Plasma Mass Spectrometry Laboratory

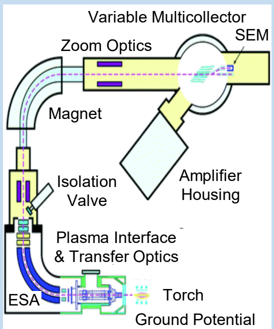
Geochemistry at the University of Maryland | Elemental and Isotopic Analysis of Solids and Liquids

www.geol.umd.edu/plasma-lab

MULTICOLLECTOR ICP-MS

ThermoFinnigan Neptune Plus

- Multiple Faraday cups for simultaneous high precision isotope measurement



- Installed July 2019
- Grant funding from NSF and NASA

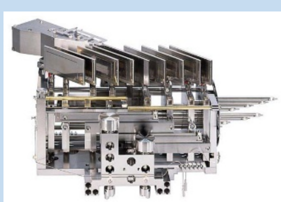
High Precision Isotope Analysis

- Applications include cosmochemistry, geochemistry, geochronology, and environmental chemistry
- Isotope systems from lithium to uranium

Isotope	Precision (at ±2σ)
$^{6}Li/^{7}Li$	± 0.5 ‰
$^{196}Pt/^{195}Pt$	± 7 ppm
$^{100}Ru/^{101}Ru$	± 18 ppm (40 ng sample)
$^{97}Mo/^{96}Mo$	± 11 ppm
$^{235}U/^{238}U$	± 30 ppm

Innovative Collector Assembly

- 9 Faraday cups
- Switchable amplifiers
  - 4 10^{13} Ω resistors
  - 6 10^{11} Ω resistors
- Central ion counter



LASER ABLATION SYSTEMS

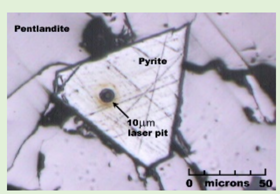
Deep Ultraviolet Laser

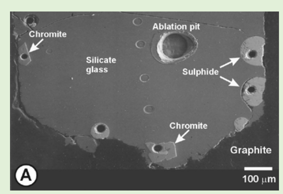
- Deep UV wavelength couples effectively with most materials
- Uses: *In situ* analyses of solids and liquids
- Can be used in tandem with either Neptune Plus for isotope ratio determination or Element 2 for trace element abundance determination
- Applications include cosmochemistry, environmental chemistry, geochemistry, geochronology, material science, biological tissue analysis, archaeology and forensic science

New Wave UP213

- 5^{th} harmonic of Nd:YAG: λ = 213 nm, E = 5.83 eV
- Ablation Energy: $2.5x10^{-4}$ Jcm^{-2}
- Spot size diameter: 4 to 250 µm

Laser Spots in Natural and Experimental Samples



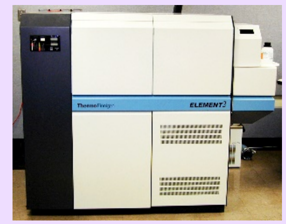


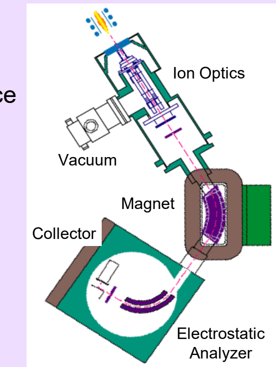
Photomicrograph and BSE image of a natural pyrite and a synthetic charge showing the ability of the laser to target *in situ* analysis of individual phases

SINGLE COLLECTOR ICP-MS

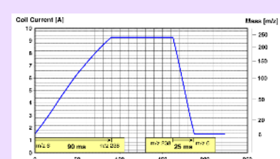
ThermoFinnigan Element 2

- Inductively Coupled Plasma – Mass Spectrometer
- Single electron multiplier detector
- Trace element abundance determination



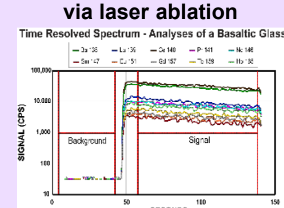


- Abundance determinations for most element from Li to Pu, except noble gases
- Solution analysis of waters, sludges, airborne particulates, dissolved rocks and metals, *etc*.
- *In situ* laser ablation analyses of solids or liquids, including fluid and solid inclusions
- Low detection limits: *e.g.* U in solution has a detection limit of <1 ppq
- High resolving power to avoid interfering isobars



Fast scanning magnet: needed for time resolved analyses

***In situ* analyses via laser ablation**



This facility continues to be supported by the University of Maryland and grants from the National Science Foundation and NASA

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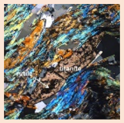
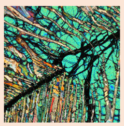
LABORATORY HIGHLIGHTS

Geochemistry



Tracing fluid flow through subduction zones using trace elements and lithium isotopes. [Penniston-Dorland]

