

# Earthly insights

NU PLASMA II & 1700 MC-ICP-MS  
IN NUBC © DOMINIQUE WEIS

PCIGR

As the director of a world-leading integrated analytical mass spectrometry facility, **Dr Dominique Weis** leads a unique group of scientists and students keen to explore the isotopic and geochemical compositions of a wide range of materials



NU LAB © MARTIN DEE

## Could you begin by introducing the Pacific Centre for Isotopic and Geochemical Research (PCIGR)?

PCIGR officially opened in December 2002 and has become a world-class geochemical facility providing the Canadian and international scientific community with a synergistic research environment supported by highly qualified technical personnel and advanced analytical infrastructure. Together, these allow researchers to trace the sources of different materials and quantify exchanges between Earth's lithosphere, biosphere, hydrosphere and atmosphere to the highest standards of analytical precision and accuracy.

With its 15 state-of-the-art instruments, sample preparation laboratories and resident research team and support staff, PCIGR is among the best-equipped geochemical mass spectrometric facilities worldwide.

## Multidisciplinary research and collaboration forms the foundation of the Centre. Has this approach proved successful to the work of PCIGR?

Our management philosophy and day-to-day practice makes PCIGR an efficient, flexible and open facility, where input and interactions between all members of the research community are encouraged and solicited, allowing new research initiatives to be developed. Our research group is a major player in the International Ocean Discovery Program

(IODP) and GEOTRACES – global collaborative marine research programmes involving more than 25 nations each.

Multidisciplinary research and open access at PCIGR have been critical in addressing key scientific and economic priorities, such as climate change, biogeochemical cycles in the oceans, groundwater contamination, composition of the Earth's mantle and lithosphere, timescales and rates of geological processes, natural hazards and mineral exploration.

## How are you building on this culture of fostering collaborative research and innovation?

Our ongoing dedication to analytical excellence, innovation and collaborative research is highlighted by two recent achievements. The first is the 2012 launch of the Multidisciplinary Applied Geochemistry Network (MAGNET), a Natural Sciences and Engineering Research Council of Canada Collaborative Research and Training Experience (NSERC CREATE) initiative devoted to analytical, environmental and exploration geochemistry (see p40). The programme currently involves key researchers and 17 trainees at six Canadian universities, as well as numerous academic and industry partners.

Also in 2012, PCIGR formally established an R&D partnership with Nu Instruments Ltd, UK; a market-leading designer and manufacturer of high-performance mass spectrometers. This partnership provides training for young scientists and is enabling major advances in method development and instrument design that allow researchers to tackle new key scientific questions that will benefit the international community.

## Could you discuss the relatively new nUBC facility – the most recent addition to PCIGR?

The facility was named nUBC (Nu + UBC) to emphasise our partnership with Nu Instruments, which designed and manufactured four of the six instruments housed in the laboratories. Nu Instruments will use nUBC as a demonstration and testing facility for North America and as an R&D centre in collaboration with PCIGR scientists and students.

Construction of the new 2,200 ft<sup>2</sup> clean laboratories was completed in September 2011 and was followed by instrument deliveries, the last of which was installed in October 2014. The laboratories and instruments represent an investment of ~\$7.5 million and have allowed significant expansion and improvement of our analytical capacity.

Importantly, these new-generation instruments have higher mass resolution, sensitivity and stability, and allow the community to analyse smaller sample volumes as well as isotopic ratios with major isobaric interferences. The new excimer laser ablation system, equipped with a two-volume cell, enables ablation of a wide range of materials at high spatial resolution, low absorbance and with better controlled fractionation. These capabilities have opened avenues for the development of new isotopic tracer studies and broadened the PCIGR user base to include investigators from a range of fields in the Earth and environmental sciences as well as in pathology, forestry, soil science, anthropology and forensic science.

## You also work with the Pacific Museum of Earth. Why was this collaboration formed?

The new PCIGR laboratories directly border the Pacific Museum of Earth, and the facility was specifically designed with education and outreach in mind. Floor-to-ceiling windows were incorporated wherever possible to permit what we call 'science that you can see'. At each window, QR codes link to three short documentary videos that explore the science and applications of geochemistry; describe the features and importance of a clean laboratory; and explain how samples are analysed on a mass spectrometer. In addition, we have installed a large (47") digital display facing the museum that showcases science facts, current research, recent publications, people and upcoming events using a broad range of multimedia.

