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# Pliocene-Pleistocene tectonic, eustatic and climatic forcing at Altavilla Milicia (Sicily)

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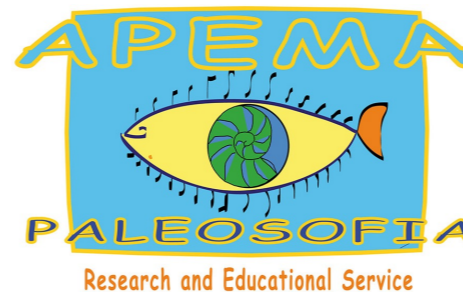
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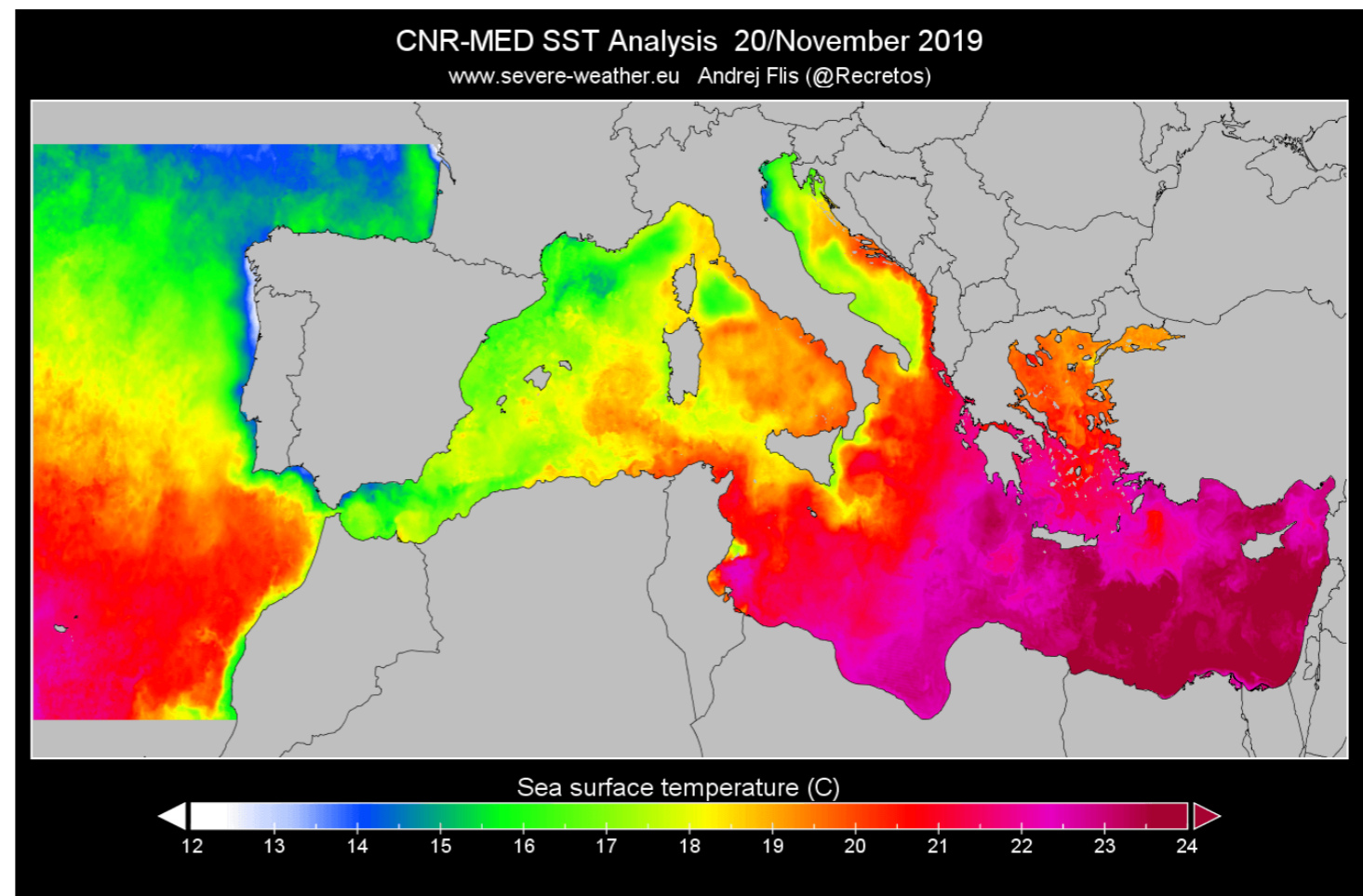
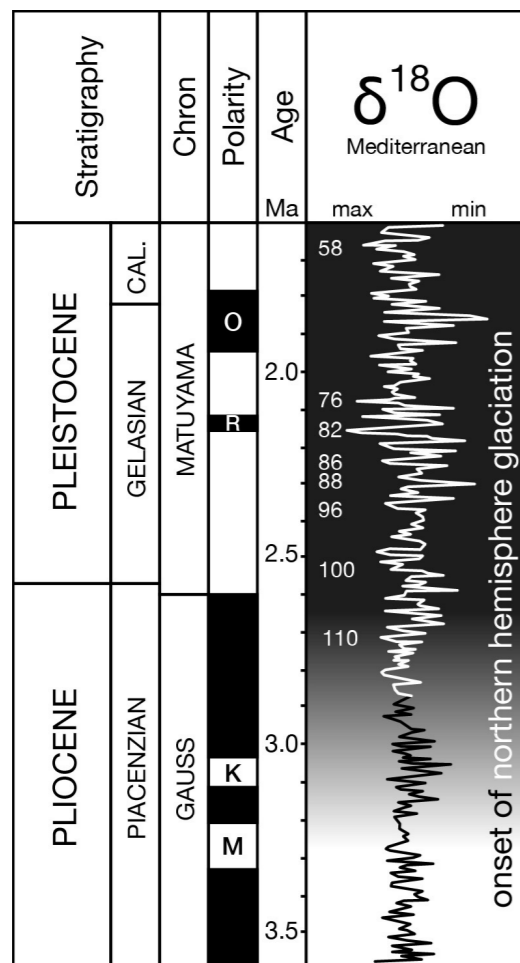
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# Crossroads

