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Indiana University College of Arts and Sciences-Graduate School

# HOOSIER GEOLOGIC RECORD

Alumni Newsletter of the Department of Geological Sciences

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August 1992

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## GREETINGS FROM THE CHAIRMAN'S OFFICE

Much has happened in the Department since I first wrote you as Chairman in the last Newsletter. Approval of a new introductory course in earthquakes and volcanoes, planning for a large enrollment, 100-level Earth Systems course and changes designed to provide more flexibility in course selection leading to the B.S. degree highlighted undergraduate activities. Good news affecting both our teaching and research came from the National Science Foundation in the form of a \$305,000 grant to partially support the purchase of a new electron microprobe and from the University administration in the form of a commitment of over \$700,000 for renovation of our geochemistry laboratories and the petrology classroom. Our faculty has grown in number and in luster with the addition of Simon Brassell in the area of biogeochemistry; we are also seeing remarkable growth in the number of undergraduate students expressing interest in careers in the geological sciences. At the Geologic Field Station, an exciting and innovative new program, the Alumni College, was introduced.

In this Newsletter you will learn more about these and other achievements. We are proud of the progress that they represent and we hope that the achievements will intensify good feelings and loyalty toward us among our most important constituency -- our alumni. Without your generous support, the optimistic and enthusiastic vision we have for the Department cannot become reality.

I hope that you enjoy this year's new and expanded version of the Newsletter.

*BEST WISHES FOR A SUCCESSFUL YEAR*

Lee J. Suttner

## DEPARTMENTAL NEWS

This summer, a new Cameca SX50 electron probe microanalyzer will be installed in the Department. This will be a major improvement in our analytical abilities since it replaces our 20-year old microprobe with a state-of-the-art, fully-automated system. The proposals to the National Science Foundation for \$305,000 and to the College and other University sources for matching funds have been funded due to the efforts of numerous persons, especially **Bob Wintsch** who was the principal architect of the NSF

proposal and **Abhijit Basu**, the chief associate. Other faculty and research staff closely involved with this project were **James Brophy**, **Michael Dorais**, and **Edward Ripley**.

In August 1991, **Simon Brassell** left Stanford University to join us as Professor of Biogeochemistry. He further strengthens our international stature in biogeochemistry through his status as one of the world's most prominent researchers in this field. Related to this is an approximately \$750,000 renovation of the analytical and biogeochemical laboratories and the petrology teaching laboratories scheduled to begin soon. Simon's laboratory will occupy the present site of the Department's analytical chemistry laboratories on the third floor. The analytical laboratory will be moved to the fourth floor and displace the petrology laboratory to a new site on the third floor. Also associated with this is the renovation of faculty office space on the third floor.

September 26-28, 1991, "A Dinosaur Gathering" organized by **Gary Lane**, was convened on the Bloomington campus. Sigma Xi co-sponsored the event. Three leading dinosaur experts were featured: **Jack Horner** of the Museum of the Rockies and Montana State University; **James Farlow**, Professor of Geology at Indiana-Purdue University at Ft. Wayne; and **James Weishampel**, Professor of Anatomy at the Johns Hopkins University School of Medicine. The three gave the annual Sigma Xi research lecture, met with graduate students, and also gave special lectures for teachers and students from the Monroe County Community School Corporation. News in paleontology this year includes the addition to **Mike Savarese's** laboratory of both a flume for hydrodynamic studies of fossil organisms as well as new image analysis hardware and software. These additions will substantially strengthen our research in frontier areas of paleontology. Also, they have the potential to be a major benefit to other areas of research and teaching in the Department.

Major pieces of equipment donated to the Department in 1991 include: (1) laser microprobe (\$70,000) and (2) X-ray diffraction unit (\$35,000). Over \$420,000 has been committed by funding agencies and the University to purchase a variety of instrumentation for the biogeochemical laboratories by 1993. As a further indication of our growing national stature in research, the National Science Foundation reported that of the total of \$8 million dollars in NSF research grants in geology and paleontology awarded to some 56 universities during the 1991 fiscal year, Indiana University-Bloomington was the

only institution that received as many as four grants. They went to Professors **John Hayes**, **Enrique Merino**, **Vishnu Ranganathan**, and **Lee Suttner**.

The Geophysics Computer Laboratory continues to grow rapidly. A third Sun Workstation was recently added to the facility, this time a high-powered Sparc 2 Workstation with powerful color graphics capabilities. In addition to the three workstations, the laboratory now boasts three tape drives, a compact disk reader, three graphics plotters, a digitizing tablet, and approximately three gigabytes of disk space. The Department's Siesmograph Station has been selected as the future site of a new National Seismic Network Station, currently under development by the U.S. Geological Survey. The station will become a state-of-the-art, digital, broadband seismic station, whose sensors will be located in a 100 m deep borehole located adjacent to the Geology Building.

In May 1991, a group of fifteen students and ten faculty participated in a six-day field trip on sequence stratigraphy of the Book Cliff area of Utah and Colorado led by geologists from Exxon Production Research Corporation. The trip followed a semester-long seminar taught by our faculty and concluded with a one-day course taught by Exxon. Both the seminar and short course focused on application of sequence stratigraphy concepts to subsurface exploration. This was the first time that Exxon has taught this course to any group outside their corporation. The seminar and field trip were made possible by a grant of \$6,000 from British Petroleum, Inc., and a \$2,500 grant from the University. Exxon probably contributed more than \$15,000 in terms of employee time, publications, lodging and other expenses, to conduct the program for the Department.

Another short course, entitled "Quantitative Sedimentary Basin Modeling," was given February 3-6, 1992, in the Department by Professor **Paul Heller** of the University of Wyoming. This was essentially the same course which has been presented for members of AAPG and GSA. The course is designed to introduce the concepts and techniques of quantitative modeling of basin subsidence histories and to describe the methods and results of modeling the development of basin filling sequences generated by the interaction of subsidence, sediment supply, and sea-level changes. Graduate students and faculty alike profited from Dr. Heller's course and the related colloquium, seminar and meetings.

The 1992 Richard Owen Award presented to a graduate of the Department who has distinguished himself

or herself in either industry/government or academia is being awarded to **Larry Woodfork** (B.S., '64; M.A., '65). Larry is the State Geologist and Director of the West Virginia Geological and Economic Survey. After receiving his master's degree from I.U., he worked for Humble Oil and Refinery Co. (now Exxon), and in 1968 joined the West Virginia Geological and Economic Survey as a geologist in the Oil and Gas Section. In 1969 he was promoted to Assistant State Geologist, and in 1989 became the Director and State Geologist. He has been very active in AAPG, AIPG, and AGI. In 1979 he was the first recipient of the American Institute of Professional Geologists Martin C. VanCouvering Award for outstanding contributions to the Institute, and in 1983 was National President of AIPG. In 1987 he received the Distinguished Service Award from AAPG, and in 1990 was made an Honorary Member of AAPG.

Undergraduate majors in the department now number 51 and this should increase based upon the larger enrollment this year in sophomore petrology (32 versus 17 in 1991). The B.S. curriculum has been modified somewhat to provide flexibility of degree requirements and scheduling, while retaining a strong core of fundamental geology courses and additional allied science and mathematics at the advanced level. The significant changes are that the minimum number of senior-level geology courses (including the 7-credit summer field course, G429) are reduced from four to three, and the options among allied sciences and mathematics at the junior-senior level are less specific. The reduction in required geology courses will, in most cases, be made up by students taking 400-level courses as electives, and/or as undergraduate research credit. We are pleased to have seen an increase in the latter option in recent years. Rather than specifying that two of the advanced allied sciences/mathematics courses must be from chemistry and mathematics, they can be chosen in any combination from biology, chemistry, mathematics, and physics. This will permit students to combine disciplines (e.g., geochemistry, geobiology) or cross-over more easily into Geological Sciences from other majors later in their undergraduate careers.

A second important curriculum initiative surrounds 100-level course offerings. A long-range plan has been developed for courses to deal with upcoming faculty retirements and the opportunity for the geological sciences to fill the very real need to educate the general population (i.e., non-majors) about geologic processes and scientific thought and problem-solving. A new course, G141, Earthquakes and Volcanoes, was approved by the College

earlier in the year and more recently, a 100-level course in environmental geology was approved at the departmental level. Major progress has been made in plans to phase in a new undergraduate "flagship course" for non-majors which is expected to replace G103 (Earth Science: Materials and Processes). G104 (Earth Science: Evolution of the Earth) will continue to be offered. The new course will combine aspects of historical and physical geology and will have a new perspective of the earth as an integrated system. The goal is to teach what students need to know if they never take another geology course. However, the course will be designed so that students could move easily into other appropriate introductory courses in geology.

The Undergraduate Minority Achiever's Program enters its third year with continued growth. A second scholarship student has enrolled as a freshman to join the first recipient who is now a senior. Funding for a third scholarship is now in hand. The two students are doing very well academically and in one case we have had strong positive feedback concerning the student's performance during a summer internship sponsored by MIT.

On-campus graduate student enrollment is currently 69 with 42 students working on Ph.D. degrees and 27 on M.S. degrees. Twenty-one are research assistants and twenty are associate instructors. Domestic and international applications for entrance for graduate study beginning in August 1992, were increased approximately 80% and 60%, respectively, over 1991. Nine energy companies interviewed in the Department in the fall of 1991 and seven in 1992 (BP Exploration, Chevron Exploration and Production Services, Chevron U.S.A., Exxon, Exxon Production Research, Mobil Oil Company Research, and Shell Oil Company) as well as a major environmental firm. Efforts are under way to arrange for other environmental companies to interview in the near future and, thus, more formalize our placement efforts for students in related specialties.

The Geology library continues to grow in size and reputation and has now passed 93,000 volumes, 290,000 maps, and 23,000 microfilms. CD-ROM continues to be a growing format in the earth sciences. The library currently has three CD-ROM stations, and 27 data files on 44 disks. GEOREF receives the greatest use. The ability to set up a separate workstation allows students and faculty to search GEOREF for as long as they need. Improvements continue to be made in the automated IU library catalog. It is possible to display current issues of journals received as well as the call number and holdings of the bound volumes. In addition, the user can immediately see the status of any

title (reserves, charged out, lost) or journal runs which have been shelved in the storage area.

## GEOLOGIC FIELD STATION

The summer of 1991 was the forty-third at the Geologic Field Station in the Tobacco Root Mountains of Montana. Although Options I and II of G429 had the lowest enrollments in many years (37 and 28, respectively), the introductory courses, G111-G112 had their largest enrollment in nearly a decade at 23. We will have a lower enrollment in G111-G112 during this summer (1992), but G429 will be dramatically greater than last summer. Total enrollments in Options I and II will top 100 students again with final totals being 55 and 47 students, respectively. In 1993, we expect a further increase based upon increased enrollments at the junior level both at I.U. and elsewhere.

In 1991, we presented another offering of G690, our graduate-level team field research seminar, this time titled "Structural and Stratigraphic Controls on Locations of the Southwest Montana Transverse Zone". The seminar was led by Professor **Bill Thomas** of the University of Kentucky and Professor **Bob Dodd** of I.U. The five students and two faculty expect to present their results at a professional meeting soon and ultimately plan to publish a paper in an appropriate journal.

The first offering of our Alumni College was held at the Field Station in 1991. Two one-week sessions with a total enrollment of 16 persons were held during the last two weeks of August. Everyone involved was enthusiastic about the experience and two sessions will again be offered August 22-28, and August 29-September 4, 1992. Professors **Gary Lane** of I.U. and **Tom Straw** (B.S., '58; M.A., '60; Ph.D., '68) of Western Michigan University did a superb job in presenting participants with a stimulating week of field trips to experience the geology, botany, zoology, and mining history of the Field Station area. Evening study of astronomy with the unsurpassed Montana night sky also was included as were some outstanding excursions, including an overnight hike and a fishing expedition to Lost Cabin Lake in the northern Tobacco Root Mountains. The Alumni College and the experiences of the participants were featured in an article by **Susan Green** and **Joan Zirker** in the Spring 1992 issue of The College published by the Alumni Association. Noteworthy was the cover on this issue, a color photograph of the Station, upper South Boulder Valley, and Cataract Mountain.





*Charles Vitaliano and Ralph E. Esarey*

The final major event at the Field Station during 1991 was a two-week structural mapping workshop led by **Lee Suttner** for a small group of Amoco photo geologists. Participants were given an introduction to some of the structurally complex areas studied by students and faculty in G429. The Amoco group was very enthusiastic about the course and will be sending eight geologists to the Station for another workshop in August 1992.

The endowment established in 1989 to provide support for maintenance of the Field Station has grown to nearly \$10,000. A list of non-I.U. alumni of the Field Station has been completed and a campaign seeking support from this group was mailed recently. **Marcia Engle**, with help from the College Development Office, was instrumental in organizing this effort. She deserves high praise for her work.

## INDIANA GEOLOGICAL SURVEY

Trackways of early Pennsylvanian amphibians were discovered by **Erik Kvale** while conducting field work for a study of tidalites in Martin County, Indiana, in late April. Kvale speculates that the trackways were made by a salamander-like amphibian that ventured onto a tidal flat in search of insects. This is only the third discovery of

ancient footprints in Indiana. It is the largest and best-preserved specimen.

The Environmental Geology Section is working on ground water protection studies in a number of areas. These include Allen, Marion, and Porter Counties and work began last April in the dunes area of northwestern Indiana. In the latter case, the study will examine the effects of drywells on interdunal wetlands, on ground water contamination, and on Lake Michigan. The Section also recently completed a one-year study of hydrostratigraphy at an abandoned coal mine at Cannelburg. The Section is in the fifth year of continuing a study of soil and water as part of the reclamation of the site of the abandoned Friar Tuck surface and underground coal mines in Sullivan County. More effective reclamation techniques have been developed that can be applied to similar abandoned mines elsewhere. A project in conjunction with the Geochemistry Section concerns the ambient chemistry of certain aquifers in northwest Indiana which may contain naturally-occurring contaminants.

The Mineral Resources Section recently completed a study of the geologic and economic potential for shallow underground limestone and dolomite mines in Indiana. The study discusses the potential benefits, especially at existing open-pit quarries in urban areas where expansion of current operations may be hindered by high cost and zoning laws. The Survey's file of coal analysis data has now been transferred into a computer database. The Section also has projects in cooperation with the Ohio, Illinois, and Kentucky Surveys involving construction of regional stratigraphic and structural cross-sections for the Illinois Basin and a study of basement tectonics and the resulting effect on Paleozoic sedimentation.

