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Style and timing of tectonic deformation in the frontal accretionary wedge of Sicilian-Maghrebian fold and thrust belt in the SW Sicily and its offshore region during the Late Neogene to Pleistocene time interval

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INTRODUCTION

The outer segment of fold and thrust belt are usually associated to several geological processes: tectonic deformation, seismicity, extensive fluid seepage, gravitative induced sedimentary mass transport processes. All these processes have been detected in the outer sector of the Sicilian-Maghrebian fold-and-thrust belt outcropping in the south-western Sicily and adjacent offshore (Sicilian Channel). All these processes can generate dangerous geological risks, as actually happened in 1965 when a magnitude 6.4 earthquake hit the Belice Valley causing over 250 victims. In this poster we illustrate a reconstruction of the structural setting and tectonic evolution of the investigated Sicilian-Maghrebian chain segment (Fig. 1), as preliminary step of research devoted to assess the wealth of energy resources as well as the geological hazard of this geologically active region.

GENERAL GEOLOGICAL SETTING

The foreland-foredeep-chain system related to the Sicilian-Maghrebian fold-and-thrust belt developed during Neogene-Quaternary time interval in the framework of Europe-Africa plates convergence (Fig. 1). The continental collision process affected a Meso-Cenozoic shallow to deep water carbonate succession (locally named "Saccense domain"), a deep water carbonate to siliceous succession (locally named "Sicilian basin"), both two formerly belonging to the northern African continental margin, as well as the syntectonic infilling of Neogene-Quaternary wedge-top basins (Fig. 2). The following crustal shortening generated an about 10 km thick tectonic wedge where the main tectonic structures display a general south-eastern tectonic transport direction (Fig. 3).

DATA AND METHODS

Results illustrated in this poster coming from a geological survey recently carried out in the framework of the Italian National Geological Mapping program at 1:50.000 scale (CARG Project, Geological Sheet n° 628 "Sciaca", www.isprambiente.gov.it). In detail, original data come from: field geological survey implemented with sedimentological, paleontological and structural analyses; seismic reflection profiles interpretation; well-log analysis (Fig. 4). An in deep correlation of mainland and submerged sectors has been accomplished, and a 3-D geological model has been also worked-out, that is the subject of the communication by Rizzo *et alii* in this Conference (Session 7: Hydrocarbon Trapping Mechanisms in Mediterranean Provinces).

STRUCTURAL SETTING

The tectonic wedge outcropping in the investigated area of SW Sicily and adjacent offshore sector is made up by a pile of superimposed tectonic units belonging to the following domains: "Saccense carbonate platform", "Sicilian basin", "Gela thrust system". The current structural setting, generated by subsequent tectonic events, is imaged in the geological cross-sections and geoseismic sections here illustrated.

The geological cross section in Fig. 5 shows the structural setting of the Saccense tectonic unit on the left stretch, and of the Gela thrust system on the dextral stretch.

Structural setting of the Saccense tectonic unit - The Jurassic - Paleogene succession (units: SIA, INI, BCH, LTM, AMM) appears to be intensely folded and faulted. The succession is unconformably covered by in turn deformed Miocene terrigenous deposits (CIP). The most recent deformation is associated with high-angle reverse and transpressive faults stretch in a roughly east-west direction (Fig. 6).

Structural setting of the Gela thrust system - This latter represents an accretionary wedge in which a high number of reverse faults has displaced Messinian to Lower Pleistocene succession made up by evaporitic deposits (GS, GPQ), marly-limestone (TRB) and sandy-clay (BLC). This succession also appears intensely folded: the compressive deformation of the deposits of Messinian-Zanclean displays small wavelength (about 1.5 km); the compressive deformation involving Upper Pliocene - Lower Pleistocene deposits show a higher wavelength (about 4 km; Fig. 7). The tectonic wedge thrusts over the Pliocene marly clays, which unconformably cover the Meso-Cenozoic succession referable to the Saccense domain, that has been intercepted by the Cianciana well at the footwall of the overthrusting surface (Fig. 5). The outer front of the Gela thrust system is defined by the envelope of reverse faults and overthrusts that stretch in variable direction from NNE-SSW to NW-SE with variable vergence from W to SW (Figs. 5, 8): the frontal ramps display dip between 20° and 50° with the lowest values close to the tectonic wedge front, the flats have dip between 3° and 8°. In the study area, the upper tip is always buried at depths between - 800 m and - 2000 m. The most recent deformation event was dated to 0.8 Ma (CATALANO *et alii*, 1993).

