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**The Messinian salinity crisis: old and new problems from the
recentmost interdisciplinary researches**

Convener and Chairperson: Stefano Lugli and Marco Roveri

Oral and poster sessions

**MACROPALAEONTOLOGICAL DOCUMENTATION OF PROGRESSIVE ANOXIC
CONDITIONS IN THE PRE-EVAPORITIC MESSINIAN SECTION OF MONTICINO QUARRY
(BRISIGHELLA, FAENZA, ROMAGNA APENNINES)**

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The uppermost ten meters of the pre-evaporitic Messinian section of Monticino quarry in the Romagna Apennines (Brisighella, Faenza) are an alternation of euxinic and non-euxinic marls and carbonates at places considerably fossiliferous. Non-euxinic gray marls prevail in the lower part of the section; these sediments are characterized by relatively diverse macrofossil assemblages dominated by infaunal (*Nucula*, *Nuculana*, *Abra*, *Cuspidaria*, *Cardiomya*) and epifaunal (*Propeamussium*) benthic bivalves, gastropods (*Aporrhais*, *Nassarius*, cf *Acteon*), decapods and, at places, holoplanktic mollusks. These macrofaunal data point out a bathyal-marine offshore setting and quasi-normal oxygen bottom conditions. Carbonate layers show faint to distinct laminations and deep-water benthic bivalves are occasionally still recognizable. Euxinic marls alternated to limestones make up most of the upper section. The euxinic marls contain oligotypic macrofaunal assemblages dominated by lucinid bivalves (cf *Myrtea*) up to the very last hydrocarbon-rich euxinic layer; these specialized bivalves were adapted to high levels of hydrogen sulfide and indicate dysaerobic bottom conditions. The overall macropalaeontological legacy of Monticino quarry documents a trend of dramatic environmental deterioration of bottom conditions (strong oxygen impoverishment) in a bathyal setting, shortly before the onset of the first evaporitic phase.

THE MESSINIAN LOWER EVAPORITES IN THE MEDITERRANEAN: A NEW FACIES MODEL

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The only available facies model for the Messinian Lower Evaporites in the Mediterranean is the "ideal cycle" proposed by Vai and Ricci Lucchi (1977) for the Vena del Gesso basin. A revisitation of these sulfates and a comparison with other marginal basins in the Mediterranean (Sicily, Crete and Spain) and elsewhere (Babel, 2004) suggest a new facies model for their deposition. The Vena del Gesso evaporites consist of 16 cycles separated by organic-rich argillaceous sediments. The basal portion (up to 5th bed) is made of thick beds (up to 30 m) of vertically grown massive selenite grading into banded selenite (F3 and F4 facies of Vai and Ricci Lucchi, 1977). The upper part of the section (from the 6th to the 15th bed) consists of thinner beds (average thickness 15 m) with cycles showing a basal massive and banded selenite, followed by nodular and lenticular selenite (F5 of Vai and Ricci Lucchi, 1977). This nodular and lenticular selenite was considered by Vai and Ricci Lucchi (1977) as a clastic deposit (gypsarenite) that was subaerially exposed and developed sabkha features, such as anhydrite nodules. The detailed study of this facies shows no clastic and supratidal features, but reveals that clusters of selenite crystals grew laterally, grouped in branches projecting outward from a nucleation zone into a carbonate/marly matrix. We interpret this facies as an extreme evolution of subaqueous selenite supercone structures (Dronkert, 1985). The presence of clastic deposits (gypsrudite and gypsarenite, F6 of Vai and Ricci Lucchi, 1977) is limited to the uppermost part of the succession (16th cycle), indicating that erosion and redeposition of evaporites began after the main evaporite period (Manzi et al., 2005). According to this new facies interpretation, the depositional cycles can be described as follows: 1) Initial evaporite precipitation at relatively low salinity produced the vertical massive selenite in a relatively deep setting; 2) Continuous evaporation and drawdown produced the relatively higher salinity conditions and growth of sulfate crystals was controlled by oscillating brine level (banded selenite); 3) A general brine level rise and dilution introduced significant carbonate materials in the system; selenite crystals growth was characterized by formation of large supercones branching laterally and producing the nodular and lenticular selenite; growth of cones and branches was controlled both by brine level and spacing of cones; 4) Flooding by undersaturated water stops gypsum precipitation with the deposition of argillaceous sediments and carbonates; The stacking pattern of these facies describes a complete small scale sedimentary cycle made up of both regressive and transgressive phases: respectively F3 facies represents the initial fall, F4 the lowstand, F5 the transgressive and, finally, F1 the highstand. The cyclic occurrence of the F5 facies within the main successions of the Messinian primary evaporites of the marginal Mediterranean basins (Northern Apennines, Spain, Sicily) can be related to a generalised climate change affecting the whole Mediterranean area coinciding with a minimum in the Earth eccentricity (Krijgsman et al., 1999). The end of the sulfate evaporite precipitation in the Mediterranean coincides as well with a minimum in the Earth eccentricity. Evaporite geochemistry indicates that the development of the F5 facies occurs in correspondence of major oceanic influxes in a general setting dominated by solutions strongly modified by continental waters (Bassetti et al., 2004).

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THE DEEP-WATER COUNTERPART OF THE MESSINIAN LOWER EVAPORITES IN THE APENNINE FOREDEEP: THE FANANTELLA CORE (NORTHERN APENNINES, ITALY)

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A general consensus has been reached in the last years in placing the onset of the MSC at 5.96 Myr, with the precipitation of evaporites in marginal peri-Mediterranean basins. More controversial is the definition of what happened in deep-basins during the deposition of the Lower Evaporites, due to the lack of outcropping basinal successions and well-data from the deepest Mediterranean basins. To this respect the Apennine foredeep represents an exception; both marginal and deep-water successions crop out extensively and can be compared. The main depocenters are dominated by clastic, resedimented evaporites, mostly gypsum, deposited in relatively deep-water settings by a variety of gravity flows, ranging from low-density turbidity currents to olistostromes. Primary evaporites only precipitated in shallow-water, semi-closed wedge-top basins and their top is cut by an angular unconformity related to an important deformational phase affecting the whole Apenninic-Maghrebid chain. Biomagnetostratigraphic studies carried out in the last years show that primary evaporites of the Apennine developed synchronously with the other Mediterranean successions at 5.96 Myrs; based on cyclostratigraphic considerations, a maximum age of 5.6 Myrs has been calculated for the top unconformity. Physical-stratigraphic considerations based on regional-scale study of the Messinian successions throughout the whole Apennine foredeep led Roveri et al. (2001) to suggest that this unconformity could be traced basinward at the base of the resedimented evaporites complex, thus implying the occurrence in basinal settings of a deep-water counterpart of the Lower Evaporites. Preliminary studies carried out in outcrop sections in the Sapigno syncline led to the recognition of a 40 m thick, barren unit consisting of organic-rich clays underlying the resedimented evaporites unit, that was suggested to be a good candidate for correlation with the Lower Evaporites. In order to have a complete record of such unit and of the underlying deposits for detailed biomagnetostratigraphic and paleoenvironmental studies, a 140 m long core was recovered in the Sapigno syncline starting from the base of the resedimented evaporites. The core consists of a rhythmic alternation of dark, organic-rich shales and lighter marls, indicating cyclical development of low-oxygen conditions at the sea-bottom (from the bottom to 110 m) capped by a unit made up of dark, organic rich clays with very thin silt and fine sand laminae (from 110 m to the top). The occurrence of the most significant calcareous plankton events documents an upper Lower Messinian age for the lower half of the core and allows the calibration of the magnetic reversal observed at 70 m as the C3r-C3An.1n transition. The upper part of the core, from 70 m up to the top, falls entirely in the C3r chron and shows a characteristic sequence of bioevents with the disappearance of foraminifera, nannoplankton and bivalves at 60 m; from 60 to 40 m only high-salinity tolerant pteropods assemblages are found; from 45 m to the top no pollen or dyncocists were recognised; then, from 40 m to the top the succession is totally barren. The anomalous thickness of the C3r unit below the resedimented evaporites, which has no equivalents in pre-evaporitic successions capped by primary evaporites, as well as the peculiar sequence of observed bioevents suggests that at least the barren deposits could be considered a basinal equivalent of the Lower Evaporites, thus confirming the preliminary interpretation of outcrop data. According to this interpretation, the pteropods unit could record the progressive transition toward hypersaline conditions just before the onset of evaporite precipitation in restricted basins; alternatively, it could be considered an equivalent of the lower part of the evaporitic sequence. The Fanantello core data confirm the hypothesis previously made that the resedimented evaporites complex completely postdate the Lower Evaporites.