Survey researchers are currently involved in two projects to determine the danger of seismic activity in southwestern Indiana. One study involves testing the unconsolidated materials in seismically-active areas to determine how they will affect the propagation of shear waves. This will allow the State to develop more accurate seismic-zoning maps. The other project involves the study of a prehistoric earthquake. Extensive field surveys have been made to locate and study clastic-filled dikes in the bottomlands along the Wabash River and its tributaries. The cause for these features appears to be liquefaction of fluvial deposits induced by strong earthquakes. All dikes appear to have resulted from a single ancient earthquake or multiple earthquakes occurring between 2,500 and 7,500 years ago with an epicenter in the general vicinity of Vincennes.

On a personal note, **Nelson R. Shaffer**, Geologist with the Survey, has been awarded a Staff Merit Award. University Vice President and Bloomington Chancellor Kenneth R. R. Gros Louis presented the award to Shaffer and six others at a reception held on November 8, 1991.

## FACULTY NEWS

**Abhijit Basu** convened a theme session on provenance at the 1991 San Diego GSA Meeting, the proceedings of which will be published as a GSA Special Paper. He also taught an honors seminar for non-science majors; their report was published in the *Journal of Geological Education* as a book-review. Dr. **Emanuela Molinaroli** has returned to the University of Venice. She was back for the San Diego GSA Meeting to report on her new work on Saharan dust in Europe.

**James Brophy** spent two months this past winter as a research scientist on the Ocean Drilling Program Leg 142 to the East Pacific Rise. The project involved efforts to drill into youngest oceanic crust near Panama.

**David Dilcher**, formerly of the Departments of Geological Sciences and Biology remains active at I.U. by way of teaching the course "Tropical Biology" in Costa Rica each winter through our Overseas Study Program. He welcomes visitors to his Paleobotany Laboratory, Department of Natural Science, Florida Museum of Natural History, University of Florida, Gainesville, FL 32611-2035. His telephone number is 904-392-6560.

**Robert Dodd** just finished a term as President of the Great Lakes Section, SEPM. He is also President of the Indiana University Chapter of Sigma Xi. He spent a month in fall 1991, while on sabbatical leave, collecting lower Carboniferous limestone samples in Australia. He and **Donald Hattin** will lead a post-meeting field trip at the 1992 Cincinnati GSA Meeting to look at exposure features and sedimentary cycles in the St. Louis and Ste. Genevieve Limestones.

**Michael Hamburger** made a return visit to WFIU Radio's *Friday Edition* interview show last fall. He remains active in the Indiana Earthquake Advisory Panel, and in a particularly enjoyable project, is working with a southern Indiana puppet company to develop a nationally distributed children's video on earthquake hazards. He has been nominated as a director of the Seismological Society of America and chaired a special session on earthquake studies in the former USSR at the American Geophysical Union's

annual meeting at San Francisco in December 1991. Research Associate **Haydar Al-Shukri** continues his research to develop and analyze data from seismic monitoring networks in the former Soviet Union with Professors Hamburger and Pavlis. He is supported by a large, multi-year grant from the Incorporated Research Institutions for Seismology (IRIS). **Hanan Al-Khataib** is now a part-time research associate with the geophysics group and has begun a project to analyze surface-wave dispersion and attenuation, using data from digital seismic stations recently established throughout the former USSR.

**Donald Hattin** is co-leader with **Robert Dodd** of a 1992 GSA post-meeting field trip described above. Also, a fossil, "Mytiloides Hattini", an index for the base of the Turonian Stage (Cretaceous) in the western interior of North America, has been named in his honor.

**Brian Keith** is currently past-President of the Eastern Section of the American Association of Petroleum Geologists and a member of the National Advisory Council of that organization.

**Noel Krothe** presented a series of invited lectures in the People's Republic of China during Spring 1992. Topics included the use of stable isotopes as tracers for groundwater flow in karst terrains and the High Plains Regional Aquifer, as well as recent research in agricultural waste transport in macropores. Trips to Rome to finish on-going research in karst thermal springs of Southern Italy are scheduled for late summer. Cooperative research projects involving China and Italy are in the planning stage. The hydrogeology laboratory now has a Dionex conductivity detector for major and minor anion analysis and a spectrofluorometer for organic dye analysis.

**N. Gary Lane** spent five weeks in China in July and August 1991, supported by a grant from the National Geographic Society doing field work in Xinjiang and Guangxi Provinces. He was in remote areas west of Mongolia where his group, including **Johnny Waters** (M.A., '76; Ph.D., '78) and **Chris Maples** (M.S., '85; Ph.D., '85) found one of the world's largest faunas of late Devonian crinoids and blastoids. The third edition of Dr. Lane's non-major textbook, *Life of the Past*, was issued by Macmillan Publishing Co. last year. He also taught a new course for the Honors Division on the natural history of southern Indiana and also helped teach a summer workshop on earth sciences for 32 elementary school teachers in Monroe County. This was funded as part of an NSF sponsored program through the Science Education Department of the I.U. School of Education.

**Haydn Murray** was appointed editor of the international symposium on the quantification of crystalline silica in industrial minerals to be held by the Chemical Manufacturers Association in August 1992. Three international post-doctoral visitors are currently working with Dr. Murray. Dr. **Eva Kocsardy**, from Hungary, presented a paper on kaolinite crystallinity determined by infra-red spectroscopy at the 1991 Clay Minerals Meeting. At the same meeting, Dr. **Silvana Bertolino**, from Argentina, presented a paper on exceptionally well-crystallized and pure illite from a hydrothermal deposit in Argentina. This year, Dr. **Peter Braendlein**, from Germany, is working on the genesis of the kaolins found near Redwood Falls, Minnesota. Dr. Murray's clay group now is using a fully automated and computerized Norelco X-ray diffraction unit donated by Texaco along with a new laser microprobe mass spectrometer installed in 1991 for the determination of oxygen, hydrogen, and sulfur isotopic abundances.

**Lisa Pratt** will co-teach with **John Comer** of the Indiana Geological Survey an SEPM continuing education, one-day course entitled "Organic Geochemistry of Sediments and Sedimentary Rocks". This will be a pre-meeting course on October 25 at the 1992 GSA and associated meetings in Cincinnati, Ohio.

**Edward Ripley** has had a visiting senior researcher in his laboratory this past year, Dr. **Jae-III Chung** from Chonbuk National University, South Korea. His research involves stable isotopic analyses of samples from lead-zinc-silver deposits of Korea.

**Robert Shaver** (Emeritus) wrote, printed privately, and distributed copies of an autobiographical novel entitled To Beyond the North Sea and Back (104 p., 26 illus.). He did it mainly for family members, but also for some friends, old Army acquaintances, and a few pertinent libraries, including the Eighth Air Force Memorial Room in the Norwich, England, Public Library. He also wrote, illustrated, printed and distributed still another book of sorts that chronicles one of the most exciting and eye-opening adventures of his life. During last summer he and his wife, Sue, took a vacation cruise, "The Passage of Peter the Great", by river boat from Moscow to Leningrad (now St. Petersburg). They were between Moscow and Leningrad when the erstwhile ill-fated Communist coup occurred and had reached Leningrad before the climax of the following "revolution". Indeed, they saw the climax in Palace Square where 200,000 Russians amassed and said "No" to the coup

leaders and their followers. The Shavers' tour bus was stopped nearby to allow 17 truckloads of soldiers or police pass. Palace Square was the very place where the first shot was fired in 1917 at the beginning of the Bolshevik Revolution, and the Shavers were seeing its end 74 years later. Bob believes as well that they saw the end of 1,000 years of enslavement of the Russian people by one government or another. Having felt they witnessed one of history's great moments, and because Bob considers himself a "ham" as well, he was inspired to produce that "book of sorts", We Cruised the Passage of Peter the Great, or How We Abetted the Russians Who Punched on the Dirty Commie Coup (about 50 p. and 125 illus.).

**Lee Suttner** and **James Meyers** (M.A., '69; Ph.D., '71) were co-conveners along with **Douglas Burbank** (U. Southern California) and **Cai Puigdefabregas** (Servei Geologic de Catalunya, Barcelona) of a Geological Society of America Penrose Conference entitled "Development and Evolution of Foreland Basins" held at Can Boix, Spain, on the south flank of the Pyrenees in October 1991. Some 78 scientists, including 18 present or recent doctoral students, attended the conference. Other Department and Indiana Geological Survey participants included **Gordon Fraser**, **Lloyd Furer**, and doctoral student **Michael May** (B.S., '82). Department alumni participating included **Peter DeCelles** (M.A., '84; Ph.D., '84), **Stephan Graham** (A.B., '72), and **Robert Schwartz** (M.A., '68; Ph.D., '72), professors at the University of Rochester, Stanford University, and Allegheny College, respectively. Following the conference, nearly half of the participants went on a six-day field trip that traversed the Treppe-Graus and Ainsa basins and provided a further sampling of the broad range of depositional environments and deformational styles that characterize the southern Pyrenean foreland basin.

**David Towell** has just completed a five-year period as Director of Graduate Studies for the Department. He also is completing the first year of a new two-year elected term on the Bloomington Faculty Council. Towell serves on the Council's Student Affairs Committee and also on the Bloomington Campus Calendar Committee. In the fall of 1991, he co-chaired a subcommittee of the University Radiation Safety Committee which reviewed the radiation safety program at Indiana University. The Committee prepared a report mandated by the Nuclear Regulatory Commission.



**Charles Vitaliano** (Emeritus) is still working with archaeologists. He published a paper recently as senior author with **S. Ross Taylor** (Ph.D., '54) and others on ash layers of the Thera Volcanic Series, its stratigraphy, petrology, and geochemistry. On a personal note he and **Dorothy** are the proud grandparents of a second grandson, **Matthew A. Vitaliano**, born October 20, 1991.

**Robert Wintsch** is spending considerable time with graduate students doing field work in southern New England, Pennsylvania, and Virginia. He is conducting isotopic dating, geothermal, and geobarometric studies at the U.S.G.S. in Reston, Virginia. He also will be attending the International Geological Congress in Japan in August.

## GRADUATE FACULTY AND RESEARCH

### Faculty and Research Staff

Members are listed below together with their research interests, titles and affiliations, and educational histories. Research programs within the department are summarized in detail on the following pages.

#### **Abhijit Basu**

Petrology, Lunar Geology  
Professor, Geological Sciences; B.Sc. Presidency College (India); M.Sc. Calcutta; Ph.D. Indiana, 1975.

#### **Ned K. Bleuer**

Quaternary Geology & Geomorphology  
Associate Scientist, Indiana Geological Survey and Assistant Professor, Part-time, Geological Sciences; B.S. Wisconsin, M.S. Illinois; Ph.D. Wisconsin, 1971.

#### **Simon C. Brassell**

Biological, Organic & Petroleum Geochemistry; Basin Analysis  
Professor, Geological Sciences and Professor, Part-time, Environmental Sciences; B.Sc., Ph.D. Bristol (England), 1980.

#### **James G. Brophy**

Igneous Petrology & High-Temperature Geochemistry, Tectonophysics of Magma  
Associate Professor, Geological Sciences; B.A. Amherst; M.Sc. Colorado School of Mines; Ph.D. Johns Hopkins, 1985.

#### **Donald D. Carr**

Industrial Minerals, Coal Geology  
Senior Scientist, Indiana Geological Survey and Professor, Part-time, Geological Sciences; B.S. Kansas State; M.S., Ph.D. Indiana, 1969.

#### **J. Robert Dodd**

Paleoecology, Carbonate Sedimentology and Petrology  
Professor, Geological Sciences; B.A. Indiana; M.A., Ph.D. Caltech, 1961.

#### **Michael J. Dorais**

Igneous Petrology & High-Temperature Geochemistry  
Assistant Scientist, Geological Sciences; B.S. Brigham Young; M.S. Oregon; Ph.D. Georgia, 1987.

#### **Bruce J. Douglas**

Tectonics & Structural Geology  
Assistant Scientist, Geological Sciences; A.B. Colgate; M.A., Ph.D. Princeton, 1983.

#### **John Droste**

Stratigraphy, Subsurface Geology  
Professor, Geological Sciences; B.S., M.S., Ph.D. Illinois, 1956.

#### **Jeremy Dunning**

Structural Geology, Tectonics  
Associate Professor, Geological Sciences and Associate Professor, Part-time, Environmental Sciences; B.A. Colgate; M.S. Rutgers; Ph.D. North Carolina, 1978.

#### **Gordon S. Fraser**

Quaternary Geology & Geomorphology; Sedimentology & Stratigraphy  
Senior Scientist, Indiana Geological Survey and Associate Professor, Part-time, Geological Sciences; B.S., M.S., Ph.D. Illinois, 1974.

#### **Lloyd C. Furer**

Basin Analysis  
Associate Scientist, Indiana Geological Survey; B.S. Ohio University; M.A. Wyoming; Ph.D. Wisconsin, 1966.

#### **Hendrik M. Haitjema**

Hydrogeology & Groundwater Modelling  
Associate Professor, Environmental Sciences and Associate Professor, Part-time, Geological Sciences; Ir. Delft University of Technology (Netherlands); Ph.D. Minnesota, 1982.

#### **Michael W. Hamburger**

Geophysics & Tectonics, Basin Analysis  
Associate Professor, Geological Sciences; B.A. Wesleyan; M.Sc., Ph.D. Cornell, 1986.

