Journal of African Earth Sciences 140 (2018) 212–224

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Geological heritage diversity in the Faiyum Oasis (Egypt): A comprehensive assessment

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ARTICLE INFO

Article history:

Keywords:
Geodiversity
Geopark
Geotourism
Paleogene
Western desert

ABSTRACT

The Faiyum Oasis in the Western Desert of Egypt is famous for its palaeontological localities (Cenozoic whales, primates, etc.) of global importance, but its geological heritage has been not studied in the modern theoretical frame. The new investigation based on the field studies and the literature review permits comprehensive assessment of the geological heritage diversity in this oasis. For this purposes, unique geological features are inventoried with establishment of their geological essence, rank, relative abundance, and intrinsic diversity. As a result, the existence of ten geological heritage types in the Faiyum Oasis is found. These include palaeontological, palaeogeographical, geomorphological, stratigraphical, sedimentary (merged with mineralogical), hydrological coupled with geochemical, igneous, and economical types. From them, the palaeontological and palaeogeographical types are ranked globally, and the geomorphological and hydrological types are ranked nationally. The other types are either of regional (provincial) or local importance. Some hills and cliffs can serve as viewpoint sites for observation of the local geological landscape. The relative abundance and the intrinsic diversity of the unique geological features vary between low and high. Generally, the concentration of this geological heritage in the Faiyum Oasis permits recognition of the geodiversity hotspot that requires conservation and use for tourism purposes. The protected areas located in the oasis and the existing tourism programs do not offer geoconservation and geotourism activities for the entire hotspot. The possible solution of this problem would be creation of a large geopark similar in its design to the Jeju Island Geopark in South Korea. There are important premises for geotourism development in the Faiyum Oasis and its combination with the archaeological and industrial tourism. Nature conservation failures in this geopark should be avoided; some recommendations are given on the basis of the review of conservation failures in geoparks of the other countries.

1. Introduction

Geological heritage (*geoheritage*) encompassing unique geological features valuable for science, education, and tourism has been recognized as a new kind of geological resource, and it has been explored actively in the world since the mid-1990s (Wimbledon, 1996; Prosser et al., 2006; Ruban, 2010, 2017; Henriques et al., 2011; Wimbledon and Smith-Meyer, 2012; Erikstad, 2013; Gray, 2013; Prosser, 2013; Thomas, 2016; Escorihuela, 2017; Henriques and Brilha, 2017). However, the knowledge of this resource remains poor or incomplete in many countries of Africa and the Middle East, and filling this gap is a very urgent task. Additionally, recognition of geoheritage is not only a new research direction, but this also feeds with new material for various geological investigations.

Previous studies of the Egyptian geoheritage (Shata, 1988; El-Asmar et al., 2012; AbdelMaksoud and Hussien, 2016; Plyusnina et al., 2016; Sallam and Ruban, 2017; Sallam et al., 2018) emphasized on its outstanding richness, but the relevant knowledge is

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https://doi.org/10.1016/j.jafrearsci.2018.01.010
1464-343X/

highly incomplete and fragmentary. This is the case even for the Faiyum Oasis (there may be different spelling of this geographical name) where the Wadi El-Hitan ("Whale Valley") UNESCO World Heritage Site famous for the Cenozoic whale (and not only) remains is located (Fig. 1). The global importance of this palaeontological locality is unquestionable (Lotfy and Van der Voo, 2007; Peters et al., 2009; Abdel-Fattah et al., 2010; Gameil et al., 2016), but the locally available unique geological features seem to be more diverse (e.g., Sallam and Ruban, 2017). Geoheritage assessment in this oasis on the systematic basis and in the modern theoretical frame is necessary.

The objective of this paper is to reveal the geological heritage diversity (*geodiversity*) of the Faiyum Oasis on the basis of new field investigations, synthesis of the already published information, and conceptual interpretations. Practical implications for geological conservation (*geoconservation*) and tourism (*geotourism*) are also worth to consider.

2. Geological setting

The Fayium Oasis (29°18′ N and 30°30′ E) is a depression located in the northeastern part of the Western Desert of Egypt (Fig. 1). It lies ~100 km southwest of Cairo and occupies the area of ~1500 km^2. Its shape looks like a tree's leaf connected to the Nile through the narrow Bahar Youssef canal. The floor of the depression is covered by the Nile alluvial silts and clays. Two brakish lakes are located in the depression, namely the Qarun Lake in the north and the Wadi El-Rayan Lake in the southwest; the water level in the both is below the global sea level.

The geological, palaeontological, and geomorphological characteristics of the Faiyum Oasis are given in numerous works (Beadnell, 1905; Said, 1962; Vondra, 1974; Bown and Kraus, 1988; Gingerich, 1993; Zalat, 1995; Lotfy and Van der Voo, 2007; Issawi et al., 2009; Abdel-Fattah et al., 2010; El-Fawal et al., 2013; Anan and El Shahat, 2014; King et al., 2014). The Faiyum area is dominated by faulting, fracturing, jointing, and minor pseudofolding structural features formed before the Eocene and in the Oligocene (Said, 1990). The area is characterized by a series of faulted blocks forming SW–NE trending horsts and grabens (e.g., the Qaret Gehannam, Sandouk El-Bornita, and Minqar El-Hut horsts) (Abu El-Kheir, 2010).