OPEN QUESTIONS IN THE MESSINIAN CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY AND THEIR PALEOCEANOGRAPHIC IMPLICATIONS

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During the Messinian (7.2 to 5.3 Ma) the mediterranean area experienced fast and deep climatic and eustatic structural changes. The combined effect of these factors lead to drastic paleogeographic changes that are recorded in the mediterranean sedimentary basins. The stratigraphic framework for this interval is relatively well constrained and the base of evaporites dated at approximately 6 Ma determine a duration of at least 1.2 Ma for the pre-evaporitic Messinian, whereas the evaporites should account for 350 Ka and the post evaporitic interval should span 300 Ka. The post evaporitic interval, despite its short duration (less than 300Ka, it spans from 5.6 to 5.32 Ma), represents a complex problem. The Mediterranean paleogeographic framework characterizing this interval sees a great number of unconnected endoreic basins, characterized latitudinally by very different climatic conditions and different hydrological balance. The hydrological regime changes abruptly turning from iperhaline to ipohaline conditions. This explains the mainly terrigenous composition and high sedimentation rates (varying in the different context, but always in the magnitude of 100 meters). This interval is characterized by a very low, if not null stratigraphic resolution due to the impossibility to use the classical stratigraphic methodologies since the succession is non-marine and also because it falls in a single magnetic chronozone (Gilbert, inverse polarity). However, despite its short duration this interval is important because here are concentrated all the main problems that as a whole defines the salinity crisis. In this abstract we present the preliminary data concerning some key sites (Fanantello Borehole, Trave section, Ca Blindana Borehole where we obtained important close up on the messinian succession. A detailed study performed by means of Calcareous nannofossils, in these sites, and the comparison with other Mediterranean sites in fact evidenced some peculiar micropaleontological features characterizing the different depositional units of the Messinian that contribute improving the knowledge of this geological period.

A HIGH-RESOLUTION STRATIGRAPHIC FRAMEWORK FOR THE LATE MESSINIAN LAGOMARE EVENT IN THE MEDITERRANEAN AREA: TIME CONSTRAINTS FOR BASIN-WIDE CORRELATIONS PALAEOENVIRONMENTAL RECONSTRUCTIONS

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Due to the impossibility of using the classic biomagnetostratigraphic approaches, the comprehension of Late Messinian events of the Lagomare phase, as well as the definition of a reliable high-resolution time framework for this interval, need to be based on an integration between physical- and ecobiostratigraphy. A preliminary high-resolution physical-stratigraphic scheme for the Late Messinian is here presented which allows to better constrain the time and space distribution of the main palaeoenvironmental proxies as well as to evaluate the chronostratigraphic potential of bioevents usually thought to have a mainly palaeoecological meaning. This scheme, reconstructed through the interdisciplinary study of new surface and subsurface data and the review of older ones from different basins throughout the Mediterranean area, is an intermediate step of the work that is being carried out within a MIUR Cofin 2003 Project. The post-evaporitic stage is bounded at the base by the intra-Messinian unconformity on basin margins and by its correlative conformity in deeper settings, aged at 5.6 Ma. The sudden return to open marine conditions at the base of the Pliocene at 5.33 Ma marks the end of the Lagomare phase. This interval, lasting around 270 kyrs, is characterized by a generalized development of apparently non marine basins, whose palaeoenvironmental characteristics are still far from being fully understood. The post-evaporitic phase can be split into two units by a minor unconformity; the lower unit (p-ev1) is only found in structural depression and records the transition from hypersaline to hyposaline conditions during the so called "Messinian gap". This unit is only found in structural depressions and formed during an important deformation phase affecting many tectonically active Mediterranean basins; it is usually characterized by the occurrence at its base of a great variety of resedimented evaporites; significantly, it doesn't show any clear cyclical pattern but an overall shallowing upward trend leading to basin fill. The upper unit (p-ev2) is characterized by a well-developed cyclical pattern in both shallow and deeper depositional settings and is more widely distributed across the Mediterranean basins. An interesting and diagnostic feature is the usually coarser-grained character of the p-ev2 deposits with respect to the underlying p-ev1 unit, suggesting important modifications in the drainage systems, possibly related to huge relief rejuvenation and/or to the precipitation regime. Lithological cyclicity is controlled by precession and this allow to establish accurate correlations across different basins. This unit contains four complete sedimentary cycles driven by precession-related climatic changes and the Miocene/Pliocene boundary falls within the fifth one; correlation with astronomic curves suggests that its base could be tentatively placed at 5.44 Ma. The revision of a large number of published data and the study of new stratigraphic sections allow to trace more accurately the vertical distribution of taxa belonging to different groups. This shows that while the upper unit is characterized by the most typical hyposaline Lagomare assemblages, the lower one should record a transition toward such environments. The reconstructed stratigraphic framework allows the recognition and correlation across different basins of small- and large-scale changes in the distribution of different biological, geochemical

and mineralogical palaeoenvironmental proxies that can be related to high-frequency climatically driven changes of basin(s) hydrology and to a superimposed longer-term trend. The possibility to compare the palaeoenvironmental record of very short time slices from different basins offers a great opportunity to better define the paleogeography of the Mediterranean area in the final stage of the Messinian salinity crisis.

THE RECORD OF THE LATE MESSINIAN LAGO-MARE EPISODE IN THE EASTERN MEDITERRANEAN BASIN (CRETE ISLAND, GREECE)

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From the eastern Mediterranean Basin, upper Messinian Lago-Mare deposits were recorded in the DSDP sites 375 and 376 (Benson, 1978), and more recently in the ODP site 968 (Shipboard Scientific Party, 1996; Blanc-Valleron et al., 1998; Rouchy et al., 2001). The late Messinian Lago-Mare biofacies has been also pointed out from the southern-east Mediterranean borderlands and from the Ionian and the Aegean islands. Ostracod assemblages with Paratethyan affinity have been found on the Corfu Island (Vismara-Schilling et al., 1976), on the Aegina Island (Krstic and Dermitzakis, in Krstic and Stancheva, 1990), in the Strimon Basin (Gramann, 1969), on the Kos Island (Guernet et al., 1976). On the Crete Island, late Messinian Lago-Mare facies are not well known. At present, the occurrence in Crete of the uppermost Messinian post evaporitic deposits is a matter of debate. According to several authors the well-known late Messinian Lago-Mare facies does not occur in Crete. However, late Messinian Lago-Mare biofacies has been recently observed in the Messarà Plain (southern part of central Crete; Pipponzi et al., 2004). In this paper the results obtained from the biostratigraphical analysis of some sections sampled in the Messarà Plain will be shown. Nearby Faneromeni and Ano Akria villages, the Miocene/Pliocene boundary is well exposed. There, gypsum-bearing clay, laminate microcrystalline gypsum and gypsum-rudites characterise the evaporitic deposits of the Messinian stage. In these areas, above the Messinian evaporite, post-evaporitic fine-laminated polychrome clays, with intercalations of sandstones and conglomerates, have been found. In both the Faneromeni and Ano Akria area, the Pliocene grey clays and conglomerates rest unconformable on the uppermost Messinian post-evaporitic deposits. The occurrence of both *Sphaeroidinellopsis* and *Neoglobobulimina acostaensis* suggest an Early Pliocene age for the first transgressive strata above late Messinian post-evaporitic deposits (MPI1 zone). A 20 cm-spaced sampling has been performed in both the sections, for more than 100 samples collected. The results of the micropaleontological analysis performed on the Faneromeni and Ano Akria sections point to the occurrence of ostracod assemblages containing: *Pseudocythere limata* SCHNEIDER in Agalarova, Djafarov, Halilov, *Pseudocythere* sp., *Cyprideis* sp., *Cyprideis* sp. 5 GLIOZZI and GROSSI, *Cyprideis anlavauxensis* CARBONNEL, *Amnocythere* cf. *A. palimpsesta* (LIVENTAL), *Amnocythere idonea* (MARKOVA), *Amnocythere propinqua* (LIVENTAL), *Amnocythere multituberculata* (LIVENTAL), *Amnocythere* sp.1 GLIOZZI and GROSSI, *Amnocythere* sp. D MICULAN in Bassetti et alii, *Amnocythere* sp., *Euxinocythere* (*Maeotocythere*) *praebaquana* (LIVENTAL), *Pontoniella* sp., *Camptocypris* sp. 1 GLIOZZI and GROSSI, *Caspiocypris* sp., *Zalanyiella* cf. *Z. venusta* (ZALANYI), *Tyrrhenocythere ruggierii* DEVOTO, *Tyrrhenocythere pontica* (LIVENTAL), *Lineocypris* sp., *Loxoconcha* sp., *Loxoconcha eichwaldi* LIVENTAL, *Loxocorniculina djafarovi* (SCHNEIDER in Suzin). In the analysed samples, reworked planktonic foraminifers and other fully marine remains as well as well-preserved charophyte gyrogonites have been also found. The ostracod assemblages found in the Messarà Plain belong to the *Loxocorniculina djafarovi* Zone (sensu Carbonnel, 1978), which characterises the uppermost Messinian deposits of the whole Mediterranean Basin. The presence of Paratethyan ostracods in the post-evaporitic Messinian deposits of both Faneromeni and Ano Akria sections suggests that in the latest Messinian Crete Island was affected by sedimentation processes in brackish water palaeoenvironments. The occurrence in the Faneromeni and Ano-Akria sections of vertical changes both in the ostracod assemblages, showing palaeodepth and salinity variations, and in the clastic sedimentary supply suggest an instable late Messinian sedimentary basin, probably affected by tectonics.

