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CHARACTERISTICS AND POTENTIAL APPLICATION OF HOLOCENE TIDAL INLETS IN THE NORTHERN ADRIATIC SHELF (ITALY)

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ABSTRACT: In the last decades a series of offshore seismic and stratigraphic surveys revealed the presence of several infilled palaeo tidal inlets which punctuate the subsoil of the northern Adriatic shelf. The morphologic, morphometric and sedimentary characteristics of these landforms constitute remarkable database for the reconstruction of palaeo coastline positions and to constrain the post-LGM sea-level rise, especially during the beginning of the Holocene period. This work provides a first overview on the significance of the Adriatic tidal inlets and their response to the interplay between upstream and downstream controls.

KEYWORDS: Holocene, sea-level rise, palaeo tidal inlets

1. INTRODUCTION

The constant adjustment and refining of the models predicting past sea-level position necessitate a continuous improvement and widening of sea-level indicators databases, which are essential for the calibration of the geophysical models (cf. Vacchi et al., 2016; Roy & Peltier, 2018; Stocchi et al., 2018). The peculiar low gradient (~0.4‰) that characterises the northern Adriatic shelf made it extremely sensible to the eustatic variations, as even small increments of the sea level would have caused the drowning of large areas of the shelf. Therefore, the transgressive record of the northern Adriatic potentially represents an ideal environment for the reconstruction of a detailed post-LGM relative- sea-level rise curve. The configuration of the northern Adriatic shelf promoted the deposition of relatively thin layers of transgressive deposits which were dismantled after their drowning due to the wave effect of the rising sea (Cattaneo & Steel, 2003; Fig. 1). Thus, one of the few available indicators is represented by the tidal inlets, as their depth promoted their conservation within the stratigraphic record. These relict landforms could represent privileged spots for reconstructing timing and modes of the last marine transgression, before 7.5 ka BP, when the rate of sea-level rise was fast, since they are one of the few available, and sometimes almost continuous, sedimentary record of that period. This work offers a preliminary analysis of the tidal inlets on the scale of the whole northern Adriatic and, in particular, it focuses on their evolution and significance in a sea-level and coastline reconstruction perspective.

2. MATERIAL AND METHODS

The entire northern Adriatic area has been investigated with more than 1000 CHIRP profiles (Compressed High Intensity Radar Pulse), for a total length of more than 12,300 km. All the CHIRP profiles analysed in this work were collected during the oceanographic campaigns named CM92, CM95, VE04, VE05, RI09, NAD12 and ASCI14, which were organized by the CNR-ISMAR institute of Bologna. These seismic lines were acquired in water depths ranging from -10 and -45 m mean sea level (MSL). The collected data have a vertical resolution in the order of ca. 50 cm. Along with the seismic data, several cores were analysed in order to provide ground truth for the interpretation and to obtain radiocarbon dates and micropalaeontological data. The available literature provided several additional sedimentary, palaeontological and chronological constrains that were integrated in our analysis (cf. Correggiari et al., 1996; Trincardi & Argnani, 2001; Trincardi et al., 2011, Storms et al., 2008; Moscon et al., 2015).

3. RESULTS

More than 100 points with evidence of past tidal inlets were recognized on the Italian side of the northern Adriatic shelf (Fig. 1). The morphometric characteristics and stratigraphic positions of all these landforms were stored in a database. The analysed tidal inlets show a wide range of dimensions: the thickness of their infilling spans from few to nearly 20 metres, their length can reach ca. 5 km, but normally its smaller than 1 km and their width can reach up to 400 m. A complete morphometric characterization is not possible for all the analysed features, as most of them were intercepted only by one or few CHIRP lines, but at least in two cases, which are being studied in detail, we have enough data to produce a detailed reconstruction of the palaeotopography of the inlets (Fig. 2). The analysis of the position of the upper portion of all the tidal inlets indicate the presence of a clustering at the level of the entire northern Adriatic

