Chemical Geology 455 (2017) 32–43

Contents lists available at ScienceDirect

Chemical Geology

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

# Timing and genesis of the Karoo-Ferrar large igneous province: New high precision U-Pb data for Tasmania confirm short duration of the major magmatic pulse

Alexei V. Ivanov [a,*], Sebastien Meffre [b], Jay Thompson [b], Fernando Corfu [c], Vadim S. Kamenetsky [b], Maya B. Kamenetsky [b], Elena I. Demonterova [a]

[a] Institute of the Earth's Crust, Siberian Branch of the Russian Academy of Sciences, 128 Lermontov Street, 664033 Irkutsk, Russia
[b] University of Tasmania, School Earth Sciences, Hobart, Tasmania 7001, Australia
[c] University of Oslo, Department of Geosciences, Postboks 1047, Blindern 0316, Oslo, Norway

ARTICLE INFO

*Article history:*
Received 25 March 2016
Received in revised form 4 October 2016
Accepted 6 October 2016
Available online 8 October 2016

*Keywords:*
Karoo-Ferrar-Tasmania
Large igneous province
U-Pb dating
Subduction
Plume

ABSTRACT

The Karoo-Ferrar igneous province is one of the largest igneous provinces on Earth. It extends from South Africa, along the Trans-Antarctic Mountains to Tasmania and South Australia. Reconstruction of the continents back to the Gondwana configuration in the Early Jurassic reveals a total length of the Karoo-Ferrar province of > 5000 km. New isotope dilution thermal ionization mass spectrometry (ID-TIMS) single grain U-Pb ages for zircon and baddeleyite from Tasmanian dolerites combined with ID-TIMS literature single grain U-Pb ages from the Ferrar and Karoo suites are consistent with the major pulse of synchronous magmatism throughout the province lasting about 1 Ma or less for the major pulse of magmatism at the time of the Toarcian mass extinction event. We argue that the mechanism of synchronization of magmatism over such a short period of time along such a long distance is the major question which has to be answered in search of the correct model for the origin of the Karoo-Ferrar large igneous province. It cannot be reconciled with the lower mantle plume head model with the plume impingement beneath the Karoo. Plume material could not spread beneath the lithosphere at a rate of ~5–10 m/yr (5000 km per 0.5–1 Myr), at least based on the current knowledge of the mantle physical properties. It seems unlikely that the entire Karoo-Ferrar large igneous province formed due to long distance magma migration through dykes from the same mantle plume irrespective on the proposed plume centre location. In such case, magma would have had to cross the boundaries (and thus weakness zones) between three future continents. In the framework of the dyke propagation model we would expect dykes to follow these weakness zones, not cross them. In addition to this, the Karoo and Ferrar contain geochemically different igneous rocks, which were not formed from the same magma source, preventing interpretations based on one single plume. Both the Karoo and Ferrar contain low-Ti tholeiites, which are similar by their trace element patterns to modern arc analogues – the Central Andes and Kamchatka, respectively. Thus, our preferred model for the origin of the Karoo-Ferrar large igneous province is associated with subduction of the Phoenix plate beneath the southern Gondwana. Probably, deep slab dehydration at the depth of the mantle transition zone modulated surface volcanism or the Toarcian tectonic event triggered voluminous but short-term melting of mantle, which was metasomatized by subduction-derived fluids.

© 2016 Elsevier B.V. All rights reserved.

## 1. Introduction

The Karoo igneous suite is a significant part of a large igneous province which extends from South Africa, along the Trans-Antarctic Mountains to Tasmania and South Australia (Figs. 1, 2). When the plates are reconstructed to Early Jurassic configuration (Seton et al., 2012), the total length of the Karoo-Ferrar (KF) province is >5000 km and width from about 2000 km at Karoo to 1200 km at the Tasmania-Kangaroo Island end (Figs. 1, 2). Inclusion of Ferrar geochemical type dolerites found in New Zealand (Fig. 3, Mortimer et al., 1995) extends the KF province by additional 4000 km (Fig. 1). Thus, the KFT is among the largest igneous provinces on Earth (Ernst and Buchan, 1997; Bryan and Ernst, 2008).

Although previous studies have shown that the Ferrar dolerites and basalts were broadly coeval with the Karoo suite (Encarnación et al., 1996; Minor and Mukasa, 1997) published K-Ar, Re-Os and U-Pb ages for the Tasmanian dolerites are generally younger than the oldest

* Corresponding author.
*E-mail address:* aivanov@crust.irk.ru (A.V. Ivanov).

http://dx.doi.org/10.1016/j.chemgeo.2016.10.008
0009-2541/© 2016 Elsevier B.V. All rights reserved.