- Donald E. Hattin**  
Stratigraphy, Sedimentology, Paleoecology, & Paleontology  
Professor, Geological Sciences; B.S. Massachusetts; M.S., Ph.D. Kansas, 1954.
- John M. Hayes**  
Biological, Organic & Petroleum Geochemistry  
Distinguished Professor, Geological Sciences, Chemistry, and Professor, Part-time, Environmental Sciences; B.S. Iowa State; Ph.D. M.I.T., 1966.
- Norman Hester**  
Depositional Environments, Stratigraphy, Coal & Petroleum Geology  
Director, Indiana Geological Survey and Professor, Geological Sciences; B.S., M.S., Ph.D. Cincinnati, 1968.
- Alan S. Horowitz**  
Geobiology & Paleontology  
Senior Scientist and Professor, Part-time, Geological Sciences; B.A. Washington & Lee; M.S. Ohio State; Ph.D. Indiana, 1957.
- John P. Jasper**  
Chemical Oceanography, Biogeochemistry, Organic Geochemistry  
Research Associate, Geological Sciences and Chemistry; A.B. Chicago; Ph.D. M.I.T. (Woods Hole), 1988.
- Brian D. Keith**  
Basin Analysis, Sedimentology & Stratigraphy, Petroleum Geology  
Associate Scientist, Indiana Geological Survey and Associate Professor, Part-time, Geological Sciences; B.A. Amherst; M.S. Syracuse; Ph.D. Rensselaer Polytechnic Institute, 1974.
- Noel C. Krothe**  
Hydrogeology & Aqueous Geochemistry  
Associate Professor, Geological Sciences; B.S. Bloomsburg State; M.A.T. Indiana; M.S., Ph.D. Penn State, 1976.
- N. Gary Lane**  
Geobiology & Paleontology  
Professor, Geological Sciences; B.A. Oberlin; M.S., Ph.D. Kansas, 1958.
- Enrique Merino**  
Geochemistry and Petrology  
Associate Professor, Geological Sciences; Ing. School of Mining Engineering (Spain); Ph.D. California/Berkeley, 1973.
- Haydn H. Murray**  
Economic Geology, Clays & Industrial Minerals  
Professor, Geological Sciences; B.S., M.S., Ph.D. Illinois, 1951.
- Greg A. Olyphant**  
Hydrogeology, Quaternary Geology & Geomorphology  
Associate Professor, Geological Sciences and Geography; B.A. Cal State; M.A., Ph.D. Iowa, 1979.
- Lawrence J. Onesti**  
Quaternary Geology & Geomorphology  
Associate Professor, Geological Sciences; B.S. Northwestern; M.A. Michigan State; Ph.D. Wisconsin, 1973.
- Peter J. Ortoleva**  
Geochemistry, Kinetics & Transport Mechanisms, Basin Analysis  
Professor, Chemistry and Professor, Part-time, Geological Sciences; B.S. Rensselaer Polytechnic Institute; Ph.D. Cornell, 1970.
- Gary L. Pavlis**  
Geophysics & Tectonics  
Associate Professor, Geological Sciences; B.S. South Dakota State; Ph.D. Washington, 1982.
- Lisa M. Pratt**  
Sedimentary & Organic Geochemistry, Basin Analysis  
Associate Professor, Geological Sciences; B.A., M.S. North Carolina; M.S. Illinois; Ph.D. Princeton, 1981.
- Vishnu Ranganathan**  
Hydrogeology & Aqueous Geochemistry, Basin Analysis  
Assistant Professor, Geological Sciences; B.S. Bombay; M.S. Cincinnati; Ph.D. Louisiana State, 1988.
- Carl Rexroad**  
Geobiology & Paleontology  
Senior Scientist, Indiana Geological Survey and Professor, Part-time, Geological Sciences; B.A. Missouri, M.S., Ph.D. Iowa, 1955.
- Edward M. Ripley**  
Petrology of Metallic Ore Deposits, Isotopic Geochemistry  
Professor, Geological Sciences; B.S. Illinois State, M.S. Minnesota; Ph.D. Penn State, 1976.
- Albert J. Rudman**  
Geophysics  
Professor, Geological Sciences; B.S., M.A., Ph.D. Indiana, 1963.
- Michael Savarese**  
Geobiology & Paleontology  
Assistant Professor, Geological Sciences; B.S., M.S. Rochester; Ph.D. California/Davis, 1989.

**Lee J. Suttner**

Sedimentary Petrology, Basin Analysis, Sedimentology  
Professor and Chairman, Geological Sciences; B.S.  
Notre Dame; M.S., Ph.D. Wisconsin, 1966.

**David G. Towell**

Trace-Element & Isotope Geochemistry  
Associate Professor, Geological Sciences; B.S. Penn  
State; Ph.D. M.I.T., 1963.

**Jeffrey R. White**

Aqueous Geochemistry, Biogeochemistry, Limnology  
Associate Professor, Environmental Sciences and  
Professor, Part-time, Geological Sciences; B.A.  
Gettysburg; M.S. Rutgers; Ph.D. Syracuse, 1984.

**Robert P. Wintsch**

Metamorphic Petrology, Tectonics & Structural Geology,  
Sedimentary Petrology  
Associate Professor, Geological Sciences; B.A. Beloit;  
Ph.D. Brown, 1975.

**QUATERNARY GEOLOGY  
AND GEOMORPHOLOGY**

Research in Quaternary Geology and Geomorphology by I.U. faculty and research associates in the Indiana Geological Survey includes studies of contemporary erosional and depositional processes as well as local and regional studies of depositional environments and glacial land-systems. We place a special emphasis on environmental geology with current projects directed toward effects of tectonism on fluvial systems, development of hydrogeologic facies models for glaciated areas, erosion and sedimentation in areas affected by surface mining, and susceptibility of unconsolidated deposits to earthquake hazard. Our research projects are supported by grants from the USGS, NOAA, NASA, OSM, NSF, EPA as well as state and local agencies.

**Ned K. Bleuer** - Glacial geology, stratigraphy, with special interest on morphology and sequences of glacial and Quaternary deposits in Indiana. Air-photo and satellite imagery applied to glacial land-system definition, down-hole logging techniques with application to glacial vertical sequence definition, application of vertical sequences to environmental concerns, soil and fluvial stratigraphies as applied to earthquake liquefaction features, southern Indiana.

**Gordon S. Fraser** - Geomorphology and environmental geology with emphasis on application of facies of Quaternary depositional sequences to

environmental problems. Recent research focuses various aspects of proglacial sedimentation, fluvial and coastal sedimentary processes, glacial depositional processes in stagnating ice sheets, sedimentological effects of catastrophic flow in river valleys, and Holocene paleoclimatology in the Great Lakes region. Future research includes study of the impact of neotectonism on fluvial systems.

**Noel Krothe** - Noel Krothe is a hydrogeologist-/geomorphologist. His research projects all utilize major and minor ion chemistry, physical flow, and stable isotope geochemistry centering in three main areas.

*Carbonate Systems.* Research projects concerning the dissolution rates of carbonate rocks and the development of epikarst are ongoing. Additionally, his research group is actively engaged in addressing physical flow, epikarst storage and macropore flow in karst terraces.

*Arctic Hydrology.* Research concerning the formation of icings, groundwater flow, ground/sulfur water chemistry, and stream discharge has been completed in the Brooks Range of Alaska. Future studies are planned to determine dissolution rates in arctic carbonate areas.

*Abandoned Coal Areas.* Research concerning groundwater conditions in coal terrain and at abandoned mine sites has been ongoing since 1978 with research grants from Argonne National Laboratories, United States Geological Survey and the Office of Surface Mining. Additional support has been provided by the Division of Reclamation and the Indiana Department of Natural Resources through grants from the Office of Surface Mining. Abandoned coal spoils have been studied to determine the effects of acid waters and the rate of oxidation of pyritic materials in coal refuse. Groundwater arriving naturally in undisturbed bedrock has been characterized chemically to determine if the water is being impacted by shallower surface mining activities.

**Greg A. Olyphant** - Geomorphology, environmental geology with emphasis on monitoring and computer modeling of surficial processes. Current geomorphologic research focuses on aspects of rainfall-runoff, erosion and sediment yield at abandoned strip mining sites in southwestern Indiana, and mechanics of eolian sand transport and the role of eolian processes on the sediment budget of southern Lake Michigan. Other research interests include geomorphic response to Holocene climatic changes in alpine areas and temporal and spatial dynamics of fluvial systems.

**Lawrence J. Onesti** - Geomorphology, environmental geology with special interest in arctic-alpine regions, fluvial systems, snow and ice hydrology, natural hazards and neotectonics. Recent research has focused on release mechanisms, debris entrainment processes, depositional environment and impact pressure of slush avalanches in the central Brooks Range, Alaska, Rana District north Norway, and Khibins Mountains Kola Peninsula (USSR). Also included are alluvial river response and Pleistocene depositional terrace systems response to neotectonic activity in southern Indiana, paleohydrology using channel geometry characteristics of dry bed channels in Karst regions, river channel migration history and changes in channel geometry characteristics as indicators of climatic change.

#### **Representative Publications**

Bleuer, N. K., (1991) The Lafayette Bedrock Valley System of Indiana; Concept, Form and Fill Stratigraphy. *Geology and Hydrogeology of the Teays-Mahomet Bedrock Valley System: Geological Society of America Special Paper 258*, Melhorn, W. N. and J. P. Kempton, eds. Pp. 51-77.

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Fraser, G. S. and N. K. Bleuer, (1988) Sedimentological consequences of two floods of extreme magnitude in the late Wisconsinian Wabash Valley. *Sedimentological consequences of extreme events: Geological Society of America Special Paper 229*, Clifton, H.E., ed. Pp. 111-125.

Fraser, G. S., (in press) Sedimentology and history of alluviation of the Late Wisconsinian Wabash River: Indiana Geological Survey Special Report.

Fraser, G. S., C. E. Larsen and N. C. Hester, (1990) Climatically Controlled High Lake Levels in the Lake Michigan and Lake Huron Basins. *Quaternary Geology of the Lake Michigan Basin: Geological Society of America Special Paper 251*, Schneider, A. E. and G. S. Fraser, eds. Pp. 75-89.

Giles, B.E., J.E. Cocroft and N.C. Krothe, (1984) Hydrochemical Study of Mined and Unmined Areas in the Carbondale Group (Pennsylvania), S.W. Indiana *Proceedings of the Fifth Annual Water Resources*

*Symposium, Bloomington, IN*, J.D. Martin (editor).

Krothe, N. C. (1981) Water chemistry in a permafrost environment, Alaska. pp. 570-590 in *The Northern Community - A Search for Quality Environment* (Proc. ASCE Ann. Mtg., Seattle, WA).

Morris, S. E. and G. A. Olyphant, (1990) Alpine Lithofacies Variation: Working Toward a Physically Based Model. *Geomorphology 3*: pp. 73-90.

Obermeier, S. F., N. K. Bleuer and others, (1991) Evidence of Strong Earthquake Shaking in the Lower Wabash Valley from Prehistoric Liquefaction Features. *Science*. V. **251**: pp. 1061-1063.

Olyphant, G. A., C. P. Carlson and D. Harper, (1991) Seasonal and Storm-related Aspects of Sediment Yield from a Rapidly Eroding Coal Refuse Deposit in Southwestern Indiana. *Water Resources Research*. 27(11): pp. 2825-2833.

Onesti, L. J., (1983) Hydrologic Characteristics of Six Small Arctic-Alpine Watersheds, Central Brooks Range, Alaska. *Proceedings IV<sup>th</sup> International Conference on Permafrost, Fairbanks, Alaska*. Pp. 957-961.

Onesti, L. J., (1984) Meteorological Conditions that Initiate Slushflows in the Central Brooks Range, Alaska. *Annals of the International Glaciological Society, Sapporo, Japan*. Vol. **6**: pp. 23-25.

Onesti, L. J., (1986) Slushflow Release Mechanism: A First Approximation. *Proceedings International Symposium on Avalanche Formation, Movement and Effect: Proceedings International Association of Scientific Hydrology, Swiss Institute for Snow and Avalanche Research, IAHS Publication, Davos, Switzerland*. No. 162: pp. 331-336.

Onesti, L., (1989) Suspended Sediment Load Variation of Arctic-Alpine Watersheds in Alaska. *Symposium on Headwater Hydrology, American Water Resources Association, Missoula, Montana*.

Onesti, L. J. and T. K. Miller, (1987) Interregional Comparison of Alluvial Stream Channel Morphology: Great Plains vs. Central Lowlands. *Water Resources Bulletins, American Water Resources Association*. Vol. **24**, No. 6: pp. 1207-1217.

## **HYDROGEOLOGY AND AQUEOUS GEOCHEMISTRY**

Research in hydrogeology and aqueous geochemistry at Indiana University deals with:

1) Large-scale groundwater flow, the estimation of fluid and solute fluxes and transport properties of rocks (Ranganathan and Haitjema), the use of groundwater

models in designing pumping schemes to withdraw contaminants from the subsurface (Haitjema).

2) Aqueous chemistry and biogeochemistry of lakes and lake sediments (White), the geochemistry of groundwaters, the use of dyes as tracers for subsurface flow in karst terrains, and the movement of agricultural contaminants in groundwaters (Krothe).

3) Acid mine drainage, erosion and sediment transport near abandoned coal mines and the movement of water in the unsaturated zone (Olyphant).

Professors White and Krothe have laboratories for water analyses which contain a wide suite of instruments for aqueous analytical chemistry including an ion chromatograph and spectrophotometers. Quantitative hydrogeologic research at IU benefits from a two well-networked array of powerful workstations with sophisticated 3-D computer graphics for scientific visualization of data and for mathematical modeling, operated by Professors Ranganathan and Haitjema.

**Hendrik Haitjema** - Our research group focuses on the development and application of groundwater flow models, which use a rather new modeling technique: the analytic element method.

*Conjunctive Surface/Groundwater Modeling.* Regional groundwater movement is composed of infiltrating rainwater which eventually finds its way to surface waters. Traditionally, when modeling groundwater, surface water bodies (streams, lakes, etc.) are merely seen as "boundary conditions" on the groundwater elevation. We are now predicting the groundwater inflow rates into the streams, in order to compare it to observed "base flows" in the streams. By integrating this stream flow analysis in our models we are developing a more coupled surface water-groundwater modeling technique.

*Three-Dimensional Flow Modeling.* Most saturated flow models, particularly when applied on a regional scale, deal with horizontal flow only. When modeling groundwater flow on a local scale, however, a complete three-dimensional solution may be needed. We are developing three-dimensional solutions with several features. For example, we are including partially penetrating wells in a horizontal flow model. The resulting model is very efficient, modeling three-dimensional flow locally (near the well), while treating the regional flow as horizontal.