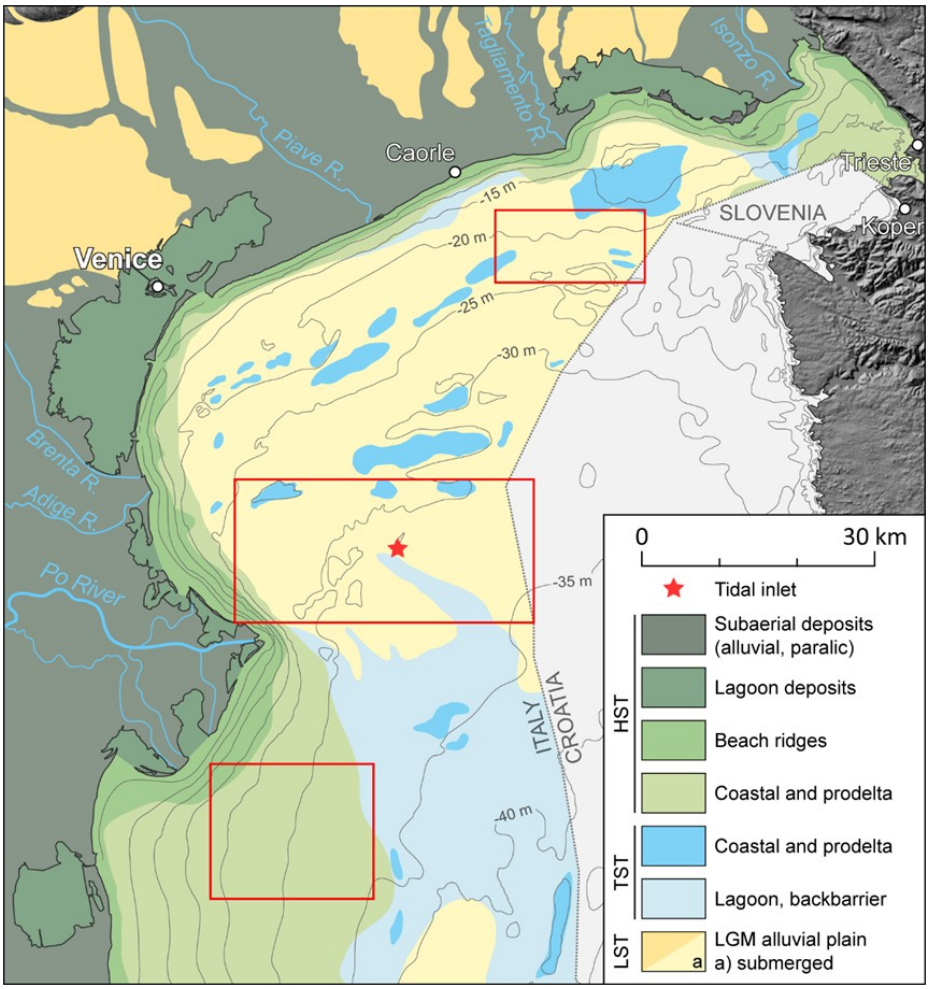

Fig. 1 - Geological map of the northern Adriatic area. The red rectangles indicate the areas where the tidal inlets are mainly concentrated. The red star indicates the position of the inlet reconstructed in Fig. 2.

Shelf, with several cases localized at ca. -13 m, -24 m, -27 m and in the range between -30 and -34 m MSL.

4. DISCUSSION

4.1 Transgressive tidal inlet evolution

In order to produce palaeo-environment reconstructions it is necessary to clearly understand the evolution of these landforms. In the study area, modern analogous systems are available for comparison purposes, as the conditions of sea-level rise rate and geometry of the continental shelf are not available in the present. The presence of groups of palaeo tidal inlets at clustered depths suggests the recurrent arising of conditions suitable for the development of lagoon-barrier complexes. These conditions may have different origin and controls. For example, climatic oscillations may have induced a temporary and general decreasing of the sea-level rise rate on a global or basin scale. These conditions have to be evaluated also in the framework of the palaeogeography and palaeoenvironmental evolution of the different areas, as the growing or waning of a lagoon complex may have been the result of a localized upstream river shifting.

Except for few cases (cf. Storms et al., 2008, Moscon et al., 2015), the analysis of the CHIRPs highlighted the common absence of preserved barrier complexes. These landforms were usually erased along with the backbarrier basins after the overstepping of the lagoon system. The obliteration of these features from the stratigraphic record enhance the value of the tidal inlets, which, with their depth and infilling record, stand as one of the only witnesses of the post-LGM transgression in this area.

It is likely that during a marine transgressive phase, tidal inlets are subjected to a rapid evolution due to the continuous forcing exerted by the rising sea. No large mobility of the inlet is expected in such dynamic environment, as the data collected so far suggest that the scouring and infilling phases of these landforms took place in the time frame of few centuries (Ronchi et al., submitted).

The sea-level rise recurrently induced the landward migration of backbarrier areas, which lead to periodic phases of tidal inlets abandonment and barrier complexes demolition. In particular, the abandonment and

