



COCARDE Workshop and Field Seminar
Sicily, 23-27 September 2013

**Bridging off-shore and on-land research on carbonate
mounds: common concepts and techniques**

Buildups from Sicily: Triassic to Quaternary examples

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Report





Science Meeting – Scientific Report

Proposal Title: *Bridging off-shore and on-land research on carbonate mounds: common concepts and techniques – Buildups from Sicily: Triassic to Quaternary examples*

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1. Summary

The itinerant COCARDE Workshop 2013, held in Sicily from the 23rd to the 27th of September, gathered scientists interested in carbonate build-ups, from academy and industry, in order to promote and facilitate the collaboration between the scientific communities studying ancient and modern carbonate mounds. The event aroused great interest among junior and senior carbonate experts from different specialty areas. The meeting was attended by forty scientists belonging to several academic and industrial institutions from Europe and beyond (Appendix 1). Among them, six young scientists were awarded with a research grant assigned in a competitive context to fully cover their participation in the event.

After a short introductory set of presentations, held at the Botanical Garden of the University of Catania on the 23rd of September, the participants attended a two-and-a-half-day field seminar, during which they visited representative carbonate outcrops from Sicily. The field trip included stops at well exposed buildups formed in different paleoenvironmental settings and ranging in age from Triassic to Pleistocene. On September 26-27th, an intensive workshop hosted presentations on ancient-to-modern mound typologies aimed at crossing cultural borders between offshore and on-land carbonate research. The first workshop day took place in the countryside, close to Siracusa (Carlentini), the second and last workshop day was held at the University of Catania. Post-dinner debates, animated by young scientists at the end of each fieldwork day, and two main roundtable discussions aimed at defining the scientific purpose and the data structures of the COCARDE mound database currently in progress.

The workshop and field seminar were co-organized by two supporting institutions of the ESF COCARDE Research Networking Programme: the University of Milano-Bicocca (Daniela Basso, Agostina Vertino) and the University of Catania (Antonietta Rosso). The field seminar was led by the workshop conveners in collaboration with Rosanna Maniscalco, Rossana Sanfilippo, Francesco Sciuto, Giovanni Sturiale (University of Catania), Pietro Di Stefano, Angelo Tripodo (University of Palermo), Marco Taviani (CNR – ISMAR, Bologna), and Barbara Cavalazzi (University of Bologna).

2. Description of the scientific content and discussions at the event

One of the main goals of the workshop was to promote the collaboration between the scientific communities working on ancient and on modern carbonate buildups by identifying common protocols for the settlement of an integrated database. For this purpose the itinerant meeting hosted key presentations which encompassed a range of topics related to Geosphere-Biosphere coupling in fossil and recent environments, as well as visits at a variety of carbonate build-ups from upper Triassic to Quaternary.

The meeting started in Catania, at the Botanical Garden (Department of Biological, Geological and Environmental Sciences), in the morning of the **23rd of September**, with a brief speech of welcome to the participants delivered by the Rector of the University of Catania and an introductory presentation by the meeting conveners on aims and expected results of the workshop. Afterwards Silvia Spezzaferri (COCARDE-ERN Chair) and Jean-Pierre Henriet summarised the history, goals and achievements of the COCARDE network. Originally focused on modern cold-water coral mounds, COCARDE aims nowadays to integrate and compare studies on modern and ancient carbonate mounds formed in warm-, cold-water and extreme (e.g. high-T and hypersaline) environments, through scientific drilling research on land and at sea. An example of extreme and frontier carbonate system was introduced by Jacques Varet during his speech on the AFAR geology. The second half of Monday morning was devoted to short presentations by six young scientists (Master students: Eline Feenstra, Ane Elise Schroeder, PhD students: Giovanni Coletti, Michal Jakubowicz, Aaron Lim, and Post-Docs: David Jaramillo) awarded, in a competitive context, with a grant for the participation in the workshop and field seminar. They shortly summarised their scientific interests within the COCARDE network and the main results of their research dealing with: interactions between marine nutrient availability and benthic communities in the fossil record (Coletti); stable isotope chemistry of fluid inclusions in cold-water coral skeletons (Feenstra); venting- and seepage-derived mud mounds and related authigenic buildups (Jakubowicz); early diagenesis processes in buildups from shallow-, deep- and extreme waters (Jaramillo); habitat zonation model of modern cold-water coral mounds (Lim) and paleoecology of deep-water brachiopods, from late Cretaceous soft bottoms to Danian coral mounds (Schroeder).



