waves are responsible of the boulders accumulation. Two waves can be associated to the strongest storms responsible of the motion of many boulders. Whereas the third one, responsible of the transport of boulders at longer distance from the coastline, is probably a tsunami wave having a longer period and therefore a lower attenuation. This kind of wave could also remove and displace further inland boulders that have been previously displaced on the rocky platform by storm waves.

Radiocarbon dating performed on three likely tsunami boulders, having weight of about 15 t and sited at a distance >40 m from the shoreline, suggests that two of them were probably deposited by the 1693 tsunami, and one by a tsunami occurred after 650-930 AD. This inundation could be both an unknown event but also one of the historical tsunamis (1169, 1542, 1693) that affected the Ionian coast of Sicily. In fact, since the radiocarbon datings are made on Vermetids and Lithophaga shells, they estimate the age of organism death, but not the moment of the boulder final displacement and impact. Absolute age dating, such as optical stimulated luminescence, should be necessary to gather a correct imprint of the paleotsunami event.

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References

Gerardi F., Barbano M.S., De Martini P.M., Pantosti D.; 2008: Discrimination of tsunami sources (earthquake vs. landslide) on the basis of historical data in eastern Sicily and southern Calabria. Bull. Seism. Soc. Am. 98 (6), 2795–2805.

Mastronuzzi G., Pignatelli C., Sansò P., Selleri G.; 2007: Boulder accumulations produced by the 20th February 1743 tsunami along the coast of southeastern Salento (Apulia region, Italy). Marine Geology, 242 (1), 191-205.

Noormets R., Crook K.A.W., Felton E.A.; 2004: Sedimentology of rocky shorelines: 3. Hydrodynamics of megaclast emplacement and transport on a shore platform, Oahu, Hawaii. Sedimentary Geology 172, 41–65.

Nott J.; 2003: Waves, coastal boulder deposits and the importance of the pre-transport setting. Earth and Planetary Science Letters 210, 269– 276.

Pignatelli C., Sansò P., Mastronuzzi G.; 2009: Evaluation of tsunami flooding using geomorphological evidence. Marine Geology, 260, 6–18.

Scheffers A., Scheffers S.; 2007: Tsunami deposits on the coastline of west Crete (Greece). Earth and Planetary Science Letters, 259, 613–624.

Tinti S., Maramai A., Graziani L.; 2007: The Italian Tsunami Catalogue (ITC), Version 2. Available on-line at: http://www.ingv.it/servizi-e-risorse/BD/catalogo-tsunami/catalogo-degli-tsunami-italiani

IDENTIFICATION OF TSUNAMI DEPOSITS IN SOUTH-EASTERN SICILY: EVIDENCE OF THE 365 A.D. CRETE EARTHQUAKE?

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In the past decade, the methodologies and techniques of paleoseismological studies have evolved towards a multidisciplinary approach for the characterization of past earthquakes. Along with traditional geologic and geomorphologic *near-fault* investigations, *off-fault* studies of evidence for past earthquakes, such as soft sediment deformation (e.g. Moretti, 2000; Marco and Agnon, 2005), evidence of liquefaction (e.g. Tuttle et al., 2002; Guarnieri et al., 2009) and tsunami deposits (Dawson and Stewart, 2007; Pantosti et al., 2008; De Martini et al., 2009) are considered useful tools in the assessment of paleoearthquakes ages, magnitudes, and earthquake recurrence rates. The outcomes obtained from these type of studies should be also consistently combined with on-fault results. In particular, among off-fault studies, the research of paleotsunami deposits can play an important role in areas without clear surface faulting evidence and strong earthquake instrumentally recorded or where the potential seismic sources are located off shore such as Eastern Sicily. In

