Journal of African Earth Sciences 112 (2015) 55–72

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

The thermal history of the Karoo Moatize-Minjova Basin, Tete Province, Mozambique: An integrated vitrinite reflectance and apatite fission track thermochronology study

Paulo Fernandes [a, *], Nathan Cogné [b], David M. Chew [b], Bruno Rodrigues [a], Raul C.G.S. Jorge [c], João Marques [d], Daud Jamal [e], Lopo Vasconcelos [e]

[a] Universidade do Algarve, Centro de Investigação Marinha e Ambiental (CIMA), Campus de Gambelas, 8005-139 Faro, Portugal
[b] Department of Geology Trinity College Dublin, Museum Building, Dublin 2, Ireland
[c] Centro de Geologia da Universidade de Lisboa (GeGUL), Faculdade de Ciências, Departamento de Geologia, Edifício C6, Piso 4, Campo Grande, 1749-016 Lisboa, Portugal
[d] Gondwana, Empreendimentos e Consultorias Lda., Rua B, n° 233, Bairro da Coop, Caixa Postal 832 Maputo, Mozambique
[e] Departamento de Geologia, Universidade Eduardo Mondlane, Av. Moçambique km 1,5, Caixa Postal 257 Maputo, Mozambique

ARTICLE INFO

Article history:
Received 16 December 2014
Received in revised form
11 September 2015
Accepted 12 September 2015
Available online 14 September 2015

Keywords:
Vitrinite reflectance
Apatite fission track
Moatize-Minjova basin
Karoo
Mozambique

ABSTRACT

The Moatize-Minjova Basin is a Karoo-aged rift basin located in the Tete Province of central Mozambique along the present-day Zambezi River valley. In this basin the Permian Moatize and Matinde formations consist of interbedded carbonaceous mudstones and sandstones with coal seams. The thermal history has been determined using rock samples from two coal exploration boreholes (*ca.* 500 m depth) to constrain the burial and exhumation history of the basin. Organic maturation levels were determined using vitrinite reflectance and spore fluorescence/colour. Ages and rates of tectonic uplift and denudation have been assessed by apatite fission track analysis. The thermal history was modelled by inverse modelling of the fission track and vitrinite reflectance data. The Moatize Formation attained a coal rank of bituminous coals with low to medium volatiles (1.3–1.7%*Rr*). Organic maturation levels increase in a linear fashion downhole in the two boreholes, indicating that burial was the main process controlling peak temperature maturation. Calculated palaeogeothermal gradients range from 59 °C/km to 40 °C/km. According to the models, peak burial temperatures were attained shortly (3–10 Ma) after deposition. Apatite fission track ages [146 to 84 Ma (Cretaceous)] are younger than the stratigraphic age. Thermal modelling indicates two episodes of cooling and exhumation: a first period of rapid cooling between 240 and 230 Ma (Middle – Upper Triassic boundary) implying 2500–3000 m of denudation; and a second period, also of rapid cooling, from 6 Ma (late Miocene) onwards implying 1000–1500 m of denudation. The first episode is related to the main compressional deformation event within the Cape Fold Belt in South Africa, which transferred stress northwards on pre-existing transtensional fault systems within the Karoo rift basins, causing tectonic inversion and uplift. During the Mesozoic and most of the Cenozoic the basin is characterized by very slow cooling. The second period of fast cooling and denudation during the Pliocene was likely related to the southward propagation of the East African Rift System into Mozambique.

1. Introduction

The geology of the northern and central provinces of Mozambique broadly comprises Precambrian metamorphic and igneous basement rocks, bordered to the east and south by the Meso-Cenozoic Rovuma and Mozambique sedimentary basins (Afonso, 1976; Afonso et al., 1998; Lächelt, 2004; Grantham et al., 2011) (Fig. 1). Located within the basement rocks are Karoo rift

* Corresponding author.
E-mail addresses: pfernandes@ualg.pt (P. Fernandes), cognen@tcd.ie (N. Cogné), chewd@tcd.ie (D.M. Chew), bmgrodrigues@sapo.pt (B. Rodrigues), rjorge@fc.ul.pt (R.C.G.S. Jorge), joaomarques@gondwana.co.mz (J. Marques), daudjamal1@gmail.com (D. Jamal), lopovasconcelos@gmail.com (L. Vasconcelos).

