Geological Field Trips and Maps

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Field Trip T1 Messina Strait.

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Tidalites Field Trips Special Volume - Tidalites 2021 - 10th Congress of Tidal Sedimentology. Matera, Italy, 5-7 October 2021. Field Trip T1 Messina Strait.

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Cover page Figure: Aerial overview from the south of the modern Messina Strait. In the background to the right, the hills forming the north-western margin preserves remnants of sedimentary deposits testyfing the depositional activity of the early Pleistocene strait, subject of the present field guide.

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Abstract

The Messina Strait excursion opens a series of geological field trips associated with the 10th International Congress of Tidal Sedimentology (Tidalites), Matera, Italy, 5-7 October 2021. This guide aims at documenting a number of selected outcrops located along the eastern margin of the modern Messina Strait, in order to illustrate the sedimentary dynamics of the Early Pleistocene tide-dominated Messina Strait. Since the Pliocene, this extensional basin separated Sicily from Calabria, forming a wide non-tidal seaway. Successively, this basin turned into a ca. 10-15 km-wide and 40 km-long, tide-dominated strait during the Early Pleistocene, prior to its definitive closure following a Middle Pleistocene phase of tectonic uplift. As for today in its modern analogue, the ancient strait acted as a major conduit for marine water exchanges between the Ionian and the Tyrrhenian seas. Semi-diurnal, reverse bidirectional tidal currents flowed in phase opposition parallel to the strait margins, being subject to tidal amplification due to bathymetric restriction across the shallower strait-centre zone. This oceanographic setting partitioned the strait into specific environments. Nowadays, their sedimentary record is exposed in a series of outcrops across the western (Sicily) and eastern (Calabria) margins of the modern strait.
A series of stops along a south-to-north transect covers a total distance of ca. 20 km. Outcrops of the first day show coarse-grained deposits lying adjacent to a block-faulted central horst and transgressively overlain by cross-stratified, mixed bioclastic-siliciclastic arenites. These strata record bypass and residual sedimentation in the strait-centre zone of the ancient system. The second day, large- and medium-scale cross-stratification exhibiting a variety of tidal sedimentary indicators are observed, interpreted as the ancient northern tidal dune field. The third day focuses on one major section representing the north-eastern flank of the ancient strait, where subaqueous canyon-fill strata, mass-wasting deposits and tide-influenced delta front-facies are exposed.

Key words

Tidal strait, tectonic control, tidal amplification, sedimentary processes, sedimentary facies, tidal structures, cross stratification, palaeogeography.

Programme summary

Along a three-day itinerary, the field trip aims at discovering the most significant outcrops exposed in the north-eastern onshore margin of the modern Messina Strait (Fig. 1a), which reveals some of the principal aspects necessary for understanding the sedimentary dynamics of the ancient strait. The excursion is continuously referenced to aspects related to the hydrodynamics and sedimentary features of the modern strait, providing a general framework of the present-day strait as a modern analogue to constrain the reconstruction of the ancient strait. At the beginning of the first day, participants are introduced to the geological setting and recent history of southern Italy and the Messina Strait. This marine conduit, together with other adjacent straits, formed a multiple system connecting the Tyrrhenian Sea and the Ionian Sea during the Plio-Pleistocene (Longhitano et al., 2012). A series of outcrops belonging to the 'strait-centre zone' (*cf*. Longhitano, 2013) show coarse-grained deposits and other associated facies, representing residual accumulations flanking the northern side of a subaqueous structural high (Fig. 1b). The Pellaro horst separated two opposite depositional areas of the ancient strait, respectively located to the south and to the north, where reversal tidal currents reworked sand-size sediments into bedform fields. The itinerary begins from the southern E-W-elongate flank of a hill near the village of Oliveto at ca. 318 m above sea level (a.s.l.), explores a 30-to-120 m-thick sedimentary succession and proceeds northwards to observe other adjacent outcrops. In the evening, participants return to the hotel enjoying the sunset over the modern strait.

During the second day (Fig. 1c), a series of outcrops located between an elevation of 225 m and 650 m a.s.l., reveal different scales and architectures of cross-stratification in mixed bioclastic-siliciclastic arenites. Their textural features represent an example of 'compositional mixing' (*sensu* Chiarella et al., 2017). Large-scale cross-stratification is the most distinctive expression of processes of tidal dune superimposition occurring within the main body of a subaqueous bedform field. Their position with respect to the central tectonic high and the reconstructed net-sediment pattern at basinal scale suggests that these dunes developed in the northern depositional area of the ancient Messina Strait (i.e. the 'dune-bedded zone', *cf*. Longhitano, 2013) under the dominance of the north-directed tidal flux. At the end of the day, participants will return to Reggio Calabria, one of the best-known seafront promenades of this part of southern Italy.

The third and last day (Fig. 1d) is dedicated to the visit of one of the most outstanding geological sections of the ancient Messina Strait at the village of Calanna, north-east of the Calabrian margin of the modern strait, at an elevation between 380 and 580 m a.s.l. After a first comprehensive observation of the outcrops from

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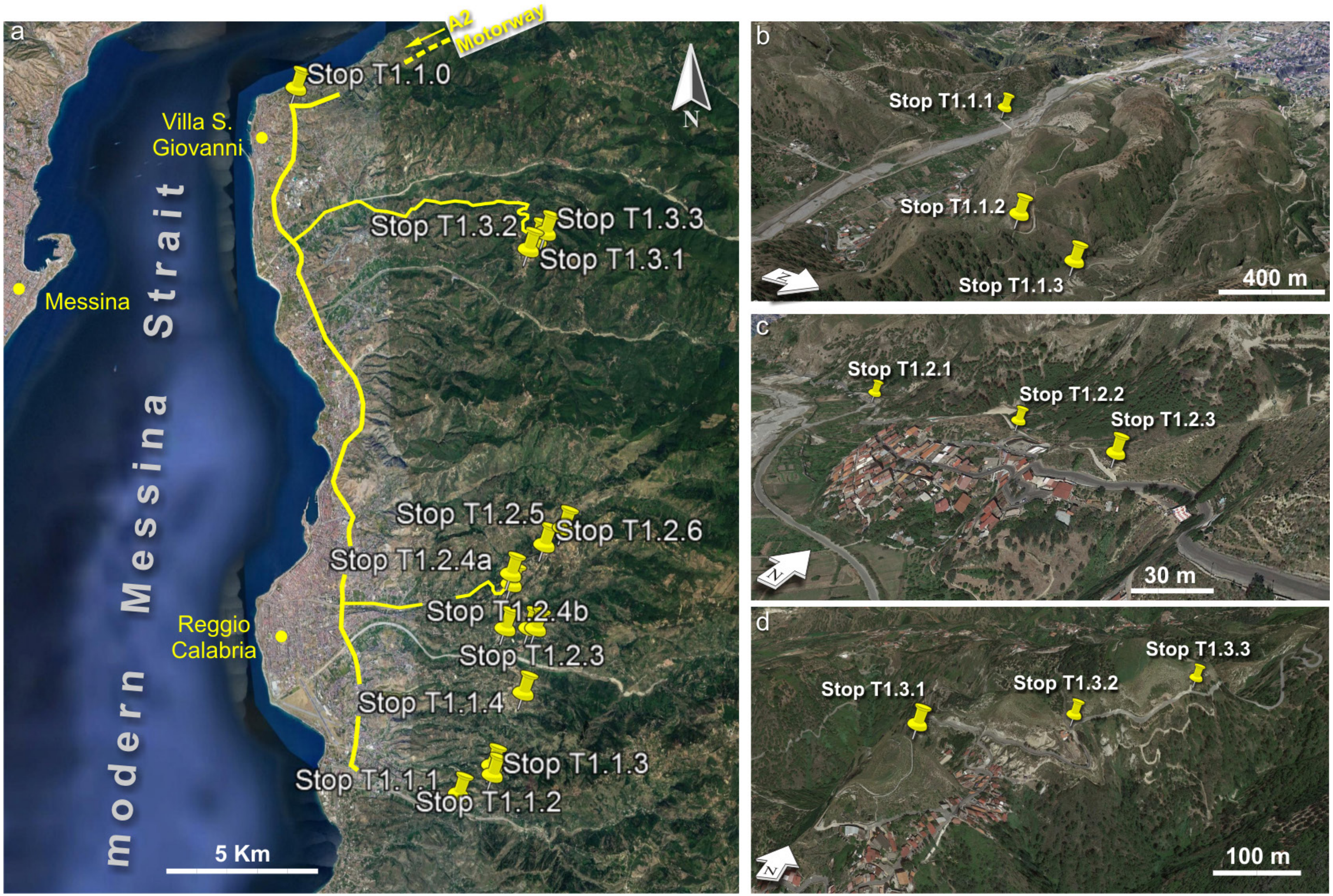

Fig. 1 – (a) General itinerary of the T1 Field Trip in the ancient Messina Strait. (b) Detail of the stops of the first, (c) second and (d) third day.

a panoramic viewpoint (Calanna Castle), participants are guided to the visit of discrete parts of the section, offering details describing the anatomy of a sedimentary succession ca. 150-200 m thick. The deposits consist of stratified pebbly sandstones exhibiting complex motifs of channel-form discontinuities and up-slope dipping foresets, interpreted as cyclic-steps and antidunes structures, overlain by mixed bioclastic-siliciclastic arenites showing trough and planar cross-stratification at different scales, indicating superimposition of tidal bedforms migrating roughly parallel to the palaeocoastline. This succession records a river-delta complex, entering a series of shallow-marine canyon heads, incising the eastern sublittoral zone of the ancient strait. A final summary on the topics discussed during the field trip will take place in a wooded area where refreshments will be available before participants depart for Matera, venue of Tidalites 2021.

Safety

Outcrops are often very close to the areas were the vehicles are parked and are easily accessible. However, a number of panoramic viewpoints are located close to the edge of high and steep cliffs for which particular caution is recommended. Facilities to ensure accessibility for participants with physical disabilities are also contemplated (*cf.* Chiarella and Vurro, 2020). The visit to some localities requires walking over moderate distances (ca. 500 m) along accessible roads and paths. The use of sturdy boots and comfortable clothing is advised. For all the stops, high-visibility jackets and protective helmets are mandatory. All places are close to towns with small shops, facilities and pharmacies. Lunch packs and continuous water supply to the participants are ensured. Southern Italy is usually sunny and relatively dry during the early fall, but downpours can occasionally occur. Sunscreen protection and rain jackets are thus needed. We suggest also the use of binoculars during outcrop panoramic observations, in order to better appreciate details of thick sedimentary successions exposed along extensive cliffs. Insurance against accidents or claims of any kind is in charge of the participants. The organisers are therefore not responsible for any event or occurrence not directly related with civil and / or criminal liability.

Emergency contact numbers

112 – Carabinieri (Police)
113 – Polizia (Police)
115 - Fire Department
118 – Ambulance

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Hospitals

Grande Ospedale Metropolitano Bianchi-Melacrino-Morelli - Via G. Melacrino, 21, Reggio Calabria
Phone: +39 0965 397111

Accommodation

There are several lodging options in Reggio Calabria and adjacent towns (hotels, guesthouses, bed and breakfasts).

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General geological setting of the Calabrian Arc and the Messina Strait

The Messina Strait (Figs. 2 and 3) lies at the boundary separating the southward-migrating European plate and the northward-subducting African plate in the central Mediterranean (Malinverno & Ryan 1986; Patacca et al. 1990; Doglioni, 1991; Doglioni et al., 2001). This structural setting lead to a process of crustal collision that occurred mostly during the Cenozoic and resulted in the accretion of the Apennine Orogen, which divides the Neogene back-arc Tyrrhenian Basin to the NW from the Mesozoic-Palaeogene fore-arc Ionian basin to the SE (Fig. 2, inset) (Doglioni et al., 1999; Polonia et al., 2011). Calabria and NE Sicily (i.e. the 'Calabro-Peloritani Arc', *Auct*.) represent the presently uplifted segments of a small orogenic belt, which became superimposed onto the Apennines during the Neogene (Ghisetti, 1981a; Ghisetti and Vezzani, 1982; Dewey et al. 1989; Lentini et al., 1994; Finetti et al., 1996). From the Middle Miocene to the Middle Pleistocene, the Calabro-Peloritani Orogen migrated E-SE-wards across an

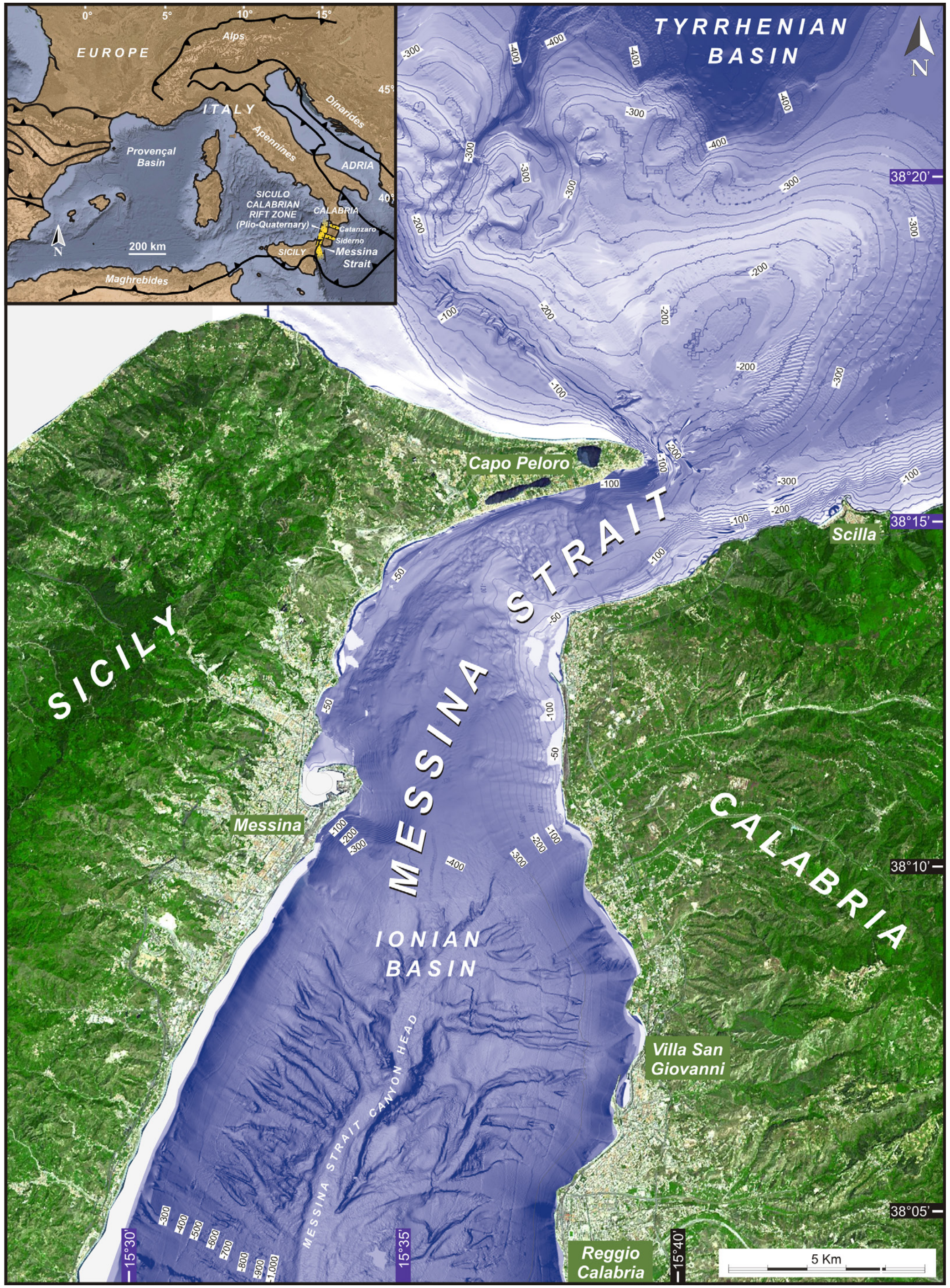

Fig. 2 - The Messina Strait in the central Mediterranean Sea (modified, from Longhitano, 2018a). Re-processed bathymetric data of the strait bottom are from Chiocci et al. (2008), Ferranti et al. (2008) and Doglioni et al. (2012). Remote-sensing data used to fill the land areas are from NASA land-sat database.