Between the front of the Gela thrust system and the Alto di Sciacca there is a narrow basin that constitutes the westernmost sector of the Gela Foredeep basin (Fig. 8). Within the foredeep deposits there are no tectonic structures, but rather some features associated with gravitative processes. Underwater landslides are identified on the basis of reflectors whose geometries simulate those of structures of tectonic origin such as folds and overthrusts. At the bottom of these deposits a detachment surface is identified which defines the plane of sliding. It is believed that the formation of these landslides can be related to the latest displacement of the Gela front occurred at 0.8 Ma (CATALANO *et alii*, 1993). Their characteristics are mainly three:

- the deposits laterally are confined by faults, resulting very deformed but without considerable volume losses;
- they are confined between undeformed layers in the lower and upper boundaries (an important characteristic to distinguish a tectonic structure from a gravitative one);
- they are of moderate size, from one to a few km.

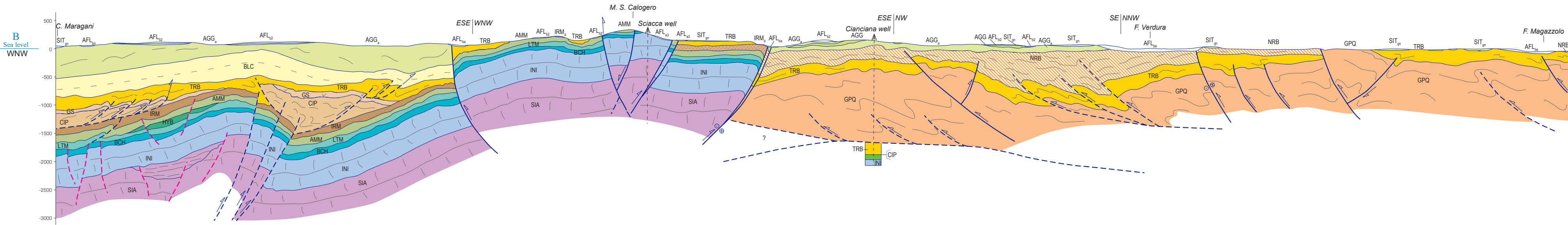


Fig. 5 - Geological cross-section along the coastal belt of the investigated area, representative of the structural setting in the outer front of the fold-and-thrust belt. The section crosses the M. nt San Calogero whose tectonic setting is controlled by recent (Pleistocene) high angle reverse faults and where geothermal fluid activity occurs.

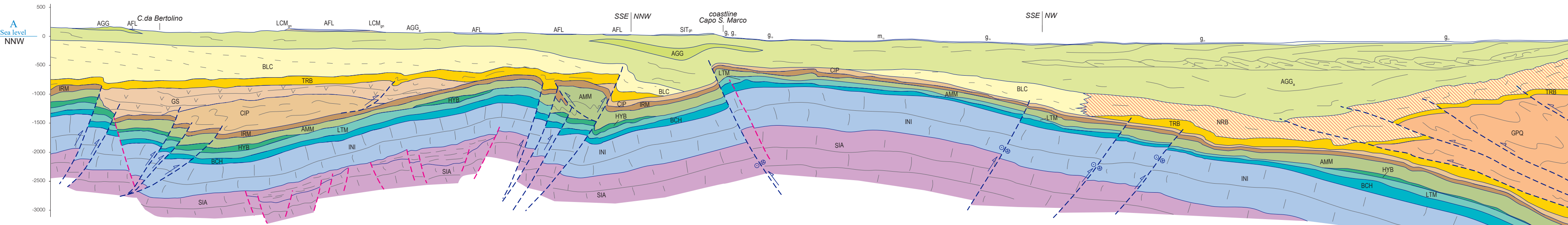


Fig. 9 - The cross-section shows the tectonic deformation affecting both the Meso-Cenozoic carbonate units of the "Saccense palaeodomain" and related late Neogene to Pleistocene syn-tectonic deposits, as well as, on the dextral, offshore stretch, the tectonic structures affecting the outer front of the Gela thrust system.

TECTONIC EVOLUTION

The outcomes of our research allowed for to define the kinematics and the timing of the tectonic deformation, by distinguishing three main steps (Fig. 10):

- the **first** compressive event occurred during the **Messinian to Early Pliocene** and originated south-east vergent folds in the post-early Jurassic portion of the sedimentary succession as well as local decollement surfaces at different stratigraphic intervals;
- the **second** compressive event, occurred during the **Late Pliocene**, was responsible for: i) (a) high-angle reverse faults, along which Mesoziotic carbonate successions exhumated, forming the current, most prominent relieves of present-day landscape physiography (Rocca Ficuzza, Rocca Nadore, Monte San Calogero); ii) thrusting, accounting for small wave length folds involving the Eocene-Oligocene succession and the Lower Pliocene deposits; (iii) shortening and south-westward translation of the Gela Thrust System, representing the outermost tectonic unit of the SMFTB;
- during the **third** compressive event (post **Early Pleistocene**), high angle reverse and transpressive faults acted, that affected the foreland as well as the formerly deformed outer sector of the orogenic wedge. More in detail, during this stage the following tectonic structures originated: i) the sx transpressive fault currently bounding the Monte San Calogero that, with a NNE-SSW trend, extend toward the offshore sector; ii) an E-W oriented, northward dipping, reverse fault bounding the Rocca Ficuzza - Caltabellotta carbonate ridge (Fig. 6). Both these two tectonic structures also affect the decollement surface at the bottom of the Gela Thrust System.

