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Pre- and post-Marinoan carbonate facies of the Democratic Republic of the Congo: Glacially- or tectonically-influenced deep-water sediments?

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A B S T R A C T

The upper carbonate-rich parts of the West Congo Supergroup (~1000–560 Ma) from the Democratic Republic of the Congo have hitherto been considered as a record of abrupt eustatic and climatic events accompanying glaciation and deglaciation of a Snowball Earth-type Marinoan ice age that was of global extent. These strata have however never been investigated in detail. Results of new sedimentological work at key outcrops over a 1300 km outcrop belt show that pre- and post-Marinoan carbonates are respectively, storm-influenced sediments deposited principally in a mid/outer-ramp setting, and deep-water slope carbonates (calciturbidites) representing a lobe-fringe or levee-overbank setting. The Upper Diamictite Formation held previously by some to be a subglacial tillite, comprises gravity flows (debrites) deposited in deep water below wave base along the unstable margins of a carbonate ramp. A direct glacial influence on sedimentation for diamictites or any accompanying facies cannot be readily identified. Sedimentary facies reported here primarily record the presence of deep-water submarine to alluvial fan systems related to extensional tectonic processes of the central-southern Macaúbas Basin (now located in Brazil) between 700 Ma and 660 Ma followed by the 630-Ma onset of the pre-collisional magmatic arc in the Araçuaí-West Congo Orogen. No extreme short-lived climatic or eustatic events of a Snowball Earth-type ice age are recorded in the studied succession, which primarily reflects long-term overriding regional tectonic controls resulting in diachronous sedimentation along the western margin of the Congo Craton.

1. Introduction

The Neoproterozoic Era (~1000–540 Ma) has been argued by some to be characterized by several catastrophic Snowball Earth-type ice ages involving short-lived global climate and eustatic events (Kirschvink, 1992; Hoffman et al., 1998; Hoffman and Schrag, 2002). The model postulates extremely low global temperatures (−50 °C) during several long-lived Neoproterozoic glacioeras (~770–735 Ma Kaigas, ~715–680 Ma Sturtian, ~660–635 Marinoan, and ~585–582 Ma Gaskiers events). Each event has been argued to involve the growth of large continental-scale ice sheets at sea level in areas near the equator, and a thick ice cover on the world's oceans. Based on the commonly considerable thickness of Neoproterozoic diamictites (to 1 km), lateral extent and in some cases, diagnostic glaciogenic features, such as subglacially striated pavements, facetted and striated clasts, ice-rafted dropstones and far-travelled extrabasinal clast assemblages (Boulton, 1978; Etienne et al., 2007; Arnaud and Etienne, 2011; Arnaud, 2012 and references therein), diamictites have at one time or another been reported as terrestrial glacial or cold climate deposits left by the melting of continental ice sheets ('tillites'). The presence in places of rocks interpreted as glaciogenic in origin with an overlying dolomite unit has been described as evidence of abrupt warming related to an increase of atmospheric carbon dioxide due to volcanic degassing.

However, other work has cautioned that thick diamictites more often than not lack convincing glacial indicators and are deep marine deposits intimately associated with thick (~1 km) turbidite successions. These facies together form distinct tectonostratigraphic successions that were deposited in evolving tectonically-active rift basins as Rodinia broke apart. Diamictites often many hundreds of metres in thickness, are commonly amalgamated debrites recording repeated reworking and often mixing of gravelly and muddy coastal facies into deep water, thereby demanding caution in inferring direct glacially-controlled climatic and eustatic interpretations from such successions (see Eyles and Januszczak, 2004a, 2004b, 2007; Arnaud and Eyles, 2002, 2006; van Loon, 2008; Direen and Jago, 2008; Evans and Raub, 2011; Arnaud, 2012; Carto and Eyles, 2012 and discussion therein). Varying degrees of glacial influence have certainly been identified but point to regional, not global, ice covers strongly

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influenced by tectonically-generated topography and changing rates of subsidence and accommodation.

This paper contributes to the discussion of the putative global nature of Marinoan glaciation by describing pre-, syn- and post-glacial facies exposed along the West Congo Belt, immediately adjacent to the Congo Craton in the Democratic Republic of the Congo (DRC). These deposits record several tectono-eustatic events that occurred diachronously sometime between 700 Ma and 630 Ma along the eastern margin of the newly rifted São Francisco Craton and illustrate the challenges of identifying a direct climate signal from ancient rocks deposited in tectonically-active settings. In what follows, we describe the regional context of deposits exposed at several key sites in the West Congo Belt of the Lower Congo region in the DRC (Fig. 1). We then interpret these facies and their broader depositional setting, and then expand on their wider significance for understanding Marinoan glaciation.

