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Cenozoic stratigraphy of the Sahara, Northern Africa

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ABSTRACT

This paper presents an overview of the Cenozoic stratigraphic record in the Sahara, and shows that the strata display some remarkably similar characteristics across much of the region. In fact, some lithologies of certain ages are exceptionally widespread and persistent, and many of the changes from one lithology to another appear to have been relatively synchronous across the Sahara. The general stratigraphic succession is that of a transition from early Cenozoic carbonate strata to late Cenozoic siliciclastic strata. This transition in lithology coincides with a long-term eustatic fall in sea level since the middle Cretaceous and with a global climate transition from a Late Cretaceous–Early Eocene "warm mode" to a Late Eocene–Quaternary "cool mode". Much of the shorter-term stratigraphic variability in the Sahara (and even the regional unconformities) also can be correlated with specific changes in sea level, climate, and tectonic activity during the Cenozoic. Specifically, Paleocene and Eocene carbonate strata and phosphate are suggestive of a warm and humid climate, whereas latest Eocene evaporitic strata (and an end-Eocene regional unconformity) are correlated with a eustatic fall in sea level, the build-up of ice in Antarctica, and the appearance of relatively arid climates in the Sahara. The absence of Oligocene strata throughout much of the Sahara is attributed to the effects of generally low eustatic sea level during the Oligocene and tectonic uplift in certain areas during the Late Eocene and Oligocene. Miocene sandstone and conglomerate are attributed to the effects of continued tectonic uplift around the Sahara, generally low eustatic sea level, and enough rainfall to support the development of extensive fluvial systems. Middle–Upper Miocene carbonate strata accumulated in northern Libya in response to a eustatic rise in sea level, whereas Upper Miocene mudstone accumulated along the south side of the Atlas Mountains because uplift of the mountains blocked fluvial access to the Mediterranean Sea. Uppermost Miocene evaporites (and an end-Miocene regional unconformity) in the northern Sahara are correlated with the Messinian desiccation of the Mediterranean Sea. Abundant and widespread Pliocene paleosols are attributed to the onset of relatively arid climate conditions and (or) greater variability of climate conditions, and the appearance of persistent and widespread eolian sediments in the Sahara is coincident with the major glaciation in the northern hemisphere during the Pliocene.

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1. Introduction

The Sahara is an area of about 8–9 million km^2 in North Africa that extends from the Atlantic Ocean to the Red Sea, between the latitudes of approximately 16° and 34° North (Fig. 1). In some descriptions, this region is divided into two parts, with the eastern area being called the Libyan Desert and the central and western areas being called the Sahara Desert. In this paper, however, the term "Sahara" is applied to this entire region from the Atlantic Ocean to the Red Sea. In northwest Africa (Morocco, Algeria, Tunisia) the Sahara is bounded on the north by the Atlas Mountains, whereas farther east (Libya, Egypt) the Sahara is bounded on the north by the Mediterranean Sea. The Sahara is bounded on the south by a region called the Sahel, which is characterized by vegetated sand dunes. Today, the Sahara is a desert, and mean annual rainfall over most of the region is less than 100 mm/year (Dubief, 1963). The landscape of the Sahara is characterized primarily by exposed rock of Paleozoic and Mesozoic age, with accumulations of Cenozoic strata occupying structural and topographic basins. Eolian sand (sand sheets and ergs) of Quaternary age covers much of the Cenozoic strata.

This paper presents an overview of the Cenozoic stratigraphic record in the Sahara. Although much has been written on Quaternary strata in the Sahara (e.g., Gasse et al., 1987; Swezey, 2001; Kröpelin et al., 2008), the emphasis in this paper is on pre-Quaternary strata of Cenozoic age. The Cenozoic stratigraphic record is generally considered to be "remarkably sparse" (Ruddiman et al., 1989), poorly documented, and difficult to characterize on account of various differences in published descriptions, interpretations, and stratigraphic nomenclature. A closer examination, however, reveals that this record may not be as sparse as previously believed. As outlined in this paper, the Cenozoic strata of the Sahara display some remarkably similar characteristics across much of the region. In fact, some lithologies of certain ages are exceptionally widespread and persistent, and many of the vertical changes from one lithology to another appear to have been relatively synchronous across the Sahara. As outlined in greater detail below, the general strati-