BIODIVERSITY CHANGES IN THE PARATETHYAN OSTRACOD ASSEMBLAGES OF THE MEDITERRANEAN BASIN: A NEW TOOL FOR CORRELATING LATE MESSINIAN POST-EVAPORITIC DEPOSITS?

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This paper deals with the biodiversity changes in the Paratethyan ostracod assemblages occurring in some Messinian post-evaporitic deposits of the Adriatic foredeep and foreland domains. Ostracod and foraminifer assemblages from five upper Messinian-Lower Pliocene successions have been studied using qualitative and quantitative approaches and the obtained results have been compared. Four successions from land and subsurface are located in Romagna-Marche area: Montepetra was drilled within the Sapigno syncline, while Perticara section crops out to the east of the same structure; Ca' Blindana drill and Buttafuoco section are located within the Giaggiolo-Cella syncline. The fifth study section (Fonte dei Pulcini) crops out on the southeastern flank of the Majella Mts., near Lama dei Peligni village (Abruzzo, central Italy). The Messinian post-evaporitic succession of the Romagna-Marche basin (north-eastern Apennines) has been subdivided in two units according to their physical features; the lower p-ev₁ unit is mainly fine grained, while the upper p-ev₂ unit is made up of cyclical alternation of coarse and fine grained deposits, micritic limestones ("colombacci") and paleosoils. This cyclical pattern has been tentatively correlated with the astronomical time scale in order to reconstruct a chronostratigraphic framework. P-ev₂ unit should contain 4 and a half astronomical cycles and the fifth one overpass the M/P boundary. All the examined successions (except Ca' Blindana) include the upper Messinian p-ev₂ deposits, the M/P boundary and the Lower Pliocene deposits, in which foraminifer and nannoplankton bioevents of the MPI1 biozone were determined. Finally they have been tuned with the astrochronological timescale proposed for the Romagna-Marche basin. Foraminifer assemblages of Messinian age were studied to test, as many authors suggested, the possibility of the presence of marine environment during post-evaporitic sedimentation. The foraminifer assemblages generally show a wide range of diversity and abundance along the study successions, tests are frequently small sized and sometimes badly preserved; they are often associated with ipohaline ostracods. Thus, even if there are no extinct species, they are considered reworked. Particular attention is given to Montepetra drill, where different assemblages are found at levels from the bottom to the top, whose characteristics avoid to easily get rid of them as reworked. Ostracod assemblages recovered from the p-ev₂ deposits are mainly made of Paratethyan species, including: *Camptocypria* sp.1, *Zalanyiella venusta*, *Caspiocypris pontica*, *Pontoniella pontica*, *Euxinocythere* (*Maeotocythere*) *praebaquana*, *Amnicythere* spp., *Loxoconcha eichwaldi*, *Loxocorniculina djafarovi*, *Tyrrhenocythere ruggierii*, *Tyrrhenocythere pontica*, *Semicytherura pyrama*, *Pseudocythere limata* and *Cyprideis anlavauxensis*. Differences in the composition of the assemblage collected in the study sections have been detected and linked to local palaeoenvironmental conditions. On the contrary, a common trend concerning the assemblage diversity (community structure indexes) has been recognized. In particular, in the p-ev₂ deposits it is possible to recognize three intervals characterized by different biodiversity. Moving downsection from the M/P boundary, these intervals are: 1) interval A, barren of ostracods; 2) interval B, made by rich and diversified ostracod assemblages; 3) interval C, made by scarce and/or oligotypic ostracod assemblages. Interval A seems to correlate with the last half cycle ("strato nero" or correlative deposits). If the occurrence of interval B within the last Messinian precessional cycle will be confirmed, then it could be used as a correlation tool. However, to consider interval B as a useful tool for correlating different p-ev₂ sections we need to evaluate the real significance of this change in biodiversity in other Mediterranean sites, testing it at a Mediterranean Basin scale.

FISH OTOLITHS FROM THE UPPER MESSINIAN 'STRATI A CONGERIE' OF CAPANNE DI BRONZO (PESARO PROVINCE)

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A new otoliths assemblage from the 'Lago-mare' deposits of the Colombacci Formation is presented. The fossils have been collected from the Messinian post-evaporitic clays outcropping near Capanne di Bronzo (Ca' Ciuccio section; Borsetti et al., 1972; Carloni et al., 1974), NW of Urbino. In the area surrounding this locality post-evaporitic (p-ev2 sensu Roveri et al., 1998) terrigenous deposits of the Colombacci Formation (Outer Marche Basin; Montecalvo in Foglia Syncline) are largely exposed, represented by approximately 500 meters of grey clays interbedded with three main sandstone bodies and Colombacci limestone (see Bassetti, 2000). Fossiliferous clays are placed approximately 1 meter below the Mio-Pliocene boundary, several meters above the uppermost Colombacci horizon. The otoliths are associated with abundant gastropods (*Hydrobia*, *Melanoides*, *Melanopsis*) and bivalves (*Dreissena*, limnocoardiids), previously described by Bellagamba (1978). 159 otoliths have been extracted from a 100 kg sample after processing with hydrogen peroxide, drying and sieving. The material is well preserved and morphological structures useful for taxonomic diagnosis are clearly discernible. Representatives of at least four teleostean families have been recognized among the examined material, including: Gobiidae, Moronidae, Myctophidae, and Sciaenidae. Moronid otoliths are by far the most common elements of the assemblage, followed by representatives of the family Gobiidae. The families Myctophidae and Sciaenidae are represented by two taxa each. From a paleoecological point of view, euryhaline fishes are largely dominant suggesting brackish/quasi-marine conditions of the depositional environment (deltaic; see Moleenar & De Feyter, 1985). However, although sharply subordinate, the occurrence of the lanternfishes of the family Myctophidae, which are typical marine stenohaline fishes, indicates the existence of normal marine conditions in the areas close to the depositional environment. These findings confirm and reinforce the evidence described from coeval deposits of Tuscany (Carnevale et al., 2005), providing an unquestionable demonstration that marine reflooding preceded the Mio-Pliocene boundary.