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oblique transpressional fault zones (Fig. 3a), mainly dipping towards NE and characterised by left-reverse movements, along which deep-seated units of the Calabro-Peloritani Arc and underlying Mesozoic carbonate rocks took place (van Dijk et al., 2000). During the Late Pliocene-Early Quaternary, these structural zones reactivated with eastward-diverging, N-NE- and S-SE-oriented major strike-slip faults, associated with transversal minor dip-slip structures (e.g. Ghisetti, 1979; Turco et al., 1990; Ghisetti, 1992). The consequent block-faulting of the arc caused the fragmentation into structural highs isolating marine seaways and embayments, such as the Crati, Crotone, Catanzaro, Siderno and the Messina basins (Fabbri et al., 1980; Ghisetti, 1981b; 1992; Dumas et al., 1982, 1987; Westaway, 1993; De Guidi et al., 2003; Zecchin, 2005; Argnani et al., 2009; Doglioni et al., 2012). These depocentres were affected by a transtensional tectonic regime responsible for the modern physiographic setting of the region (Fig. 3a). The restriction of previous larger non-tidal seaways in the central Mediterranean was

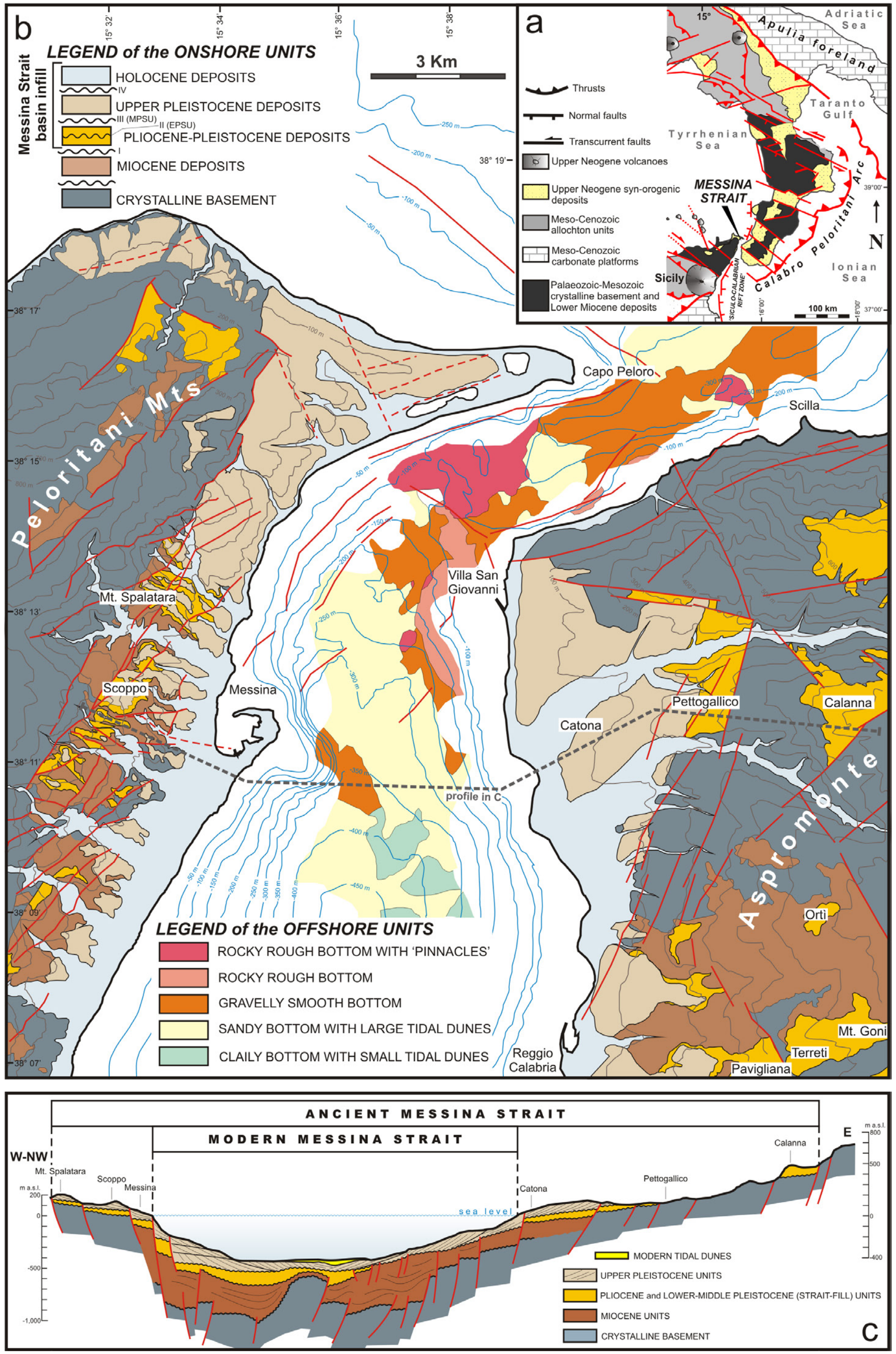

Fig. 3 - (a) Structural framework of southern Italy, with indicated the Messina, Catanzaro and Siderno straits within the 'siculo-calabrian rift zone' (modified, from van Dijk and Okkes, 1991). (b) Onshore-offshore geology of the Messina Strait, with the distribution of clastic sediments in the modern strait bottom (modified, from Selli et al., 1979; Ghisetti et al., 1983, Gargano, 1994, and Lentini et al., 2000). (c) Geological cross section showing the subsurface reconstruction of the Messina Strait, with the comparison between the width of the modern and the ancient strait (compiled from Bonfiglio, 1974; Del Ben et al., 1996; Chiocci et al., 2008) (modified, from Longhitano, 2018b).

due to a Late Pliocene-Early Pleistocene tectonic uplift, caused by a contractional–transpressive stage after a longer subsidence phase (de Jonge et al., 1994). This tectonic phase promoted a generalised episode of relative sea-level fall, associated with accumulation of coarse-grained deposits in the depocentres (Monaco et al., 1996). During the subsequent Early Pleistocene marine transgression, previously isolated basins turned into marine straits dominated by tidal hydrodynamics similar to that affecting the modern Messina Strait. Dune-bedded successions some 10s m-thick accumulated in discrete sectors of such basins (e.g. Longhitano et al., 2014). These are exposed today and represent a key-element for correlations in this sector of the central Mediterranean (Barrier, 1986; 1987a; Longhitano et al., 2011; 2012b) (Fig. 3a).
At the beginning of the Middle Pleistocene, a new phase of regional-scale uplift (Westaway, 1993; Wortel and Spakman, 1993; Tortorici et al., 1995; Monaco et al., 1996) caused the closure of many of these straits and the deactivation of previous marine connections among these small Mediterranean basins (e.g. Colella and D'Alessandro, 1988; Barrier et al., 1993; Rossi et al., 2017).
The present-day configuration of the Messina Strait developed mostly during the Late Pliocene, after a local narrowing linked to the activity of NNE-SSW-oriented faults. These structures belong to a larger fault array extending from western Calabria to eastern Sicily, known as "Siculo-Calabrian Rift Zone" (Ghisetti, 1984, 1992; Doglioni, 1991; Monaco et al., 1996; Tortorici et al., 1995; Finetti et al., 1996; Lentini et al., 1996; Monaco and Tortorici, 2000; Galli and Bosi, 2002; Catalano and De Guidi, 2003; Guarnieri et al., 2004; Catalano et al., 2008) (Fig. 3a). During the Early-Middle Pleistocene and onwards, the episodes of uplift resulted from the displacement along NE-SW-oriented faults with short-term vertical slip rates of 1-2 mm/y in the Messina Strait area (e.g. Bordoni and Valensise, 1998; De Guidi et al., 2003; Antonioli et al., 2006; Ferranti et al., 2006; 2008). Due to strong differences between the uplift rates of its opposite margins, Plio-Pleistocene strata belonging to the infill of the ancient strait present variable degrees of exposure and preservation (Figs. 3b, 4 and 5a). Most of these sediments currently lie beneath the modern strait bottom, sealed by upper Quaternary-to-Recent deposits (Chiocci et al., 2008; Goswami et al., 2014; Longhitano, 2018a) (Figs. 3c and 5b).

The Messina strait-fill stratigraphy

The Plio-Pleistocene sedimentary succession filling the Messina Strait has been largely investigated thanks to detailed stratigraphic and palaeontological analysis by Barrier (1984; 1986), Barrier et al. (1987a,b), Di Stefano and Longhitano (2009), and more recently revised by Longhitano (2012b; 2018b).

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The Messina basin-fill stratigraphy includes four main unconformities, spanning chronologically from the Early Pliocene to the Middle-Late Pleistocene, and thought to represent main regional-scale correlative surfaces in the Plio-Quaternary stratigraphy of this part of the Mediterranean (Fig. 6) (Ogniben, 1960; Di Stefano and Lentini, 1995; Lentini et al., 2000; Di Stefano et al., 2007; Zecchin et al., 2015). The Neogene deposits cropping out in NE Sicily (Peloritani Mts in Fig. 3b) and SW Calabria (Aspromonte in Fig. 3b) record the tectonic and sedimentary evolution of this complex area during the opening of the southern Tyrrhenian Basin and of the eastern Ionian Basin. From the Late Oligocene onwards, the terrigenous successions of the Messina Strait (Fig. 3b) formed distinct depositional cycles ('onshore units' in Fig. 3b) bounded by regional unconformities, each one indicating a stage in the complex polyphase evolution of the area (Lentini et al., 1995; Monaco et al., 1996; Guarnieri et al., 2006 and references therein). Upper Oligocene to Lower Miocene sediments fill a series of perched forearc basins, separated by intervening highs of crystalline basement. Thick Middle Miocene clastic successions indicate accumulation in tectonically downthrown depocentres (e.g. 'Flysch di Motta' or 'San Pier Niceto Fm', *Auct*).
The onset of tide-dominated sedimentation in the Messina Strait area is recorded in the Lower Pleistocene interval (Figs. 4 and 5) comprised between the base of the Gelasian (ca. 2.5 My) to the Calabrian (Santernian, ca. 1.5 My) (Barrier, 1984; Barrier et al., 1987a,b; Lentini et al., 2000; Di Stefano and Longhitano, 2009; Longhitano et al., 2012b).
Tidal strata filling the ancient Messina Strait are nowadays comprised between an elevation of 200 and 700 m a.s.l., as a consequence of the differential uplift exerted by syn- and post-sedimentary normal faults dipping towards the modern strait (Fig. 4) (Montenat and Barrier, 1987; Monaco and Tortorici, 2000; Catalano et al., 2008; Ferranti et al., 2008; Argnani et al., 2009; Bonini et al., 2011). This succession consists of up to 250 m-thick, cross-stratified sandstones and mixed arenites, associated with conglomerates, breccias, sandstones and mudstones (Fig. 4) (Ogniben, 1960; Barrier, 1987a; Di Stefano and Lentini, 1995; Lentini et al., 2000; Di Stefano et al., 2007). The lowermost basal boundary of the tidal cross-stratified deposits is a sharp erosional surface (paraconformity), locally incising the underlying shelf sands. The same surface becomes an angular unconformity near the main margins, where the tidal cross strata lap onto block-faulted Miocene turbidites and Mesozoic crystalline/magmatic basement rocks (Fig. 6). A basal boundary (i.e. the Early Pleistocene Unconformity *EPSU*; *cf*. Zecchin et al., 2015) with similar features has been described also at the base of cross-stratified successions filling adjacent tidal straits of the Calabro-Peloritani Arc (Colella and D'Alessandro 1988; Barrier et al., 1993; Chiarella et al., 2012; Longhitano, 2012; Longhitano et al., 2012b; 2014; Rossi et al., 2017).

