latest studies of 3D seismic interpretation of the Quaternary turbiditic reservoirs in the Italian Northern Adriatic and in the Norther Croatian offshore have always found remarkable difficulties in time-depth conversions made with standards methods. Frequent and irregular seismic velocity anomalies due to gas presence (even if in traces) are responsible of time image distortions. Very often the pull-down effects, occurring on the flat Quaternary gas bearing sediments, totally modify the real structures of the gas traps. Density and distribution of velocity data (3D AVA, 2D AVA or well velocities) have always been inadequate to properly recover the pull-down effects, in order to detail the real shapes and extensions of the studied fields and prospects.

On the other hand the amplitude and frequency anomalies detected in the gas zones can provide excellent information about the geometries of the gas bearing areas.

The depth conversion on the Pleistocene reservoirs has traditionally been performed on the basis of amplitude, frequency or acoustic impedance anomaly maps and well data, taking into account the
Isochrone maps (in order to define the main structural items and to describe the pull-down areas) in several Italian fields with very good results.

New structure maps took into account more recent amplitude and frequency extractions from the final 3D seismic volume, calibrated with the GWC provided by the M1 logs and RFT interpretation (figure 3). Also the new seismic attributes anomaly maps are severely disturbed by the shallow gas accumulations and can’t describe the whole gas bearing area geometry and extension. The pull-down effect distribution is correctly described by the twt maps all over the gas bearing areas and is coherent with the attribute extractions indications. The new depth structure maps were performed mostly taking into account the pull-down distribution, the new correlation with the nearby wells and the latest seismic attribute anomaly maps. The depth maps of more reservoirs were obtained by layering and well calibration.

SELECTED REFERENCES


Fig.1 – Seismic line passing through the M1 well location

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Fig. 2 – Seismic amplitude and twt map of the reservoir 2

Fig. 3 – Structure map of the reservoir 2