After brunch, the participants left for Messina to visit one of the best exposed fossil cold-water coral deposits known so far (Vertino 2014): the Pleistocene outcrop of La Montagna (Fig. 1). Agostina Vertino shortly introduced the geology of the area, the sedimentological and palaeontological features of the outcrop and its palaeo-environmental interpretation, triggering discussions about the origin of the CWC coral rudstone (see also Appendix 4d and chapter 3).

Fig. 1. La Montagna: a. View of the Messina Strait from the outcrop; b. Short introduction about the Messina Strait geology and Quaternary deposits; c. Western part of the cold-water coral outcrop; d. Detail of a colony of *Lophelia pertusa*.

Tuesday 24th was devoted to two field seminars, the first one held on the Madonie Mountains, the so-called "dolomites of Sicily", and the second one in the surrounding of the village of Roccapalumba. The Madonie field seminar was led by Pietro Di Stefano that, after an extensive introduction on the geological evolution of the area and its Upper Triassic to Miocene sedimentary succession, guided the participants to two well exposed buildup outcrops: the Upper Triassic sponge reef at Piano Battaglia (e.g. Senowbari-Darian et al. 1982; Di Stefano and Senowbari-Daryan 1985) and the Upper Jurassic coral framestone cropping out in the vicinity of Rifugio Marini (for more details, see Appendix 4d).

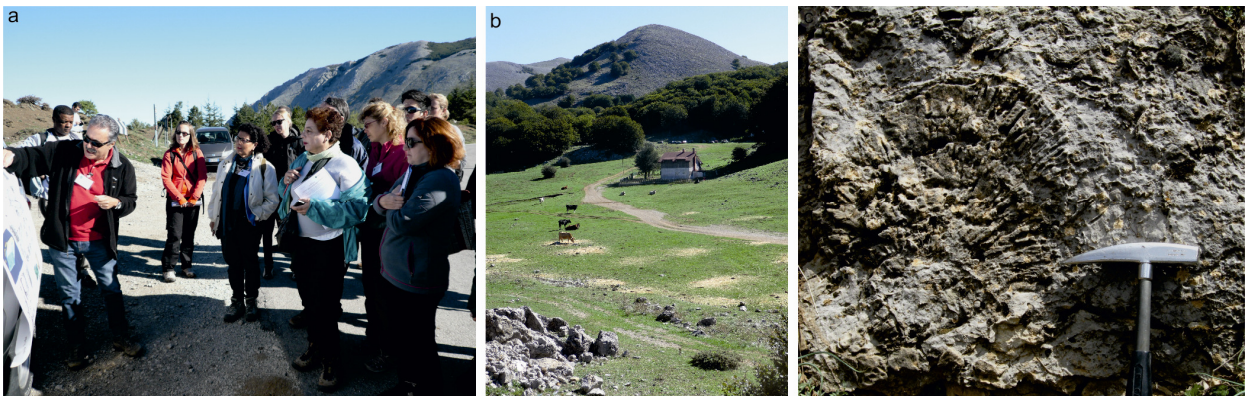


Fig. 2. Madonie Mountains: a. Pietro Di Stefano introducing the participants to the geology of the area; b. Typical landscape of the Madonie Mountains (Piano Battaglia); c. Upper Jurassic coral colony (Rifugio Marini).

