Journal of African Earth Sciences 83 (2013) 74–103

Contents lists available at SciVerse ScienceDirect

Journal of African Earth Sciences

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

Variations in eruptive style and depositional processes of Neoproterozoic terrestrial volcano-sedimentary successions in the Hamid area, North Eastern Desert, Egypt

Ezz El Din Abdel Hakim Khalaf

Cairo University, Faculty of Science, Geology Department, Giza, Egypt

ARTICLE INFO

Article history:
Received 6 June 2012
Received in revised form 29 November 2012
Accepted 20 February 2013
Available online 4 March 2013

Keywords:
Hamid area
Volcano-sedimentary successions
Facies analysis
Vent and eruption column dynamics
Basin-fill architecture

ABSTRACT

Two contrasting Neoproterozoic volcano-sedimentary successions of ca. 600 m thickness were recognized in the Hamid area, Northeastern Desert, Egypt. A lower Hamid succession consists of alluvial sediments, coherent lava flows, pyroclastic fall and flow deposits. An upper Hamid succession includes deposits from pyroclastic density currents, sills, and dykes. Sedimentological studies at different scales in the Hamid area show a very complex interaction of fluvial, eruptive, and gravitational processes in time and space and thus provided meaningful insights into the evolution of the rift sedimentary environments and the identification of different stages of effusive activity, explosive activity, and relative quiescence, determining syn-eruptive and inter-eruptive rock units.

The volcano-sedimentary deposits of the study area can be ascribed to 14 facies and 7 facies associations: (1) basin-border alluvial fan, (2) mixed sandy fluvial braid plain, (3) bed-load-dominated ephemeral lake, (4) lava flows and volcaniclastics, (5) pyroclastic fall deposits, (6) phreatomagmatic volcanic deposits, and (7) pyroclastic density current deposits. These systems are in part coeval and in part succeed each other, forming five phases of basin evolution: (i) an opening phase including alluvial fan and valley flooding together with a lacustrine period, (ii) a phase of effusive and explosive volcanism (pulsatory phase), (iii) a phase of predominant explosive and deposition from base surges (collapsing phase), and (iv) a phase of caldera eruption and ignimbrite-forming processes (climactic phase). The facies architectures record a change in volcanic activity from mainly phreatomagmatic eruptions, producing large volumes of lava flows and pyroclastics (pulsatory and collapsing phase), to highly explosive, pumice-rich plinian-type pyroclastic density current deposits (climactic phase). Hamid area is a small-volume volcano, however, its magma compositions, eruption styles, and inter-eruptive breaks suggest, that it closely resembles a volcanic architecture commonly associated with large, composite volcanoes.

1. Introduction

Explosive volcanic eruptions commonly result in thick accumulation of pyroclastic debris over wide areas and instantaneous modification of the topography and drainage networks around a volcano (Manville et al., 2009; Németh et al., 2012; Smith, 1991). Large volumes of pyroclastic debris are also delivered rapidly to nearby sedimentary basins and lowlands, forming "syneruption" (Smith, 1991) or "posteruption" (Manville, 2001) deposits during and immediately after major eruptions. The influence of explosive volcanism on sedimentation, especially in nonmarine settings, has been therefore investigated in a number of studies (Kataoka, 2005; Mcclaughry and Gaylord, 2005; Palmer and Shawkey, 1997; Smith, 1991; Smith et al., 2002). The volcaniclastic deposits in a sedimentary basin can in turn provide valuable information on the location or direction of the source vent and the changing eruption styles of a volcano that has since been removed by erosion or buried in the subsurface (Kataoka et al., 2001; Lipman, 1976; Németh, 2010; Riggs and Busby-Spera (1990)). They also provide excellent chronostratigraphic marker horizons that can help correlate isolated sedimentary sections and unravel complex sedimentary facies architectures (Karaoglu and Helvaci, 2012; Knott et al., 2005).

Upward volcano growth, combined with tectonic uplift produces prograding coarsening-upwards volcaniclastic successions to $\geqslant$1 km thick in intra-arc or arc-marginal basins. Accumulations are thickest close to each volcano and fine and thin distally, giving rise to proximal–distal facies patterns (Kano and Takarada, 2007; Smith, 1991; Zernack et al., 2009). Proximal facies corresponding to the volcanic edifice comprise lava flows, autoclastic, and pyroclastic breccias and hypabyssal intrusions and pass laterally into medial apron associations of pyroclastic-flow, debris-avalanche,

E-mail address: E.2012_Khalaf@hotmail.com

1464-343X/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jafrearsci.2013.02.009

debris- and hyperconcentrated flow (lahar) deposits and then distal facies association of braided to meandering fluvial system deposits, overbank alluvium, and interbedded tephras (Kataoka, 2005; Maeno and Taniguchi, 2009). In weakly extensional, low-relief intra-arc basins, andesitic–dacitic stratovolcanoes may co-exist with intermediate-silicic composition calderas, resulting in complex intercalations of volcaniclastic rocks, lavas, and intrusions of varying composition and depositional environment (Smith et al., 1993; White and Robinson, 1992).

