THE UNIVERSITY OF MARYLAND GEOLOGY DEPARTMENT'S
GEOGRAM
2003

LETTER FROM THE CHAIR

A Department on the move — Fear the turtle!

Four years ago, I commented in the first GEOGRAM that I was finishing "my second and last term as Chair of the Department". Well, guess what, after discussion among senior faculty and an independent review of performance by a committee of the Department, the Dean persuaded me to accept a third term. Plus ça change, plus c'est la même chose! Now that I am in sight of the end of my third term as Chair (in 2005), it is appropriate to engage in retrospection and dreaming about the future.

Research strengths of the department (see http://www.geol.umd.edu/pages/facilities.htm) lie primarily in the field of *Earth Chemistry*, which encompasses topics ranging from investigations of low-temperature processes occurring at or near Earth's surface, through high-temperature processes operating in the deepest regions of Earth, to investigating aspects of the Solar System. In this area the Department has gained considerable international recognition in addition to its national prominence. The Department also has strengths in the overlapping fields of *Earth Materials* and *Earth Environment*, but is understaffed in the broad field of *Earth Physics*. Our broad-ranging Geochemistry program recently was the subject of an article in Maryland Research, illustrating some of our research confronting the frontiers of Geoscience, and this article is reprinted in the GEOGRAM to give you a flavor of how far we have come in nearly 40 years! In October, as part of the periodic review of the Department, an External Panel assessed the Geochemistry group at UMd to be the best in the Nation. We anticipate the present decade to be the one in which we achieve national ranking as a research department. To achieve this, we will strive to add to our broad-based strength in Geochemistry by developing further our distributed strength in cognate areas of Geoscience.

We begin the new millennium with a great faculty, a wonderful staff, a high-quality Graduate Program and a strong B.S. program (25% of our majors are in Departmental Honors). This has been accomplished through the addition of outstanding faculty and staff, the development of world-class analytical facilities, and by attracting top-ranked post-doctoral researchers, and some of the Nation's best graduate and undergraduate students to work with us. Most of our undergraduate majors are involved in the work of one of our research laboratories, in addition to the research each undertakes for their Senior Thesis, ensuring that each will graduate with the requisite technical skills to succeed in their chosen profession. However, the Department

A brief history

As many of you know I'm sure, Geology has been taught at Maryland for more than 40 years. The 1960s were the formative years (with Profs Fernow, Segovia, Siegrist, Stifel and Weidner) that provided the foundation for the largest solely Undergraduate Geology Program in the United States between 1977 and 1981, reaching a maximum of close to 200 Geology majors enrolled. The growth during the 1970s (hiring Profs Wylie, Ridky and Onasch, and receiving help from the Geochemistry Program in Chemistry & Biochemistry) enabled the development of a Graduate Program that began in the early 1980s (which period also saw retirements and hiring Profs Candela, Chang, Nielsen and McLellan). The 1990s were a decade of consolidation (retirements of Profs Siegrist and Weidner and hiring Profs Brown, Krogstad, Prestegaard and Walker early in the decade, and retirements of Profs Segovia and Stifel and hiring Profs Gallup, Jiang and Kaufman late in the decade) during which the Department reached maturity, although remaining small in size. Around the Millenium, Profs Gallup, McLellan and Ridky moved on and we hired Profs Farquhar, Lower, McDonough and Rudnick, but only Wylie (from the 70s) and Candela and Chang (from the 80s) now remain from the first 25 years. Turnover has provided the opportunity to change direction and move into new areas of Geoscience. Now we anticipate a period of stability, and as a first step we have put a process in place to produce the GEOGRAM annually, as promised in the first issue four years ago!

Where are we located?

Space may be the last frontier, and water may be the cause of the next major international conflict (rather than oil), but on campus, particularly in our College, square feet are at a premium, and facilities will be the big issue for the next decade. The Department now occupies the Geology Building (some faculty with laboratories and associated graduate students, the teaching laboratories, computing support, and some administrative staff), a super newly-renovated suite of Geochemistry Laboratories (at a cost of >$1M) within the Chemistry Building (some faculty and associated graduate students, and part-time administrative support) and space in the Computer and Space Sciences Building (two faculty with laboratories and associated graduate students, one administrative staff and business services support); the Department has storage space in Jull Hall (hydrology field equipment) and Parking Garage 1 (rock storage). What are our long-term plans? Ten years down the road we expect the Earth Science units (Geology, Earth System Science Interdisciplinary Center and Meteorology) to move into a renovated Physics Building after a new Physical Sciences complex is completed.

