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# Detrital apatite fission-track ages in Middle Jurassic strata at the rifted margin of W Madagascar—indicator for a protracted resedimentation history

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**Abstract**

The combination of litho- and biostratigraphic data, detrital apatite fission-track (FT) ages, and palaeocurrent data from Jurassic sedimentary successions in the southern Morondava Basin (SW Madagascar) suggests a resedimentation of the detrital material. Detrital apatite FT ages of Middle Jurassic sedimentary rocks range between 428 ± 31 Ma to 233 ± 18 Ma. All apatite FT ages are older than their stratigraphic ages and become younger from top to the bottom of a Middle Jurassic profile. Such an apatite FT age distribution can be produced by a double inversion of the stratigraphic succession. Since the Late Carboniferous crustal extension between East Africa and Madagascar occurred. The sampled material was initially deposited prior to the Middle Jurassic, most probably during the Karoo Rifting (Latest Carboniferous–Late Triassic). Subsequently, resedimentation occurred during a second sedimentation cycle, which was probably connected to rift jump during the Jurassic Gondwana breakup and passive margin development between East Africa and Madagascar. This study demonstrates that under certain temperature constraints detrital apatite FT age distributions combined with litho- and biostratigraphic data can be used to verify sedimentation–resedimentation events.


*Keywords:* Madagascar; Gondwana; Fission-track dating; Stratigraphy

## 1. Introduction

Previous studies demonstrate that fission-track (FT) ages of detrital apatites are useful for provenance analysis under certain circumstances (e.g. Gallagher et al., 1998). Apatite FT ages record the cooling of a rock through the 110 ± 10 °C to 60 °C temperature range (e.g. Green et al., 1986). Detrital grains can contain the FTs that accumulated in the original source rock (Gallagher et al., 1998). The low temperature stability of FTs limits the application of the method to sedimentological problems but the results give good constraints for the thermo-tectonic setting of a sedimentary succession in a sedimentary basin.

In this paper, the detrital apatite FT age distribution in a Middle Jurassic series is used to verify resedimentation of material by analysing the stratigraphic order of the apatite FT ages in sediment samples. In general, vertical basement apatite FT age distribution is inverted when basement rocks of an undisturbed tectonic block are

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eroded. Assuming a simple 2D source to sink model within a basin temperature regime <60 °C, oldest apatite FT ages from the top of the basement succession are deposited at the bottom of the sedimentary basin. Younger apatite FT ages from deeper basement levels are deposited at the top of the sedimentary succession. During resedimentation this primary detrital apatite FT age distribution can be again inverted resulting in a secondary detrital apatite FT age distribution characterised by decreasing ages with depth. Consequently, the evidence of resedimentation is based on the double inversion of the apatite FT age distribution of a vertical profile.

Extraordinary vertical distribution of detrital apatite FT ages can also be produced by sedimentation of material that is being derived from different source regions with dissimilar apatite FT ages. In this study, we will demonstrate that this case is unlikely and we will constrain a resedimentation model. A resedimentation model based on apatite FT age distribution requires a uniform sedimentary environment with constant transport directions to minimise mixing from different sources. Stratigraphic control within the sedimentary successions can be best provided by a combination of bio- and lithostratigraphy. Constant transport directions, biostratigraphic potential, and proximal sediment sources can be assumed for the coastal marine environments found in the Jurassic strata of the southern Morondava Basin, western Madagascar.

## 2. Geological overview

Madagascar is characterised by crystalline and metamorphic basement exposures in the central and eastern part of the island and a belt of sedimentary basins along its western margin (Fig. 1). The eastern two-thirds of Madagascar is mainly composed of Archean and Palaeoproterozoic basement rocks that record a long-lasting deformation history (Collins et al., 2000, 2001; de Wit et al., 2001; Fernàndez and Ranalli, 1997; Kröner et al., 2000; Martelat et al., 2000; Meert et al., 2001; Nédélec et al., 2000; Tucker et al., 1999; Windley et al., 1994). The major part of the basement of Madagascar has been overprinted by the collision forming the Late Neoproterozoic/Early Paleozoic East African Orogen, with most geochronological systems being reset. The overprint reached medium- to high-grade conditions. Only the easternmost part of Madagascar lacks reworking. The major part of the island, however, shows U–Th–Pb zircon and monazite ages ranging from c. 590 to 500 Ma (e.g. Martelat et al., 2000; de

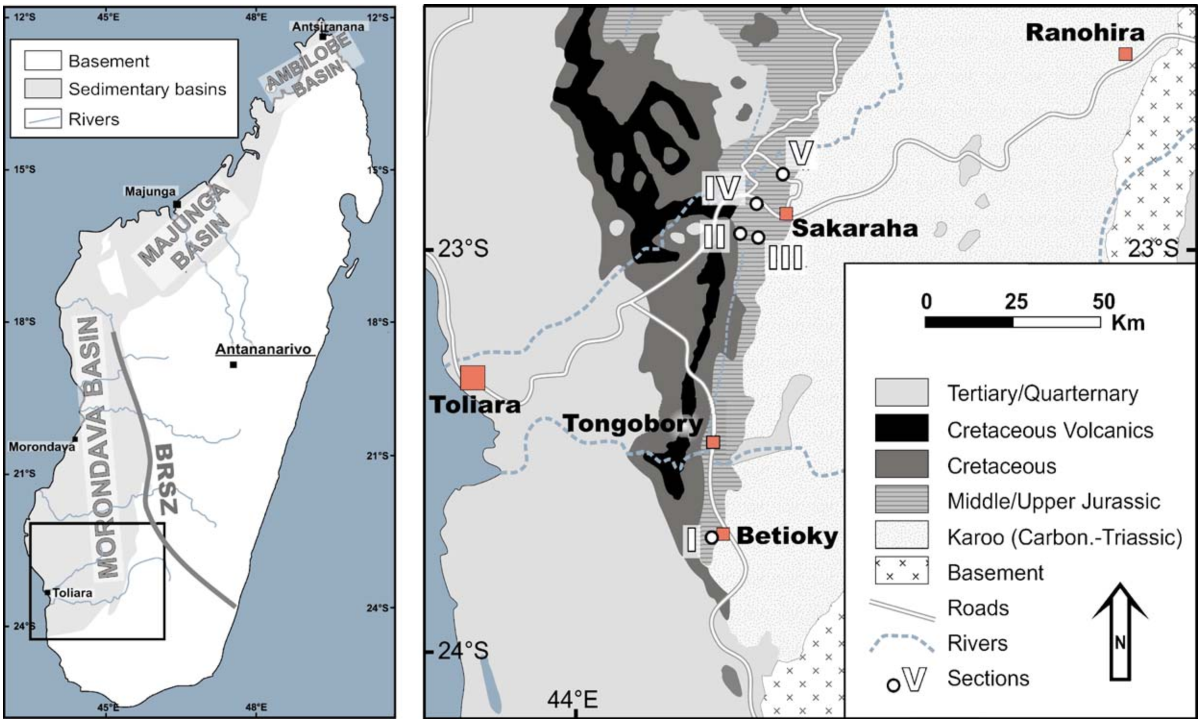


Fig. 1. Simplified geological maps of Madagascar. Detailed map with sample locations modified from the UNESCO International Geological Map of Africa at 1: 5 000 000 provided by the USGS. BRSZ = Bongolava–Ranotsara shear zone.