2. Regional basinal context

The research area encompasses some 1300 km of exposures along the western margin of the Congo Craton extending from southwestern Gabon, across the Republic of Congo (RC) to the western part of the DRC, and to northern Angola. The Pan-African West Congo Belt is part of the Araçuaí-West Congo Orogen formed during Gondwana amalgamation (550 Ma) (Pedrosa-Soares et al., 2008) and is subdivided into

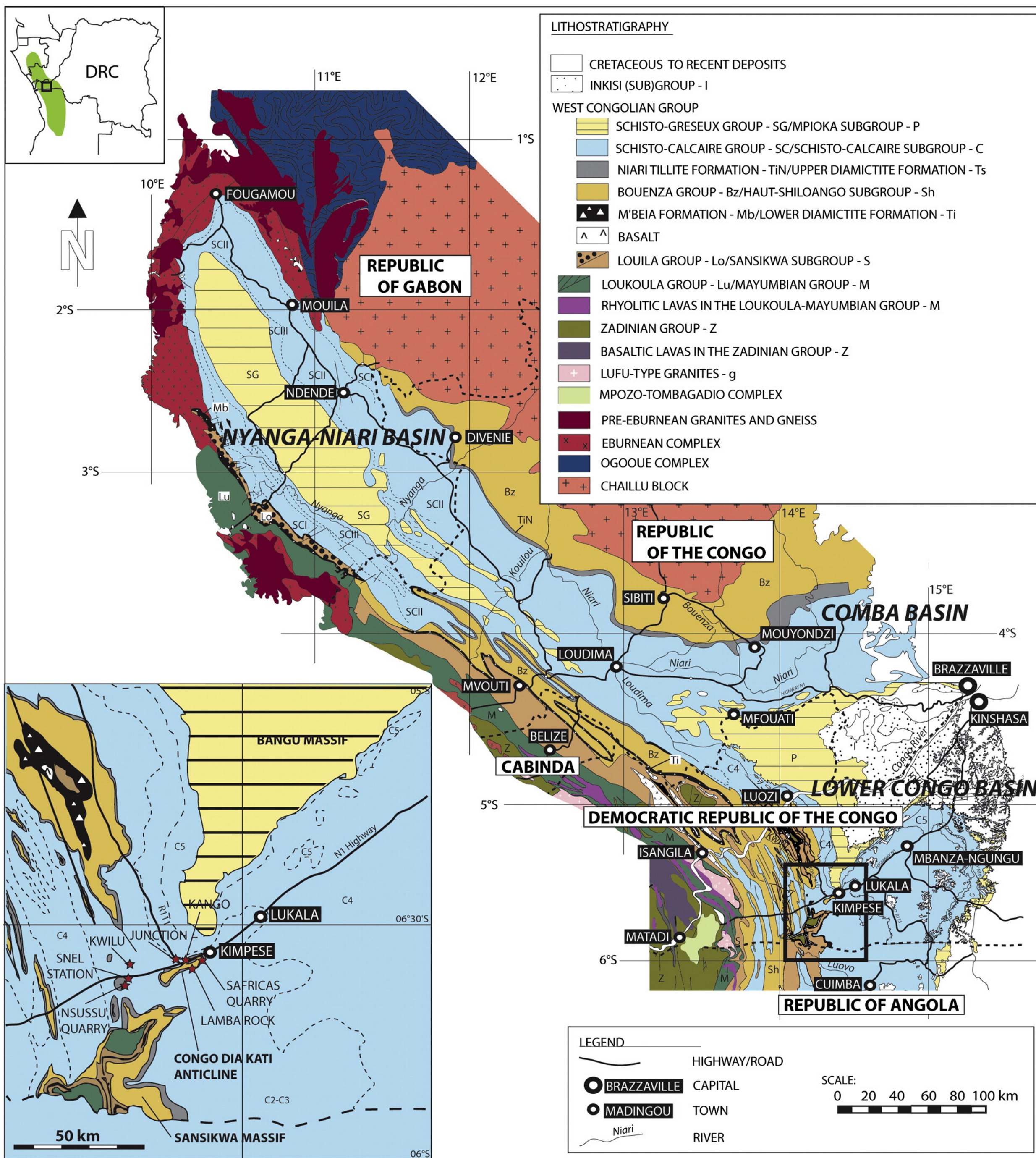

Fig. 1. Geological maps of the West Congo Belt and Kimpese area (from Lepersonne, 1973, modified). Locations of studied outcrops (red stars). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)