PCIGR also participates in the Museum's professional development weekend for teachers from across the province. In our geochemistry training workshops participants learn about elements, compounds, the periodic table, qualitative and quantitative properties, Earth's composition and applications of geochemistry.



# Nature's composition

The **Pacific Centre for Isotopic and Geochemical Research** in Vancouver, Canada, is a hotbed of research investigating the isotopic and geochemical compositions of a wide range of materials relevant to mechanisms governing the most important systems in the Earth and the environment

**BURIED WITHIN EARTH'S** liquids, gases and mineral deposits lies an abundance of information concerning the composition, structure and processes involved in microscopic to massive geological and environmental phenomena. Digging up and making sense of this information is the remit of geochemists, whose insights inform not only human understanding of the Earth but also practical concerns such as resource management, climate change control and pollution regulation.

Although a field in existence since the 19<sup>th</sup> Century, interest in the discipline continues to grow, particularly as highly refined instrumentation becomes available, allowing unprecedented information to be gleaned from geochemical tracers at extremely low concentrations and enabling the isotopic composition measurement of a far wider range of elements than previously possible.

## A CENTRE OF DISCOVERY

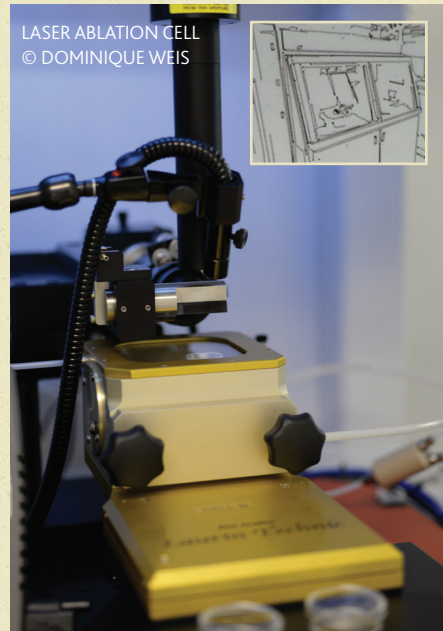
Providing a pool of world-class analytical instruments and geochemical expertise, the Pacific Centre for Isotopic and Geochemical Research (PCIGR) in Vancouver, Canada, facilitates the work of a diverse range of investigators, including Canadian university-based scientists, government agencies, the mineral and environmental industries, and the international research community. "It is a pleasure working with such enthusiastic and

dedicated individuals," enthuses PCIGR Director Dr Dominique Weis, Canada Research Chair in Geochemistry of the Earth's Mantle and Professor at the University of British Columbia. "I am also very proud of the openness of the facility and the internationalisation of users – collaboration is the key to innovation."

PCIGR houses six inductively coupled plasma mass spectrometers (MC- or HR-ICP-MS), four thermal ionisation mass spectrometers (TIMS), two stable isotope ratio mass spectrometers, a noble gas mass spectrometer and two laser ablation systems. Of particular note is the Nu Plasma 1700, an extended geometry high-resolution multicollector ICP-MS, as Weis elaborates: "The Nu Plasma 1700 is not available anywhere else in Canada, and is just the fifth of its kind in the world". The instrument provides the opportunity to pursue novel isotopic tracer studies and collaborative interdisciplinary research through its ability to make precise and accurate radiogenic and heavy/transition metal stable isotope measurements – especially for historically challenging systems, such as iron, chromium, silicon.

## GEOCHEMICAL OUTLOOK

In the future, Weis is keen for the Centre to expand its mandate: "My main objective in the coming years is to collaborate with medical doctors and use the analytical pool available at PCIGR to decipher fundamental questions relevant to understanding the chemical



pathways within the human body". There will also be a focus on chemical speciation – the distribution of an element in a system in terms of its specific forms defined by isotopic composition, electronic or oxidation state, and complex or molecular structure. Developments in this area made by PCIGR and other labs will be key to understanding the transport and fate of heavy metals in the environment.