*Groundwater Response to Global Climate Change.* We are currently studying the range of effects climate change may have on regional groundwater flow. The project, funded by the U. S. Department of Energy's National Institute for Global Environmental Change

(NIGEC), is designed to provide information about the sensitivity of the groundwater resource to geographically large-scale changes in recharge. The anticipated changes in recharge and our modeling experiments are on an unprecedented scale, including the entire northern half of the state of Indiana, as well as parts of Illinois, Michigan and Ohio. Our objectives include an assessment of groundwater levels, and of groundwater availability both regionally and locally.

**Noel Krothe** - is a hydrogeologist/hydrogeochemist specializing in ground and surface water flow and chemistry. His research projects all utilize major and minor ion chemistry, physical flow, and stable isotope geochemistry to determine groundwater movement and genesis. Personal and student research centers in three main areas.

*Pollution Problems.* The fate and transport of both inorganic and organic pollutants are being investigated in varied geologic terranes. Specific problems dealing with transport of nitrogen, polychlorobiphenyls, and acid water are currently under investigation.

*Carbonate Hydrogeology.* One of the areas most problematic to the hydrogeologist is flow and water chemistry in fractured and solution controlled terranes. Normal groundwater modeling such as finite element and finite difference is difficult to use since most significant flow does not obey Darcy's Law. Field investigation utilizing organic and inorganic tracers are the preferred research approach in such terranes. His research group is actively engaged in addressing physical flow, epikarst storage and macropore flow in karst terranes. Additional, similar studies are also being conducted in other fractured rock and unconsolidated deposits.

*Mineral Spring Genesis.* The genesis of mineral springs occurring in Southern Indiana is part of ongoing research. Stable isotopes, tritium, and water chemistry of these springs are being studied to determine their origin. Recent research indicated two possible mechanisms: evaporite dissolution or mixing of fresh water and brines.

**Greg Olyphant** - My recent research concerns hydrologic conditions at abandoned coal mining sites in southwestern Indiana. The research consists of monitoring and computer modelling of rainfall-runoff relationships, unsaturated groundwater flow, and acid drainage in strip mined areas with the goal of evaluating the feasibility of direct revegetation as a method of reclamation.

I recently completed a study of hydrologic conditions in an area experiencing mine subsidence. The study



focused on the hydrologic response of abandoned, flooded, underground mines to natural and man induced stresses, and provided inference for the existence of pathways of rapid subsurface water movement into the abandoned mine works.

I have had a long term interest in watershed hydrology, especially the role of snowmelt in the generation of runoff from mountainous areas. Recent publications on this topic have emphasized the effects of radiation and turbulent heat fluxes in the generation of snowmelt-runoff from late-lying snowfields in the Colorado Rockies.

**Vishnu Ranganathan's** - recent research has centered on the dynamics of fluid-, mass-, and heat transport in sedimentary basins over time scales of 10,000 yrs to 100 Ma and distance scales of kilometers to hundreds of kilometers. The deep interstitial waters of many intracratonic and passive margin basins are often much more saline than seawater, although deep interstitial waters in intermontane basins are often fairly fresh because of groundwater recharge. Ranganathan has just begun a project in which he is using a computer model to estimate the rates at which interstitial brines in intracratonic sedimentary basins such as the Illinois Basin are flushed out by recharging groundwaters. The study may help constrain field scale permeabilities of rocks in such basins. A second project he is working on entails mapping salinity plumes and thermal plumes of groundwaters around salt domes in the Gulf of Mexico Basin using geophysical well logs and using computer models of groundwater flow, coupled with heat and mass transport, to simulate the behaviour of brine plumes under a variety of subsurface P-T-X conditions and permeability distributions. This research has been funded by grants from the National Science Foundation, the American Chemical Society, and by private industry.

**Jeffrey R. White** - We are interested in processes controlling the cycling of elements in aquatic and terrestrial systems and in the potential impact of human activity on element cycles. We study cycling of elements at sediment/water interfaces in fresh water systems and within soils of agricultural systems. We also contribute to interdisciplinary research on changes in the biology and chemistry of lake/watershed systems.

Increased deposition of atmospheric sulfate is affecting the cycling of sulfur, iron, manganese, and carbon in lake ecosystems of northeastern North America. We have been investigating these effects by measuring chemical changes over short distances (1 cm) at the sediment/water interface of acidic lakes in the Adirondack Mountain region of New York State. Evidence of changes in element cycling is drawn from chemical diffusion gradients, chemical mass balances, sediment geochemistry, and stable isotopic

analyses. We have accumulated evidence of profound changes in the importance of sulfate reduction - and, thus, the cycling of carbon - in remote lakes, and have found that the cycling of trace metals has also been altered.

Additionally, we have begun work on methane cycling in wetlands. Freshwater wetland environments are particularly conducive to methanogenesis because they are often rich in organic matter and depleted in O<sub>2</sub> and sulfate. On a molar basis, each increment of CH<sub>4</sub> emitted to the atmosphere is 25-fold more efficient at energy retention than are corresponding additions of CO<sub>2</sub>. With atmospheric methane concentrations increasing at a rate of 1% per year, the role of methane as a greenhouse gas is of major concern. To improve understanding of natural sources of atmospheric methane, we are currently investigating a number of wetland types. The role of local climate (temperature, insolation, and water level) in controlling methane budgets is being studied using chemical mass balances, stable isotopic analyses, isolation of specific bacterial populations, and continuous records of climatic variables. We aim to develop mechanistic models that will describe methane cycling in detail and which will allow prediction of responses of natural rates of methane production to climatic change.

Other areas of research include: the development of stable isotopes of nitrogen as a "fingerprinting" tool to identify the sources of ammonia and nitrate in surface water; improvement of sampling and analysis techniques for trace metals in gravel sediments; and development of new isolation techniques for microbial communities inhabiting wetland sediments.

#### **Representative Publications**

Charles, D., J. White, D. and 11 others (1990) Paleocological Investigation of Recent Lake Acidification in the Adirondack Mountains, N.Y., *Journal of Paleolimnology*, **3**, 195-241.

Gubala, C. P., D. R. Engstrom, and J. R. White, (1990) Effects of Iron Cycling on 210Pb Dating of Sediments in an Adirondack Lake, U.S.A. *Can. J. Fish. Aquat. Sci.*, **47**, 1821- 1829.

Gutentag, E. D., J. J. Heines, N. C. Krothe, R. R. Lucky and J. B. Weeks, (1984) Geohydrology of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas and Wyoming, *U.S. Geological Survey Professional Paper 1400-B*, 63p.

Haitmeja, H. M., (1991) An analytic element model for transient axi-symmetric interface flow, *Journal of Hydrology*, **129**, 215-245.

Haitjema, H. M., A. M. Ebrahim, and S. Mitchell-Bruker (1989) Very large scale regional aquifer modeling including local detail, presented at the International Conference on Solving Groundwater Problems with Models, Indianapolis, Indiana.

Haitjema, H. M. and S. R. Kraemer, (1988) A new analytic function for modeling partially penetrating wells, *Water Resources Research*, **24**, 683-690.

Kraemer, S. R. and H. M. Haitjema, (1989) A modeling approach to regional fracture flow systems, International Conference on Solving Groundwater Problems with Models, Indianapolis, IN.

Krothe, N. C., (1988) Hydrologic Connection Between Spring Water and the Evaporite of the Lower St. Louis Limestone, Karst Mitchell Plain of Southern Indiana, *Karst Hydrogeology and Karst Environment Protection, Proceedings of the International Association of Hydrogeologists, Guilin, China, October 1988*, Volume XXI, Part 1.

Olyphant, G. A., E. R. Bayless and D. Harper, (1991) Seasonal and weather-related controls on solute concentrations and acid drainage from a pyritic coal-refuse deposit in southwestern Indiana, U.S.A. *Journal of Contaminant Hydrology*, **7**, 219-236.

Olyphant, G. A. and S. I. Isard, (1988) The role of advection in the energy balance of late-lying snowfields: Niwot Ridge, Front Range, Colorado. *Water Resources Research*, **24**(11), 1962-1968.

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Ranganathan, V., and J. S. Hanor, (1988) Density-driven groundwater flow near salt domes. *Chem. Geol.*, **74**, 173-188.

Wells, E. R. and N. C. Krothe, (1989) Seasonal Fluctuation in  $\delta^{15}\text{N}$  of Groundwater Nitrate in a Mantled Karst Aquifer due to Transport of Fertilizer-Derived Nitrate, *J. Hydrogeol.*, **112**, 191-201.

White, J. R., C. P. Gubala, B. Fry, J. Owen and M. J. Mitchell, (1989) Sediment biogeochemistry of iron and sulfur in an acidic lake, *Geochimica et Cosmochimica Acta*, **53**, 2547-2559.

White, J. R., and C. T. Driscoll, (1987) Zinc Cycling in an Acidic Adirondack Lake, *Env. Sci. Technol.*, **21**, 211-216.

White, J. R., and C. T. Driscoll, (1987) Manganese Cycling in an Acidic Adirondack Lake, *Biogeochemistry*, **3**, 87-103.

## BIOGEOCHEMISTRY AND ORGANIC GEOCHEMISTRY

A growing community of students, faculty, post-doctoral fellows, and research staff (a total of 29 people during 1991) is working on the analysis and interpretation of molecular and isotopic records of ancient environments and biogeochemical processes. Both details of specific environments and global phenomena are being explored. In order to develop an improved understanding of biogeochemical processes, considerable attention is being devoted to the study of modern environments. The work of biogeochemists is relevant to the search for fossil-fuel resources and to the monitoring of environmental changes. Projects within the laboratories are focused both on petroleum geochemistry and on the study of ancient greenhouse phenomena.

Simon Brassell's - research is focussed on molecular organic geochemistry; the occurrence and formation of petroleum source rocks and petroleum; and molecular records for environmental, climatic, and stratigraphic assessment.

The record of climatic variability in marine sediments from the Santa Barbara Basin, offshore southern California, is being documented using molecular stratigraphic techniques. The relative abundances of unsaturated alkenones synthesized by phytoplankton provide an annually resolved record of oceanic temperatures during the present century. Positive excursions in the "alkenone temperature" profiles coincide with each major 20th-century El Niño event and are in close agreement with measured water temperatures. Similarly, the abundances of dinosterol, which is a molecular marker for dinoflagellate contributions to sediments, correlate well with reports of dinoflagellate blooms. This clear correspondence between observed biological responses to changes in environmental conditions and their molecular profiles preserved as a stratigraphic record (Kennedy and Brassell, in press) provides a basis for much further exploration of the molecular record of earth history. For example, another on-going project seeks to combine molecular, paleontological and isotopic measures of climatic variability in studies of glacial sedimentary sequences from the Japan Sea.

A study of petroleum and source rocks from Brazilian marginal basins has shown that organic-molecular signals can reflect the migration history as well as the source and maturity of oils (Trindade *et al.*, in press). The molecular characteristics of a series of petroleum accumulated in reservoirs extending from offshore to onshore areas show that the more migrated oils contain greater contributions from freshwater sources, whereas the less migrated oils suggest more pronounced contributions from the younger, hypersaline beds. Also, molecular maturity parameters indicate that the more migrated oils are of comparatively low maturity, consistent with their early generation from the older lacustrine freshwater source beds and their migration to fill the shallower, more distant reservoirs.

Other current research projects include investigations of petroleum, petroleum source rocks (see Basin Analysis Section) and examination of sequences that can assist in assessment of the causes and characteristics of mid-Cretaceous stratigraphic events associated with the major episodes of deposition of organic-rich sedimentary sequences (Farrimond *et al.*, 1990).

**John M. Hayes** - and his students and postdoctoral associates study the cycling of carbon in ancient and modern environments; the isotopic biogeochemistry of carbon, hydrogen, and nitrogen; and techniques of isotopic analysis.

Techniques of compound-specific isotopic analysis are being applied to the study of biogeochemical processes in ancient depositional environments. In the first case in which  $^{13}\text{C}$  abundances were determined for numerous individual hydrocarbons (Freeman *et al.*, 1990), it was shown that isotopic compositions of individual compounds in lacustrine sediments varied widely and reflected derivation of some substances from  $\text{CH}_4$ -consuming bacteria. Other aspects of the flow of carbon in the ancient ecosystem were also clarified and the potential of this line of inquiry was demonstrated dramatically. A much more detailed, stratigraphic study of units within the Green River Oil Shale is just being completed. Because the abundance of sulfur varied cyclically in the Green River lakes, it has been possible to study effects of varying mechanisms of anaerobic diagenesis and to show that the isotopic record reflects these changes. Future studies will focus on late Proterozoic and early Cambrian marine sediments.

As work on compound-specific isotopic investigations of ancient systems has proceeded, an information gap has become clearly evident. Although isotopic compositions of numerous individual compounds are becoming known for *paleoecosystems*, there have been no parallel examinations of modern systems. Because interpretations of compound-specific isotopic compositions

cannot be refined until such information is available, a major field program has now been undertaken in collaboration with oceanographic experts (S. G. Wakeham and colleagues, Skidaway Institute of Oceanography). Isotopic compositions of lipids from particulate organic carbon recovered from a range of depths in the water column of the Santa Monica Basin, offshore southern California, are being determined in the course of an annual cycle of cruises. Results are developing nicely and reveal that much of the isotopically significant reworking of primary products is taking place within the marine water column rather than in sediments.

**John P. Jasper** - and coworkers employ molecular and isotopic geochemistry to reconstruct levels of marine dissolved  $\text{CO}_2$  and atmospheric  $\text{CO}_2$  partial pressure.

Cooperative research projects with John Hayes in "CO<sub>2</sub> paleobarometry" have developed from earlier work of Popp *et al.* (1989) which summarized evidence that the abundance of  $^{13}\text{C}$  in marine organic matter should vary with the dissolved  $\text{CO}_2$  concentration in photic-zone water. In a study of organic materials from the Gulf of Mexico, Jasper and Hayes (1990) showed that, for the past 100,000 years, variations in the abundance of  $^{13}\text{C}$  in compounds derived from coccolithophorid algae (alkenones) are well correlated with changes in atmospheric  $\text{pCO}_2$  independently known from analyses of the Vostok ice core. More recently, based on relationships between  $\text{CO}_2$  levels and isotopic compositions of gross photosynthate, Freeman and Hayes (in press) have developed new estimates of variations in paleoatmospheric  $\text{CO}_2$  levels during the past 160 million years.

