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DIAGENESIS IN THE COASTAL QUATERNARY CARBONATES IN QATAR, ARABIAN GULF

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ABSTRACT: Combined field studies, thin-section examination and scanning electron microscopy were utilized to study the diagenesis of the Quaternary carbonates in twelve stratigraphic sections along the coastline of Qatar. The sequence is dominated by calcarenites. It comprises three lithostratigraphic units representing two transgressive phases of the Pleistocene sea separated by a regressive phase.

Diagenesis has modified the original textural and compositional characteristics of the Quaternary rocks considerably. Dissolution and cementation played major roles, whereas neomorphism and compaction were much less effective. Dissolution resulted in the development of fabric-and nonfabric- selective types of porosity. Cementation was mainly by calcite and, rarely, aragonite, gypsum and silica. Calcite crystals are nonferroan, mainly low-magnesian and have wide ranges of size, habit and distribution patterns. Aragonite cements are commonly isopachous and consist of fibrous and needle-like crystals. Massive and fibrous gypsum and cryptocrystalline and microcrystalline silica fill intergranular pores and microchannels. Aggrading and degrading neomorphism were selective. Compaction effects were more profound in calcarenites which were not subjected to early cementation.

The diagenesis of the Quaternary carbonates occurred in a wide spectrum of settings which prevailed during the eogenetic, mesogenetic and telogenetic phases. The marine phreatic environment witnessed the commence of cementation with aragonite and high-magnesian calcite and the formation of micritic envelopes of fossil shells. The early phases of dissolution, micritization of other allochems and aggrading neomorphism occurred under mixed phreatic conditions. Most of the recorded diagenetic effects were developed in the meteoric vadose and phreatic environments. These include the completion of the dissolution events, the cementation with sparitic low-magnesian calcite, silica and gypsum, and the conversion of aragonite into low-magnesian calcite. There are remarkable variations in the nature and intensity of freshwater cementation throughout the sequence which indicate marked fluctuations in the groundwater levels.

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MICROTEXTURAL PROPERTIES OF OOIDS IN THE MIDDLE JURASSIC-LOWER CRETACEOUS, CENTRAL TAURUS CARBONATE PLATFORM, ANTALYA, TURKEY

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ABSTRACT: Ooids occurring in the middle Jurassic-lower Cretaceous carbonate sediments of Akseki, Antalya (Turkey) are of two distinct kinds. Type 1 ooids are small and of irregular shape. They have 1 to 4 cortical laminae with a fine radial structure and patchy micritization. The nucleus of this type is composed of micrite and in places is not visible. In the radial part of this kind of ooid, microporosity and/or microopenings seem to be micro-borings. Type 2 ooids are large and well rounded with vaguely visible nuclei. They display fine concentric micritic laminae which coincide with endolithic microorganisms and microborings of fossils.

These ooids accumulated in a subtidal and lagoonal calm-water environment. Cyanobacteria and endolithic algae are thought to have contributed to the formation of these ooids.

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NATURE AND GENESIS OF SILT-SIZE CARBONATE SEDIMENTS; NORTHERN RED SEA, EGYPT

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ABSTRACT: The nature and genesis of silt-size carbonate fractions in the Northern Red Sea is investigated via detailed SEM, XRD and ICP analyses of the sediments. Results show that inorganic aragonite represents only 25% of the fine silt and clay fractions, but up to 60% of the total coarse silt. In general there is a compositional trend of increasing proportion of Mg-calcite with decreasing grain size of the sediments. Petrographic examination demonstrates that the coarse silt size carbonates are mainly composed of comminuted pieces of unaltered carbonate or micritized marine skeletal debris. On the other hand, the fine and very fine silt fractions are mainly composed of authigenic carbonate, formed *in situ*, and replacing the comminuted pieces of carbonate debris. The argument for the inorganic origin of the fine carbonate fractions is based on the detectable increase in the Sr content of aragonite, and the increasing proportion of Mg-calcite with decreasing grain size of the sediments. It is concluded that the Mg-calcite component provides a more important clue to the origin of the silt fraction. Micritization of skeletal grains is an important source of carbonate mud. Thus Mg-calcite from the Red Sea reefal sediments, either as skeletal or cryptocrystalline lumps, is the principal source of this component in the carbonate mud, especially in the clay size fractions. The Carbonate mud in the study area is mineralogically similar to the Belize carbonate mud, and differs from the Bahamas and Arabian Gulf carbonate sediments.

