# Integrating microbeam research instrumentation into the classroom to teach mineralogy and petrology: Outcomes

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A range of activities have been employed in Mineralogy and Petrology courses involving the use of analytical research instrumentation [1, 2], all dealing in different ways with the logistical and instructional challenges this entails. Using Web-based remote operation technologies, classroom access to microbeam instruments (SEM and EPMA; electron microprobe [3]) can now become routine, permitting easy integration of research activities into instruction.

My students use EPMA as part of term projects examining suites of metamorphic/igneous rocks collected in the field, following a studio classroom instructional model [4]. EPMA use is introduced via lectures and whole-class participatory activities before students collect their own imagery and mineral chemistry data. Students work in teams choosing the samples to study, preparing and polishing thin sections, conducting optical petrography, and doing EPMA measurements in class during lab periods and/or scheduled times outside of class.

The project seeks to measure:

1) student impressions of the experience. Three years of survey data indicate strongly positive student perceptions, as has been observed in other projects [1].

2) Student learning of mineralogy and petrology. Pretest/post-test results using both content-specific questions and a subset test from the GCI [5] indicate overall better understanding of the course content.

3) Student interests: ~20% of students have taken a post-course, permit-only Senior research class focused on EPMA/SEM use, and thus far five students have presented EPMA research results on metamorphic petrology at sectional GSA meetings.

[1] Beane (2004) *J. Geosci Ed.* **52,** 250-253; [2] Argast and Tennis (2004) *J. Geosci. Ed.* **52,** 213-217; [3] www.fiu.edu/~emlab/home.html; [4] Perkins (2005) *J. Geosci. Ed.* **53**, 101-109; [5] Libarkin and Anderson (2005) *J. Geosci. Ed.,* **53**, 394-401.

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# Novel continuous flow-cavity RingDown spectroscopy systems for high-precision bulk and compound-specific $^{13}C/^{12}C$ measurements

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Light stable isotope analysis is a valuable tool to elucidate pathways and provide a better insight into physiological, biochemical and geochemical processes. Isotope ratio mass spectrometry (IRMS) is usually used for these measurements; however, here we present the results of both bulk stable isotope analysis (BSIA) of soil organic matter (SOM) and compound-specific isotope analysis (CSIA) of short chain hydrocarbons using two novel laser-based systems: the world's first combination of either a bulk combustion module (CM) or gas chromatography-combustion (GC-C) interface with an isotopic $CO_2$ cavity ring-down spectroscopy analyzer (CRDS) for the measurement of $^{13}C/^{12}C$ BSIA and CSIA, respectively. CRDS is a highly sensitive optical spectroscopy technique due to a highly reflective optical cavity with many kilometers effective path length. It first measures the quantities of each isotopologue independently using their distinct ro-vibrational spectra, and then infers the stable isotopic ratios in the analyzed small molecules. The Combustion Module was interfaced to the CRDS analyzer using Liaison, an innovative multi-tasking interface that runs three operations simultaneously; it automatically collects the generated combustion gas from the current analyzed sample in one bellows for isotopic homogenezation, it diverts a second bellows' gas content from the previous collected sample for isotopic measurement with CRDS, and it purges a third bellows with high-purity nitrogen gas in preparation for the next sample combustion and the collection of its generated gas. The SOM samples analyses using the compact and easy-to-use CM-CRDS system were rapid and achieved an average precision of 0.1permil. On the other hand, using the novel GC-C-CRDS system, we analyzed a mixture of methane, ethane, and propane for $^{13}C/^{12}C$ isotopic ratio without the need for water removal. Measurements were achieved with a precision of 0.95 permil or better. Compared with IRMS, the current Continuous Flow-CRDS systems are robust, simpler to operate, and could be made field-portable. We anticipate that advances in spectroscopic analysis will improve the precision of the GC-C-CRDS isotopic measurements, making it comparable with CM-CRDS.