Comment on "Lost tsunami" by Maria Teresa Pareschi et al.

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1. Introduction

[1] A numerical simulation recently published by *Pareschi et al.* [2006a] (hereinafter referred to as PAR2006) suggests the possible occurrence of a major tsunami that should have hit the eastern Mediterranean in the early Holocene. The catastrophic collapse of the eastern flank of the Etna Volcano that formed the Valle del Bove [*Calvari and Groppelli*, 1996; *Calvari et al.*, 1998] is reported as the trigger of this tsunami that generated a pelagic turbidite nicknamed "Homogenite" [*Kastens and Cita*, 1981] or "Augias turbidite" [*Cita et al.*, 1984; *Hieke*, 1984] throughout the eastern Mediterranean. Since its discovery, this deposit characterized by an acoustically transparent facies on seismic profiles has been related to the 3500 years old collapse of the Santorini Caldera [*Kastens and Cita*, 1981]. Several papers published in the last 25 years followed this interpretation [see *Cita and Rimoldi*, 2005, and references therein]. So there is a general agreement about the tsunamigenic origin for the widespread homogenite deposits, while a big discrepancy exists between the timing of this event and the formation of the Valle del Bove which cannot be younger than 7600 calibrated yr. B.P. [*Calvari and Groppelli*, 1996].

[2] This comment aims to clarify the stratigraphic constraints about the timing of the homogenite deposition challenging the proposed genetic link between the collapse of the Valle del Bove and the Homogenite or Augias deposits.

2. Stratigraphic Constrains

[3] More than 70 cores collected over the last 25 years recovered the deposits of the acoustically transparent homogenite in the eastern Mediterranean [*Kastens and Cita*, 1981; *Hieke and Werner*, 2000; *Reitz et al.*, 2006]. Several cores penetrated the entire homogenite (up to 24 m.) and recovered the dark anoxic sediments representing the sapropel S1 beneath it. About 15–32 cm of normal pelagic ooze have been found between sapropel S1 and the homogenite that is overlain by 16–36 cm of sediments [*Kastens and Cita*, 1981]. This finding is a well-defined time constrain for the observed megaturbidites considering that Sapropel S1 represents the youngest organic rich-layer deposited in the eastern Mediterranean. By assuming an age of 8000 yr. for the top of S1 and a constant sedimentation rate, *Kastens and Cita* [1981] extrapolated the age of the homogenite between 3100 and 4400 yr. B.P. A plethora of papers have been published in the last 20 years about Mediterranean sapropels including an ODP LEG (160) focused on this theme. Sapropel S1 is probably one of the most studied layers of the world [e.g., *Mercone et al.*, 2001; *Meier et al.*, 2004, and references therein]. Apart from the long lasting discussion about mechanisms and processes leading to its formation, break and preservation it is well established that it occurred during the first half of the Holocene (9.5–6 kyr B.P.). ^{14}C dating and calibration precisely define the age of S1 in several different basins even if the end of this event may have been not fully synchronous across the entire basin [*Troelstra et al.*, 1991; *Fontugne et al.*, 1994; *Mercone et al.*, 2000]. Compilation of early radiocarbon dating by *Vergnaud-Grazzini et al.* [1986] and by *Fontugne et al.* [1994] suggested a duration of about 2000 yr between 9000 and 7000 yr. B.P. Recently *Mercone et al.* [2000] revised the S1 duration in slowly and rapidly accumulated sediments indicating that the base of the sapropel formed around 9500 yr B.P. whereas the top ranges between 6000 and 5300 yr. B.P. (uncalibrated radiocarbon age). The larger time interval found by *Mercone et al.* [2000] is due to the fact that sometimes the sapropel is susceptible of extensive oxidation responsible of a thinning of the layer that could lead to an older dating of the top. The ages reported by *Mercone et al.* [2000] are conventional ^{14}C dating. Considering ^{14}C ages increase after calibration [*Stuiver and Reimer*, 1993] we can be confident that in most of the eastern Mediterranean the top of the Sapropel S1 is no older than 6000 cal. yr. B.P. Furthermore it has been observed that the anoxic layer is not a continuous deposit, but can be divided in two intervals named S1a and S1b separated by a break reflecting short-term variations in oceanographic conditions [*Rohling et al.*, 1997; *Myers and Rohling*, 2000; *Ariztegui et al.*, 2000; *Mercone et al.*, 2000; *Giunta et al.*, 2003; *Sangiorgi et al.*, 2003]. The duration of this interruption is centered around 7900 yr. B.P. according to *Mercone et al.* [2000] and occurred between 8000 an 7500 yr. B.P. as proposed by *Ariztegui et al.* [2000].