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REGIONAL STRUCTURAL SKETCH

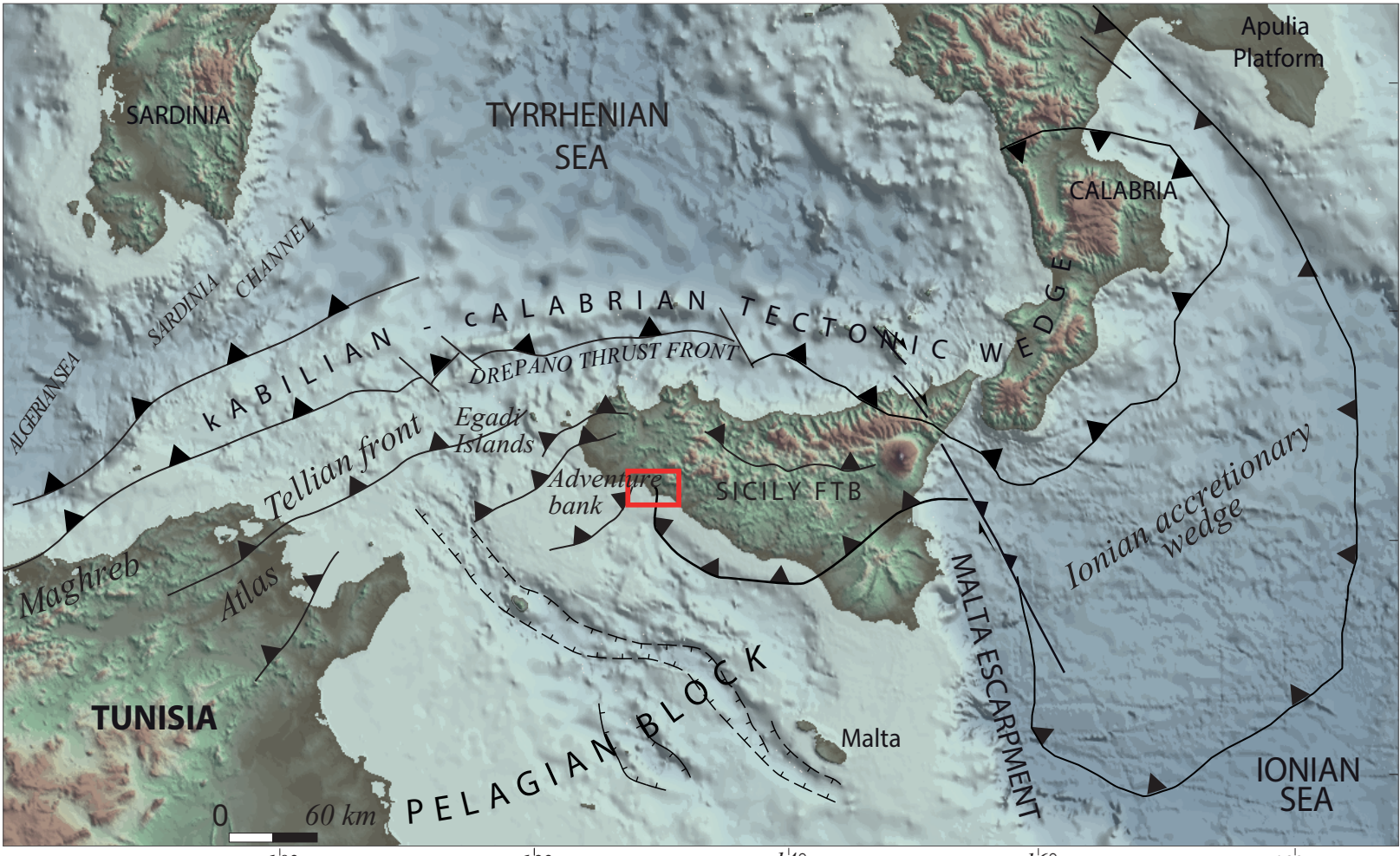


Fig. 1 - Simplified structural sketch of central Mediterranean region surrounding Sicily Island.