The Hamid area (600 km^2) is located between 26°58′ and 27°10′N latitude and 32°50′ and 33°02′E longitude (Fig. 1). Wadi Hamid area, known for its Pb-mining activity, lies to the west of Gabal Dokhan and is occupied by the Neoproterozoic Dokhan-Hammamat volcano-sedimentary successions (Fig. 1). These successions are unconformably overlain from the west by Phanerozoic sandstone of Nubia facies. Publications on the North Eastern Desert (NED), including the study area, are few in number if compared with the published works on the central and southern parts of the Eastern Desert (e.g., Dardir and Abu Zied, 1972; Ghanem et al., 1973; Khalaf, 1999; Mohamed et al., 2000). Previous works focused on the larger scale implications involving geochemistry, geotectonic setting, and very few radiogenic dating of the volcano-sedimentary successions in Egypt (Breitkreuz et al., 2010; Willis et al., 1988; Wilde and Youssef, 2002). Comparatively little is known about the internal lithofacies subdivisions of the eruptive sequence, volcanological, and sedimentological facies analysis and the implications for the eruption style, transport, and depositional processes. New field observations and a stratigraphy for the internal subdivision of the Neoproterozoic volcano-sedimentary successions in the Hamid area, based on regional mapping, extensive

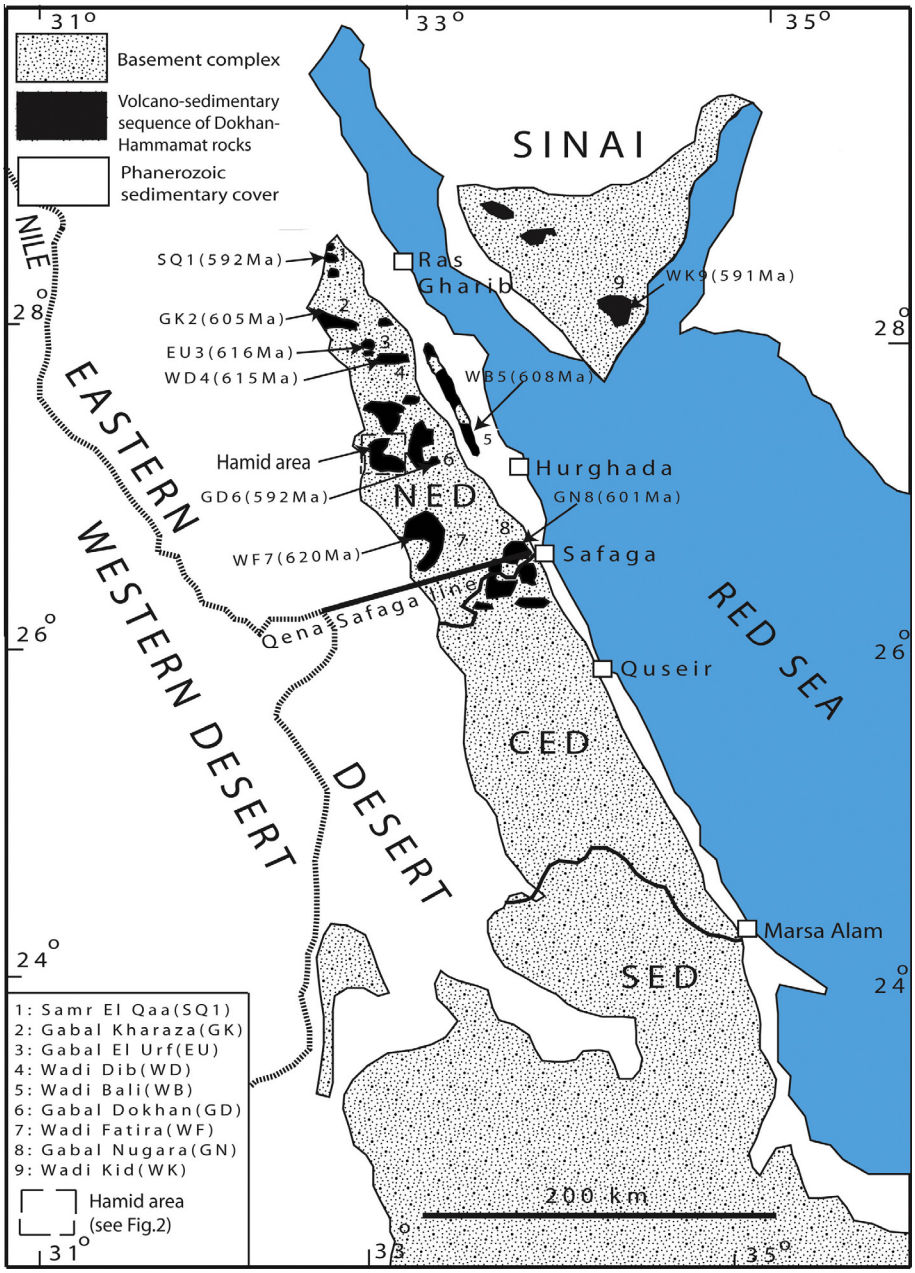

Fig. 1. Simplified geologic map showing the distribution of the Dokhan Volcanics and Hammamat Group in the North Eastern Desert, Egypt (data were collected from several resources including Abdel Rahman, 1996; Hassan and Hashad, 1990; Grothaus et al., 1979; Wilde and Youssef, 2002). The approximate boundary between North Eastern Desert (NED), Central Eastern Desert (CED), and South Eastern Desert (SED) according to Greiling et al. (1994).