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## **DATA REPOSITORY**

DR1. Whole rock geochemistry methods.

Table DR1. Whole rock compositions for the Don Manuel Igneous Complex - see Excel file.

Table DR2. Plagioclase compositions for the Don Manuel Igneous Complex - see Excel file.

DR3. Zircon U-Pb geochronology:

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DR4.  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  Geochronology:

- Sample preparation
- $^{40}\text{Ar}$ - $^{39}\text{Ar}$  geochronology methods

Table DR4. Whole rock  $^{40}\text{Ar}/^{39}\text{Ar}$  data for basaltic andesite dikes from the Don Manuel Igneous Complex – see Excel file.

Figure DR5. Figure showing secondary biotite alteration in mafic enclave.

Figure DR6. Internal ductile contact within a composite intermediate porphyry dike (IPD).

## **DR1. WHOLE ROCK GEOCHEMISTRY METHODS**

A mass of  $0.1 \text{ g} \pm 0.002$  of sample was measured, placed in a platinum crucible with  $0.4 \text{ g} \pm 0.005$  lithium metaborate flux (Alfa Aesar Spectroflux 100B) and 0.5 mL of lithium iodide 25% solution (Alfa Aesar) that was used as a non-wetting agent, and fused in a Claisse FLUXY automated fusion system. The melt was automatically poured into a Teflon beaker with 50 ml of 4%  $\text{HNO}_3$  acid solution and stirred until completely dissolved. One mL of 100 ppm rhodium spike solution was added as an internal standard. All samples were diluted to 100 mL with 18.2 M $\Omega$  deionized water, resulting in a spiked rock solution in 2%  $\text{HNO}_3$ . Solutions were then analyzed for bulk composition using Inductively Coupled Plasma – Optical Emission Spectrometry (ICP-OES) using a JY Horiba ULTIMA2. Analyses of trace and rare earth elements were performed on some solutions that were first further diluted by 10 times with 2%  $\text{HNO}_3$  spiked to correct for instrument drift at low and high masses (5 ppb In and Tl internal standards). These solutions were analyzed using a Thermo Elemental X Series (X7) ICP-MS system. Calibration was carried out using reagent blank and international certified reference materials (CRM) (DTS-1, W2, BIR1, MRG1, JA2, STM-1 and JG3) and JA2, JG1a and JB1a as secondary standards. The relative analytical errors ( $\pm 2\sigma$ ) for major elements were less than 1% (with the exception of Fe and Na, where the error was 2%) and  $\sim 5\%$  for trace elements. The loss on ignition determination error is  $\sim 10\%$ .

## **DR3. ZIRCON U-PB GEOCHRONOLOGY**

### **Sample Preparation**

Four samples were split using a hydraulic rock splitter to reduce the sample to manageable fragments for the jaw-crusher. The jaw-crusher is used to reduce the split sample to a size suitable for sieving. Sample concentrates were prepared from sieve fractions from 50 to 250  $\mu\text{m}$  using a hand magnet, heavy liquid (LST, density at 2.85 g/mL), and a Frantz magnetic separator. Approximately 50 zircon grains from each sample were hand-picked from each concentrate. Grains were photographed in transmitted light (Figure DR3.1).

### **Zircon Characterization**

Grains were photographed in transmitted light (Figure DR3.1). Additional zircons from each sample were mounted in epoxy disks and polished to expose a cross-section through the grain. Zircons were then imaged in BSE and Cathodoluminescence (CL) at the British Geological Survey, and at the University of Bristol to (Figure DR3.2). CL imaging was done to texturally characterize each sample's zircon population. Zircons typically showed mixed populations of: 1) multifaceted crystals with large, rounded and resorbed antecrystic cores with late-stage discordant rims; and 2) elongate or prismatic zircons which showed simpler growth evolution within their CL images. For the zircon grains or fragments that were dated we favored the selection of elongate prismatic morphologies - as these were likely to contain the simplest growth histories that predated emplacement, and therefore give the best approximation of the emplacement age of their host intrusion. As DMIC zircons are typically small in size and have low concentrations of radiogenic Pb, we generally favored dating whole zircons or fragments rather than those that had been CL imaged due to the reduced mass resulting from polishing.