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The surface bounding the top of the strait-fill succession (i.e. the Middle Pleistocene Unconformity *MPSU*; *cf*. Zecchin et al., 2015) is overlain by middle Pleistocene deltaic sediments (i.e. the 'Messina Gravels and Sands' Fm) (Ogniben, 1960; Ghisetti et al., 1983; Barrier, 1987a; Mercier et al., 1987; Di Stefano and Lentini et al., 1995) (Fig. 6). These deposits represent the normal- to forced-regressive filling of the ancient strait during a generalised phase of Middle-to-Late Pleistocene relative sea-level fall (Barrier, 1986). A possible persistence in time of the tidal circulation between the ancient and modern Messina Strait

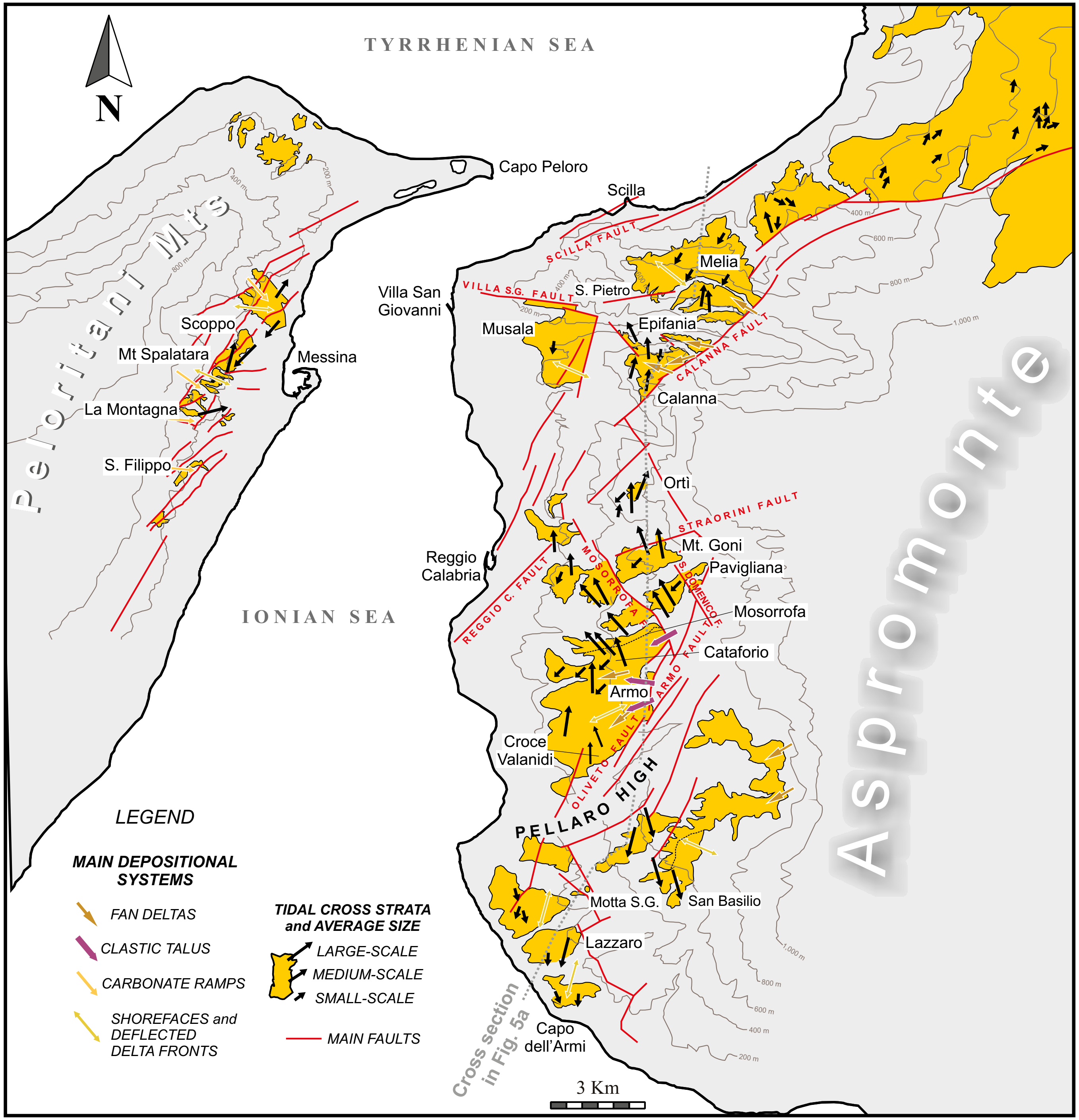

Fig. 4 - Sketch map of the distribution of the lower Pleistocene strait-fill deposits across the two onshore sides of the Messina Strait (modified, from Longhitano, 2018b), with indication of the type of depositional system, the average palaeocurrent directions measured on tidal foresets, relative inferred dune size and main Plio-Quaternary faults. These latter are from Ghisetti et al. (1983); Gargano (1994); Lentini et al. (2000), Guarnieri et al. (2004) and Guarnieri (2006) (modified, from Longhitano 2018b).

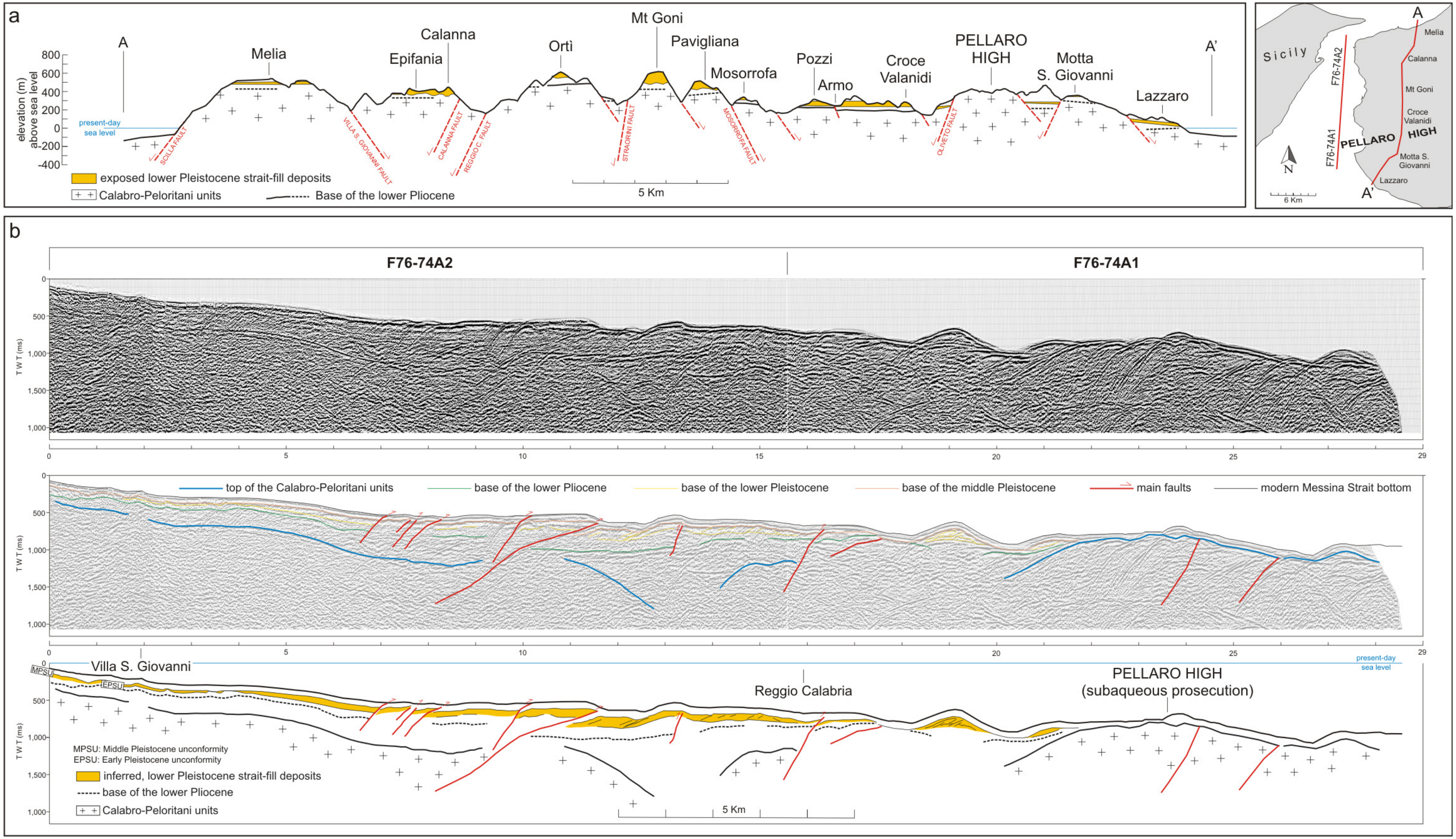

Fig. 5 - (a) Onshore N-S-oriented geological cross section reconstructed along the eastern margin of the Messina Strait and showing the lateral thickness variation of the lower Pleistocene strait-fill deposits (in yellow). (b) Interpreted offshore seismic line (VIDEPI Project) showing similar thickness changes in the correlative deposits presently occurring below the modern Messina Strait bottom. Note in both cases the tidal succession pinching out against the flank of the Pellaro High. The thicker offshore strait-fill deposits (compared with the thinner onshore correlative strata) possibly indicate the correspondence of the ancient depocentre with the axis of the modern strait (modified, from Longhitano 2018b).

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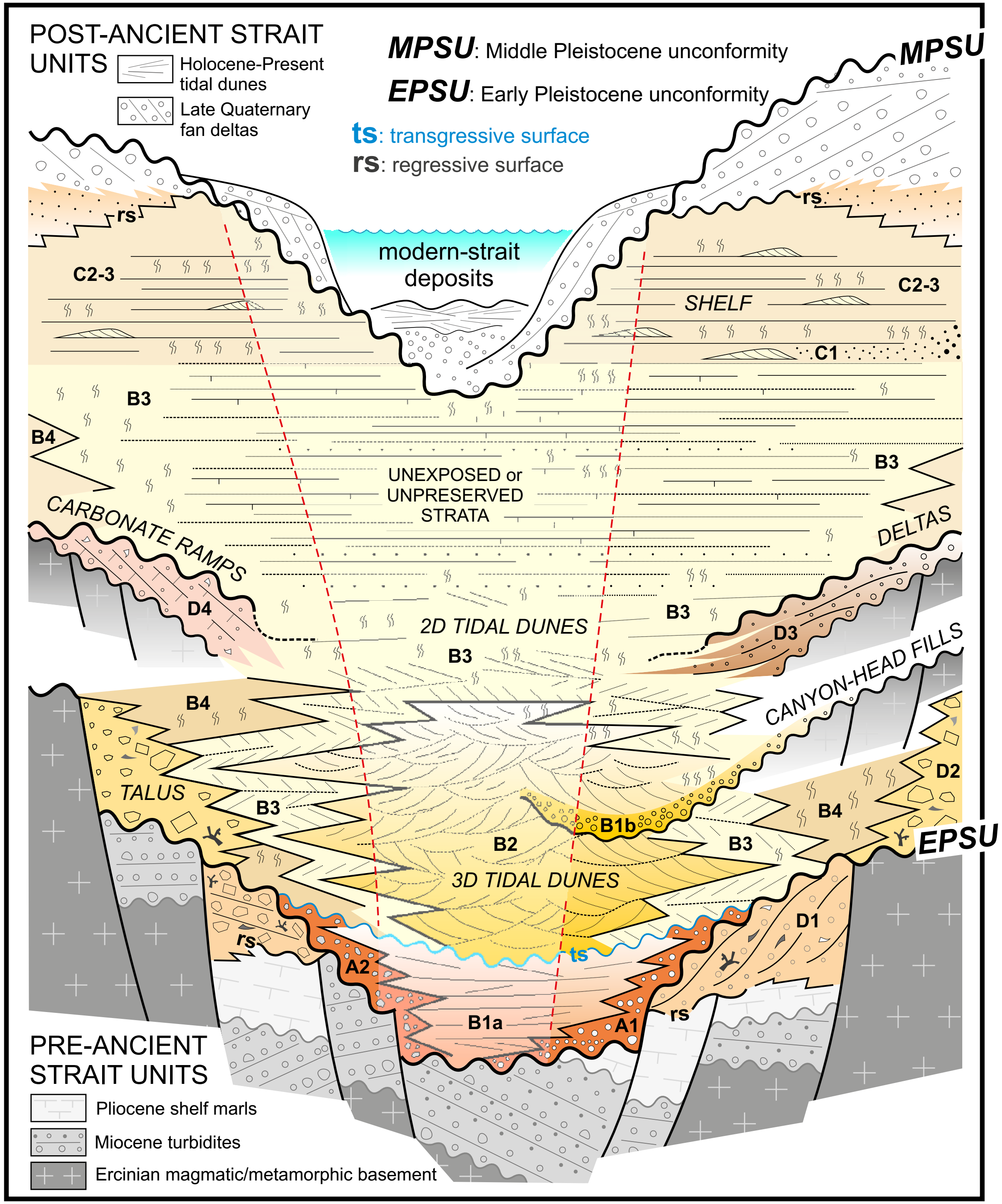

has been envisaged by some authors (e.g. Barrier, 1987b). In contrast, other researchers suggest the emersion of the central sill at the end of the LGM period (ca. 21 ky) and the re-establishment of the oceanographic connection between the Tyrrhenian and the Ionian basins during the ensuing Holocene transgression (Antonioli et al., 2014).

The Lower Pleistocene tidalite-bearing interval

The Lower Pleistocene sedimentary deposits are exposed across the margins of the Messina Strait in a number of stratigraphic sections (Fig. 2), many of which have been investigated by Barrier (1984; 1986), Barrier et al. (1987a,b), Mercier et al. (1987), Di Stefano and Longhitano (2009), Longhitano et al. (2012b), Longhitano (2018b), and Chiarella et al. (2020).
Generally, the infill of the ancient Messina Strait comprises marginal-marine conglomerates and breccias, associated with pebbly sandstones and passing basinwards and upwards to

Fig. 6 - E-W-oriented lithostratigraphic reconstruction showing the various strait-fill units and their reciprocal stratigraphic relationship (see Fig. 7 for facies codes and descriptions) (modified, from Longhitano, 2018b).

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tidal cross-stratified sandstones, mixed arenites and conglomerates, indicating an overall transgressive-to-regressive vertical trend (Figs. 6 and 7). In turn, these deposits are often adjacent with, or overlain by, thinly-bedded shelfal mudstones. Intercalated at different stratigraphic positions, isolated biocalcarenitic complexes reflect the occurrence of carbonate factories adapted to a variety of strait conditions (Figs. 6 and 7).