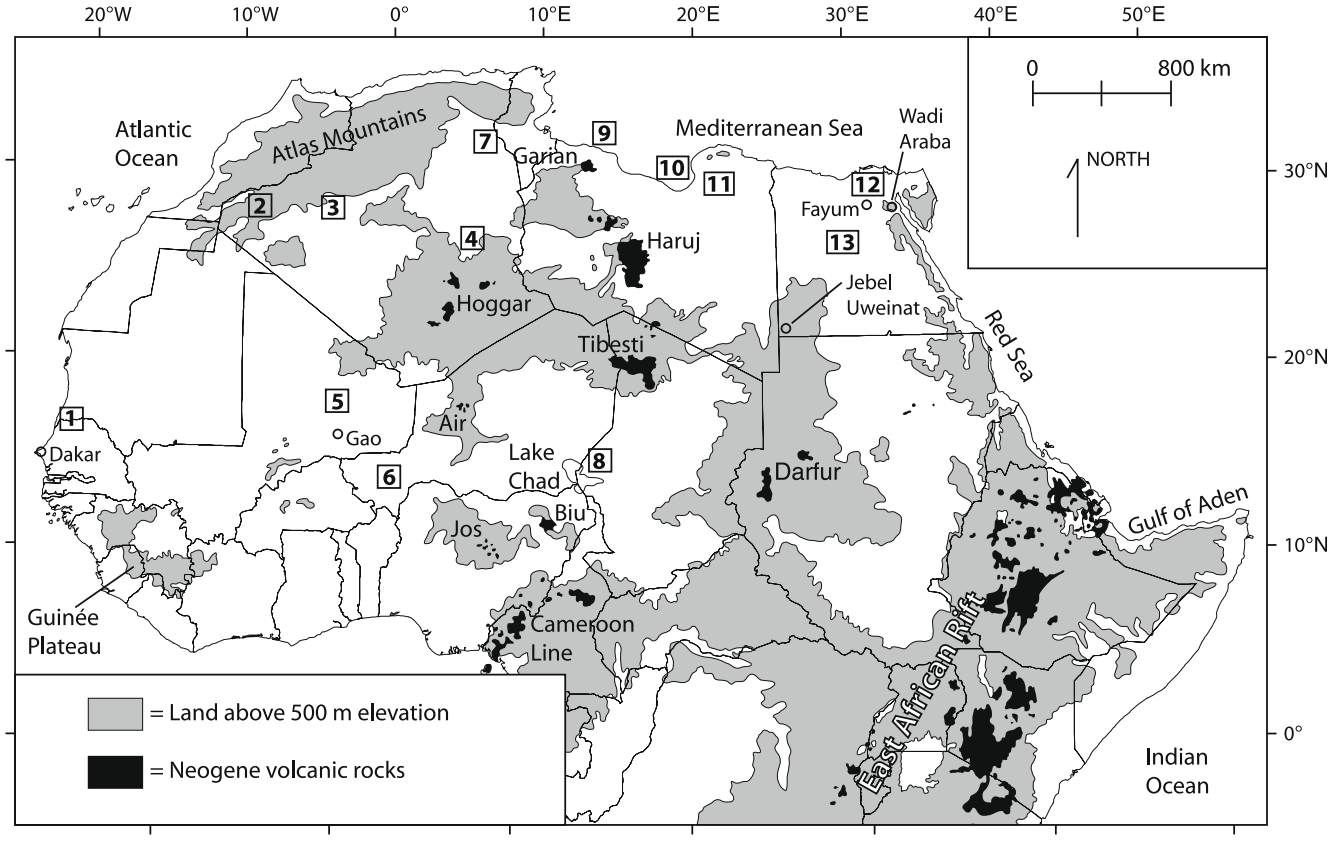

Fig. 1. Map of northern Africa showing topographic relief and the locations of selected Neogene volcanic rocks [modified from Burke and Wells (1989) and Wilson et al. (1998)]. The numbers 1–13 (in boxes) denote the locations of stratigraphic columns shown in Fig. 2.