Current research includes  $\text{CO}_2$  reconstructions in the late Quaternary on the timescales of glacial-interglacial climatic variations and of the Industrial Revolution. The goals of these investigations are to reconstruct high resolution ~250,000-year records of dissolved  $\text{CO}_2$  and equilibrium  $\text{pCO}_2$  levels in oceanic surface waters that were expected to have (1) remained near air-sea equilibrium, and (2) been removed from air-sea equilibrium by the balance of processes affecting dissolved  $\text{CO}_2$ . A sediment core from the central equatorial Pacific provided an opportunity to investigate a "non-equilibrium" environment. Isotopic analyses of a time-series record of alkenones indicate that the climatically-varying balance of physical and biological processes attenuates the subsurface eutrophic layer's  $\text{CO}_2$  levels relative to paleoatmospheric levels (Jasper *et al.*, 1992). In an analogous study on a core from the Feni Drift in the northeast Atlantic, oceanic and atmospheric  $\text{CO}_2$  levels will be reconstructed in a high

latitude, near-equilibrium environment. Secondary projects include examination of ~200 year records of the effects of dissolved CO<sub>2</sub> on organic biomarker biosynthesis in marginal sea environments (the Black Sea and the Gulf of California) and a preliminary map of glacial-to-interglacial pCO<sub>2</sub> variations in the equatorial Pacific (Jasper *et al.*, 1991). The examination of relatively short records of <sup>13</sup>C abundance and CO<sub>2</sub> levels give further insight into the processes recorded in more ancient records. Understanding the environmental and biosynthetic factors bearing upon the carbon isotopic composition of organic compounds will continue to be an area of inquiry.

**Lisa M. Pratt** - and her students study the geology and organic geochemistry of fine-grained sediments, with particular emphasis on paleoceanographic processes in sedimentary basins and the isotopic records of carbon and sulfur.

Recent studies have focussed on the biogeochemistry and sedimentology of the middle Precambrian Nonesuch Formation, North American Midcontinent Rift (Hieshima and Pratt, 1991; Pratt *et al.*, 1991). This research has shown that this unit, often described as being of lacustrine origin, almost certainly was deposited in a marine environment. Organic matter from primitive eukaryotic algae are clearly recognizable in the suite of biomarker compounds. Concentrations of organic carbon are generally much less than 1%; thus, although levels of maturity are moderate, the unit cannot be regarded as an economic petroleum source. The implied nature of the producer community and apparent development of the marine carbon cycle, however, indicate that other Precambrian environments in which depositional conditions favored accumulation of more concentrated organic matter could yield productive source beds.

Large quantities of sedimented organic matter can be lost due to the activities of sulfate-reducing bacteria while traces of bacterial biomass are added to sediments during early diagenesis. Cross plots of concentration of organic carbon vs. pyritic sulfur are widely used to infer the efficiency of sulfate reduction and the position of the O<sub>2</sub>/H<sub>2</sub>S boundary relative to the sediment-water interface. These plots fail, however, to incorporate information on monosulfides, organosulfur compounds, and elemental S which are also reduced relative to seawater sulfate (Zaback and Pratt, 1992). The quantitative importance of these other reduced sulfur species in fine-grained sediments is only now being recognized. Investigations of the sulfur budget for the Miocene Monterey Formation are now being followed up by studies of analogous sediments in the modern Santa Monica Basin, offshore California.

**Jeffrey White** and his coworkers are studying origins and fates of methane in sediments and water columns, the biologically mediated partitioning of trace metals, and human impacts on the biogeochemical cycles of nitrogen and sulfur.

Freshwater wetland environments are particularly conducive to methanogenesis because they are often rich in organic matter and depleted in oxygen and sulfate. Because they appear to play a major role in the growth of methane as an important greenhouse gas, they are being studied intensively. The production and consumption of CH<sub>4</sub> at various depths in wetland environments is being mapped and variations of these processes over time are being followed. Rates of other processes that can affect methanogenesis are also being studied. Evidence is drawn from chemical mass balances, stable isotopic analyses, and microbiological study of specific bacterial populations. The aim is to describe in detail the cycling of methane and to develop mechanistic models that will allow prediction of the effects of climate change on natural rates of methane production.

#### **Representative Publications**

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Freeman, K. H., J. M. Hayes, J.-M. Trendel, and P. Albrecht (1990) Evidence from carbon isotope measurements for diverse origins of sedimentary hydrocarbons. *Nature* **343**, 254-256.

Hayes, J. M., B. N. Popp, R. Takigiku, and M. W. Johnson (1989) An isotopic study of biogeochemical relationships between carbonates and organic carbon in the Greenhorn Formation. *Geochim. Cosmochim. Acta* **53**, 2961-2972.

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Hieshima, G. B. and L. M. Pratt (1991) Sulfur/Carbon ratios and extractable organic matter of the Middle Proterozoic Nonesuch Formation, North American Midcontinent Rift. *Precambrian Research* **54** 65-79.

Jasper, J. P. and J. M. Hayes (1990) A carbon-isotopic record of CO<sub>2</sub> levels during the Late Quaternary. *Nature* **347**, 462-464.

Jasper, J. P., F. G. Prahl, A. C. Mix, and J. M. Hayes, (1992). Photosynthetic <sup>13</sup>C fractionation and estimated CO<sub>2</sub> levels in the Central Equatorial Pacific over the last 255,000 years. *Paleoceanography* (invited manuscript in progress).

Jasper, J. P., J. M. Hayes, F. G. Prahl, A. C. Mix, S. G. Wakeham, J. Crusius and R. F. Anderson, (1991). Isotopically-derived estimates of dissolved CO<sub>2</sub> and equilibrium pCO<sub>2</sub> from late Quaternary sedimentary records in the equatorial Pacific and the Black Sea. *Trans. A.G.U. Eos* **72**, 272.

Kennedy J. A. and S. C. Brassell (accepted) Molecular Records of 20th Century El Nino Events in Laminated Sediments from the Santa Barbara Basin, California. *Nature*.

Popp, B. N., R. Takigiku, J. M. Hayes, J. W. Louda, and E. W. Baker (1989) The post-Paleozoic chronology and mechanism of <sup>13</sup>C depletion in primary marine organic matter. *Amer. J. Sci.* **289**, 436-454.

Pratt, L. M., R. E. Summons, and G. B. Hieshima (1991) Sterane and triterpane biomarkers in the Precambrian Nonesuch Formation, North American Midcontinent Rift. *Geochim. Cosmochim. Acta* **55**, 911-916.

Trindade L. A. F., S. C. Brassell and E. V. Santos Neto (in press) Petroleum migration history in the Potiguar Basin, Brazil, as reflected by mixed oils. *Amer. Assoc. Petrol. Geol. Bull.*

Zaback, D. A. and L. M. Pratt (1992) Isotopic composition and speciation of sulfur in the Miocene Monterey Formation: Reevaluation of sulfur reactions during early diagenesis in marine environments. *Geochim. et Cosmochim. Acta* **56**(2).

## GEOBIOLOGY AND PALEONTOLOGY

**J. Robert Dodd** - Carbonate sedimentology and paleoecology.

For a number of years I have worked with Bob Stanton of Texas A&M University on using fossils and sedimentary rocks to interpret the paleoecology and sedimentologic features of Neogene strata in the Eel River and San Joaquin Basins of California. I am also co-author of a textbook on concepts and applications of paleoecology.

**Donald Hattin** - Paleoecological studies of Upper Cretaceous benthic organisms, especially including oysters, cirripeds, and rudists. Taxonomic studies of Upper

Cretaceous benthic organisms, including oysters, anomiids, and cirripeds.

### Graduate Student Research

Hirt, David, Taxonomy, paleoecology, and evolution of scalpellomorph cirripeds, Upper Cretaceous of Kansas (Ph.D.)

Larabee, John: Stratigraphy and paleoecology of coralline biostromes and patch reefs, Upper Ordovician of southeastern Indiana (M.S.)

Archer, Allen (1983): Analysis of Upper Cretaceous trace-fossil assemblages, U.S. Western Interior (Ph.D.)

Boberg, Wesley (1990): Paleontology, taphonomy, and sedimentology of unusual coquinooidal limestone lenses in the Graneros Shale of western Kansas (M.S.)

**A. S. Horowitz** - My general interests are in Mississippian paleontology and stratigraphy, but I work on the systematics of Paleozoic bryozoans and blastoids. Both fossil groups have a long history of study at Indiana University extending to the beginning of the century and both groups are well represented in the Paleozoic section exposed in Indiana. I am currently investigating the diversity of bryozoans in the fossil record compared with Recent faunas, the taxonomy of some Mississippian bryozoans and blastoids, and the biochronology of conodonts in the Devonian and Mississippian. The bryozoan studies have been a collaborative effort with J. F. Pachut of Indiana University-Purdue University at Indianapolis. J. A. Waters of West Georgia College is collaborating with me on studies of blastoids and I collaborate with C. B. Rexroad of the Indiana Geological Survey on conodont projects.

**N. Gary Lane** - This year my research has focused on two projects. During July and August I did field work in Xinjiang and Guangxi Provinces in China. The field work was supported by the National Geographic Society, and, in addition to Chinese colleagues, Johnny Waters of West Georgia College and Chris Maples of the Kansas Geological Survey, both alumni of this department and both former Ph.D. students of mine, were collaborators. At the Xinjiang sites we found the world's largest known fauna of Late Devonian crinoids and blastoids, including several new genera and species. These show biogeographical relationship with fossils from western Europe, especially Germany and England, and they provide evidence for existence of an extensive east-west seaway across Eurasia, the paleo-Tethys, during



Devonian time. At the Guangxi sites we collected Mid-Carboniferous crinoids and blastoids that include some with Australasian affinities. We now have National Science Foundation support and plan to return to China for additional field work at new localities in the summer of 1993.

I am also working on a very unusual Silurian crinoid fauna from the Mississinewa Shale of northeastern Indiana with Bill Ausich of Ohio State University. While the fauna is not very diverse it is the only inter-reef crinoid fauna known from Indiana. The preservation is remarkable and the taxa are all conspicuously different from reef-dwelling echinoderms that occur nearby. The specimens are very delicate and lightly constructed, with thin plates, long, narrow stems, and slender arms.

**Carl B. Rexroad** - Rexroad's research deals with conodont biostratigraphy and paleontology, including paleoecologic interpretations. Primary interest has been Silurian and Mississippian faunas, but recently emphasis has turned to Pennsylvanian strata. Most of the work has been in the Mid-continent.

**Michael Savarese** - My primary research effort has been directed to the interpretation of the paleobiology of an enigmatic group of fossils, the Archaeocyatha. Archaeocyathans were the principal frame-builders of Early Cambrian reefs. Despite this, many fundamental paleobiological questions have remained unanswered. For example, an algal-*versus*-sponge affinity is still debated. Testing paleobiological hypotheses has required a multi-disciplinary approach. By incorporating evidence from functional morphology, comparison with modern analogs, cladistic studies, and stratigraphic and paleoecological analyses, I have corroborated a hypothesis of sponge affinity and have shown that they were capable of generating flows needed for suspension feeding. Many aspects of archaeocyathan paleobiology remain unexplored that have significance for macroevolutionary questions. A better understanding of the metazoan radiation at the base of the Phanerozoic requires that the temporal and geographic distribution of taxa are well documented. Consequently, I am compiling archaeocyathan diversity data for the Great Basin. The paleoecology of Early Cambrian reefs is still relatively unstudied. The Flinders Ranges of South Australia contain well preserved archaeocyathan bioherms and are ideal for such a study. A project to work on these bioherms has been funded by the Petroleum Research Fund. Reconnaissance field work was conducted in August, 1991, and an expedition is planned for the summer of 1992.

*Biomechanics of Benthic Marine Invertebrates*. A second aspect of my research considers the effects morphology of free-lying benthic organisms has on fluid-induced forces and substrate stability. Marine life in the Paleozoic was dominated by epifaunal, soft substrate animals. Many of these, namely brachiopods and rugose corals, possessed no means of attachment and, therefore, were susceptible to disturbance caused by waves. These flow-induced forces are partly a function of organism size, shape, and orientation. Consequently, morphology and behavior may have an adaptive significance. Finally, these forces may operate during the life of an animal or after its death. Taphonomic and functional hypotheses are being tested experimentally in Geobiology's flume and image analysis laboratory. This facility is designed for the study of boundary layer phenomena and for measurement of forces benthic organisms experience. In addition, field based paleoecologic studies are being conducted to corroborate results from biomechanical experimentation.

*Algal Symbiosis and Reef Ecology*. Research on fossil reefs has piqued my interest in other aspects of reef ecology, and I am undertaking several smaller research projects in this area. Algal symbiosis in animals is important to modern reef development, but its existence is difficult to evaluate in the fossil record since no obvious record is left behind. Testing for algal symbiosis in fossil reef builders can be done using indirect criteria. High calcification rates, tropical paleobiogeographic distributions, and morphologies for maximum light exposure are suggestive of symbiosis. Such a study is presently underway for Lower Cambrian reefs. Under ideal conditions the presence of algal symbiosis is directly expressed as a deviation in the carbon isotopic composition between the host's organic and skeletal tissues and sea water. These materials can then be chemically analyzed to test hypotheses of symbiosis. This effect has been documented for a number of extant symbiont bearers, though at times has yielded ambiguous results. A collaborative study with Dr. Lisa Pratt has begun to explore these in modern scleractinian corals.

#### **Representative Publications**

Dodd, J. R. and R. J. Stanton, (1990) *Paleoecology, Concepts and Applications* (Second Edition): Wiley-Intersciences, New York, 400p.

Droste, J. B., and A. S. Horowitz, (1990) Influences on the position of Chesterian sand belts in Indiana. *Proceedings of the Indiana Academy of Science*, 99, 39-45.

Hasenmueller, W. A., and D. E. Hattin, (1990) New species of the bivalve *Anomia* from Lower and

Middle Turonian parts of the Greenhorn Limestone, central Kansas: *J. Paleontol.*, **64**, 104-110.

Hattin, D. E., (1990) *Puebloites greenhornensis* Cobban & Scott from Turonian part of Greenhorn Limestone, north-central Kansas and northeastern Wyoming: *Cretaceous Research*, **11**, 351-358.

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Horowitz, A. S. (1991) A fossil site near Sulphur, Indiana (Chesterian, Mississippian). In M. E. Kahrs, ed. *Lagerstätten (Extraordinary Preserved Fossil Faunas). MAPS Digest - EXPO XIII Edition*, p. 61-70.