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THE MESSINIAN SALINITY CRISIS AS RECORDED IN THE CROTONE BASIN (CALABRIA, ITALY). NEW STRATIGRAPHIC AND SR ISOTOPES CONSTRAINS

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The Messinian stratigraphy in many areas of the Mediterranean has puzzled scientists since more than 30 years. A new piece of the puzzle comes from the study of the Crotona Messinian sediments that were virtually ignored since the first published study (Ogniben, 1955; Roda, 1964). The Crotona Basin represents the wedge-top basin of the foreland basin system developed on the Ionian side of Calabria (DeCelles and Giles, 1996, Critelli, 1999). The more relevant regional structures are crustal-scale NW-SE shear zones along with other structurally connected lineaments tied to the formation and evolution of the Calabrian Arc. The study area is located in the north-western part of the basin, bounded to the N and W by the basement complex, to the S by the Neto R. and to the E by the Seccata R. The area shows two closely spaced stratigraphic-structural settings. The north-western setting consists of Middle Miocene shallow marine conglomerate deposits of the San Nicola Fm. passing upward into the offshore Ponda Clay (Tortonian) and to organic-rich laminites (Tripoli Fm.) at the Tortonian/Messinian boundary. On top of these sediments conformably lay limestone breccias and gypsarenites, which represent the uppermost rocks cropping out in the north-western area. The south-eastern setting, on the contrary, is characterized by a younger sedimentary chaotic complex consisting of Messinian sulphate and carbonate blocks into an arenaceous-pelitic matrix overlain by latest Messinian arenites, pelites and minor gypsarenites showing a Lago Mare fauna at the top. The overlying fluvial conglomerates (Carvane conglomerates), which reach as well their maximum thickness in the south-easternmost Belvedere di Spinello area, are transgressed by the Early Pliocene offshore Cavalieri Marls. The marls grade upward into the shallow-marine Zinga Molasse (Roda, 1964; Zecchin et al., 2003). Salt diapirs pierce this cover up to various levels: the latest Messinian sediments in the southern area and the Lower Pliocene Cavalieri Marls in the north-eastern area, nearby the Zinga village. Due to its diapiric setting, the stratigraphic position of the salt as, well as its depositional sedimentary features, are not well constrained at present. The marine origin of halite and its relative age are testified by the Sr isotopic ratio (0,708918), which is in the range of the Lower Evaporite in the Mediterranean (Flecker et al., 2002). Halite deposition possibly followed the emplacement of the chaotic complex, which may have modified the basin topography in hydrologically-restricted sub-basins. Another possibility is that the halite deposit is sealed by the chaotic complex. Halite deposition was limited to the basinal areas, while the marginal settings, dominated by primary sulfate (Lower Evaporites), were probably located outside the studied area. The studied gypsarenites (0,708917) show as well the isotopic signature of the Lower Evaporites and thus derive from their dismantlement. One of the source areas was probably the S. Nicola structural high, as testified by the presence of poorly reworked gypsrudites composed of corroded selenite crystals, again showing the isotopic signature of the Lower Evaporites (0,708972). The relationships between primary and reworked evaporites are similar to those verified also for other sulfate clastic settings, such as the Messinian of the Northern Apennines (Manzi et al., 2005).

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MESSINIAN IN TUSCANY: AN APPROACH TO HIGH RESOLUTION STRATIGRAPHY FROM THREE SELECTED SECTION

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In the Messinian Research Program 'COFIN 2003', interdisciplinary studies have been performed on several upper Miocene stratigraphic sections of Tuscany. In this work three sections representative of the middle-upper Messinian interval are discussed. These are: Gello Section (located to the SW of Montecatini V.C.- Pisa), Serredi Quarry Section (located to the NE of Rosignano - Livorno) and Migliarino Section (located to the ENE of Rosignano - Livorno). The first section pertains to the Volterra Basin and the others two to the Fine River Basin. Messinian in Tuscany was an age characterized by a complex evolution. Sedimentation, paleogeography, tectonic style, rapidly changed depending on regional and global factors. The reconstruction of Messinian history in Tuscany was an aim of several authors and many aspects were explained in the past, but now we have the possibility to reconstruct the stratigraphic evolution using a modern approach based on high resolution. Sedimentological, chemical, palaeomagnetic and palaeontological data have been used to recognize milankovich periodicity and tentatively to calibrate three selected sections with the astronomical time scale. The researches are in progress, but we can anticipate that 1) the Messinian salinity crises and the Pliocene transgression realized in Tuscany at the same time of many others Mediterranean areas; 2) evaporitic sedimentation in marginal area was controlled by astronomical periodicity like in the Vena del Gesso Area, 11 cycles pelite-gypsum (deposition is precessionally controlled) are present in Rosignano Area; 3) a regional unconformity encompasses the evaporitic - lacustrine transition; 4) lacustrine sedimentation was characterized from the base by fauna of the Parathethyan realm; 5) volcanic activity was recorded in sedimentary sequence, in fact, two different ash layers have been recognized in the studied sections.

THE MESSINIAN SEDIMENTS OF THE TERTIARY PIEDMONT BASIN (TPB): NEW DATA FROM RECENT GEOLOGICAL MAPPINGS

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Until today, the most detailed description of the Messinian succession of the TPB was that provided by STURANI (1973), at the western border of the Langhe Basin (Alba). He described a "normal" succession, characterized by: a lower "pre-evaporitic" deep-water marine interval, (uppermost part of the S.Agata Fossili Marls=SAF); an intermediate "evaporitic" shallow water interval (Gessoso-solfifera Fm.=GS); an upper "post-evaporitic" brackish interval ("Strati a Congerie"), mapped in the southern TPB as the Cassano Spinola Conglomerates. However, the analysis of geological maps of remaining sectors of the TPB shows that large sectors of it are composed of a chaotic interval, with a "blocks-in-matrix" texture, that has been informally named "Valle Versa Chaotic Complex" (CTV). Owing to these different results, geological mapping and stratigraphic analysis of the Messinian succession of the northeastern edge of the Langhe Basin and of the southern margin of the Torino Hill has been carried out. The recognition and correlation of main regional unconformities has allowed to obtain an updated physical-stratigraphic scheme of the Piedmont Messinian succession. The main prominent results of this contribution can be summarized as follows: 1) The recognition of the limited areal extent of the "Alba-type" normal succession, only preserved in the north-western border of the Langhe Basin. 2) The subdivision of the Messinian succession into three mappable unconformity bounded stratigraphic units, separated by two important discontinuity surfaces (D1 and D2), that record regional phases of tectonic deformation. The lower (Tortonian-Messinian) unit groups the SAF and terrigenous and evaporite (both selenite and "balatino-like" laminated facies) well bedded deposits, that represent the lateral equivalent of the "evaporitic" interval of Alba. For historical reasons, we continue to refer the primary evaporites to the GS. The intermediate unit (upper Messinian) is bounded at the base by the D1, that corresponds to an erosional surface, associated with an angular unconformity, cutting first into the GS and down to the SAF and pre-Tortonian sediments. This unit is entirely represented by the chaotic sediments of the CTV, that consist of resedimented pieces of the GS, and of a wide range of carbonate blocks, floating within a poorly exposed fine-grained matrix. The CTV forms an irregular body, several kms wide and with a maximum thickness of about 250-300 m, that is referable to the "post-evaporitic stage" of the Messinian. The uppermost unit (upper Messinian) is floored by the D2 and consists of fine to coarse-grained terrigenous sediments, correlatable to the "Lago-Mare" deposits, that are here reported for the first time also in the Torino Hill domain. In conclusion, the presented data depict a new sketch for the TPB Messinian stratigraphy, that seems to be better comparable to that reconstructed by ROVERI et al., (2001) in the Apennine foredeep, than to the classical scheme proposed by STURANI (1973), that anyway is still valid for the western marginal sector of the TPB.

THE INTERPLAY BETWEEN MESSINIAN SALINITY CRISIS EVENTS AND FORELAND BASIN EVOLUTION IN SOUTHERN APENNINES THRUST-BELT (IRPINIA-DAUNIA MTS.)