During this field trip, these sedimentary facies associations are observed and critically compared with those proposed by the depositional model presented for tectonically-confined tidal straits (i.e. Longhitano, 2013) (Fig. 8). Tidal-strait sediment partitioning in modern systems can be defined by the progressive decrease in the tidal-current strength both laterally away from the strait axis and distally as the strait becomes wider at both axial ends (Fig. 8a). Tidal currents converge in the narrowest 'strait-centre zone' where the tidal maxima prevent significant sediment accumulation due to the highest bed shear stress. The stratigraphic expression of this zone is thus an interval of erosion or sediment condensation, transgressively overlain by

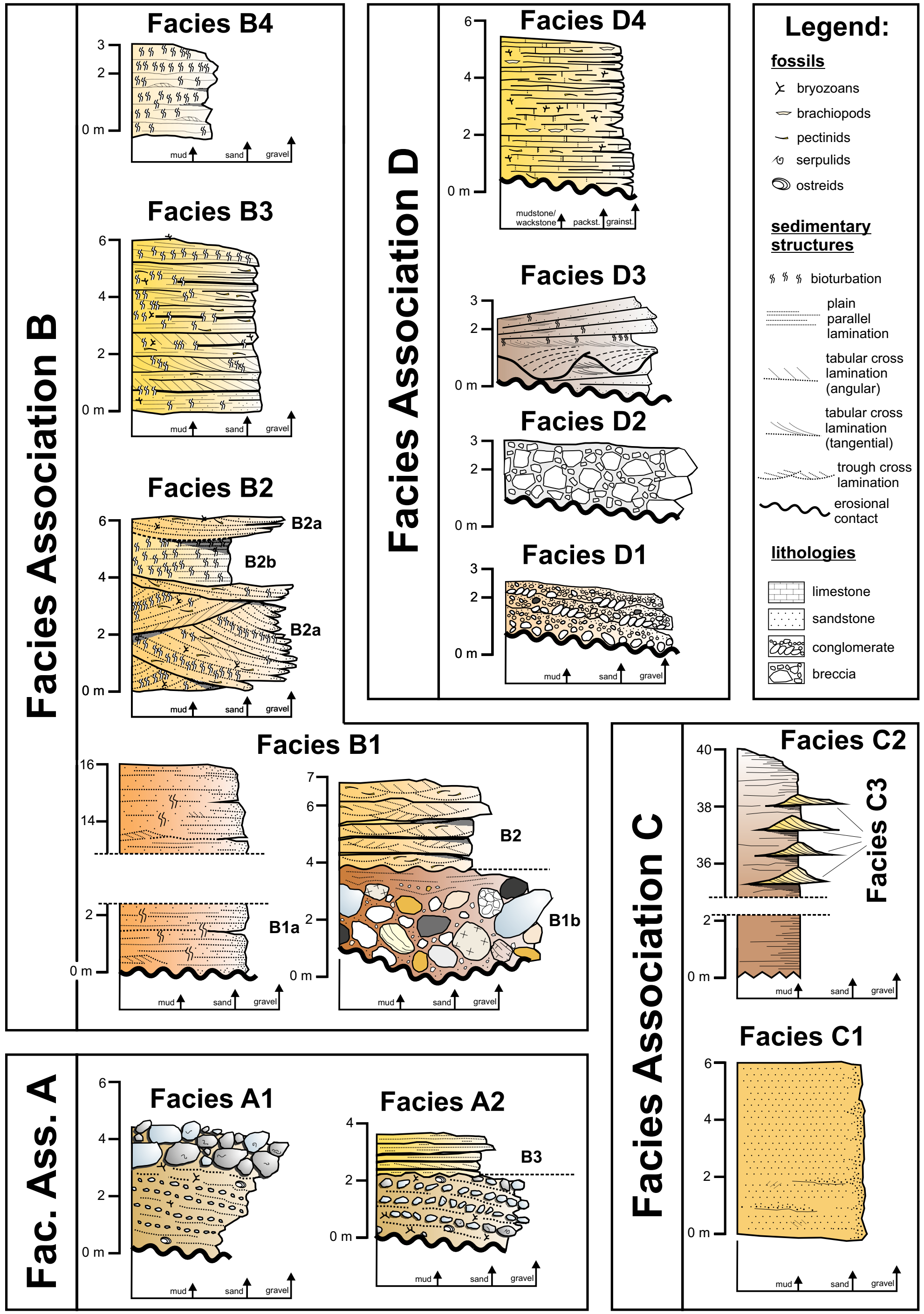

Fig. 7 - Main facies associations represented as 'bed type' observed in the lower Pleistocene deposits filling the ancient Messina Strait. Facies association A: Basal conglomerates, breccias and shelly sandstones; Facies association B: cross-stratified sandstones and mixed arenites; Facies association C: highly-bioturbated and thinly-stratified fine-grained sandstones; Facies association D: Marginal conglomerates, sandstones and carbonates (from Longhitano, 2018b).

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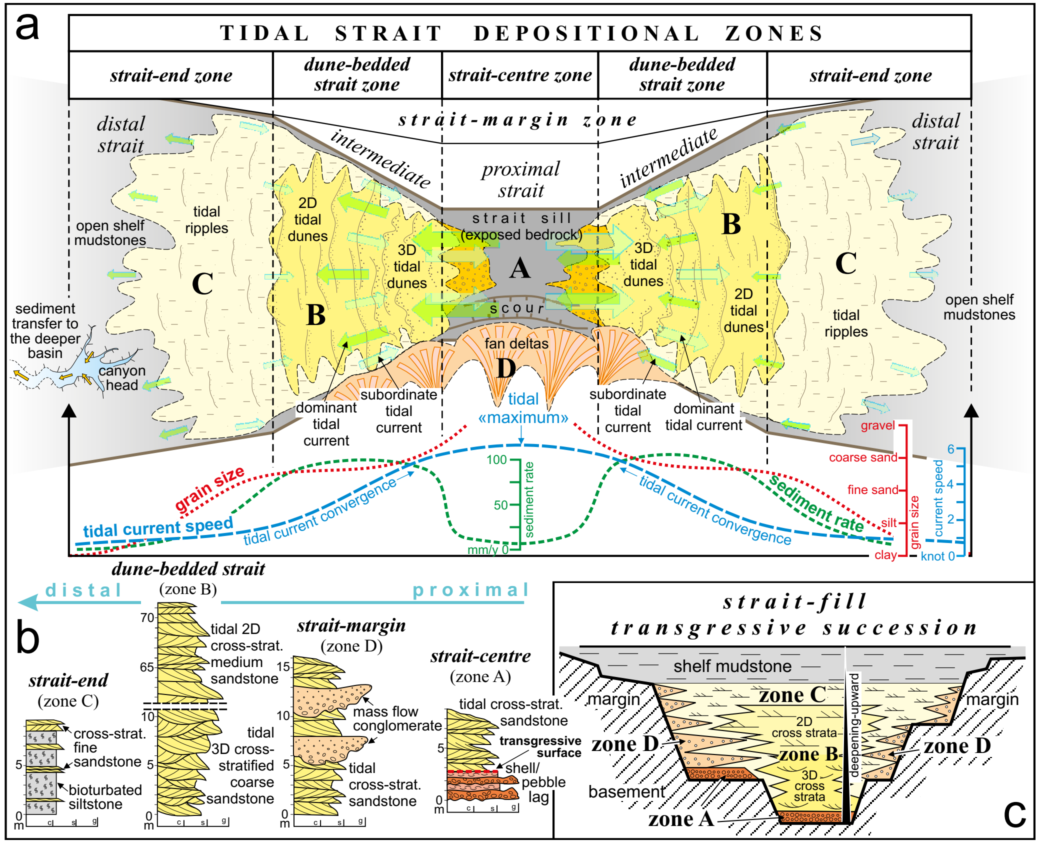

Fig. 8 – (a) Depositional model for tectonically-controlled, tidal straits. The system is partitioned into depositional zones, which are symmetrically distributed with respect to the strait centre (Zone A). Bedforms, sediment grain size and sediment deposition rate vary according to the tidal current strength distribution across the strait. (b) Reference vertical-facies stacks inferred for each depositional strait zone. (c) Idealised cross section across a transgressive strait-fill succession (modified, from Longhitano, 2013).

cross-stratified tidal deposits recording stages of subsequent relative sea-level rise (Stop T1.1.2). In the 'dune-bedded strait zone' (Fig. 8a), tidal dunes change down current from 3D into 2D (Stops T1.2.1 to 2.4), due to a progressive decrease in flow strength, as the strait cross-section enlarges towards the distal 'strait-end zone'. Here, tidal currents slacken, consenting the accumulation of the finest sediment fraction (Fig. 8a). In the modern southern Messina Strait, as in other ones worldwide (e.g. the Cook Strait of New Zealand), this zone is linked to a deep-marine canyon system, which transfers significant clastic volumes towards the deeper basin, preventing substantial sediment accumulation. Diagnostic components of a tidal strait are the 'strait-margin zones', where sediments are wave-worked in gently-sloping strait margins, or accumulate intermittently under tractive and gravity-driven processes in straits with bathymetrically steeper margins. The resulting distinctive facies association is key in identifying the strait boundaries, especially in case of later structural deformations (Fig. 8a) (e.g. Stops T1.1.3, 1.4 and 3.1 to 3.3).

Intermittent phases of structural extension tend to generate strong subsidence and consequent dramatic transgressions, accumulating deepening-upward successions (Fig. 8b, c). Where preserved, transgressive deposits are capped by shelf mudstones (Fig. 8b) or by normal- to forced-regressive coastal deposits, as in the case of the deltaic conglomerates encountered in this field trip (not explicitly represented in the model of Fig. 8c).

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Day 1

The meeting point of this field trip is at the car parking in front of the Lamezia Terme Airport, which is located along the A2 “Mediterranean Motorway”. The airport is connected with many international and domestic flights and is well linked with the closest railway station. Participants are then transferred with minivans to the Messina Strait area, located in the southernmost sector of the Calabria, travelling for a distance of ca. 100 km (1h 20 min). The first stop of the field trip is from a terrace located behind the ‘Villa San Giovanni Ovest’ gasoline station, along the A3 motorway (Stop T1.1.0). This panoramic overview of the modern Messina Strait introduces participants to the area and to the main subject of the excursion. After having travelled for ca. 18 Km southwards, along the final tract of the A2 motorway, the field trip itinerary moves for additional 3,5 km eastwards towards the hinterland of the modern strait, to explore the exposed Quaternary strait-fill succession. The goal of the morning stops is the observation of strait-centre facies accumulated under conditions of tidal maxima along the northern flank of a tectonic horst (i.e. the Pellaro High) (Stops T1.1.1 and T1.1.2). This structural saddle, which separated two main depositional areas of the Messina Strait to the north and south probably acted as a bedload-parting zone as occurs today across the central sill of the modern strait. A series of outcrops also documents the interplay between active tectonics and sedimentation in this central sector of the ancient strait (Stops T1.1.3). In the afternoon, a variety of marginal, mass-wasting facies, accumulated during periods of active faulting are observed (Stop T1.1.4), located less than 2 km north of the outcrops visited during the morning.

Stop T1.1.0. General introduction to the modern Messina Strait and to the field trip itinerary (38°13’43.95”N - 15°38’50.24”E)

Topic: Hydrodynamics and sediment distribution of the modern Messina Strait and observation of some local phenomena of water surface turbulence. As in the other similar sections, a paragraph (space) would be needed, here?

This panoramic viewpoint over the northwestern sector of the Messina Strait (Fig. 9a) introduces participants to the general oceanographic and geological setting of the modern system. The main morphological features of the present-day margins can be seen, together with some occasional singularity of water surface turbulence, related to the tidal currents flowing through the strait and interplaying with surface waves and local winds (Fig. 9b to

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Fig. 9 – (a) A very rare southwestern view of the modern Messina Strait seen from the panoramic Stop T1.1.0, where the descending (north-to-south), ebb-tidal wave front is propagating (arrow). (b to d) Examples of sea-water agitations observable during the various tidal phases acting in the strait.

d). In order to observe the tidal phase running at the moment of the observation, participants are invited to check on their smartphones or tablets the state of the currents at the link: http://www.correntidellostretto.it/. The understanding of the present-day features of the Messina Strait is key for the interpretation of the sedimentary facies that participants are going to visit during the field trip.

Stop T1.1.1. Introduction to the general geology of the area and the ancient Messina Strait (38° 2’49.58”N – 15°41’41.49”E)

Topic: Quaternary tectonic lineaments and general Neogene-to-Quaternary stratigraphy.

Stop T1.1.1 (Fig. 10a) faces the southern flank of an E-W-striking hill between the villages of Oliveto and Croce Valanidi (Fig. 11a), which exposes Lower Pleistocene strata lying on an angular unconformity over the underlying tectonically-inclined Miocene turbidites (Fig. 11b). This section helps attendees to get acquainted with the general geological setting of the area, with special emphasis on the structural lineaments active during the Plio-Quaternary and responsible for the morpho-tectonic shaping of the ancient strait. Faults also promoted the uplift of the central Pellaro High (Fig. 10a), which divided the two principal depositional areas to the north and south, at that time. From this stop, the northern flank of this tectonic horst can be observed and the relationships between the substrate units and the strait-fill succession can be discussed preliminary.

Stop T1.1.2. Strait-centre facies: sediment by-pass and ensuing transgression (38° 3’8.09”N – 15°42’23.45”E)

Topic: Sedimentary features of strait-centre facies and their relationships with the basement and adjacent/overlying strait-fill deposits

Lower Pleistocene strait-centre deposits result from the entrapment of coarse-grained sediments within morpho-bathymetric irregularities that characterised the strait-centre bottom at that time. This sector received detrital sediments derived from subaerial erosion of cliffs, exposed fault scarps and ephemeral beaches, mixed with residual deposits deriving from subaqueous incision of bare basement units intensely swept by strong tidal currents. Analogous detrital facies have been observed in the modern strait-centre sill, where bathymetric lows comprised between local highs preserve an entrapped mixture of coarse-grained pebble and cobble-

