

New stratigraphic data on the Aptian of the Persian Gulf

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ABSTRACT

During Aptian times the northeastern corner of the African plate, the Arabian craton, was in the tropics. Two-thirds of it was covered by a broad epeiric sea opening eastward into the Tethys Ocean. Carbonate sedimentation recorded several environmental perturbations caused by changes in relative sea-level and by interconnected coeval global events. A well in offshore Abu Dhabi was used as the reference because it was drilled through the whole of the interval of interest and cored strata dated Gargasian (middle Aptian *sensu gallico*, early late Aptian *sensu anglico*) downward to beds of Late Barremian age. The holostratigraphic approach employing biostratigraphy, lithostratigraphy and sequence stratigraphy, along with basic well log interpretation and $\delta^{13}\text{C}$ -based chemostratigraphy, facilitated correlation with outcrops in Iran and Oman, and with other wells in Iraq, Qatar and the United Arab Emirates, over distances of several hundreds of kilometers. This approach made possible refinement of our regional model for this interval and the identification of a set of events that included several forced regressions, transgressions of varying importance (by extension in the literature those floodings of greatest magnitude have been called "drownings"), the Oceanic Anoxic Sub-Event 1a and a microbial *Bacinnella* "bloom".

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1. Introduction

In mid-Cretaceous times a wide epicontinental sea occupied almost two-thirds of the Arabian craton, the northeastern corner of the African plate, with its eastern limit facing the Tethys Ocean. The region studied includes the whole of the Persian Gulf and the countries bounding it. During Aptian times it was in the paleotropical realm and so at the heart of a domain of biologically-enhanced carbonate production. That sedimentation recorded the several environmental changes that disturbed it.

A prerequisite to the determination of the sequence of events recorded in the Aptian series of the Persian Gulf region is to have the most complete record possible from a source, either outcrop or cored well, to be used as a reference. The dataset used for this type of integrated approach known as holostratigraphy can include:

biostratigraphy (ammonites, foraminifera, calcareous algae, etc.), sedimentological information, sequence stratigraphic interpretation, a Gamma-ray log, a $\delta^{13}\text{C}$ curve, a calcimetric curve, etc. It should be supplemented by a consistent and robust stratigraphic framework. In the Middle East petroleum province high-resolution correlations were obtained for some stratigraphic units of economic interest, i.e. reservoir units, but they are mostly based on wireline logs and 3D seismic reflection data, therefore they are considered as proprietary and confidential data by the oil companies; finally, they commonly lack substantial biostratigraphic support.

2. Stratigraphical classification of the Persian Gulf

On the Arabian side of the Persian Gulf (Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates, and Oman; Fig. 1), the Shu'aiba Formation is usually equated with the Aptian Stage (Dunnington, 1967; Hassan et al., 1975; Pratt and Smewing, 1993, etc.). However, some stratigraphic units framing the Shu'aiba may also be ascribed, in part at least, an Aptian age. In the emirate of Abu Dhabi, the area of reference for this contribution, the Kharaiib and the Hawar underlie the Shu'aiba, and the Bab, the Sabsab and the

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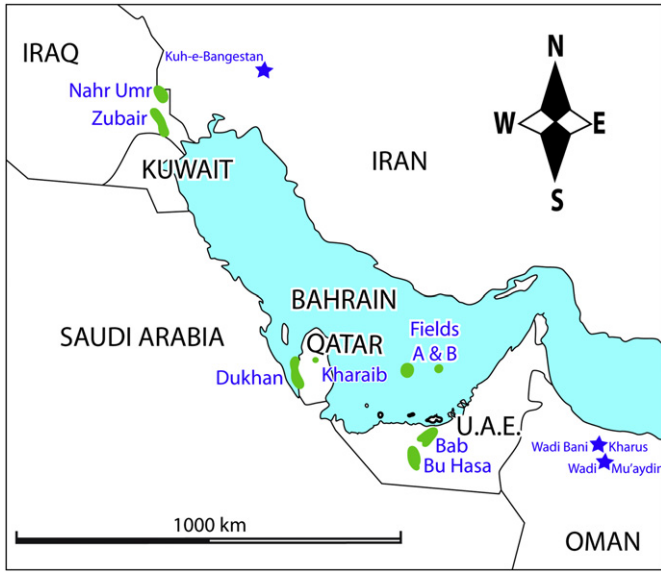


Fig. 1. Location map of the type-localities of the Kharaiab (Kharaiab 1), Hawar (Kharaiab 1), Shu'aiba (Zubair 3), Bab (Murban-Bab 2), Sabsab (Dukhan 27) and Nahr Umr (Nahr Umr 2), of the Abu Dhabi onshore field Bu Hasa and offshore fields "A" and "B", the Kuh-e-Bangestan outcrop in Iran, and the wadis of the Oman Mountains (Wadi Bani Kharus and Wadi Mu'aydin).