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During Messinian, the southern Apennines thrust belt experienced a period of strong tectonic accretion (related to the "intra-Messinian tectonic phase") and migration of depocenters. The late-Miocene successions cropping out in the northern segment of southern Apennines have a good potential for the understanding of the interplay between Messinian salinity crisis events and foreland basin evolution. An integrated study (detailed mapping, stratigraphy, facies analysis, petrography and strontium isotopes) has been carried out with reference to Messinian units cropping out in Irpinia-Daunia Mts. The local stratigraphy includes: (a) pre-evaporitic thin-bedded euxinic marly clay and diatomaceous marls; (b) evaporitic limestone, crystalline and reworked gypsum (Monte Castello Evaporites); (c) post-evaporitic deposits (T. Fiumarella and Anzano Molasse units), that grade upward into ostracod-rich deposits. The evaporitic and post-evaporitic sequences are separated by an erosional surface that coincides with an angular unconformity. Genetically related gypsum lithofacies of the Monte Castello Evaporites can be grouped into two facies associations. The shallow water association consists of selenitic, acicular, and laminated gypsum. The deeper-water association consists of fine-grained laminated gypsum, gypsarenite and gypsrudite, showing common features of redeposited sediments. Nodular structures in the laminated gypsum occur and are mostly of diagenetic origin. Primary gypsum has $^{87}\text{Sr}/^{86}\text{Sr}$ average value of 0.70898, close to the Sr isotopic value of coeval seawater. The sedimentary evolution during the evaporative phase was characterized by a gradual increase in salinity until gypsum precipitated; then the conditions in the basin were influenced by events of gypsum re sedimentation probably related to flooding episodes and local tectonic activity. The gypsum deposited from mainly marine brines, according to Sr isotopic composition; it could be an equivalent to the Lower Evaporites of the Mediterranean. The T. Fiumarella unit includes lacustrine and alluvial conglomerates, quartzolithic sandstones containing abundant carbonate detritus, shale and reworked clastic gypsum. The Anzano Molasse includes thick bedded deltaic to turbiditic conglomerates and sandstones passing upward to turbidite sandstones and marly-clayey siltstones. Sandstones are quartzofeldspathic with variable proportions of sedimentary (both carbonate and siliciclastic) and plutonic detritus. Volcaniclastic layers, composed of dominantly vitric particles (shards and pumice) are interbedded within Anzano Molasse. The Lago Mare-type deposits are represented by silty-marly clay with Ostracoda shells (*Ilyocypris gibba*, *Cyprideis torosa* and *Candona* sp.) and intrarenite having abundant intrabasinal carbonate particles (ooids, peloids, and bioclast) and subordinate extrabasinal noncarbonate and carbonate particles. The post-evaporitic sequences can be referred to an infilled foredeep basin with a lacustrine environment progressively deepening and submitted to gravity re sedimentation. The studied successions record both the effects of foreland evolution and Mediterranean salinity crisis. The intra-Messinian tectonic phase caused the depocenter migration in the study area just during the salinity crisis. The Monte Castello Evaporites represent an evaporitic deposition in a basin located in the Messinian Apulian foreland region, in contrast with the northern Apennines and Sicilian Messinian evaporitic basins (e.g. Vena del Gesso and Caltanissetta basins), which are referred to thrust-top basins of the Apennine foreland basin system. Post-evaporitic sandstones (Anzano and Fiumarella units) represent late Messinian thrust-top basin infillings located in a wedge-top depocenter of the southern Apennines foreland basin system. Detrital modes testify complex provenance relations from Messinian accreted terranes of the southern Apennines thrust belt.

THE NORTHERN APENNINES PALYNOLOGICAL RECORD AS A CONTRIBUTE FOR THE RECONSTRUCTION OF THE MESSINIAN PALAEOENVIRONMENTS (poster)

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Palynology (pollen and dinocysts) allows the reconstruction of the main palaeoenvironmental changes involving the terrestrial and aquatic ecosystems during the Messinian. The onset of the Mediterranean salinity crisis (MSC) is recorded in the Gessoso-solfifera of the Vena del Gesso (western sector of Northern Apennines). Cyclical humid conditions, corresponding to precession minima, developed during the deposition of the shales interbedded with the gypsum (5.9 Ma to 5.6 Ma); some cooler events took also place under the effects of global (glacial stadials) and regional factors (Apennines uplift). No major changes from moist to dry conditions are attested to just before the salinity crisis, as well as to the south. So climate was not the trigger for the onset of the salinity crisis despite the favourable context provided by inferred thermo-xeric conditions in the south. A drier episode indicated by the expansion of the open vegetation including the northward migration of *Lygeum* postdates the onset of the salinity crisis of about 400 kyr, in the lower post-evaporitic deposits of Maccarone (eastern sector of Northern Apennines). It falls within a period of global warming whereas at a regional scale it could correlate p.p. to the evaporite deposition in deeper basins and to hiatuses in the marginal basins of Sicily and of the western sector of Northern Apennines. Its sudden end, about 100 kyr later, in coincidence with a significant increase of Pinaceae, indicates a turnover in the terrestrial setting not linked to major climate changes; by contrast dinocysts exclude significant modifications in aquatic settings (instauration of either open marine or brackish conditions). In the latter, a later change is marked by the arrival of *Impagidinium* (?) sp. 1., about 7 meters below the first *colombaccio*. This occurrence together with the spread of *Pediastrum* indicates a freshwater dilution i.e. the "Lago-Mare" event during wetter climatic conditions on the adjacent landmass (increase of *Tsuga* and *Cedrus*). The successive arrival and/or dominance of other "Paratethyan" taxa such as *I.* (?) sp. 1-3 and *Galeacysta etrusca* indicate highly variable water environments (marine vs. continental water inputs) during the deposition of the upper post-evaporitic deposits. The Lago-Mare is stratigraphically sandwiched between an ash layer (130 m below) dated at 5.5 Ma and the beginning of the Pliocene where a peak of *Impagidinium patulum* marks the onset of open marine conditions. The dominant humid, subtropical to warm temperate climate indicates differences in both temperature and moisture values with respect to the coeval southern sections, revealing climatic gradients within the Mediterranean, at least from the Messinian. No dramatic vegetation and climate changes have been recorded during the MSC; major changes occurred later as indicated by the palynological record from 2.6 Ma.

EVOLUTION OF THE MEDITERRANEAN WATER BODY DURING THE MESSINIAN SALINITY CRISIS: THE RECORDS FROM MARGINAL BASINS ON SICILY (poster)

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The Messinian Salinity Crisis in the Mediterranean resulted from plate reorganizations in western Tethys, with resulting regional climate change within a framework of eustatic sea level variation. On Sicily, evaporites accumulated in a bathymetrically linked array of variably confined mini-basins developed across an active thrust belt. They famously contain two distinct groups of evaporites (one regressive, one transgressive), separated by a major sequence boundary with associated palaeo-valleys and emergent surfaces. Facies variations in the first cycle evaporites occur over very short (km) distances, correlating with structural position (Calcare di Base on the highs, halite and K-salts in the lows). These indicate that fold growth modulated the isolation of mini-basins generating unique stratigraphies. However, depositional cycles are recognized, especially near anticline crests, manifest by repeated carbonate deposition, in situ halite accumulation, karstification then drowning. The cyclic deposition both in the pre-evaporitic Tripoli laminites and in the Calcare di Base has been calibrated, using magnetostratigraphy, to precession cycles. This provides a very high resolution tool by which to date the onset of hypersaline conditions across the array of mini-basins. Relative sea level fall, manifest by the "first cycle" evaporites (including halite and K-salts) took at least 700ka, with base-level fall of c. 300m and concomitantly diachronous evaporite accumulation through the mini-basin array. Aridity is indicated by the absence of clastic input to the basins. During the regression each mini-basin was linked to, the isolated from, world ocean, as indicated by precession-cyclic base-level variations, faunal assemblages and Sr isotopic composition. Regional low-stand (and Mediterranean-wide isolation from world ocean) happened between 6.0 and 5.5 Ma. There is nothing on Sicily to support the notion of complete desiccation of the Mediterranean. However, following low stand, the central Mediterranean climate became humid, indicated by abundant late Messinian subaqueous depositions that testify to greatly increased run-off. Compared with the regression, transgression was much more rapid (200-300 ka). This returned base-level to above that which recorded world ocean conditions during the regression. These "second cycle" deposits include primary gypsum that show, together with shelly fauna, a reduced 87-86 Sr ratio compared with "first cycle" materials. These are identical between mini-basins - suggesting that local run-off water composition had no influence on the chemistry of basin waters. However, this transgressive water body was not fully linked to world ocean (distinct Sr signature), in common with other parts of the western Mediterranean. The start of the Pliocene (5.3 Ma) is manifest by only a minor rise in base-level on Sicily (although it represents a dramatic change in the biology and chemistry of the water body), indicating that the Mediterranean was largely filled prior to a renewed connection to world ocean.