of Geology remains an unfinished project. Our success in achieving worldwide recognition in Geochemistry, although prescient for expansion into other important areas in the Geosciences, was achieved without increasing significantly the number of faculty; consequently, it has come partly at the expense of balance within the Department. Our goal is to improve the Department further with the addition of faculty and facilities in one or more of the following fields: Geological Perspectives of Earth System Science, particularly Paleoclimatology and Tectonics & Land Surface Evolution (including Land Surface Hydrology); Biogeosciences & Nanotechnology; and, Mineral Physics.

Increasing our breadth is critical for maintaining the quality and currency of our undergraduate and graduate programs, from both training and funding perspectives. Some of the most important scientific advances and funding opportunities now appear at the seams between the traditional divisions within the Geosciences. In order for our students to take full advantage of such opportunities, and pioneer new frontiers, we will require a more scientifically diverse program. We anticipate that this increased diversity of scientific interest among our faculty will impact undergraduate education by further development of collaborative programs in addition to offering a wider choice of research opportunities for our graduate and undergraduate students. However, budgetary constraints and the shortage of space within the Department and the College make this our biggest immediate challenge.

How does all of this help you? You may have read in the press about the enhanced ranking of the University of Maryland, College Park, as a campus with a strong national and international profile across the whole spectrum of disciplines. President Mote has made the point frequently and loudly that the value of a Maryland degree increases with time. This is particularly true of your degree in Geology. The increased on-campus profile has enabled our Department to garner additional resources, but it is the enhanced off-campus image and reputation that is adding value to your degree. Every one of our present and future students and our alumni will continue to experience, and hopefully benefit from, the increased value of their degree.

It is important that we recognize the distinction of our former students. To this end, Departments in our College (see http://www.cmps.umd.edu/) have each developed a Distinguished Alumnus Award. The Department will recognize the distinction achieved by one of you at each CMPS Annual Academic Festival. This is also the event where we recognize outstanding teaching and advising by Faculty, Instructors and Teaching Assistants, recognize our Honors Seniors in the College, and recognize outstanding contributions by staff. Furthermore, a College Distinguished Alumnus will be recognized at the Annual Alumni Association Awards Gala in April each year. Let me take the opportunity to congratulate again the Geology distinguished alumni for the past 3 years: 2001 - Frank Chapelle (B.S. 1976); 2002 - Frederick W. (Rick)

The Department Chair praying for help in South Africa (Margaret Baker, a graduate student, looks on).

Zimmerman (B.S. 1975); and, 2003 - Michael J. Wietrzychowski (M.S. 1989). If you are aware of notable distinction among our alumni, please do not hesitate to make a nomination using the space for "Alumni News and Notes" on the enclosed envelope (or e-mail Phil Candela at: candela@geol.umd.edu).

One last comment about the next GeoGram - we want the 2004 issue to be news-oriented, so please, please write in with updates about yourselves and your families, and about other Geology alums; you may write to one of us (http://www.geol.umd.edu/pages/faculty.htm), or provide information to Mary Kearney, who is Program Director, Alumni and Public Relations in the College (at mkearney@deans.umd.edu). Even better, call in to see us anytime or come to the College annual alumni reunion and cook-out (Fall semester 2004, e-mail Mary Kearney for information).

In closing I would like to acknowledge the help we have received from the College and the Campus in advancing our Geology agenda. We are determined to provide our students with a rounded education in Geology, but one within which there is the opportunity to experience the excitement of cutting-edge research using the most advanced technology. Dean Halperin and Provost Destler have invested heavily in our future, and we thank them for their confidence in us as well as their support. None of this would be possible, however, without the hard work of our faculty, staff and students, and the support of our alumni and friends. Also, it is important to bear in mind that Geology is only part of the Maryland success story during the past few years. In fact, we're now ranked 17th among public universities, with 68 programs in the Top 25 and 50 programs in the Top 15. Truly, this is a University of which we can all be proud. Experience the excitement by visiting us during Maryland Day 2004 (https://www.marylandday.umd.edu/) on April 24 – we will be hosting visitors in the Gems and Minerals Museum in the Geology Building, and I look forward to seeing you there!

