Historical Instrument Performance for Radiogenic Isotope Analysis in SRMs

PCIGR is committed to providing accurate, precise and reproducible data through careful sample preparation and analysis.

The following pages showcase a gallery of our instrument accuracy and precision over time, for a number of standard reference materials (SRMs), on the following isotopes:

- Sr isotopes (by TIMS)
- Nd, Hf and Pb isotopes (by multicollector ICP-MS)

For more information about our instrumentation and services, to view the references cited in this document, or to contact us, please visit our website at https://pcigr.ubc.ca/.

Sr Isotopes (by TIMS)

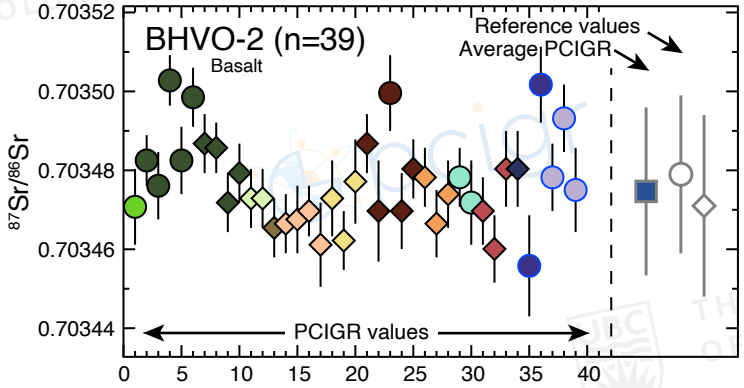
Our Nu Instruments Nu TIMS is configured for simultaneous collection of Sr (masses 84, 86, 87, 88) and Rb at mass 85, which allows for interference corrections to be applied to ^{87}Sr and for the potential presence of ^{87}Rb.

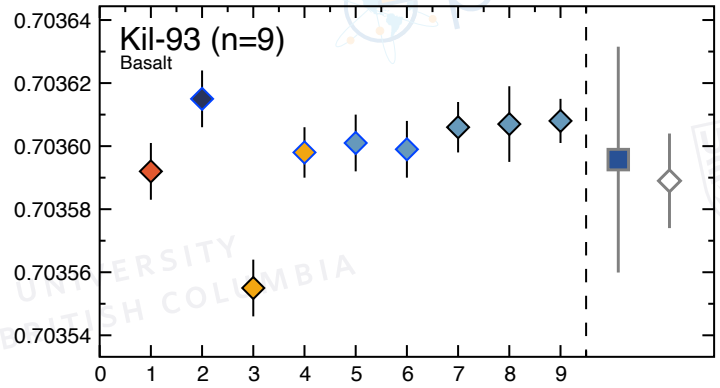
Nu TIMS at PCIGR. Photo: D. Weis.

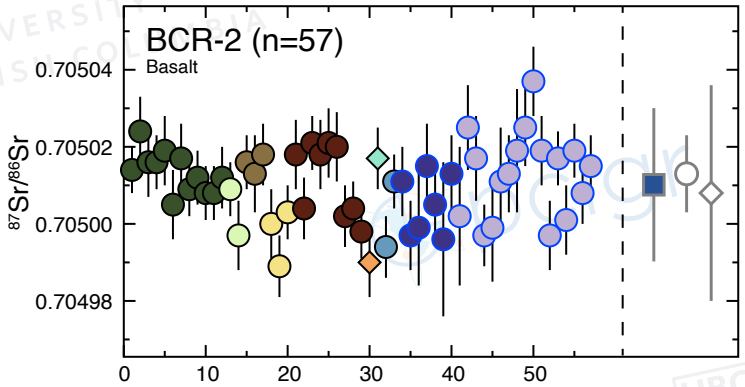
Sr isotope measurements are normalized internally to a $^{86}Sr/^{88}Sr$ ratio of 0.1194, using an exponential correction. For sample runs, data are normalized to the average value of SRM 987.

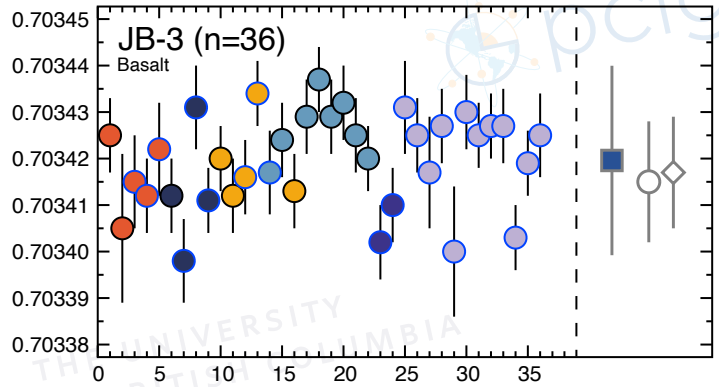
Each analysis takes ~ 1 hour to complete. We typically analyze 3–4 standards for every wheel of 17–18 samples.

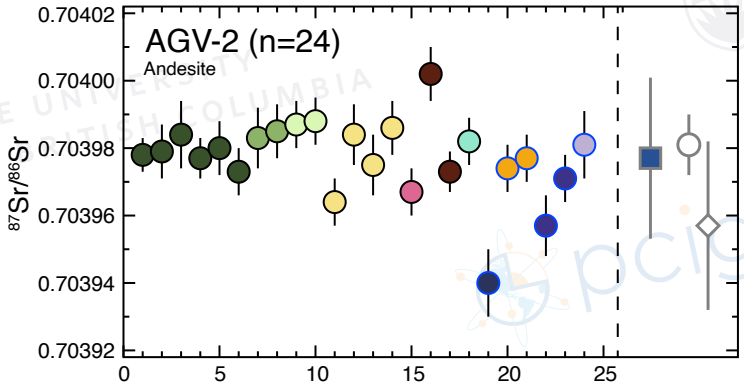
Volcanic Rocks

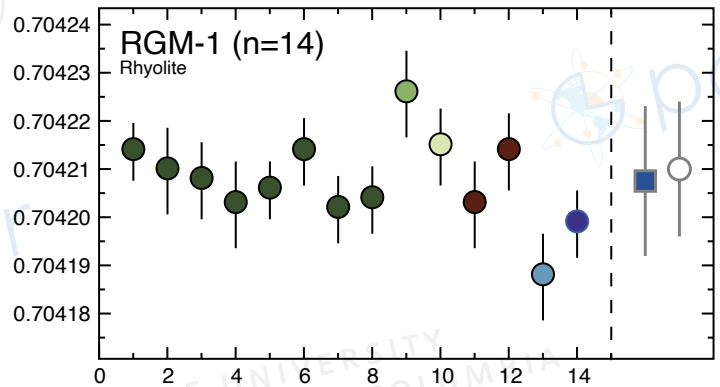


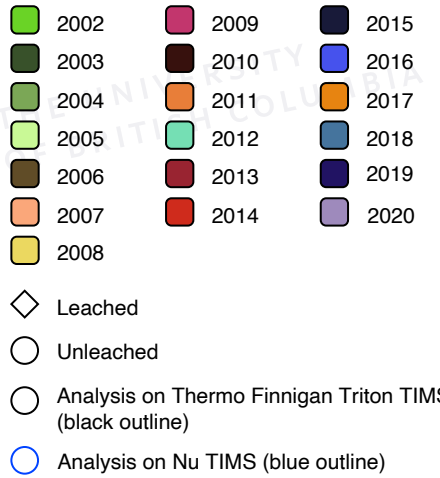






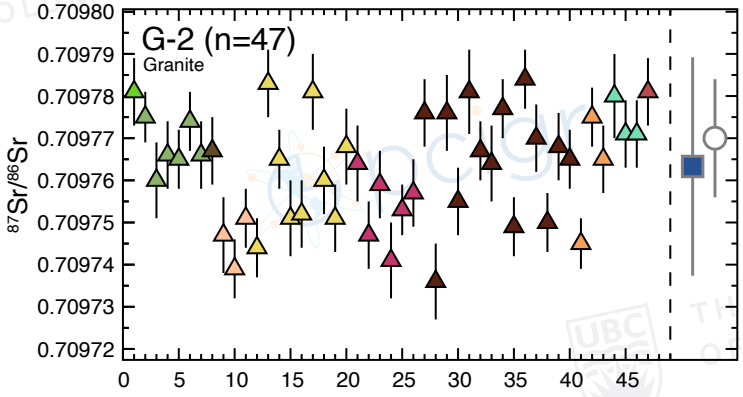


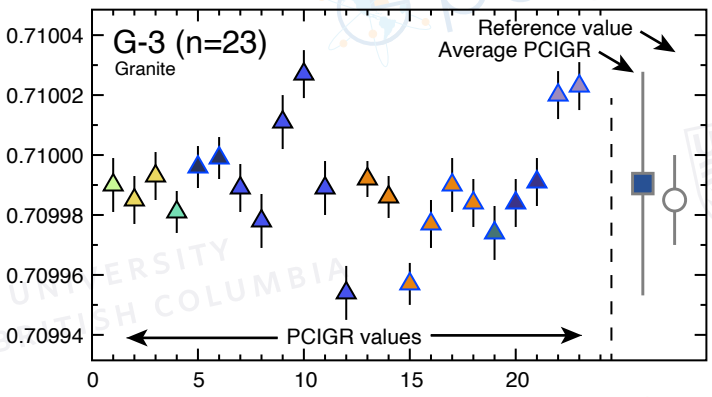


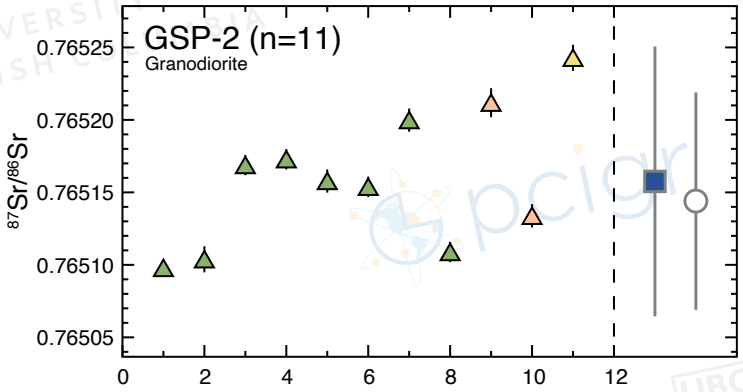


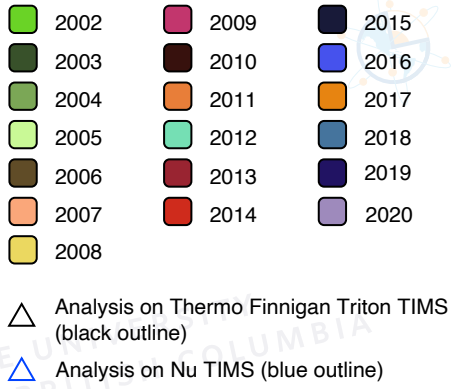
Individual $^{87}Sr/^{86}Sr$ analyses of volcanic reference materials via TIMS (Thermo Finnigan Triton TIMS, Nu TIMS) at PCIGR, organized by year. AGV-2, BCR-2, BHVO-2, and RGM-1 are USGS reference materials. The mean and 2 standard deviations of each reference material are represented by the blue square, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by the white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference values sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).

Plutonic Rocks

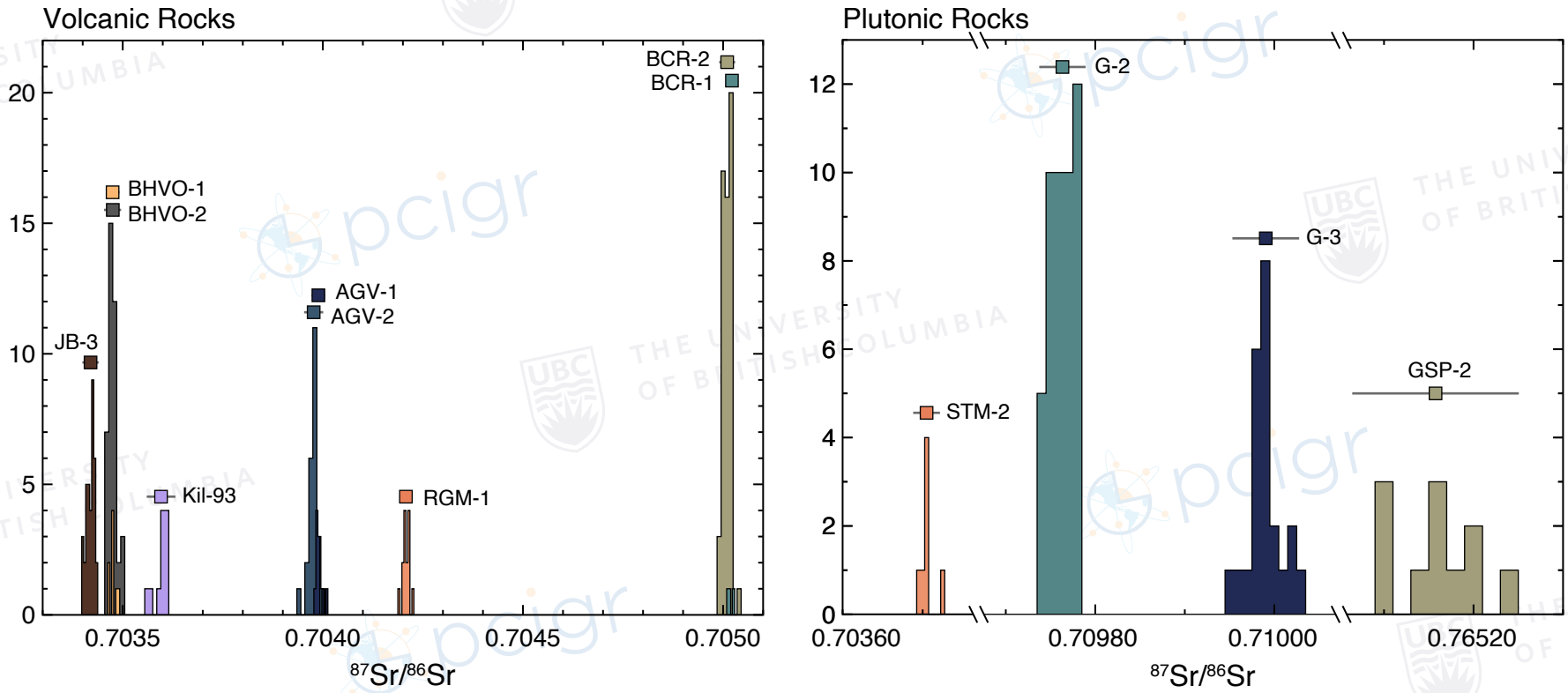








Individual $^{87}Sr/^{86}Sr$ analyses of plutonic USGS reference materials via TIMS at PCIGR, organized by year. All samples were dissolved in high-pressure vessels prior to analysis (triangle symbols). The mean and 2 standard deviations of each reference material is represented by the blue square and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by white circles. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference values source: Weis et al. (2006).



