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Post-glacial filling of a semi-enclosed basin: The Arguin Basin (Mauritania)

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ABSTRACT

Semi-enclosed basins are not very common features in the world and are most frequently the result of tectonic movements. Studies of their filling are usually based on the micropaleontological analyses of sediment cores (Torgersen et al., 1988; Reeves et al., 2007) or seismic analyses (Lykousis et al., 2007; Çagatay et al., 2009; Van Daele et al., 2011). The morphology of semi-enclosed basins is generally simple and bowl-shaped, and their edges are marked by one or more sills. Their depths range from a few dozen to several thousand meters. Semi-enclosed basins are however present in some regions in the world. The semi-enclosed basin of the Golfe d'Arguin (Northwest Africa) is present on a wide, shallow shelf, bordering the Sahara desert, in a stable tectonic context. Its sedimentary filling took place during the end of the post-glacial transgression. The current knowledge on sedimentary filling of semi-enclosed basins is rather limited and inadequate to fully understand the processes at play. Three campaigns have allowed the creation of the first morpho-bathymetric map of the Golfe d'Arguin, shedding new light on its large-scale morphology. A series of rocky shoals (Banc d'Arguin), interrupted by two sills in the north and south, divides the shelf into two parts, the inner and outer. The inner part of the Golfe d'Arguin, called the Arguin Basin, forms a shallow semi-enclosed depression. The basin is situated on the stable West African margin and the lack of any vertical tectonic movement provides an ideal situation for studying the progradation/regression variations and the sediment depositional conditions caused by the post-glacial sea level changes.

Based on the analysis of very high-resolution seismic data, seven units were identified. The sedimentary sequence of deposition of the Arguin Basin was interpreted in relation to the bedrock morphology, the sea-level rise and the climatic changes. Their chronology was established in comparison to the regional sea-level curve, basin physiography and unit distribution.

The Arguin Basin is interpreted as a land-locked freshwater lake during the post-glacial sea-level rise, corresponding to wet climatic conditions. The inner part was flooded ca. 8.7 ka BP when the sea level reached the sills. The filling then corresponded to a marine–estuarine environment. The climatic aridification and the sea-level stabilization from 6.5 ka BP onwards allowed the deposition of the last units, which are composed of aeolian sand combined with a significant marine biogenic carbonate fraction.

Bedrock morphology plays a major role in determining the depositional sequence architecture. It controls the available accommodation space and, in conjunction with climate changes, influences the environmental processes that shape the deposit geometry.

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1. Introduction

The northwest coast of Africa is sensitive to climatic fluctuations due to intertropical convergence zone (ITCZ) movements (Gasse, 2000; Michel et al., 2009). Dramatic climate changes (desert/green Sahara) may have been the cause of profound changes in the environments (Nicholson, 2000; Mainguet et al., 2001; Nierdermeyer, 2009) and have implications for human populations (Kuper and Kropelin, 2006; Vernet, 2007).

In this context, sediment accumulations within the semi-enclosed Arguin Basin (AB in the text) offer a unique opportunity to study NW Africa paleoclimate. Indeed, semi-enclosed basins are depressions whose sedimentary records are likely to yield information about the nature of the input, the sources and conditions of deposit and can be used to describe more generally the climatic and environmental conditions. The filling of the AB, however, was never studied and knowledge of this area is very limited.

This paper studies the sedimentary succession of the AB using Very High-Resolution (VHR) seismic data. Despite the lack of sedimentary core (technical, geographical and political constraints), seismic data will allow for studying both the filling history of the AB and the processes involved in the filling of semi-enclosed basins in general. Thus, a scenario

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of the sedimentary filling of the semi-enclosed AB is provided, and related to sea-level, climatic changes and sediment sources. The results will be correlated with work carried out on other basins and studies that are currently in progress concerning the construction and evolution of the coastline under the influence of large sedimentary input.

2. Study area

The Golfe d'Arguin, a shallow water (<20 m) over an area of 7500 km^2, is located on the northwest coast of Mauritania (21°10–19°20 N, 17°20–16°15 W). It has a N–S extension of ca. 200 km, bounded by the Cap Blanc to the north and the Cap Timiris to the south (Fig. 1A). It forms a stable margin (Faure et al., 1980) and a shallow zone, bordered by a coastal plain for which satellite views have revealed several currently inactive paleo-wadis. The Golfe d'Arguin, separated from the 50 km-wide continental shelf (Hanebuth and Lantzsch, 2008) by a steep break (Michel et al., 2009), is divided into two parts between the Tintan peninsula and Cap Timiris by a shallow 150 km-long strip of shoals (Fig. 1A). These shoals define an inner part forming a shallow basin (Arguin Basin) roughly corresponding to the boundaries of the Banc d'Arguin National Park and an outer part that extends to the 20 m isobath. The shoals thus form an effective barrier protecting the semi-enclosed basin against open ocean hydrodynamics. Although Sevrin-Reyssac (1993) speaks of sand banks, their nature and origin are poorly documented and will be studied in this article.

The AB is described as a marine lagoon system shaped by numerous channels and banks and considered as a legacy of an "undoubtedly deltaic" past (Mahé, 1985). Because of the shallow water depth, and navigational issues, the nature of the sedimentary filling of the basin has been poorly documented, in contrast to the studies which refer to the outer shelf and shelf break (Domain, 1985; Antobreh and Krastel, 2006; Wien et al., 2006, 2007; Zühlsdorff et al., 2007; Hanebuth and Lantzsch, 2008; Hanebuth and Henrich, 2009; Michel et al., 2009; Hanebuth et al., in press). The AB coast is lined by sandy beaches and sand flats. Some rocky capes bear witness to the Middle Pleistocene Tafaritian formation (Hébrard, 1973; Elouard, 1975; Giresse et al., 1989). The sandy beaches and sand flats are the result of the sedimentary evolution during the Late Holocene (Barusseau et al., 2007). In the southern part, the coast intersects the Azefal and Agneitir dune systems. Offshore, a string of islands around Tidra Island (the largest one) is surrounded by tidal flats (Fig. 1B).