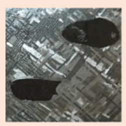
Using tungsten, molybdenum, and ruthenium isotopes to understand the preservation of primordial terrestrial reservoirs. [K. Bermingham]



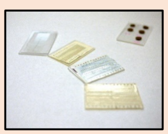
Trace element and isotopic analysis of komatiites allows us to model the thermal and chemical evolution of the mantle (Puchtel)

Cosmochemistry

The origin and evolution of asteroidal cores using trace element laser ablation ICP-MS and MC-ICP-MS isotope dilution. [Walker, McDonough & Ash]

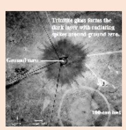


Forensics

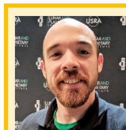


Thallium poisoning chronology through single human hair analysis by laser ablation ICP-MS. [Ash]

Trinitite: isotopic and trace element analysis of materials resulting from the detonation of the first atomic bomb. [McDonough]



RECENT STUDENT PROJECTS



Sam Crossley (PhD) studies the evolution of oxidized asteroids using HSE abundances of brachinite meteorites and R chondrites (Ash & Sunshine [Astronomy]).

Connor Hilton (PhD) works on the measurement and modeling of HSE in iron meteorites to understand the origin and evolution of planetary cores (Walker).

Will Hoover (PhD) studies Alpine metamorphism using trace elements and Li isotopes to understand water-rock interactions during subduction (Penniston-Dorland).

Emily Chiappe (MS) has just started using HSE and isotopes to understand the early evolution of metallic materials in the early Solar System (Walker).

Willie Nicklas (PhD) used vanadium fractionation between komatiite melts and crystalizing olivine to determine the change of mantle oxidation state through time (Puchtel).

Hope Tornabene (Ugrad/MS) measures HSE concentrations and isotopic characteristics of iron meteorites and applies modelling understand the evolution of planetessimal cores (Walker).

SELECTED PUBLICATIONS

Nicklas R.W., Puchtel I.S., Ash R.D., *et al.* (2019) Secular mantle oxidation across the Archean-Proterozoic boundary: evidence from V partitioning in komatiites and picrites. *Geochim. Cosmochim. Acta* **250**, 49-75.

Hilton C.D., Bermingham K.R., Walker R.J. and McCoy (2019) Genetics, crystallization sequence, and age of the South Byron Trio iron meteorites: New insights to carbonaceous chondrite (CC) type parent bodies. Geochim. Cosmochim. Acta **251**, 217-228.

Ash R.D. and Min He (2018) Details of a thallium poisoning case revealed by single hair analysis using laser ablation inductively coupled plasma mass spectrometry. *Forensic Sci. Int.* **292**, 224-231

Nicklas R.W., Puchtel I.S., and Ash R.D. (2018) Redox state of the Archean mantle: evidence from V partitioning in 3.5-2.4 Ga komatiites. *Geochim. Cosmochim. Acta* **222**, 447-466.

Crossley S.D., Mayne R.G., Lunning N.G *et al.* 2018) Experimental insights into Stannern-trend eucrite petrogenesis. *Meteoritics Planet. Sci.* **53**, 2122-2137.

Greaney A.T., Rudnick R.L., Helz R.T., *et al.* . (2017) The behavior of chalcophile elements during magnetic differentiation as observed in Kilauea Iki Lava Lake, Hawaii. *Geochim. Cosmochim. Acta* **210**, 71-96.

Ming Tang, McDonough W.F. and Ash R.D. (2017) Europium and strontium anomalies in the MORB source mantle. *Geochim. Cosmochim. Acta* **197**, 132-141.

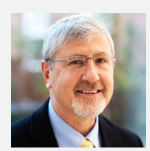
Chabot N.L., Wollack E.A., McDonough W.F., Ash R.D., and Saslow S.A. (2017) Experimental determination of partitioning in the Fe-Ni system for applications to modeling meteoritic metals. *Meteoritics Planet. Sci.* **52,** 1133-1145.

McCoy T.J., Marquardt A.E., Wasson J.T., Ash R.D. and Vicenzi E.P. (2017) The Anoka, Minnesota iron meteorite as a parent to Hopewell metal beads from Havana, Illinois. *J. Archaeo. Sci.* **81**, 13-22.

Rettie A.J.E., Chemlewski W.D., Wygant B.R *et al.* (2016) Synthesis electronic transport and optical properties of Si:α-Fe_2O_3 single crystals. *J. Mater. Chem. C.* **4**, 559-567.

Nicklas R.W., Puchtel I.S. and Ash R.D. (2016) High-precision determination of the oxidation state of komatiite lavas using vanadium liquid-mineral partitioning. *Chem. Geol.* **433**, 36-45.

Research Assistants	Research Students		Publications		
>40 undergraduate students	**34** undergraduate	**47** graduate	**>180** total publications	**19** with undergrad. students	**91** with graduate students



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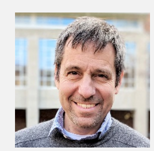

Laboratory Manager and Research Scientist
Dr. Richard Ash
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