

ABSTRACT

The sedimentary section at Gebel Naqus (southwestern Sinai), together with some subsurface core samples from Ras Budran oil field are studied in detail from the petrographic, diagenetic and hydrocarbon reservoir quality points of views. This section is represented by the entire Naqus Formation (Upper Cambrian) and the uppermost part of the underlying Araba Formation (Lower Cambrian). The section constitutes a thick succession of laminated sandstones that are very fine- to medium-grained, occasionally coarse-grained, and poorly- to moderately well-sorted. Grain shape varies from angular to well-rounded; the majority of the sand-sized grains are subangular to subrounded.

Different types of sedimentary structures are recognized in the studied sandstones. They include: erosional surfaces, channel-fill structures, massive bedding, graded bedding, flat bedding, cross-bedding (tabular and trough), planar and cross-lamination, deformed structures (convolute bedding and recumbent foresets), chemical structures (differential coloration, liesegang bands and mottling), mechanical structures (differential weathering and joints) and biogenic structures (*Skolithos* tubes).

The studied sandstones are composed of detrital quartz grains and subordinate to minor proportions of highly altered feldspars, rock fragments, clay minerals and heavy minerals. Quartz grains are monocrystalline and, less commonly, polycrystalline having different habits and displaying undulose or non-undulose extinction. Quartz types are: common, volcanic, recrystallized metamorphic, stretched metamorphic and quartz vein. Quartz grains may envelope inclusions of

different types and shapes. Feldspars are nearly absent. The recorded rock fragments are sedimentary and, much less commonly, metamorphic or volcanic. The recorded non-opaque heavy minerals are zircon, tourmaline, rutile, garnet, sphene, epidot, staurolite, sillimanite, monazite and hornblende. Opaques are represented mainly by hematite.

The studied rocks are affected by several diagenetic processes which include: 1- mechanical infiltration of clay minerals; 2- dissolution and leaching of unstable detrital silicate mineral grains such as feldspars and ferromagnesian minerals; 3- formation of an authigenic mineral assemblage that includes quartz, calcite, iron minerals (mainly hematite) and clay minerals (mainly kaolinite); 4- development of compaction features such as closer packing, mechanical fracturing, deformation and bending of ductile and cleavable grains; 5- dissolution of early-formed carbonate cements and 6- development of late diagenetic cements consisting of quartz, K-feldspars, kaolinite, iron minerals, calcite, gypsum and halite. The paragenetic sequence of the diagenetic processes began shortly after deposition of the sediments by a limited infiltration of clays. A phase of precipitation of quartz cement occurred soon after deposition at shallow depths before the commence of real burial compaction. Cementation with iron minerals occurred early in the burial history and continued for a long time. The major part of cementation by calcite preceded significant mechanical compaction and followed quartz cementation. Dissolutions of feldspars and rock fragments probably occurred after the main episode of calcite cementation. Kaolinite, K-feldspars and late stage iron minerals cement were deposited following the dissolution process probably late mesodiagenesis. Kaolinite commonly breaches secondary pore spaces and is mainly interpreted as a late diagenetic cement.

In spite of their age and the large volumes of ground water that probably passed through them, the studied sandstones retain, with a few exceptions, sufficient porosity and permeability to possess a good reservoir quality. In the present study, porosity was measured petrophysically by using a helium porosimeter and in thin sections by point counting. Naqus Sandstone has helium porosity that averages 23.1 %. About 84 % of Naqus samples have porosity greater than 20 %. Sandstone of this porosity magnitude makes an excellent reservoir rock. In Araba Sandstone, helium porosity averages 17.8 %. This sandstone has a high kaolinite content and its porosity is usually intercrystalline. On the other hand, helium porosity in the subsurface sandstone averages 10.4 %.

Thin section porosity in Naqus Sandstone has a mean value of 17.7 %, while in Araba Sandstone it averages 3.6 %. On the other hand, thin section porosity in the subsurface sandstone averages 4.9 %. Development of secondary porosity (about 4.39, 1.54 and 0.21 % total rock volume in the Naqus, Araba and subsurface sandstones, respectively) locally enhanced the reservoir quality of the studied sandstones.

In Naqus Sandstone, permeability averages 2818 md. About 46 % of Naqus samples have permeability greater than 1000 md. Sandstone having this permeability magnitude has an excellent reservoir characters. On the other hand, permeability in Araba Sandstone averages 50 md. 50 % of Araba samples have permeability values between 10 and 50 md, indicating a moderate reservoir quality. The subsurface sandstone has an average horizontal permeability of 92 md. On the other hand, its average vertical permeability is 100 md. This slight difference is attributed to the presence of small-scale open vertical fractures, which enhance the vertical permeability. Sandstone having this permeability magnitude makes a good reservoir rock.