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THE LATE MESSINIAN LAGO-MARE EPISODE OF THE MEDITERRANEAN BASIN: INSIGHT FROM AN INTEGRATED MULTIDISCIPLINARY ANALYSIS OF THE FONTE DEI PULCINI SECTION (CENTRAL ITALY, MAJELLA MTS.) (poster)

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In the external Abruzzi area (Majella Mts.) the post-evaporitic upper Messinian deposits are mainly characterized by hypohaline ostracod-bearing pelites and subordinately by medium- to coarse-grained deposits, which rest above resedimented evaporites (p-ev₁). On the southeastern slope of the Majella Mts. uppermost Miocene-Lower Pliocene deposits extensively outcrop. At Fonte dei Pulcini, between the villages of Taranta Peligna and Lama dei Peligni, the post-evaporitic succession of the Majella Mts. is well exposed. From the base to the top, it consists of: 1) resedimented evaporites (uppermost Messinian); 2) fine- and coarse-grained deposits (uppermost Messinian); 3) Lago-Mare clays (uppermost Messinian); 4) Taranta Peligna clays (lower Zanclean p.p.); 5) Majella flysch (lower Zanclean p.p.). The Messinian post-evaporitic deposits have been sampled and studied along two subsections: 1) Fonte dei Pulcini A and 2) Fonte dei Pulcini B. This paper deals with the integrated multidisciplinary analysis of the Fonte dei Pulcini A section, through the quantitative analysis of: 1) ostracods; 2) nannofossils; 3) CaCO₃ content, 4) clay minerals; 5) magnetic susceptibility. Moreover, qualitative analyses on the occurrence of pollen grains and dinoflagellates have been performed. Fonte dei Pulcini A section entirely belongs to the Lago-Mare clays and has been sampled along a new road-cut of the S.P. Frentana. A 50 cm regular-spaced sampling has been performed in the uppermost 53 m of the upper Messinian Lago-Mare clays. From this section 107 samples have been collected (FP1-FP107). The ostracod assemblages found in the post-evaporitic upper Messinian deposits contain Parathetyan immigrants such as: *Amnocythere palimpsesta*, *Amnocythere gubkini*, *Amnocythere aff. A. schweieri*, *Amnocythere idonea*, *Euxinocythere (Maetocythere) praebaquana*, *Loxocorniculina djafarovi*, *Loxoconcha (L.) ?ludica*, *Loxoconcha muelleri*, *Caspiocypris aff. C. pontica*, *Camptocyprina venusta*, *Camptocyprina sp.*, *Cyprideis aff. C. tuberculata*, *Cyprideis spp.*, *Pseudocythere limata*. Only reworked forms characterise the nannofossil assemblages in all the analysed samples. In particular, four groups of reworked nannofossils have been distinguished on the basis of their stratigraphic range: 1) Cretaceous, 2) Paleocene - Oligocene p.p., 3) Oligocene p.p. - Early Miocene and 4) long-ranging species. This latter group comprises species, whose wide stratigraphic range spans the latest Messinian. In the Fonte dei Pulcini A section, the Messinian clays are characterized by the presence of high values of smectites, which ranges from 60% up to 80%. Similar smectite percentages have been computed in the Messinian clays from the ODP sites of the central-western Mediterranean Basin. In the Fonte dei Pulcini section, different pattern of cyclicity have been recognized both by field observations and spectral analyses computations. Spectral analyses have been done on different parameters such as: 1) frequency of well-distributed ostracod species; 2) % of CaCO₃ content; 3) % of detrital grains; 4) % of different clay minerals; 5) magnetic susceptibility. Besides the 1000 cycles/m and 100 cycles/m frequencies observed in the field, spectral analyses indicated other high-frequency cyclicities: 0.47 cycles/m; 0.35 cycles/m; 0.17 cycles/m. Taking into account the estimated sedimentation rate, these frequencies correspond, respectively, to periodicities of: 1 year, 10 years, 2.1 ky; 2.8 ky and 5.6 ky. These sub-Milankovitch cyclicities have been related to annual and sunspot solar activity. Besides these sub-Milankovitch cyclicities, the vertical change of the magnetic susceptibility has also revealed a precessional signal. The astronomical tuning of the Fonte dei Pulcini A section with the Laskar 2004 insolation curve shows that the study section encompasses the last two late Messinian precessional cycles.

THE UPPERMOST MESSINIAN AND THE MIOCENE-PLIOCENE TRANSITION IN TUSCANY: THE SUCCESSION OF CAVA SERREDI (FINE RIVER BASIN) (poster)

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The succession of Cava Serredi has been studied along artificial cuttings of an active brick clay quarry. The succession, about 160 m thick, has been detailed described and sampled. On the whole more than 800 samples have been collected in order to carry out qualitative and quantitative micropalaeontological investigations (foraminifers, ostracods, calcareous nannofossils, pollens), magnetic susceptibility, calcimetric and colorimetric analyses. Paleomagnetic investigations have been performed only on the Pliocene portion of the succession, the Miocene sediments being referable on the basis of literature data to Subchron 3r. From a lithological viewpoint the succession can be divided into three intervals. - The lower interval (25 m thick) consists of yellowish or grey laminites interbedded to thin layers of fine sands with evident tractive structures. A 1,5 cm thick, well preserved ash layer is present at about 10 meters from the base. - The middle portion, characterized at the base by a conglomeratic level filling erosive pockets, comprises pelites with centimetric levels of sands deposited by unidirectional tractive currents, sandy-conglomeratic bodies, paleosoils, carbonate levels and pyrite or gypsum rich layers. These different lithotypes are cyclically organized into characteristic facies. - The uppermost interval consists of massive grey-blue marls (Pliocene Auct.) and it is separated from the middle portion by a dark horizon with high sulphides content. The macrofossil content includes rare imprints of fishes in the lower interval, remains of molluscs such as *Dreissena*, *Melanopsis*, *Teodoxus* and other small gastropods in the middle interval and, finally, common centimetric fossil traces and molluscs shells in the Pliocene portion. Microfossils from the lowermost part of the succession include only very rare brackish ostracods. In the upper part of the lower interval the ostracods faunas become locally very rich and comprise mainly *Candona* specimens; a single sample revealed the occurrence of taxa characteristic of the *Loxoconcha djafarovi* Zone. In the middle interval completely barren samples alternate with very rich microfaunas. The associations, which are dominated by ostracods pertaining to *Candona*, *Amnicythere*, *Euxinocythere*, *Loxoconcha*, *Cyprideis* and include rare benthonic foraminifers such as *Ammonia tepida*, *Bolivina parolica* and a small *Discorbidae*, indicate oligohaline to mesohaline water conditions. Calcareous plankton recovered in this interval have been interpreted as reworked. Microfaunas of the upper interval consist mainly of planktonic and benthonic foraminifers and calcareous nannofossils. The rich and well diversified assemblages document a rapid drowning with a depositional environment which reached bathymetry referable to the outer neritic-upper epibathyal zone. From a biostratigraphical viewpoint the poor ostracods assemblages recovered and the still in progress analyses of the ash layer cannot at present supply reliable age constraints for the lowermost part of the investigated succession. Conversely, the upper part of the lower interval and the middle interval can be confidently referred to the *Loxoconcha djafarovi* Zone for the occurrence of typical ostracods assemblages. The upper part of the succession is referable to the lowermost Pliocene, notwithstanding that paleomagnetic analyses provided untrustworthy data. Particularly, the limit between the middle and upper portion of the succession is correlatable to the Miocene-Pliocene boundary, since the immediately overlaying sediments are characterized by two intervals yielding left-coiling *Neogloboquadrina acostaensis* which mark the base of the Pliocene. Forthcoming further investigations particularly on lithological cyclicity (which has been attested by some preliminary analyses) and age of the ash layer together with data available for the Miocene-Pliocene boundary will allow a calibration of the succession with the astronomical time scale.