CHRONOSTRATIGRAPHIC CHART

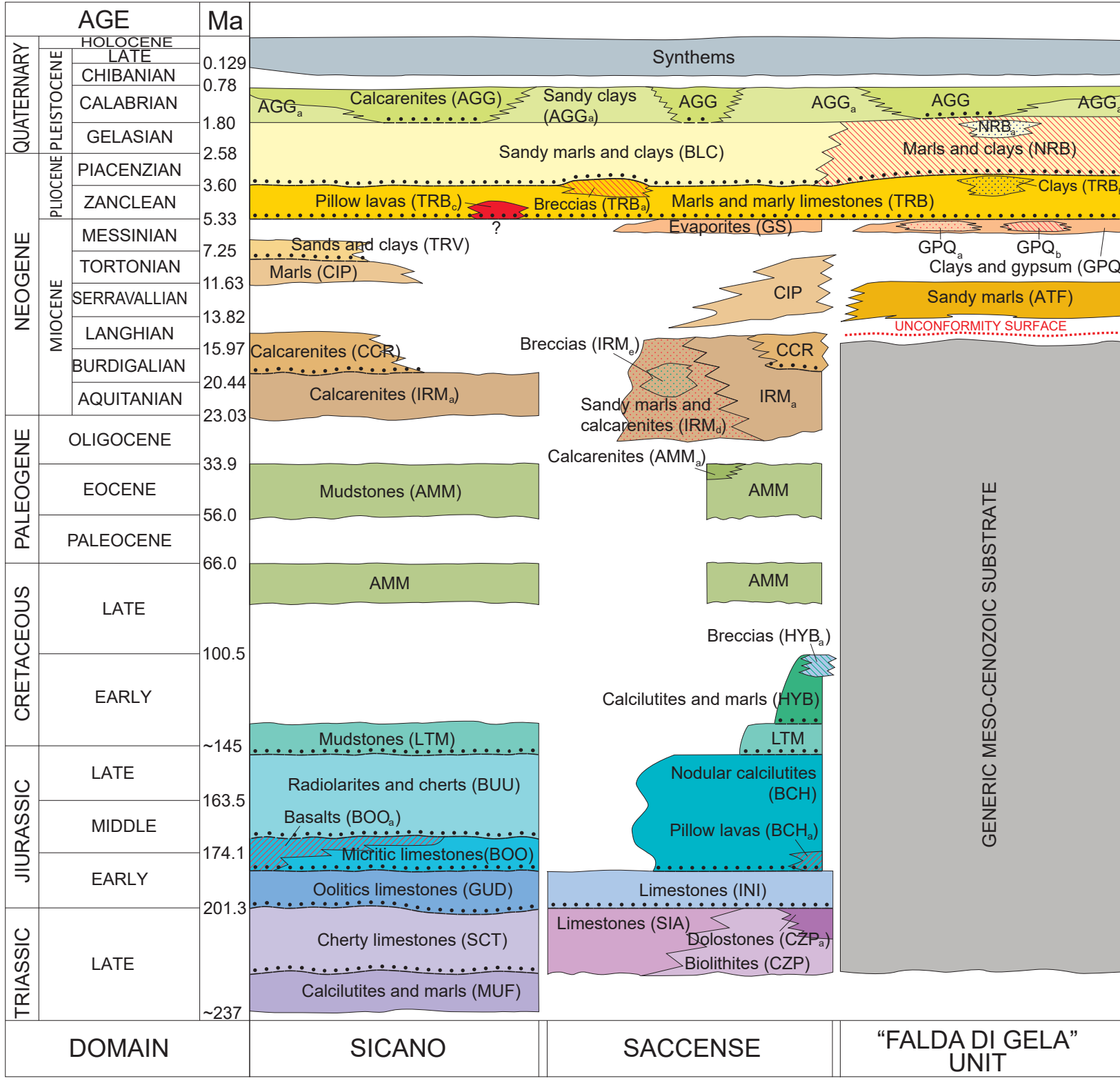


Fig. 2 - Chronostratigraphic chart of sedimentary successions outcropping or buried in the study area.