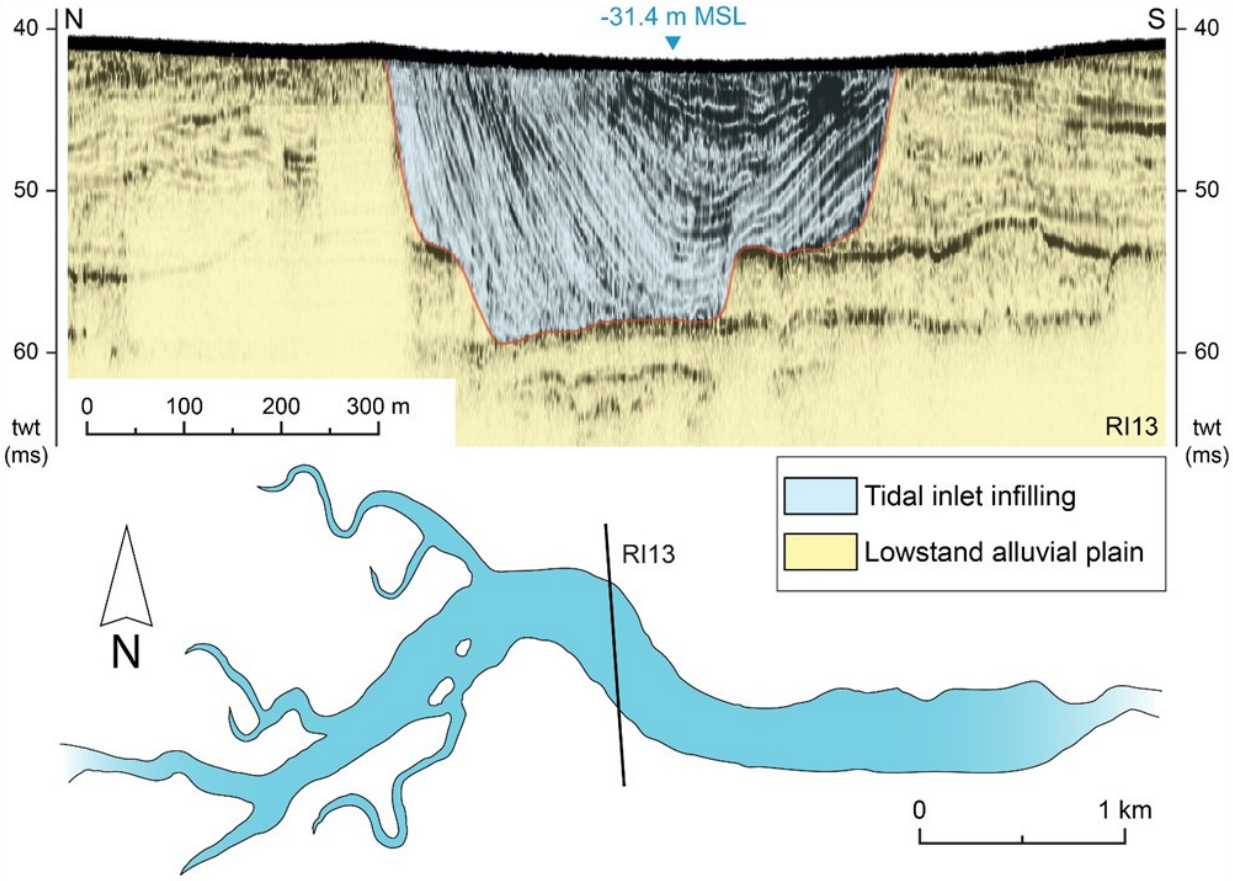

Fig. 2 - Upper portion: example of tidal inlet cross section visible in a CHIRP profile. Lower portion: reconstruction of the planform of the tidal inlet. The black line indicates the position of the CHIRP profile. After Ronchi et al. (submitted).

submersion of an older lagoon in favour of a new inner lagoon would led to the deactivation of the tidal inlets and their consequent infilling guided by the progressive decrease of the tidal flow running through the inlet.

4.2 Sea-level rise reconstruction

In the light of the previous reconstruction, it must be noticed that any radiocarbon date obtained on organic samples from the filling of an inlet, must be accurately evaluated in order to understand its real meaning. The easiest case would be to obtain a date from a lateral accretion bar within the infilling, considering that the lateral migration of an inlet would take place before the beginning of its deactivation. This kind of date would be indicative for reconstructing the sea-level rise curve, supposing to know the exact depth of the tidal inlet top. Unfortunately, the analysed transgressive inlets are usually filled by draping layers as time and equilibrium conditions for the lateral or landward migration of these landforms were usually lacking. In this second case, in order to obtain an age for the peak of activity, the sample must be collected from the very bottom of the infilling sequence, therefore before the deactivation and blanketing of the inlet began. This evaluation must also take into account the provenance of the organic sample and the possible origin from a previous deposit eroded in the upstream catchment of the lagoon or during the scouring of the tidal inlet.

4.3 Palaeo coastline reconstruction

The presence of tidal inlets is also a clear indicator for the reconstruction of the position of the coastline. By their subdivision in clusters of depth it is possible to delineate the seaward limits of a series of barrier-lagoon complexes along palaeo coasts. The presence of more than one tidal inlets at the same depth and within the same region may allow to delineate, with a good approximation, the coastline position over a wide area. Such reconstruction needs a careful evaluation of the stratigraphy of the area in order to correctly attribute different tidal inlets to the same coastline as the top of these landforms are usually subjected to the ravinement erosion, which can affect up to 6 m of their upper stratigraphy (cf. Rieu et al., 2005). The internal geometry of the infilling of most of the analyzed tidal inlets suggest that the upper portion removal was usually small in the Adriatic area, and probably never greater than 2 m.

5. CONCLUSION

The analysis of the palaeo tidal inlets constitutes an innovative tool for the reconstruction of the palaeogeography, palaeoenvironment and sea-level rise history of the post-LGM transgression. The case of the northern Adriatic represents a perfect test area for this method. More than 100 specimens of palaeo tidal inlets were recognized and analysed. This allowed the preliminary definition of at least four main phases of relative decrease in the sea-level rise rate. The interpretation of the obtained data must be preceded by a site-specific stratigraphic analysis in order to infer the correct palaeogeographic and chronologic information.

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