## Methods

Sample preparation and analyses for Chemical Abrasion Isotope Dilution Thermal Ionisation Mass spectrometry were carried out at the NERC Isotope Geosciences Laboratory (NIGL), British Geological Survey, Keyworth, UK. Methodology and instrumentation follows those described by Tapster et al. (2016). The important points are outlined here: Zircons were thermally annealed and chemically abraded prior to dissolution (Mattinson, 2005); The mixed  $^{205}\text{Pb}$ - $^{233}\text{U}$ - $^{235}\text{U}$  EARTHTIME solutions (ET535; (Condon et al., 2015; McLean et al., 2015); Common Pb was attributed to the NIGL laboratory blank isotopic composition and associated uncertainty based upon repeat analysis of total procedural blanks during the analytical period, U blanks were assigned a value of  $0.1 \pm 0.01$  pg ( $1\sigma$ ); Processing of isotope measurements, data reduction, error propagation, and date calculation was conducted using the TRIPOLI software package (Bowring et al., 2011) and ET\_Redux and related algorithms (McLean et al., 2011);  $^{206}\text{Pb}/^{238}\text{U}$  zircon dates were corrected for initial Th/U disequilibrium between the crystallizing zircon and its host magma, which leads to the preferential incorporation of  $^{238}\text{U}$  and exclusion of  $^{230}\text{Th}$ , a daughter isotope within the decay series of  $^{238}\text{U}$  to  $^{206}\text{Pb}$ . In turn, this leads to an eventual deficit in  $^{206}\text{Pb}$  within the analyzed zircons and younger apparent dates (Schärer, 1984). For the correction we assumed a  $\text{Th}/\text{U}_{(\text{melt})} = 3.5$  and concordance between the  $^{206}\text{Pb}/^{238}\text{U}$  and  $^{208}\text{Pb}/^{232}\text{Th}$  systems. Using the  $\lambda^{230}\text{Th}$  of Cheng et al., (2000), and the  $\lambda^{238}\text{U}$  of Jaffey et al., (1971) this correction results in an increase in  $^{206}\text{Pb}/^{238}\text{U}$  dates on the order of ca. 100 k.y. for individual fractions.

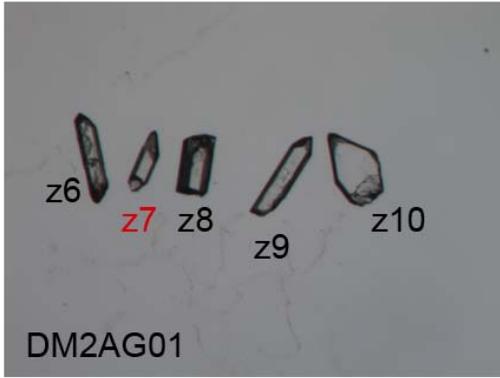
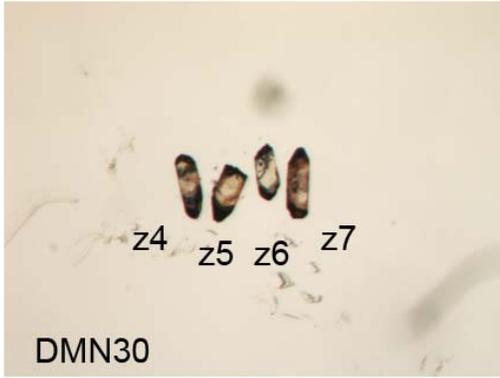
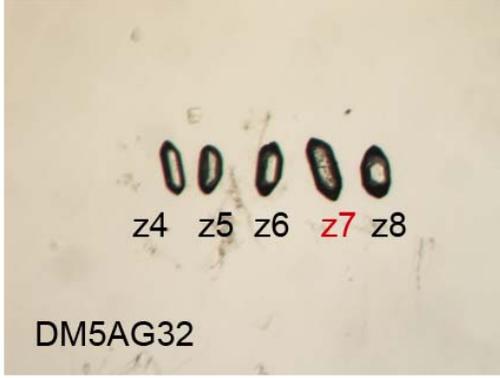


Figure DR3.1: Transmitted light images of annealed zircons. Red labels indicated zircons that were selected but were not analyzed. FOV = 1.2 mm. Not all samples shown.