Michael Brown
December, 2003

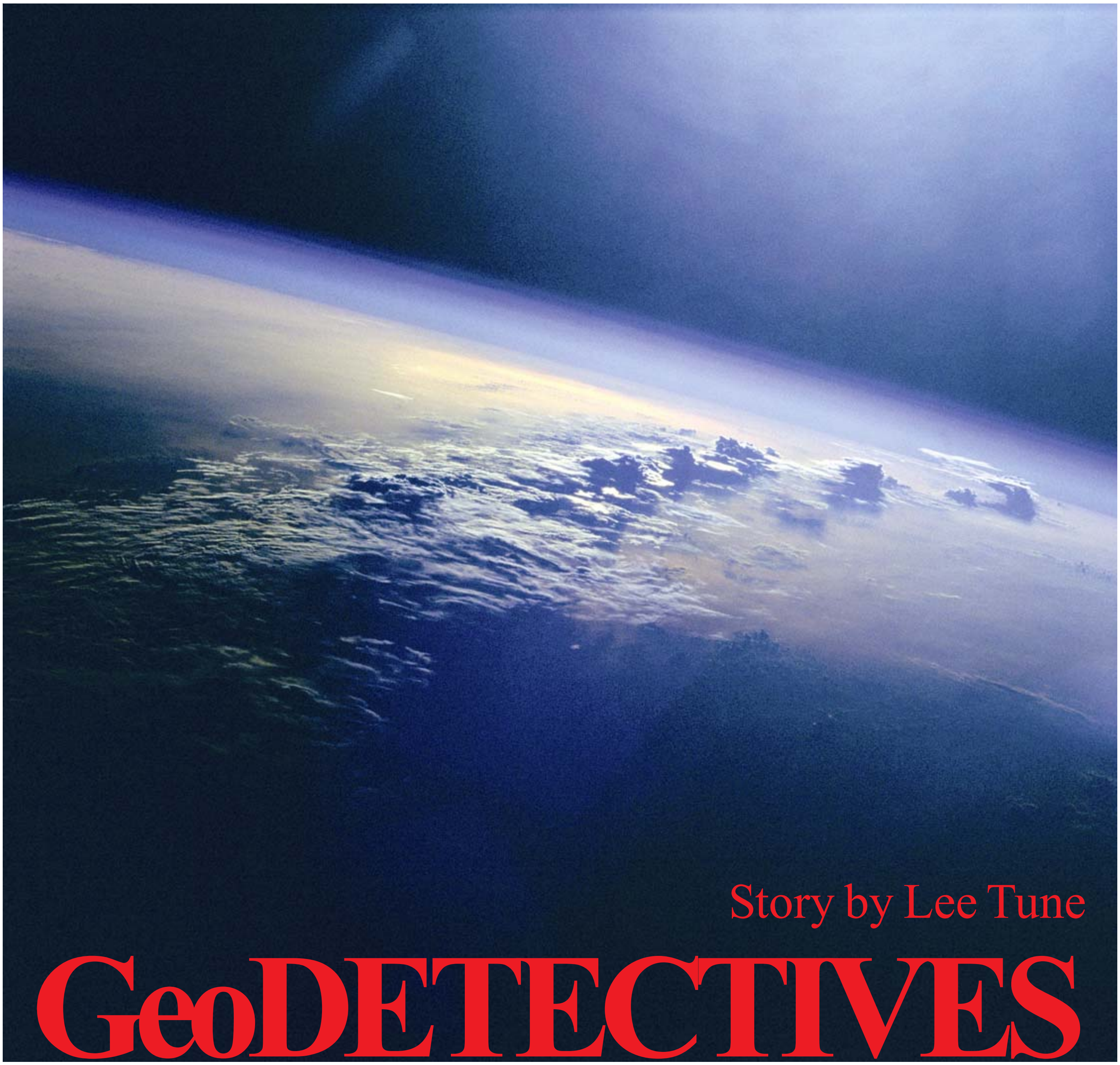
How can you help us?

A growing problem is the transfer of the cost of Tertiary education from the State to the individual via reduced State support and increased tuition rates. For our undergraduates, the increased cost commonly increases the time it takes to complete their degree, and our ability to help is limited by a significant under-funding in scholarship support for students. As at other major research universities, our department needs the generosity and philanthropic support of our alumni and friends to maintain our commitment to excellence. In Geology, this is particularly important, since there are the additional costs associated with fieldwork, particularly Field Camp and research for the Senior Thesis, and additional financial help from the Department for those students in need commonly allows them to succeed.