Around the **turning point** between warm Pliocene and cold Pleistocene and at the **crossroad** between a species-rich western Mediterranean and a species-poor eastern one, the highly fossiliferous sedimentary succession cropping out at Altavilla Milicia, near Palermo (Sicily), offers the chance to add new data on which to build general models of benthic community assembly in the largest enclosed sea of the globe.

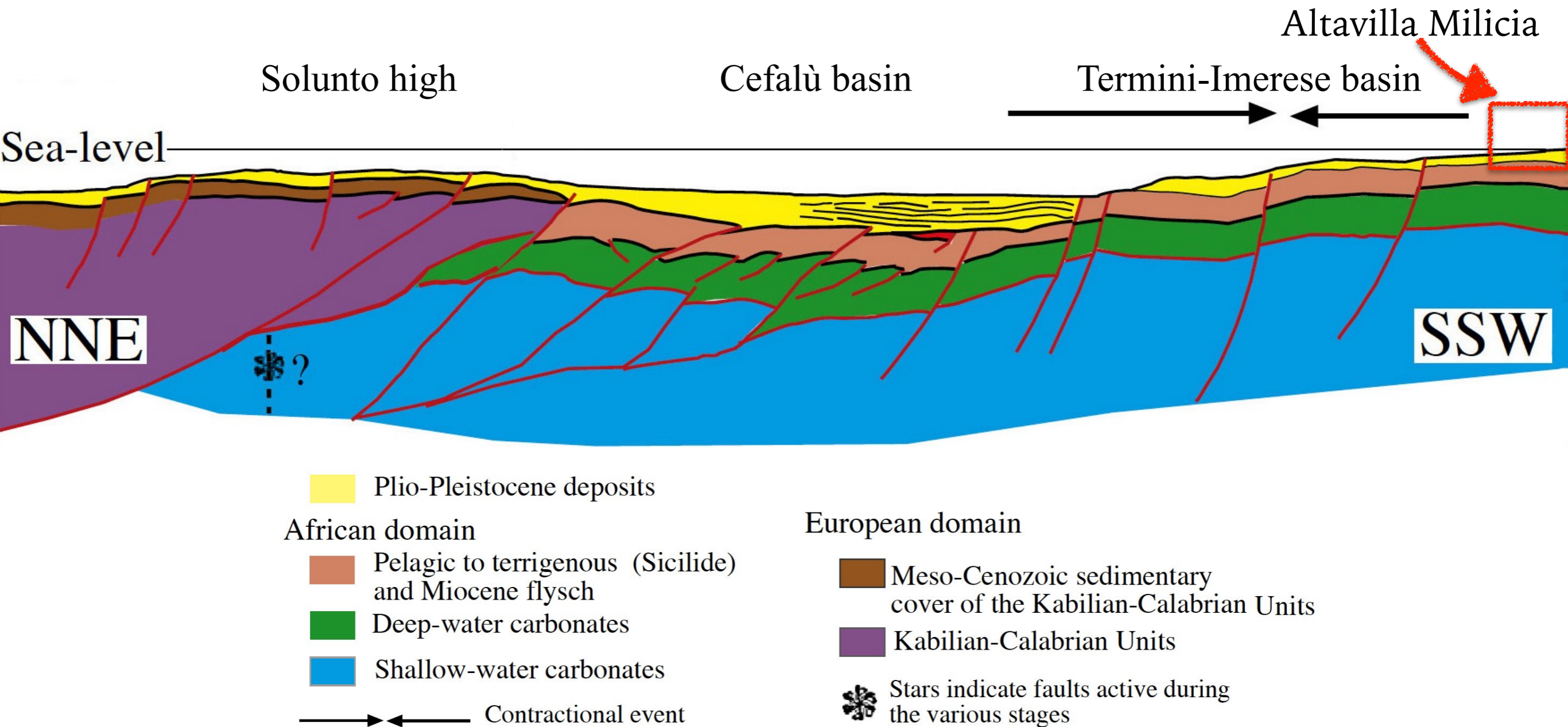


# Altavilla Milicia

Below the surface of the Altavilla Milicia outcrops, a complex chain of **imbricated thrusts** occurs. The basin belongs to the Maghrebian thrust belt, the most external of three structural elements that make up the collisional complex of Sicily and adjacent offshore areas. Studied outcrops are Cannamasca, Costagrande and Altavilla. Stratigraphic units are Cannamasca (CNM) and Altavilla (ALT).



# Imbricated thrusts



During the main late Pliocene extensional stage, normal faulting and crustal thinning developed. Presently, seismological data indicate that the margin is a zone of compressive stress (Pepe et al., 2005, *Tectonophysics* 409: 1–18).