MESSINIAN DEPOSITS OF THE NORTH SARDINIA-NORTH TYRRHENIAN SEA AREA

(poster)

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The North Sardinia-Corsica Basin and Tuscan Shelf system underwent to a similar tectonic evolution since the early Miocene time. Basins formed due to the extension occurred on the back of the neo-forming Apennines chain. However, some differences in sedimentation and evolution can be traced out. These can be underlined following an ideal transect from the western Asinara Gulf (to the eastern Tuscan Shelf. Aim of this work is to present similarity and differences of sedimentation along the transect focussing in the late Miocene-early Pliocene interval. North Sardinia: Asinara Gulf. The basin is characterised by a suite of NW-SE oriented half graben filled by a thick (about 3.000 m), mainly marine shallow water, Neogene-Quaternary succession. Sedimentation was mainly controlled by tectonic up to the late Miocene (Tortonian). Messinian strata are only represented by valley fill deposits interpreted as the lowstand deposits of the early Pliocene transgression. Valleys are still preserved on the North-Sardinia coast and can be followed down to the Asinara Gulf up to the Balearic Sea where thick salt deposits formed evident diapirs. No evidences have been found to document a connection during Messinian between the Asinara Gulf and the North Tyrrhenian Sea suggesting the presence of a prominent high separating the two areas. North Tyrrhenian Sea: Corsica Basin. The basin is a N-S oriented half graben filled with more than 4.000 m of Neogene-Quaternary marine and continental deposits. Faults controlled sedimentation in the basin up to the late Miocene (Tortonian). Messinian strata are well recognizable, and the intra Messinian unconformity related to the Mediterranean salinity crisis is normally associated to a well marked continuous reflector. Valleys on the eastern side of the basin are also quite common. No diapirs have been recognised throughout the whole Corsica Basin, and seismic reflectors referred to the late Messinian deposits are well defined and continuous at the basin scale. This suggest that no thick evaporite deposited in the Corsica basin and that its evolution was much more similar to that of western Tuscany than Balearic. North Tyrrhenian Sea: Tuscan Shelf. It is characterised by a suite of N-S to NW-SE oriented half graben basins. They are filled with more than 2.500 m of Neogene-Quaternary marine and continental deposits. Faults controlled sedimentation up to early Pliocene. The intra Messinian unconformity is always well recognizable as well as the early Pliocene transgressive surface. Seismic reflectors referred to Messinian deposits can be subdivided into a lower and upper part. The lower is represented by downward concave to chaotic reflectors, whereas the upper part by well defined, horizontal and continuous at the basin scale reflectors. The lower part appears for some aspects similar to the resedimented evaporites as defined in the Adriatic side of the Apennines, whereas the upper part can be associated to the alternate clay-sand typical of the lago-mare interval. The study as underlined that in the Messinian the Asinara Gulf evolved as the proximal landward part of the Balearic Basin where a thick evaporitic succession deposited. At this time no connection there were between Balearic and North Tyrrhenian Sea. Corsica Basin and Tuscan Shelf (North Tyrrhenian Sea) had a similar sedimentary evolution with a thin evaporitic succession followed by a relatively thick post evaporitic (lago-mare) one. In the Tuscan Shelf, tectonic activity allowed the deposition of resedimented evaporites.

FINE, VOLTERRA AND ELSA BASINS: TWO KEY AREAS TO UNDERSTAND THE MESSINIAN EVOLUTION OF THE WESTERN SIDE OF THE NORTHERN APENNINES

(poster)

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Tuscany represents the western inland part of the Northern Apennines and is characterised by a suite of NW-SE oriented basins separated by ridges. Basins developed since Miocene time in a general extensional regime. They are filled with 2-3.000 m thick Neogene-Quaternary deposits. Three of the most important depressions the Fine, Volterra and Elsa basins, represent an ideal transect along which understand the Messinian evolution of the western side of the Northern Apennines. These basins are separated by a continuous elongated ridges, the western Perityrrhenian Ridge and the eastern Middle Tuscany Ridge. The last one is an important morphological and structural high that controlled sedimentation in Tuscany during Neogene and Quaternary. Six major unconformities all but Seq 4, recognised both on seismic and outcrop have allowed to distinguish seven unconformity bounded Neogene units (1-7). The older Seq 1 is represented by shallow marine deposits referred to late Serravallian-early Tortonian. Deposition of this unit occurred in wide basins probably during a pre-narrow rift phase. Seq 2 deposited during the narrow rift phase in normal faults controlled sedimentary basins (triangular shaped) and it is characterised by late Tortonian continental fluvio-lacustrine deposits. West of the Middle Tuscany Ridge, the continental deposits were in turn followed by early Messinian brackish to marine sediments of Seq 3. To the east, instead, marine conditions never established and continental deposits are only capped by brackish one. Moreover, Seq 3 is not distinguishable from Seq 2. The brackish event at the base of Seq 3 is considered the eastern inland equivalent of the marine environment developed westward in the neo-forming Tyrrhenian Sea. Deposition of Seq 3 occurred during a general, probably thermal, subsidence that followed the narrow rift phase. This phase allowed the expansion of the basins outside the previous faulted margins. Local tectonic uplifts are however recognised as well at the new basin borders (i.e. conglomerate at the boundary brackish-marine deposits). Seq 4 is still early Messinian and corresponds to the marine and evaporitic environment associated with closure of the Mediterranean Sea -- Atlantic Ocean communications. The following late Messinian Seq 5, west of the Middle Tuscany Ridge, developed during the Mediterranean salinity crisis. East of the Middle Tuscany Ridge, although still under continental conditions, a prominent unconformity allowed to recognise the eastward equivalent of the post-evaporitic Seq 5. During the late Messinian subsidence was continuous and mainly tectonic with normal faults controlling deposition in the basins (new narrow rift phase). However, the presence of some conglomeratic bodies into Seq 5, interpreted as valleys fill deposits, is the local response to the uplift of western Tuscany due to the emplacement of granitic pluton at shallow depth. The following early Pliocene transgression is responsible for the deposition of Seq 6. It developed under marine conditions in basins locally controlled by normal faults. The upper marine Seq 7 ends the Neogene deposition in Tuscany and marks post-rift conditions.

MESSINAN CHAOTICS: DISTRIBUTION AND SIGNIFICANCE OF LARGE-SCALE MASS WASTING BODIES IN THE MEDITERRANEAN AREA (poster)

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Large scale submarine mass wasting deposits, exceeding hundreds of meters of length and width and a ten of meters of thickness, are a recurrent character of sedimentary successions. Their distribution in the Mediterranean mainly follows the circum-Mediterranean chains and spans in age from Precambrian to Quaternary (Camerlenghi and Pini, 2005). They can be of both intrabasinal and extrabasinal composition, made up of rocks and non-consolidated sediments, and are related to various processes, such as block slides, slumping and debris avalanches and flows. These deposits have been defined, therefore, with various terms in the geological literature, such as slide, (mega)slump, olistostrome, olistoliths accumulation and field, olistolithic flysch, wildflysch and sedimentary melange. Some of these terms point out the general stratally disrupted to chaotic aspect of these bodies at the outcrop observation. Recent works show that submarine instability played an important role in defining the present-day sedimentological characters and the structural setting of the evaporitic succession cropping out in the Northern Apennines, Sicily and Spain (Roveri et al., 2003 and in progress). Moreover, the majority of the chaotic bodies by mass wasting accumulation buried beneath the Po Plain occurs into seismic units of Messinian age and involves evaporitic rocks (Argnani et al., 2003; Artoni et al., 2004). Finally, the classic olistostromes in Sicily are associated to Messinian successions. Mass wasting bodies seem, therefore, to be of particularly importance in the Messinian, in association with the evaporites. This has been confirmed by a detailed study of the distribution of large-scale mass wasting bodies during the Miocene in the Apennines and Sicily: their distribution is not continuous through time, but appears to be concentrated in well defined stratigraphic intervals. In these intervals, large mass wasting deposits occur almost contemporaneously in different parts of the foreland basins, suggesting regional scale instability of the entire accretionary wedge-foredeep system (Lucente and Pini, 2003). As far as the Messinian is concerned, large mass wasting episodes are concentrated in the post-evaporitic interval, even if in some cases they are associated to the continuation of instability processes onset in the lower Messinian (Artoni et al., 2004). Messinian examples derive from a wide range of mass wasting processes, spanning from gliding of blocks to slumping of beds and bed packages of clastic gypsum, avalanches of gypsum blocks and to muddy debris flows (olistostromes). This and the unusually widespread occurrence of Messinian chaotic bodies are probably related to the activation of thrust and wedge fronts during an important tectonic phase (intra-Messinian phase), associated with a chronic instability of submarine slopes due to the presence of already consolidated rocks (gypsum) resting on non-consolidated and wet, fine-grained pre-evaporitic deposits. Other triggering effects can be related to variation of sea level and to destabilization of gas-hydrates. The contribution of mud volcanism and diapirism has been recently suggested (Festa et al., 2005) and might be a concomitant triggering mechanism. The distribution and characters of mass wasting deposits and the different genetic hypotheses will be discussed in this communication.

