AUTHIGENIC CARBONATE MINERAL FORMATION IN A LATEST PLEISTOCENE PALEOLAKE, GREECE

INTRODUCTION

In the eastern Mediterranean, particularly in Greece (Fig. 1), a complex coastline configuration includes several semi-enclosed gulfs separated from the open sea by shallow sills (cf. Perissoratis and Conopoulias 2003, and references therein). During the last glacial maximum (LGM), these areas operated as palaeolakes until the sea over-passed the shouls, during deglaciation and subsequent sea-level rise. The Pagassitikos Gulf, in central Greece, is a prime example of that evolution, and forms the subject of the present study.

The transition of the Pagassitikos Gulf from a palaeolake system to a marine embayment during the latest Pleistocene is characterised by entirely different types of sediments, namely carbonate minerals (cf. Perissoratis and Conopoulias 2003, and references therein). The areas today enclosed by the Pagassitikos Gulf, the Gulf of Corinth, the north Evvoikos Gulf, and the Marmara Sea (Fig. 2).

Within this context, the present work at the Pagassitikos Gulf aims at studying: (1) the types of carbonate mineral formation observed in core B-4; (2) their variability over time; (3) the identification of geochemical conditions associated with their deposition; and (4) the transition from lacustrine carbonate mineral deposition to typical marine sedimentation.

2. REGIONAL SETTING

The Pagassitikos Gulf is a roughly circular, semi-enclosed bay covering ~520 km² (Fig. 3) off the eastern Greek mainland and communicating with the open Aegean Sea through the narrow Trikeri channel, 5.5 km wide and 68-82 m deep. The flat-sloping of the gulf has an average depth of about 70 m; the deepest, NE sector lies at 102 m.

No perennial streams flow into the gulf and therefore limiting terrigenous riverine input. The Pagassitikos Gulf (Greece), general bathymetry (depth contours in metres) and core B-4 sampling location.

3. METHODS

-Grain-size (Micrometics Sedigraph 5100)
-Mineralogy (XRD: Rigaku D/MAT B, Bruker AXS D8)
-Scanning electron microscope (Philips XL20 and EDAX EDXRF)
-Organic carbon and nitrogen (Vario EL III and EA1108 of Microanalytical Laboratories, Florida)
-Major and minor elements (XRF: Philips 2100)
-(oxygen and carbon isotopes (Finnigan MAT 251 isotope ratio mass spectrometer)
-Radiocarbon dating (Beta Analytics Laboratories, Florida)

4. RESULTS

Sedimentary units

Based on initial visual inspection and laboratory analyses of grain size, as well as organic carbon, and carbonate contents, three main sedimentary units were identified in core B-4 (Fig. 4). These units, labelled A, B, and C from the top to base are described below:

Unit A: 0–234 cm (18.14 cal. ka B.P. – present day)

Homogeneous mud, with low sand contents, low organic carbon, and carbonate content increasing from the top (13.7%) towards the deeper layers to 41.2%. Calcite, aragonite, and gypsum are also present at different depths and relative abundance. The sediment samples of unit A exhibit homogenous distribution in δ13C and δ18O values varying between -0.8 to -2.2 ‰ (VPDB) and -1.1 to -2.5 ‰ (VPDB), respectively (Fig. 4).

Unit B: 234–242 cm (19.46–18.14 cal. ka B.P.)

Unit B can be clearly distinguished by its characteristic whitish–light grey colour, in contrast to the olive–brown–reddish brown colour of unit A. Unit B is characterised by the highest sand contents observed throughout the core (52.4–56.0%). The mineralogical composition of unit B is characterised as an admixture of carbonate minerals (Fig. 5) dominated by aragonite (~69%), and followed by calcite (6.6-8.1%). The δ13C and δ18O values of bulk sediment samples of units B and C exhibit a continuous enrichment in δ13C and δ18O down-core, respectively (Fig. 4).

Unit C: 242–258 cm (19.46-19.16 cal. ka B.P.)

Unit C is distinguished as a sequence of fine laminae of whitish-grey colour. Silt (60.0-68.8%) and clay (30.4-38.4%) predominate over sand content. In unit C an apparent gradual decrease of aragonite is observed down-core (from 61.4% to 40.6%), and calcite (from 8.4% to 5.1%), while dolomite increases rapidly from 9% to 29.4%. SEM observations revealed that dolomite is hardly distinguishable, probably due to its small size or imperfect crystal growth, but some well-formed crystals were identified (Fig. 6). Unit C is characterised by the highest sand contents observed throughout the core (52.4–56.0%).

5. DISCUSSION & CONCLUSIONS

During MIS-2 at 26 cal. ka B.P., the mean sea-level was ~120 m lower than at present (LGM) and started rising, marking the beginning of deglaciation (Peltier and Fairbanks 2006). According to the model predictions of Lambeck and Peltier (2005) for the Mediterranean, the sea-level at 13 cal. ka B.P. was ~75 ± 3.7 m. This age represents the period when the sea level reached the sill depth (70-75 m) of the Pagassitikos gulf, and passed through the Trikeri channel, enabling seawater to pour into the gulf, thus marking the commencement of marine sediment deposition (unit A). The carbonate minerals present in units B and C were deposited during the times when the Pagassitikos Gulf was isolated from the sea.

Casing assemblages (calcite and dolomite in the same sedimentary unit) is an enigmatic issue, and a number of possible formation mechanisms were examined, using different proxies. Heavy δ18O values recorded in the lowest part of the core were associated with hypersaline and evaporative depositional environment. The most plausible explanation directs to dolomite precipitation from hypersaline evaporating water bodies at extremely low precipitation rates (Meister et al. 2011). Under varying seawater conditions, and enhanced cation inputs, the precipitation of aragonite is favoured. Alternatively, high evaporation rates and gypsum formation, favouring an increase in Mg/Ca ratio, is proposed as a possible mechanism supporting authigenic dolomite precipitation, probably in concert with bacterial activity (Karagogeoglu et al., 2012). The enhanced evaporation-hypersaline model proposed in the case of the Pagassitikos Gulf may be applicable for other gulls as well (Fig. 2), since climatic conditions during MIS-2 in the region can be considered similar.

The thickness of the deposits in some gulls, directs to massive precipitation processes, at least for the Saronikos Gulf and Corinth Gulf, this could be attributed to the large seawater volume that was entrapped in the palaeolakes, thus resulting in greater availability of calcium cations.

REFERENCES

-Grain-size (Micrometics Sedigraph 5100)
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