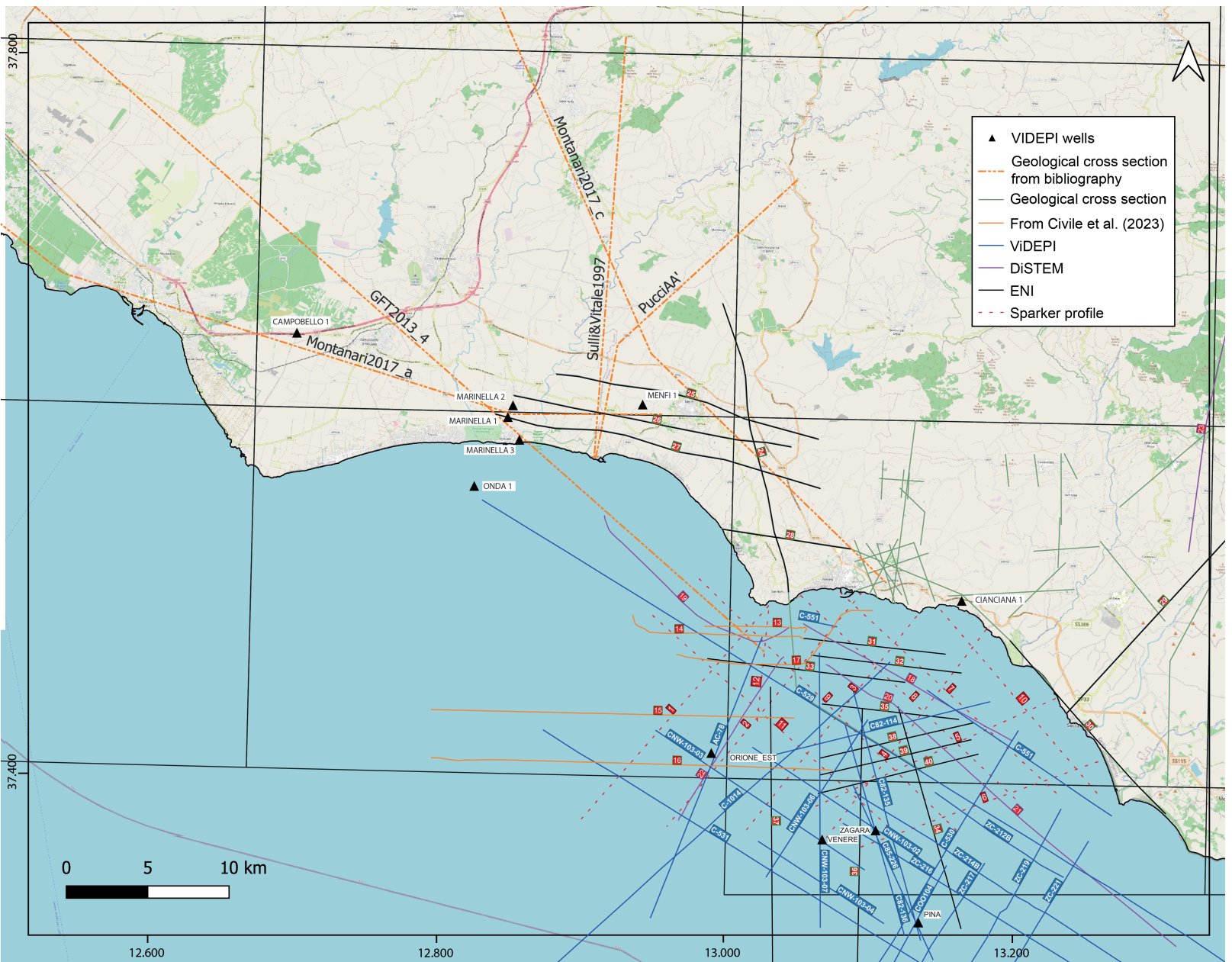


Fig. 4 - The map displays the location of seismic lines and boreholes analysed in this study.

