Application of stratigraphic frameworks and thermochronological data on the Mesozoic SW Gondwana intraplate environment to retrieve the Paraná-Etendeka plume movement

Florian C. Krob a,⁎, Ulrich A. Glas macher b, Hans-Peter Bunge b, Anke M. Friedrich c, Peter C. Hacks pacher d

⁎ Institute of Earth Sciences, Heidelberg University, Im Neuenheimer Feld 234, 69120 Heidelberg, Germany
b Department of Earth and Environmental Sciences, Geology, LMU, Lichtenbergstr. 27, 80333 Munich, Germany
c Department of Earth and Environmental Sciences, Geophysics, LMU, Theresienstr. 3, 80333 Munich, Germany
d Institute of Earth Sciences, Heidelberg University, Im Neuenheimer Feld 234, 69120 Heidelberg, Germany

Abstract
Since plate tectonics has been linked to material transport in the planet's mantle, it is commonly accepted that convective movements in the sub-continental mantle result in vertical flexures and horizontal plate motion on the Earth's surface. These mantle flow-driven vertical flexures are recognized through significant signals and traces in the stratigraphic record (e.g., unconformities and missing sections). Recently, Friedrich et al. (2018) introduced an event-based plume stratigraphic framework that uses such signals in the stratigraphic record to detect geological evolution and, on the Earth's surface, areas of intercontinental scale caused by mantle plume movement. Information about these dynamic processes is stored in geological archives, such as stratigraphic records of sedimentary basins and thermochronological data sets of igneous, metamorphic, and sedimentary rocks. The first for the first time, this research combines these two geological archives and applies them to the Mesozoic SW Gondwana intraplate environment to retrieve the Paraná-Etendeka plume movement for the first time. This research combines these two geological archives and applies them to the Mesozoic SW Gondwana intraplate environment to retrieve the Paraná-Etendeka plume movement prior to the Paraná-Etendeka Large Igneous Province. We compiled 18 stratigraphic records of the major continental and marine sedimentary basins and over 35 thermochronological data sets including 130 apatite fission-track ages surrounding the Paraná-Etendeka Large Igneous Province to test the event-based plume stratigraphic framework and its thermal evolution and therefore, we suggest that the Paraná-Etendeka plume movement may be retrieved in the sedimentary record. This study combined with stratigraphic records has the potential to retrieve the Paraná-Etendeka plume movement.

1. Introduction
Ever since plate tectonics has been linked to material flow in the Earth’s mantle (Wilson, 1963; 1965; Davies and Richards, 1992), it is commonly accepted that convective motion in the sub-continental mantle results in vertical flexures and horizontal plate motion on the Earth’s surface (Davies, 1999; Davies et al., 2019). These mantle flow-driven vertical deflections, known as dynamic topography (Hager et al., 1985; Braan, 2010), have attracted considerable attention lately (Bunge and Glas macher, 2018). Evidence for dynamic topography changes over geologic time comes from passive continental margins, in particular in the South Atlantic region (Paton et al., 2008; Guillocheau et al., 2012; Austin et al., 2013; Dussol et al., 2015), where spreading rate changes appear to correlate with uplift events, presumably owing to variations of upper mantle flow (Coll et al., 2013; Coll et al., 2016; Brune et al., 2016). Dynamic topography thus links to the convective mantle flow regime. Theoretical considerations based on the dynamic topography response of Earth models in internal loads (e.g., hot rising plumes or cold sinking lithosphere) imply that the Earth’s surface sustains deflections on the order of ±1 km (Coll et al., 2016), resulting in significant signals and traces in the stratigraphic record (e.g., Stille, 1919).
Late Neoproterozoic-to-recent long-term t–T-evolution of the Kaoko and Damara belts in NW Namibia

Florian C. Krob1 · Daniel P. Eldrache1 · Ulrich A. Glaesemann1 · Sabine Husch1 · Eric Salomon2 · Peter C. Hackspacher3 · Nortin P. Titus4

Received: 29 August 2019 / Accepted: 8 January 2020
© Geologische Vereinigung e.V. (GV) 2020

Abstract

This research aims to reconstruct the Late Neoproterozoic-to-recent long-term time–temperature-evolution of the NW Namibian Kaoko and Damara belts combining numerical modeling of new thermochronological data with previously published geochronological data. Our study demonstrates that the rocks of the Kaoko Belt in the NW Kaoko Belt with youngest ages confined to the coastal area and significant age increase towards the inland. New apatite fission-track data reveal ages between 429.5 ± 47.8 and 313.9 ± 53.4 Ma for the rocks of the Kaoko Belt. In the central Damara Belt, new apatite fission-track ages range between 138.5 ± 25.3 Ma to 63.8 ± 4.8 Ma. Combined apatite fission-track age distributions from Angola to Namibia and SE Brazil correlate for both sides of the South Atlantic passive continental margin and the reset ages overlap with the lateral Paraná–Etendeka dikes swarm distribution.

