

Reviewer comments on:

Ebner and Meijer (under review in Climate of the Past, 2024)

A question of time and space: A model approach to the synchronicity of gypsum and halite during the Messinian Salinity Crisis

Summary

Despite more than five decades of research, several mysteries related to the Messinian Salinity Crisis (MSC) remain unresolved. One such controversy is the order of deposition of different units in marginal versus deep basins of the Mediterranean (for example, Primary Lower gypsum/ Upper gypsum units in the marginal basins. Halite-Resedimented lower gypsum and Upper gypsum units in deep basins – Roveri et al., 2014). Ebner and Meijer employ simplified box modeling to test whether gypsum and halite could have been simultaneously precipitated in marginal and deep basin settings during the MSC, rather than during different stages. Their thought experiments are carried out with 3 basin configurations (A1, A2 and B).

Each configuration includes 3 main boxes (open, extra and deep), where the extra box represents a restricted marginal basin in A2 and B configurations. The numerical model design incorporates volume fluxes within the basins, two-way exchange with the Atlantic, a freshwater budget and circulation mechanisms including convection and vertical diffusion. These processes are then employed in calculating salinity evolution of different boxes. The dependency of salinity evolution of the boxes on Gibraltar Strait restriction effect, freshwater budget and volume kept in convection are evaluated subsequently.

I appreciate the effort put into this thought experiment. Such simple models may provide starting points for further development of more complex models in future studies. However, I think there are a few aspects that need to be improved, prior to publication.

Below, I in detail explain my major and minor concerns.

Specific comments:

1. A proper comparison with the real-world scenario

The aim of the authors is to test if their simplified model predicts whether the salt units (gypsum and halite) in marginal and deep basins could have been precipitated concurrently. Even though they briefly explain the existing hypotheses for the depositional patterns within the MSC, I suggest that proper definitions of marginal *versus* deep basins should be provided prior to elaborating their experiments, with suitable diagrams of existing models for depositional units in each setting (for example, a simplified version of Roveri et al (2014) synthesis). Such insight would make it easier for the reader to follow the author's intentions, in relation to their model experiments. I propose that the same diagram may be used to show the ambiguity in horizontal continuity of the PLG, as the authors indicate in their introduction.

2. Organization

Added to my above suggestion, the manuscript may be ordered in the following sequence: A general introduction to the MSC, with explanations on marginal versus deep basins; Existing hypotheses for the different timing of sedimentary unit deposition (including diagrams); Methods; Results; Discussion – here, I suggest including a better explanation of their model results with respect to actual observations they provided in the revised introduction. Under implications, the authors combine their different configurations to develop a timeline of salinification. I suggest adding a new diagram to explain their timeline, as this is one of their final interpretations, and Conclusions.

3. Timescales

A majority of MSC researchers suggest that the PLG unit was developed as an alternating sequence of gypsum-marl couplets, with up to 17 units paced by insolation (Lugli et al., 2010, Manzi et al., 2013). For someone who may try to compare the suggested scenarios with existing timescales of PLG/ Halite unit deposition (eg: PLG stage during 5.97-5.60 Myr, Halite deposition during 5.60-5.55 Myr), no information has been provided regarding the timescales considered for model experiments.

For instance, it has not been shown how long it will take to reach halite saturation in the extra box in A1 scenario. Provided that, the extra box should precipitate gypsum before reaching halite saturation. What are the periods required to reach gypsum and halite saturation points? How do they compare to the suggested insolation-paced alternations for marginal basins? How would the strait efficiency parameter impact these timescales?

Unless I'm mistaken, such information does not exist in the present manuscript. Because the authors are aiming to relate their experiments with existing hypotheses, I suggest that these comparisons would be important. Is it possible to add a brief explanation of these to the manuscript?

Technical corrections and minor comments:

Title- *A question of time and space: A model approach to the synchronicity of gypsum and halite deposition during the Messinian Salinity Crisis*. Suggestion to add 'deposition' to the title.

Line 4 – Earth Sciences – 2 words

Line 6 – well studied....

Line 7 – define Ma

Line 11 – ...for different configurations... of what?

Line 17 - ...a sufficiently restricted marginal basin....

Line 18 – remove 'the one of' and 'areas of the' → gives- ...once the average salinity approaches halite saturation it can also form in the open basin...

Line 19 – same as for Line 17

Line 20 – define kyr

Line 21 - ...within a one basin... rephrase

Line 27 – change to ...youngest salt giant formation...

Lines 28-29 – suggestion to reorganize for clarity

Lines 47-48 – vague statement ...a more recent study, however, reopened this question again...

Figure 1 – Add labels of different parameters (eg: evaporation, convection, diffusion) to one of the configurations. Strait of Gibraltar is not properly visible as you have not shown the Atlantic side.

Line 95 – add citations: From previous studies, we know...

Model symbols and parameters – If the relative size of the extra box is f , shouldn't A_{open} be $(1-f)A_{tot}$ and A_{extra} be fA_{tot} ?

For V_{extra} , you have not prescribed what 500 m is (which, I assume is the depth/ thickness of the water column)

Line 135 – To arrange the diffusivity term in order → suggestion to rearrange the equation to

$$j_{mix} = K_{mix} \cdot (S_{open} - S_{deep}) \cdot \frac{A_{open}}{d_{mix}}.$$

Line 140 – Shouldn't the salt flux be upward, therefore for equations 5a and 5c the j_{mix} terms become opposite in sign (positive for 5a and negative for 5c)?

Lines 156 – should you mention the Black Sea as well?

Figure 3c – Suggestion to update the label ca to ca_2 (correct?)

Line 271 – can you state the salinity difference?

Line 274 – You have not stated to which figure you are referring to.

Lines 283 – perhaps move 'also' in front of 'halite'?

Line 300 – Reads disorganized when you start the sentence with 'which'.

Line 362 – Should 'Sea' be removed?

Line 362 – Reads disorganized when you start the sentence with 'those'.

Lines 363 - ...to be represented?

Line 383 – suggestion to add a figure explaining you time series of salinification.

Lines 388 and 391 – into the deep basin?

Line 427 – majorly?

Line 428 – Explain why your results do not exclude this (vague statement).