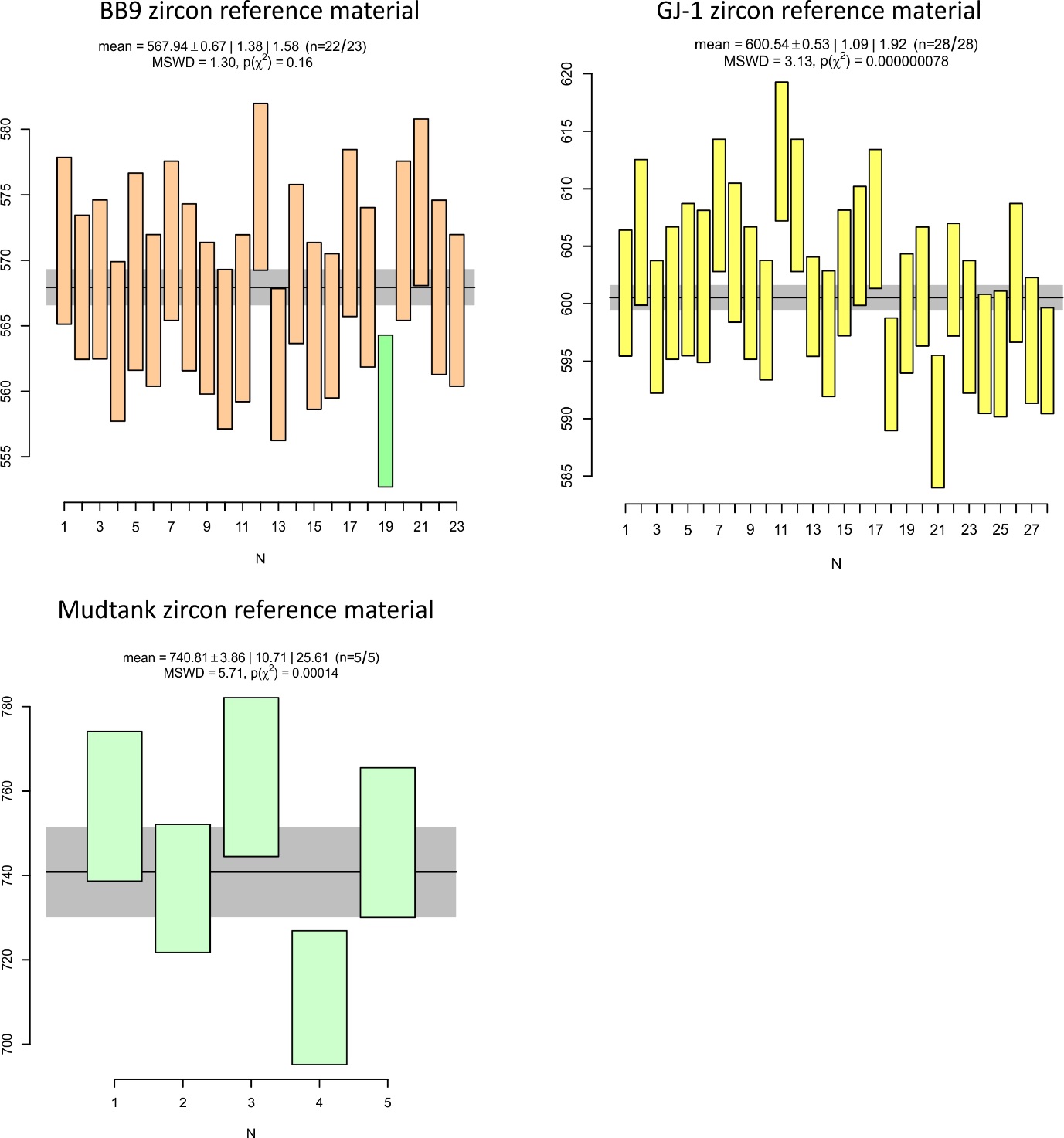