Histograms showing the full range of $^{87}Sr/^{86}Sr$ analyses conducted via TIMS at PCIGR of volcanic (left) and plutonic (right) reference materials. The mean (square symbol) and 2 standard deviations (SD; grey bar) of each reference material is indicated above the histogram. Values of 2 SD that are smaller than the symbol size are not shown. Y-axis represents the number of analyses.

Nd, Hf and Pb Isotopes (by multicollector ICP-MS)

Nd, Hf and Pb isotope ratios are measured on our Nu Instruments Nu Plasma, Nu Plasma II and Nu Plasma 1700 multicollector ICP-MS instruments.

Nu Plasma 1700 at PCIGR. Photo: D. Weis.

Using regular settings, each analysis consumes 100, 75 and 40 ng of Nd, Hf and Pb, respectively. With enhanced sensitivity, the analyte size can be reduced to 25, 20 and 10 ng of Nd, Hf and Pb, respectively.

Each analysis takes ~13 minutes, after an additional 5 minutes of washout time between samples. Standards bracket every two samples, and data are normalized to these bracketing standards offline.

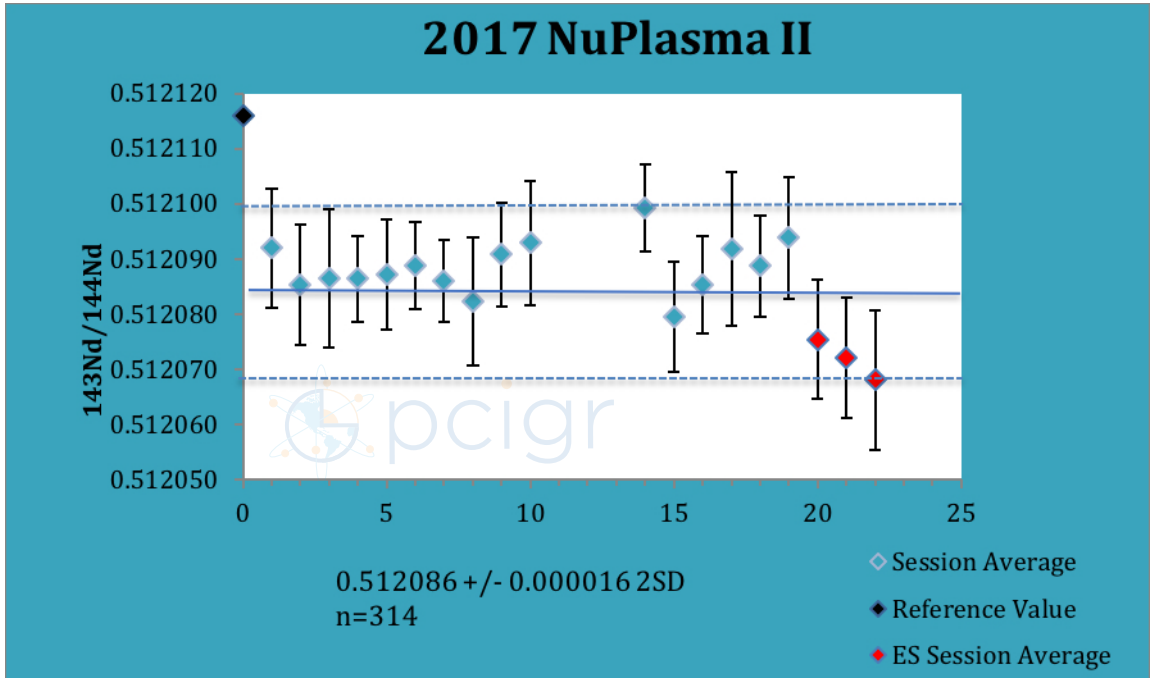
Annual external reproducibility (2SD) for standards is the following:

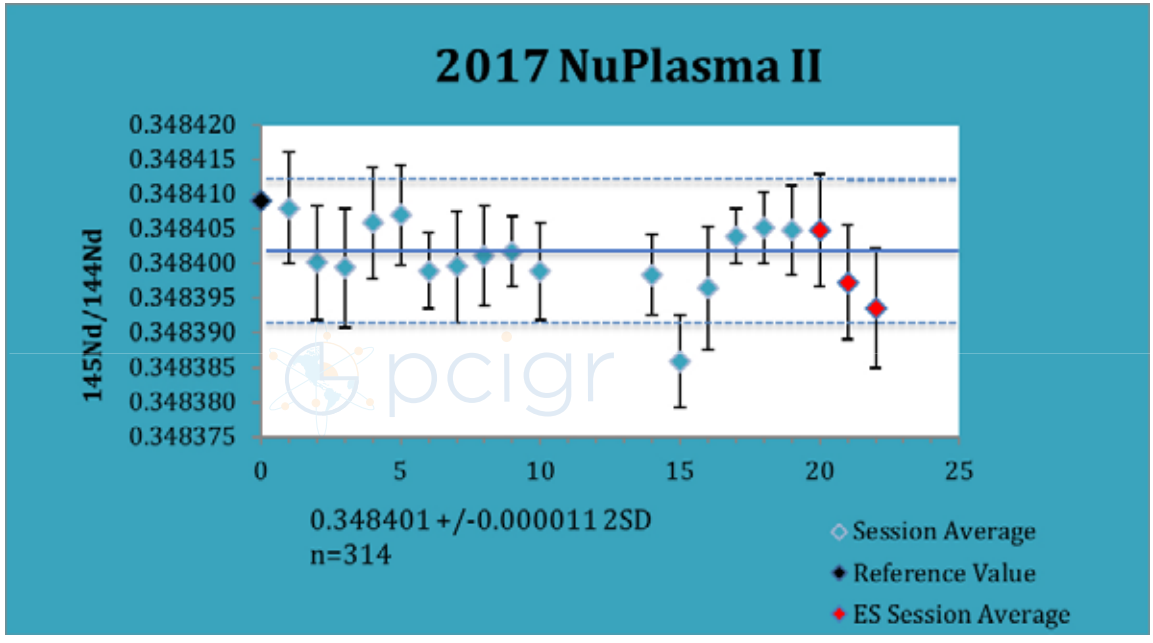
- $^{143}Nd/^{144}Nd$: 43 ppm (40 ppm, offline normalization)
- $^{176}Hf/^{177}Hf$: 27ppm (70 ppm, offline normalization)
- $^{206}Pb/^{204}Pb$: 91 ppm (200 ppm, offline normalization)

Nd isotopes—Masses 150, 148, 146, 145, 144, 143 and 142 are measured together with monitoring of Sm at mass 147 and Ce at mass 140. This allows interference corrections to be applied to masses 150, 148, 144 and 142.

Nd isotope measurements are normalized internally for instrumental mass fractionation to a $^{146}Nd/^{144}Nd$ ratio of 0.7219, using an exponential correction. Interferences on Nd are calculated using natural abundances for the interfering element and adjusting them for instrumental mass fractionation, as monitored by the normalizing ratio used to correct Nd.

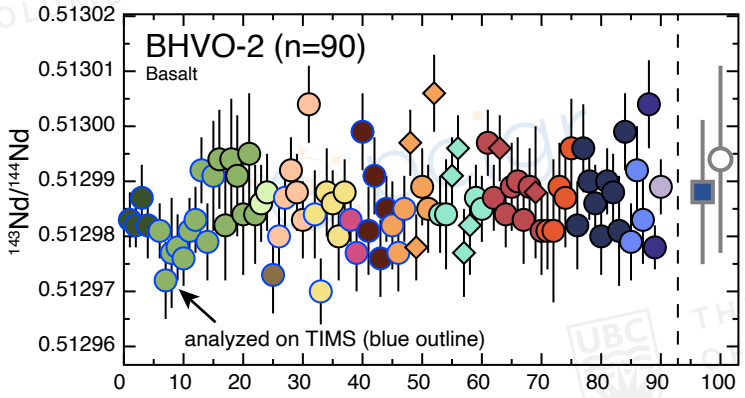
At PCIGR, Nd isotopes can also be measured by TIMS. However, multicollector ICP-MS is preferred because of its faster output (~18 minutes/sample instead of ~2 hours) for similar precision, and if sample material is sufficient.

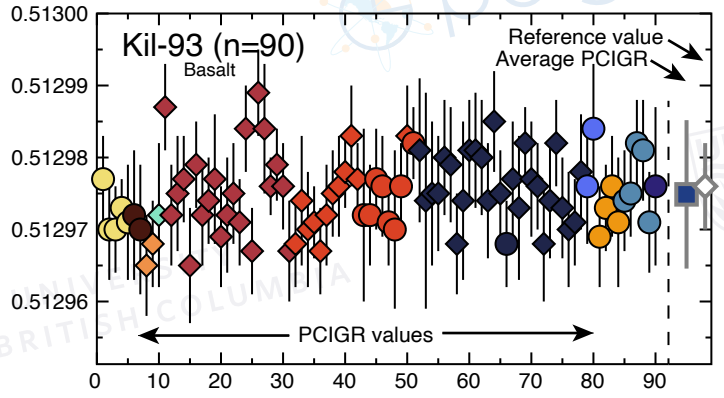


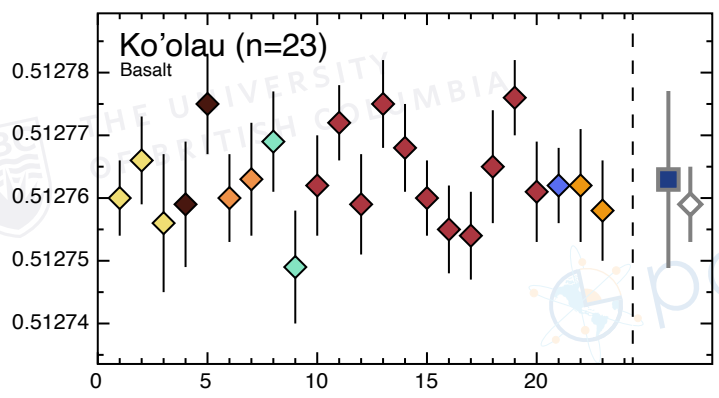


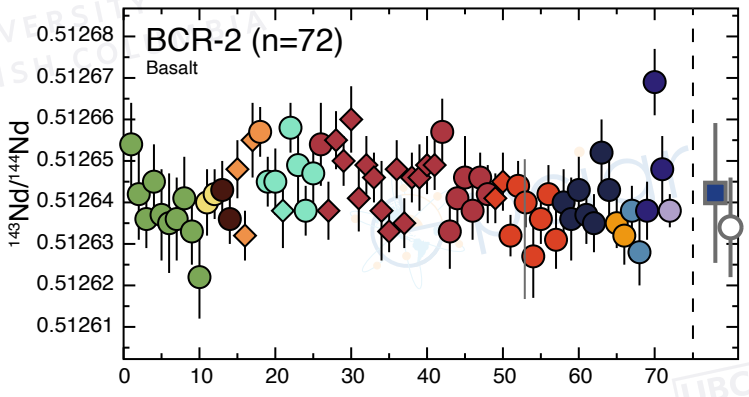
Annual values and reproducibility for the JMC Hf standard (2017)