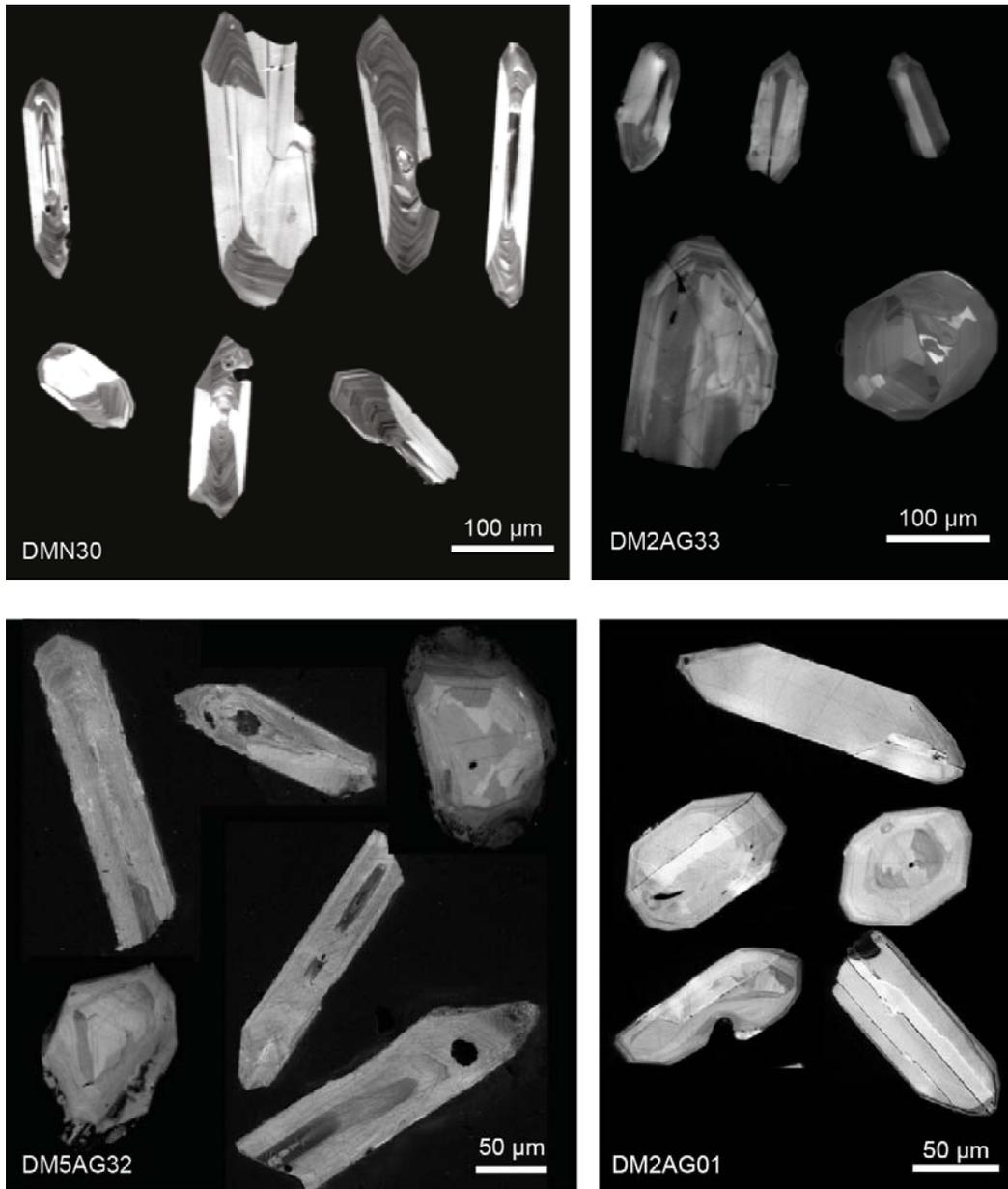


Figure DR3.2: CL images of representative zircons from dated samples. Not all samples shown.