## PCIGR research themes

- Global climate
- Biogeochemical cycles in the oceans
- Groundwater contamination
- Composition of the Earth's mantle and lithosphere
- Timescales and rates of geological processes
- Metals in the Earth

GARIBALDI VOLCANIC BELT © CHARLIE BEARD



## Case studies

### EYE-OPENING SHELLFISH

Bivalves, such as oysters and mussels, are molluscs with hinged double shells. For over 40 years, these sessile creatures have been used to monitor spatial and temporal trends in coastal water metal levels due to their ability to absorb and concentrate metals, some potentially toxic. Traditionally, elemental concentrations have been measured in these creatures, but concerns over the ability to differentiate between anthropogenic and natural metal sources and whether relatively low metal concentrations represent the natural baseline level have increasingly been raised.

In a study published in *Geochimica et Cosmochimica Acta* in 2013, Shiel, Weis and Orians (all PCIGR colleagues) also measured isotopic compositions of cadmium, zinc and lead in bivalves collected from a well-studied area of the French coastline. Results from the investigation were enlightening: "In some key locations in France, cadmium concentrations are directly related to historical pollution events, with long persistence in rivers, sediments and ponds," elucidates Weis. In addition, because lead isotopes do not fractionate during bivalve processing like cadmium and zinc, they can be used to identify emissions from industrial processes, metallurgical refineries, unleaded gasoline and diesel fuel.

Crucially, the precision and ionisation of the MC-ICP-MS instrument allowed minute variations to be resolved – a level of detail traditional thermal ionisation instruments would be incapable of reaching. Weis is therefore optimistic that the technique may find further application: "The methods we developed will be applied by other researchers to trace metal dispersion in the environment, with implications for consumption of bivalves".

### ALKALIC DISCREPANCY

In 2013, *Geochemistry Geophysics Geosystems* published a study by Mullen and Weis exploring the northern Cascade Arc, known as the Garibaldi Belt – a line of volcanoes in western North America. The study aimed to uncover the source composition of the volcanoes. Unlike the rest of the Cascade Arc, volcanoes from the Garibaldi Belt are composed of alkalic basalts, a relatively unusual composition for an arc setting.

The PCIGR researchers aimed to decipher which of three hypotheses previously proposed for this discrepancy was true by systematically studying the geochemical 'fingerprint' of lavas from major volcanoes within the Arc. Using the suite of facilities at the Centre, high-precision Sr-Nd-Hf-Pb isotope ratios and trace element abundances were carefully determined, allowing Mullen and Weis to conclude that the alkalic basalts were a result of upwelling of a highly viscous region of the upper mantle of the Earth through a gap along the Nootka fault. The upwelled asthenosphere underwent decompression melting to generate alkalic basalts free of subduction input yet located in an arc setting.

Continuing this work, Weis and colleagues are now attempting to answer why volcanoes in the Garibaldi Belt formed and why their sources appear different from those in the High Cascades. New insights are being provided through analysis of the basaltic lavas collected from the Garibaldi Belt volcanoes and sediment accumulated atop the Juan de Fuca oceanic plate. In addition, PCIGR researchers are exploring the volcanoes of Hawaii in an attempt to gain a better understanding of the physical and chemical structure of the Earth's mantle and the geochemical evolution of hotspot and subduction-related volcanism.

## INTELLIGENCE

### PACIFIC CENTRE FOR ISOTOPIC AND GEOCHEMICAL RESEARCH (PCIGR)

#### OBJECTIVES

- To foster innovative and collaborative research in the Earth, ocean, atmospheric, environmental and biological sciences
- To attract and retain outstanding researchers from the Canadian and international scientific communities
- To train students and young researchers for careers in industry, government and academia
- To provide high-quality analytical services and support for the community at large

#### KEY PARTNERS/COLLABORATORS

**James Scoates; Roger Francois; Matthijs Smit; Jim Mortensen; Kristin Orians**, PCIGR, University of British Columbia, Canada • **Mike Garcia**, University of Hawaii at Manoa, USA • **Fred Frey**, Massachusetts Institute of Technology, USA • **Nadine Mattielli**, Université Libre de Bruxelles, Belgium

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**DR DOMINIQUE WEIS** obtained her BS at the Université Libre de Bruxelles, Belgium, in 1979, followed by a PhD in Sciences in 1982 and Habilitation in Geochemistry in 1992. Postdoctoral fellowships (Université Paris VII, France; California Institute of Technology, USA) allowed her to perfect her training in geochemistry with some of the best teams in the world.



PCIGR TEAM © DOMINIQUE WEIS



a place of mind  
THE UNIVERSITY OF BRITISH COLUMBIA