STRUCTURAL SETTING MAP

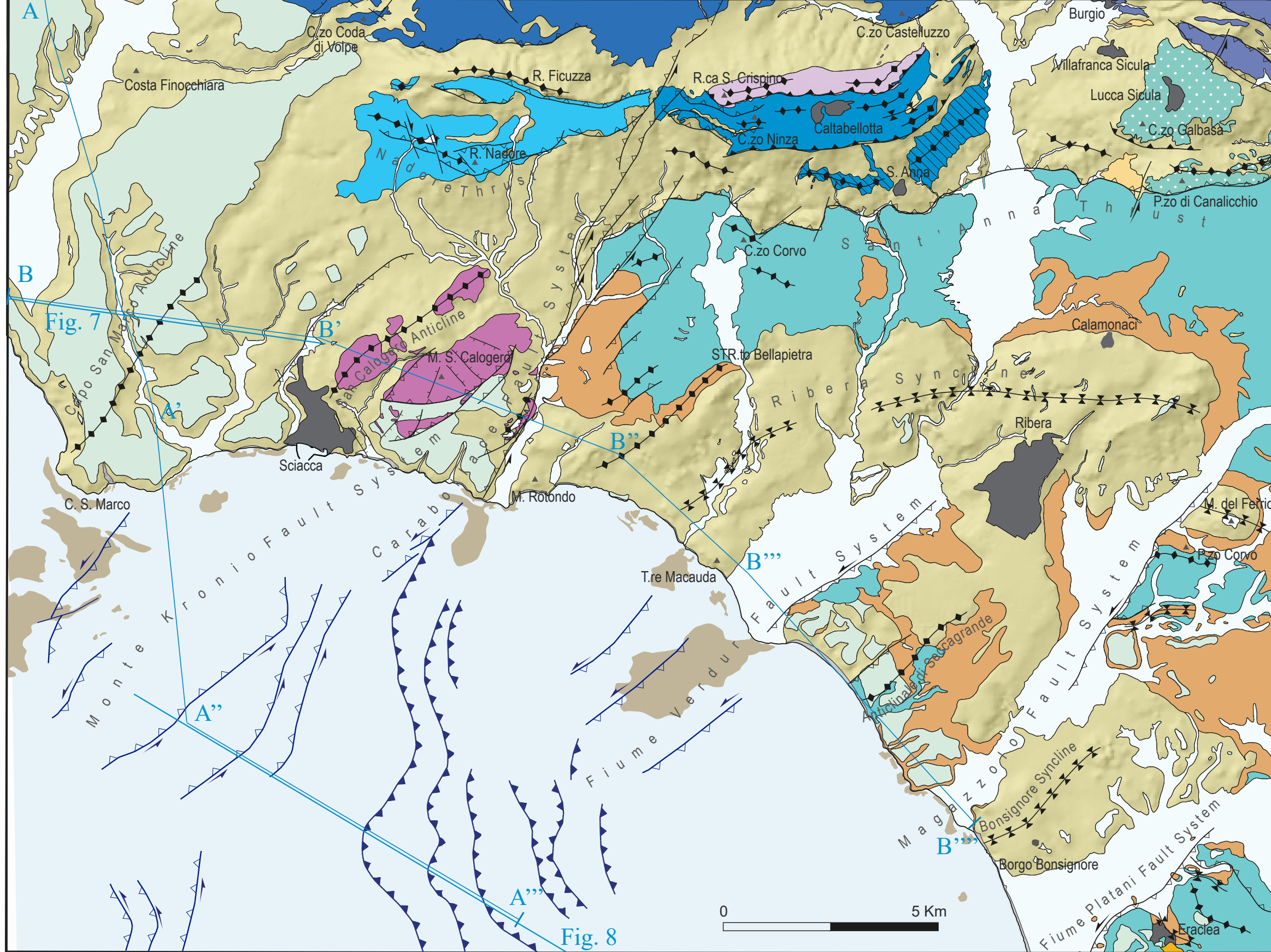


Fig. 3 - Six tectonic units were distinguished in the study area; each tectonic unit is bounded by first-order overthrust surfaces which are associated with the main tectonic shortening.



Fig. 6 - Panoramic view of the Rocca Nadore ridge where the main tectonic structures outcropping in this area are shown: along the southern slope of the ridge, a major overthrust is visible which determines its tectonic contact on the Neogene-Pleistocene succession; towards the west, the succession is involved in the folding of an overturned anticline.