The Paleogene sedimentary rocks outcrop widely in the Faiyum Depression (Issawi et al., 2009) (Fig. 2). The Rayan Formation was originally described by Beadnell (1905). It consists of 100 m glauconitic greenish clayey sands and sand clays interbedded with

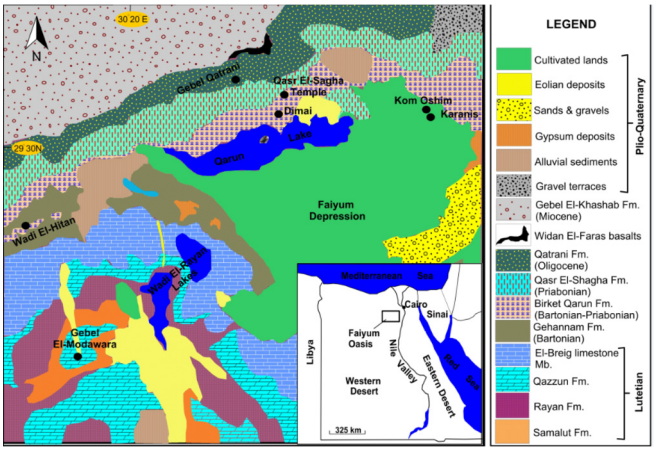

Fig. 1. Geological map of the Fayum Oasis and its vicinities (based on Swedan, 1986).

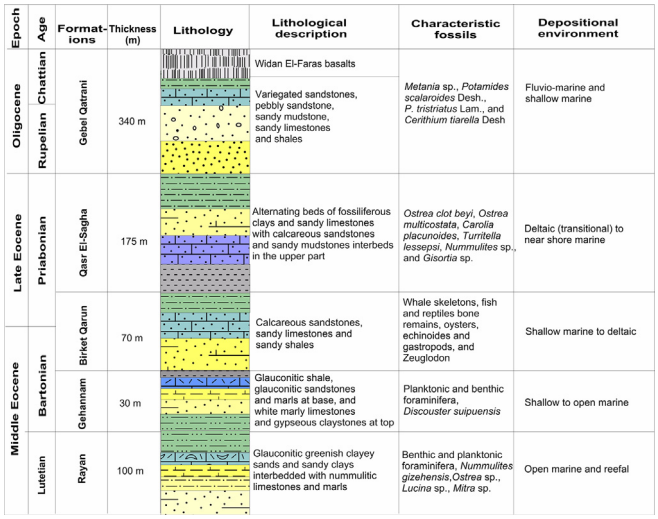

Fig. 2. Generalized stratigraphical scheme of the Paleogene deposits of the Faiyum Oasis (see explanations and literature sources in the text).

nummulitic limestones and marls. The Gehannam Formation was introduced by Said (1962) to substitute the Ravine beds of Beadnell (1905). It consists of fossiliferous glauconitic shales, glauconitic sandstones, and marls at base overlain by white marly limestones and gypseous claystones with a thickness of ~30 m. The uppermost part of the Gehannam Formation is characterized by the occurrence of a distinct bed (~2.5–3.0 m thick) of fossilized mangrove roots. The Birket Qarun Formation was introduced by Beadnell (1905) to distinguish the ~70 m thick succession composed of calcareous sandstones, sandy limestones, and sandy shales. This formation contains rich fauna including both vertebrates (whales, fish, and reptiles) and invertebrates (bivalves, gastropods, and echinoids). The Qasr El-Sagha Formation forms an escarpment consisting of 175 m thick alternating beds of clays and sandy limestones with calcareous sandstone and sandy mudstone interbeds in the upper part (Beadnell, 1905). This formation contains rich invertebrate assemblages. Bown and Kraus (1988) subdivided the Qasr El-Sagha Formation into two members, namely the Temple Member (123 m) and the Abu Lifa Member (77 m). The Gebel Qatrani Formation was described by Beadnell (1905) and Said (1962). It is composed of ~340 m of variegated sandstones, pebbly sandstones, sandy mudstones, sandy limestones, and shales. The Gebel Qatrani Formation is fossiliferous and, particularly, bears land-animal remains and silicified wood fragments. A thick Oligocene basaltic sheet (~30 m thick) known as the Widan El-Faras basalt outcrops locally.

The Faiyum Oasis is well-known for its important palaeontological localities and, first of all, Wadi El-Hitan ("Whale Valley") with exceptionally-preserved Paleogene whale skeletons. This has been proclaimed a World Heritage Site by UNESCO in 2005. The Faiyum Oasis is characterized by the presence of different landforms such as escarpments, pediplains, isolated conical hills, desert "tables", "sculptured" rocks, sand dunes, and sand sheets. This territory also possesses several important archeological sites (Davoli, 2012), including ruins of old towns (Dimai and Karanis), temples (Qasr El-Sagha), and pyramids (El-Lahun and Hawara).

3. Methodology

In order to assess the geoheritage of the Faiyum Oasis, the naturally exposed geological features of the latter should be inventoried. Field investigations with visits to Wadi El-Hitan, Wadi El-Rayan, Gebel Qatrani, and the Qarun Lake (Fig. 1), as well as a