# Historical outcrops



Cannamasca  
(person for scale)

Altavilla



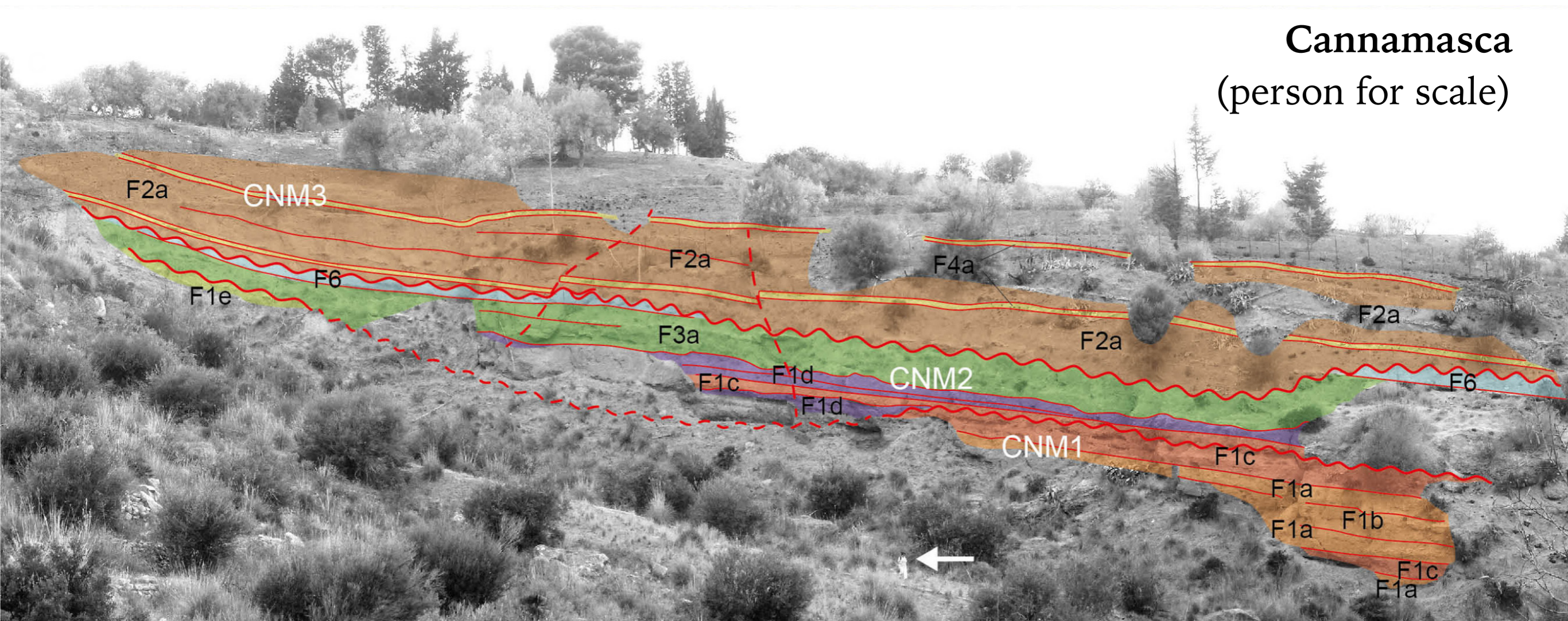
In the search for a way to measure geological time, fossil molluscs of **Cannamasca** and **Altavilla** have been studied for almost two centuries (Calcara, 1841; Aradas, 1846; Libassi, 1859; Seguenza, 1873-77; Cipolla, 1914; Ruggieri et al., 1959, 1967).

# Factor 1: tectonics



The main asset of the succession is driven by tectonic compression and accommodation by transpressional faults, a regime that led to a change in the direction of fluvial sediment delivery, from axial (mid-Piacenzian: unit CNM), to transverse with respect to the basin elongation (upper Piacenzian-Gelasian: unit ALT).

# Stacking pattern

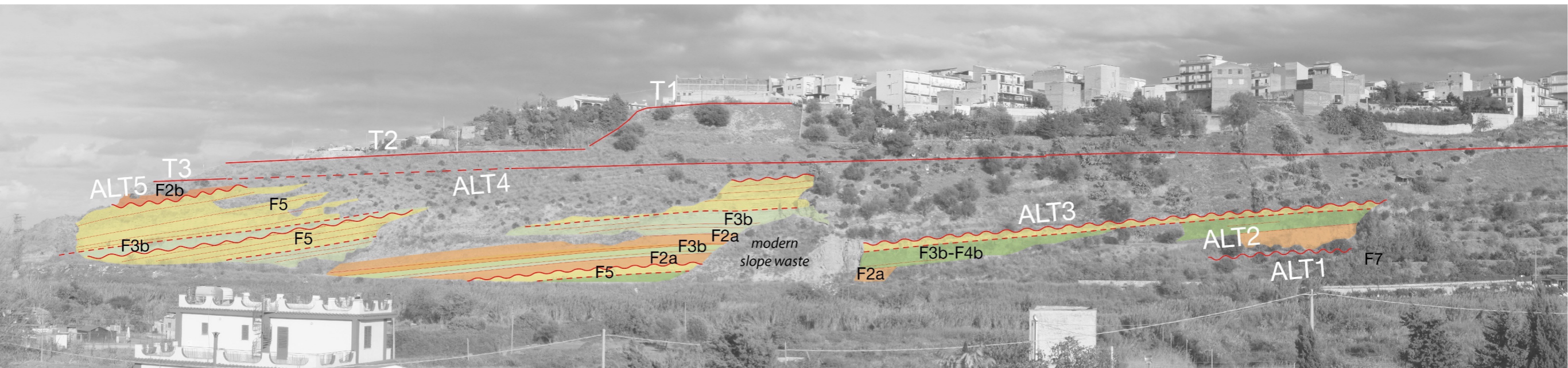


Cannamasca  
(person for scale)

CNM sedimentary facies types range from fluvial conglomerates (F1a-d) to lagoonal mudstones (F1e), marine sandstones (F2-F4) and marine mudstones (F6), stacked to form elementary depositional sequences (EDSs), in a deepening-upward trend (CNM1-CNM2), followed by a shallowing-upward trend (CNM3-CNM4; the last EDS crops out at Costagrande, see slide 3).