We ask you to consider strengthening your connection to the Department. The University recognizes an annual contribution of at least $1,000 with membership in the Colonnade Society. I invite you to join the College as charter members of the Isaac Newton Society, which will recognize those Colonnade Society Members who direct their contributions to the College or its units. The Isaac Newton Society also recognizes recent alums who contribute at least $100. An envelope is enclosed, giving you a convenient opportunity to participate, right now, in the exciting and important work that our students and faculty are doing. You can help future generations of Geology majors by earmarking your tax-deductible gift for Geology, and you may additionally specify one of the following funds, the Fernow Field fund or the Stifel Undergraduate Research fund or the Hutton general fund by annotating the grey stripe on the back of the envelope accordingly.

On behalf of the Department, let me offer my thanks, in advance, for your early and positive response.

Michael Brown



Story by Lee Tune

GeoDETECTIVES

Maryland Geologists Are Hot on the Trail of Some of the Earth's Oldest Mysteries

In recent years the popularity of TV crime lab dramas like "CSI" has made many of us acutely aware of the crucial role a forensic laboratory can play in solving a difficult case, even when the trail has been cold for decades. But what if the mystery you want to unravel is, say, 4 billion years old?

For a case like that, even the most dynamic detectives and the cream of crime labs just can't cut it. What you need, instead, are top earth science sleuths and state-of-the-art geochemistry laboratories like those of the University of Maryland's Department of Geology.

The department's new geochemistry research facilities, widely regarded as among the best in the world, are located down a long bright corridor in the basement of the chemistry building. Once rather dungeon-like, this completely refurbished space now houses windowed offices; high-tech sample preparation laboratories, including a clean room; and three testing laboratories that contain nine mass spectrometers. One of the most powerful tools in any investigator's lab, mass spectrometers can detect and identify elements or molecules in a speck of rock, a bit of diamond, or a tiny fossil.

It is in these facilities that more than a dozen Maryland scientists, aided by graduate and undergraduate students, are working to read clues buried in ancient rock samples from the Earth and space. Their detective work is shedding new light on some of our planet's oldest mysteries.

CASE 1: The Golden Paradox

Why do we wear gold rings? On the surface this might seem an odd question for a geologist to study. But, to Richard Walker, gold rings are shining examples of a perplexing aspect of the composition of our planet's crust—the presence of significant amounts of gold, platinum, palladium and other highly "iron-loving" elements that current understanding suggests really should not be there.

Walker, who studies the origin and evolution of early solar system materials and the Earth's crust and mantle, says

gaining an understanding of this strange case will add an important piece to two much larger puzzles: How did our planet form and what are the ongoing processes that have shaped it into the place we know today?

Our sun was created some 4.6 billion years ago. Scientists think that a cloud of gas, dust and ice from the vast regions between existing stars gradually coalesced under the attraction of gravity to form a diffuse slowly spinning mass known as a nebula. This nebula gradually formed into a disk of material, most of which then moved inward to form the sun. However, some of the dust, gas and ice near the edge of the nebula formed solids that smashed into each other, and occasionally stuck and grew larger. As they grew larger, their gravitational field increased. These larger clumps were able to attract other clumps until they grew to become the building blocks of planets, moons, asteroids or comets.

After its initial formation, the proto-Earth heated then segregated into a mostly iron core and rocky mantle, an event estimated to have been completed around 4.5 billion years ago. According to Walker, during this segregation process the core would have pulled in almost all of the iron-loving or siderophilic elements, such as gold, platinum and palladium, leaving essentially none in the mantle. The Earth's crust, which is equivalent to the skin of an apple in thickness relative to the entire earth, is thought to have been formed primarily out of molten rock from the mantle. As a result, the crust should also be devoid of metals such as gold and platinum.

"We should have an Earth that essentially has no siderophile element ores in its crust for us to mine," says Walker. "The fact that we do, suggests that something must have happened to Earth after formation of the core and mantle that brought new iron-loving elements to our planet."