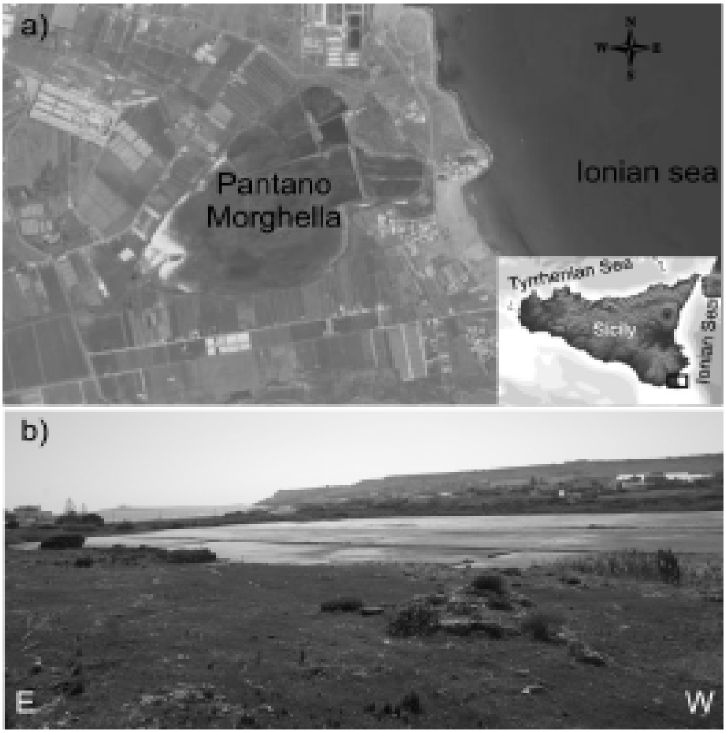

Fig.1 – a) Google earth location of Pantano Morghella; b) picture of the site.

fact, Sicily has been affected in historical time by large earthquakes (CPTI Working group, 2004), among which the 1693 and 1169 events, followed by devastating tsunamis, that have seismic sources not well identified yet. Furthermore, both historical data (Tinti et al, 2007) and tsunami modelling (Lorito et al., 2008) show that the Sicilian Ionian coast can also experience the effects of tsunamis originated from distant sources, such as those belonging to the Aegean subduction zone (e.g. the A.D. 365 Crete earthquake). We present the preliminary results of *off-fault* paleoseismological studies carried out in south-eastern Sicily, focused to identify evidence of tsunami inundations. Following a multi-theme approach, we used the available historical information to address geomorphological study of the coastal landscape. Aerial-photographs and satellite images interpretation and field surveys allowed us to select areas likely invaded by tsunami waves in the past and that represent trap-site for sedimentation and preservation of their deposits.

Pantano Morghella, a lagoon environment located along the southeastern Sicilian coast shows the morphologic condition of coastal low-land, favourable for tsunami deposit findings. It is a area 1.3 km long and 0.8 km wide

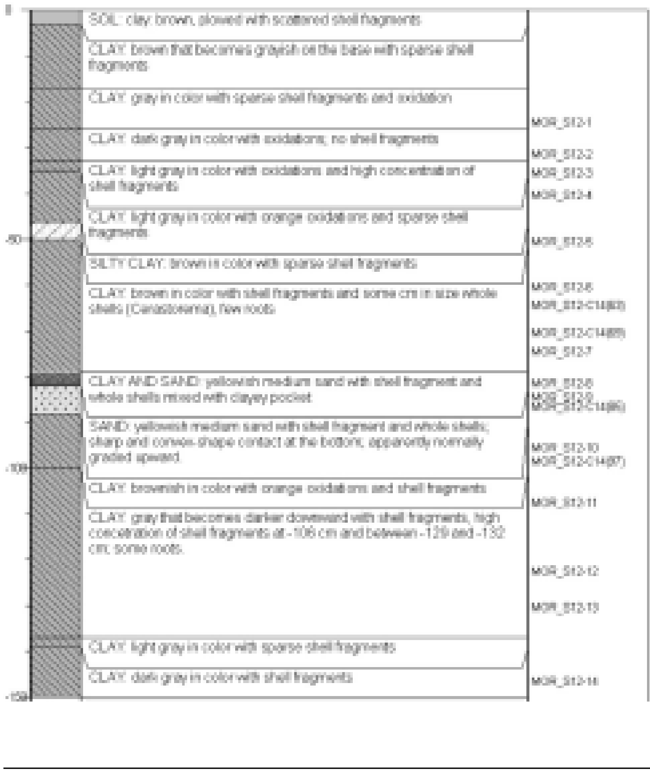

Fig. 2 – Log representing Pantano Morghella stratigraphy from 0 cm to -150 cm depth.

(Fig. 1), surrounded by Upper Cretaceous lavas and volcanoclastic deposits, Late Cretaceous limestone calciruditi, calcarenites and Marls (Pliocene). To the east quaternary deposits, beach sands and fossil dunes (Holocene and Late Pleistocene) separate the Pantano from the sea (Lentini et al., 1986) forming the intertidal ponds with a little channel from which sea water can rush into. The wet land, was partially used as salt-pans in the past. In the Pantano Morghella site, we dug 33 cores down to a maximum depth of 5.80 m, until to 1200 m from the coastline. Test coring campaigns were carried out using hand auger equipment for preliminary stratigraphical reconstruction of the sedimentary sequence and the collection of samples for laboratory analyses. Coring of 100 cm long undisturbed samples, within specific pvc tubes, were successively realized thanks to appropriate vibracoring device (gasoline powered percussion hammer).

