Phanerozoic evolution of the basins of Northern Egypt and adjacent areas

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Abstract  The results of integrating geological well data and geophysical information from the subsurface of northern Egypt are presented in terms of basin dynamics. Recent biostratigraphic data from wells and scarce outcrops are shown to be critical to an understanding of syndepositional tectonics. Six tectonostratigraphic phases of basin evolution are recognized to span the Phanerozoic. These phases initially record the development of intracratonic subsidence, controlled by deep crustal strike-slip tectonics, as Nubian continental and Tethyan marine influences competed across the northern margin of Gondwanaland. Evidence is also presented for the formation of the present day continental margin to northern Egypt. After a phase of crustal stretching, oceanic rifting focused on the western margin of the Arabian Platform, propagating progressively westwards during the Early—Mid-Jurassic. Thereafter, the effects of passive subsidence on the continental margin were disturbed by discrete phases of intracratonic strike-slip, associated 'Syrian Arc' folding, and the formation of deep basins in the opening Red Sea and Gulf of Suez. Three structural fabrics persisted throughout Phanerozoic basin evolution, the result of repeated extensional reactivation and inheritance from Pan-African basement.

Key words  Basin dynamics · Biostratigraphy · Well data · Geophysical data · Egypt

Introduction

Commercial oil exploration first began in northern Egypt a little over 100 years ago, on the Gemsa peninsular in the southern Gulf of Suez. Since then, and particularly in the last 30 years, there has been intense subsurface exploration in several areas of northern Egypt (north of 29°N): the Gulf of Suez (Clysmic Basin), northern Sinai, the Nile Delta and the basins of the northern Western Desert (Fig. 1).

Seismic reflection profiling, gravity and magnetic surveying and drilling routinely to depths of 2000—5000 m have provided information on subsurface hydrocarbons, traps and petroleum systems. Advances made over the last decade in seismic acquisition and processing techniques, as well as modern preparation techniques on downhole biostratigraphic material have enabled sophisticated geological studies to be carried out, significantly advancing our understanding of the complex mechanisms controlling Phanerozoic basin evolution. Such methods are necessary because, with the exception of the Gulf of Suez, rocks no older than Neogene occupy over 90% of the northern Egyptian land surface. The exceptions, the exposed 'Syrian Arc' arches of Bahariyah, Abu Roash, Wadi'Araba, Gebel el Maghara and Gebel Arif en Naqa (Mesozoic and Upper Palaeozoic), provide important detailed control to subsurface models.

An indication of the exploration and development success of this activity, managed by the Egyptian General Petroleum Corporation (EGPC), is given by the maintenance of oil production at about 800 000—900 000 barrels of oil per day (BOPD) for well over a decade. As Gulf of Suez production shows signs of decline, so the smaller, more complex fields of the Western Desert have come on-stream. With the formulation of economic gas contracts, exploration activity is now stepping up in basins previously disdained.

In this paper, some of the results of this recent, more rigorous scientific endeavour will be presented. In particular, the application of micropalaeontology and palynology has revised, substantially in places, our understanding of the Phanerozoic stratigraphic succession. With these geological fundamentals in place, it has become possible to produce a more coherent and elegant geological model for the evolution of this entire area from Mid-Cambrian times onward.
Methodology

The stratigraphy of the Palaeozoic of the northern Western Desert and of the Jurassic of northern Egypt have recently been revised completely (Keeley, 1989; Keeley et al., 1990). Stratigraphic revisions of the Cretaceous and Miocene have yet to enter the public domain, but the problems associated with these systems are not as far-reaching in regional terms. In all these instances revision has been based on the results of systematic sampling and analysis of ditch cuttings and core material from exploration wells. The stratigraphic ranges of acritarchs, chitinozoa, dinoflagellate cysts, spores, foraminiferids and ostracods are compared with reference sections nearby, in Algeria and Libya, in Palestine and in Europe.

This biostratigraphic information can be applied in conjunction with downhole lithological information to construct a chronostratigraphic scheme. This in turn is