NAME: Richard Walker

RANK: Professor

DEPARTMENT: Geology

HIGH-PROFILE CASE: Detected evidence of late accretion gold heist

Narrowing the Suspects

According to Walker, scientists believe this added material came to the Earth as so called "late additions." One possibility is that new material (equivalent to about the mass of the moon) was heisted by the Earth's gravity soon after the core formed, providing us with gold and other highly prized elements. This "quick grab" version suggests that the late accretion occurred at a relatively heavy rate for tens of millions of years after the segregation of the core and mantle.

Another possibility is that the late accretion was more like a carefully planned embezzlement, a gradual accreting of clumps of matter for several 100 million years after formation of the proto-Earth. Under this scenario, the shower of material that occurred after segregation of core and mantle was relatively light at first, got heavier starting some 4 billion years ago and eventually tapered off to the "misting" of material that continues to fall onto our planet even today.

To better understand the kind of stuff that might have been added to Earth during its late accretion period and where this stuff might have come from, Walker and his students analyze and compare the relative abundances of these highly siderophile elements in meteorites, lunar materials and the Earth's mantle. They also determine the ages of these materials through measurements of radioactive elements they contain. They haven't found a "smoking gun," but their findings are helping to narrow the possibilities. By studying lunar samples obtained during the Apollo missions, Walker's team has determined that the abundances of these elements in the lunar mantle are much lower than in the Earth's mantle. This may mean that the addition of materials to the Earth occurred mostly after the lunar crust formed between about 4.5 and 4.3 billion years ago.

"Since we know the age of the oldest crustal rock on earth is about 3.9 billion years, this suggests that the late accretion period happened well after formation of the moon," says Walker. "This may ultimately eliminate the front-loaded [quick heist] accretion model. If proven correct, the back-loaded model may indicate something major happened in our solar system very late in its evolution that sent large quantities of mass into the inner solar system. Some researchers have previously suggested that the shifting of the orbits of Uranus and Neptune could cause such a 'rain' of materials into the inner solar system."

CASE 2: The Continents' "Missing" Material

Geologist Roberta Rudnick is fascinated by all things continental. Her husband, geologist William McDonough, is a core kind of guy. But, though their research may focus on different layers, this dynamic duo is not about to let a little thing like 1,800 miles of mantle come between them. That's especially true when it comes to using the university's plasma mass spectrometry lab, which McDonough directs, to try and finger some of the Earth's real movers and shakers: the geological processes responsible for our planet's differentiation and ongoing evolution.

Rudnick, a leading expert on the Earth's continents who just authored a chapter on their composition for a major geochemistry reference book, is pursuing processes she believes may explain the unusual composition of the Earth's continental crust.

The Earth's crust is of two different types, continental and oceanic. The continental crust is thicker and much older than oceanic crust. Continental crust also has a composition that is significantly less dense than that of either oceanic crust or the mantle, which underlies and is the "parent" layer for both types of crust. One effect of the low density of continental crust is that continental masses, or plates, "float" atop the mantle. Scientists call the movement and interaction of crustal plates, plate tectonics. Earth's continental crust is unique in our solar system because no other planet has such thick, low-density crust or shows evidence of the action of plate tectonics.

The earliest known remnants of the Earth's continental crust are about 4 billion years old. However, exactly when and how the continents formed, or how the mass of the continents might have changed over Earth's history is uncertain.

In trying to understand continental formation, scientists start with the formation of oceanic crust, a process that is understood reasonably well. Oceanic crust is basaltic, a type of rock rich in magnesium and iron, and depleted in silica. Lava, or magma, formed by melting of the Earth's mantle is also basaltic. It's fairly clear that basaltic oceanic crust forms from the rising and cooling of such basaltic lava.

However, the continents are composed of a wide variety of rock types that have an average composition equivalent to a type of rock that scientists call andesite. Andesitic rock is lighter, or less dense, than basaltic rock because it contains much more silica and much less iron. Andesitic rock cannot be generated by melting Earth's mantle.

"Exactly how the formation of the continents occurred remains one of the great unsettled questions in geology," says Rudnick, who together with McDonough left Harvard to come to Maryland two years ago. "Magmatism [movement of molten rock or lava from deep in the mantle up to the surface of the Earth] clearly is the primary source of material for the continents. However, magmas generated in the Earth's mantle are basaltic in composition, and do not match the continents' composition. Therefore other processes, probably some form of recycling of material back into the mantle, must also play a role."

