

Zircon oxygen isotope map of Western Australia

by

Y Lu, MTD Wingate, RH Smithies, L Martin¹, H Jeon^{1,2}, DC Champion³,
SP Johnson and DR Mole⁴

Abstract

The oxygen isotope compositions of igneous rocks are preserved in zircon crystals from the time of crystallization. The $^{18}\text{O}/^{16}\text{O}$ ratios are reported in delta notation as $\delta^{18}\text{O}$ (‰) values, normalized to Vienna Standard Mean Ocean Water (V-SMOW). Zircons crystallized from uncontaminated mantle-derived magmas have homogeneous $\delta^{18}\text{O}$ values ($5.3 \pm 0.6\text{‰}$, 2σ). Low-temperature interaction with surface waters leads to elevated $\delta^{18}\text{O}$ values, and high-temperature ($\geq 350^\circ\text{C}$) interaction with meteoric water or seawater leads to lower $\delta^{18}\text{O}$ values. Therefore, zircon $\delta^{18}\text{O}$ values can be used to fingerprint reworking and recycling of supracrustal rocks that have interacted with the hydrosphere of the Earth, and can be related to geodynamic processes.

The oxygen isotope map of Western Australia (Fig. 1) is based on primary zircon $\delta^{18}\text{O}$ data from igneous rocks. Zircon $^{16}\text{O}^{1}\text{H}/^{16}\text{O}$ ratios, together with cathodoluminescence texture and zircon age discordance, are used to assess whether the measured oxygen isotope ratios represent primary magmatic compositions, or if they potentially reflect alteration, weathering or contamination by inclusions. After filtering, the zircon $\delta^{18}\text{O}$ data show no correlation with $^{16}\text{O}^{1}\text{H}/^{16}\text{O}$, U, Th, Th/U and discordance on an individual sample basis, attesting to retention of primary magmatic compositions. Although zircon oxygen isotope data from altered, xenocrystic, metamorphic and detrital grains were not used in constructing the isotope map, this sample-level information is presented as a separate layer. All spot-level zircon data are provided as a CSV file.

The median $\delta^{18}\text{O}$ values of primary magmatic zircons from each igneous rock sample are visualized spatially using graduated symbols in a Manual Interval Classification in ArcGIS (Fig. 1). The Archean Pilbara and Yilgarn Cratons are dominated by mantle-like $\delta^{18}\text{O}$ values ($4.7 - 5.9\text{‰}$), consistent with reworking of igneous material that had not been exposed at the surface. Some igneous rocks in the Pilbara and Yilgarn Cratons exhibit weakly elevated zircon $\delta^{18}\text{O}$ values ($6.0 - 6.5\text{‰}$) which, together with trace element enrichment, are attributed to hydrous sanukitoids or to derivation from a sanukitoid-enriched source. The Capricorn, Paterson and Albany–Fraser Orogens and the Eucla Basin basement contain rocks that mainly indicate elevated $\delta^{18}\text{O}$ values ($6.6 - 10.4\text{‰}$), suggesting significant reworking of upper crustal material subjected to weathering or low-temperature hydrothermal alteration. Submantle $\delta^{18}\text{O}$ values ($1.7 - 4.6\text{‰}$) were found in zircons from igneous rocks in the Pilbara Craton, the Narryer and South West Terranes of the Yilgarn Craton, and the Albany–Fraser Orogen and Musgrave Province, and suggest reworking of crustal material subjected to high-temperature hydrothermal alteration, such as observed in rift systems or calderas.

The oxygen isotope data were compiled as part of a collaboration between the Geological Survey of Western Australia (GSWA) and Geoscience Australia (GA). Acquisition of GSWA's oxygen isotope data was funded by the Exploration Incentive Scheme (EIS), and was conducted using a Cameca IMS 1280 ion microprobe with the scientific and technical assistance of Microscopy Australia at the Centre for Microscopy, Characterization and Analysis (CMCA), a facility at The University of Western Australia (UWA) funded by UWA and by State and Commonwealth Governments.

¹ Centre for Microscopy, Characterization and Analysis, University of Western Australia, 35 Stirling Highway, Perth, WA 6009, Australia

² Swedish Museum of Natural History, PO Box 50007, SE-104 05 Stockholm, Sweden

³ Geoscience Australia, GPO Box 378, Canberra, ACT 2601, Australia

⁴ Mineral Exploration Research Centre, Harquail School of Earth Sciences, Laurentian University, 935 Ramsey Lake Road, Sudbury, ON P3E 2C6, Canada