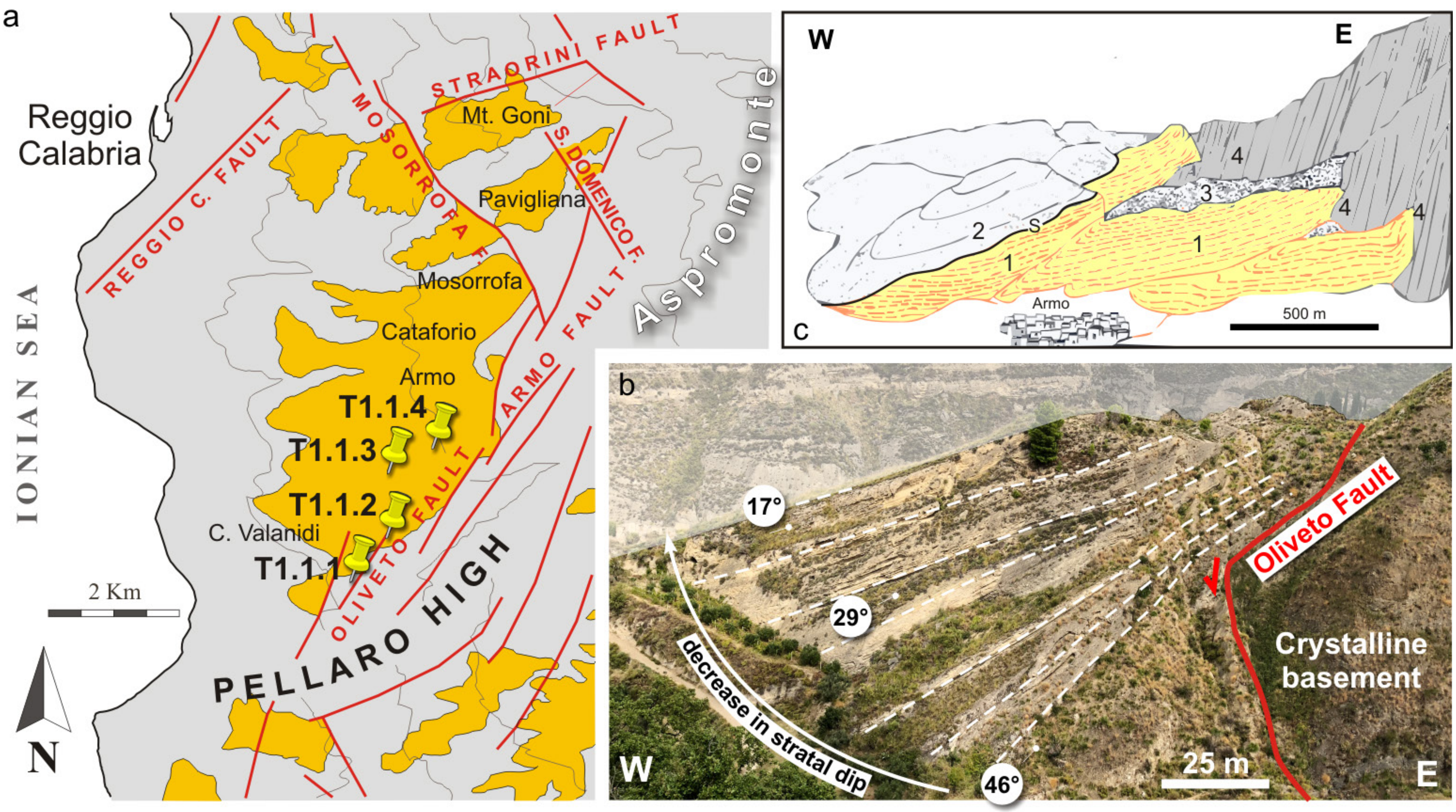

Fig. 10 – Location of the stops of Day 1. From south to north, facies are distributed along the inferred down-current direction of the tidal palaeoflows dominating over this depositional side of the Messina Strait. The tectonic horst coinciding with the Pellaro High presumably acted as 'bed-load parting zone' in the ancient strait. (b) Detail of the section observed from the panoramic Stop T1.1.2 and (c) from the Stop T1.1.4. Here, large-scale truncation and associated mass-wasting deposits related to the Armo Fault can be seen (S = truncation surface; 1 = mixed arenites; 2 = Pozzi sands; 3 = colluvium; 4 = crystalline basement (modified, after Barrier et al., 1987b).

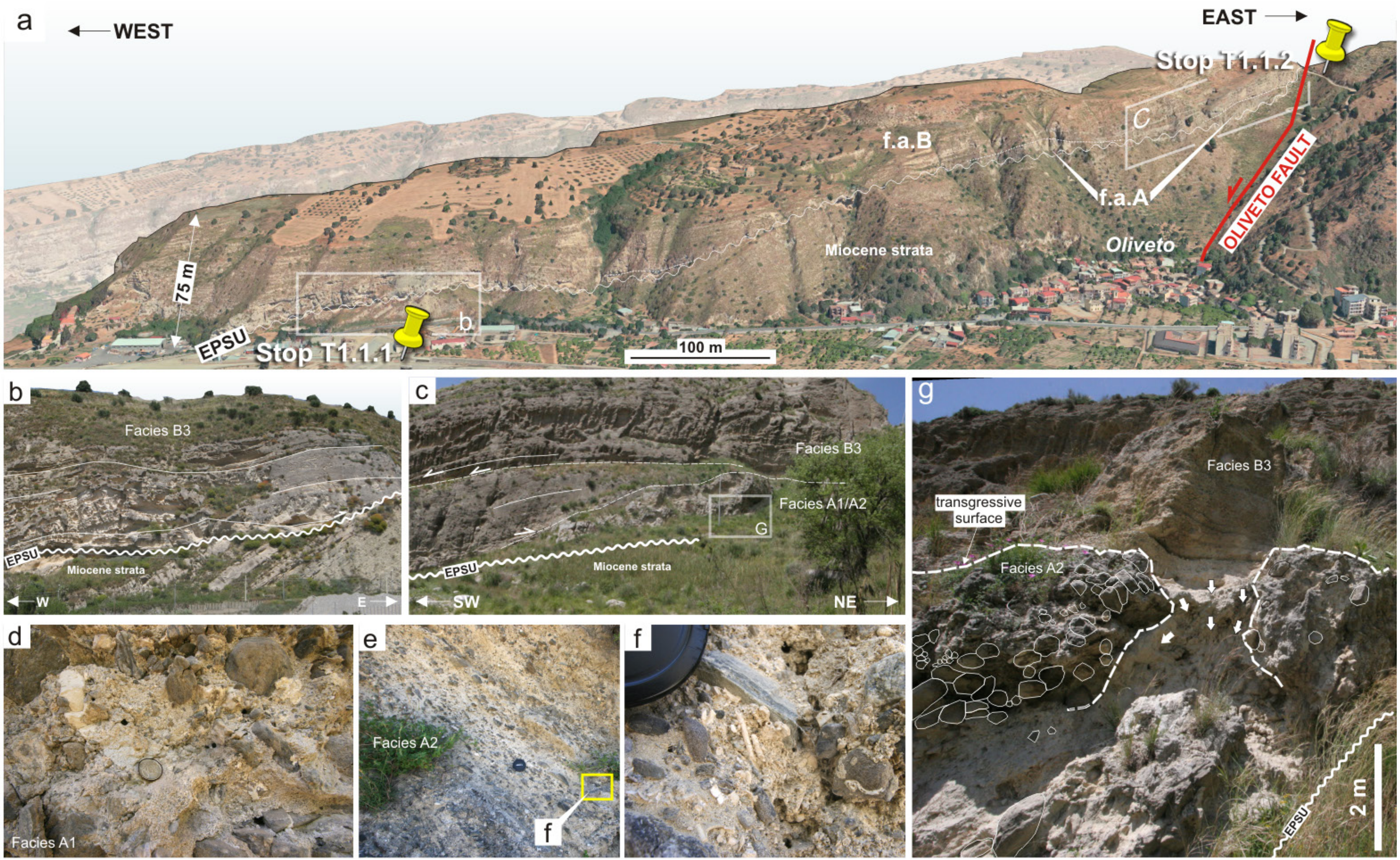

Fig. 11 – (a) Outcrop view of the section comprised between Stops T1.1.1 and 1.2. (d) Basal unconformity EPSU separating the overlying strait-fill deposits from the underlying Miocene substrate. (c) Detail of the lithofacies observable at the very base of the strait-fill succession. (d to f) Close-up outcrop photographs of coarse-grained basal deposits filling local scours in the substrate. (g) Neptunian dike observable close to Stop T1.1.2.

size elements (Antonioli et al., 2014). In this stop, lowermost pebble conglomerates form 10-20 m-wide and 4-5-m-deep lenses filling pre-existing scours on the substrate (Fig. 11c). Pebbles are monomictic and oligomictic, comprising mollusc, coral and bryozoan fragments (Fig. 11d). Common attributes of these repeated layers are their overall textural immaturity and their matrix-supported character, with abundant coarse-grained carbonate matrix (Facies A1 in Fig. 7). Other layers are less rich in matrix and show indistinct internal stratification due to pebble alignment and grain-size breaks (Facies A2 in Fig. 7). Clasts, up to 25 cm in diametre (Fig. 11e), are diffusely encrusted by serpulids associated with large (up to 3 cm long) branching bryozoans (Fig. 11f). Pebble imbrication infers palaeocurrent directions towards N-NW and away from the Pellaro High. This facies assemblage is transgressively overlain by sets of tabular cross-stratified mixed arenites of facies association B, forming an aggrading succession up to 75 m thick (Fig. 11a). These deposits locally fill 1-2 m-deep fractures in the underlying conglomerates, forming neptunian dykes (Fig. 11g). The top of the hill where these facies can be observed in detail also offers a panoramic overview of an outcrop exposing a stratigraphic section oriented perpendicularly or at high angle with respect to the palaeomargin of this central sector of the ancient strait (Fig. 10b), and which is the subject of the next stop.

Stop T1.1.3. Base-of-scarp deposits, subaqueous canyon infill and large-scale supercritical-flow bedforms (38° 3’16.57”N - 15°42’23.24”E)

Topic: Example of base-of-scarp deposits representing the embryonal stage of a system adjacent to the tectonically controlled central-eastern margin and large-scale supercritical-flow canyon-fill structures.

The Oliveto Fault, a SW-NE-striking normal structure dipping towards the strait axis and active during the Pleistocene (Fig. 10a), controlled the steep morphology of the central-eastern flank of the ancient strait. As a result, the sublittoral strait zone was a steep, 4-5°-dipping slope, rapidly descending towards the deeper strait and characterised by phenomena of subaqueous instability (Chiarella et al., 2020). The shallow-water sublittoral zones of the modern strait offer formidable present-day analogues useful for reconstructing the palaeoenvironmental setting that characterised this part of the ancient strait. Many subaqueous fault-controlled scarps host basal chaotic deposits, whereas a number of gullies and canyons descend towards the strait axis, with their heads rapidly receding and indenting the more proximal and shallower sector of the modern strait (e.g. Casalbore et al., 2014; 2019) (see Fig. 2).

This stop offers the rare opportunity to observe the architectural and textural features of a 'base-of-scarp' deposit (cf. Chiarella et al., 2020), which lies adjacent to the Oliveto Fault plane and whose immature basal facies evolve rapidly, and through a series of angular internal discontinuities progressively less inclined upwards, to shallow-water wave-worked deposits (Fig. 10b). A second section shows a series of cross-cutting erosional surfaces filled by immature conglomerate, breccia and pebbly sandstone deposit exhibiting large-scale, upslope migrating backsets. These features form an outcrop laterally continuous for more than 100 m and 60-70 m-thick. It is retained to represent the cross-sectional view of a magnificent example of a subaqueous canyon system, descending from the tectonically-active flank shaped by the Oliveto Fault zone. The canyon was filled by supercritical-flow bedforms deposited by density currents affected by flow instability and repeated hydraulic jumps as they attained high propagation velocities down the subaqueous slope (e.g. Cartigny et al., 2014; Slootman et al., 2019).

Stop T1.1.4. Large-scale instability processes along the eastern margin of the ancient strait (38° 4'22.23"N – 15°43'2.04"E)

Topic: Large-scale discontinuity at the top of cross-stratified mixed bioclastic-siliciclastic arenites and associated sediments.

Large-scale subaqueous truncation surfaces are common along the central-eastern margin of the ancient Messina Strait, tectonically controlled by the Armo Fault, which is the north-eastern continuation of the Oliveto Fault seen in the previous stops (Fig. 10a). This extensional structure is composed of a series of minor faults, which may have been characterised by significant cumulative vertical displacement (several hundreds of metres) during the Pleistocene. Large-scale stratigraphic discontinuities can be observed closely linked to the Armo Fault. Their horizontal extension is of the same order of magnitude as that of the volume of mass-wasting deposits involved. An outstanding example is the truncation visible near Armo (Fig. 10c), over which a mass-wasting deposit extends for over 10 km^2. The spatial location of the truncations is not fortuitous. These "spoon" ablation surfaces are established on a series of tilted blocks located below and in the immediate vicinity of major faults, often at the interception of major structures (Fig. 12a). The large and often abrupt bathymetric jumps recorded at such surfaces are a direct consequence of the displacement exerted by these faults (Fig. 12b, c), which probably triggered repeated collapses of the footwall compartment and local sediment instability (Barrier et al., 1987b).

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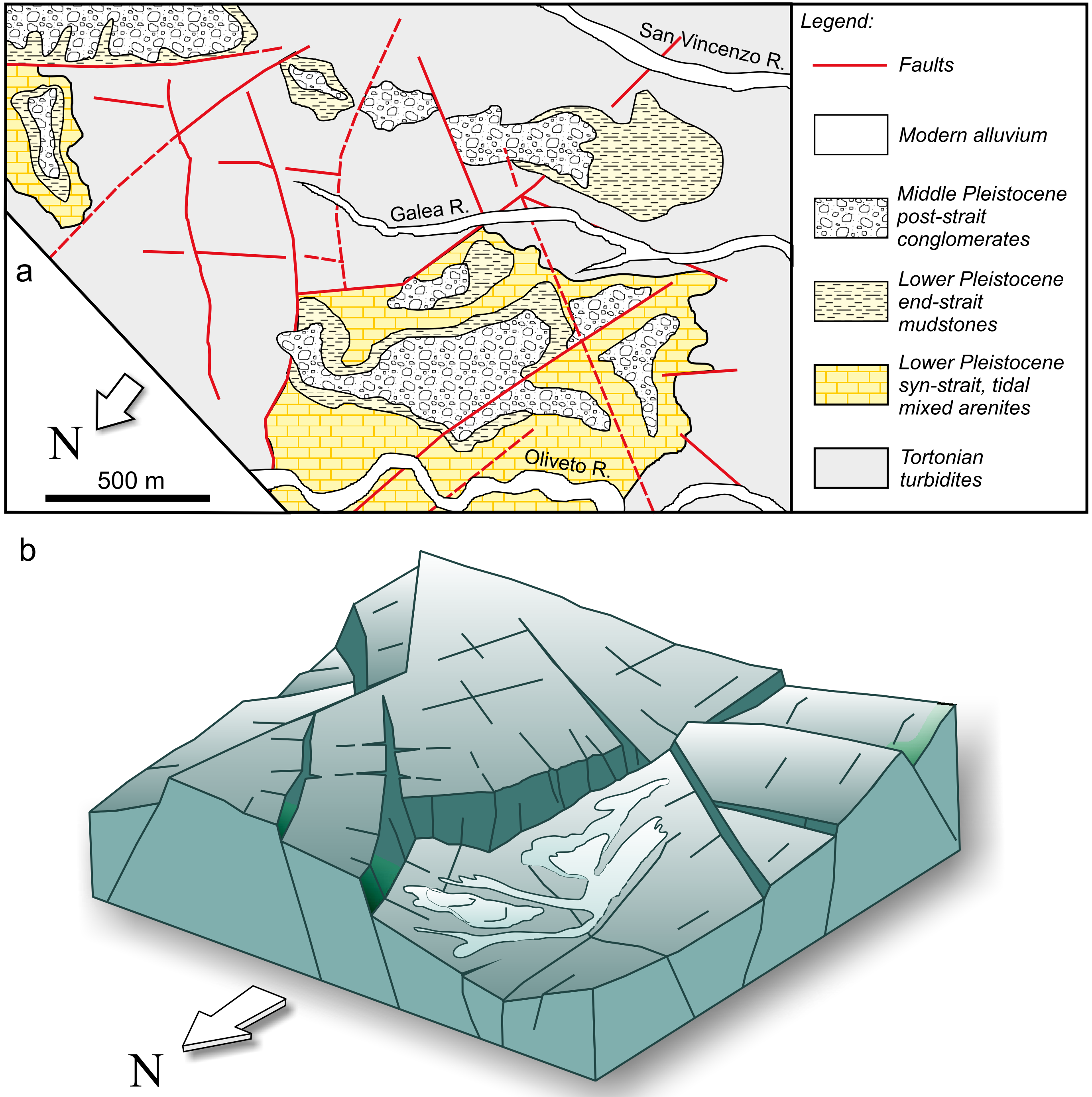

Fig. 12 – (a) Geological sketch-map of the area around Pozzi showing the orientation of the main normal faults active during the sedimentation of strait-margin deposits. (b) Block model reconstructed for the same marginal sector (redrawn, after Barrier et al., 1987b).