Keywords

Long-term t–T-evolution · Thermochronology · Numerical modeling · South Atlantic passive continental margin of NW Namibia

Multi-chronometer thermochronological modelling of the Late Neoproterozoic to recent t-T-evolution of the SE coastal region of Brazil

Florian C. Krob*, Ulrich A. Glaesemann, Markus Karl, Melissa Perner, Peter C. Hackspacher, Daniel F. Stockli

1 Institute of Earth Sciences, Heidelberg University, Im Neuenheimer Feld 234, 69120 Heidelberg, Germany
2 Department of Earth Sciences, University of Bergen, Realfagbygget, Allégt. 41, 5020 Bergen, Norway
3 Departamento de Geociências e Ciências Exatas, Universidade Estadual Paulista, Av. 24-A, 1515, B. Vila, SP 13506-900, Brazil
4 Department of Geological Sciences, University of Texas, Austin, 1 University Station C9000, Austin, TX, 78712-0254, USA

ABSTRACT

South-eastern Brazil is an important geological archive for understanding and reconstructing various plate tectonic stages of the Wilson Cycle. In the Neoproterozoic, the area of today’s South Atlantic passive continental margin (SAPCM; e.g. between São Paulo and Lagosa) of south-eastern Brazil underwent subsidence, followed by the collision of the contemporary plates of South America and Africa creating a Neoproterozoic orogeny within the supercontinent Gondwana. During the Paleozoic and Lower Mesozoic (stage 1), the future SAPCM, as an intracratonic area, experienced erosion, denudation of the Neoproterozoic mobile belts (Pan African/Brasiliano orogeny), and large basin formation (Paraná Basin) (stage 2). Possibly plate-driven pre-to syn-rift (embayment), ocean spreading (jump), and post-break up (maturation) processes led to the recent evolution of the SAPCM since the Upper Mesozoic (stage 3).

For the first time, this research aims to reconstruct the syn-to post-orogenic t–T-evolution of Neoproterozoic basement rocks of the SE coastal region of Brazil covering the entire geologic evolution since the Late Neoproterozoic. Therefore, this study uses geochronological and thermochronological data combined with numerical modeling. This includes published geochronological data of Neoproterozoic basement samples such as 40Ar/39Ar and Rb-Sr analyses, and low-temperature thermochronometry (LTT) data revealed by U/Th–He and Ar–Ar analyses. To this existing LTT data set, we report new apatite (AFT) and zircon (ZFT) fission-track, and U–Th–He (Ar–Ar) data. Numerical modelling of that LTT data attached to the existing geochronological data indicates the following evolution:

Stage 1: In the central part of the future SAPCM, the Pan African/Brasiliano post-orogenic cooling and exhumation (uplift and erosion) of Neoproterozoic rocks to the surface occurs in three phases: (i) rapid Late Neoproterozoic exhumation, (ii) a period of relative thermal stability (temperatures of about 200–200 °C) in which rocks reside at upper crust levels during the Early Cambrian to Devonian, and (iii) a second rapid exhumation phase moving the Neoproterozoic basement rocks to the surface during the Devonian. The northern and southern parts indicate a distinct post-orogenic exhumation suggesting faster cooling and exhumation from the Late Neoproterozoic to Devonian/Carboniferous than in the central section.

Stage 2: A phase of subsidence leading to the formation of the Paraná Basin followed by pre-to syn-rift processes and the emplacement of the Paraná–Etendeka flood basalts.

Stage 3: Post-South Atlantic break up processes, such as erosion and exhumation.

Introduction

Precambrian metamorphic and magmatic rocks are important archives that have stored information about long-term landscape forming processes, e.g., extensive and localized tectonic and volcanic activity, surface uplift and erosion (exhumation), and crustal scale subsidence. These long-term landscape forming processes are related to upper mantle and crustal tectonic-thermal dynamics, which can be reconstructed from the long-term time (t)–temperature (T) evolution of rocks in specific geological environments, i.e., along passive continental margins around the world (e.g., Brown et al. 2014; Green et al. 2015, 2018; Japsen et al. 2012, 2014; Braun 2018).

Until recently, most of the research along the South Atlantic passive continental margin (SAPCM) in NW Namibia was either focused on the Precambrian deformation, the