#### DR4. $^{40}\text{Ar}/^{39}\text{Ar}$ GEOCHRONOLOGY

##### Sample Preparation

Samples were trimmed to remove any weathering/staining using a diamond water saw. Six samples were split using a hydraulic rock splitter to reduce the sample to manageable fragments for the jaw-crusher. The jaw-crusher is used to reduce the split sample to a size suitable for sieving. Samples were sieved to obtain a 250–500 µm aliquot. They were then

passed over with a strong hand magnet to remove any metal particles introduced during crushing. Dust was removed by washing the samples in deionized water in an ultrasonic bath for 10 min. Samples were leached in 3N HNO<sub>3</sub> for 20 min in an ultrasonic bath at 50 °C. This was repeated until a clear solution was obtained. Samples were then rinsed with deionized water and then washed with deionized water in an ultrasonic bath for 10 min. Samples were then hand-picked under a binocular microscope and care was taken to remove all phenocrysts and altered grains. For each sample 1 g of groundmass separate was attained.

## Methods

Samples and neutron flux monitors were placed in aluminum discs and stacked in quartz tubes. The relative positions of wells in the discs were precisely measured for later reconstruction of neutron flux gradients. The sample package was irradiated in the Oregon State University reactor, Cd-shielded facility. Alder Creek sanidine ( $1.2056 \pm 0.0019$  ( $1\sigma$ ) Ma, (Renne et al., 2011) was used to monitor <sup>39</sup>Ar production and establish neutron flux values (J) for the samples. Gas was extracted from samples via step-heating using a mid-infrared (10.6 μm) CO<sub>2</sub> laser with a non-gaussian, uniform energy profile and a 3.5 mm beam diameter. The samples were housed in a doubly-pumped ZnS-window laser cell and loaded into a copper planchette containing four 2.6 cm<sup>2</sup> square wells. Liberated argon was purified of active gases, e.g., CO<sub>2</sub>, H<sub>2</sub>O, H<sub>2</sub>, N<sub>2</sub>, CH<sub>4</sub>, using three Zr-Al getters; one at 16 °C and two at 400 °C. Data were collected on a GVi instruments ARGUS V multi-collector mass spectrometer using a variable sensitivity faraday collector array in static collection (non-peak hopping) mode (Mark et al., 2009; Sparks et al., 2008). Time-intensity data are regressed to  $t_0$  with second-order polynomial fits to the data. Mass discrimination was monitored on a daily basis by comparison to running-average values of an air standard. The average total system blank for laser extractions, measured between each sample run, was  $2 \times 10^{-15}$  mol <sup>40</sup>Ar,  $1 \times 10^{-17}$  mol <sup>39</sup>Ar,  $2 \times 10^{-17}$  mol <sup>36</sup>Ar. All data are blank, interference and mass discrimination corrected using the *MassSpec* software package (*MassSpec*, version 8.058, authored by Al Deino, Berkeley Geochronology Center, Version 8.058).

—Atmospheric argon ratios and discrimination—

( <sup>40</sup> Ar/ <sup>36</sup> Ar) <sub>atm</sub>	$298.56 \hat{A} \pm 0.31$
( <sup>40</sup> Ar/ <sup>38</sup> Ar) <sub>atm</sub>	$1583.5 \hat{A} \pm 2.5$

—Minor irradiation parameters (see also Irradiation Data File)—

( <sup>38</sup> Ar/ <sup>37</sup> Ar) Ca	$0.0000196 \hat{A} \pm 8.160000e-7$
( <sup>38</sup> Ar/ <sup>39</sup> Ar) K	$0.0122 \hat{A} \pm 0.000027$
P(36Cl/38Cl)	$262.9 \hat{A} \pm 1.1$

—Decay constants—

Lambda <sup>40</sup> K epsilon	$5.757000e-11 \pm 1.600000e-13$
Lambda <sup>40</sup> K Beta	$4.955000e-10 \pm 1.340000e-12$
Lambda <sup>37</sup> Ar	$0.01983 \pm 0.0000454$
Lambda <sup>39</sup> Ar	$7.068000e-6 \pm 7.882200e-8$
Lambda <sup>36</sup> Cl	$6.308000e-9 \pm 0$