After visiting the archaeological and geological "Museo Civico A. Collisani" in Petralia Sottana, guided by the local geologists Alessandro and Fabio Torre, and having lunch in a typical "trattoria" of the Madonie area, the COCARDE group continued the itinerant field seminar moving to Roccapalumba. In this area, Marco Taviani, Barbara Cavalazzi and Angelo Tripodo led a field seminar about a *Lucina* limestone, interbedded in the Numidian Flysch and belonging to a chemoherm complex made up by quartzarenitic turbidites, microbreccias, hemipelagic marls and limestones (Tripodo 2000, Vai et al. 2003, Cavalazzi 2007). This succession contains obvious

imprints of deep-submarine cold-fluid seepage under the form of authigenic carbonates, chemosynthetic microbial signatures and fabrics and specialized chemosymbiotic biota (e.g. common lucinids, often still articulated). More information about this outcrop can be found in Appendix 4d.

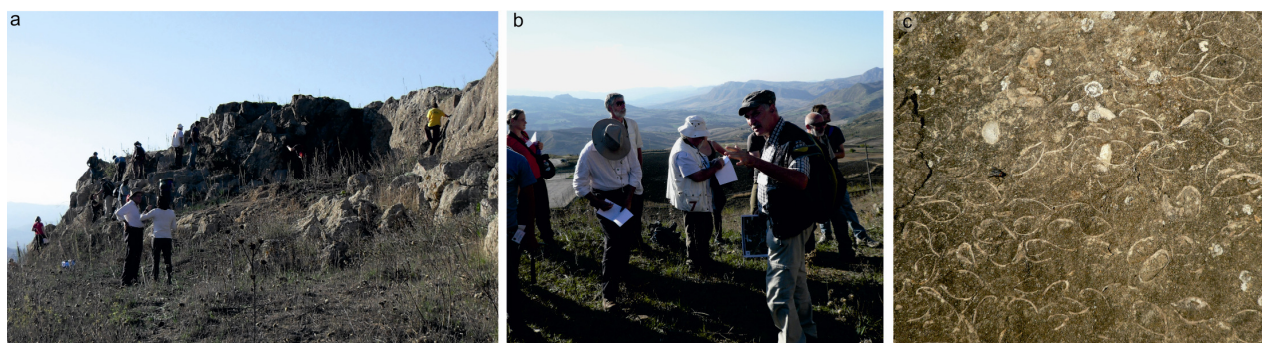


Fig. 3. Roccapalumba: a. Observations and discussion at the *Lucina* limestone outcrop; b. M. Taviani introducing the participant to fossil chemoherms; c. Detail of the outcrop with articulated lucinids.

The scientific day ended in the Villa Dafne agriturismo (close to the village of Alia) where, after dinner, the participants took part in a discussion, led by three young scientists (Giovanni Coletti, Aaron Lim and David Jaramillo), about the geological interpretation of the outcrops visited during the two days. In particular, the debate regarding the Pleistocene cold-water coral outcrop from La Montagna focused on the following questions, raised during the field trip: which is the origin of the cold-water coral rudstone? Was it a result of an *in situ* growth of a deep water community in a current-swept environment, was it an accumulation of transported material moved by currents to its final burial location or was it a combination of both processes? Most participants agreed that palaeocurrents could have had enough energy to move small skeletal grains but not large coral colonies or frameworks (over 40 cm²), such as the ones locally preserved in the visited outcrop. Moreover, the preservation degree of the material suggested a very short transport. Evidence of shallow-marine material (e.g. coralline algae), locally rather common, scattered within the deep water deposit was explained by the field trip guides by taking into account a reduced littoral plain bounded by steep (active) fault escarpments. Concerning the Roccapalumba outcrop, questions were aimed at the determination of potential mechanisms producing the deposition of pluri-metric sequence without resulting in self-sealing of the seepage. The general conclusion was that, although knowledge of the thickness of contemporary active chemoherms is incomplete, the high porosity and permeability of the embedding material may have been enough to allow fluid seepage throughout the structure. It was suggested that coring of this deposit with analysis of porosity might confirm this interpretation.