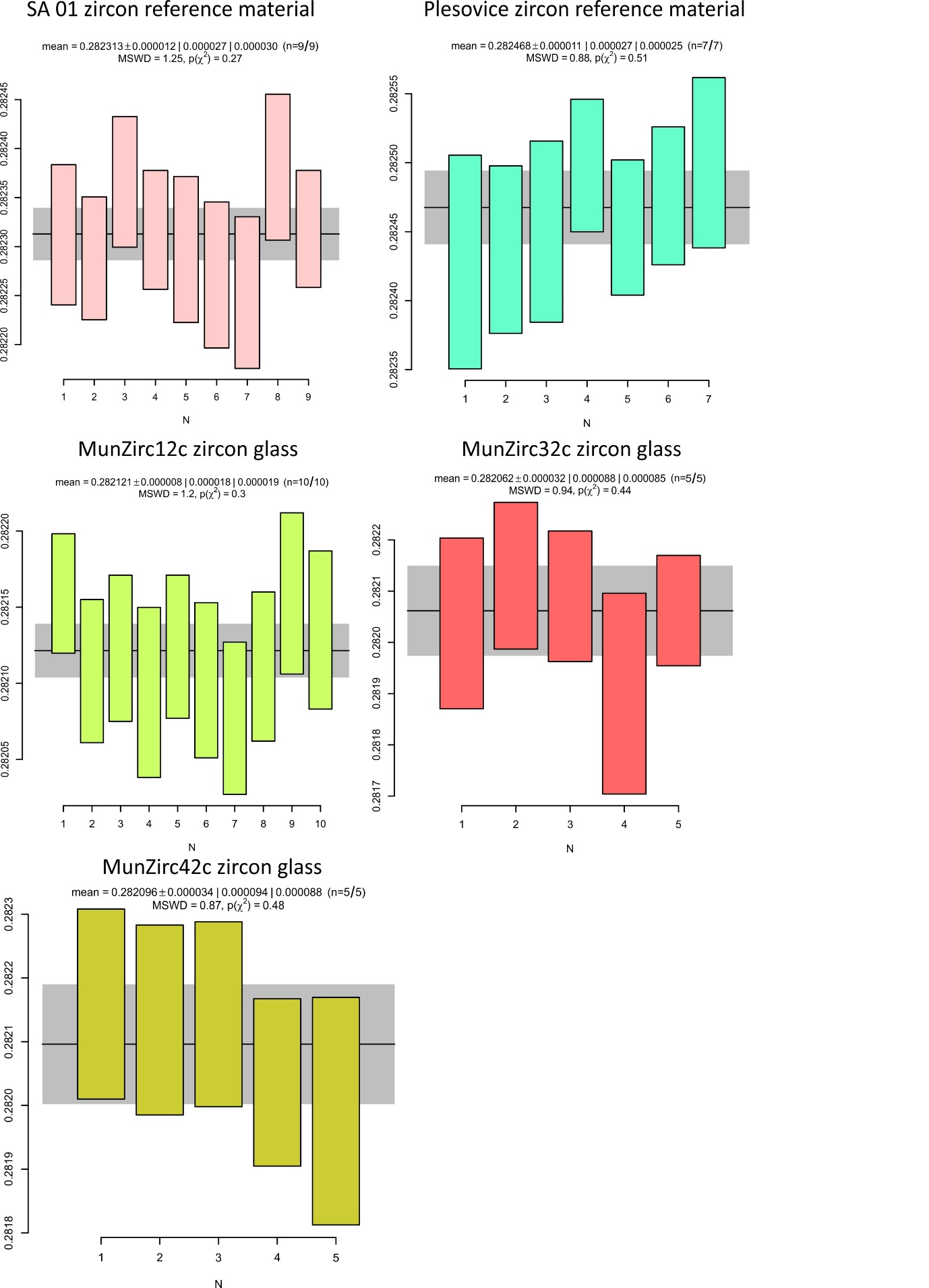
**Supplementary material**