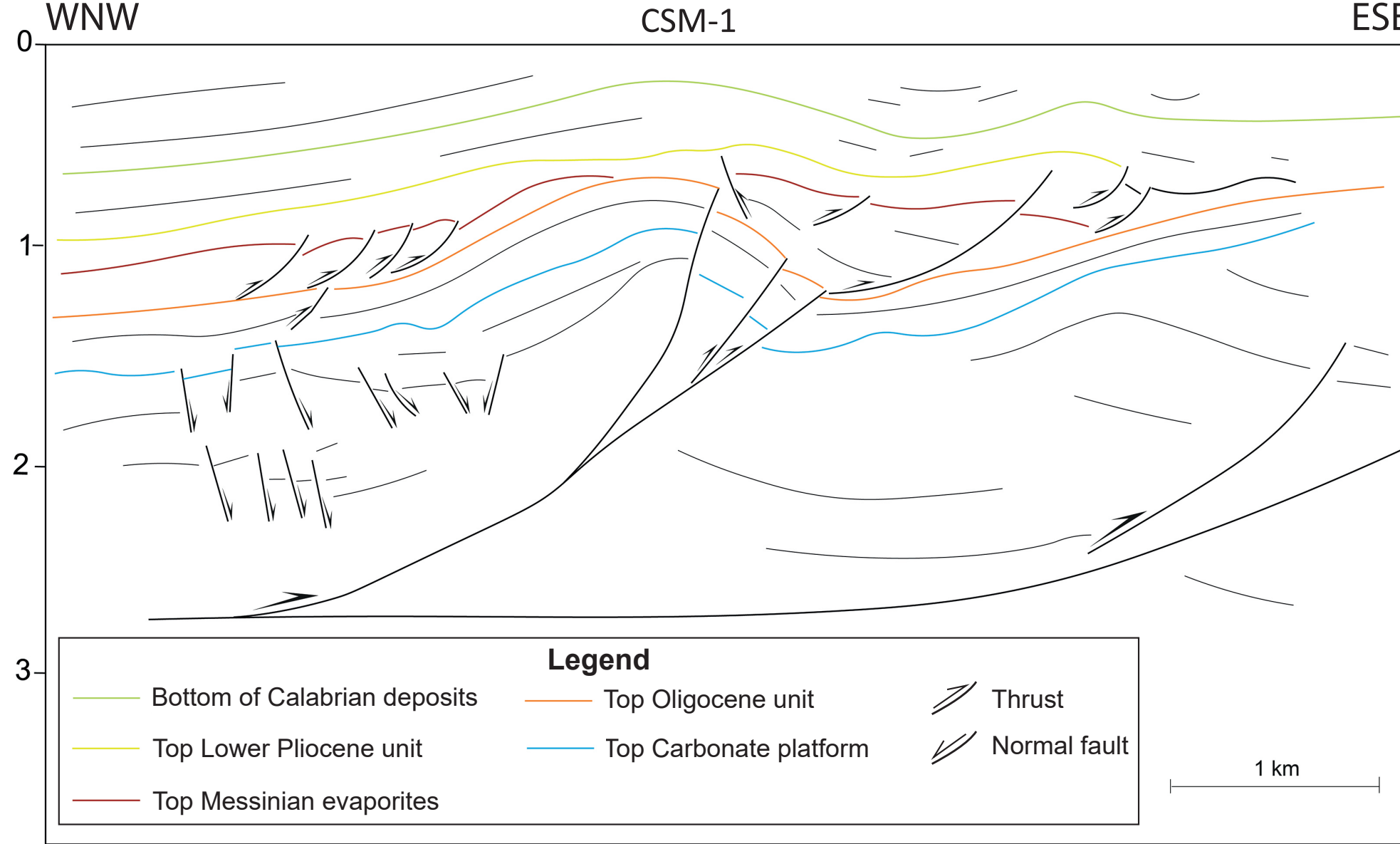


Fig. 7 - Line drawing of multi-channel seismic profile located offshore Capo San Marco. The interpretation of seismic profile highlights subsequent tectonic events affecting the submerged succession (see the text for more detail).

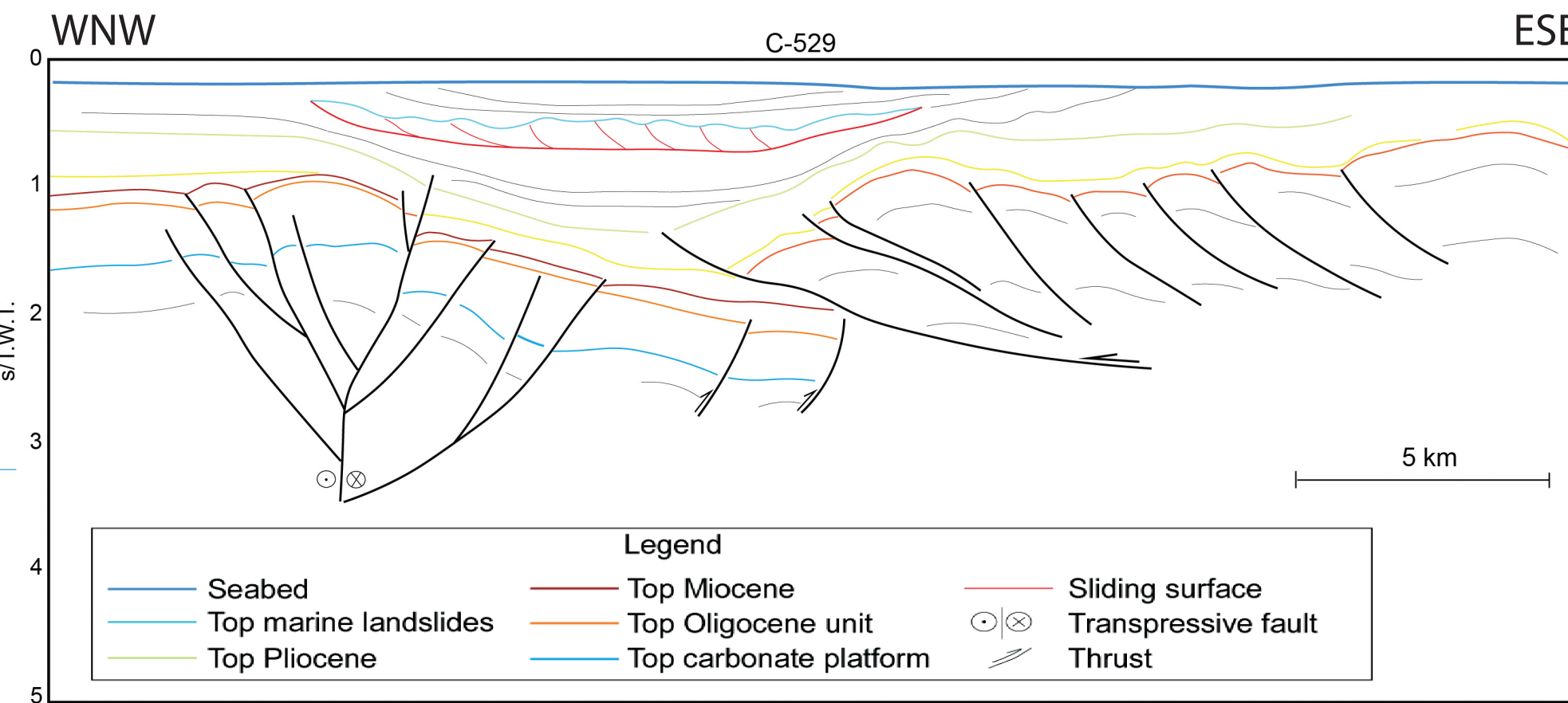


Fig. 8 - The seismic line drawing shows the main tectonic structures submerged in the Sciaca offshore area: the buried outer front of the Gela thrust system and, in the central sector of the section, an extensive deposit of submarine slide.