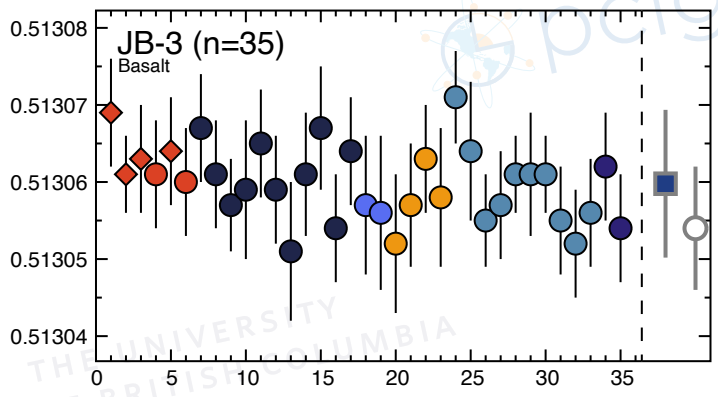
Volcanic Rocks

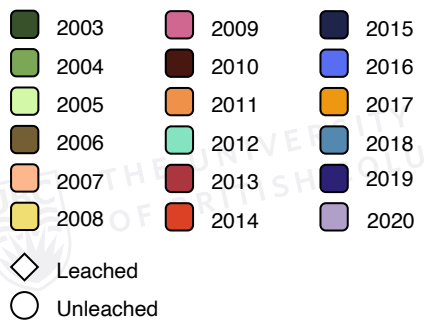


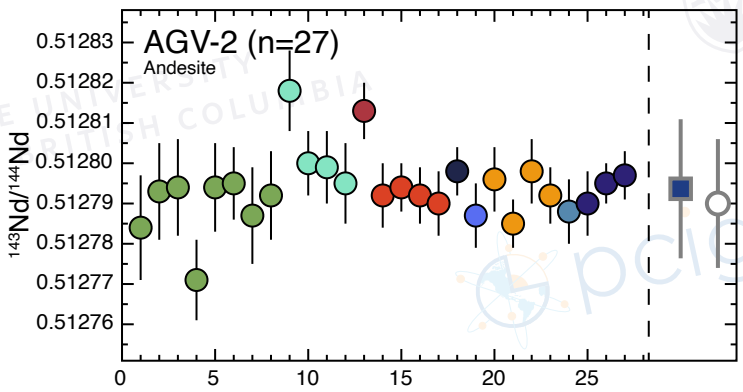


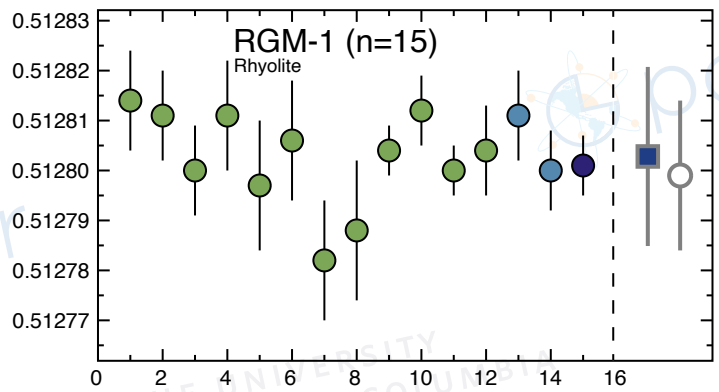






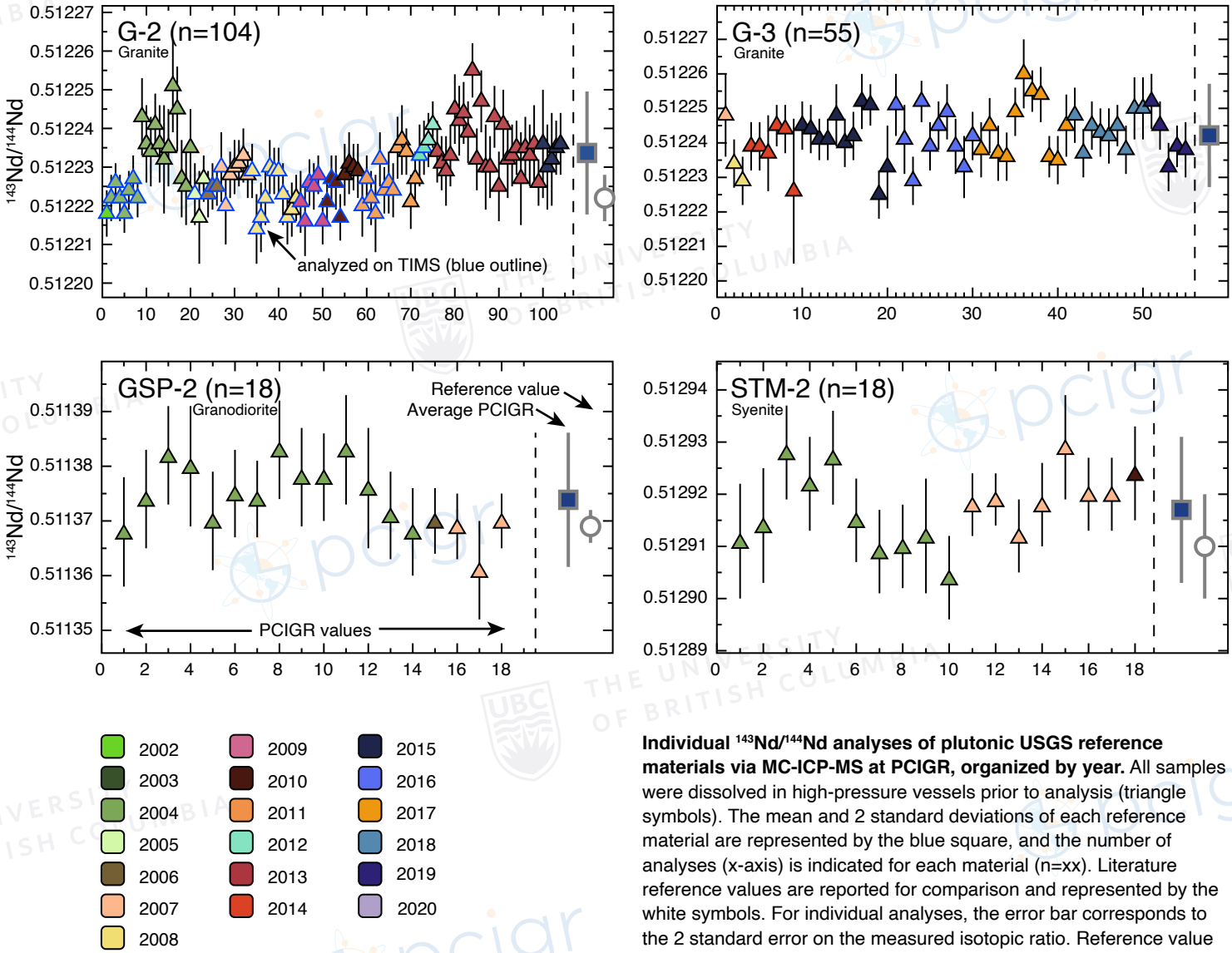




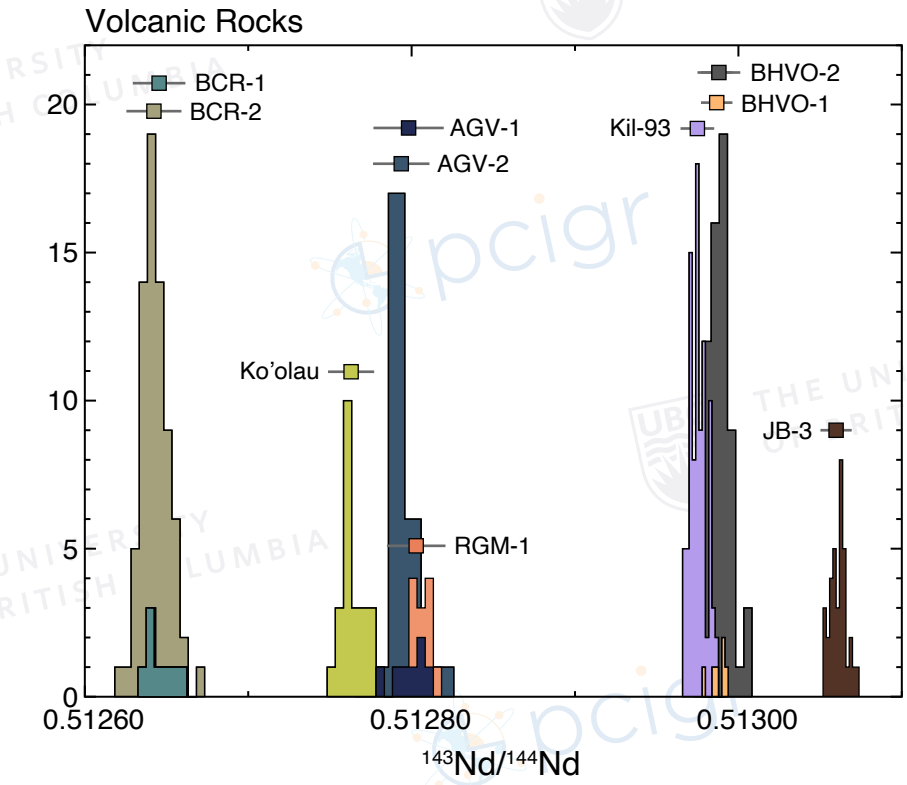


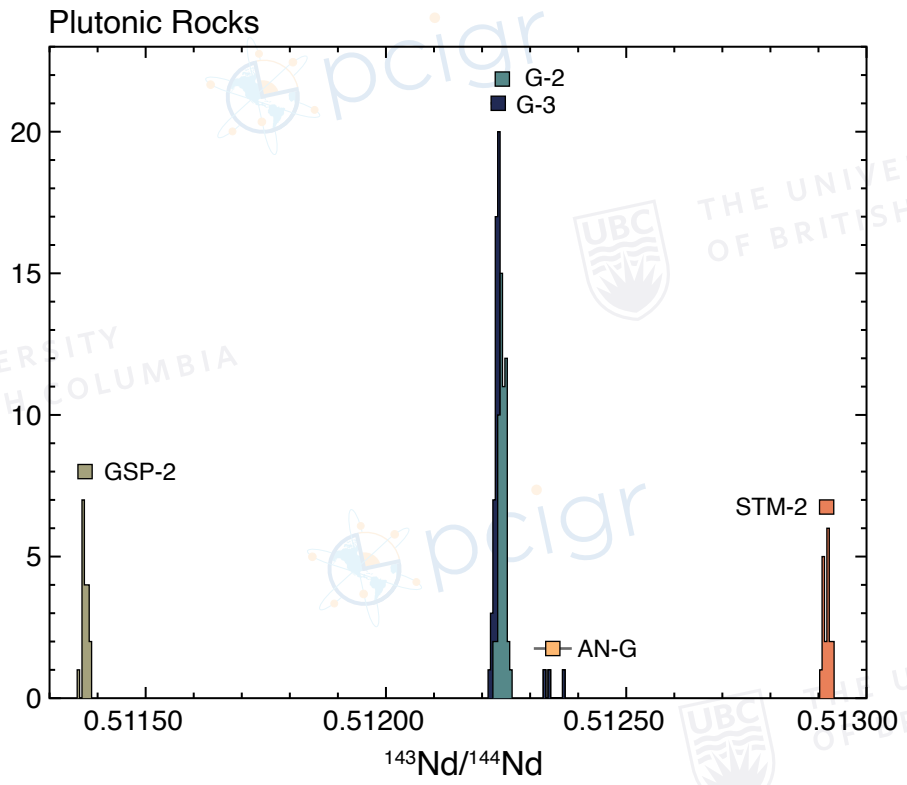
Individual $^{143}Nd/^{144}Nd$ analyses of volcanic reference materials via MC-ICP-MS at PCIGR, organized by year. AGV-2, BCR-2, BHVO-2, and RGM-1 are USGS reference materials. The mean and 2 standard deviations of each reference material are represented by the blue square, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by the white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).

Plutonic Rocks



Individual $^{143}Nd/^{144}Nd$ analyses of plutonic USGS reference materials via MC-ICP-MS at PCIGR, organized by year. All samples were dissolved in high-pressure vessels prior to analysis (triangle symbols). The mean and 2 standard deviations of each reference material are represented by the blue square, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by the white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference value source: Weis et al. (2006).





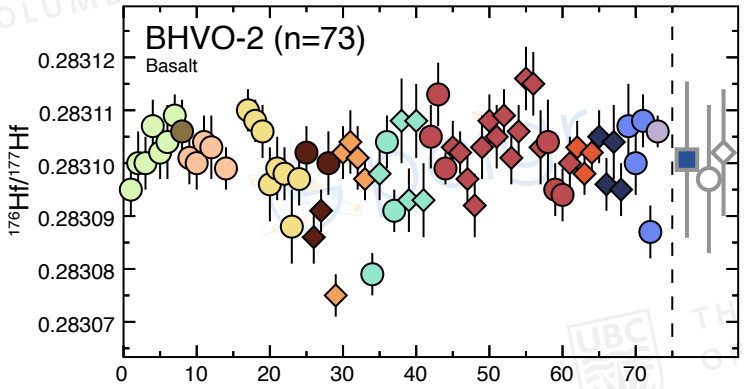
Histograms showing the full range of $^{143}Nd/^{144}Nd$ analyses, conducted via MC-ICP-MS at PCIGR, of volcanic (left) and plutonic (right) reference materials. The mean (square symbol) and 2 standard deviations (grey bar) of each reference material is indicated above the histogram. Values of 2 SD that are smaller than the symbol size are not shown. Y-axis represents the number of analyses.

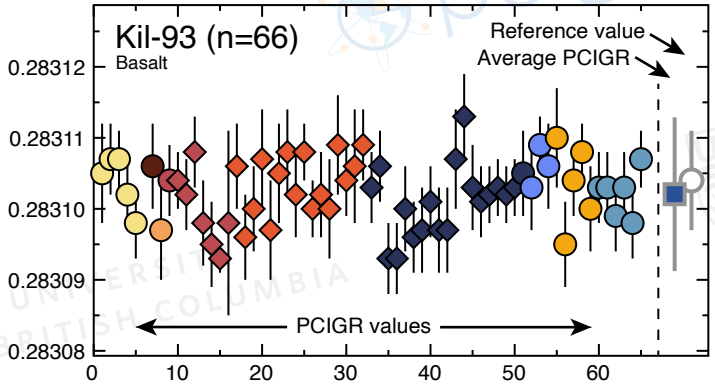
Hf isotopes—The configuration used to measure Hf isotopes enables simultaneous collection of Hf (masses 180, 179, 178, 177, 176 and 174), together with monitoring of Lu at mass 175 and Yb at mass 172. These allow interference corrections to be applied to masses 174 and 176.