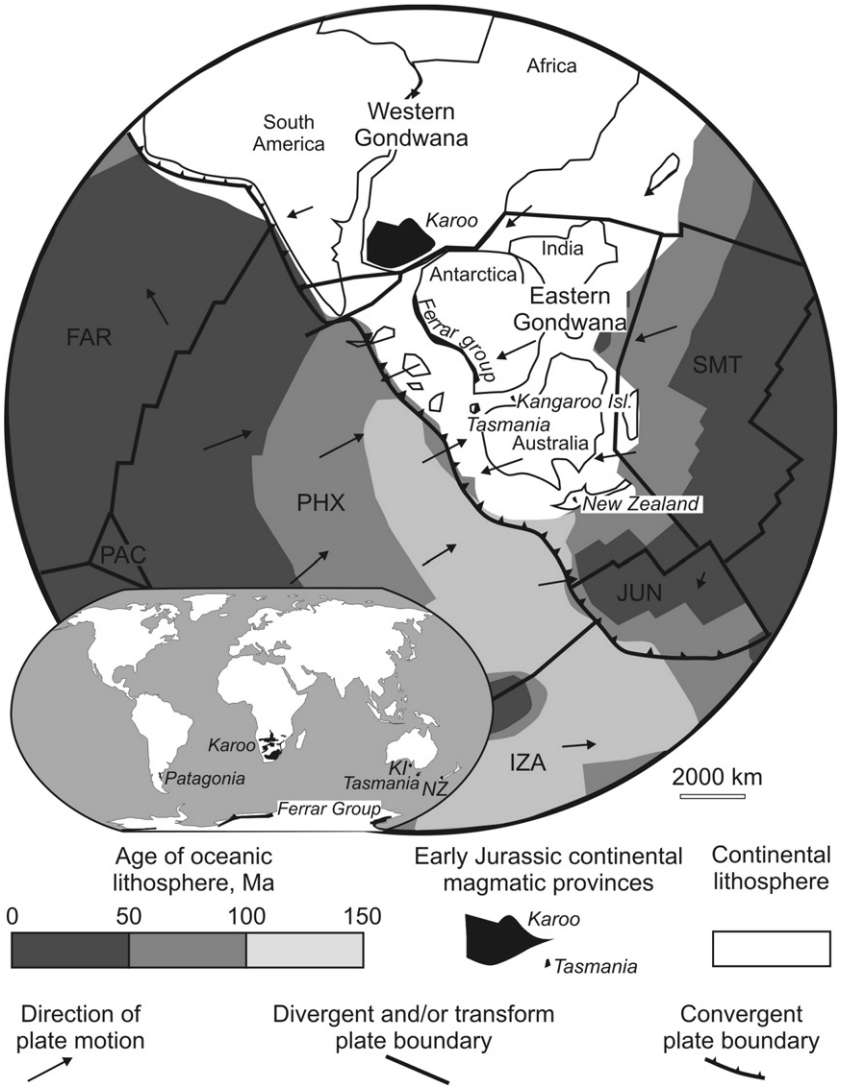


**Fig. 1.** Plate tectonic reconstructions of Gondwana at 180 Ma after Seton et al. (2012) and location of the Karoo-Ferrar large igneous province. Oceanic plates: PHX – Phoenix, FAR – Farallon, IZA – Izanagi, JUN – Junction, PAC – Pacific, SMT – South Meso-Tethys. Insert shows modern position of the continents. NZ and KI are acronyms for New Zealand and Kangaroo Island, respectively.

parts of the Karoo, supporting a temporal shift of volcanism towards the New Zealand-Australia end of the system (Brauns et al., 2000; McDougall, 2008; White and Ireland, 2012). In contrast, the only isotope dilution thermal ionization mass spectrometry (ID-TIMS) zircon U-Pb

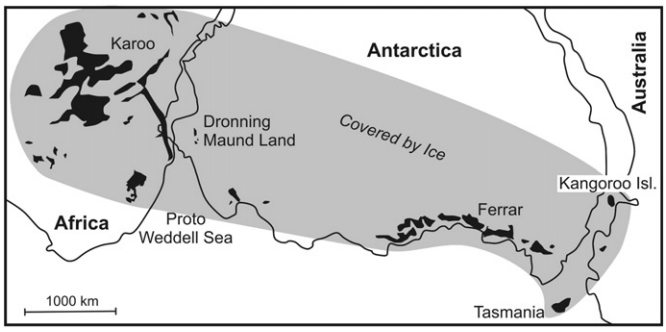


**Fig. 2.** Plate tectonic reconstructions of Gondwana at 180 Ma and location of the Karoo-Ferrar large igneous province with minor simplifications and modifications after Luttinen et al. (2010). Shaded field marks possible extent of the Karoo-Ferrar large igneous province.

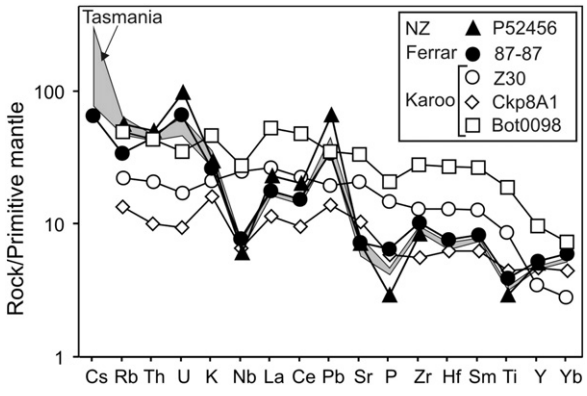


**Fig. 3.** Primitive mantle (McDonough and Sun, 1995) normalized diagram for Tasmanian, Ferrar and New Zealand low-Ti tholeiites in comparison with low-Ti rocks of Karoo. For Tasmania the field of the average ± 1 standard deviation is shown after Hergt et al. (1989a). For Ferrar and New Zealand (NZ), two selected rock compositions are provided after Hergt et al. (1989b) (sample 87-87) and Mortimer et al. (1995) (sample P52456), respectively. Selected low-Ti tholeiite (sample Ckp8A1), high-Ti tholeiite (sample Bot0098) and picrite (sample Z30) of Karoo are after Jourdan et al. (2007c).

Download English Version:

https://daneshyari.com/en/article/5782727

Download Persian Version:

https://daneshyari.com/article/5782727

Daneshyari.com