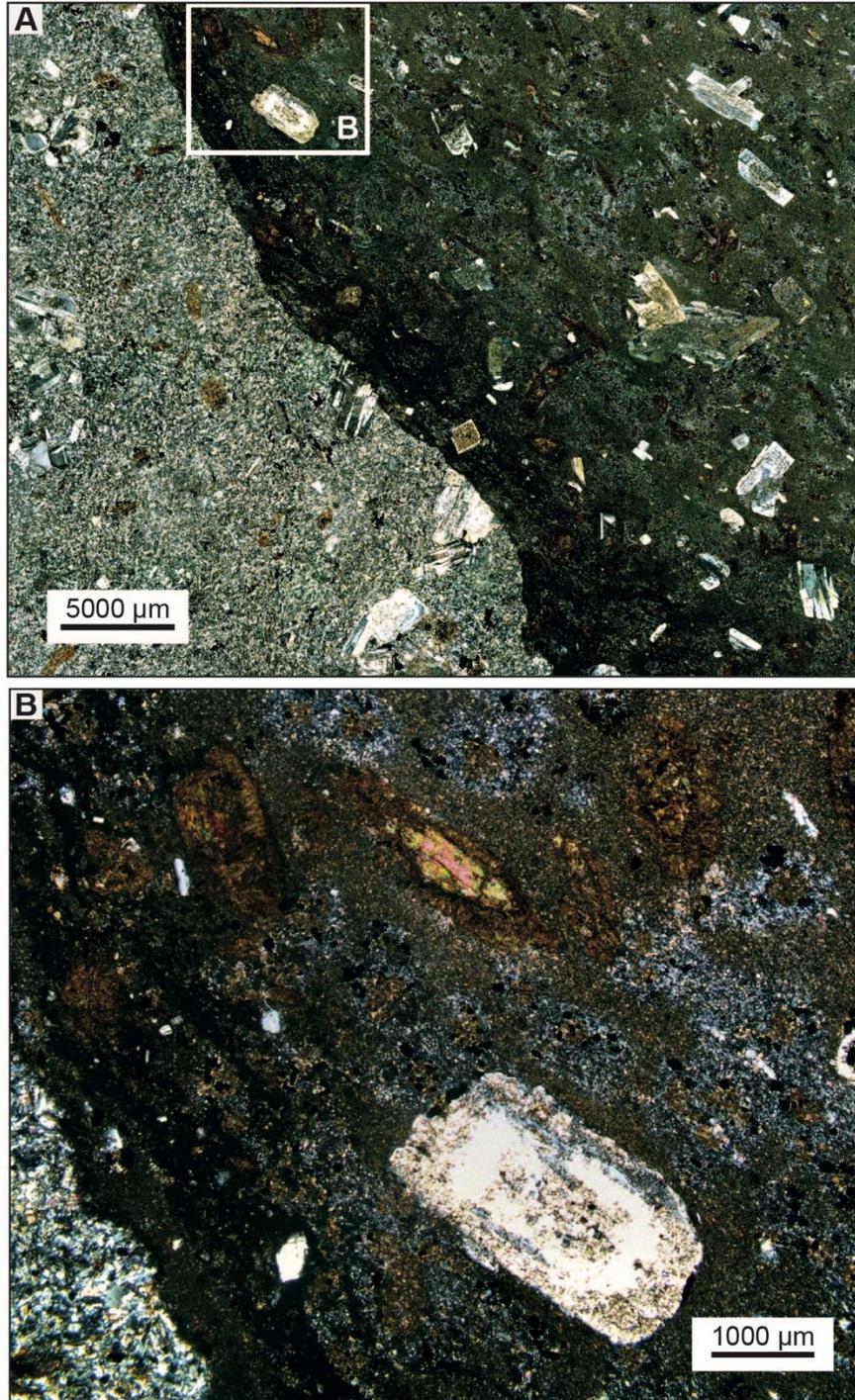


Figure DR5. (A) Mafic enclave in an intermediate porphyry dike showing plagioclase phenocryst likely entrained. (B) Inset showing significant secondary biotite alteration of mafic phases and groundmass.



Figure DR6. (A) Internal ductile contact within a composite intermediate porphyry dike (IPD). Yellow dashed line follows the contact (B).

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