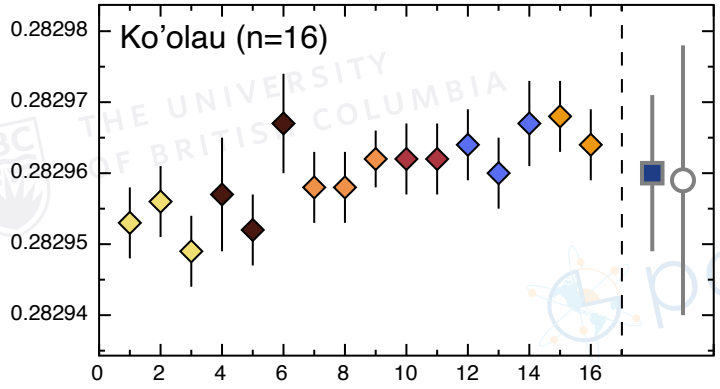
Hf isotope measurements are normalized internally to a $^{179}Hf/^{177}Hf$ ratio of 0.7325, using an exponential correction.

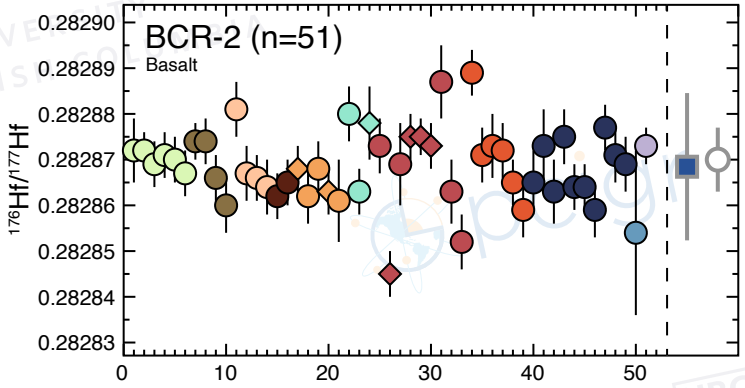
Instrument performance for Hf isotopes in SRMs is shown in the next few pages.

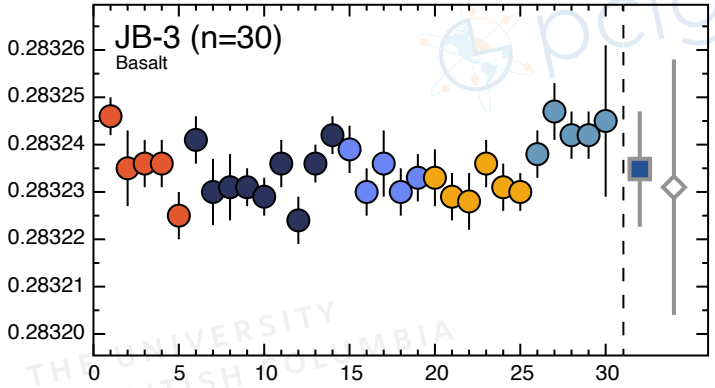
Volcanic Rocks

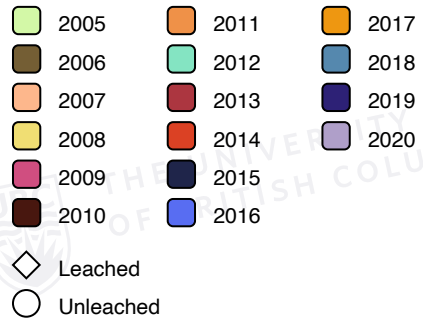


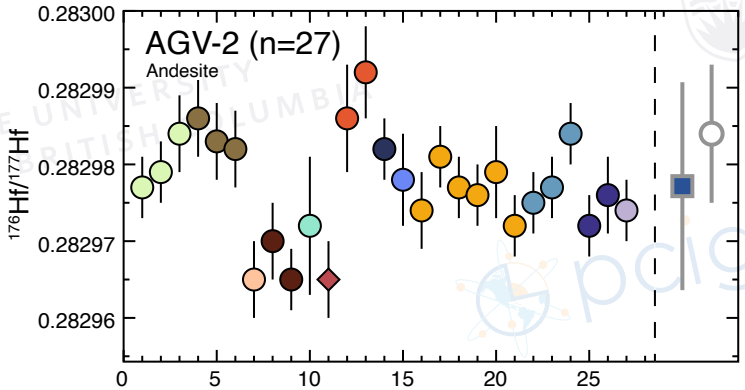


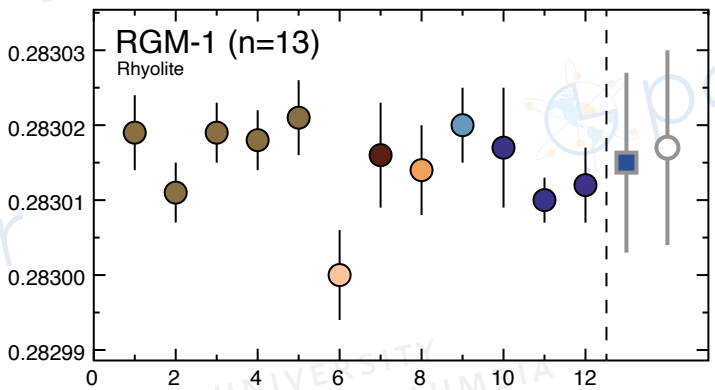






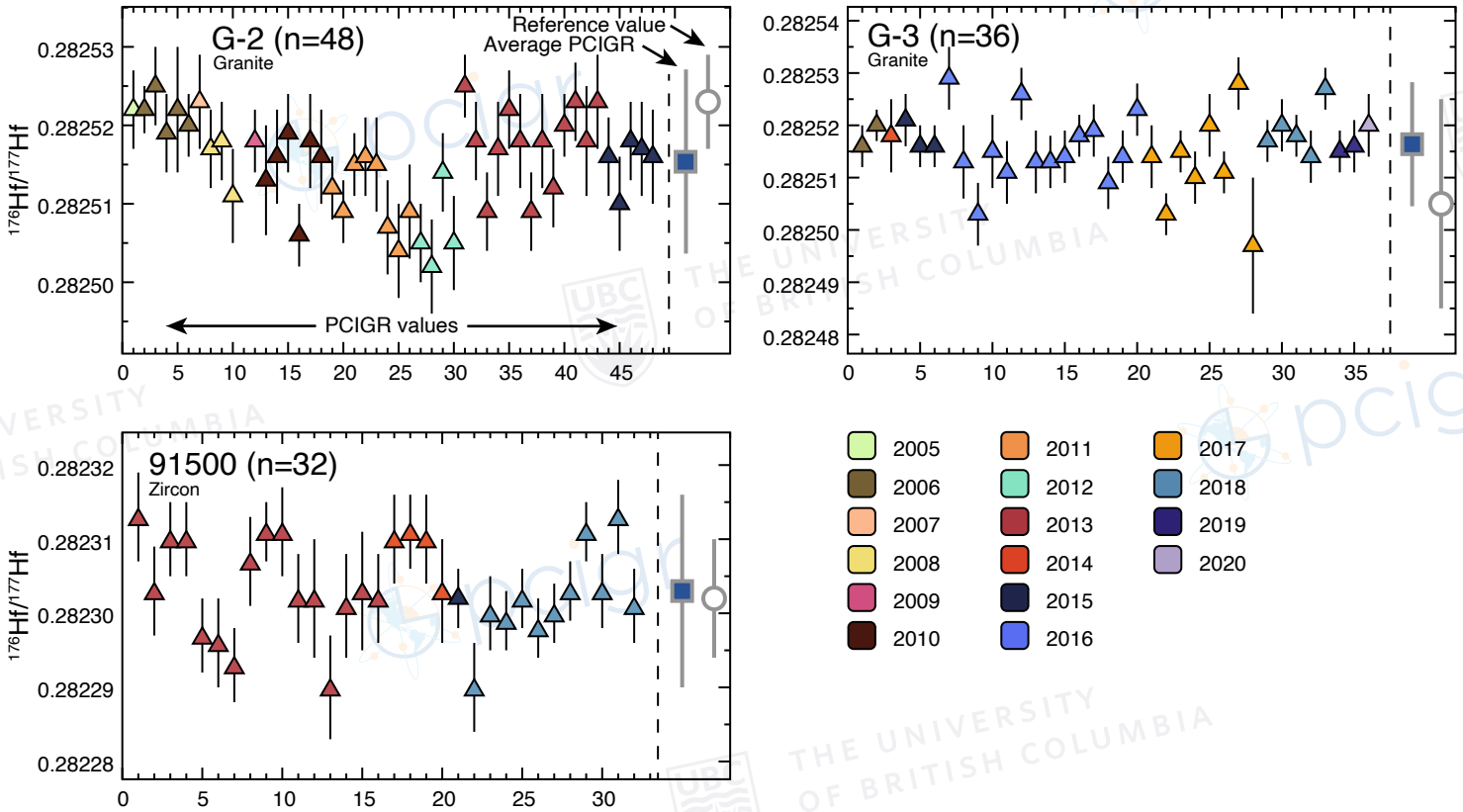




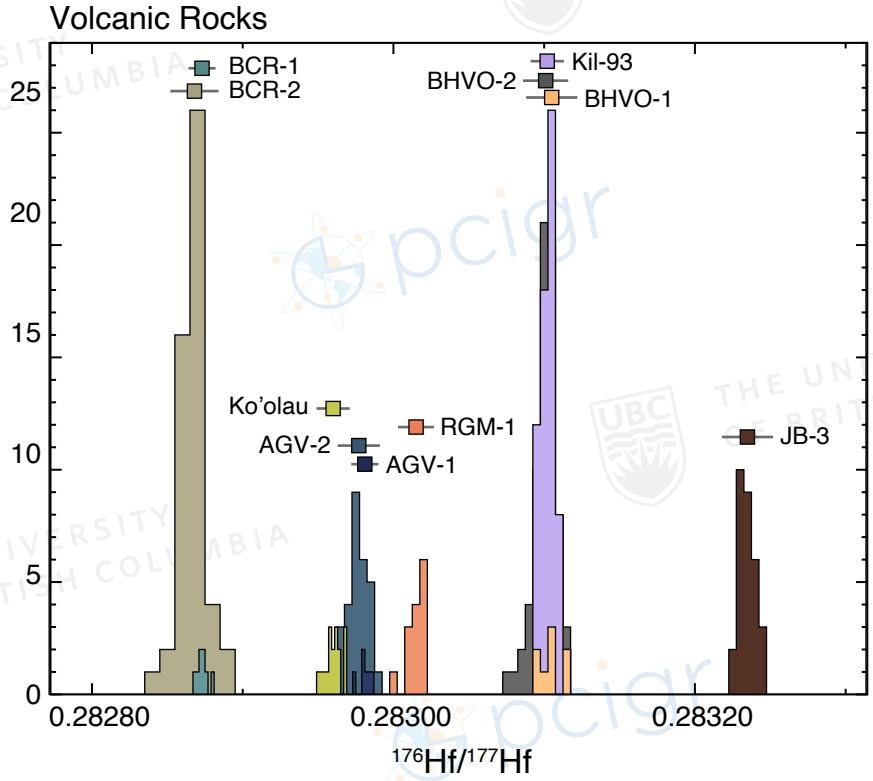


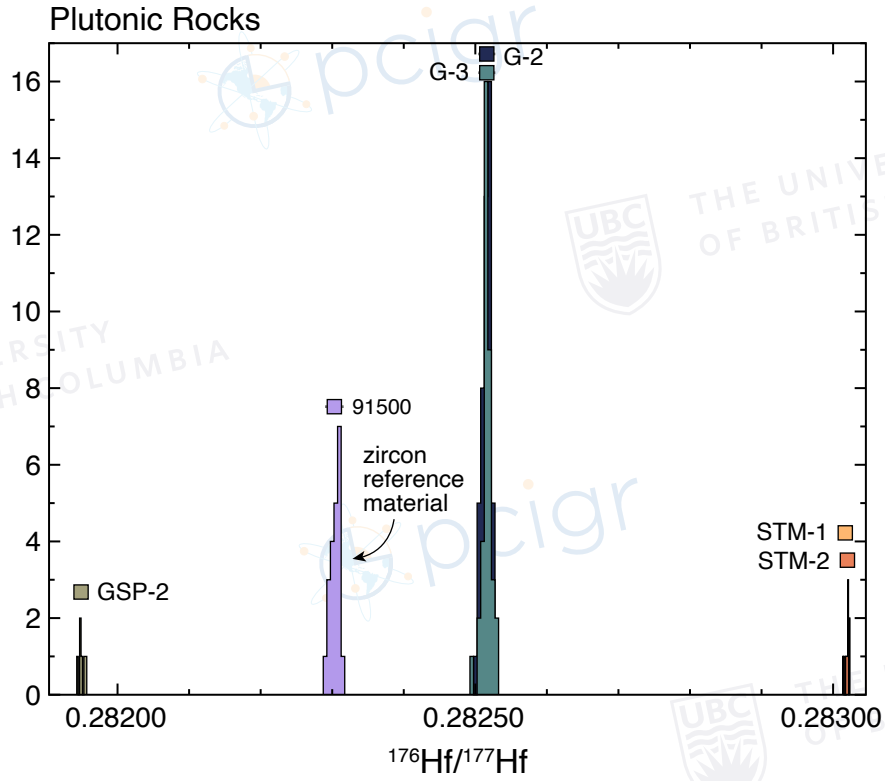
Individual $^{176}Hf/^{177}Hf$ analyses of volcanic reference materials via MC-ICP-MS at PCIGR, organized by year. AGV-2, BCR-2, BHVO-2, and RGM-1 are USGS reference materials. The mean and 2 standard deviations of each reference material are represented by the blue square, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by the white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference value sources: Weis et al. (2007); Nobre Silva et al. (2013); Fourny et al. (2016).