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Day 2

Day 2 is dedicated to the observation of sedimentary deposits interpreted as the record of the northern dune-bedded strait zone of the ancient Messina Strait and its vertical facies stacking describing the stratigraphic evolution of this zone. Tidal currents were dominantly NW and WNW-directed, as suggested by thick tidal foresets, with a SSW-directed subordinate phase (Stops T1.2.1 to 2.3 in Fig. 13a). They reflect flood and ebb tidal phase currents governing the ancient strait, analogous to those active in the present-day passage. In the modern Messina Strait, tidal currents attain mostly a semi-diurnal (M2) tidal cyclicity with current velocities ranging from 0.5 to 1.5 m sec^{-2} in velocity (Bignami and Sallusti, 1990). Based on the position with respect to the two depositional areas of the strait, one tidal phase dominates over the opposite one, so that in the northern zone of the strait the flood component prevails over the ebb tidal component, and *vice versa* in the southern zone (Longhitano, 2018a; Longhitano and Chiarella, 2020). This hydrodynamic setting probably governed also the oceanography of the ancient strait, as tidal asymmetry is reflected by the mutual size diversity observed in the cross-beds exhibiting reversals in foreset dips, indicating changing directions of migration (Longhitano, 2018b). The largest cross beds (visible at the Stop T1.2.4 in Fig. 13a), up to 5 m-thick and dipping N-NW-wards, record the dominant tidal phase, whereas the superimposed smallest foresets, up to 0.3 m-thick and usually oriented at high angle with respect to the underlying largest ones, reflect the subordinate tidal phase (Longhitano and Chiarella, 2020). Cross-stratification is interpreted to be the basic structure resulting from large compound dunes. During the various stops, a variety of tidal sedimentary structures, regarded as 'tidal indicators', are observed in sand and mixed arenitic strata of various geometry and scale.

Stop T1.2.1. Vertically-stacked tabular cross stratification in mixed bioclastic-siliciclastic arenites (38° 5'20.31"N - 15°42'41.10"E)

Topic: Introduction to the depositional setting of the northern dune-bedded zone of the ancient Messina Strait and general characteristics of distinctive tidal cross-stratification.

This first stop of the day (Fig. 13a) allows attendees to observe tabular cross-stratification, cross-cut by undulating master surfaces (1st-order discontinuities) and comprising angular to tangential foresets indicating a dominant direction of migration towards N-NW (Fig. 13b). Strata form a ca. 25 m-thick cross-stratified complex

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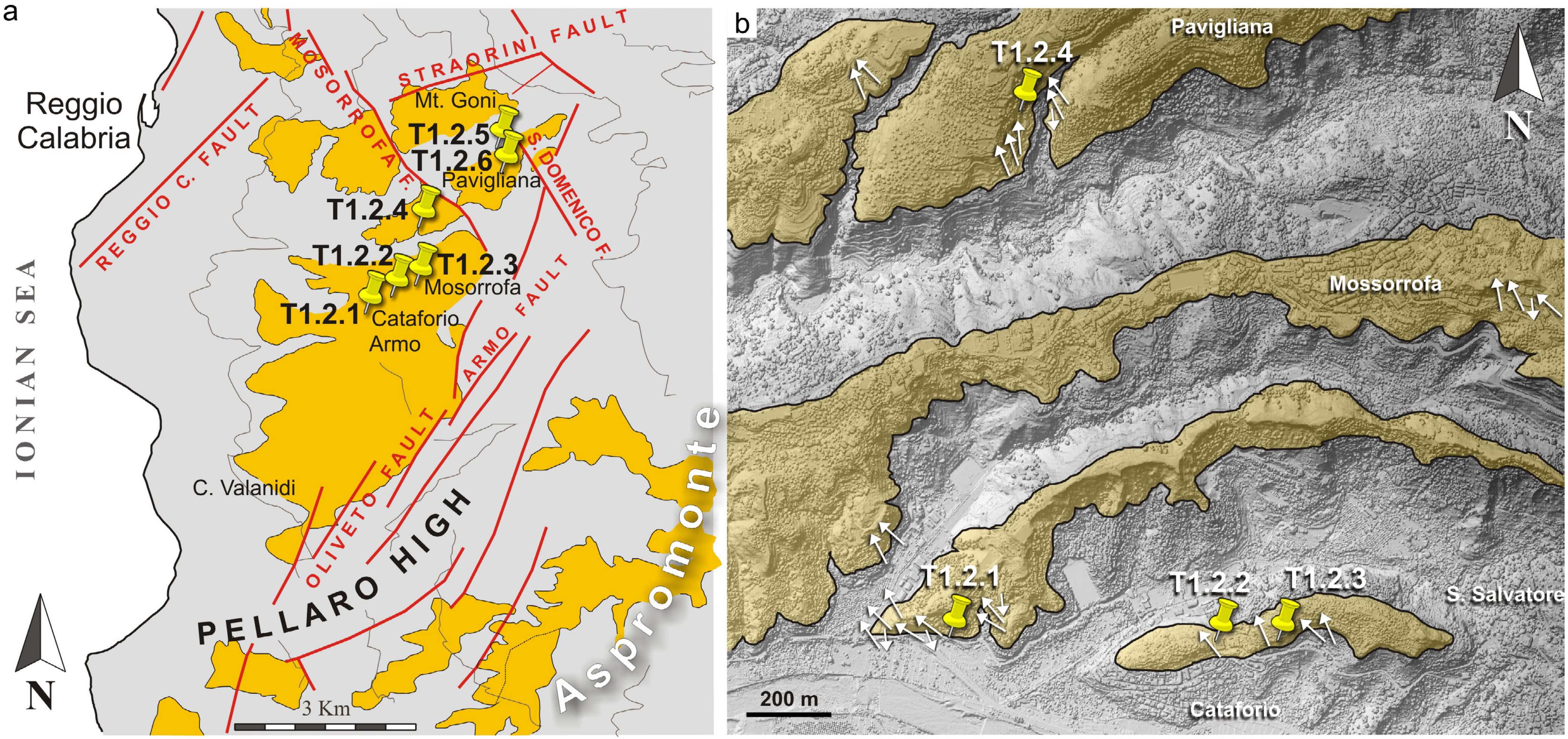

Fig. 13 – (a) Locations of the stops of Day 2. Stops are positioned within the northern depositional area (i.e. the dune-bedded zone) of the ancient Messina Strait. (b) Digital Terrain Model (DTM) of the zone including the stops showing the present-day distribution of mixed bioclastic-siliciclastic arenitic cross-stratified deposits, presumably coinciding with the perimetre of large dunes migrating towards NW and WNW (white arrows indicate palaeocurrent directions). The sections allow observing small-scale internal features of these large bedforms.

(Fig. 14) interpreted as the intermediate segment of a larger dune field. Post-depositional normal faulting affecting the succession keeps these facies in contact with the underlying deposits, interpreted as high-energy facies filling local depocentres and including parting lineations and 'humpback' dunes.

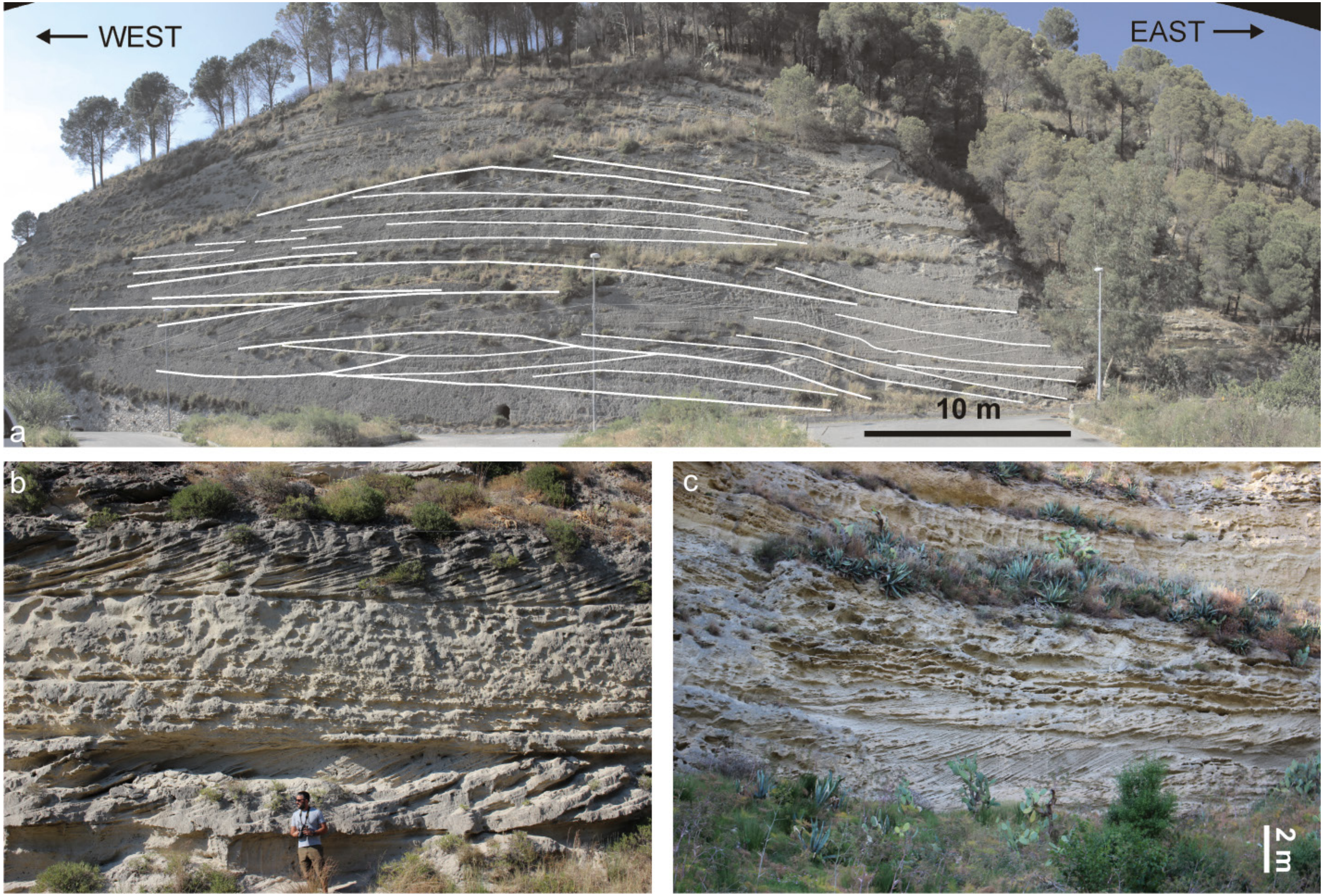

Fig. 14 – (a) Outcrop showing a complex of cross-stratified mixed sandstones and arenites along the road to Cataforio (Stop T1.2.1). Foresets indicate a palaeocurrent direction oriented towards N-NW (approximatively perpendicular to the section). (b and c) Details from the photograph in a).

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Stop T1.2.2. Architectural elements and internal basic features of individual tidal sand dunes (38° 5’20.06”N – 15°43’9.54”E)

Topics: Individual tabular-based cross beds indicating straight-crested dunes with lamina-scale examples of bioclastic-siliciclastic segregation and reactivation surfaces.

This small outcrop (Fig. 15a) shows an example of a tabular cross-stratification, including individual beds up to 1.2 m-thick and comprising tangential laminasets, separated by reactivation surfaces. Internally, foresets exhibit a certain degree of segregation between siliciclastic and bioclastic particles, possibly due to a hydrodynamic process of grain segregation by density, shape and weight (Longhitano, 2011; Chiarella and Longhitano, 2012). Adjacent to this outcrop, a private road allows a panoramic overview on part of a dune-bedded complex, revealing large-scale depositional architectures, characters of the main stratigraphic discontinuities (internal and master surfaces) and the general features of the overlying deposits. The latter are thought to have recorded the cessation of the tidal dominance in the ancient Messina Strait at the beginning of the Middle Pleistocene (Longhitano, 2018b; Chiarella et al., 2020).