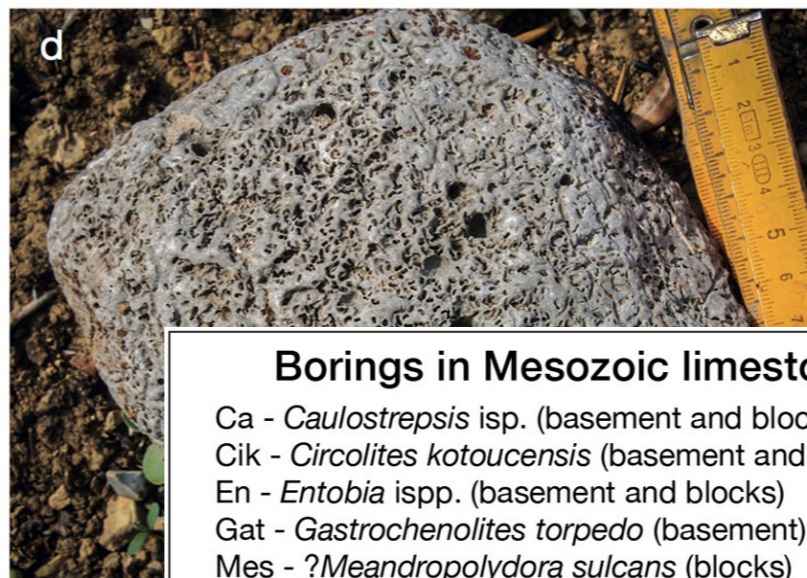
# Stacking pattern

Altavilla



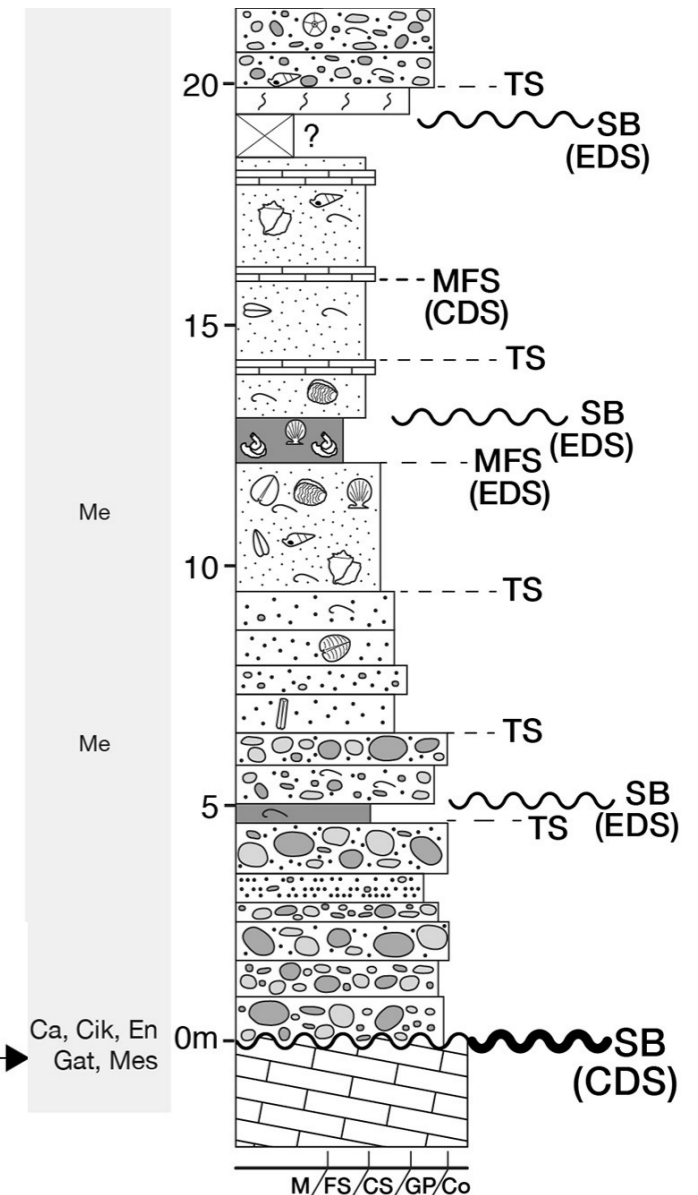
ALT facies types range from marine sandstones (F2-F3) to open shelf mudstones (F7). With the exclusion of EDS ALT1, represented here only by facies F7 and with unknown relationships with the rest, EDSs ALT2-ALT5 are stacked to form elementary depositional sequences in a deepening-upward trend (ALT2-ALT3), followed by a shallowing-upward trend (ALT-ALT5).