On **Wednesday, 25th**, the participants visited other two exceptionally well preserved carbonate outcrops: the Upper Miocene coral reef from Balza di Rocca Limata (Caltanissetta Basin) and the Pleistocene algal-bryozoan limestones from Augusta (more information about the outcrops can be found in Appendix 4d). The field seminar in the Caltanissetta Basin was led by Rosanna Maniscalco and Giovanni Sturiale who exposed the main geological features and tectonic evolution of the basin. Moreover they guided the participants during the visit at the impressive coral reef cliff at Balza di Rocca Limata, containing huge *in situ* coral colonies (Fig. 4a), and at a small Messinian outcrop of brecciate “Calcare di base” and evaporites from where it was possible to have a panoramic view of the folded Corvillo Basin evaporite succession (Fig. 3b-c).



Fig. 4. Caltanissetta Basin: a. W. Kiessling observing huge coral colonies at the Balza di Rocca Limata outcrop. B. Typical landscape of the inner part of Sicily, showing (on the right) the folded Messinian “Calcare di Base” of the southern edge of the Corvillo Basin; c. Evaporate detail.

In the afternoon the group moved from the inner to the eastern part of Sicily to reach the Augusta coastline (Castelluccio), where well exposed Pleistocene algal-bryozoan limestones crop out. In Castelluccio, A. Rosso presented the carbonate succession, laying upon the irregular surface of tholeiitic basalts (Fig. 5), and its exceptionally preserved fossil assemblages mostly consisting of rhodoliths beds alternated to branched bryozoan- and pectinid-dominated layers (for more information about the Castelluccio outcrop, see Appendix 4d).

The last scientific appointment of the day was the post-dinner meeting at the Roccadia agriturismo (Carlentini), led by the young scientists Eline Feenstra, Anne-Edwige Schroeder and Michal Jakubowicz (Fig. 6a). The main debated issues were (1) the relationships between the coral reef diversity of the Balza di Rocca Limata outcrop and the Messinian salinity crisis and (2) the paleoenvironmental conditions that caused the alternation of the bryozoan- and coralline algae-dominated layers in the Castelluccio outcrop.

On **Thursday 26th** a full day workshop, hosting talks on modern and fossil mounds, took place in the Roccadia agriturismo. The main topics debated were as follows (more information can be found in the Abstract Book, Appendix 4c): connections between cold-water coral- and seep-related carbonates, causes of the unusual abundance of Devonian-Mississippian mud mounds, role of hydrothermal vent fluids and earth element chemistry in Moroccan Devonian mounds, importance of glendonite as indicator for methane seepage; microbial algal and coral facies from the Bashkirian platform of northern Spain, sedimentology and palaeoecology of Upper Triassic build-ups from southern Japan, distribution and evolution of tropical and cold-water reef systems through time, Early Paleogene Scandinavian bryozoan and coral mounds, sedimentation patterns in cold-water coral mounds, variety of build-up strategies and common features, modern and ancient carbonate build-ups in extreme settings, Afar geology and prospective research in frontier carbonates (Appendix 4c). The last presentation, given by Andres Rueggeberg opened a round table discussion on the COCARDE Carbonate Mound Database currently in progress. The participants debated on the database protocol to be used, in order to include information on both modern and ancient build-ups, and on the main scientific questions that this database should address. It was decided that the COCARDE database will focus on those “carbonate niches” that so far have been little considered in existing literature, such as cold-water and extreme environment carbonate build-ups.