Accurate sedimentological descriptions, collection of samples for paleontological analyses and isotopic dating have been executed. Magnetic and X-ray analyses were also performed on the undisturbed core to observe possible susceptibility variations and peculiar small-scale sedimentary structures (e.g. sharp contacts, convoluted layers, etc.) not easily detectable trough the standard stratigraphic analysis. The Pantano Morghella cores reveal a fine stratigraphic sequence mainly composed by clay and silty clay (Fig. 2), interrupt by a yellow bioclastic sandy layer, detected at about one meter of depth (Fig. 3a). Sedimentological and paleontologic analyses showed that the sandy samples have different lithic and microfauna composition with respect to the samples collected above and below in the sedimentary sequence, characterized by an oligothipic lagoonal assemblage of benthic foraminifera (*Haynesina germanica* and *Ammonia tepida*). The sandy samples show an assemblage made of several reworked foraminifera (both planktonic and benthonic), few littoral and well preserved benthic foraminifera, marine macro fossil fragments (corals, sea urchins, bryozoa and molluscs), few lagoonal specimens and also it contain a lithic component made of well-rounded yellowish mainly carbonatic clasts, revealing similarity to the local beach sand. Moreover, X-ray analysis reveals that this out of sequence sandy layer is characterized by a fining upward granulometry and a sharp, possibly erosional, basal contact (Fig. 3b).

The anomalous sandy layer, interpreted as a tsunami deposit, was mainly detected in most of the numerous cores dug in the central area of Pantano Morghella. The reconstruction of its distribution allowed us to delineate the probable inundation area of about 350 m^2 and to assess a possible tsunami flooding until 1.2 km from the coastline (Fig. 4), the deposit thickness decrease with distance

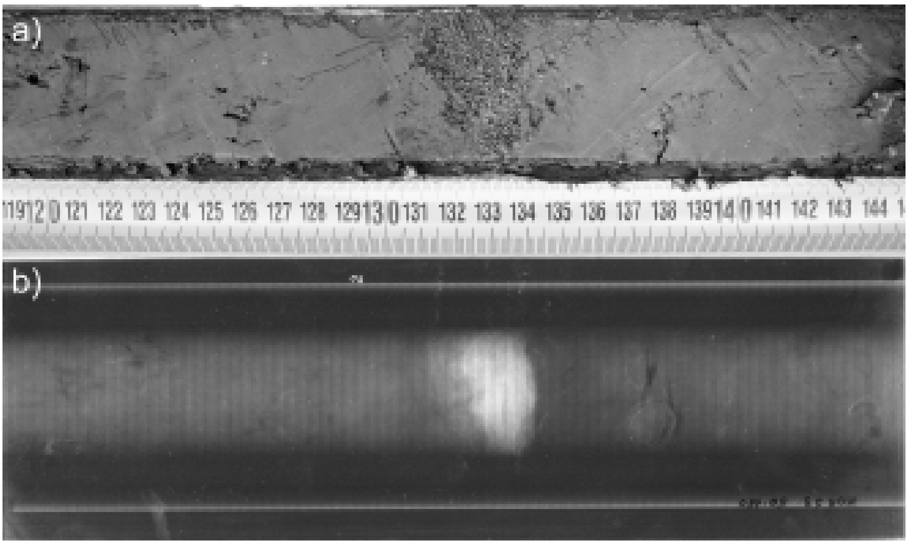

Fig. 3 – (a) Detail of the MOR-S3 core showing the sandy layer within the silty clay; (b) X-ray film of the core.