Nahr Umr overlies it. All of these formational names were originally coined to designate subsurface "operational units" as defined in unpublished proprietary reports of oil companies (Table 1). They were formally published during the two following decades (Owen and Nasr, 1958; Sugden and Standring, 1975; Hassan et al., 1975) and were amended thereafter (Al Naqib, 1967; Granier, 2000).

Because a stage includes all strata deposited during a certain interval of time, it can be defined in two ways (Remane et al., 1996; Rey and Galeotti, 2008):

- by a reference section, *i.e.* by its stratotypic section: the classical approach to denominating chronostratigraphic units,
- by a lower boundary of reference, *i.e.* by its "Global Stratotype Section and Point" (GSSP), which is the modern approach of the "International Commission on Stratigraphy". If so defined, it is represented by all strata deposited between its lower boundary and the lower boundary of the following stage.

A GSSP has not yet been selected for the Aptian stage, nor for the following Albian stage. But historical sections in the stratotypic areas of the Aptian and of two of its substages, the Bedoulian (Lower Aptian) and the Gargasian (middle Aptian *sensu gallico* = lower upper Aptian *sensu anglico*) are accessible, along with the ammonite zones identified therein. These have been thoroughly revised during the last decade (Moullade et al., 1998, 2009, 2011; Ropolo et al., 1998, 2006, 2008a, 2008b). Unfortunately, in the subsurface of offshore Abu Dhabi, due to restricted sampling opportunities, ammonite zonation has been feasible only in the basal facies in the Bab and to a limited extent in the Shu'aiba where two ammonite zones have been found: the Furcata Zone and the Martini Zone of the Gargasian* (Granier, 2000, 2008; Granier et al., 2003, 2011; Busnardo and Granier, 2011).

* Note: the association includes among others *Gargasicerias* sp., as its generic name – derived from the type-species, "*Ammonites gargasensis* Orbigny", – indicates a marker of the Gargasian.

Granier (2000) demonstrated that the subsurface units of the Lower Cretaceous of the emirate of Abu Dhabi can be treated either

Table 1 Summary of the units studied (ADCO: Abu Dhabi Company for Onshore Oil Operations, ADPC: Abu Dhabi Petroleum Company, BPC: Basrah Petroleum Company, INOC: Iraq National Oil Company, QGPC: Qatar General Petroleum Corporation, QPC: Qatar Petroleum Company, Fm: Formation, Mb: Member).

Original status	New status	Unpublished reports	Valid publication	Country	Company	Field, well number	spudded in	completed in	Amendment	Top	Bottom	Lat. N	Long. E
Nahr Umr Fm	(-ian) regional stage	Glynn Jones (1948)	Owen and Nasr (1958)	Iraq	INOC (ex BPC)	Nahr Umr N° 2	3 June 1949	24 Feb. 1950		8688 ft (2648.1 m)	9321 ft (2841.0 m)		
Sabsab Fm	(-ian) regional sub-stage		Sugden and Standring (1975)	Qatar	QGPC (ex QPC)	Dukhan N° 27	15 Dec. 1951	24 Feb. 1952		? (1147.6 m)	3765 ft (1147.6 m)		
Bab Mb	(-ian) regional stage		Hassan et al. (1975)	U.A.E.	ADCO (ex ADPC)	Bab (ex Murban) N° 2	18 Oct. 1958	10 Nov. 1959		7907 ft (2410.1 m)	8024 ft (2445.7 m)	23° 52'	53° 44'
Shu'aiba Fm	(-ian) regional stage	Rabanit (1951)	Owen and Nasr (1958)	Iraq	INOC (ex BPC)	Zubair N° 3	9 Jan. 1950	5 Aug. 1950		9870 ft (3008.4 m)	10132 ft (3088.2 m)	49.11"	10.77"
Hawar Fm	(-ian) regional stage	Sugden (1953)	Sugden and Standring (1975)	Qatar	QGPC (ex QPC)	Kharaiab N° 1	15 Nov. 1952	29 June 1953	Al Naqib (1967) Granier (2000)	9962 ft (3036.4 m)	10132 ft (3088.2 m)		
Kharaiab Fm	(-ian) regional stage	Sugden (1953)	Sugden and Standring (1975)	Qatar	QGPC (ex QPC)	Kharaiab N° 1	15 Nov. 1952	29 June 1953		3637 ft (1108.6 m)	3689 ft (1124.4 m)	25° 25' 60"	51° 13' 00"
			Standring (1975)		QGPC (ex QPC)	Kharaiab N° 1				3689 ft (1124.4 m)	3962 ft (1207.6 m)	25° 25' 60"	51° 13' 00"

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