Lane, N. Gary, (1989) Biogeography of Lower Carboniferous crinoids (with G. D. Sevastopulo): *Geol. Soc. London, Symposium volume on Paleozoic Paleogeography and Biogeography*, p. 333-339. Lane, N. Gary, (1989) A census of past and present life: *J. Geol. Ed.*, **38**, 119-122.

Lane, N. Gary, (1990) Ontogenetic adaptations in some Pennsylvanian crinoids (with J. A. Peters): *Jour. Paleont.*, **64**, 427-435.

Lane, N. Gary, (1991) New Late Devonian (Famennian) echinoderms from Xinjiang Province, Peoples Republic of China (abst.) (with J. A. Waters, C. G. Maples, and Hou Hong-Fei): *Geol. Soc. Amer. Ann. Meeting, San Diego, California*, p. A279. Lane, N. Gary, (1991) *Life of the Past*. 3rd Edition. Macmillan Publishing, 334 p.

Pachut, J. F., and A. S. Horowitz, (1987) Multivariate discrimination and classification of some North American Mississippian species of *Fistulipora* McCoy. In J. R. P. Ross, ed. *Bryozoa: Present and Past. Papers presented at the 7th International Conference of Bryozoa. Western Washington University, Bellingham, Washington, August 4-9, 1986*, p. 205-212.

Rexroad, C. B., and A. S. Horowitz, (1990) Conodont paleocology and multielement associations of the Beaver Bend Limestone (Chesterian) in Indiana. *Courier Forschungs Institute Senckenberg*, **118**, 493-537.

Savarese, M. (submitted) A cladistics analysis of archaeocyathan phylogenetic affinities. *Journal of Paleontology*.

Savarese, M. (in press 1992) Functional analysis of archaeocyathan skeletal morphology and its paleobiologic implications. *Paleobiology*.

Savarese, M., (1991) Effects of moving fluid on the paleobiology of Paleozoic bottom-dwelling, marine animals. *Geological Society of America Abstracts with Programs* **23(3)**, 15.

Savarese M. and P. W. Signor, (1989) New occurrences of archaeocyathans in the upper Harkless Formation of Esmeralda County, Nevada, and their paleoecological significance. *Journal of Paleontology*, **63** 539-549.

Savarese, M., L. M. Gray and C. E. Brett, (1986) Faunal and lithological cyclicity in the Centerfield Member (Middle Devonian) of western New York: a reinterpretation of depositional history. *New York State Museum Science Service Bulletin*, **457** 32-56.

## SEDIMENTOLOGY AND STRATIGRAPHY

**J. Robert Dodd** - Carbonate sedimentology and paleoecology.

*Depositional processes, environments, and diagenesis of the St. Genevieve Limestone.* The St. Genevieve contains several intervals of eolian carbonates and several exposure surfaces. We have been investigating the origin of these eolian units, their geographic and stratigraphic distribution, and their relationship to subaerial exposure surfaces. The presence of unconformities within the section allow application of the methods of sequence stratigraphy to study of this unit. I am working on this project with Patty Merkley, a former I.U. student, and Ralph Hunter of the U.S.G.S. Graduate students Charles Zuppann, Clay Harris, and Karl Leonard worked on an early part of this project. Grant support for this project from PRF is in review.

*Depositional processes producing the Salem Limestone and relation of petrographic features of the Salem to sedimentary structures in the unit.* The Salem is well exposed in numerous quarries in the Bloomington area. The recent development of extensive use of a chain saw-like quarrying method has resulted in beautiful exposure of sedimentary structures. These allow a more detailed view of depositional processes than has previously been possible. I am working on this project with Todd Thompson of the Indiana Geological Survey. Mark Brown, a Ph.D. student is also involved in research with the Salem. The work is being supported by the Marathon Oil Company.

*Depositional process producing the ooid shoals of the Ste. Genevieve Limestone.* These shoals are important petroleum reservoirs in the subsurface of the Illinois Basin. Many details of their origin such as the nature of

surface on which they form, rate of deposition, nature of the depositing currents, changes during their history, cause of cessation of growth, remain to be learned. A large shoal is well exposed in two quarries near Orleans Indiana. A research seminar under my direction recently completed a preliminary study of this problem. Graduate students Clay Harris, Karl Leonard, and Charles Zuppann have worked with me on this project. More work needs to be done to follow up the tentative findings of this project.

**Gordon S. Fraser** - Sedimentology with special emphasis on the analysis of the physical processes involved in the formation of depositional sequences. Recent research focuses on glacial depositional processes, fluvial and coastal sedimentary processes, effect of geomorphological processes on deposition of stratigraphic sequences, and effects of topography on sedimentation during transgressions. Future research will include the analysis of tidal sequences to determine the history of lunar orbital mechanics, and analysis of the effects of drainage basin dynamics in uplifted areas on stratigraphy and sedimentation in adjacent depositional basins.

**Donald E. Hattin** - Cretaceous stratigraphy of the Western Interior Basin, with emphasis on depositional environments, cyclicity, basinwide correlation of carbonate-rock intervals, and stratigraphic manifestations of contemporaneous tectonic uplift.

#### **Graduate Student Research**

Holbrook, John, Sequence-stratigraphic analysis of Lower Cretaceous strata, southeastern Colorado and northeastern New Mexico (Ph.D.)

Larabee, John: Stratigraphy and paleoecology of coralline biostromes and patch reefs, Upper Ordovician of southeastern Indiana (M.S.)

Laferriere, Alan (1987): Regional analysis of rhythmic bedding in the Fort Hays Limestone Member, Niobrara Formation (Upper Cretaceous), U.S. Western Interior (Ph.D.)

Boberg, Wesley (1990): Paleontology, taphonomy, and sedimentology of unusual coquinoïdal limestone lenses in the Graneros Shale of western Kansas (M.S.)

**Norman C. Hester** studies Pennsylvanian stratigraphy with an emphasis on the reconstruction of sedimentary environments, the formation and preservation of peats, and the prediction of coal quality and the feasibility of underground mining operations. A particular project underway is the use of seismic stratigraphy to reconstruct the evolution and tectonic history of rifts and grabens,

the Rough Creek Graben of the southern Illinois Basin in particular. In connection with this, broad-scale studies of tectonic controls on sedimentation in the Illinois and Appalachian Basins are on-going.

**Brian Keith** - Research interest in the Upper Ordovician of the midcontinent area continues with detailed sequence stratigraphic work by Ph.D. student John Hohman and post-doctoral work on the evolution of the Sebree Trough in southeastern and central Indiana by Alan Swenson. There are several other areas of detailed study in diagenesis and geochemistry and sequence stratigraphy that are waiting to be done.

#### **Graduate Student Projects**

Past and present graduate research under my direction is related to studies of carbonate rocks in Indiana and usually with some application to petroleum geology:

Stratigraphy, sedimentology, and diagenesis of the Trenton Limestone (Upper Ordovician) in three regionally spaced cores in central and northern Indiana (MS 1986, Daniel R. Fara)

Geology and porosity of a Devonian reservoir in the Wilfred gas storage field Sullivan County, Indiana (MS 1987, Douglas W. Reynolds, Jr.)

Beech Creek Limestone (Upper Mississippian): Basal unit of a shallowing-upward carbonate-siliclastic couplet (Ph.D. in progress, Clayton D. Harris) and

Depositional history of the Upper Ordovician Trenton Limestone, Maquoketa shale and equivalent units in the Illinois Basin: an application of sequence stratigraphy in determining stratigraphic and sedimentological relationships in the rock record.

#### **Representative Publications**

Brown, M. A., and J. R. Dodd, (1990) Waulsortian-like carbonate mud bodies in Middle Mississippian strata of southern Indiana and northern Kentucky: *Palaïos*, 5, 236-243.

Dodd, J. R. (1987) *Valmeyeran (Middle Mississippian) carbonate rocks of southern Indiana: Great Lakes Section, SEPM, Guidebook Series, 127p.*

Dodd, J. R. and R. J. Stanton, Jr., (1991) Cyclic sedimentation in three Neogene basins in California: *Spl. Pub. Int. Assoc. Sedimentol.* 12, p. 201-215.

Fraser, G. S., (1989) *Clastic Depositional Sequences: Processes of Evolution and Principles of Interpretation*: Prentice Hall Publishing Co., Englewood Cliffs, New Jersey, 449p.

Fraser, G. S., *et al.*, (1991) Sediments and sedimentary structures of a non-tidal, barred coast, southern shore of Lake Michigan: *Journal of Coastal Research*, 7, 1113-1124.

Fraser, G. S., (in press) Sedimentation in an interlobate outwash stream: Impact of multiple lateral sediment sources on patterns of alluviation: *Sedimentary Geology*.

Hattin, D. E., (1991) Lithodemes, suites, supersuites, and complexes: intrusive, metamorphic, and genetically mixed assemblages of rocks now embraded by North American Code of stratigraphic nomenclature: *Pre-camb. Res.* 50, 355-357.

Keith, B. D. and C. W. Zuppann, eds., (in prep.), Mississippian Oolites and their modern analogs: AAPG Studies in Geology (book scheduled for publication in late 1992.)

Keith, B. D., ed., (1988) The Trenton Group (Upper Ordovician Series) of eastern North America - deposition, diagenesis, and petroleum: *AAPG Studies in Geology* 29, 317p, *Contains*:

Keith, B. D., Regional facies of the Upper Ordovician series of eastern North America, p. 1-16.

Fara, D. R. and B. D. Keith, Depositional facies and diagenetic history of the Trenton Limestone in northern Indiana, p. 277-298.

Laferriere, A. P., and D. E. Hattin, (1989) Use of rhythmic bedding patterns for locating structural features, Niobrara Formation, United States Western Interior: *Am. Assoc. Petroleum Geologists Bull.*, 73, 630-640.

## SEDIMENTARY PETROLOGY AND LOW-TEMPERATURE GEOCHEMISTRY

Petrology of sedimentary rocks is fundamental to the understanding of the processes that range from tectonism of the earth to the interaction of the atmosphere, hydrosphere, and the biosphere with the solid earth. Low-temperature geochemical processes contribute to the modification of original sediments as well as to their preservation. More than half of the faculty of the Department relate to sedimentary petrology in an interdisciplinary way. Lee J. Suttner, Enrique Merino, and Abhijit Basu are the principal researchers in this cluster; J. Robert Dodd, Haydn Murray, and Robert P. Wintsch also contribute directly to sedimentary petrologic and low-temperature geochemical research. Their research spans the gamut of clastic, authigenic and low-grade metamorphic minerals; conglomerates, claystones, and carbonate rocks; and an understanding of the earth and the moon.

**Abhijit Basu** attempts to better understand the petrological evolution of the crust, especially the surficial material, of the earth and the moon. Properties of such material are functions of provenance, weathering, transport, deposition, and diagenesis. Therefore, understanding the processes that affect any of these variables is a prerequisite. A student may expect to conduct quantitative provenance studies of sands and sandstones of the earth and the regolith of the moon if s/he works with Basu. The ultimate goal is to reconstruct the petrology and tectonics of the part of a planetary crust that has been eroded to give rise to a body of sediment. Principally these studies have centered around the determination of petrologic, structural, and chemical properties of detrital minerals and rock-fragments; and, relating these properties through mass-balance to infer the proportions of source rock contribution to bodies of sands, sandstones, and the lunar regolith through time. A second major area of research is focused on the evolution of the lunar regolith. Processes that are responsible for the production, evolution, and growth of agglutinates are investigated by studying the properties and distribution of agglutinates in lunar soils of various compositions, maturities, and geologic contexts.

Apart from using mineral-chemistry to interpret provenance, Basu is also investigating the effects of early diagenesis in destroying provenance information in sandstones. One current research project is a quantitative comparison of the petrologic, mineralogic, chemical and isotopic properties of early cemented concretions in Eocene volcanoclastic sandstones of Scow Bay, Washington with those of their host sandstones.

Basu is currently collaborating with E. Molinaroli (University of Venice, Italy), R. Cullers (Kansas State University), L. Melim (Southern Methodist University), D. S. McKay (NASA), S. Kairo (graduate student), and C. Bangs Rooney (TEXACO; former graduate student). Basu's research is supported by grants from NASA and NSF.

**Lee J. Suttner** and his students have been long interested in sandstone petrology. The composition of sandstone is a response to a complex interplay of variables related to its derivational, transportational, depositional and diagenetic history. Suttner is currently attempting to isolate and evaluate the role and relative importance of just one of the variables, depositional process, in affecting the framework and authigenic composition of sandstone. To do so, his research group is conducting comparative studies of facies- controlled differences in composition of first-cycle detritus within both river and wave-dominated

coarse-grained deltas of Pennsylvanian age in Colorado. Standard petrographic, chemical and x-ray analysis is supplemented with SEM, electron microprobe, and isotopic study of selected components. This work is significant in that it permits them to (1) characterize the extent of compositional modification due to mechanical disaggregation and hydrodynamic sorting in high relief settings characterized by high rates of sedimentation and rapid burial, and (2) document how sandstone maturation varies as a function of different energy regimes associated with wave and river-dominated shoreline settings.

This work is being jointly conducted with Prodip Dutta at Indiana State University and Suzanne Kairo, a Ph.D. student at I.U. Funding from PRF-ACS has supported this work.

**Enrique Merino's** general field of interest is low-temperature alteration and mechanisms, combining petrological, water-chemical, and theoretical approaches. Current research deals with working out the geochemical factors and mechanisms that produce different crystalline textures, with the igneous origin of agates, with the genesis of many self-organizational textures in igneous, metamorphic, and sedimentary rocks, with the geochemistry of rift-basin clastic sediments in west African and Connecticut, and with the physics and textural attributes of wind-blown sand.

Much of this work (funded by NSF, the Petroleum Research Fund, and CNRS of France) is carried out in collaboration with D. Nahon (Marseille), E. Deloule (Nancy), B. Werner (Scripps, La Jolla), J.-P. Girard (Case Western Reserve), and graduate student Y. Wang.

**J. Robert Dodd** investigates the petrology and the diagenesis of carbonate rocks to understand the processes and environmental conditions leading to their deposition. Specifically, Dodd studies optical, luminescence, and SEM petrographic, and oxygen and carbon isotopic properties of these rocks to attain his goal. A major part of his petrologic research is carried out on the Mississippian rocks of southern Indiana and neighboring States and is supported from industrial grants.