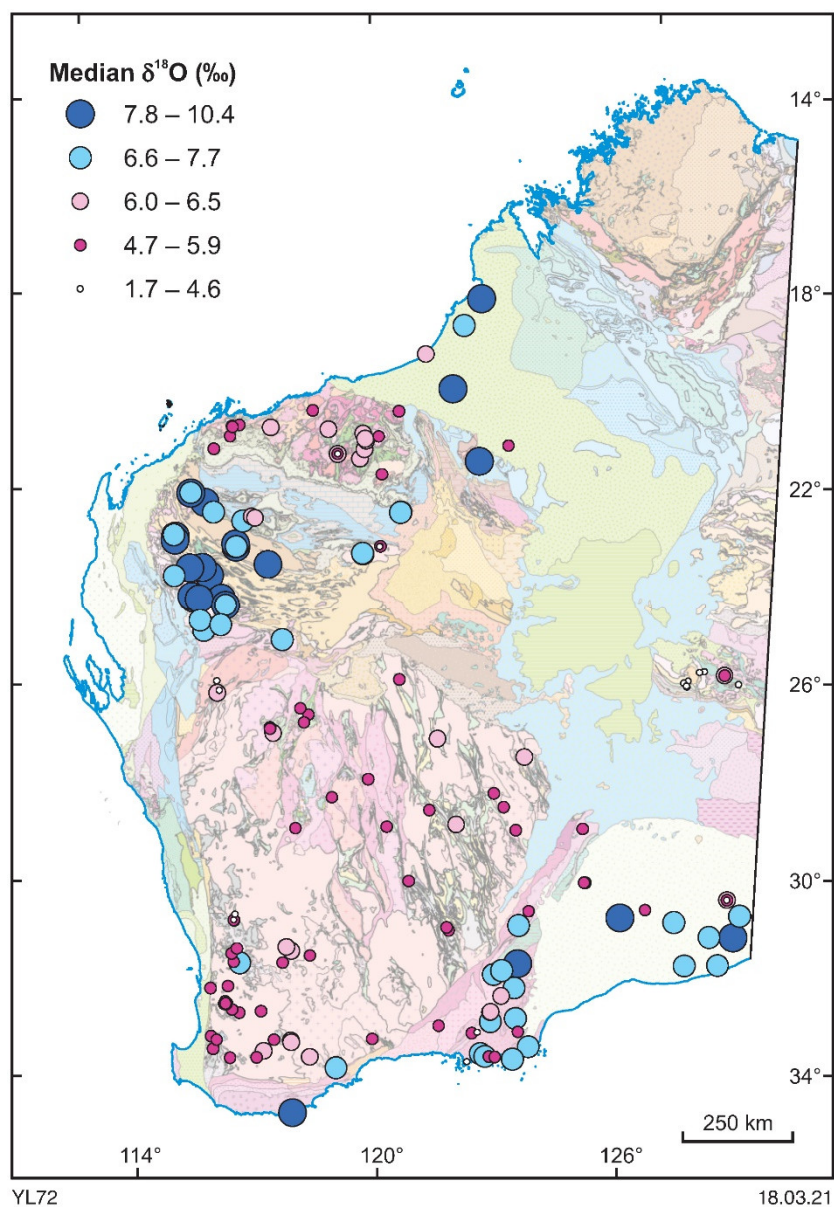


Figure 1. Zircon oxygen isotope map for igneous rocks in Western Australia. Median $\delta^{18}\text{O}$ values of primary magmatic zircons from each igneous rock sample are presented on top of the 1:2.5M interpreted bedrock geology map

How to access

The data layers are best accessed using [GeoVIEW.WA](https://www.dmirs.wa.gov.au/geoview). This online interactive mapping system allows data to be viewed and searched together with other datasets, including GSWA and GA geochronology data, geological maps and mineral exploration datasets. The **Zircon oxygen isotope map** data layer is also available as a free download from the [Data and Software Centre](#) via Datasets – Statewide spatial datasets – Geochronology & Isotope Geology – Zircon oxygen isotope map, as ESRI shapefiles and MapInfo TAB files. All spot-level zircon data are provided as a [CSV file](#). These datasets are subject to ongoing updates as new data are generated.

Recommended reference

Lu, Y, Wingate, MTD, Smithies, RH, Martin, L, Jeon, H, Champion, DC, Johnson, SP and Mole, DR 2021, Zircon oxygen isotope map of Western Australia: Geological Survey of Western Australia, digital data layer, <<https://www.dmirs.wa.gov.au/geoview>>.



THE UNIVERSITY OF
WESTERN AUSTRALIA



Australian Government
Geoscience Australia

Disclaimer

This product uses information from various sources. The Department of Mines, Industry Regulation and Safety (DMIRS) and the State cannot guarantee the accuracy, currency or completeness of the information. Neither the department nor the State of Western Australia nor any employee or agent of the department shall be responsible or liable for any loss, damage or injury arising from the use of or reliance on any information, data or advice (including incomplete, out of date, incorrect, inaccurate or misleading information, data or advice) expressed or implied in, or coming from, this publication or incorporated into it by reference, by any person whosoever.



© State of Western Australia (Department of Mines, Industry Regulation and Safety) 2021

With the exception of the Western Australian Coat of Arms and other logos, and where otherwise noted, these data are provided under a Creative Commons Attribution 4.0 International Licence. (<http://creativecommons.org/licenses/by/4.0/legalcode>)