Stop T1.2.3. (38° 5’19.63”N – 15°43’17.32”E)

Topics: Example of compound cross-stratification with internal reactivation surfaces, reversal foresets and tidal bundles

This stop shows strata-scale internal features of foresets similar to those observed at the previous stop. Facies B2 includes single sets or cosets ranging in thickness from a few decimetres up to some metres (Fig. 15b). Internal erosional surfaces (2nd-order discontinuity) are concave-up, forming scours up to 2 m-deep and 10-12 m-wide. Single cross-strata exhibit concave erosional bases and tops (3rd order) forming trough-cross stratification. Internally, they preserve angular and tangential foreset laminae, revealing simple and compound architectures. These latter include reactivation surfaces and pause planes (Fig. 15b). In places, systematic thickening/coarsening and thinning/fining trends of the inclined lamina-sets define ‘tidal bundles’ locally separated by reactivation surfaces (4th order). In turn, tidal bundles include lamina rhythmites of segregated bioclastic and siliciclastic particles (Longhitano, 2011; Longhitano et al., 2012a). Bioturbation occurs diffusely as discrete intervals through foreset laminae corresponding to neap tidal phases, during the activity of weaker currents (Longhitano et al., 2012a). Cross-beds are part of a vertically-stacked facies

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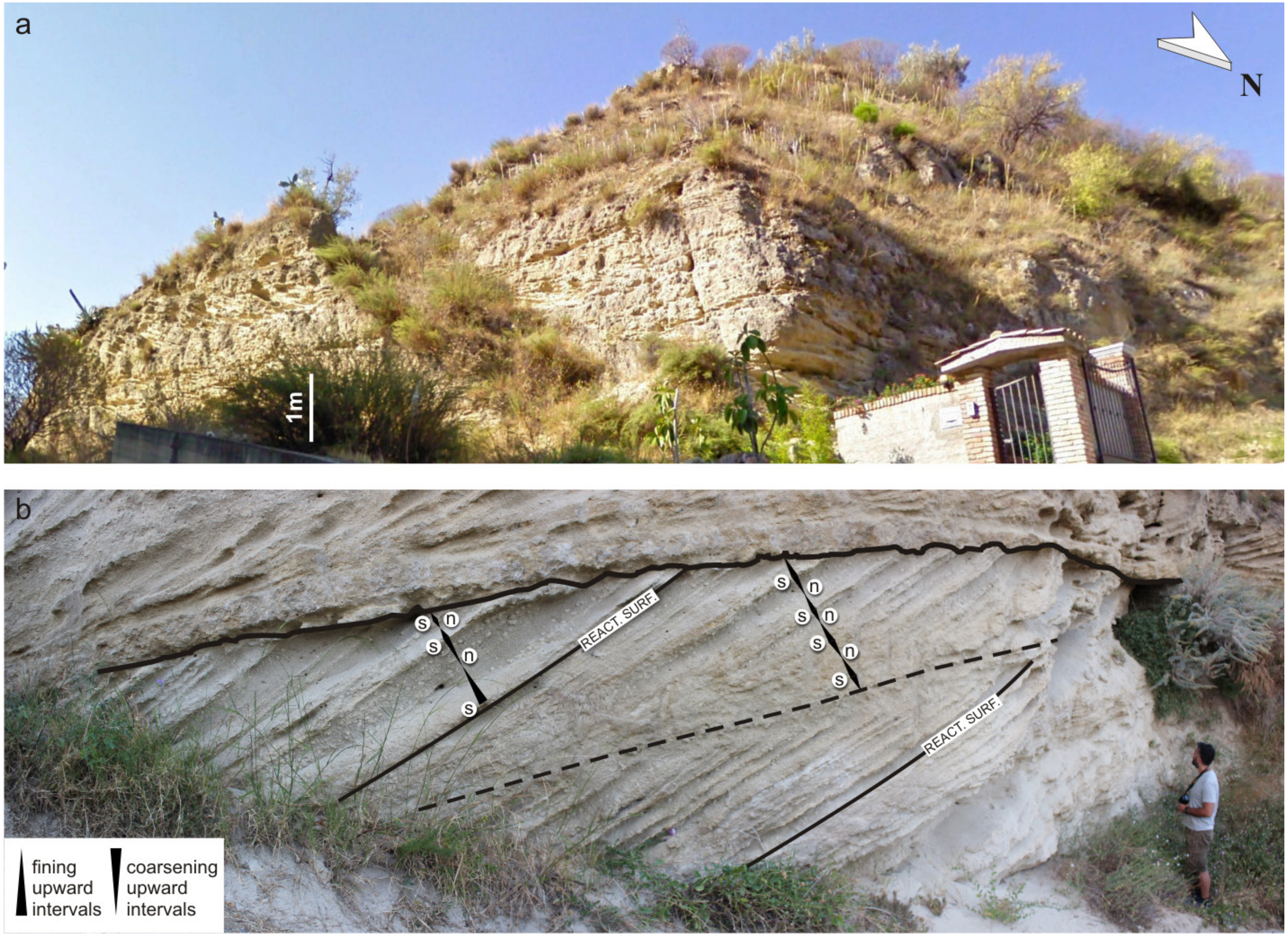

Fig. 15 – (a) Outcrop visible at Stop T1.2.2. (b) Simple and compound cross stratification alternating siliciclastic- and bioclastic-rich foreset intervals. Black arrows indicate alternating fining- and coarsening-upward trends possibly recording spring (s) and neap (n) tidal cycles. These latter are intensely bioturbated. Foresets are interrupted by a major reactivation surface (Stop T1.2.3).

Fig. 16 – (a) Example of tabular (or planar-based) cross bed. (b) Vertical superimposition of lithofacies (B1 to B4) observable close to Stop T1.2.3.

pattern composed of basal upper-stage plane beds, trough and planar cross-beds (Fig. 16a) and non-tidal fine-grained sandstones and mudstones at the very top (Fig. 16b)

Stop T1.2.4. (38° 6'1.26"N – 15°42'51.38"E)

Topics: Vertically-stacked facies recording the stratigraphic evolution of the Messina Strait during the Early Pleistocene

North of the previously observed sections (Stops T1.2.1 – 2.3), a ca. 80 m-thick succession is exposed near Pavigliana. Here, all the facies of the association B can be observed vertically stacked (Fig. 17a). From base to top, these comprise basal conglomerates (Facies B1), trough cross-stratified mixed arenites (Facies B2), tabular cross-stratified mixed arenites (Facies B3) and thinly-stratified calcareous fine-grained sandstones and mudstones (Facies B4). The section allows the observation of large-scale, 3.4 m-thick trough cross-beds (Fig. 17b) recording sinuous-crested dunes migrating under the influence of the flood-tidal component dominating this depositional sector of the strait. Internally, foresets exhibit reactivation surfaces (detectable using internal downlap lamina geometries; Fig. 17c) and, in places, thinner, 20-30 cm-thick reversal foresets pointing towards SSE. Sediments comprise large macrofossils including fragments of balanids (Fig. 17d) and branching bryozoans (Fig. 17e).

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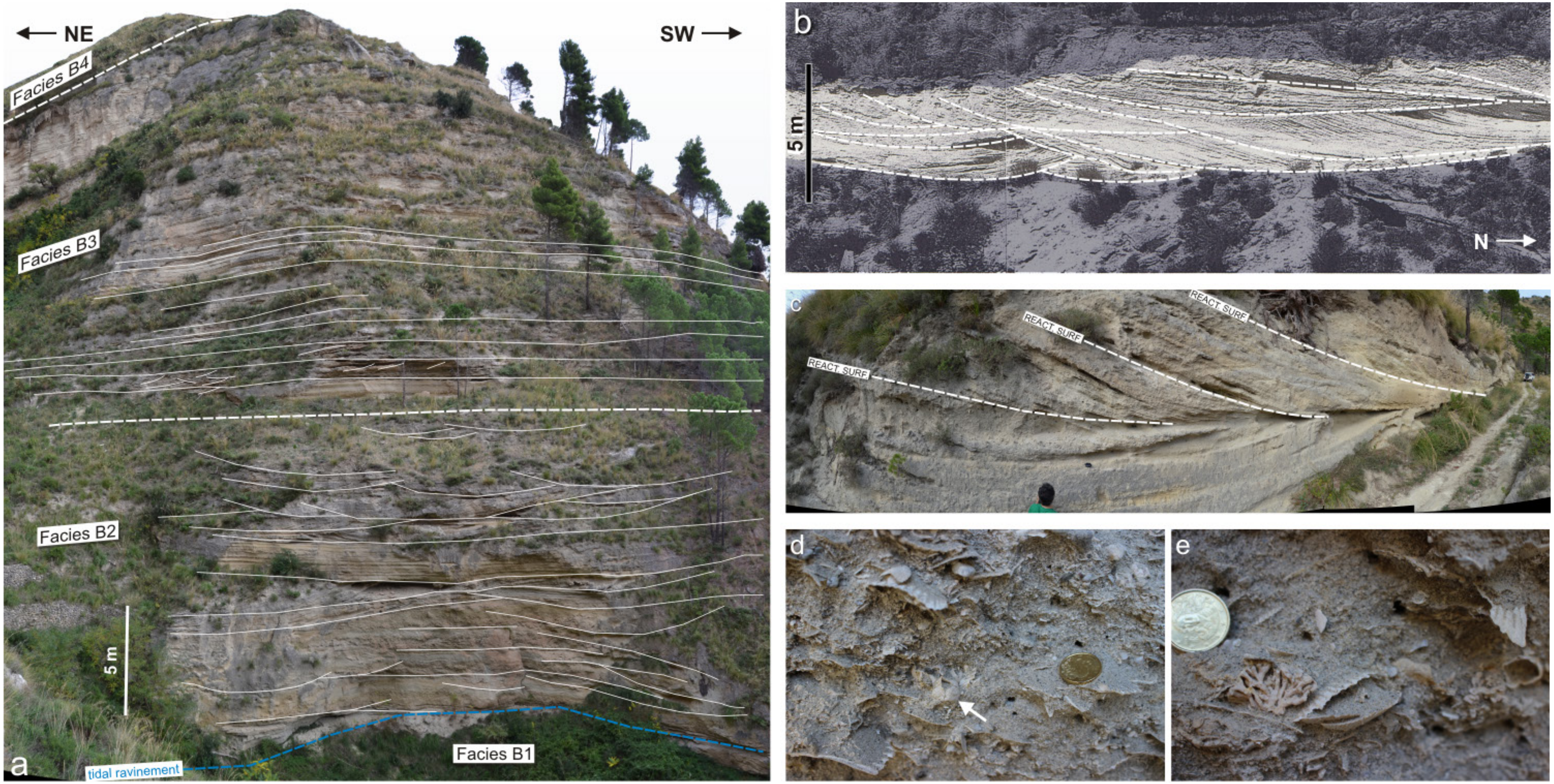

Fig. 17 - (a) Vertical stacking of Facies B1 to B4 in the Pavigliana section. Note the abrupt upward change from trough-cross strata (B2) to tabular cross strata and plain-parallel strata (B3), sealed on top by bioturbated structureless mudstone (B4) (modified, from Longhitano, 2018b). (b) Large scale trough-cross stratification (modified, from Barrier et al., 1987), with tangential foresets and (c) including reactivation surfaces. (d) Textural details of Facies B2, showing fragments of pectinids and of a balanus shell (arrow) (coin is 2 cm in diametre). (e) Molluscs with partly-articulated valves frequently coexist with branching bryozoans.

Stop T1.2.5. (38° 6’51.81”N – 15°43’56.98”E)

Topics: Panoramic view over the Monte Goni section (to the north), showing the thickness of the cross stratified succession and the discontinuity with the underlying deposits.

A panoramic overview of the rest of the northern depositional area of the ancient Messina Strait is possible from the top of the Pavigliana hill (Fig. 18a). Here, the lateral extension of the sand bodies preserved in the frontal hill of Mount Goni can be appreciated, as well as the overall geological setting of the present-day area (Fig. 18b).

Stop 2.6. (38° 6’36.95”N – 15°43’33.08”E)

Topics: Final panoramic stop over the southern Messina Strait and reconstruction of the sublittoral depositional setting.

The final stop of Day 2 offers a southern overview over the eastern border of the ancient Messina Strait. The present-day terraced landscape of the margin helps to envisage the subaqueous morphology of the faulted palaeomargin, reproducing different bathymetric conditions in adjacent environments and related sedimentary sub-environments.

Day 3

The morning of the third and final day of this field trip (in the afternoon participants depart to Matera) is focused on the observation of an example of a strait-margin succession magnificently exposed around the hills near Calanna, a small village located in the north-eastern sector of the Calabrian side of the area (Fig. 19a). The outcrops are distributed along two main sections including deposits belonging *p.p.* to facies associations B and D (Fig. 7). Marginal-marine coarse-grained siliciclastic deposits intercalate with cross-stratified mixed arenites, back-stepping onto the block-faulted basement forming the palaeoflanks of the ancient strait (Fig. 19a). The section is first observed from a panoramic viewpoint, located next to the ruins of an ancient castle (Fig. 19b). The castle of Calanna is a fortification dating back to the Norman period. The castle stands on a pre-existing Byzantine fortress, even if there are studies that attest human presence in the area already during the Iron Age. The castle was almost completely destroyed by a strong earthquake in 1783. From this vantage point

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Fig. 18 – (a) Southern view of Mount Goni. The road cut roughly corresponds with the basal boundary of the tidal succession here forming a large-scale individual bedform. The section is WSW-ENE oriented and it is ca. 2.5 km long. (b) Panoramic overview on the modern Messina Strait as seen from the Calabrian side.

(T1.3.1), the large-scale depositional architectures and master bedding of pebbly sandstones and conglomerates can be appreciated. Subsequently, participants are guided along the main road that exposes the outcrops in different cuts parallel and perpendicular to the palaeoslope direction (Fig. 19c), offering a three-dimensional perspective on bedding geometries and facies details, from the base of the succession (Stop T1.3.2) to the top (Stop T1.3.3). At the end of the morning and during the lunch break in a nearby wooded area, all the major subjects and critical discussion points of the field trip are summarised. All the reconstructed environments and processes are discussed also in the framework of what we observe nowadays in the modern analogue system, together with a critical synthesis of major still unknown aspects of the sedimentary dynamics of tidal straits.

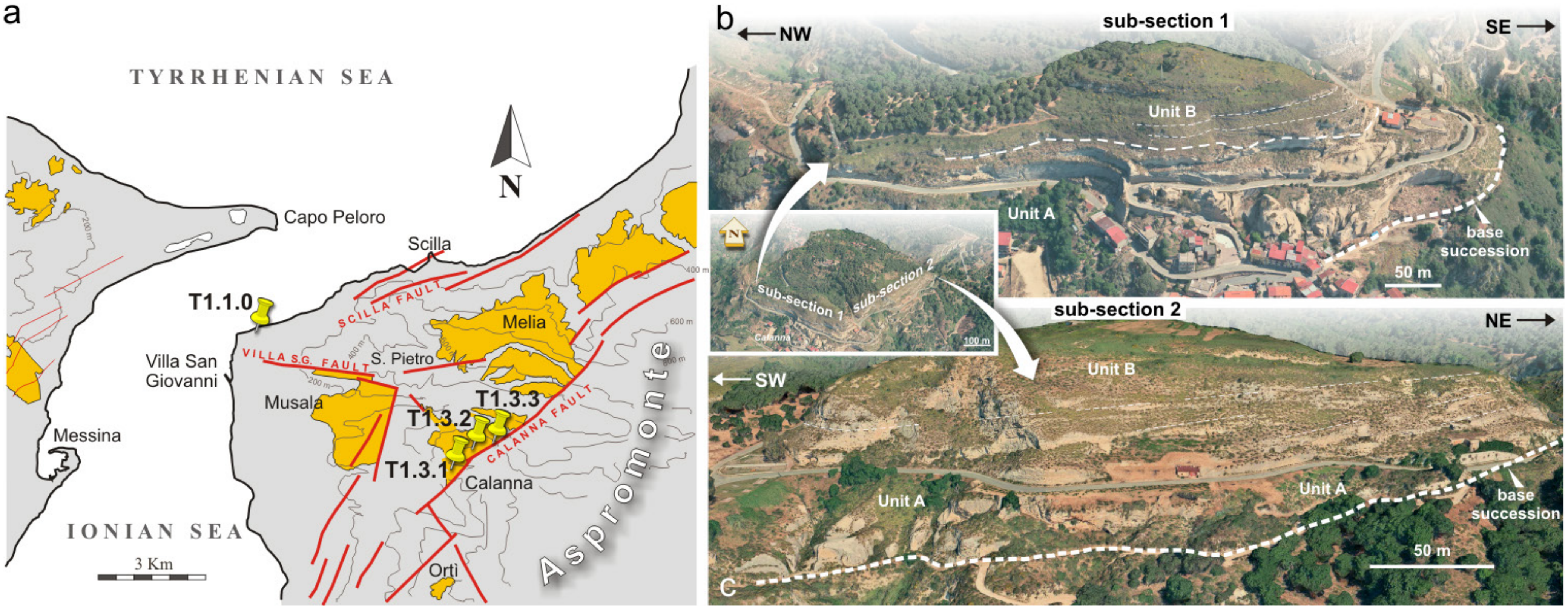

Fig. 19 – The stops of Day 3 are all focused on the observation of the Calanna section recording strait-margin deposits. (b and c) Drone photograph of the two outcrops composing the Calanna Section.

