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Modes of origin and genetic pathways of peloids within the Duwi Formation (late Cretaceous) in Eastern and Western deserts of Egypt: A petrologic perspective

Abdalla M. El Ayyat

Geology Department, Faculty of Science, Assiut University, Assiut 71516, Egypt

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ABSTRACT

Peloids are considered as major constituents of modern and ancient sedimentary rocks, although their origins and pathways of formation are not yet comprehensively understood. Based on field and petrologic investigations, peloids have been recorded in the Duwi Formation (late Cretaceous) in both Eastern and Western deserts of Egypt. The Duwi Formation represents the first onset of fully marine conditions in Egypt accompanying the major late Cretaceous marine transgression. It comprises a heterogeneous suite of shallow marine sediments (phosphorites, oyster limestones, shales, glauconites and dolomite). According to the hosted rock, peloids are classified into two types: peloids in phosphorites and peloids in limestones, which are characterized by different shapes and sizes. Systematic study indicates that peloids resulted from the interplay between physico-chemical and microbial processes. Accordingly, the more important modes of origin are peloids derived from coprolites; by micritization of bivalve shells; fragmentation and abrasion of intraclasts; by phosphomicritization of bone fragments; peloids derived from internal molds; intraskeletal and interskeletal peloids; nucleated peloids; and peloids within matrices. The size and morphology of the studied peloids are mainly controlled by the parent material.

1. Introduction

Peloids are allochems formed of cryptocrystalline or microcrystalline calcium carbonate with no restrictions on the size or origin of the grains (McKee and Gutschick, 1969). Tucker and Wright (1990) stated that peloids have various origins, and attempts of classification are hampered by doubts of their genesis (Wilson, 1965), mirrored in the common expression "peloids just a term of ignorance" (Flügel, 2004). The following hypotheses have variously been proposed: (a) fecal pellets (Land and Moore, 1980), (b) micritized grains (Bathurst, 1971), (c) intraclasts (Fåhraeus et al., 1974), (d) a precipitate origin (Macintyre, 1985), and (e) a microbially mediated precipitate (Reitner, 1993). Based on the probable origin and diagnostic criteria, Flügel (2004) proposed nine peloid subcategories. Some authors (e.g., Soudry and Nathan, 1980) prefer the term "peloids" since it is an umbrella term allowing description without implication of specific genesis.

Peloids are the most common and characteristic component of the Egyptian phosphorites, particularly in high grade ore. The matrix is usually calcitic and locally silicic. Phosphatic and clay matrices are rare. Egyptian phosphorites are widely distributed in the Eastern Desert, along the Nile Valley and in the Western Desert (Fig. 1A). They are hosted in the Duwi Formation and constitute a part of the middle-eastern to northern African phosphogenic province of late Cretaceous to Paleogene age.

The genesis of the Egyptian phosphorites however, remains obscure. Three scenarios have been suggested: direct precipitation from upwelling pore waters (Soliman and Amer, 1972); biochemical processes (Youssef, 1965); and formation by means of microbial mediation (Ahmed, 1988).

Due to the considerable economic interest in Egyptian phosphorites, many lithostratigraphical, sedimentological and mineralogical studies have been carried out. The most relevant studies are those of Klitzsch et al. (1979); Barthel and Herrmann-Degen (1981); Hendriks and Luger (1987); Hermina et al. (1989); Glenn (1990); Ahmed and Kurzweil (2002); Baioumy and Tada (2005); and El Ayyat (2014).

2. Aims of the present work

This study reports on the different sedimentological processes (physical, biological and/or chemical), which promote peloid formation; illustrates and analyzes the order of events leading to formation of each type of peloid; describes the various genetic pathways for their formation; and discusses the possible interrelationships between different types of peloids and the environmental conditions in which they formed.

E-mail addresses: abdallaelayyat1961@hotmail.com, abdallaelayyat@yahoo.com.