SCHEMATIC TECTONIC EVOLUTION

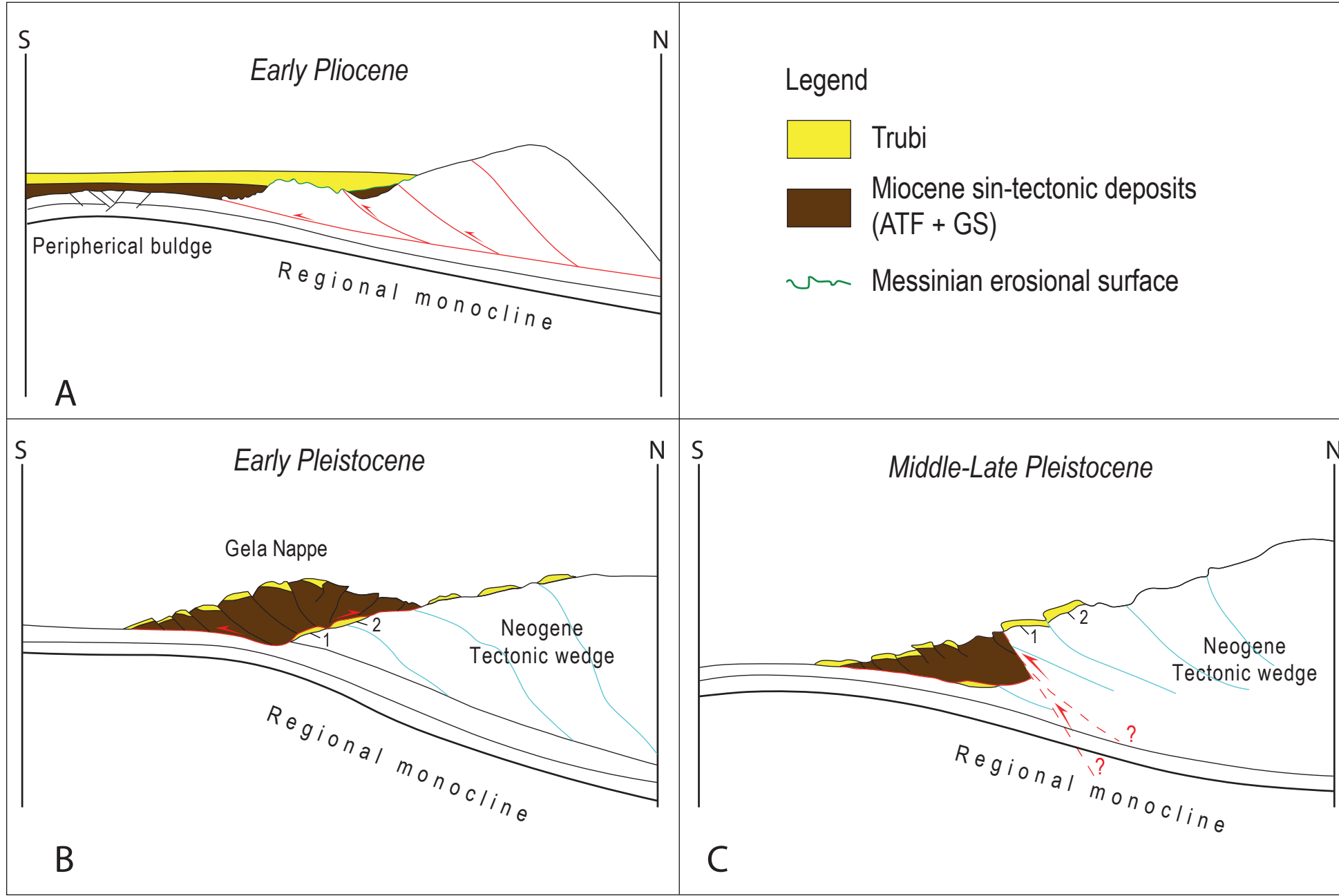


Fig. 10 - Non-scale evolutive cartoon of the main compressive deformation events that affected the successions cropping out in the eastern sector of the investigated area (Gela thrust system sector). The numbers 1 and 2 in figures b and c represent homologous rocky bodies.