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Stop T1.3.1 (38°11'4.82"N – 15°43'23.05"E)

Topics: Panoramic view over the Calanna section (to the north), showing the general stratigraphic architectures, lithostratigraphic features and the structural setting of the area.

The Calanna Section is considered among the most spectacular outcrops of the Calabrian side of the Messina Strait (Fig. 19b, c). The succession, already documented by Barrier (1987), Mercier et al. (1987) and more recently by Longhitano (2016; 2018b) and Longhitano et al. (in press) consists of two main lithostratigraphic units A and B, separated by an extensive discontinuity (Fig. 19b, c). Unit A includes lower pebbly sandstones, conglomerates and breccia, exhibiting complex motifs of channel-form discontinuities and up-slope dipping backsets. These specific structures, which are diffusely observable as cross-cutting and vertically/laterally stacked channel-fills in the Unit A, are interpreted as cyclic steps and antidunes (Longhitano, 2016; Longhitano et al., in press). Overlying Unit B comprises trough and planar cross-stratified, mixed siliciclastic-bioclastic arenites, indicating bedforms migrating roughly parallel to the palaeocoastline, driven by tidal currents amplified by the narrowing of the ancient Messina Strait (Longhitano et al., 2012b; Longhitano, 2018b).

Stop T1.3.2 (38°11'12.65"N – 15°43'32.74"E)

Topics: Observation of three-dimensional physical features of large-scale supercritical-flow bedforms.

Along the roadcut that incises the section three-dimensionally, the complex geometry of the master erosional can be appreciated (Fig. 20a to d). This stop allows the detailed observations of the basal facies (D1 and D2) as well as channel-fill deposits (D3) exhibiting indistinct foreset architectures migrating dominantly up-slope (Fig. 20c, d). Sediments consist of coarse-grained sandstones, including scattered pebbles and fragments of molluscs and other undetermined marine fossils in a generally immature textural framework. These deposits suggest rapid deposition in a proximal subaqueous environment. Sediments were transported by energetic riverine (flash?)-floods issued from the steep block-faulted margin through ephemeral river-deltas. These deposits are confined between basement blocks, from which they receive breccias after local collapses, suggesting the infilling of a system of canyon-heads indenting the sublittoral zone of this margin of the ancient strait (Longhitano, 2016; Longhitano et al., in press).

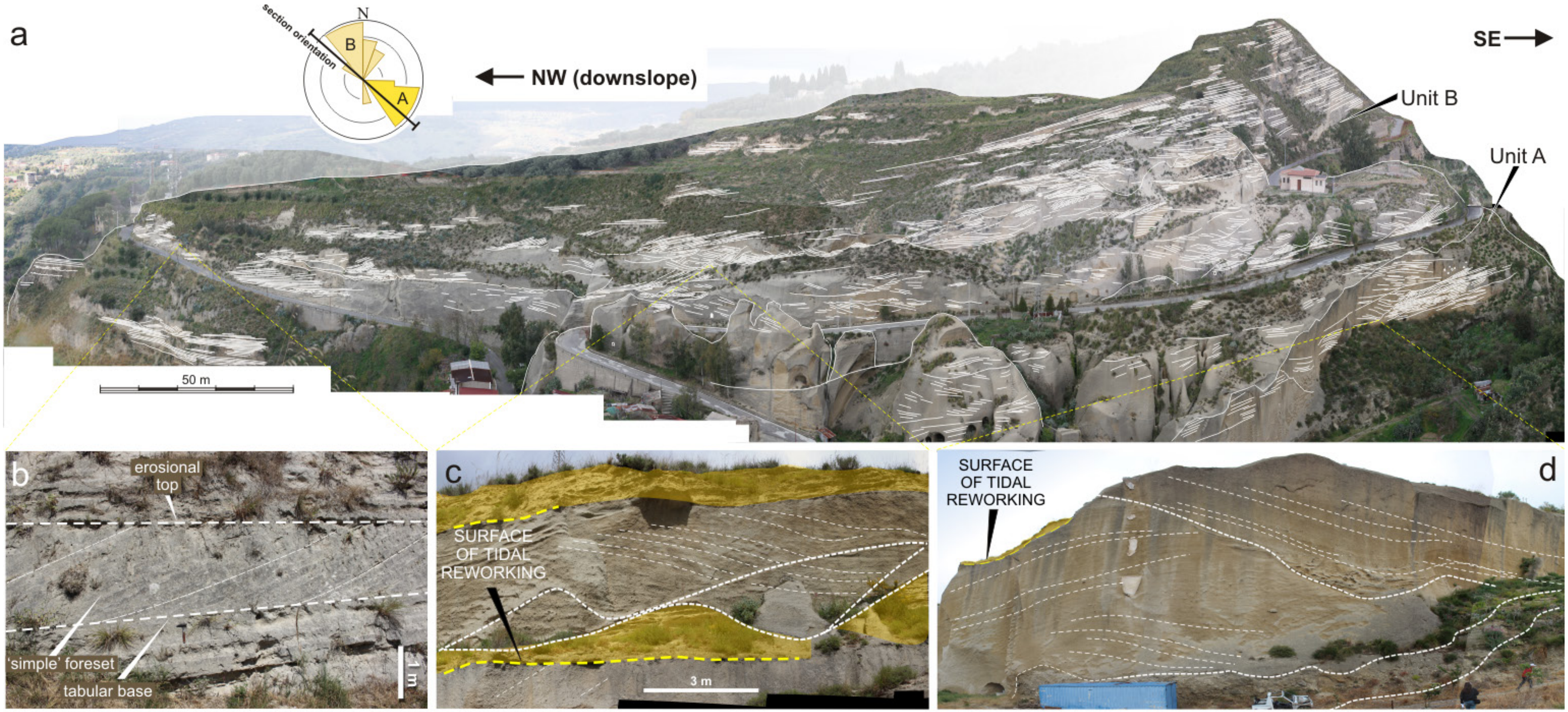

Fig. 20 – (a) Panoramic view of the Calanna section. (b to c) Details observable from the photograph in (a).

Stop T1.3.3 (38°11’18.59”N – 15°43’44.12”E)

Topics: Cross-stratified mixed arenites recording tidal dunes on top of the deltaic complex

The uppermost part of the Calanna Section (Fig. 21a) reveals the occurrence of extensive cross-stratified mixed arenites (Facies D4), including large-scale foresets up to 2.5 m thick separated by undulating discontinuities (Fig. 21b, c). This facies exhibits overall sedimentological features similar to those observed on the stops of Day 2 stops and suggests possible correlative elements with the sedimentary succession exposed further south.

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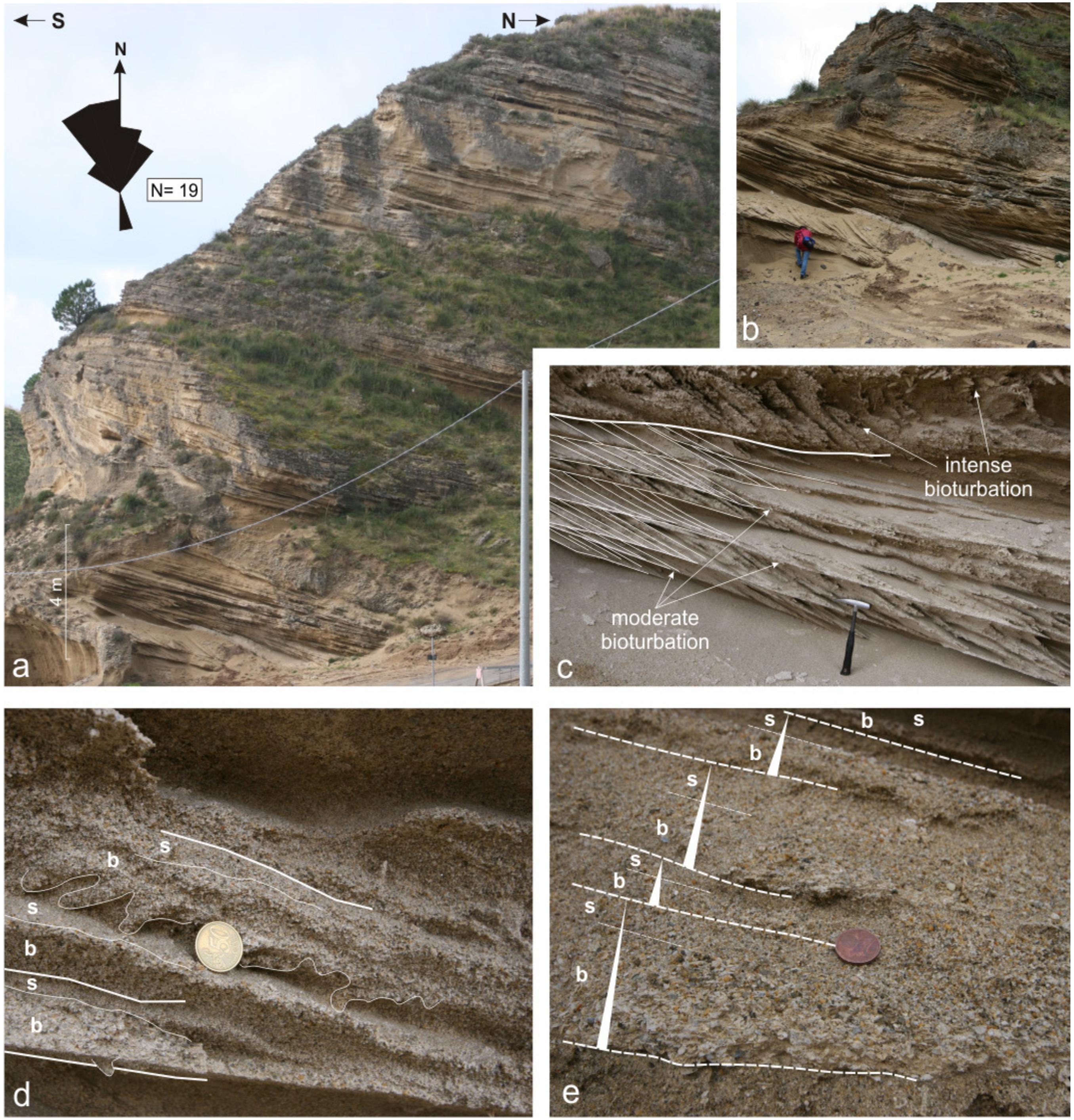

Foresets comprise angular and tangential geometries, are sparsely burrowed (Fig. 21d), and include tidal bundles (Fig. 21e) and reactivation surfaces, together with a systematically increasing bed thickness observable towards N-NW (basinwards) (Fig. 20b). Palaeocurrents suggest N-NW and W-NW flow directions, with rare and isolated thinner foresets pointing towards S-SE. Upwards, the succession shows a dominance of thinly-stratified mixed arenitic intervals with scarce or absent foresets, indicating a progressive weakening of the tidal currents.

Fig. 21 - (a) The Calanna section in its intermediate-to-uppermost interval exhibits diffuse motifs of cross stratification (palaeocurrents in the top-left corner). (b) A closer view reveals cross sets generated by mostly unidirectional dunes and ripples. (c) Bioturbation is concentrated in discrete intervals and at the base of bioclastic laminae of mixed bioclastic-siliciclastic sediments (d) (hammer 35 cm long; coin 2.5 cm in diametre). Foreset lamination is characterised by bundles of segregated bioclastic/siliciclastic (b/s) particles that reflect semi-diurnal to neap-spring tidal cycles (e) (coin 2 cm in diametre).

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Concluding Remarks

The present field trip and the proposed outcrops offer the visitor some essential elements useful for the reconstruction of the sedimentary dynamics of the ancient Messina Strait, a 10-15 km-wide and 40 km-long, tide-dominated arm of sea that separated Sicily from Calabria during the Early Pleistocene. The reference to the modern Messina Strait and its well-known processes, environments and sedimentary features serves as analogue to reconstruct the past strait setting.

The facies-based observations of the first-day's stops provide constraints for the localisation of a central tectonic horst that worked as bedload parting zone for sediment transport and distribution during the first stage of strait infill. Here, coarse-grained deposits suggest deposition in a zone of tidal maxima, where currents flowed at high energy due to the -local funnelling and shallowing of the strait. Northwards, the itinerary of the second day shows architectural and sedimentological features of an extensive bedform field that occupied the northern depositional sector of the ancient strait. Here, a variety of scales of cross-bedding and internal tidal indicators (such as reactivation surfaces, tidal bundles, rhythmic lamination and bio-/siliciclastic lamina pairs) represent the most distinctive example of tidal-strait deposits. The vertical stacking of facies recording conditions of even weaker tidal currents indicates a progressive weakening of tidal circulation during the late stage of infill of the ancient Messina Strait, possibly connected to a major phase of tectonically controlled transgression, with consequent enlargement of the marine passageway. The last day of the field trip analyses a typical strait-margin succession represented by a deltaic complex, which impinged the strait from its north-eastern border. The sedimentary record derived from the interplay of river-dominated flood deposits and marginal tidal currents represents another stratigraphic proxy for the detection of strait-margin facies in other similar tidal-strait successions.

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