**Haydn Murray's** research interests focus largely on the origin, depositional environments, geochemistry, and applications of the various clay minerals. Sedimentary petrology of various clay and hydrothermal deposits is an integral part of this research. Specifically, determination of crystallinity and oxygen isotopic compositions of kaolinite, smectite and bauxite minerals lead to an understanding of the genetic processes of these deposits to the extent that

predictions for economic use may be made. Researchers from all over the world work in Murray's laboratories which are funded mostly by industrial grants.

**Robert P. Wintsch** is interested in the diagenesis and very low grade metamorphism of siliciclastic and carbonaceous sedimentary rocks. He is investigating the role of the metastable detrital mineralogy in defining the reactions that occur during diagenesis and graphitization, and the effect of these reactions on the chemical composition of the bulk rock. He has worked on very mildly metamorphosed sandstones and mudstones, and his deductions of the bulk rock chemistry have contributed to a revised understanding of diagenetic reactions and pressure solution.

#### **Representative Publications**

Basu, A., (1990) Recycled grains in lunar soils as an additional, necessary, regolith evolution parameter. *Proc. Lunar Sci. Conf. 20th, Lunar and Planetary Institute*, Houston, pp. 231-238.

Basu, A. and E. Molinaroli, (1991) Reliability and application of detrital opaque Fe-Ti oxide minerals in provenance determination. *Spec. Pub., Geol. Soc. Lond.*, No. 57, pp. 55-65.

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Suttner, L. J. and P. K. Dutta, (1986), Alluvial sandstone composition and paleoclimate. Part I - Framework Mineralogy: *J. Sed. Pet.* **56**, 329-345.

Wang, Y. and E. Merino, (1990) Self-organizational origin of agates: Banding, fiber twisting, composition, and dynamic crystallization model. *Geochim. Cosmochim. Acta* **54**, 1627- 1638.

Wang, Y. and E. Merino, (1992) Dynamic model of oscillatory zoning of trace elements in calcite: double layer, inhibition, and self- organization. *Geochim. Cosmochim. Acta* **56**: to appear Feb. 92.

Werner, B. and E. Merino, (1992) Quantitative model for concavity formation in eolian sand grains. Scripps Institution of Oceanography Reference Series no. 92-2, 6 p.

Wintsch, R. P., C. M. Kvale, and H. J. Kisch, (1991) Open system, constant volume development of slaty cleavage, and strain induced replacement reactions in the Martinsburg Formation, Lehigh Gap, PA, *Geological Soc. Am. Bull.*, **103**, 916-927.

## BASIN ANALYSIS

Regional-scale, geodynamic analyses of sedimentary basins at Indiana University are integrative and multidisciplinary. They span a range of topics including documentation and interpretation of (1) stratal patterns of basin-fill, (2) depositional systems and facies, (3) structural architecture and lithosphere deformation, (4) fluid migration and associated burial diagenesis, and (5) hydrocarbon potential. Although the research of nearly all faculty in the Department probably can be linked in some form to the broad topic of basin analysis, faculty listed below are especially active in first-principle studies of basin-wide scope.

**Simon Brassell's** research activities include investigations of the organic geochemical characteristics of organisms and sediments (see Biogeochemistry and Organic Geochemistry section), petroleums and petroleum source rocks and the recognition, development and application of molecular tools in the evaluation of depositional environments, the assessment of thermal history and the processes of petroleum formation and accumulation. The diverse structural architecture of molecular species preserves information of their biological origins and such "chemical fossils" help constrain depositional settings. Also, the systematic and sequential nature of the transformations of individual organic components in sedimentary rocks provides evidence for the thermal evolution of sedimentary basins. Current projects include investigations of migration

processes in Brazilian marginal basins and, in collaboration with Stephan Graham and colleagues at Stanford University, studies of the petroleum geology and geochemistry of various Chinese basins. Funding for this research stems largely from a consortia of industrial sources.

**Lloyd Furer** is involved jointly with Lee Suttner in study of Cretaceous fluvial systems in the Rocky Mountain foreland basin and is primarily responsible for coordinating all subsurface aspects of the study. He has over 25 years of experience in subsurface stratigraphic studies of a variety of continental-margin basins in California and Alaska and interior basins of the western U.S. and Canada during his employment in the petroleum industry. Since joining the Indiana Geological Survey in 1988, he has also developed and continues to refine models linking recurrent movement of high-angle faults in basement rocks both to the location of Silurian reefs and Pennsylvanian coastal-plain rivers located along the margins of the Illinois basin. Funding for this work is provided by industry and government sources.

**Michael Hamburger** is involved in seismotectonic studies of basins in the collisional plate-tectonic settings of Central Asia, the Philippines and the Southwest Pacific. His principal area of study is in the Pamir-Tien Shan region of Soviet Central Asia, where he and his colleagues are involved in integrative geological-geophysical studies of an actively deforming fold-thrust belt. A significant expansion of this project involves application of new satellite geodetic techniques to provide direct measurement of regional deformation patterns resulting from the India-Eurasia collision.

**Brian Keith** is working on a variety of local to regional-scale outcrop and subsurface studies in the Illinois basin. He is primarily interested in long term tectonic controls on Paleozoic carbonate facies and the application of sequence-stratigraphy concepts to interior cratonic basins, particularly oriented toward defining the occurrence of potential petroleum reservoirs within the bodies.

**Vishnu Ranganathan's** research is on dynamics of fluid-, mass-, and heat transport in sedimentary basins over time scales of 10,000 to 100 million years and distance scales of kilometers to hundreds of kilometers. [Refer to Hydrogeology section]

**Lee J. Suttner's** research centers on field-based studies of Cretaceous fluvial systems in the Rocky Mountain foreland basin of Colorado, Wyoming, and

Montana. Traditional models of foreland-basin evolution emphasize the importance of fold/thrust belt tectonics along the basin margin in controlling stratigraphic patterns within the basin. Suttner's work elucidates the role of intra-basin lithosphere deformation, in all probability forced by plate-margin tectonic events, in influencing the location, morphology, and direction of flow of river systems and their associated deposits within the foreland basin. Outcrop studies are supplemented with detailed subsurface analysis made possible with the Department's well-log library. A number of faculty from other institutions are involved in this study including Gary Johnson at Dartmouth University (paleomagnetic and fission-track stratigraphy), Peter DeCelles at the University of Rochester (Jurassic/Cretaceous fluvial-systems analysis in the Wyoming-Idaho thrust belt), James Schmitt at Montana State University (Cretaceous fluvial-systems analysis in outcrop belts along the flanks of the Bighorn Mountains), and James Meyers at Winona State University (Jurassic/Cretaceous non-marine facies analysis in Montana). This work is being supported by grants from NSF.

#### **Representative Publications**

Carroll, A. R., S. A. Graham, and S. C. Brassell (in press 1992) Upper Permian lacustrine oil shales of the Junggar Basin, northwest China. *Amer. Assoc. Petrol. Geol. Bull.*

Furer, Lloyd C., (in review) Basement tectonics in the Illinois Basin and their effect on Paleozoic sedimentation: *Am. Assoc. Pet. Geol. Bull.* 21 p.

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Hamburger, M. W., D. E. Sarewitz, T. L. Pavlis and G. A. Popandopulo. (in press 1992) Structural and seismic evidence for intracontinental subduction in the Peter the First Range, Soviet Central Asia. *Geol. Soc. Amer. Bull.*

Malone, A. and L. J. Suttner, (in press) Evidence against recurrent movement along the Willow Creek fault zone during deposition of the Morrison Formation (Jurassic), Northern Tobacco Root Mountains, Montana: *Rocky Mountain Geologist*.

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Ranganathan, V., (1991) Salt diffusion in interstitial waters and halite removal from sediments -examples from the Red Sea and Illinois Basins, *Geochimica et Cosmochimica Acta*, **55**: 1615-1625.

#### **ECONOMIC GEOLOGY, CLAYS AND INDUSTRIAL MINERALS**

**Donald D. Carr** - Geology of the industrial minerals, particularly carbonate rocks for building stone and crushed-stone aggregates, gypsum, and sand and gravel. I am presently senior editor for the 6th edition of *Industrial Minerals and Rocks*, to be published by the Society of Mining Engineers in 1993. My research deals with the chemical and physical properties of materials and how they relate to stone use, preservation, and durability.

**John B. Droste** - For several decades my research has treated the subsurface geology of the Paleozoic rocks of Indiana and adjacent states. These studies are focused on lithostratigraphy, on interpretation of environments of deposition, and on local and regional tectonic events as they relate to petroleum geology.

**Brian Keith** - A major effort is starting in the study of geologic controls over reservoir character and the potential for future exploration. Some of this effort will involve cooperative research with research personnel at the Illinois and Kentucky Surveys and with industry. Considerable potential exists for graduate student research

in the depositional and diagenetic history of carbonate reservoirs and the controls over reservoir quality.

#### *Recent Graduate Student Research*

Reynolds, D. W. Jr., (Reynolds Resources, Owensboro, KY) Geology and porosity of a Devonian reservoir in the Wilfred Gas Storage Field, Sullivan Co., Indiana. M.S. thesis.

**Haydn H. Murray** - Clay Mineralogy, Industrial Minerals, and Sedimentary Petrology and Low-Temperature Geochemistry. My research interests focus largely on the origin, depositional environments, geochemistry, and applications of the various clay minerals. Specific projects are listed as follows:

A. Genesis and properties of the kaolin clays along the Minnesota River near Redwood Fall, MN. This research is being done in conjunction with Dr. Peter Brandlein, a post-doctoral research associate from Germany.

B. Genesis and characterization of a hydrothermal deposit in Argentina. This research project is being carried out in cooperation with Dr. Silvana Bertolino, a post-doctoral research associate from Argentina.

C. Relationship between kaolinite crystallinity and overlying bauxite deposits in Brazil, Suriname, and Australia. This research is being done with Dr. Eva Kocsardy, a post-doctoral research associate from Hungary.

D. Oxygen isotope composition of residual, hydrothermal, and sedimentary kaolins and smectites. This work is being done in cooperation with Tim Johnson, who has established a new laser ablation fluorination system.

#### *Recent Ph.D. Thesis Topics*

Tim Salter (University of Kentucky) "Texture and Composition of a Residual Lateritic Bauxite from Saline county, Arkansas."

Roland Merkl (Sud Chemie Corp., Munich, Germany) "A Sedimentological, Mineralogical and Geochemical Study of the Fuller's Earth Deposits of the Miocene Hawthorne Group of South Georgia-North Florida."

Jessica Elzea (Industrial Minerals Specialist, McCrone Corp., Chicago, IL) "Geology, Geochemistry, Selected Physical Properties, and Genesis of the Cretaceous Clay Spur Bentonite in Wyoming and Montana."

Robert Pruett (ECC/America, Sandersville, GA) "Mineralogical and Geochemical Comparison Between Primary and Secondary Kaolins of Cretaceous and Tertiary Age in the United States and Canada."

Thomas Dombrowski (Engelhard Minerals & Chemical Corp., Edison, NJ) "Trace Element Distributions in the Georgia Kaolins."

Karan Keith (Current Student) "The Affect of Selected Chemical Pollutants on the Hydraulic Conductivity of Smectite, Palygorskite and Sepiolite Clay Blends."

Jun Yuan (Current Student) "Mineralogy, Geochemistry, and Economic Evaluation of Some Kaolin Deposits from Jujian and Guangdong Provinces, P.R. China and from Idaho and Washington States, USA."

Nelson Shaffer (Indiana Geological Survey) "Lateral Variations in Mineralogy and Geochemistry of Pennsylvanian Black Shale Sequences Related to Contemporaneous Fresh Water Channels, Southwestern Indiana."

**Edward M. Ripley** - Research interests include the genesis of metallic ore deposits and application of stable isotopes to petrogenetic problems. Research topics have dealt with the origin of low-temperature through high-temperature deposits. Examples of deposit types studied include metal-rich black shales in Indiana, sediment-hosted copper mineralization in Permian units of Kansas, hydrothermal gold-silver mineralization in Montana and Idaho, rare earth element mineralization associated with monzogranites in Argentina, and copper-nickel-platinum group element occurrences in the Duluth Complex of Minnesota. Analytical research focuses on the refinement of methods for small sample isotopic analyses, including the use of laser ablation systems.

#### *Graduate Student Projects*

Mr. In Sung Lee and Mr. Iskandar Taib are conducting Ph.D. research on the genesis of platinum-group element and copper-nickel mineralization in the Duluth Complex of Minnesota. Mr. Tracy Branam's Ph.D. research is focused on diagenesis and copper sulfide deposition in Permian sedimentary rocks of Kansas. Mr. Lee is also involved in a project dealing with tin mineralization in Korea. Mr. Tim Johnson is an M.S. candidate working on gold mineralization in Utah. He is also involved in the development of laser ablation methods for stable isotope analyses.

Dr. Jae-Il Chung is a visiting researcher from Chonbuk National University in Korea. He is working in our labs doing stable isotopic measurements of samples from lead-zinc-silver deposits in Korea.

#### *Representative Publications*

Branam, T. D., and E. M. Ripley, (1990) Genesis of sediment-hosted copper mineralization in south-central Kansas: I. S/C and sulfur isotopic relationships: *Econ. Geol.*, **85**, 601-622.

Carr, D. D., (1990) Economic Geology of Salem Limestone in the Indiana Building-Stone District in

Architectural Elements and Paleocology of Carbonate Shoal and Intershoal Deposits in the Salem Limestone (Mississippian) in South-Central Indiana: *Ind. Geol. Survey Guidebook 14*, p. 53-56.

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Ripley, E. M., N. R. Shaffer and M. S. Gilstrap, (1990) Distribution and geochemical characteristics of metal enrichment in the New Albany Shale (Devonian-Mississippian), Indiana: *Econ. Geol.*, **85**, 1790-1808.

Ripley, E. M., and T. Al-Jassar, (1987) Sulfur and oxygen isotopic studies of melt-country rock interaction, Babbitt Cu-Ni deposit, Duluth Complex, Minnesota: *Econ. Geol.*, **82**, 87-107.