http://dx.doi.org/10.1016/j.jafrearsci.2015.09.009
1464-343X/

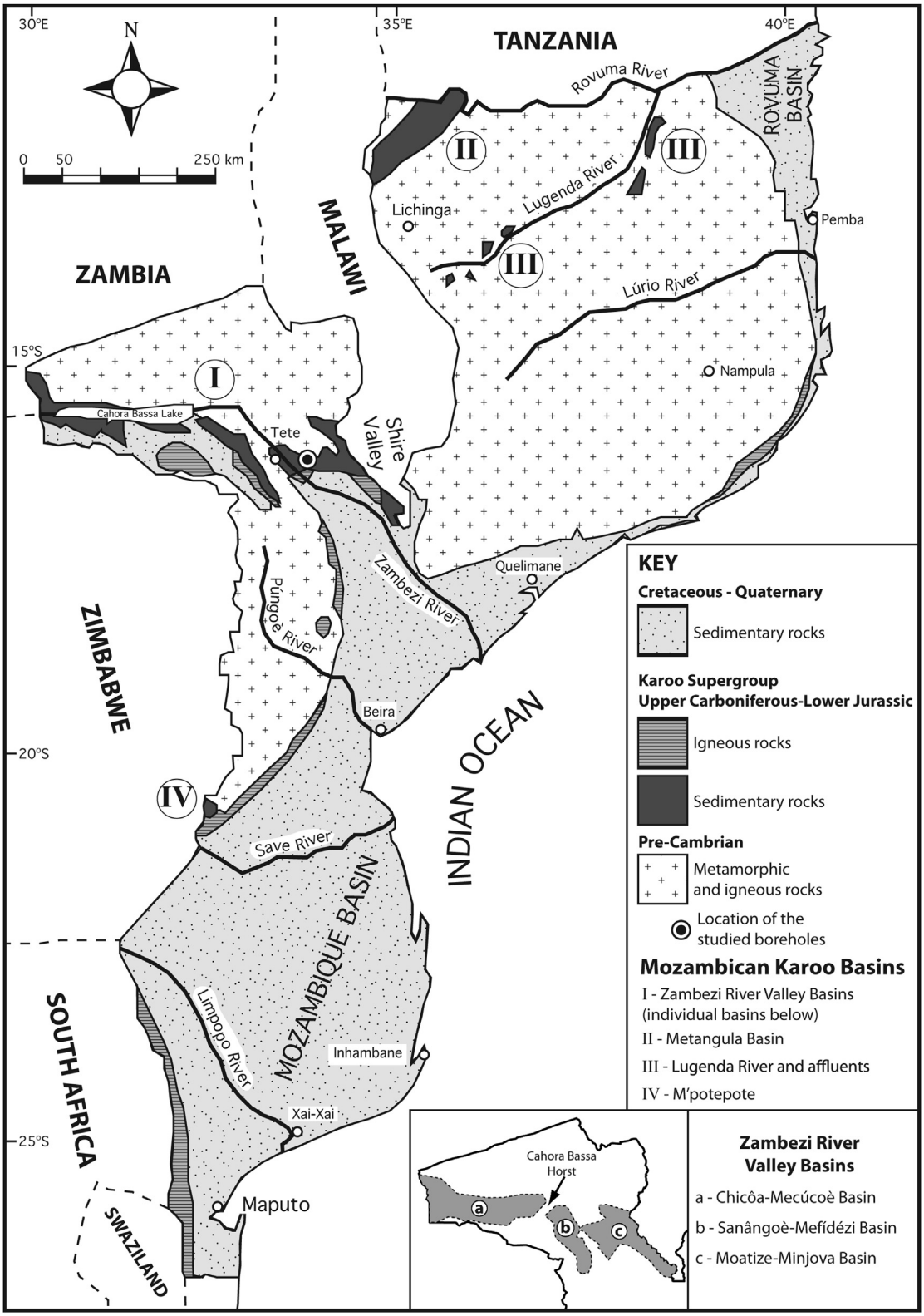

Fig. 1. Simplified geological map of Mozambique highlighting the location of the Karoo basins and the Rovuma and Mozambique Meso-Cenozoic basins. Adapted from Lächelt, 2004.

basins that developed during the Permian – Lower Jurassic (Hankel, 1994; Catuneanu et al., 2005). Basin development was associated with old crustal sutures that were formed during the Pan-African or East-African Orogeny (620–530 Ma) by collision of Mesoproterozoic and Neoproterozoic crustal blocks (Afonso, 1984; Pinna et al., 1993; Meert, 2003; Jamal, 2005; GTK Consortium, 2006; Norconsult Consortium, 2007; Grantham et al., 2008; Jacobs et al., 2008; Viola et al., 2008). The Karoo rift basins that