[4] The timing of the events is critical for establishing a robust relationship between the Etna-generated tsunami and the Homogenite emplacement. The age of 8000 yr B.P. assigned by PAR2006 to the sapropel S1 refers to few papers [*Hieke and Werner*, 2000; *Rebesco et al.*, 2000] that simply refer to old papers [*Kidd et al.*, 1978; *Cita and Grignani*, 1982]. Presently instead it is well known that the top of sapropel S1 cannot be older than 6000 yr.

[5] Even if there are no ^{14}C datings on cores showing both sapropel and homogenite the correlation of the anoxic layer throughout the basin is a constrain that cannot be

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ignored. Furthermore a decisive contribution to establish a reliable stratigraphy is given by geochemistry. The boundaries of sapropel S1 are defined by variations of element/Al ratios [*Thomson et al.*, 1999], in particular Ba/Al. Geochemical data from a core (SL139) collected in the Sirte Abyssal Plain clearly show that the peak of Ba/Al corresponding to the sapropel S1 ends well before the deposition of the homogenite [*Reitz et al.*, 2006]. So clearly there is no time relationship between the two events.

[6] Therefore the debris avalanche from Mt. Etna cannot be responsible of a certainly younger mass-transport event. Furthermore PAR2006 identify the sapropel (in both text and auxiliary material) with the name S1 or S1-A interchangeably. It is unclear if the latter refers to early part of the sapropel that ended around 8000 yr. B.P. which would support better the proposed reconstruction. However, if the homogenite was emplaced after the first part of the sapropel we should expect to find S1-b above this layer, but this has not been observed in any core.

3. Lost Tsunami

[7] As just discussed above, the timing of a possible Etna tsunami is close to the interruption of the sapropel S1. Certainly, paleoceanographic conditions favored the ventilation and re-oxygenation of the basin. However, in the Adriatic Sea it has been observed that the interruption is characterized by partially reworked material [*Giunta et al.*, 2003] and also by the presence of a turbidic layer [*Jorissen et al.*, 1993] that could be triggered by earthquake or tsunami. So it is possible that the avalanche following the collapse of the Valle del Bove was the mechanism driving the re-mixing of the stratified waters at the middle of Sapropel S1.

[8] If the Etna collapse is not responsible of the Homogenite deposits and if also the Minoan eruption of Santorini should be ruled out as possible cause as suggested by *Pareschi et al.* [2006b] we propose a third possible event: the earthquake of the 21st august 365 AD. Historic sources by Ammianus Marcellinus [*Guidoboni et al.*, 1994] strongly point to a devastating tsunami that completely destroyed the biggest towns of the North African coast such as: Sabratha, Leptis Magna, Apollonia, Cirene, Alexandria. More than 50000 casualties occurred only in Alexandria.

[9] The likely source for the proposed earthquake induced tsunami may be represented by the activity of the subduction system of the eastern Mediterranean Sea. In particular, the region of incipient continental collision south of Crete [*Polonia et al.*, 2002] is one of the candidate areas where such a basinal event may have been generated as it is characterized by the higher strain rates and the deformation front of the accretionary wedge is closer to the African coast. Extreme neotectonic events have been reported in the western part of Crete Island with a sudden uplift of several meters in correspondence of the 365 AD event [e.g., *Scheffers and Scheffers*, 2007, and references therein]. A sudden uplift of this extension certainly would have instigated a tsunami responsible for a slump along the African shelves. A further indication to locate the source of the tsunami in the African coast is that the homogenite deposits studied in the Ionian and Sirte Abyssal Plains are characterized by a significant content of aragonite and bioclasts supplied from the African continental shelf [*Hieke and Werner*, 2000; *Cita and Rimoldi*, 2005]. Further investigations are necessary to locate precisely the position of this slump, but the already existing data strongly support the relationship between the homogenite and the Early Byzantine tectonic paroxysm.

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