The day ended with a visit to the Archaeological Park of Siracusa. Guided by Laura, a brilliant local archaeologist, the participants enjoyed the extraordinary cultural heritage represented by the Greek theatre, whose cavea is one of the largest ever built by the ancient Greeks, but they could also observe the Miocene rhodolith-dominated limestones in which the theatre was dug (Fig. 6b and Appendix 4d).



Fig. 5. Castelluccio: a. Group photo; b. A. Rosso introducing the participants to the local geology and paleontological assemblages of the outcrop; c. Giovanni Sturiale, Francesco Sciuto and Andres Rueggeberg observing the contact between limestone and basal basalts (note the Etna in the background); d. Camille Peybernes taking picture of a rhodolith bed; e-f. Details of the outcrop: algal-bryozoan layer and rhodoliths, respectively.

On the last day (**Friday 27th**), the workshop was held in the Botanical Garden of the University of Catania. It hosted a series of key note speeches, by academic and industrial experts, and a short poster session (Appendix 4c). Robert Riding lecture focused on the main reef types from the Precambrian till modern times and emphasised the higher effect that evolution had on Phanerozoic photic reefs (dominated by skeletal algal/eukaryote assemblages) than on the aphotic ones. Wolfgang Kiessling speech dealt with the PaleoReefs Database and Phanerozoic reef trends emphasizing that only with databases can large scale questions be addressed and rigorously tested. Moreover he remarked that there is no perfect pre-defined database structure, but that it can be improved by working on it. Jean-Pierre Henriot continued the key note session focusing on the relationships between modern North Atlantic mound provinces and water masses. Philippe Lapointe discussed about Carboniferous hydrocarbon bearing mounds and the critical importance of coeval analogue and recent mounds as keys for reservoir modelling and for understanding reservoir characteristics. Last but not least, Alfredo Frixia speech focused on Triassic microbial reservoir rocks of the Hyblean Foreland (Sicily) consisting of coalescent mounds made of laminar and small columnar stromatolites.

The meeting ended with a final round table during which the participants continued the debate

started the day before. An example of database matrix was presented by Andres Rueggeberg et al. and commented by the participants and a list of scientific questions was compiled. It was decided to integrate the PaleoReefs database, managed by Wolfgang Kiessling and the Erlangen University group, by creating a “time-slice 33” on Pleistocene–Holocene mounds (see chapter 3).

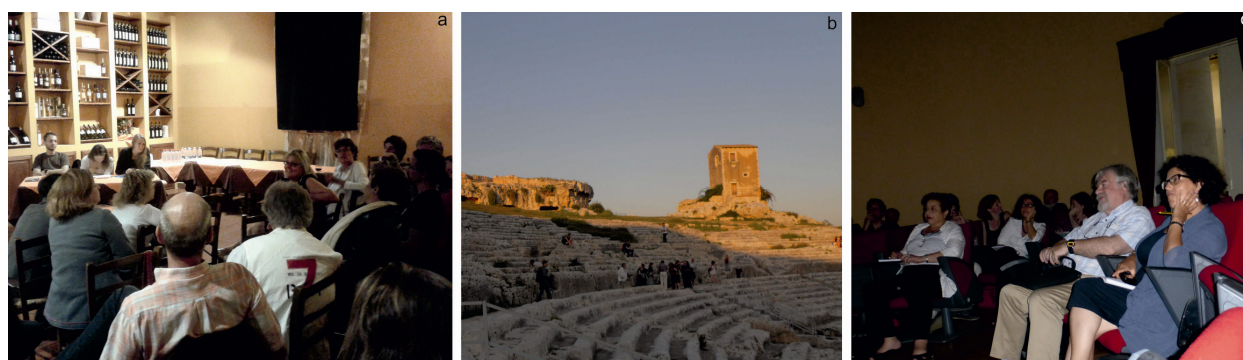


Fig. 6. a. Post-dinner meeting discussion at the Roccadia agriturismo (Wednesday 25th); b. Visit at the Archaeological Park of Siracusa (Greek Theatre); c. Final round table at the Botanical Garden of Catania.