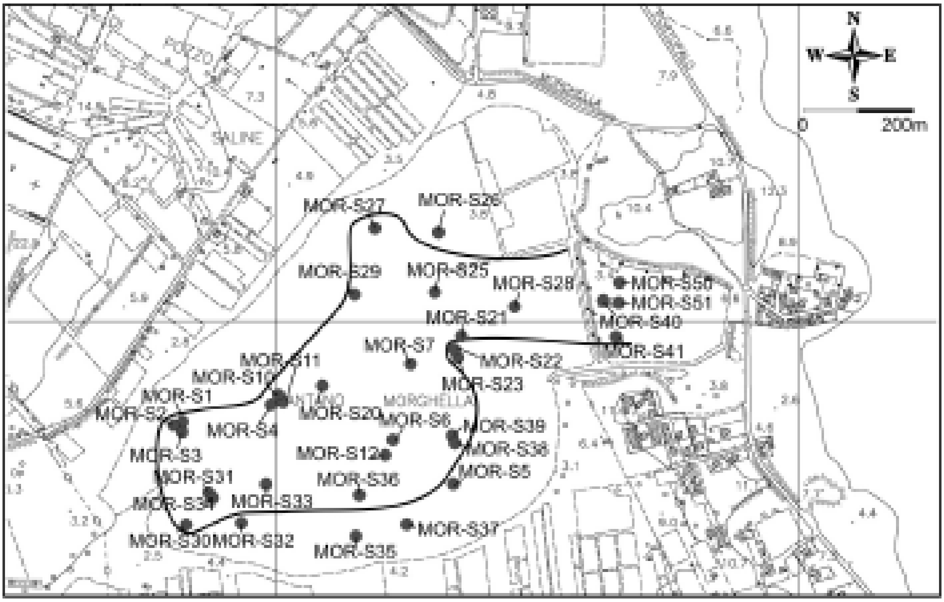

Fig. 4 – Location of the Morghella cores. The black line delimits the area where the sandy layer has been found.

from the sea. Radiocarbon dating, performed on three samples collected just above, within and below the sandy anomalous layer, gave ages close in time, confirming a sudden deposition due to a high energy event occurred in the interval 270-650 A.D. These preliminary results allow us to tentatively correlate the marine inundation of Pantano Morghella with the 365 A.D. Crete tsunami.

Further analyses are in progress to better define the sand distribution and to better constrain the age of the probable tsunami deposit.

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References

Dawson A. G., Stewart I.; 2007: Tsunami deposits in the geological record. Sedimentary Geology 200 (3-4), pp.166–183.

De Martini P.M., Barbano M.S., Smedile A., Gerardi F., Pantosti D., Del Carlo P., Pirrotta C.; 2009: A 4000 yrs long record of tsunami deposits along the coast of the Augusta Bay (eastern Sicily, Italy): paleoseismological implications. Marine Geology (submitted).

Guarnieri P., Pirrotta C., Barbano M.S., De Martini P.M., Gerardi F., Pantosti D., Smedile A.; 2009: Paleoseismic investigation of historical liquefactions along the Ionian coast of Sicily. Journal of Earthquake Engineering, 13, pp. 68–79.

Lentini F., Carbone S., Cugno G., Grasso M., Scamarda G., Sciuto F., Montanari L., Romeo M., Ferrara V., 1986. Geological map of the north-eastern Hyblean sector. Ed. S.E.L.C.A. Map scale 1:50.000, Firenze (in Italian).

Lorito, S., Tiberti, M.M., Basili, R., Piatanesi, A., Valensise, G.; 2008: Earthquake-generated tsunamis in the Mediterranean Sea: Scenarios of potential threats to Southern Italy. J. Geophys. Res. 113, B01301, doi:10.1029/2007JB004943.

Marco S., Agnon, A.; 2005: High-resolution stratigraphy reveals repeated earthquake faulting revealed by high resolution stratigraphy. Tectonophysics 408, 101–112. doi:10.1016/j.tecto.2005.05.036.

Moretti M.; 2000: Soft-sediment deformation structures interpreted as seismites in middle-late Pleistocene aeolian deposits (Apulian foreland, southern Italy). Sedimentary Geology, 135, pp. 167–179.

Pantosti D., Barbano M.S., De Martini P.M., Smedile A.; 2008: Geological Evidence of Paleotsunamis at Torre degli Inglesi (NE Sicily). Geophys. Res. Lett., 35, L05311, doi:10.1029/2007GL032935.

Tinti, S., Maramai, A., Graziani, L.; 2007: The Italian Tsunami Catalogue (ITC), Version 2. Available on-line at: http://www.ingv.it/servizi-e-risorse/BD/catalogo-tsunami/catalogo-degli-tsunami-italiani

Tuttle M. P., Dyer-Williams K., Barstow N. L.; 2002: Paleoliquefaction study of the Clarendon–Linden fault system, western New York State. Tectonophysics, 353, pp. 263– 286.