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THE STRATIGRAPHICAL RECORD AND ACTIVITY OF EVAPORITE DISSOLUTION

SUBSIDENCE IN SPAIN

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ABSTRACT: The evaporite formations (in outcrop and at shallow depth) cover an extensive area of the Spanish territory. These soluble sediments are found in diverse geological domains and record a wide time span from the Triassic up to the present day. Broadly, the Mesozoic and Paleogene formations (Alpine cycle) are affected by compressional structures, whereas the Neogene (post-orogenic) sediments remain undeformed.

The subsidence caused by subsurface dissolution of the evaporites (subjacent karst) takes place in three main types of stratigraphical settings: a) Subsidence affecting evaporite-bearing Mesozoic and Tertiary successions (interstratal karst); b) Subsidence in Quaternary alluvial deposits related to the exorheic evolution of the present-day fluvial systems (alluvial or mantled karst); c) Subsidence in exposed evaporites (uncovered karst). These types may be represented by paleosubsidence phenomena (synsedimentary and/or postsedimentary) recognizable in the stratigraphical record, or by equivalent currently active or modern examples with surface expression.

The interstratal karstification of the Mesozoic marine evaporites and the consequent subsidence of the topstrata is revealed by stratiform collapse breccias and wedge-outs in the evaporites grading into unsoluble residues.

In several Tertiary basins, the sediments overlying evaporites locally show synsedimentary and/or postsedimentary subsidence structures. The dissolution-induced subsidence coeval to sedimentation gives place to local thickenings in basin-like structures with convergent dips and cumulative wedge out systems. This sinking process controls the generation of depositional environments and lithofacies distribution. The postsedimentary subsidence produces a great variety of gravitational deformations in the Tertiary supra-evaporitic units including both ductile and brittle structures (flexures, synforms, fractures, collapse and brecciation).

The Quaternary fluvial terrace deposits on evaporite sediments show anomalous thickenings (>150 m) caused by a dissolution-induced subsidence process in the alluvial plain which is balanced by alluvial aggradation. The complex space and time evolution pattern of the paleosubsidence gives place to intricate and anarchical structures in the alluvium which may be erroneously interpreted as pure tectonic deformations. The current subsidence and generation of sinkholes due to suballuvial karstification constitutes a geohazard which affects to large densely populated areas endangering human safety and posing limitations to the development. An outstanding example corresponds to Calatayud historical city, where subsidence severely damages highly valuable monuments. The subsidence resulting from the underground karstification of evaporites has determined or influenced the generation of some important modern lacustrine basins like Gallocanta, Fuente de Piedra and Banyoles lakes. The sudden formation of sinkholes due to the collapse of cave roofs is relatively frequent in some evaporite outcrops. Very harmful and spectacular subsidence activity is currently occurring in the Cardona salt diapir where subsidence has been dramatically exacerbated by mining practices.

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OCCURRENCE OF SEPIOLITE IN THE HIRSIZDERE SEDIMENTARY MAGNESITE DEPOSIT, BOZKURT-DENIZLI, SW TURKEY

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ABSTRACT: The Hirsizdere magnesite deposit is found in the upper Miocene-Pliocene lacustrine sediments of the Çameli formation in the western Aegean depression zone, which was uplifted to form a broad anticline and in which consecutive faults and fractures developed due to the neotectonic activities. Thick alternation of carbonate cemented and weakly cemented conglomerate, sandstone, mudstone intercalated with a few thin dolomite and magnesite layers is exposed at the lower part of the sequence. These units are overlain by magnesite and dolomite in association with thin claystone and sandstone layers and lenses. Green and claret red-brown smectite is observed in detrital materials as well as in sandy carbonate units, and is accompanied by serpentine, amphibole, illite, feldspar and quartz, whereas sepiolite is developed in the form of 3-5 cm thick, yellow and greenish brown colored veins, or as thin films lining parallel to the vein axis within the magnesite unit. SEM studies show that sepiolite fibers are grown in the form of meshworks and bridges between relict carbonate mineral grains. The presence of plant stem imprints, and the abundance of gastropod and ostracode shells in carbonate units indicate shallow and alkaline lake conditions. Field observations and detailed mineralogical, chemical and micromorphological determinations indicate that sepiolite is formed by diagenetical transformation of magnesite during the movement of silica-rich meteoric water through the fractures of carbonate units under near-surface alkaline conditions.