Plutonic Rocks



Individual $^{176}Hf/^{177}Hf$ analyses of plutonic reference materials via MC-ICP-MS at PCIGR, organized by year. G-2 and G-3 are USGS reference materials. All samples were dissolved in high-pressure vessels prior to analysis (triangle symbols). The mean and 2 standard deviations of each reference material are represented by the blue square, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by the white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference value sources: Weis et al. (2007); Goolaerts et al. (2004).





Histograms showing the full range of $^{176}Hf/^{177}Hf$ analyses conducted via MC-ICP-MS at PCIGR of volcanic (left) and plutonic (right) reference materials. The mean (square symbol) and 2 standard deviations (SD; grey bar) of each reference material is indicated above the histogram. Values of 2 SD that are smaller than the symbol size are not shown. Y-axis represents the number of analyses.

Pb isotopes—The instrument is configured for simultaneous collection of Pb (masses 208, 207, 206 and 204), together with Tl (masses 205 and 203), which is used to monitor and correct for instrumental mass discrimination, and Hg potential interference (mass 202), which is used to correct mass 204 for the presence of ^{204}Hg.

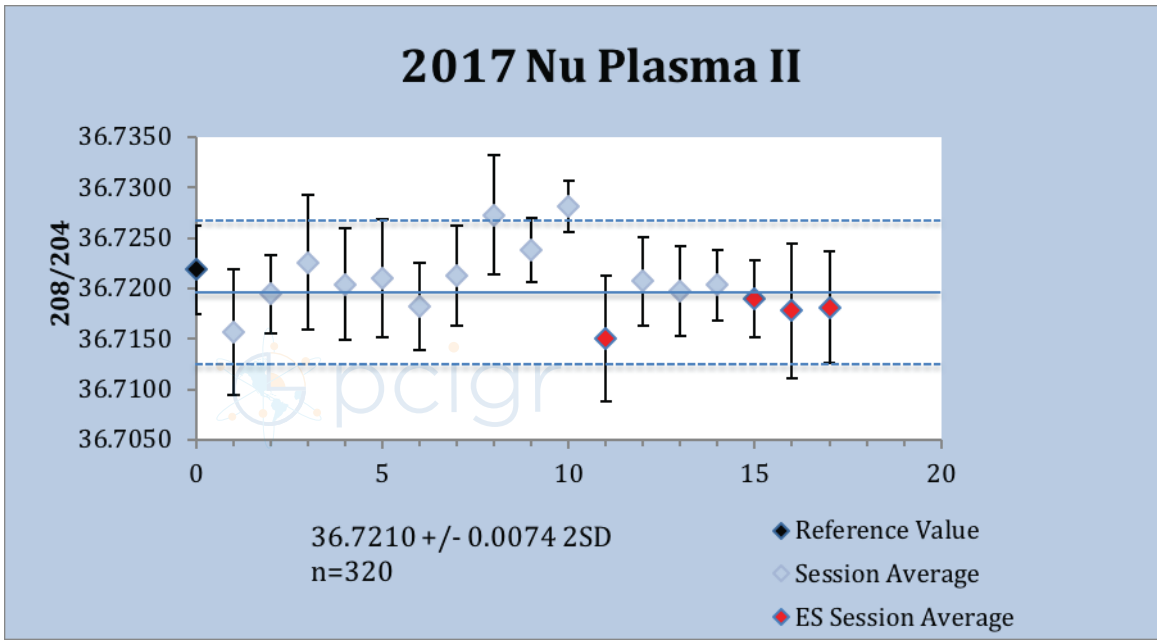
Mercury levels are always below 0.7 mV and more typically are less than 0.2 mV for mass 202, which corresponds to a correction of less than 0.18 mV on the mass 204 peak.

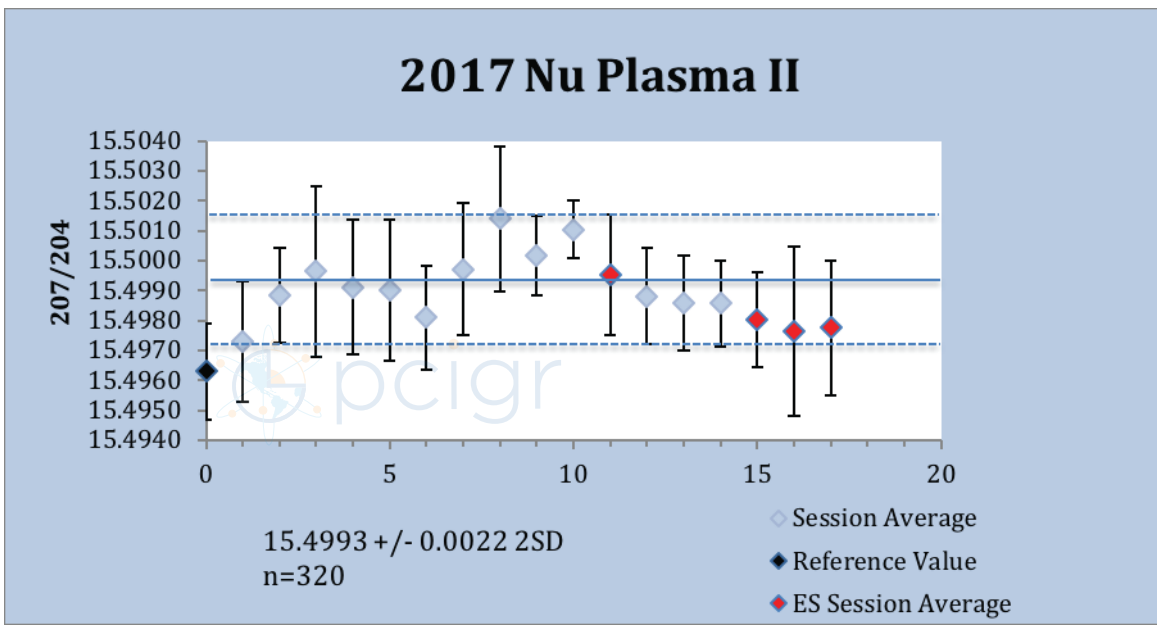
To improve the reproducibility of the analytical conditions for Pb isotopic analyses, and thus the precision, all sample solutions are analyzed with the same Pb/Tl ratios as the SRM 981 standard, which requires determination of the exact Pb content after column separation and before analysis on the multicollector ICP-MS.

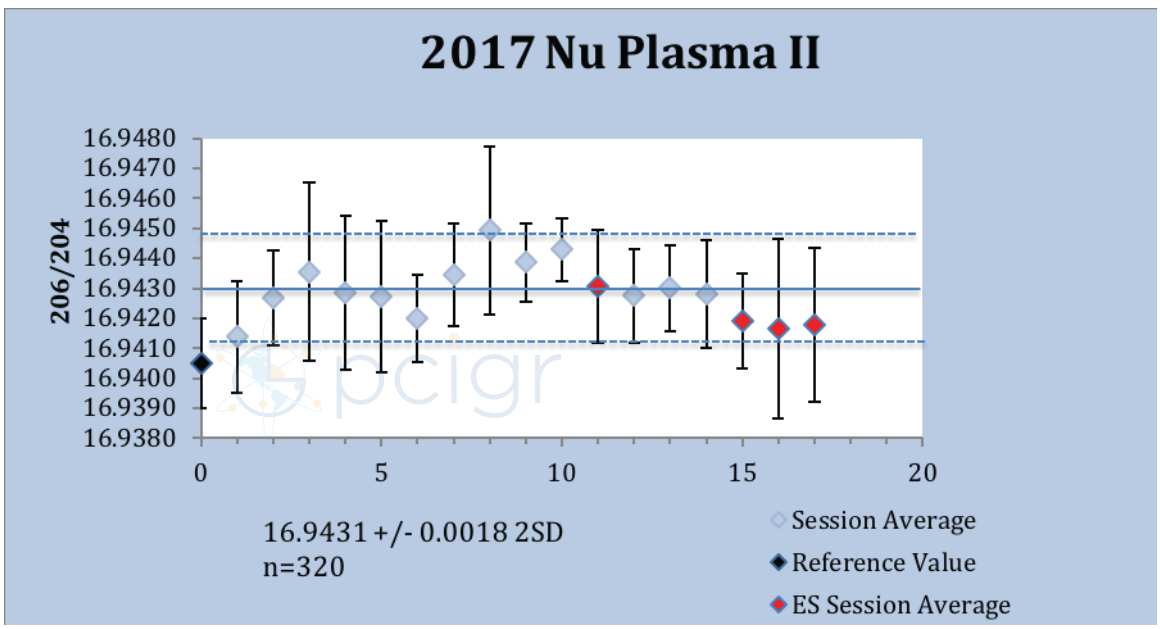
A particular concern at PCIGR is that our Pb isotope data, derived via multicollector ICP-MS, must achieve the best levels of precision and accuracy required for investigating isotope systematics in mantle geochemistry (Weis et al. 2011).

We therefore continue to investigate the roles of residual matrix, leaching and sample purification on the ultimate precision and accuracy of multicollector ICP-MS Pb data (Barling and Weis, 2008, 2012; Hanano et al., 2009; Nobre Silva et al., 2009).

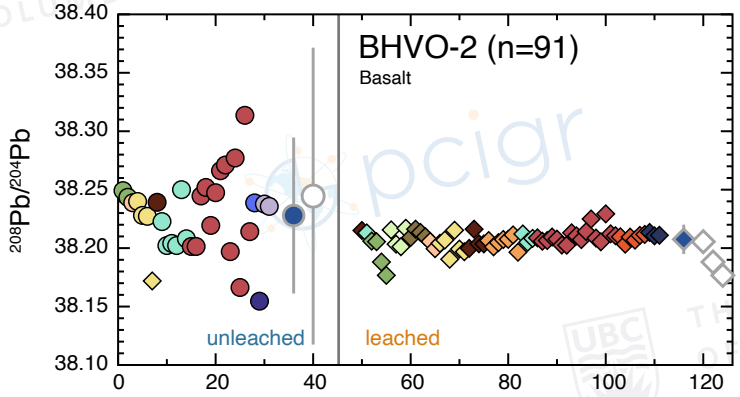
Instrument performance for Pb isotopes in SRMs is shown in the next few pages.

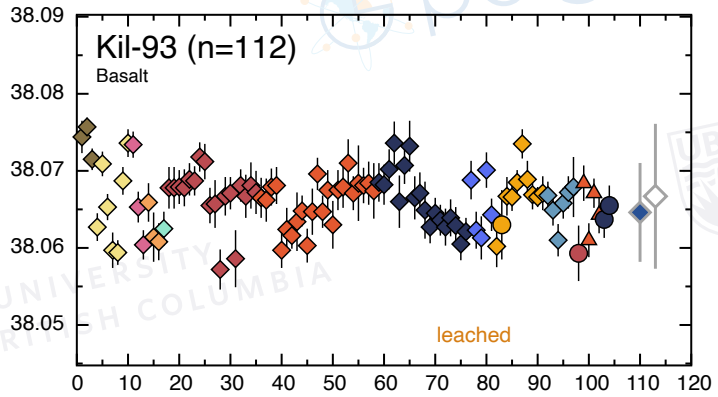

2017 Nu Plasma II
208/204
36.7350
36.7300
36.7250
36.7200
36.7150
36.7100
36.7050
0
5
10
15
20
36.7210 +/- 0.0074 2SD
n=320
Reference Value
Session Average
ES Session Average

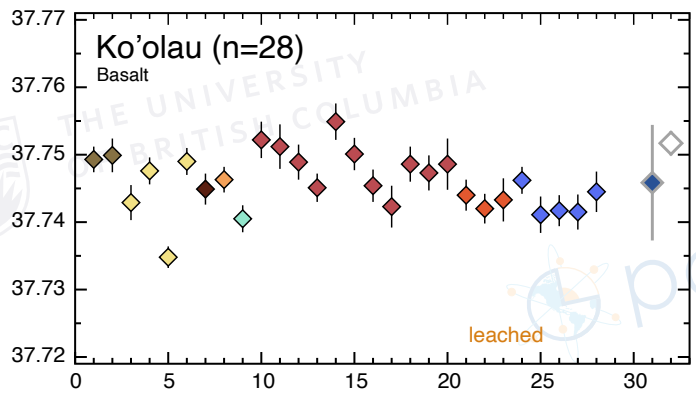

2017 Nu Plasma II
207/204
15.5040
15.5030
15.5020
15.5010
15.5000
15.4990
15.4980
15.4970
15.4960
15.4950
15.4940
0
5
10
15
20
15.4993 +/- 0.0022 2SD
n=320
Session Average
Reference Value
ES Session Average