# Ichnology



## Borings in Mesozoic limestone

Ca - *Caulostrepsis* isp. (basement and blocks)  
 Cik - *Circolites kotoucensis* (basement and blocks)  
 En - *Entobia* ispp. (basement and blocks)  
 Gat - *Gastrochaenolithes torpedo* (basement)  
 Mes - ?*Meandropolydora sulcans* (blocks)

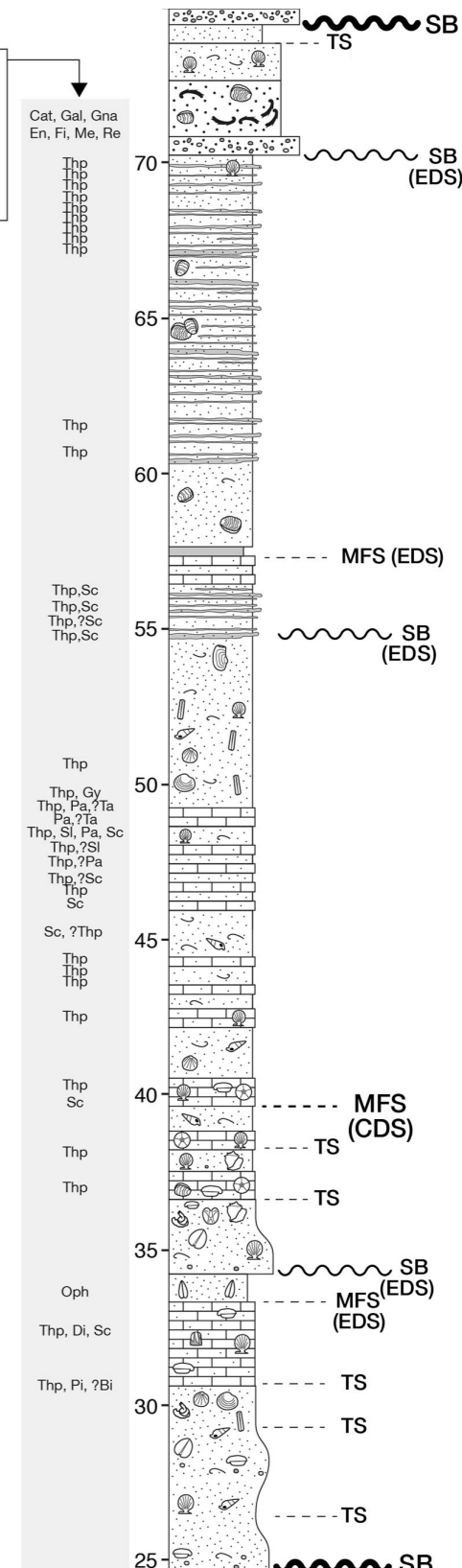
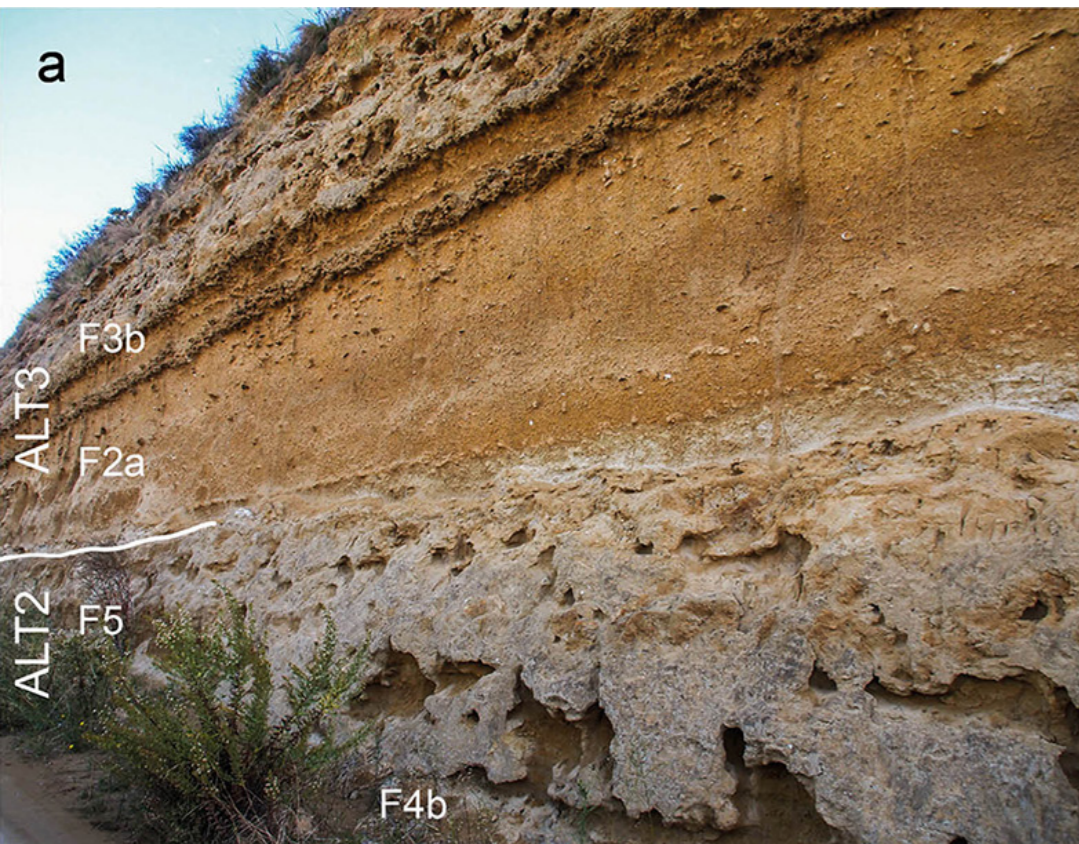


CNM onlaps on a surface of marine abrasion marked by a suite of macroborings. The ichnoassociation includes *Circolites kotoucensis* (a), *Gastrochaenolithes torpedo* (b), *Entobia* ispp. (c), *Caulostrepsis* isp., and *Meandropolydora* issp. (d). It is diagnostic of the *Entobia* ichnofacies, typical of the long-term bioerosion of lithified carbonates.

