Seasonal variations of halite saturation in the Dead Sea

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1. Introduction

The Dead Sea is the only modern analogue for a deep perennial lake that precipitates halite.

Inter-annual negative water balance (Figure A) of the terminal lake drives precipitation of halite. During the dry season the level decline rate is high whereas during the wet season the rate of level decline is low (Figure B). Thus, from mass balance consideration higher halite precipitation rate is expected during the dry summer and a lower rate during the wet season.

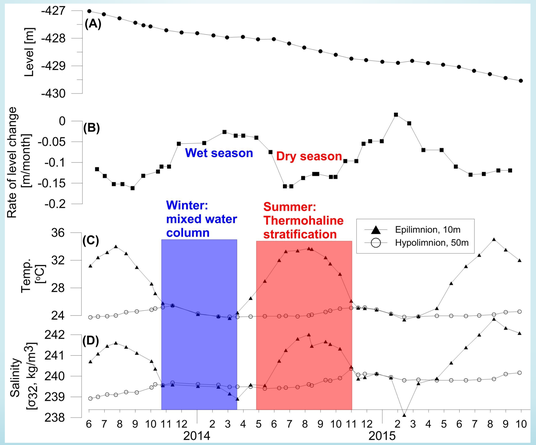
However, the degree of halite saturation (DHS) depends on temperature and salinity. In summer, the epilimnion is salty and warm whereas in the winter the entire water column is mixed and colder (Figures C, D).

Thus, the spatio-temporal dynamics of DHS is affected by both the seasonal thermohaline stratification and the hydrological cycle. The arisen question is what dominates the seasonal DHS cycle?

2. Aims

Specific goal: Characterizing the spatio-temporal dynamics of DHS in the Dead Sea and its relation to the hydrological and limnological seasonal cycle, by means of in situ observations.

Wider goal: characterize control over high-resolution Dead Sea and other deep-basin halite sequences in the geological record.



3. Methods

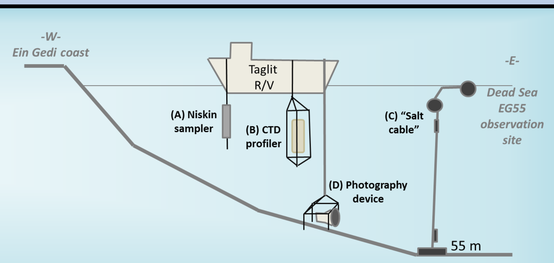
Monthly observations along the Dead Sea water column of:

(A) Salinity profile – sampling using a niskin sampler, and measuring its quasi-salinity using a density meter (DMA5000).

(B) Temperature profile – CTD (SBE19).
DHS – quasi-salinity measurements of equilibrated brine sample with halite.

(C) Crystallization rate profile – measurements along a cable.

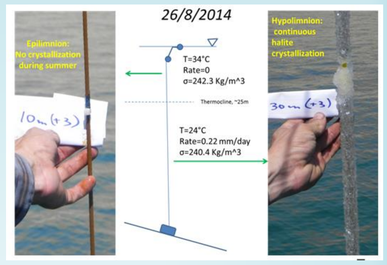
(D) Underwater photography (Nikon D810).



4. Results – DHS seasonal and depth variations

During summer, the **epilimnion** is warm, saltier, under-saturated and dissolves halite (left panel). The **hypolimnion** is colder, less salty and super saturated with respect to halite,(right panel).

Thus, opposing evaporitic processes coexist: dissolution in the epilimnion and crystallization in the hypolimnion.



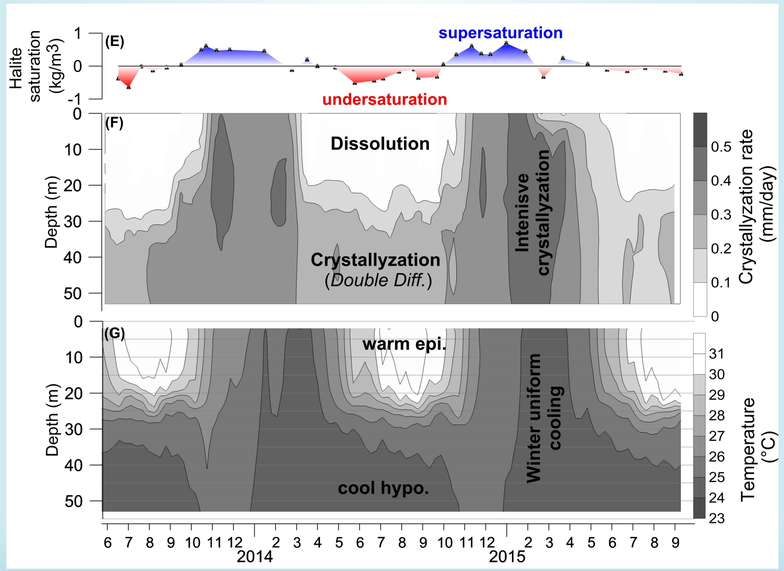
A clear DHS seasonal cycle was found in the upper layer (see below): Summer undersaturation (red) and winter supersaturation (blue) (Figure E).

In addition, Crystallization rates along a steel cable verify DHS trend and show no crystallization during summer, and high crystallization rates during winter (Figure F).

In the hypolimnion, halite continuously crystallizes along the year with higher rates during winter.

The DHS and temperature seasonal and depth variations are correlated (Figures F and G).

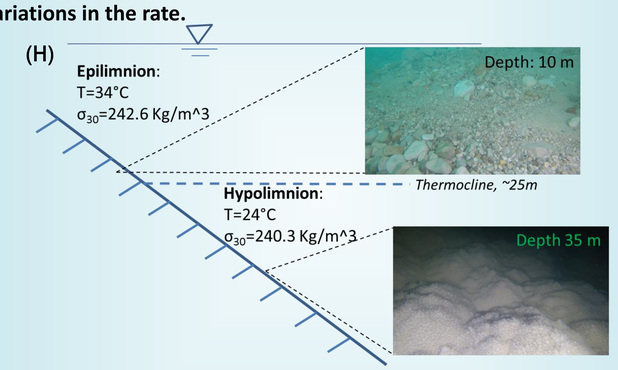
These observations emphasize the control of temperature on the DHS.



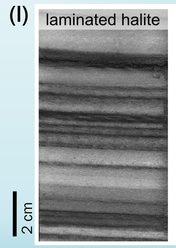
5. Geological implications

These simultaneous opposing evaporitic processes were directly observed on the Dead Sea floor as well (Figure H). In the epilimnion, detritic sediments are exposed with no evidence for halite. At the depth of the hypolimnion, the lake floor is covered by halite.

Therefore, the lake floor is divided to an epilimnetic floor that experiences seasonal dissolution and an overall net dissolution. The hypolimnion is continuously precipitating halite with seasonal variations in the rate.



The seasonal pattern of DHS and halite crystallization is expected to occur in the deposited halite. Indeed, Neugebauer et al. (2014) (Figure I), observed laminated halite in the deposits of the last interglacial recovered from the deep Dead Sea core (ICDP).



6. Conclusions

- **Seasonal temperature patterns control the distinct non-uniform vertical halite precipitation even under compositionally homogeneous near-halite saturation water body.**
- **These results point to coeval, opposing evaporitic sequence depositions. They indicate that the commonly observed layered halite deposited in the depths of the Dead Sea (and other past deep basins of the world) probably reflect the control of seasonal temperature.**

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