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YILGARN GRANITE PROJECT – NOTES TO ACCOMPANY 2023 DATA RELEASE

JR Lowrey, RH Smithies and DC Champion





Government of **Western Australia**
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Cover image: Episodic tides discharge sediments along a rocky shoreline at Cable Beach, Broome. Photo by Robin Bower

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Available with the PDF online as an accompanying digital resource

Yilgarn Granite Project geochemical dataset

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Abstract

The Yilgarn Granite Project is an initiative under the State Government Exploration Incentive Scheme (EIS) that aims to provide complete and detailed coverage of the Yilgarn Craton in terms of modern, high-quality, major and trace element data (including Li) on felsic intrusive rocks, and at the same time, expand the coverage of whole-rock Sm–Nd isotope data. We hope also to identify, within this new dataset, potential proxies for crustal source composition, melting conditions and for fertility in terms of producing precious and strategic mineral deposits. As data are accumulated, the project will provide interpretation (digital data, GIS layers, Reports) that attempts to place these data within the context of crustal scale structure, source regions and economic mineral fertility.

The vast majority of the data generated during the first two years of this project (1034 analyses in 2021 and 1994 analyses in 2022) were derived from reanalysing archived materials, mainly from Geoscience Australia's (GA) Yilgarn Craton granite collection (now housed with GSWA), using the best whole-rock chemical assay methods commercially available. In this third year of the project, data were generated by reanalysing archived material from the GSWA sample collection (n = 345) and analysing samples collected recently during the course of GSWA geological mapping projects (n = 204), many of which were collected specifically for the Yilgarn Granite Project. For most reported elements, detection levels have lowered by an order of magnitude or more compared to the original methods reported in legacy GSWA and GA published datasets. This Record and the accompanying dataset will be updated and re-released annually, and it is expected that future releases will contain significant numbers of newly collected granitic samples from outcrop and drillcores across the Yilgarn Craton.

The locations of geochemical samples contained in the dataset are shown in Figure 1 and the dataset (Appendix) itself is fully attributed with the sample details required for a range of uses, potentially beyond the scope of the project. Separate Records will present interpretations of these data in line with the aims of the Yilgarn granite geochemistry project.

KEYWORDS: Archean, granite, whole-rock geochemistry, Yilgarn Craton

Sample selection and analytical techniques

Dataset content

The dataset presented here (n = 3577; Appendix) contains only those samples collected or reanalysed specifically for the Yilgarn Granite Project. Other data produced by the Geological Survey of Western Australia (GSWA) and various universities and research organizations are available in published literature or in publicly available online datasets (e.g. GSWA Geochemistry [WACHEM]; www.dmp.wa.gov.au/geochem). The dataset includes whole-rock major and trace element data primarily covering granitic (or meta-granitic) lithologies including high-level (subvolcanic) felsic intrusive rocks (commonly referred to as 'felsic porphyry'). It also includes some mafic igneous rocks, such as lamprophyres and quartz-gabbroic rocks, where

a co-magmatic relationship with felsic derivatives can be established or realistically inferred. The 2023 release of the Yilgarn granite dataset includes 549 new analyses. The vast majority of analyses reported here are reassays of powders from GA's granite dataset (n = 2829). The dataset also contains recent geochemical data for 748 samples, including samples collected from diamond drillcores and outcrops for current GSWA projects (n = 297), samples from the GSWA sample archive (n = 430), and samples from the Curtin University sample archive (n = 21). A list of cores that were sampled is provided in the Appendix (under the spreadsheet labelled 'DDH details'). This list includes details relating to the location, length and average or initial orientation of the drillholes. Where orientation details are unavailable, the drillhole is assumed to be vertical. The sampling interval (length/depth in the relevant core) is noted for all recent drillcore samples.

Each sample is accompanied by a geological description (Lithology, Field Description, and Field notes). These are largely uncorrected or unedited notes made at the time of sampling. Additionally, each sample is assigned to a 'Granite Class' (granite chemical classification) following the procedure presented by Lowrey et al. (2023).

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Most samples in GA's Yilgarn granite dataset have ferric and ferrous proportions of iron reported. Ferric iron (Fe^{2+} ; reported as FeO) was determined by titration and then used to calculate Fe^{3+} by the difference from total Fe as measured by X-ray fluorescence spectrometry (XRF). For all new samples, ferrous and ferric iron proportions were not determined and all iron (total) is reported in the ferric state, denoted as $\text{Fe}_2\text{O}_3\text{T}$. All major element concentrations and totals are calculated and reported both considering and ignoring analytical loss on ignition (LOI), the prefix 'a' (e.g. aSiO_2) denoting a concentration recalculated volatile free. No other derived values (e.g. ratios) are provided except for Mg# (molecular $\text{Mg}/[\text{Mg}/\text{Fe}]$; with Fe calculated as Fe^{2+}) and the Aluminum Saturation Index (ASI; molecular $\text{Al}/[\text{Ca}+\text{Na}+\text{K}]$).