# Ichnology

## Ichnofossils

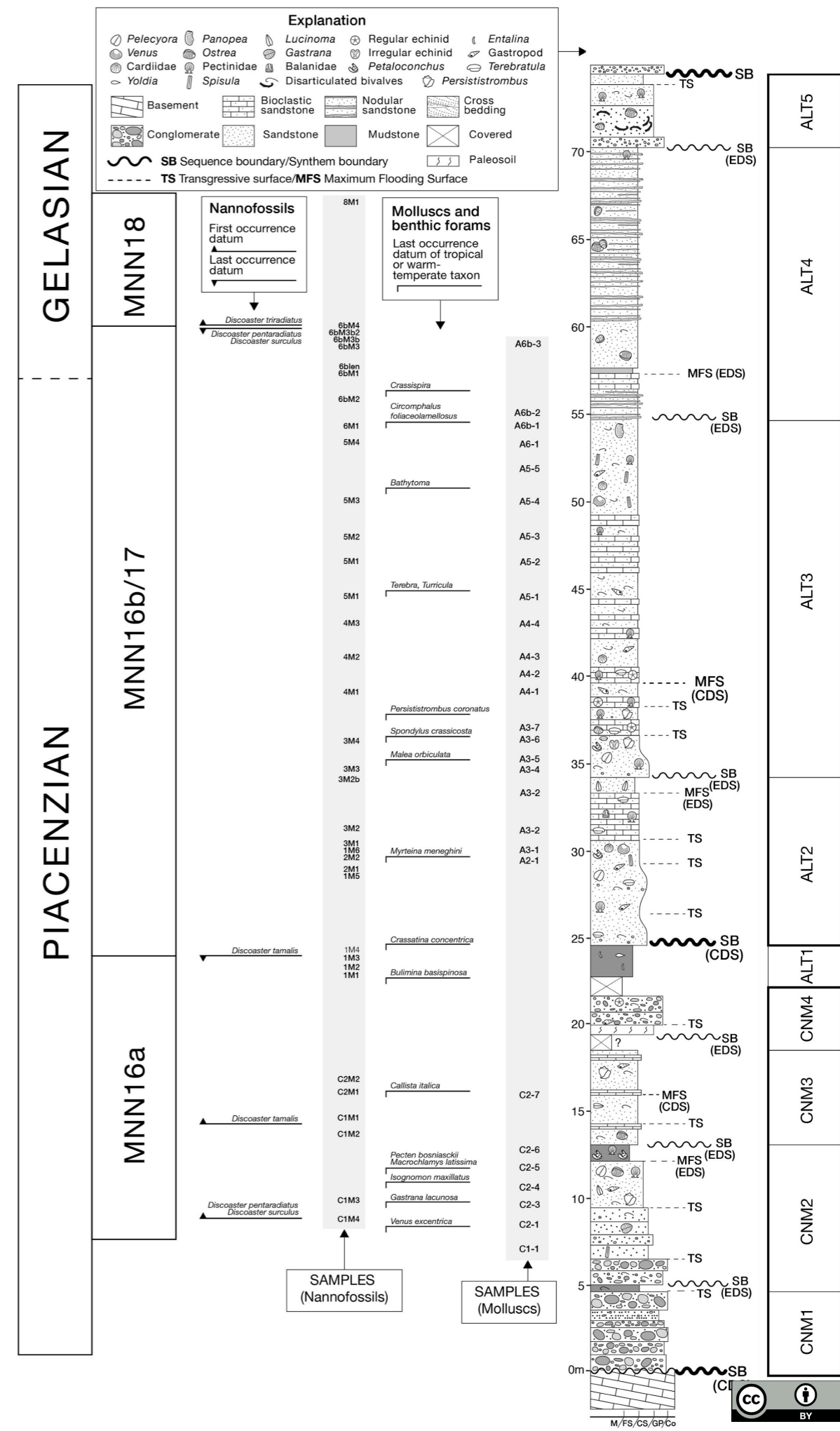
Bi - ? <i>Bichordites</i> isp.	Gy - <i>Gyrolithes</i> isp.	Re - <i>Renichnus arcuatus</i>
Cat - <i>Caulostrepsis taeniola</i>	En - <i>Entobia</i> isp.	Sc - <i>Scalichnus</i> isp.
Di - <i>Diopatrighnus</i> isp.	Fi - <i>Finichnus</i> isp.	SI - ? <i>Scolicia</i> isp.
Gal - <i>Gastrochaenolites lapidicus</i>	Me - <i>Meandropolydora</i> isp.	Ta - ? <i>Taenidium</i> isp.
Gna - <i>Gnatichnus pentax</i>	Oph - <i>Ophiomorpha</i> isp.	Thp - ? <i>Thalassinoides paradoxicus</i>
	Pa - ? <i>Palaeophycus</i> isp.	
	Pi - <i>Piscichnus</i> isp.	