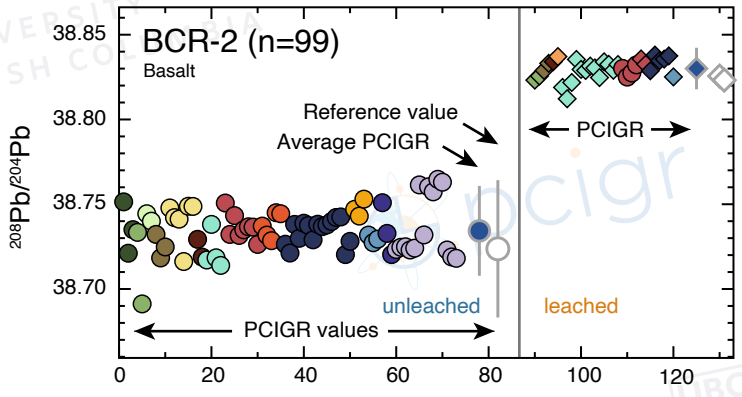

2017 Nu Plasma II
206/204
16.9480
16.9470
16.9460
16.9450
16.9440
16.9430
16.9420
16.9410
16.9400
16.9390
16.9380
0
5
10
15
20
16.9431 +/- 0.0018 2SD
n=320
Session Average
Reference Value
ES Session Average

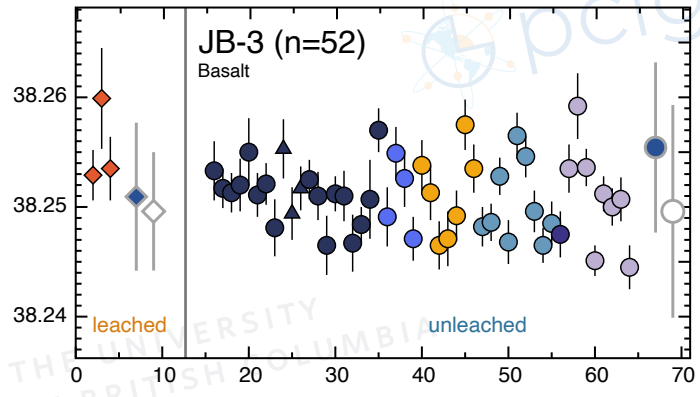
Volcanic Rocks

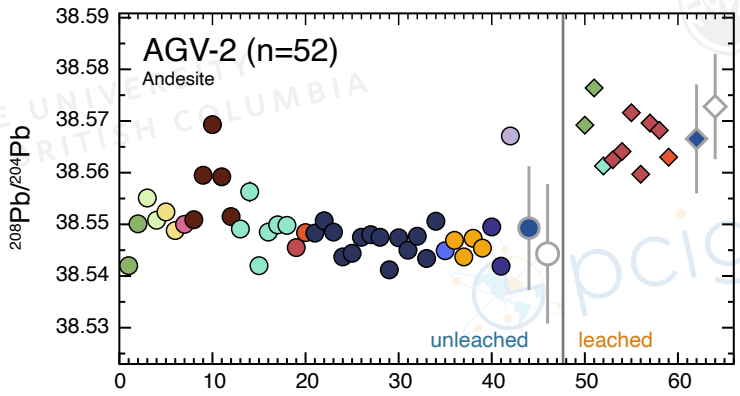


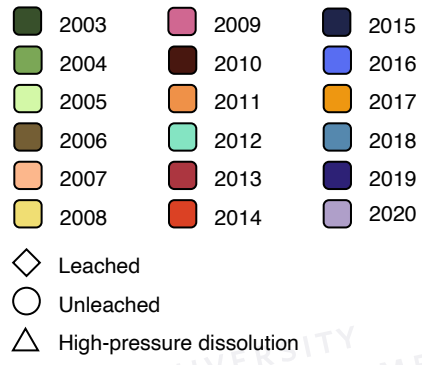






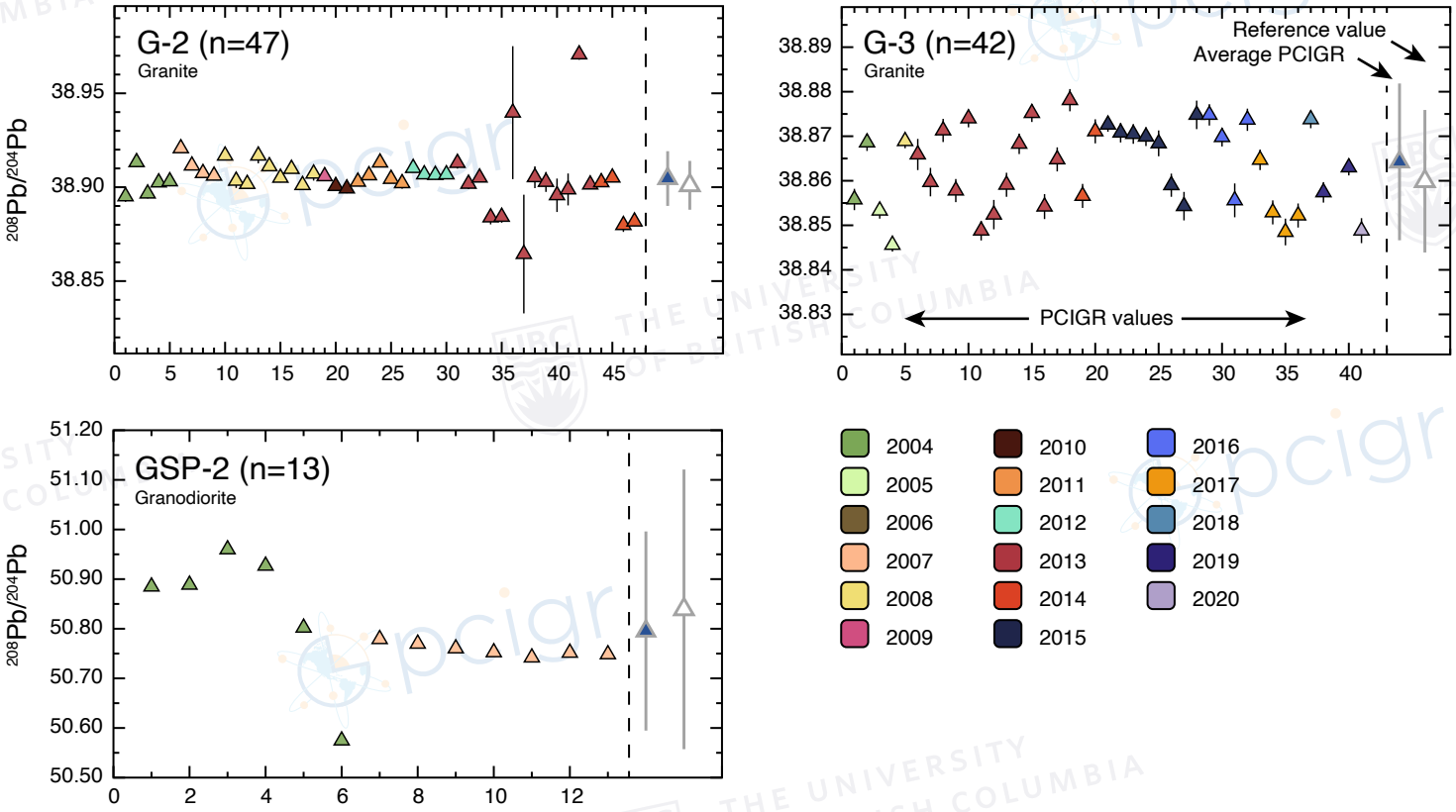




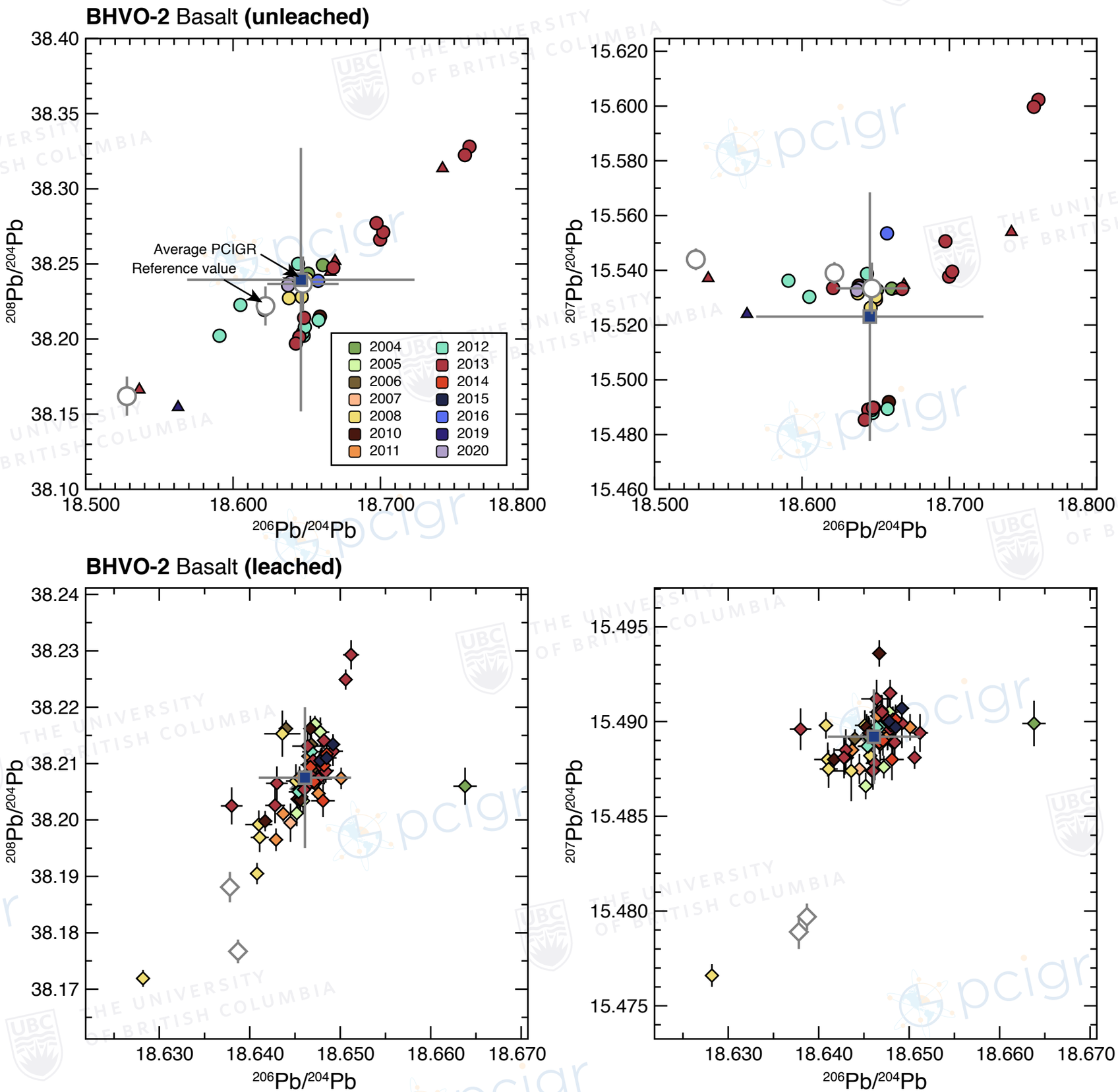


Individual $^{208}Pb/^{204}Pb$ analyses of volcanic reference materials via MC-ICP-MS at PCIGR, organized by year. AGV-2, BCR-2, BHVO-2, and RGM-1 are USGS reference materials. The mean and 2 standard deviations of each reference material are represented by the blue square, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by the white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. The better reproducibility through time of the leached analyses indicates the importance of leaching for oceanic basalts prior to analysis (Weis et al., 2005; Nobre Silva et al., 2009). Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).

