MEDITERRANEAN DEEP ANOXIC HYPERSALINE BASINS: AN OVERVIEW

Claudia Elena Casalino [1]*, Gert J. De Lange [1] and Sara Borin [2]
[1] Utrecht University, 3508 TC Utrecht, Netherlands - c.casalino@geo.uu.nl
[2] Consorzio Nazionale Interuniversitario per le Scienze del Mare (CoNISMa), Ulr Università degli Studi di Milano, 20133, Italy

Abstract
Several brine basins appear to occur in the deep waters of the Eastern Mediterranean. These are characterized by extreme environments with high pressure and density, redox conditions and saturated salt concentrations. These basins are probably the result of the dissolution of Miocene salt deposits that became exposed to seawater after tectonic activity. The high densities of the brine fluids contrast with seawater limiting the mixing with overlaying oxic seawater. As a consequence, isolated habitats evolved in which adapted microbiological life exists. Distinct differences occur between the various basins related to chemical composition and density.
Keywords: Anoxia, Eastern Mediterranean, Interfaces

At the bottom of eastern Mediterranean Sea (~3500 m water depth) several deep hypersaline anoxic brine basins have been discovered in the last 30 years. Amongst these are : Atalante (AB), Bannock (BB), Discovery (DB), Nadir (NB), Medee (MB), Tyro (TB), and Urania (UB) all names after the ships involved in their initial discovery (Fig. 1). The general composition of the brine pools resulted from the dissolution of subterranean late-Miocene evaporitic salt deposits, underlying the Mediterranean sediments . It is most likely related to the collision of the African beneath the Eurasian tectonic plate [1, 2]. Alternatively the deep submarine basins might have been formed by accretionary processes and may have subsequently been filled with fossils and highly concentrated relics of Messinian water trapped in the interstitial area of the deep-sea sediments [3]. Waters enclosed in these depressions are characterized not only by high pressure and density, but also and for most by their redox state, lack of oxygen and saturated salt concentrations. Strong salinities and density gradients prevent mixing with the oxic seawater above and hence lead to stratification of the water column forming sharp and distinctive seawater/brine interfaces of 1 - to 2 m (Fig. 2). Moreover the elevated density and salinities basically tend to reduce biodiversity [4]. Despite these extreme conditions and the limited exchanges between brine and overlying seawater, anoxic basins are not biological deserts since several microbial communities appear to have developed under these conditions, usually considered as harsh [2]. In particular the oxic/anoxic boundaries are considered to be a hot spot for biological activity where the sharp redox potential differences create favourable conditions for different types of sequential metabolic processes [3]. The main microbial reaction in the lower part of the interface is thought to be the anoxic oxidation of methane (AOM) directly coupled to the reduction of sulphate (equation 1), where sulphide oxidation and possibly ammonia oxidation are more dominant in the upper reach of the seawater - brine interface (equation 2), according to the following equation [4]: $CH_4 + SO_4^{2-}$ à $HCO_3^- + HS^- + H_20$ (eq. 1) $HS^- + 2\ O_2$ à HSO_4^- (eq. 2) According to the most recent bio-explorations the deep hypersaline basins are mostly dominated by Bacteria rather than Archaea with a great variety of microorganisms adapted to the different chemical interfaces composition. All brine basins show a relatively stable structure according to the geochemical composition and temperature gradient. Despite that, 3 specific lakes (AB, DB, UB) geographically close to each other (Fig. 1), show the largest differences in terms of geochemical composition and density. For instance in Urania concentrations of Methane and Sulfide are relatively higher, whereas the salinity is lower. The most remarkable difference is referred to the composition of Discovery mainly dominated by $MgCl_2$ in concentration considered as a limit for the life [6]. The existence of microbial life in such hostile environments suggests the high capability of microbial adaptation to salinity. It also hints to the possibility of life in other extreme environments such as the planet Mars, where the occurrence of high-salinity waters have been suggested [7]. The study of these brine basins is part of the European MIDDLE project with the general aim to investigate the extreme habitats of deep hypersaline basins of the Eastern Mediterranean Sea. Preliminary results from a multidisciplinary study of water and sediment samples collected during the 2008 DOPPIO cruise with RV Pelagia will presented.

References
1 - Camerlenghi A., 1990. Anoxic basins of the eastern Mediterranean: geological framework. *Mar. Chem.*, 31: 1-19.
2 - Van der Wielen P. W. J. J., Bolhuis H., Borin S., Daffonchio D.,et al., 2005. The Enigma of Prokaryotic Life in Deep Hypersaline Anoxic Basins**.** *Science*, 307: 121-123.
3 - Vengosh A., De Lange G.J., Starinsky A., 1998. Boron isotope and geochemical evidence for the origin of Urania and Bannock brines at the eastern Mediterranean: Effect of water-rock interactions. *Geochim. Cosm. Acta*, 62: 3221-3228.
4 - Borin S., Brusetti L., Mapelli F., D'Auria G., et al., 2009. Sulfur cycling and methanogenesis primarily drive microbial colonization of the highly sulfidic Urania deep hypersaline basin. *Proc. Natl. Acad. Sci. U.S.A.*, 106: 9151-9156.
5 - Valentine D.L., 2002. Biogeochemistry and microbial ecology of methane oxidation in anoxic environments: A review. *Anton Leeuw. Int. J. G.*, 81: 271-282.
6 - Wallmann K., Suess E., Westbrook G.H., Winckler G., et al., 1997. Salty brines on the Mediterranean sea floor. *Nature*, 387: 31-32.
7 - Altheide, T., V. Chevrier, C. Nicholson, J. Denson, 2009. Experimental investigation of the stability and evaporation of sulfate and chloride brines on Mars. *Earth Plan. Sci. Lett.*, 282: 69-78.