The Golfe d'Arguin area is exposed to the strong trade winds. The maritime trade winds, oriented NNE–SSW are generated by the Azores anticyclone. The continental trade winds ("Harmattan"), heading WSW are generated by the North African anticyclone cell (Gasse, 2000; Hanebuth and Lantzsch, 2008). These winds are responsible for significant aeolian transport. Indeed, the Sahara is currently the world's leading source of aeolian dust. The amount of dust blown from the Sahara has been estimated from 0.6 to 0.7 Pg.an^{-1} (1 Pg = 10^{15} g = 10^9 T), and 0.22 Pg is estimated to be deposited in the North Atlantic (Harrison et al., 2001). Fluvial discharges are presently non-existent. The observed tide is semi-diurnal and microtidal, with a range between 0.8 and 2 m (Mahé, 1985). The associated currents pattern is complex and not well understood (Michel et al., 2009). The main current enters by the north, crosses the entire bank from north to south in approximately 30 days and is evacuated by cascading in the southwestern area near Cap Timiris (Peters, 1976). A southern countercurrent (Guinea Current) may occur in spring and summer and affects the entire region (Peters, 1976; Sevrin-Reyssac, 1993; Hanebuth and Lantzsch, 2008; Michel et al., 2009). Along the Golfe d'Arguin shoreline, sediment distribution is controlled by a dominant N–S longshore drift. Stronger hydrodynamics in the northern part of the gulf lead to a N–S fining of the sediment grain size towards the south. The latter fine sediments feed the mud wedges on the shelf edge (Michel et al., 2009).

Climatic regime is dominantly desert with low average precipitation (Brahim, 2004; Vernet, 2007) and high potential evaporation (Peters, 1976; Michel et al., 2009). However, in the past the climate showed alternating dry/wet periods (e.g. the African Humid Period, AHP). The

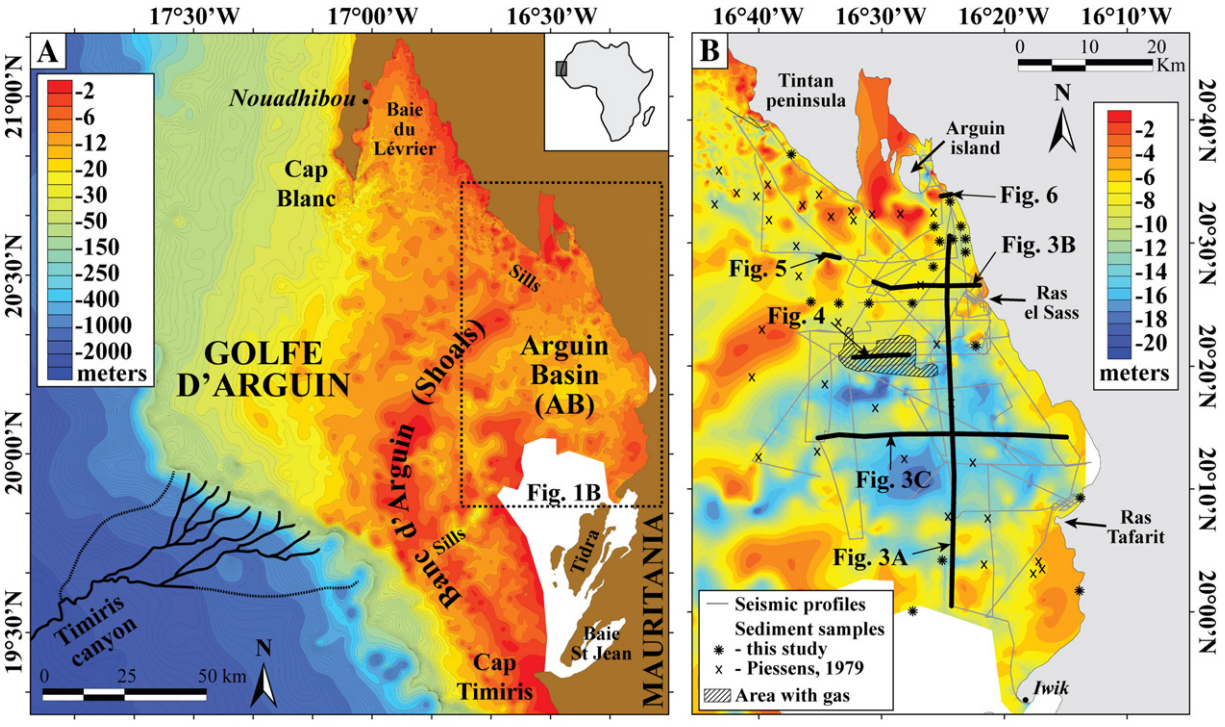

Fig. 1. (A) Morpho-bathymetric map of the Golfe d'Arguin between cape Timiris and cape Blanc. Note the shoals in the center of the gulf, known as Banc d'Arguin. They separate the outer continental shelf from the Arguin Basin. Around the Tidra island, due to very shallow waters, depths are not surveyed (in white). (B) Bathymetric map of the Arguin Basin with general grid of VHR seismic profiles (thin gray line) and the sediment samples location (black crosses). Thick black lines refer to the VHR seismic profiles illustrated in the text. Hatched zone shows gas area.

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