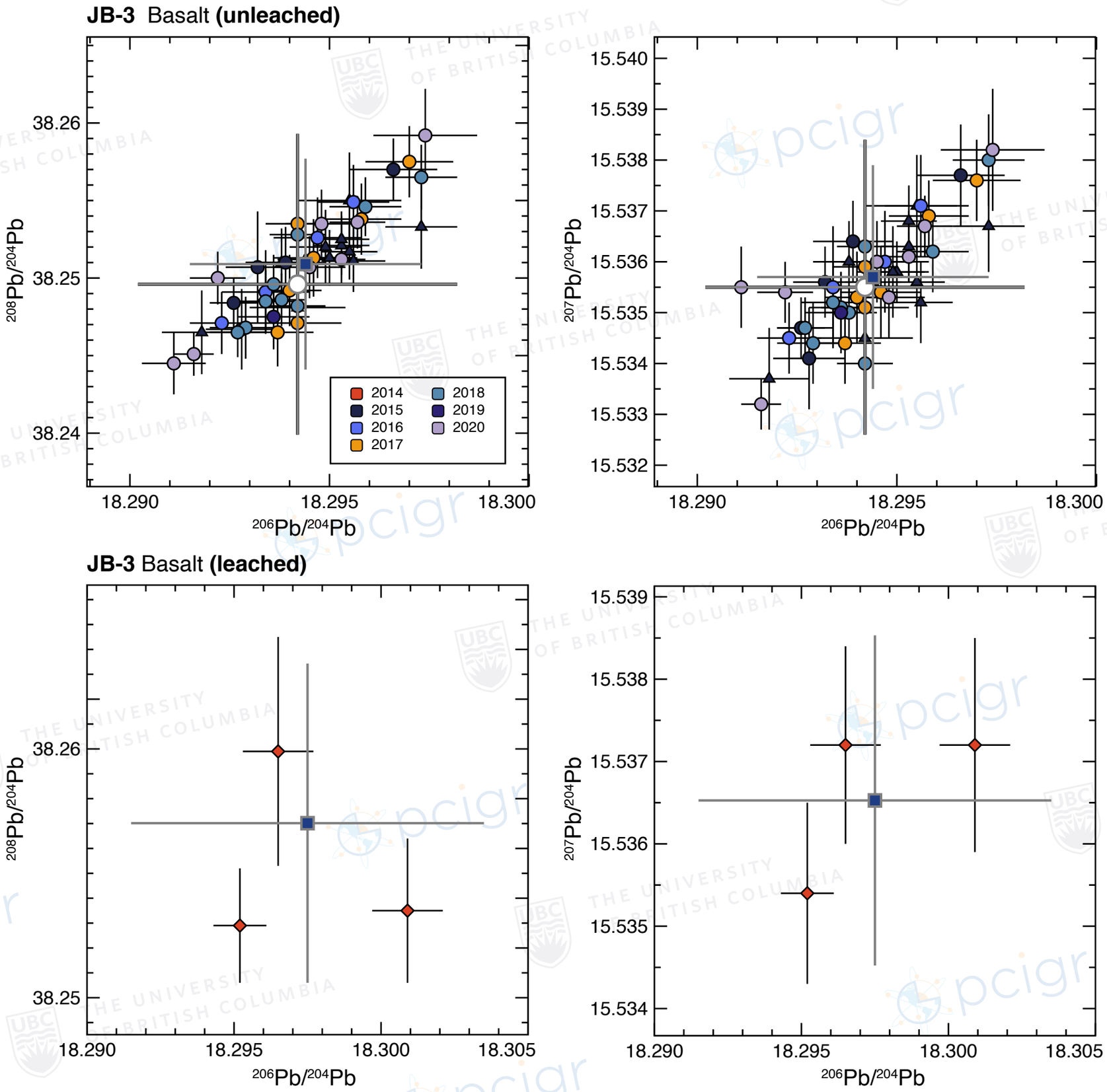
Plutonic Rocks



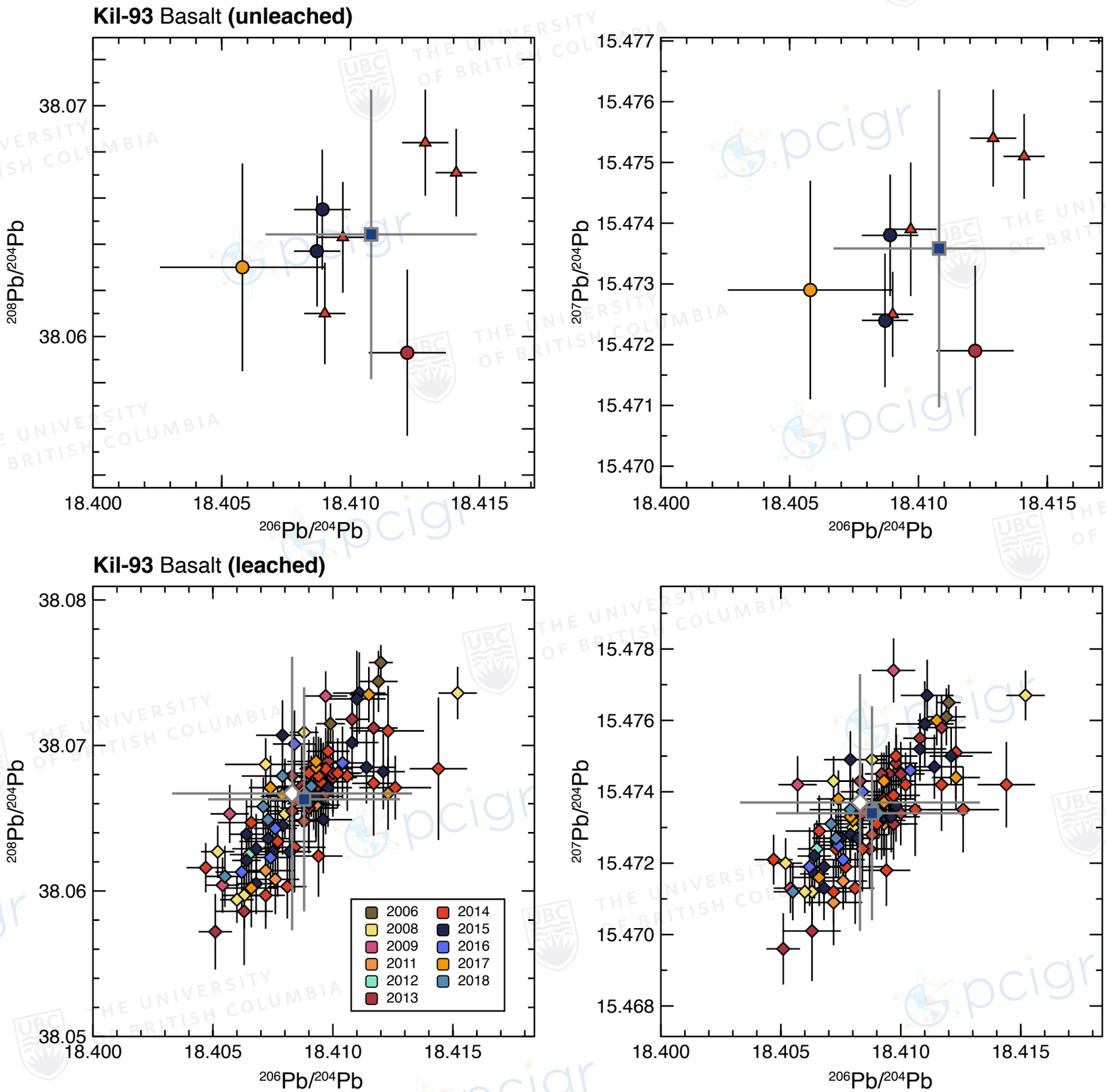
Individual $^{208}Pb/^{204}Pb$ analyses of plutonic USGS reference materials via MC-ICP-MS at PCIGR, organized by year. All samples were dissolved in high-pressure vessels prior to analysis (triangle symbols). The mean and 2 standard deviations of each reference material is represented by the rightmost blue triangle symbol, and the number of analyses (x-axis) is indicated for each material (n=xx). Literature reference values are reported for comparison and represented by white symbols. For individual analyses, the error bar corresponds to the 2 standard error on the measured isotopic ratio. Reference value source: Weis et al. (2006).



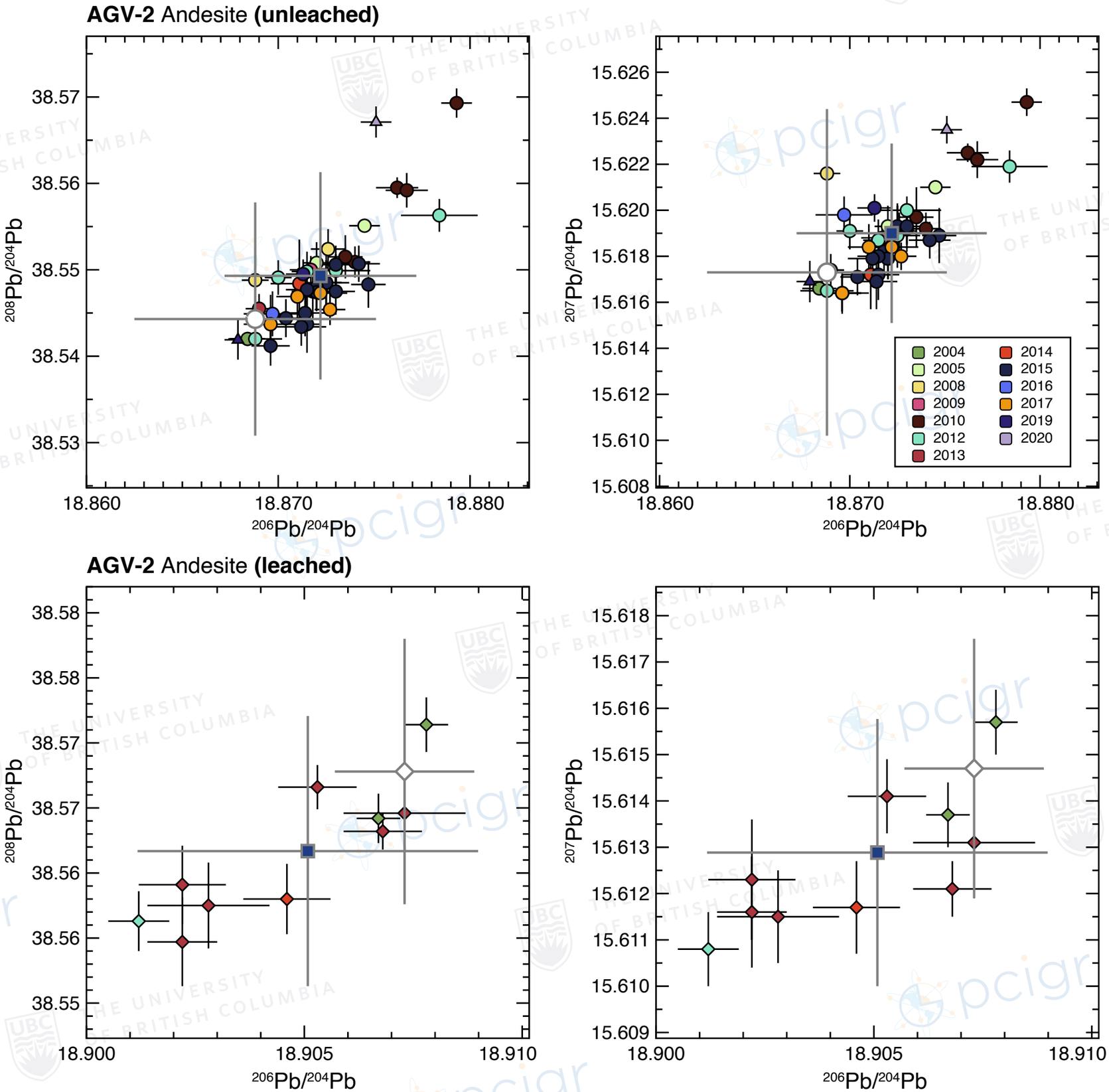
Comparison of the Pb isotopic variations between unleached and leached reference materials analyzed via MC-ICP-MS at PCIGR (5 images). Left panels: $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Right panels: $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Circles: unleached; triangles: high-pressure dissolution; diamonds: leached. The mean and 2 standard deviations of the reference material are represented by the blue square symbols, and literature reported reference values are represented by the white symbols. Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).



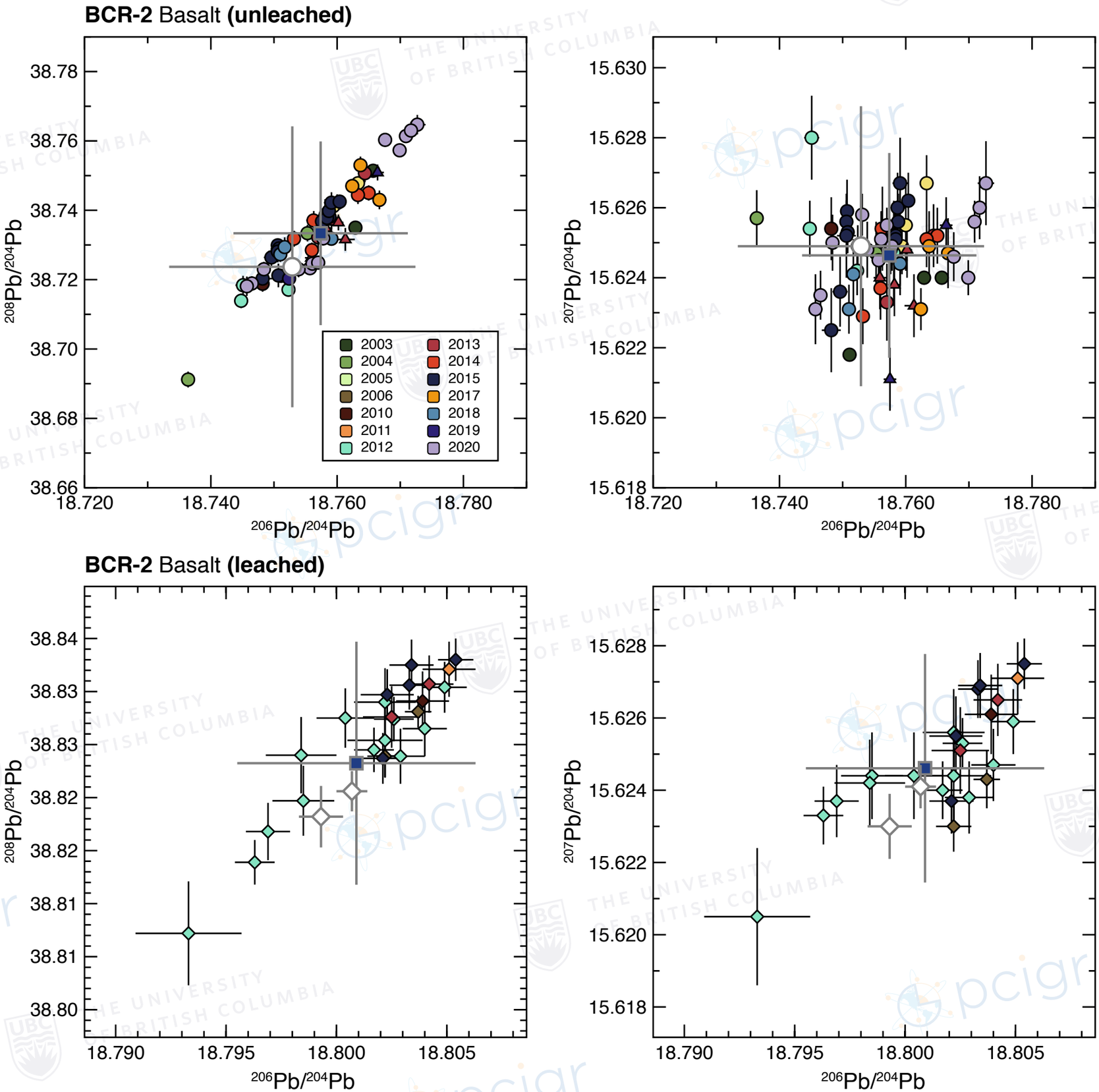
Comparison of the Pb isotopic variations between unleached and leached reference materials analyzed via MC-ICP-MS at PCIGR (cont'd). Left panels: $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Right panels: $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Circles: unleached; triangles: high-pressure dissolution; diamonds: leached. The mean and 2 standard deviations of the reference material are represented by the blue square symbols, and literature reported reference values are represented by the white symbols. Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).