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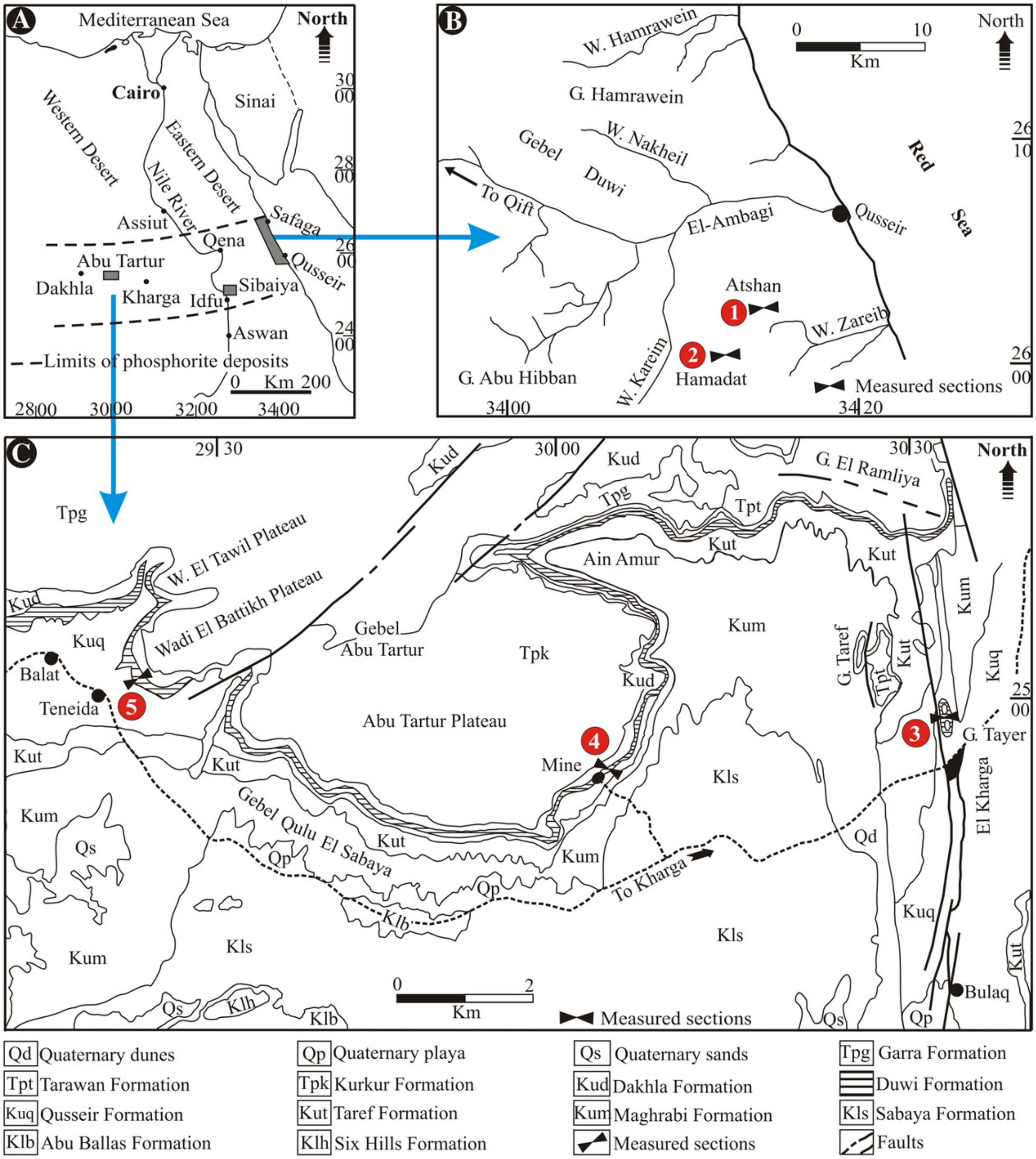

Fig. 1. A) Location map for the main phosphorite occurrences in Egypt in a general east–west trending belt (modified after Glenn and Arthur, 1990). B) Sketch map for the location of measured section west of Qusseir area, Eastern Desert. C) Simple geological map showing location of the measured sections at Abu Tartur plateau, Western Desert (modified after Hermina, 1990).

3. Methods and materials

To achieve these aims, phosphorites and associated rocks have been sampled in detailed from the Eastern and Western deserts of Egypt at five localities (Figs. 1–4). In the Eastern Desert, two stratigraphic sections representing the upper part of the Duwi Formation exposed at Hamadat and Atshan areas have been measured and sampled. The sections are located about 16 km from the Qusseir, facing Gebel Duwi, and then about 5 km and 9 km along Wadi Karim, to the south of the Qift-Qusseir asphalt road (Figs. 1B, 2). In the Western Desert, other three stratigraphic sections have been described, measured and sampled. There, the study area extends from Teneida town in the west to Gebel Tayer in the east (Figs. 1C, 3, 4).

Sampling was carried out bed by bed, with particular regard to facies changes observed in the field. For the purpose of petrographic description, more than 130 thin sections cut perpendicular to the bedding planes and representing different rock classes have been microscopically examined. Extra cut slabs (15 × 20 cm) of hard phosphorites have been sawn, polished and photographed.

Carbonate classifications by Dunham (1962) and modifications by Embry and Klovan (1971) have been applied for both phosphorites and limestones. The staining technique of Katz and Friedman (1965) has been used to differentiate the dolomites. The percentages of components have been determined using Flügel's (2004) estimation charts. Soft rock varieties (shales, silts and marls) have been processed according to micropaleontological methods and their residues have been