3. Assessment of the results and impact of the event on the future directions of the field

The COCARDE meeting in Sicily represented an important opportunity for junior and senior scientists to discuss aspects related to carbonate mound typologies and to the processes that trigger their origin, development and decline through time. Thanks to the variety of participant expertises (among whom geophysicists, marine geologists, sedimentologists, palaeontologists), of presentations, and of the visited outcrops during the field seminars, constructive discussions dealt with several aspects of carbonate research. Indeed, during the meeting it was highlighted the need to take into account the high heterogeneity of buildups through space and time in order to improve and complete existing databases.

During the round tables the participants listed the main scientific questions that the COCARDE mound database should answer to: Why do mounds appear (and why where they are) and decline? What's the link between mound provinces and (palaeo)oceanographic conditions? What was the palaeobathymetry of the ancient mound ecosystems? Are mounds center of speciation? What's the diversity structure (alpha, beta) of modern and ancient mound ecosystems? What determines the reservoir potential of mounds? How has the mound carbonate budget evolved through time? Is it possible to model mound ecosystems in order to understand the different level of energy fluxes? How vulnerable are mound systems to climate change (glacial and interglacial stages, ocean acidification)? How do primary textures and fabrics change in different mound systems through time?

In order to answer to these questions, it was decided that the common protocol for the description of both recent and fossil mounds has to be strictly descriptive and not interpretative. Another important decision was to open the COCARDE database to modern and ancient "Frontier Carbonate Systems", such as fluvial travertines, shoreline bioherms and subaqueous spring mounds. The entries of the database matrix will follow as much as possible Fluegel and Kiessling (2002) and Golonka (2002) in order to make comparison and integration possible between the COCARDE product and the existing PaleoReefs database. Actually, during the meeting, Wolfgang Kiessling (the "father" of the the PaleoReefs database) proposed to add an online portal for the COCARDE database to be integrated to the PaleoReefs one. Moreover, Rueggeberg et al. proposed a preliminary matrix example for time-slice 33 (Pleistocene–Holocene) that was commented and improved during the round tables. Following the PaleoReefs criteria and the discussions at the meeting, the COCARDE time-slice 33 will contain information on mound ID, age, location (Lat, Long, Depth), accessibility, size, environmental physical and chemical features, biotic

composition, bioerosion component, zonation, petrography, references and remarks. Regarding modern cold-water coral mounds, most information will be related to the mound provinces, and details about single mounds will be added in a subsequent phase.

The enjoyable atmosphere of the meeting and its high scientific level attracted a special interest in some participants, among whom Erlisiana Anzalone (CNR, Marine Geological Institute, Naples, Italy) who decided to join, together with Bruno D'Argenio, the COCARDE-ERN Italian consortium, adding a contribution to the networking budget for 2014 and 2015. The meeting aroused great interest also among oil company participants, and possible integration with the COCARDE network is currently under discussion. During the interactive workshop and field seminar, junior and senior participants could open stimulating discussions that contributed to strengthening of existing collaborations and creating new scientific synergies. For instance, new collaborations were established on geochemical investigations of Pleistocene limestones (Catania and Milano-Bicocca University, IAMC-CNR Naples), Phosphorus analysis on Miocene deposits (Fribourg and Milano-Bicocca University), inclusion fluids in cold-water corals (Amsterdam and Erlangen University), Afar carbonate deposits (Ghent, Fribourg and Addis Ababa University).

Moreover, during the meeting it was discussed about the possibility of the preparation of a series of scientific/educational booklets aimed at emphasizing the networking of heritage key carbonate sites. The Sicily field guide, prepared for this workshop (Annex 4d) will be further developed in this direction.

4. Annexes:

- 4a) Programme of the meeting**
- 4b) Full list of speakers and participants**
- 4c) Abstract volume**
- 4d) Field guide**

Acknowledgements

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