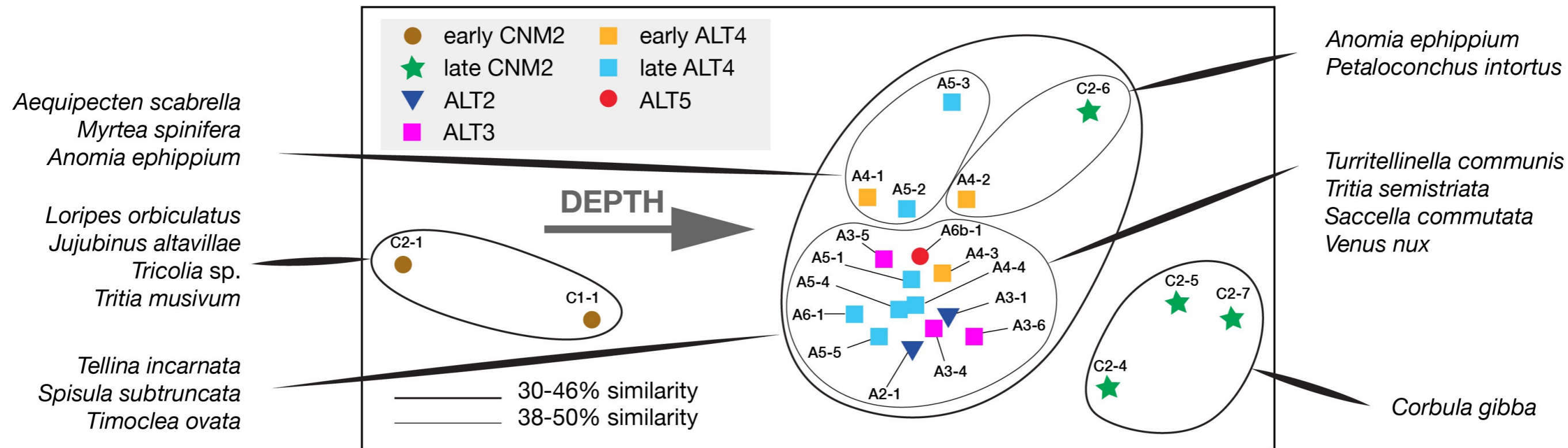
ALT shoreface cemented sandstones (a) are characterised by the *Cruziana* ichnofacies, including ?*Thalassinoides paradoxicus*, *Piscichnus* isp., *Bichordites* isp., *Diopatrighnus* isp. and *Scalichnus* isp., the latter around large individuals of bivalve *Panopea* in life position (b). The presence of echinoid pascichnial burrows suggests normal salinity.



**Molluscs** make up an important fraction of the total volume of the rock, particularly in CNM and ALT main transgressive intervals. Their distribution is consistent with the high-frequency sequence-stratigraphic interpretation. Quantitative data were collected for paleoecological analysis. **Calcareous nannofossils** allowed for the chronostratigraphic framing of the succession.