To try and identify the "culprit" processes responsible for continental crust, Rudnick is studying the geochemistry of major and trace elements such as those found in rocks from the deepest portions of the upper mantle and lower crust. Analyzed in the plasma lab, these samples are taken from rocks carried up from deep in the Earth by fast-erupting lava.

Rudnick and her colleagues measure bulk composition and trace elements in these samples looking for evidence of processes by which minerals from basaltic crust material were recycled down into the mantle, leaving behind lighter andesitic rock.

One example of such a process is that iron and magnesium rich compounds may have crystallized out of lava as it cooled deep in the crust, with the heavier crystals sinking into the underlying mantle, leaving behind the lighter andesidic rock on top.

In another process, non-basaltic lava, more enriched in silica and depleted in iron and magnesium, may have been produced by the melting of massive slabs of young oceanic type crust that had been thrust deep into the Earth at subduction zones. Subduction occurs when one crustal plate collides with another and is pushed under the second plate.

"Slab melting generally doesn't occur today, but it may have been an important process earlier in Earth's history, when mantle temperatures were significantly higher due to heat generated by radioactive elements that have since decayed away," Rudnick says.

Finally, weathering may have played a role by stripping out water-soluble elements like calcium and sodium and carrying them into the oceans where they accumulated in sedimentary rocks. These non-basaltic rocks were later moved back to the continents by tectonic activity. At the same time magnesium remained in altered oceanic crust and ultimately recycled into the mantle during subduction.

"No matter which hypothesis proves to be the most accurate, it is clear that our planet's distinctive continental crust owes its existence to the unique process of plate tectonics that operates on Earth," Rudnick says.

NAME: James Farquhar

RANK: Assistant Professor

DEPARTMENT: Geology

HIGH-PROFILE CASE: Found chemical "fingerprint" of ancient atmosphere in diamond stash

NAME: Alan Jay Kaufman

RANK: Associate Professor

DEPARTMENT: Geology

HIGH-PROFILE CASE: Dug up evidence of infamous "Snowball Earth"

CASE 3: Dead "Bodies," Buried Diamonds and Sky-High Questions

Geo sleuths James Farquhar and Jay Kaufman are finding answers to mysteries about the formation and evolution of Earth's atmosphere and oceans in some surprising places, including the fossilized remains of ancient organisms and diamonds from Africa.

Farquhar, who holds a joint appointment in the University of Maryland's Earth Systems Science Interdisciplinary Center and the Department of Geology, has gained renown in recent years for his part in work showing that a record of the chemistry of Earth's early atmosphere is recorded by sulfur trapped in rocks. This work has given scientists new insights into the evolution of oxygen, ozone and ultraviolet light in the early atmosphere—changes that coincided with the early evolution and expansion of terrestrial life.

Farquhar, added sparkle to his reputation last year when he led a team of scientists who discovered new sulfur "signatures" in diamonds from a region in Botswana, Africa.