1. Analytical details and instrumentation parameters (U-Pb and Lu-Hf isotopic analysis)

|  |  |
| --- | --- |
| **Laboratory & Sample Preparation** |  |
| Laboratory name | GEOTOP; Université du Québec à Montréal |
| Sample type/mineral | Zircon |
| Sample preparation | Conventional mineral separation, 1 inch resin mount, 1m polish to finish and thin section |
| Imaging | Centorus CL imager on a Hitachi S3400N SEM |
| **Laser ablation system** |  |
| Make, Model & type | Photon-Machines G2 |
| Ablation cell | Helix two-volume cell |
| Laser wavelength (nm) | 193 nm |
| Pulse width (ns) | 4 ns |
| Fluence (J.cm-2) | 3 Jcm-2 (U-Pb) / 9Jcm-2 (Lu-Hf) |
| Repetition rate (Hz) | 5 Hz (U-Pb)/ 15 Hz (Lu-Hf) |
| Ablation duration (secs) | 30 secs (U-Pb)/ 25 secs (Lu-Hf) |
| Ablation pit depth / ablation rate | *Not available* |
| Spot diameter (m) nominal/actual | 25 m (U-Pb)/ 50μm (Lu-Hf) |
| Sampling mode / pattern | Static spot ablation |
| Carrier gas | 100% He in ablation cell, Ar make-up gas combined using a Y-piece 35% along the sample transport line to the torch. |
| Cell carrier gas flow (l/min) | 0.7 l/min in first volume cell  0.5 l/min in second volume cell |
| **ICP-MS Instruments** |  |
| Make, Model & type | Nu Instruments, Nu Attom HR-ICP-MS and NuPlasmaII MC-ICP-MS |
| Sample introduction | Ablation aerosol |
| RF power (W) | 1300W |
| Make-up gas flow (l/min) | Ar (ca. 0.75 l/min, optimized daily) |
| Detection system | Attom: Ion counter; full size discrete dynode type  NuPlasma II : Faraday cups, 10^11 ohms resistors |
| Masses measured | 202, 204, 206, 207, 208, 232, 235, 238 for Attom  171 to 182 (Hf, Lu, Yb, Ta) for NPII |
| Integration time per peak/dwell times (µs) | 500µs per isotope, 20 sweeps per cycle for Attom  0.2 sec for NPII |
| Total integration time per output datapoint (secs) | * 1. seconds   2. seconds |
| ‘Sensitivity’ as useful yield (%, element) | 0.4%U (NIST 610 = 500ppm, #atoms sampled:  500ppm\*85um\*5hz\*3J/cm2: >20Mcps 238U) for Attom  Ca. 550 V/ppm Hf with Aridu II for NPII |
| IC Dead time (ns) | 12 ns |
| **Data Processing** |  |
| Gas blank | 30 second on-peak zero subtracted |
| Calibration strategy | 91500 used as primary reference material |
| Reference Material info | 91500 (Wiedenbeck et al. 1995) |
| Data processing package used / Correction for LIEF | Nu Instruments TRA and Iolite (Paton et al., 2011) for data normalization, uncertainty propagation and age calculation. LIEF correction assumes reference material and samples behave identically. |
| Mass discrimination | Down-hole correction and sample-standard bracketing (Iolite) |
| Common-Pb correction, composition and uncertainty | No common-Pb correction applied to the data. |
| Uncertainty level & propagation | Ages are quoted at 2*s* absolute, error propagation is by Iolite. |
| Quality control / Validation | Secondary reference materials (BB9, GJ-1, and Mudtank for U-Pb; **Figure 1**), (SA01, Plesovice, and MunZirc for Lu-Hf; **Figure 2**) |
| **Other information** |  |



**Figure 1**. Weighted average 206Pb/238U ages of the secondary reference materials BB9, GJ-1, and Mudtank that were interspersed with the unknowns during the U-Pb analytical sessions



**Figure 2**. Weighted average 176Hf/177Hf isotopic ratios of secondary reference materials interspersed with the unknowns during the Lu-Hf analytical session

2. Lu-Hf analytical details and methodology

Mass bias and isobaric interference corrections of 176Yb and 176Lu on 176Hf were made following the guidelines of previous studies (Woodhead et al., 2004, Fisher et al., 2014). The βYb (Yb mass bias) was determined by measuring the 173Yb/171Yb ratio relative to 173Yb/171Yb = 1.132685 (Chu et al., 2002). Following the calculation of βYb, the contribution of 176Yb on 176Hf was subtracted using the intensity of the interference-free 173Yb and a 176Yb/173Yb = 0.79618 (Chu et al., 2002). The contribution of the 176Lu on 176Hf signal was estimated assuming that βLu = βYb using the intensity of the interference-free 175Lu with a 176Lu/175Lu = 0.02656 (Blichert-Toft et al., 1997). The mass bias correction on the 176Hf/177Hf ratios was estimated using 179Hf/177Hf = 0.7325 (Patchett et al., 1981). Mass bias corrections for Yb, Hf, and Lu were made using an exponential law. For quality control on the mass bias corrections, the 178Hf/177Hf ratio on the analysed standards yielded a value of 1.46729 ± 10 (1s) in agreement with the published value of 1.46735 (Thirlwall and Anczkwiewicz., 2004). The 91500 was used as the primary standard using a 176Hf/177Hf value of 0.282298 ± 2 and 176Lu/177Hf of 0.000319 ± 18 (Bauer and Horstwood., 2018).

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