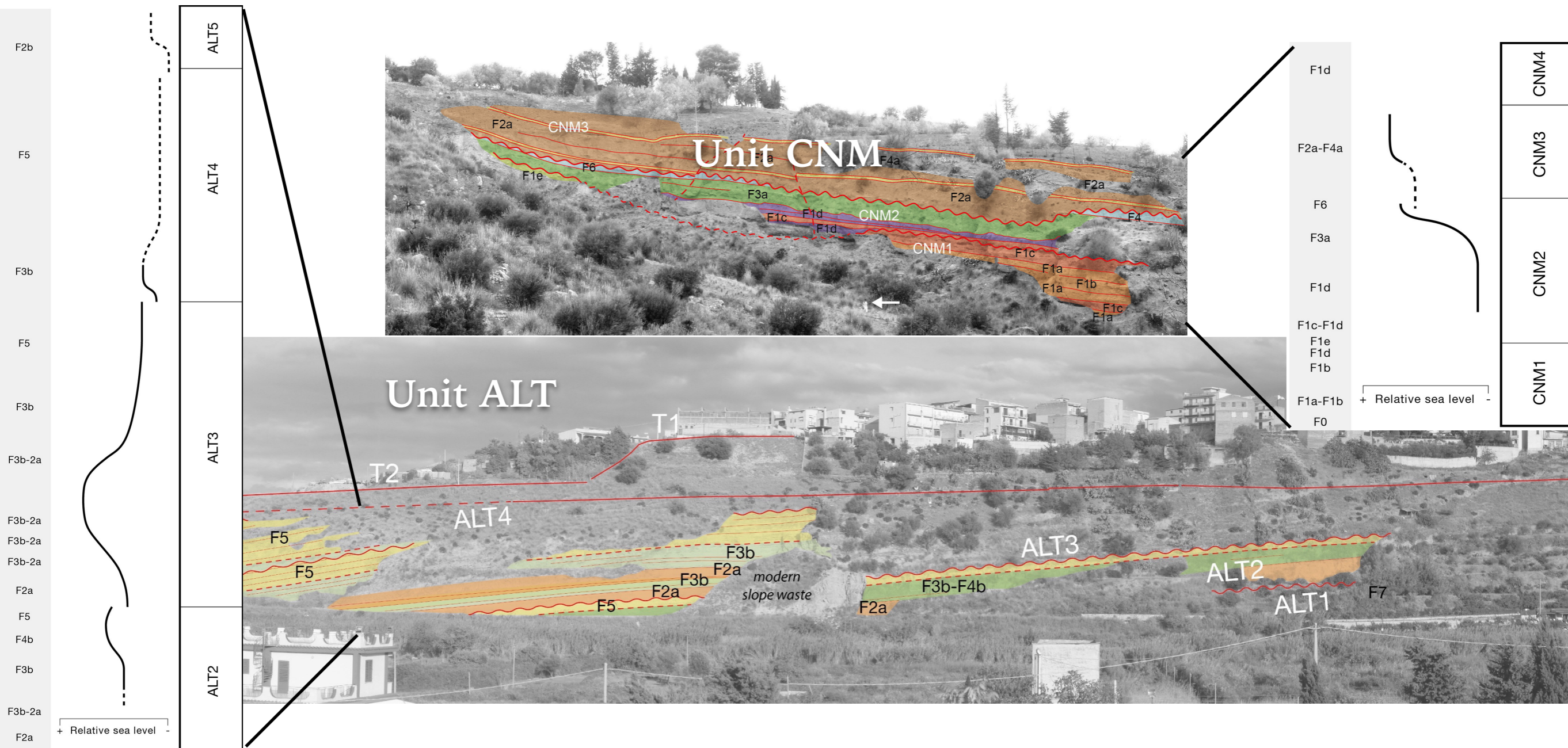


# Stratigraphic paleobiology



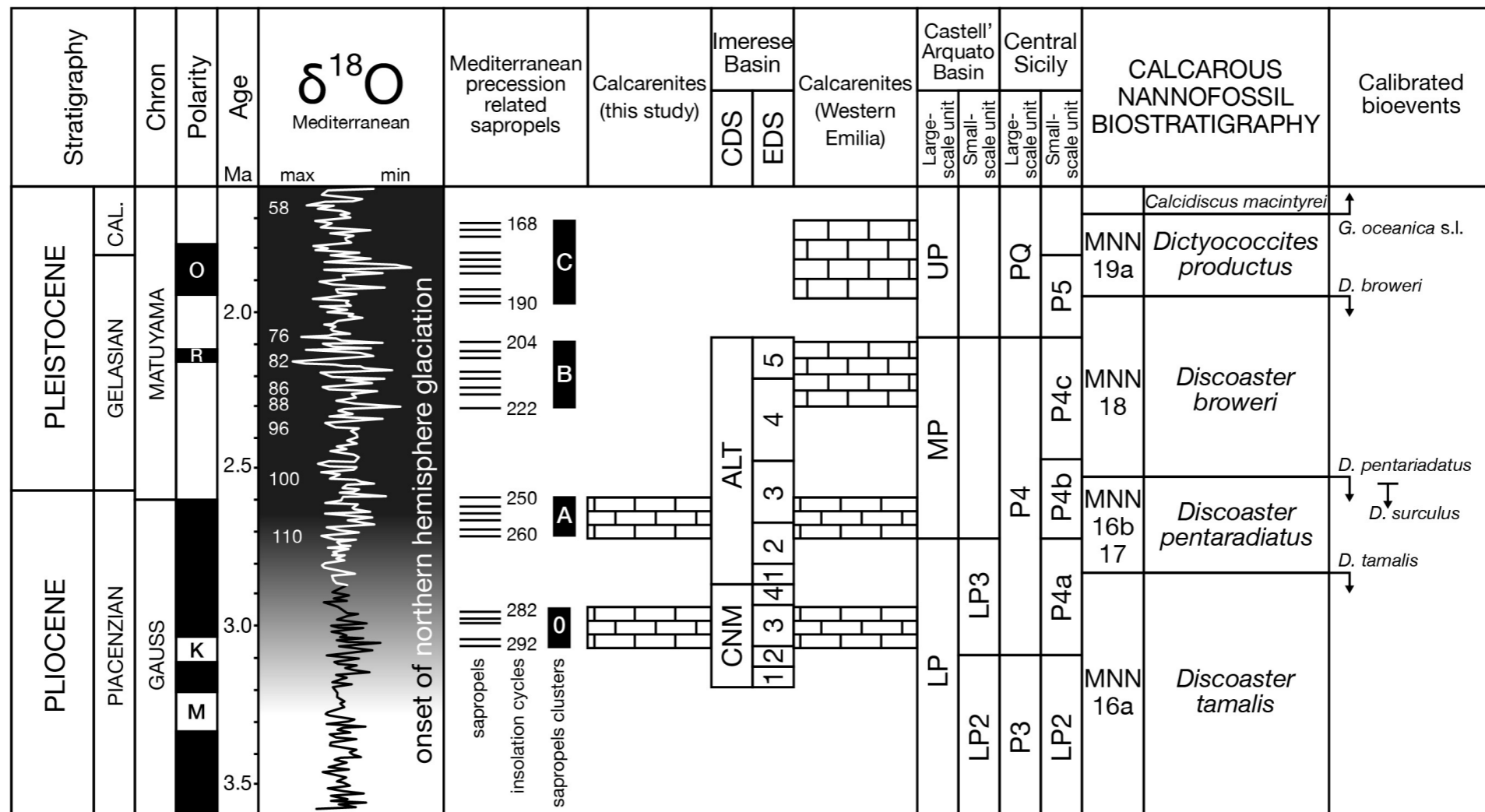
Multivariate analysis was carried out on a dataset of 22 samples and 92 species of molluscs. Q-mode cluster analysis highlighted three main groups, two clusters including CNM samples (early CNM2 and late CNM2) and the third cluster comprising all ALT samples (ALT2-5). The analysis of ordination (NMDS), with superimposed clusters, highlighted an onshore-offshore bathymetric trend, CNM samples representing both the shallowest and the deepest assemblages of the whole dataset.

# Factor 2: eustatism



Elementary depositional sequences, the building blocks of CNM and ALT, were driven by high-frequency cycles of eustatic change. Shell-rich, biocarbonatic intervals (F2-F4) are associated with the main transgressive intervals of each unit.

# Factor 3: climate



CNM and ALT mixed carbonate-siliciclastic lithosomes correlate with shallow marine shell-rich detrital carbonates of northern and southern Italy and with Mediterranean deep-water sapropel clusters, suggesting common climatic forcing. Some tropical species thought to disappear from the Mediterranean at around 3.0 Ma, including *Pecten bosniasckii*, *Gigantopecten latissimus* and others (see slide 12) are present in the upper Piacenzian of Sicily, suggesting that the disappearance of the Mediterranean Pliocene macrobenthos with tropical affinities has a geographic dimension.

# “Paleobiology in the Mediterranean”



Read the whole paper: Dominici et al. (2020), *Bollettino della Società Paleontologica Italiana*, 59: 57-83 — it's part of the thematic issue “Paleobiology in the Mediterranean”, in open access at <http://paleoitalia.org/archives/bollettino-spi/109/vol-59-1-2020-open-access/>.