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SEQUENCE STRATIGRAPHY IN THE MESSINIAN DEPOSITS OF THE CROTONE BASIN (CALABRIA, ITALY) (poster)

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Surface geology of the Crotona Basin (CB) was described over forty years ago by the first of three authors. In the area of Timpa del Salto, NW corner of the CB, Messinian rock salt has been exploited in a Solution mine since 1968. Over sixty wells were drilled in the mining area, some of which were continuously cored. Geophysical logs, particularly gamma ray and sonic log, were performed in all drilled wells. The contact between Messinian and Lower Pliocene deposits is not shown by wells. This because Messinian sediments are cut by the transgressive Spartizzo Formation, a lagoonal deposit of Middle Pliocene age. Analysis of wells of the northern area of the mine allows us to make some generalizations about the detailed sequence stratigraphy of the Messinian deposits in the CB: The Messinian deposits consist of three sedimentary sequences, which form the First order Evaporitic Cycle (FEC). The Lower sequence comprises, from the base to the top: Tripoli Formation, and Lower Evaporite Formation culminating with an halite layer (Third rock salt layer Member). This sequence is a regressive one with diachronous contacts between lithotypes. The Middle sequence comprises: clastic lithotypes and two thick salt layers, which form the Clastic-Saline Formation. The bottom Member, "Quattro strati di anidrite" (Four anhydrite layers), has a transgressive contact with the Lower sequence. This Member is very regular in thickness and easily recognisable in seismic sections. The top Member, "Primo banco di salgemma" (First rock salt layer), is formed by repeated sedimentary sequences; the most distinctive are: a. rudite which grades to lutite with clasts of anhydrite; b. nodular anhydrite which grades to clay with nodules of anhydrite, and then to clay without anhydrite; c. laminar anhydrite, rock salt with anhydrite nodules, and pure rock salt. The Upper sequence comprises: the Upper Evaporite Formation, formed of anhydrite layers interbedded with clay; layers are grouped in five members, in three of which (a1, a2, a3) clay layers prevail, whereas in the other two (A1, A2) anhydrite layers prevail. The Upper sequence is transgressive and locally unconformable on the Middle sequence. The sedimentary sequences recognized in Messinian deposits of the CB are very similar to those observed in Sicily. This allows us to consider these sequences as a product of more general controls than local tectonics.

THE ADRIATIC FORELAND RECORD OF MESSINIAN EVENTS (CENTRAL ADRIATIC SEA, ITALY) (poster)

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Commercial wells and seismic data made available by Eni-Agip and their integration with the successions outcropping along the coastline in the Gabicce promontory and in the M. Conero area allow to extend the evolutionary model proposed in the last years for the Messinian inner and central Apennine foredeep system to outer foredeep and foreland ramp settings. Primary evaporites, consisting of thick-bedded, cyclically stacked, selenites are only found in the offshore area. They show typical seismic and well-log signatures and are distributed along parallel, narrow belts, oriented NNW-SSE, corresponding to small extensional basins which started to form during the Tortonian, as suggested by the converging geometry of pre-evaporitic strata. Seismic geometries also suggest that primary evaporites formed in shallow-water semi-closed basins; they are cut on top by an erosional unconformity characterized by a strong seismic reflector, corresponding to the widespread Messinian erosional surface (MES). 3D seismic images of the gypsum top document the occurrence of both canyon-like and slump scar features, which probably formed in different times. The MES can be traced basinward (i.e. to the west) into a correlative conformity at the base of a resedimented evaporites complex observed in outcropping successions, where pre-evaporitic deposits have a deep-water character. Pliocene hemipelagic and turbiditic deposits progressively younging eastward lap onto the MES in the offshore area. Up to 300 m thick siliciclastic post-evaporitic deposits overly the resedimented evaporites in the outcrop area; both deposits thin out very rapidly toward the east against the MES. Like in the inner and central foredeep areas, post-evaporitic deposits can be split in two units: the lower one (p-ev₁) is made up of turbidites and unstable slope deposits (S. Donato Fm.), the upper one (p-ev₂) consists of shelf to coastal deposits characterized by a well-developed cyclical alternation of coarse and fine-grained lithosomes, containing thin lacustrine limestones layers ("*colombacci*"), allowing high-resolution regional-scale correlations. The Miocene/Pliocene transition consists, as usual, of a sharp transition to relatively deep marine deposits of the MPI1 zone; a notable exception occurs in the M. Conero area where the topmost Messinian deposit consists of a biocalcarenic lithosome ("Trave calcarenites") overlain by a thoroughly bioturbated and reddish horizon, here interpreted as a firmground, just below MPI3 Pliocene thin-bedded turbidites, thus suggesting a Late Messinian embryonic growth of the M. Conero structure as a intrabasinal high. Summarizing, the Late Miocene to Pliocene tectono-sedimentary evolution of the Central Adriatic area shows a progressive transition from a foreland ramp setting during the Late Miocene to a central foredeep during the Early Pliocene due to the eastward migration of the compressive front. Starting from the Late Tortonian an important thrusting phase in the inner foredeep was accompanied by the activation of extensional features on the foreland ramp, which hosted primary evaporite precipitation during the Messinian; this poli-history deformational phase culminated with the intra-Messinian pulse which led to the formation of a new foredeep depocenter along the present-day coastal belt and to the westward tilting of the inner foreland ramp, thus promoting large-scale collapse of primary evaporites. The main thrust front locally propagated along the ramp, leading to the inversion of former extensional structures and to the growth of intrabasinal highs (M. Conero). The observed erosional features associated to the MES probably formed in subaqueous settings over a prolonged time interval encompassing large part of the Early Pliocene, during which the foreland ramp acted as a transfer zone for small-volume gravity flows feeding the main foredeep from minor sediment sources.

A MESSINIAN DOLOMITIC OUTCROP NEAR SALICE, MESSINA (PELORITANI MTS): STRATIGRAPHIC, MINERALOGICAL AND CHEMICAL DATA (poster)

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Some peculiar stratigraphic, mineralogical and geochemical aspects of a messinian dolomitic level near Salice (Messina) are discussed after the previous paper of Maccarrone et al. (2000). Said level outcrops on the opposite flanks of a narrow gorge of the "Torrent Tarantonio" north-west of Messina on the Tyrrhenian sea-side of Sicily, in the nearby of Contrada Mitto next to the village of Salice. The area distribution of dolomitic outcroppings is less than 1 square km with a length of about 850 m and a thickness of 20-25 meters. These levels show a light dip to west and lie discordantly and in wedge-type, above a pre-messinian substrate made of molasses and metamorphic deposits belonging to the high grade metamorphites of the Aspromonte Unit. Dolomite levels are metrically layered, massive in shape with surfaces either smooth either covered with hollows centimetric in size. This exposure is interested by a complex fracture network, metric in size, and only in rare cases in smaller decimetre-size rock polyhedral fragments. Under percussion often give strong tonality and show high tenacity: it shows apparent high crystallinity, and a variety of chromatic effects ranging from pale green to blue and from white to deep pink. The internal structure is often massive with typical small bubbles irregularly shaped. In the less massive levels, on the fresh cut are powdered with a spongy-like structure very similar to the "Calcere di base Auct.", the so-called "perciulato" (spongy). At a lesser frequency, very fine lamination plane parallel and crossed are observed similar to stromatolites. Cavities decimetric in shape, with undulate directions, filled with green to orange red fine laminated silts together with black oxide (probable hard-ground) are observed too. To the top and side of the formation, dolomitic layers promptly change to the pinkish white "calcere di base", often milled. This quick passage is marked with a decimetric silt-clay level brown to yellow coloured, along which cargo prints are observable. The sequence is closed by messinian sandy deposits and by the overlying marly limestones of the lower Pleistocene (Trubi formation). Mineralogical XRD investigations have shown high percentages (> 97%) of dolomite showing high crystallinity. Optically two distinct textures are discernible: a first with euhedral crystals variable in size showing typical triple equiangular junctions, and a second one with rare euhedral crystals associated to large pitted areas with undefined grain boundaries. In both cases into euhedral crystals, restitic nuclei, often carbonatic, are discernible. At the scanning electron microscope barium and strontium sulphates with anhedral habit, sometimes intergrown into dolomite, have been observed. The investigated outcropping appears chemically inhomogeneous particularly regarding strontium content. Dolomite layers show a much reduced strontium content comparing the similar into the "calcere di base" (1700 ppm versus 20700 ppm). Stratigraphic data as well as sedimentary structures observed, show an inter-sub-tidal plane formation environment. On the basis of mineralogical, petrographical and stratigraphic data this dolomite outcropping is locally interpreted as part of an evaporitic sequence. Investigations are in progress in order to better define this first occurrence of dolomite levels in the Messinian sequences of the north Peloritani Mountains.

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