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MINERALOGY OF CAVE DEPOSITS ON SAN SALVADOR ISLAND, BAHAMAS

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ABSTRACT: Speleothem samples from ten caves located in the northeastern and southwestern corners of San Salvador Island (Bahamas) were analyzed by means of X-ray diffraction, scanning electron microscopy, and the electron microprobe. In addition to the prominent calcite, aragonite, and gypsum, already known to occur in San Salvador caves, eleven other minerals were identified. The minerals are celestite, $SrSO_4$; cesanite, $Na_3Ca_2(SO_4)_3OH$; ardealite, $Ca_2(HPO_4)(SO_4)\cdot 4H_2O$; brushite, $CaHPO_4.\cdot 2H_2O$; hydroxylapatite, $Ca_5(PO_4)_3OH$; fluorapatite, $Ca_5(PO_4)_3F$; chlorapatite, $Ca_5(PO_4)_3Cl$; collinsite, $Ca_2(Mg,Fe)(PO_4)_2 \cdot 2H_2O$; whitlockite, β-$Ca_3(PO_4)_2$; niter, KNO_3, and nitratine, $NaNO_3$. Cesanite has not been previously reported from a cave. This is the second reported occurrence of collinsite.

San Salvador Island, on the eastern edge of the Bahamian Platform, is the location of a large number of relatively small flank margin caves. In addition TO the more obvious speleothems - stalactites, stalagmites, and flowstone - the San Salvador caves contain a variety of crusts and soils of unknown mineralogy. This paper is an account of an investigation of samples collected from ten of these caves. Prior to the results reported here, only calcite, aragonite, and gypsum had been identified in the various speleothems from caves on San Salvador Island (Vogel *et al.* 1990; Schwabe *et al.* 1993).

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PETROPHYSICAL FACIES OF THE ORDOVICIAN RED RIVER FORMATION, WILLISTON BASIN, USA

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ABSTRACT: A petrophysical facies is a mappable rock unit of similar petrophysical characteristics, imparted by the depositional and diagenetic environment. Capillary-pressure curves are the basis for delineating a petrophysical facies.

Important parameters that affect the shape of a capillary-pressure curve are sorting of the pore-throat

size distribution, the maximum threshold-entry radius, and percent recovery efficiency. Curve types based on these parameters are spatially clustered both laterally and vertically within the Red River Formation. The ordering of petrophysical facies, vertically up-hole, is related to the maximum threshold-entry radius which range from very small radii 'A' to very large radii 'F', with 'C' and 'D' of moderate size as defined in the construction of curve type designation. In the Red River depositional sequences, petrophysical facies are ordered by 'B-C-D-C-B', where either 'A', 'E', 'F', or PS is found at the bottom or top of the sequence, defining a sandwiched sequence of pore throats with the optimum reservoir facies in the center.

The maximum-threshold entry radius, apparent porosity, and recovery efficiency are logged for each lithologic unit. Large maximum threshold-entry radii are associated with poorly sorted pore-throat size distributions and/or little to no porosity. Recovery efficiency is only meaningful for dolostones with moderate to high porosity.

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A PRELIMENARY STUDY: CELESTITE-BEARING GYPSUM IN THE TERTIARY SIVAS BASIN, CENTRAL-EASTERN TURKEY

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ABSTRACT: Celestite-bearing evaporite mineralization is common in the Tertiary evaporitic units of Ulas-Sivas basin, East-Central Turkey.

The first occurrence of gypsum which is "laminated in character" (Balatino gypsum) took place in the shallow inner-lagoon or depressions during regression in the upper Eocene. Thick gypsum and overlying beds composed of the bedded, nodular gypsum and sandstone alternations were formed in a coastal sabkha and abandoned channels within the meandered rivers through the Oligocene time. The last occurrence of evaporitic units, represented by massive and bedded gypsum alternating with sandstones and fossiliferous limestones resulted from limited marine transgression in the early Miocene along the southern margin of the Sivas Tertiary basin.

The celestite mineralization preferentially took place within the Miocene evaporites and subordinate amount in the shallow marine limestones and terrestrial siliciclastics ranging from late Eocene to Oligocene in age. Celestite shows different depositional characters such as strata-bound, massive, fracture and cave filling. According to microscopic studies, three petrographic types have been determined in these different beds of celestite. They are prismatic and bar-like; sub-idiotopic and tabular; fibrous-radial.

The source of the celestite in the Sivas Tertiary basin has been debated. There is little evidence for suggesting sedimentary-syngenetic origin. Many geologists believe that it formed during late diagenesis or epigenetic stages, but this interpretation reflects a lack of a comprehensive study and only depends on field observations. This paper includes both field and laboratory studies (light, ore and electron microscopes, microprobe, $^{87/86}Sr$ isotopes) and obtained initial results which have inclined to the diagenetic-epigenetic origin.

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