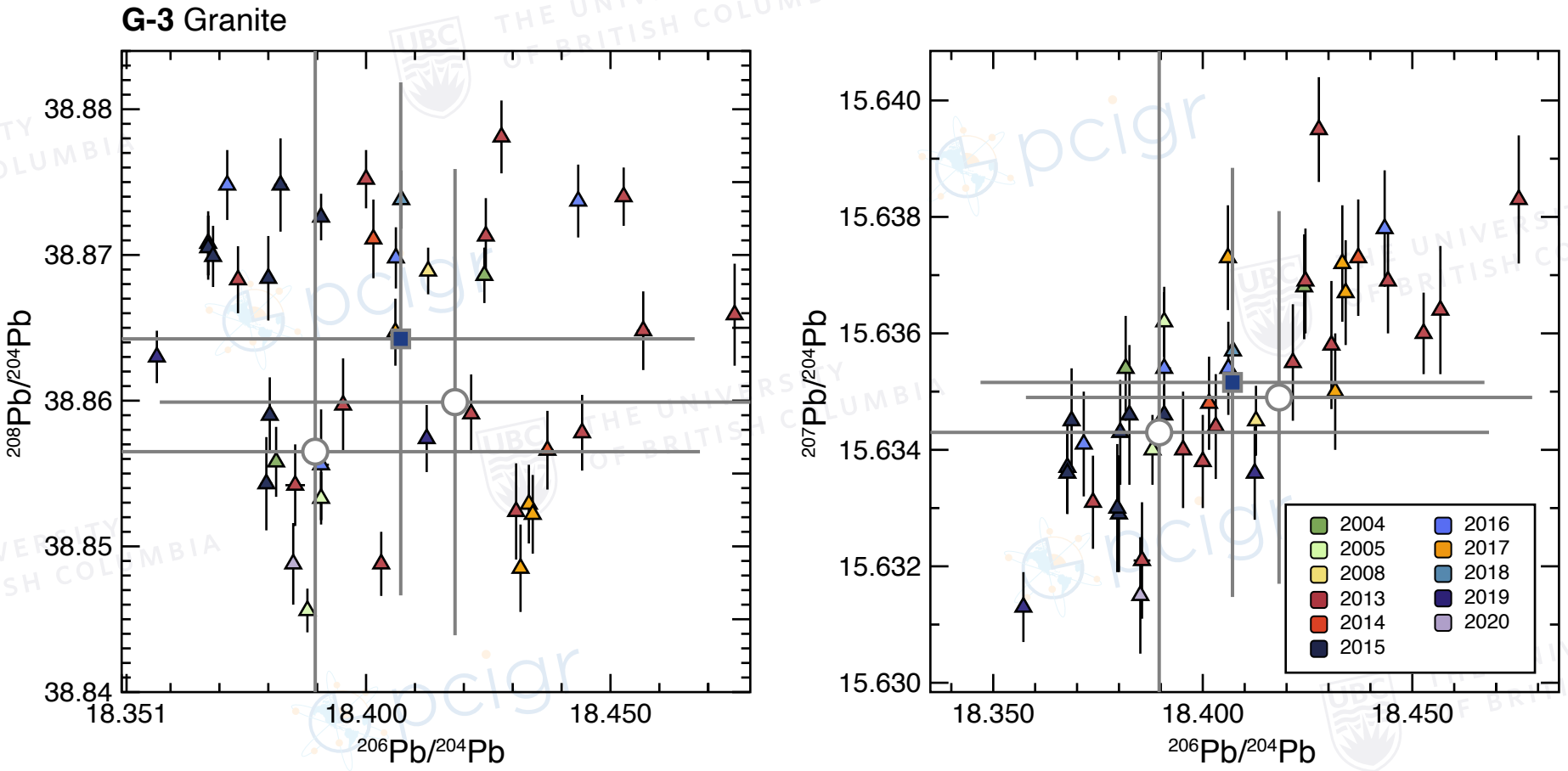
Comparison of the Pb isotopic variations between unleached and leached reference materials analyzed via MC-ICP-MS at PCIGR (cont'd). Left panels: $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Right panels: $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Circles: unleached; triangles: high-pressure dissolution; diamonds: leached. The mean and 2 standard deviations of the reference material are represented by the blue square symbols, and literature reported reference values are represented by the white symbols. Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).



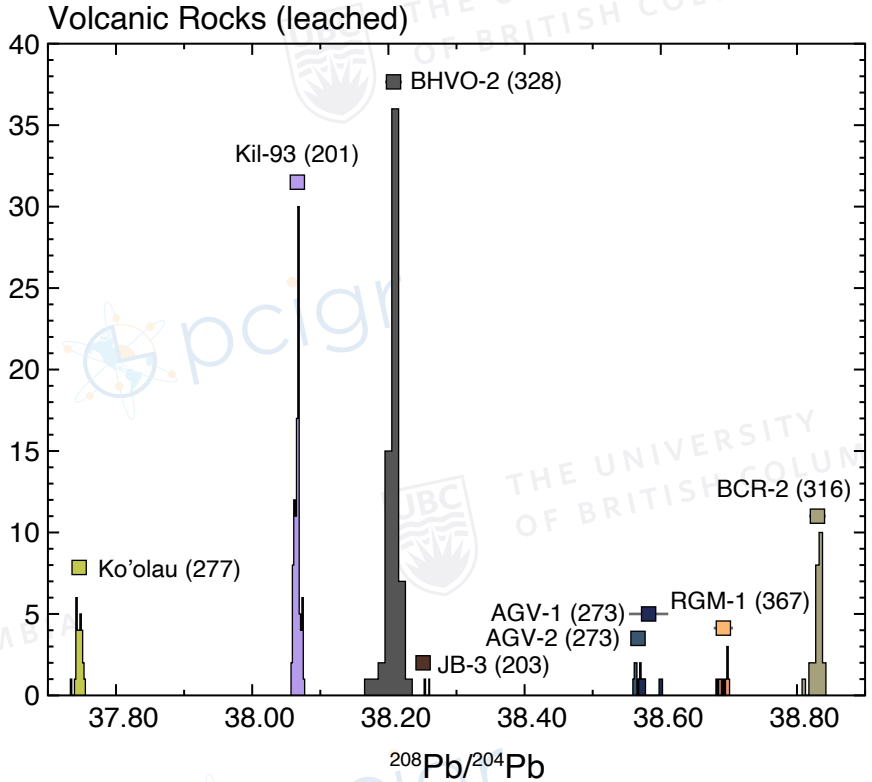
Comparison of the Pb isotopic variations between unleached and leached reference materials analyzed via MC-ICP-MS at PCIGR (cont'd). Left panels: $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Right panels: $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Circles: unleached; triangles: high-pressure dissolution; diamonds: leached. The mean and 2 standard deviations of the reference material are represented by the blue square symbols, and literature reported reference values are represented by the white symbols. Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).

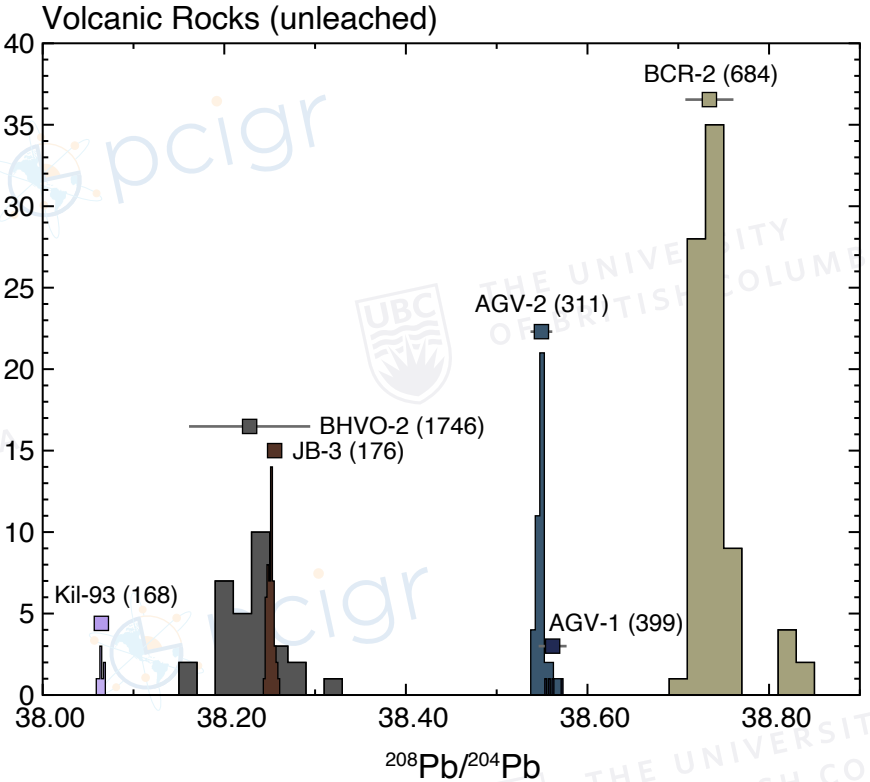


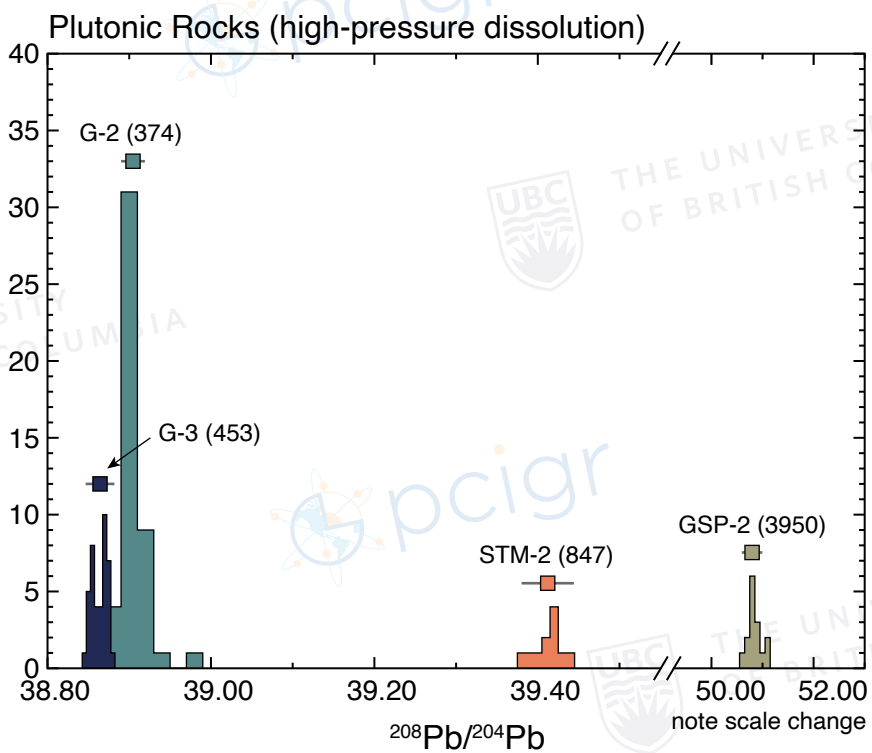
Comparison of the Pb isotopic variations between unleached and leached reference materials analyzed via MC-ICP-MS at PCIGR (cont'd). Left panels: $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Right panels: $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Circles: unleached; triangles: high-pressure dissolution; diamonds: leached. The mean and 2 standard deviations of the reference material are represented by the blue square symbols, and literature reported reference values are represented by the white symbols. Reference value sources: Weis et al. (2006); Nobre Silva et al. (2013); Fourny et al. (2016).



Pb isotopic compositions of USGS G-3 reference material analyzed via MC-ICP-MS at PCIGR. All samples were dissolved in high-pressure vessels prior to analysis. Left panel: $^{208}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. Right panel: $^{207}Pb/^{204}Pb$ vs $^{206}Pb/^{204}Pb$. The mean and 2 standard deviations of the reference material are represented by the blue square symbols, and literature reported reference values are represented by the white symbols. Reference value source: Weis et al. (2006).







Histograms showing the full range of $^{208}Pb/^{204}Pb$ analyses, conducted via MC-ICP-MS at PCIGR, of volcanic and plutonic reference materials. The mean (square symbol) and 2 standard deviations (grey bar) of each reference material is indicated above the histogram. Numbers next to reference material names are the reproducibility in ppm (2 standard deviations; SD), indicating the necessity of leaching to achieve reproducible Pb ratios in oceanic islands (e.g., Nobre Silva et al., 2009). Values of 2 SD that are smaller than the symbol size are not shown. Y-axis represents the number of analyses.