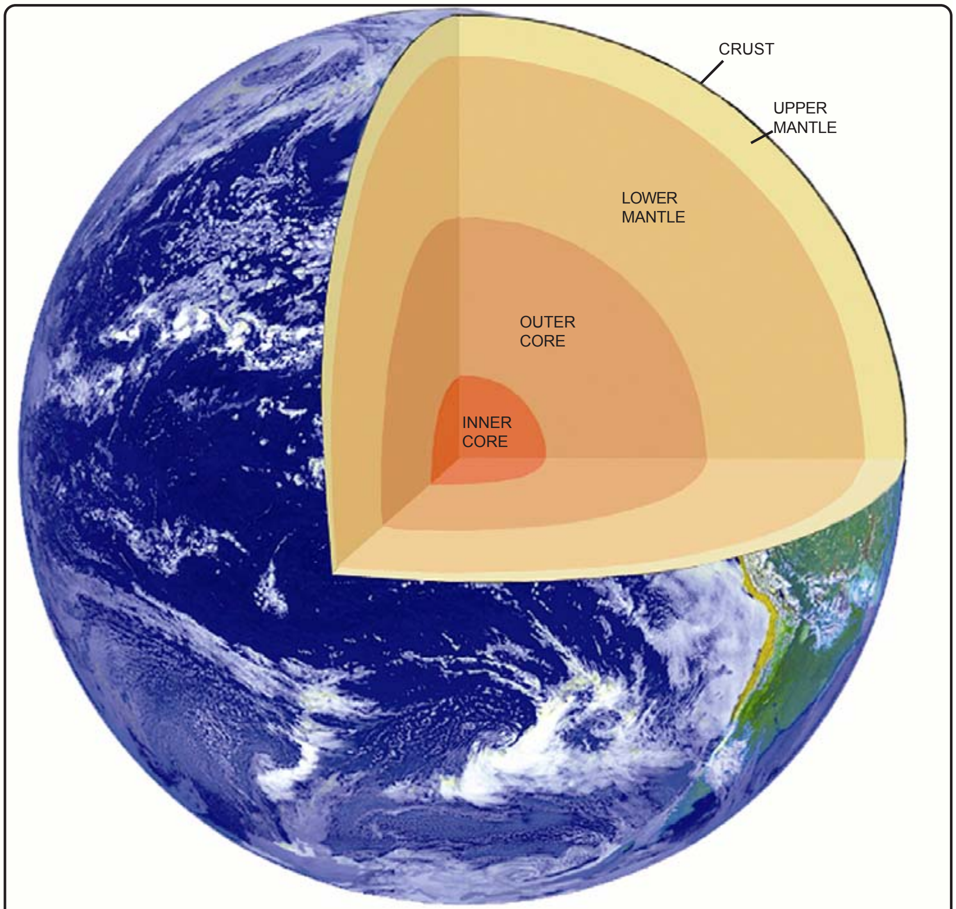
Prior to these discoveries of isotopic signatures in ancient rocks and diamonds, ice cores were scientists' only window on the Earth's atmospheric past, and the "view" only went back about 200,000 years. Through the work of Farquhar and his colleagues, scientists now have a new way to look back billions of years into our planet's past and study not only Earth's early atmosphere, but also the cycling of elements between the crust, atmosphere, and mantle, the origin of early sulfur-metabolizing life, Earth's earliest ice ages, the chemical layering of early oceans, and early plate tectonic-like processes.

Jay Kaufman is widely known for his contributions to research indicating that, between 750 million and 570 million years ago, Earth underwent periods during which the oceans were completely covered with ice causing biological activity in them to collapse. These "snowball earth" periods were ended, Kaufman says, by a warming of the Earth resulting from a build-up in the atmosphere of greenhouse gases, particularly carbon dioxide.

Kaufman's latest research casts additional light on the Earth's atmosphere during the Proterozoic period, which began 2.4 billion years ago and ended 545 million years ago. It was during the Proterozoic period that scientists think many of the most exciting events in the evolutionary history of the Earth occurred, including the appearance of abundant living organisms (probably mostly bacteria and other early single- and multi-celled organisms) and significant oxygen in the atmosphere.

One of the ocean-dwelling organisms producing oxygen during the later part of this period was Dictyosphaera delicata, a single-celled plant not much bigger than the dot in this "i." Kaufman recently conducted analyses of the different forms or isotopes of carbon present in the microfossils of this early relative of modern algae. His findings provide the best evidence to date of the antiquity of the Calvin cycle, the photosynthetic cycle by which plants convert light energy and carbon dioxide, CO_2, into cellular tissue. The relative amounts or ratios of carbon isotopes found in this tiny plant also indicate that CO_2 was an important greenhouse gas and likely dominated over methane, CH_4, after the atmosphere and oceans became pervasively oxygenated, which occurred about 2.0–2.2 billion years ago.

"The sun was not as luminous then so it did not provide as much light and heat as it does now," says Kaufman. "Our new findings confirm models of how much greenhouse gas was required to keep Earth's temperature warm enough so that the oceans didn't freeze during this time."



From the surface to the center, a distance of almost 4,000 miles, the Earth gets progressively hotter and denser. The Earth's three primary layers are the crust (15–50 miles), mantle (1,800 miles) and core (2,175 miles). The crust and mantle are composed of silicate rock. The core is 85 percent iron, 5 percent nickel and 10 percent minor components. It has a liquid outer layer, while the inner core is entirely solid. Earth's magnetic field is believed to be generated by the motions of convection in the liquid outer core.

CASE WRAP-UP

But no matter how many clues Maryland geodectives uncover, nor how well these facts link together to provide apparent answers to age old questions, scientists in the university's geochemistry suite will continue to look for new bits of evidence buried in rocks, soil and meteorites. For in science, very few cases are ever truly closed.

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