IODP Proposal Cover Sheet

857C - Add 2

Messinian Evaporite Demise

Received for: 2024-04-01

Title	The demise of a salt giant: climatic-environmental transition during the terminal Messinian Salinity Crisis
Proponents	Claudia Bertoni, Angelo Camerlenghi, Johanna Lofi, Andrew Madof, Judith McKenzie, Aaron Micallef, Iuliana Vasiliev, Hugh Daigle, Nick Evans, Daniel Garcia-Castellanos, David Hodell, Christian Hübscher, Zohar Gvirtzman, Terry McGenity, Jörn Peckmann, Tina Treude, Patrick Grunert, Francisco Sierro, Junichiro Kuroda, Giovanni Aloisi, Alice Marzocchi
Keywords	Messinian, Evaporites, Mediterranean, Lago-Mare
Area	Eastern Mediterranean

Proponent Information

Proponent	Claudia Bertoni
Affiliation	University of Oxford
Country	United Kingdom

☐ Permission is granted to post the coversheet/site table on www.iodp.org

Abstract

Approximately 6 Myrs ago, during the Messinian Salinity Crisis (MSC), the Mediterranean was transformed into a giant saline basin. This geologically short-term event (~640 ka) deposited up to 2 km of salt in the deep basin, producing the largest, youngest, and least deformed salt giant on Earth. Drilling the upper reaches of the Mediterranean Salt Giant offers exceptional opportunities to understand: (1) dramatic environmental changes and salinity fluctuations experienced during terminal stages of the MSC and (2) development of an exceptionally active deep biosphere involved in extensive mineral transformations.

After salt emplacement, the Mediterranean underwent dramatic environmental changes: 1) its deep basins were presumably subaerially exposed and became host of huge fluvial depositional systems from surrounding land-masses, 2) it experienced rapid basin-wide salinity decreases from hypersaline into brackish water conditions resulting in enigmatic Lago-Mare sedimentary accumulations and 3) it underwent a rapid return to normal open marine conditions following the catastrophic refilling of the basin with Atlantic waters during the Zanclean megaflood event, interpreted as the largest known event of this kind. The drivers responsible for the rapid and dramatic basin-wide salinity fluctuations, from hypersaline to brackish to open marine conditions, are presently unknown. The Mediterranean's near land-locked physiography makes it highly sensitive to subtle changes in insolation and associated fluctuations in freshwater input. The central and eastern Mediterranean MSC deposits are ideally located for understanding how this hydrological evolution was forced by water exchanges between Mediterranean sub-basins and the Paratethys and Atlantic Ocean, and by the climatically-influenced input of freshwater from major circum-Mediterranean rivers.

The halite – gypsum – Lago Mare succession of the terminal MSC offers a means to test our hypothesis that the upper reaches of the Mediterranean Salt Giant contain one of the most active deep biosphere environments on Earth. We propose that microbes in this deep biosphere (1) use sulphate minerals as a source of oxidative power, (2) catalyse formation of massive amounts of mineral dolomite and (3) thrive within fluid inclusions of evaporite minerals over geological timescales. Recent observations in the Ionian Abyssal Plain suggest on-going microbially-mediated dolomitization over an area as large as the island of Sicily.

We propose to drill two sites in the Ionian Basin and two in the Levant Basin, penetrating the terminal MSC successions: open-marine Pliocene siliciclastic deposits hosting the hypothesized active dolomitization front; lacustrine Lago-Mare sulphate evaporites, carbonates, marls, and siliciclastic accumulations; and Upper Messinian salts.

Scientific Objectives

SCIENTIFIC OBJECTIVES

Theme 1: Deep basin records of the demise of the Mediterranean Salt Giant.
(1.1) to test the hypothesis that fluvial deposits exists above the deep basin halite of the Levant basin;
(1.2)to establish the role of climate in the evolution from hypersaline to brackish conditions;
(1.3) to test the hypothesis that the post-MSC marine restoration was a geologically-instantaneous event involving an unprecedented water discharge.

Theme 2: Deep biosphere and dolomite formation in the upper reaches of the Mediterranean Salt Giant.
(2.1) to identify microbial populations and quantify the metabolic activity of the deep biosphere thriving on the microbial reduction of anhydrite- and gypsum-derived sulphate;
(2.2) to understand if deep biosphere microorganisms are catalysing the ongoing formation of massive amounts of dolomite;
(2.3) to document life surviving within fluid inclusions of evaporite minerals, possibly over geological timescales.

Non-standard measurements technology needed to achieve the proposed scientific objectives

ODP/IODP contamination monitoring measurements, shipboard cultivation and radiotracer facilities, GC with H2 gas analyzer, ion chromatograph for measuring low molecular weight fatty acids and dissolved nitrate.

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Science Communications Plain Language Summary

Using simple terms, describe in 500 words or less your proposed research and its broader impacts in a way that can be understood by a general audience.

Approximately 6 million years ago, there was a big event called Messinian Salinity Crisis (MSC) that changed the Mediterranean Sea into a huge salty basin. This happened over a relatively short period, about 640,000 years, and deposited up to 2000 meters of salt in the deep parts of the basin. This made the Mediterranean home to the youngest giant salt deposit on Earth. Studying the upper parts of these salt deposits can help us learn about: 1) the big environmental and saltiness changes that happened during the last stages of the MSC, and 2) how a lively microbial ecosystem formed deep underground in the salt minerals.

After the salt was put in place, the Mediterranean went through some large environmental changes:

1. The deep parts of the sea were probably exposed to the air and became home to big river deposits from nearby land.
2. The water in the basin went from very salty to somewhat salty (brackish), creating enigmatic sediment deposits called Lago-Mare.
3. The sea quickly went back to normal salty conditions after being filled up again by water from the Atlantic Ocean during a huge flood event called the Zanclean megaflood. This flood is the biggest one of its kind known to us.

We don't know exactly what caused these rapid changes in saltiness across the whole basin. But because the Mediterranean is almost cut off from the rest of the world's ocean circulation, even small changes in how much freshwater or ocean water comes in can have big effects. The layers of salt and other minerals left behind during the MSC can help us understand how water moved between different parts of the Mediterranean and other nearby bodies of water, like the Paratethys mega-lake of the Black Sea region and the Atlantic Ocean, and how climate changes affected how much freshwater came into the Mediterranean from rivers.

The layers of minerals formed during the end of the MSC give us a way to test our idea that there is a very active microbial ecosystem deep underground in the upper parts of the Mediterranean's salt deposits. We think that microscopic organisms living in this deep ecosystem:

1. Use minerals containing sulphur as a source of energy.
2. Help make a mineral called dolomite.
3. Live inside small pockets of water trapped in the salt deposits for a very long time.

Recent discoveries in the Ionian Abyssal Plain suggest that this process of making dolomite with the help of tiny organisms is still happening over a large area.

We want to drill into four specific places in the Mediterranean, two in the Ionian Basin and two in the Levant Basin, to study the layers of rocks and minerals formed at the end of the MSC. These layers include:

- Rocks from the open ocean that came after the MSC, which might have active dolomite formation.
- Layers of rocks from the Lago-Mare period, including sulphur minerals, carbonates, and a mix of different kinds of sediment.
- The upper layers of salt deposits from the final parts of the MSC.
- The megaflood deposit

Review Response

Submission Type: Resubmission from previously submitted proposal

The current submission aims at transferring the original 857C-Full2 Proposal to the IODP3 MSP Facility Board. As requested, we are adding a section detailing the steps undertaken to transfer the proposal, including three proposed implementation scenarios, re-addressing of objectives of the proposal to the 2050 Science Framework document, and in-kind contributions.