Analytical methodology

Trace element concentrations for all analyses reported here were measured at a single commercial laboratory (Australian Laboratory Services [ALS] Global Pty Ltd) employing a single set of analytical procedures, outlined below. This approach minimizes the potential for any variation in the dataset potentially attributable to variations in analytical procedure. Major element and LOI assays for new samples were also measured at ALS, whereas for the reanalysis of GA's granite collection, it was decided that since the existing major element concentrations were determined using comparable methods and of similar quality to those being offered by commercial laboratories, this component of the analysis suite would not be repeated.

New samples collected for the purpose of this study were taken by GSWA geologists from drillcore and outcrops. Samples were visibly inspected and any weathering or excessive vein material was removed. Each sample was crushed by GSWA using a plate jaw crusher and splitter and milled by ALS using a low-Cr steel mill to produce a pulp with a nominal particle size of 90% <75 μm . A quartz-feldspar aggregate material containing below detection level concentrations of transition and precious metals was milled between each sample to scrub any remaining pulp residue from the previous sample. Representative pulp aliquots were analysed for 14 elements as major and minor oxide element components (of which we report 11; BaO, Cr_2O_3 and SrO are instead reported here as trace elements [Ba, Cr and Sr]), mass loss on ignition (LOI) and 60 elements as trace elements. Major and minor elements were determined by mixing a 0.66 g aliquot of sample with lithium borate flux (LiBO_2 , LiB_4O_7 and LiNO_3) in a 1:10 ratio, and then fusing the mixture at 1025 °C and pouring it into a platinum mold. The resulting disk was analysed by XRF (ALS method ME-XRF26). LOI was determined by thermogravimetric analysis (ALS method ME-GRA05). For resistive trace elements (Cr, V, Cs, Rb, Ba, Sr, Th, U, Nb, Zr, Hf, Y, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu), an aliquot of the sample was mixed with lithium borate flux and fused, then digested in acid and analysed by inductively coupled plasma mass spectroscopy (ICP-MS; ALS method ME-MS81). For the remaining trace elements (Ag, As, Be, Bi, Cd, Co, Cu, Ge, In, Li, Mo, Ni, Pb, Re, Sb, Sc, Se, Te, Tl, Zn), i.e. predominantly transition metals, a 0.25g aliquot of sample was digested with a mixture of concentrated acids (HClO_4 , HNO_3 , HF), heated at 185 °C until incipient dryness, then leached with 50% HCl and diluted

to volume with weak HCl, then analysed by ICP-MS and inductively coupled plasma atomic emission spectroscopy (ICP-AES; ALS method ME-MS61L).

Gold concentrations reported here were measured by digesting a 25g aliquot of pulverized sample in aqua regia (HClO_4 and HNO_3 mixed in a 3:1 ratio) then analysis by ICP-MS (ALS method Au-ST43). This technique has a lower detection limit of 0.1 ppb, an order of magnitude lower than commercially available fire assay techniques (1 ppb) which were found to be of limited usefulness in characterizing low-level Au concentrations in granites of the south west Yilgarn Craton, where 82% of samples contained <1 ppb Au and 94% of samples contained <10 ppb (based on 192 samples; Smithies et al., 2018).

Data quality was monitored by 'blind' insertion of sample duplicates (i.e. a second aliquot of pulp or finely crushed material) at a rate of 1 per 10 unknown samples, as well as GSWA internal reference materials and certified reference materials (OREAS 24b; <www.ore.com.au>), also inserted at a rate of 1 per 10 unknown samples. ALS also conducted repeat analyses of samples, variably certified reference materials and blanks. Accuracy and precision were assessed using analyses of certified reference sample OREAS 24b that were submitted together with Yilgarn Granite Project samples (28 analyses by ME-XRF26, 101 analyses by ME-MS81, 107 analyses by ME-MS61L). For analytes where the concentration is at least 10 times the lower level of detection (all analytes except Ag, Cd, Cl, In, Re, Sb, Te, Tl, W), a measure of accuracy is provided by the agreement between the average determined value and the certified value according to half absolute relative difference (HARD); that is, $(\text{analysis1} - \text{analysis2})/(\text{analysis1} + \text{analysis2})$ (Stanley and Lawie, 2007). The average of measured major and minor element concentrations agree to within 2 HARD% of their certified values. The average of measured trace element concentrations agree to within 5 HARD% of their certified values, except for Be (7 HARD%). In terms of precision, the relative standard deviation (RSD), or covariance, for analysis of OREAS 24b is $\leq 3\%$ RSD for major and minor elements and $\leq 10\%$ RSD for most trace elements. The exceptions are Bi, Ge, Se and Sn (34%, 37%, 11% and 10% RSD respectively). Similar levels of agreement were found for GSWA reference materials (granodiorite GRD-1 and basalt BB1) and between duplicate pair samples. All blank values were less than three times the lower level of detection.

The precision for Au is based on 59 analyses of OREAS 24b, with an average of 2.0 ppb and standard deviation of 0.47 ppb (24% RSD).

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