Very high-resolution seismo-acoustics in the study of seagrasses. The case of *Posidonia oceanica* (Mediterranean Sea)

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Abstract *- Posidonia oceanica is a coastal Mediterranean seagrass which accumulates in its subsurface large quantities of organic material derived from its roots, rhizomes and leaf sheaths embedded in sandy sediments. These organic deposits accumulate over thousands of years forming the matte, whose high content in organic carbon plays a major role in the global ocean carbon cycle. In this study, very high resolution seismo-acoustic methods were applied to image the subsurface features of a P. oceanica seagrass meadow at Portlligat (Cadaqués, Girona, Spain), in the NW Mediterranean Sea. Our findings yield fresh insights into the settling of the P. oceanica meadow in the study area, and define with unprecedented detail the potential volume occupied by the matte.*

Keywords *– Non linear seismo-acoustics, seagrasses, Holocene, Mediterranean Sea*

INTRODUCTION

Posidonia oceanica, a widespread Mediterranean seagrass, accumulates in its subsurface large quantities of organic material, named matte. The matte is mainly composed of detritus of the seagrass, derived from their leaves and organs, embedded in the surrounding sediments [1].

The organic fraction of the matte is preserved over thousands of years forming structures several meters thick [2]. This preservation results from the highly anoxic conditions in the matte and from the refractory nature of the detritus [2]. The high content in organic carbon of these deposits plays a relevant role in the global ocean carbon cycle. Although the distribution of *P. oceanica* has been widely assessed using acoustic methodologies, informations on its internal structure obtained with seismic methods are still very rare. In this study, very high-resolution non-linear seismo-acoustic methods were applied to image the subsurface features of a *P. oceanica* seagrass meadow in the NW Mediterranean Sea (Catalonia, NE Spain). The main advantage of the non-linear parametric echosounders lies in their capability to generate low frequencies producing narrow beams with small footprints [3]. This differs substantially from the linear seismic systems, which require long pulses and large transducers to generate focused low frequencies [4].

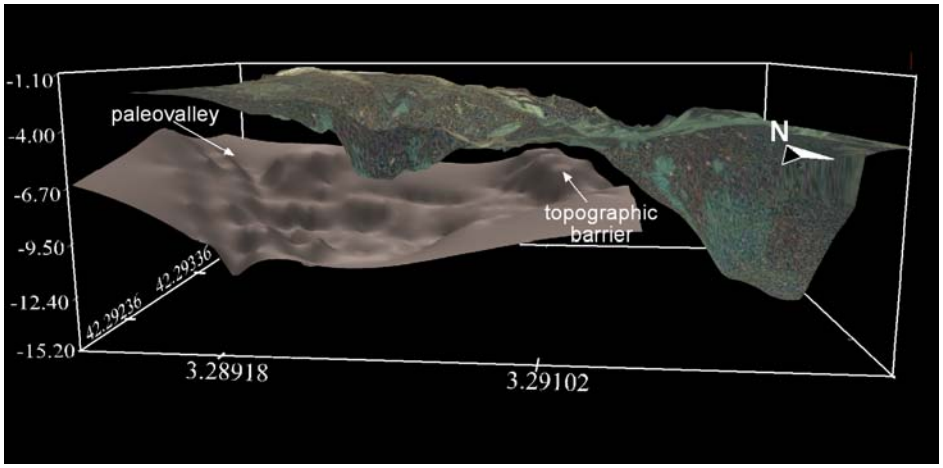
RESULTS AND DISCUSSION

The parametric echosounder "Innomar SES 2000 compact" was used to acquire 75 seismo-acoustic records. The echosounder was characterized by a primary frequency of 100 kHz and secondary frequency ranging from 5 to 12 kHz. Pulse Repetition Rate was up to 30/sec and the beamwidth of ±1.8°. *P. oceanica* meadow covers up to 60.000 m2 of the Portlligat Bay. It mainly occurs in mounds, generating irregular seabed topography, with leaves measuring from 20 to up to 60 cm long (Figure 2a). Although the seismo-acoustic method proved to be reliable in imaging *P.oceanica* meadows at Portlligat, this instrumentation suffered from difficulties in associating the internal structure of the matte with a specific seismic facies. The gradation between plant detritus and sediments along the vertical structure of the matte scarcely provided high-enough contrasts of impedance to generate neat seismic reflectors. Its heterogeneous composition is a very high dispersive medium for acoustic energy, resulting in a marked decrease in the signal to noise (S/N) ratio. Despite these limitations, in many records it was possible to detect a strong reflector, from 2 to 6 m depth, that was interpreted as the initial substratum where the seagrass established for first time. A 3D bathymetric model of this substratum allowed us to reconstruct the palaeo-environment of the area prior to the settling of *P.oceanica*, which corresponded to a shallow coastal setting protected from the open sea. A core drilled in the meadow revealed the presence of a 6 m thick dense matte composed of medium to coarse sandy sediments mixed with plant debris and bioclasts. Radiocarbon datings revealed a constant accretion rate of the meadow of about 1.1 m/kyr. Very high-resolution marine geophysical techniques allowed us to accurately define the volume occupied by *P. oceanica* matte, which in the study area reaches up to almost 220,000 ± 17,400 m^3 (Fig.1).

CONCLUSIONS

The application of nonlinear seismo-acoustic technologies proved to be a powerful non-destructive method for highlighting the settling of coastal seagrasses in the Mediterranean Sea.

Moreover, the new technological advances allowed in estimating the potential carbon retention of the *P. oceanica* meadows and better understand its relevance in the ocean carbon cycle.



"Fig.1." 3D view of the paleotopography of the matte substratum (lower gray layer) and of the actual seafloor in Portlligat Bay. Depth in meters.

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