Solomon, D. H. and H. H. Murray (1972) Acid-Base Interactions and the Properties of Kaolinite in Non-Aqueous Media: *Clays and Clay Minerals*, **20**, 135-141.

## PETROLOGY AND HIGH-TEMPERATURE GEOCHEMISTRY

Research in petrology and high-temperature geochemistry covers a wide range of topics in terrestrial and lunar igneous petrology and geochemistry, metamorphic petrology and tectonics, geochronology, and trace element and isotope geochemistry. Individual programs integrate aspects of field geology, theoretical and analytical geochemistry, and experimental petrology. Modern, well-equipped analytical facilities include a state-of-the-art electron microprobe for mineral analysis, inductively-coupled plasma (ICP) and atomic absorption (AA)spectrometers for major- and trace-element analysis, controlled-atmosphere high-temperature furnaces for experimental investigations, several mass spectrometers for stable-isotope analysis, and fully automated X-ray diffractometers. These facilities, coupled with a group of faculty with diverse but broadly overlapping interests, provides research opportunities in nearly all facets of petrology and high-temperature geochemistry.

**Abhijit Basu's** research interests center around lunar basalt petrogenesis. His primary goals are understanding the source regions and magmatic processes responsible for producing KREEP basalts. Current studies include the origin of yellow interstitial glass in KREEP basalts from several sites of the moon (Basu *et al.*, 1992) and the fractionation, if any, of lunar impact melts at different scales. This research is supported by NASA grants.

**James G. Brophy's** primary research interests center around the chemical and physical processes involved in magmatic differentiation. His research program makes use of a wide range of techniques including geologic field mapping, petrologic and geochemical laboratory analysis (major and minor element geochemistry, electron micro-probe analysis) and fluid dy-

namic modeling. Over the years, Brophy and students have conducted research in several areas including the Aleutian Islands, the Cascade Mountains of western Oregon, the Basin and Range province of the western U.S. and, most recently, the East Pacific Rise. These studies, largely funded by the National Science Foundation, have considered such diverse topics as the role of subducted oceanic crust in the high-pressure formation of island arc basalt, the relative roles of lower crustal melting, magma mixing, and fractional crystallization in the formation of andesitic magma, the growth and temporal evolution of low-pressure andesitic magma chambers and, most recently, the physical mechanisms of low-pressure fractional crystallization.

**Michael Dorais'** research focuses on chemical and physical processes of magmatic differentiation through combined field and laboratory investigations of both intrusive and extrusive igneous rocks. A major strategy is to utilize the textural, chemical, and mineralogic characteristics of mafic igneous inclusions as a window into otherwise inaccessible subsurface magmatic processes. In particular, such inclusions provide important insights into the compositional nature of liquid lines of descent in plutonic igneous rocks, and represent a key to understanding the complexity of natural differentiation processes. An additional area of interest is the application of ion-probe analytical techniques to the determination of trace element abundances in major and accessory igneous minerals. Field-based investigations have included studies in the San Juan Mountains of Colorado, the Sierra Nevada Batholith and the White Mountain Magma Series of New Hampshire. Dorais' research is funded by the National Science Foundation.

**David G. Towell's** major research goals and interests lie in the application of geochemical techniques to the solution of petrologic problems. The primary focus of his work is on plutonic and volcanic igneous rocks but also includes metamorphic and sedimentary rocks as well. The principal aspect of his research is the application of major and trace element geochemistry to modeling magmatic differentiation processes (*e. g.*, partial melting, fractional crystallization, magma mixing, *etc.*) Field mapping and sample collection are combined with extensive chemical and mineralogical analysis including petrography, inductively coupled plasma emission spectroscopy and electron microprobe analysis. Specific investigations have included studies in the Boulder and Tobacco Root batholiths, the North Doherty Intrusive Complex, and the Elkhorn Mountains Volcanic Series, all located in southwest Montana. Attempts are also being made to relate these intrusive and extrusive bodies on a regional basis in terms

of both igneous and tectonic history.

**Robert P. Wintsch's** research interests span a range of aspects of metamorphic geology, and many apply petrologic methods and tools to problems of structural geology and tectonics. This research, funded largely by the National Science Foundation, includes the petrology of deformed rocks, (particularly fault rocks) that range from low grade mylonitic rocks and slates to high grade blastomylonitic schists and gneisses. In field petrology, it also includes field mapping, thermobarometry, and thermochronology, with the goal of lithotectonic terrane analysis. Wintsch has studied low grade slates and mylonites for over 10 years. The work on slates has focused on the chemical consequences of pressure solution on mineral and rocks compositions and textures. He is also interested in mylonitic rocks and has worked on fault rocks from terrane boundaries in the northern Appalachians, the southern Alps, and the Moine thrust, Scotland. Field related research focuses on the analysis of exotic terranes and the history of terrane assembly in southern New England. This work has involved detailed mapping of lithotectonic terranes and terrane boundaries, complimented by petrographic, microprobe, and whole rock geochemical, and geochronologic analyses. The most recent focus of his research applies techniques of thermochronology (mineral age dating) to unraveling the metamorphic history of mountain belts that have been assembled by syn- and post- metamorphic accretion. Such investigations are currently centered in eastern New England and the central Appalachians.

#### **Representative Publications**

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Bean, C. L. and D. G. Towell, (1981) A geochemical study of the North Doherty Intrusive complex, Jefferson County, Montana: *Geol Soc Amer Abstr w Prog*, 13, 190.

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## **GEOPHYSICS, TECTONICS, AND STRUCTURAL GEOLOGY**

The principal emphasis of this group is in the areas of seismology and rock mechanics. In seismology, Professors Hamburger, Pavlis, and Rudman provide complementary expertise that allows this group to supervise student research over an exceptionally broad range of topics for a group of this size. Michael Hamburger's major strength is in observational seismology and tectonics. Gary Pavlis's background and interests are better classified as theoretical/computational seismology. Finally, Albert Rudman has worked on a broad range of topics in applied and exploration geophysics. These three people, along with research scientist Haydar Al-Shukri and a group of 6 - 10 graduate students, form a strong working team with a good collegial relationship. This team spirit extends throughout activities of the group to working relationships with colleagues at eight other institutions at this time.

Bruce Douglas and Jeremy Dunning jointly operate an extensive rock mechanics laboratory. The focus of their current work is understanding the influence of different chemical environments on fracture propagation in rocks.

Finally, two other faculty in the department have overlapping interests with this group. Robert Wintsch's research on fault rocks provides opportunities for multidisciplinary studies of earthquake source processes combining seismology, rock mechanics, and field observations. Vishnu Ranganathan's expertise in numerical modeling of ground water provides an opportunity for student research in a broad range of geophysical topics involving numerical modeling.

*Facilities.* The seismology group makes extensive use of a variety of computer facilities available within the Department and the University. Departmental facilities range from a large number of microcomputers to a cluster of Sun workstations within the seismology research laboratory. This includes an extensive collection of software including a commercial seismic processing system (Sier-raseis). Several of these machines are housed in a

specialized computing facility that provides an ideal environment for individual and group work by students in geophysics. In addition, the seismology group has a close working relation with the graphics group at the Indiana University Center for Innovative Computer Applications. Through this group we have access to specialized graphics facilities and programming talent that provide a unique resource for student and faculty research in an interdisciplinary setting. Finally, the central campus computer facilities provide unrestricted access to a number of VAX computers and a large IBM 3090 mainframe. All of these machines are linked in a campuswide computer net based primarily on ethernet with higher speed fiber optic links forming a campus backbone. This same network also provides access to other computers nationwide through the NSFnet. We use these connections frequently for transferring data gathered in collaborative projects with colleagues at other universities and to access supercomputers at the National Center for Supercomputing Applications in Urbana, Illinois.

The Rock Mechanics group has extensive facilities for conducting experiments over a wide range of conditions. The primary equipment includes: (1) a triaxial system with independent pore-pressure control, which with planned future upgrades will allow experiments in the 25 to 300°C temperature range; (2) a uniaxial testing machine configured for creep experiments up to 1600°C under controlled fugacity conditions; (3) a uniaxial testing machine configured for precision loading of small samples, and (4) a shock loading frame. All equipment is operated with a HP-7500 series computer data acquisition and control system. The lab also has numerous fixtures and associated measuring devices to produce specific sample configurations. Additional sample preparation equipment is available within the lab including low-speed saws and polishing laps plus an ion mill for preparing SEM /TEM samples.

**Bruce Douglas** - At the present time Douglas is engaged in several laboratory and field projects. The laboratory studies involve brittle failure studies of geologic materials and ceramics. A laboratory study being initiated involves the mechanical properties of shales under conditions of hydrocarbon maturation. Two field studies are centered in southwestern Montana. One involves studies of the deformational mechanisms of the metamorphic basement rocks in the Tobacco Root Mountains and the other involves studies in the fold and thrust belt rocks that address problems in fault mechanics and the response of quartz rich lithologies to fault propagation and folding. Finally, a regional tectonics project is in progress involving an investigation of the rheological properties of the lithosphere in

southernmost South America. All of these projects emphasize combining either theoretical or experimental data with field/natural site specific problems.

**Jeremy Dunning's** research examines the role of aqueous environments in stress corrosion (chemical weakening) of geologic materials. Typical research projects include stable crack propagation, fault mechanics stick slip experiments, and hydraulic fracturing. The lab facilities available are a rock mechanic laboratory containing two mechanical loading frames of 1000 and 20,000 lb. capacity, a 225-ton hydraulic loading frame equipped with a pressure vessel with 60,000 psi confining and pore pressure capabilities, and complete sample preparation capability.

**Michael Hamburger** - Hamburger's major research interests are in seismotectonics, earthquake prediction, and application of satellite geodetic measurements to geodynamic problems. He currently has active research programs in the subduction zone environments of the southwest Pacific (Fiji-Tonga region) and zones of continental collision in the Pamir and Tien Shan mountain region of Central Asia and the Caucasus mountains of southwestern Asia. His major field research projects in the (former) USSR include: (1) Analysis of earthquake distribution, velocity structure, and focal mechanisms in the Pamir-Tien Shan region (Soviet Tadjikistan); (2) study of deep earthquakes and mantle velocity structure associated with the Pamir-Hindu Kush deep seismic zone; (3) a project to analyze structural geology, stratigraphy, and active deformation in the Pamir-Tien Shan region (in collaboration with Professor Terry Pavlis of the University of New Orleans); (4) establishment of a new, state-of-the-art digital, broadband seismic network, designed for earthquake prediction and nuclear test monitoring studies in Soviet Kirghizia; and (5) two new projects to apply new satellite geodetic techniques (the *Global Positioning System*) for geodynamic measurements in the Caucasus Mountains (Soviet Georgia and Armenia) and in Central Asia (in collaboration with MIT's Robert Reilinger).

**Gary Pavlis** - Much of Professor Pavlis's early work focused on geophysical inversion techniques. He has written several papers on theoretical and computational aspects of earthquake location and velocity inversion from seismic travel time data. More recently his research has broadened to include two major new areas. First, through association with IRIS (Incorporated Research Institutions for Seismology) he has become involved in fundamental research in wave propagation through data collected by

passive seismic arrays. His principal interest is in improving understanding of how seismic waves are scattered and attenuated within the earth and how this limits capabilities for using seismic waves radiated by earthquakes in a variety of practical problems. These practical aspects include understanding earthquake sources and detection and discrimination of underground nuclear explosions. His second new research interest is the seismotectonics of Central Asia. This interest was born through collaborations with Michael Hamburger and has yielded several recent papers.

**Vishnu Ranganathan** - Ranganathan is engaged in research on fluid-, mass- and heat transport in sedimentary basins and on the estimation of transport properties of rocks such as permeabilities and diffusion coefficients using computer models. In addition, he is using geophysical well logs to map out spatial variations in fluid pressures, temperatures and salinities in the subsurface of the Gulf Coast Basin.

**Albert Rudman** - Rudman's research career has centered on computer applications in exploration geophysics. Recent work in potential fields includes analysis of magnetic field data from the New Madrid seismic zone and heat flow modeling of magmatic processes in Hawaii. In addition, his recent work in seismic methods includes: (1) analysis of earthquake location errors in the New Madrid seismic zone, (2) time series analysis of travel time anomalies in Soviet Central Asia, (3) development of new codes for calculating synthetic seismograms based on collaborative work with Neil Frazer at Hawaii, and (4) application of neural networks for identification of first-breaks in seismic reflection data.

#### **Representative Publications**

Douglas, B., (1986) Deformational history of an outlier of metasedimentary rocks within the Coast Plutonic Complex, British Columbia, Canada. *Can. J. Earth Science*, **23**, 813-826

Douglas, B., S. Saul, and C. Stern, (1986) Rheology of the upper mantle beneath southern Chile inferred from mantle xenoliths, *J. Geol.* **95**, 241-253.

Douglas, B. J., J. D. Dunning and D. L. Goldsby, (1990) The role of H<sup>+</sup> and OH<sup>-</sup> - like species in substantial crack propagation (abstract), *EOS Transactions Am. Geophys. Union*, **71**, 640.

Douglas, B. J., J. D. Dunning and D. L. Goldsby, (submitted) Subcritical crack propagation: The effects of temperature and aging-under-load, *J. Geophys. Res.*

Dunning, J., Brophy, J., Goldsby, D., and Douglas, B. (1991) Silicates. pp. 183-190 in *Encyclopedia of Earth Sciences*, Academic Press.

Dunning, J., Douglas, B., and Goldsby, D. (1990) The role of kinetics in subcritical cracking. *EOS, Trans. Am. Geophys. Union* **70**, 1304.

Dunning, J., Douglas, B., and McDonald, S. (1991) The role of kinetic effects in the static fatigue of quartz. *EOS, Trans. Am. Geophys. Union* **72**, 441.

Dunning, J., Kornbrenke, R., and Miller, M. (1990) Surfactant-induced weakening of geologic materials. *Surfactants in Solution* **10**, 297-320.

Eneva, M. G. and M. W. Hamburger, (1989) Spatial and temporal patterns of earthquake distribution in Soviet Central Asia: Application of pair analysis statistics. *Bull. Seis. Soc. Am.* **79**, 1439-1456.

Estey, L. and B. Douglas, (1986) Upper-mantle anisotropy: A preliminary model, *J. Geophys. Res.*, **91**, 11393-11406.

Hamburger, M. W., I. B. Everingham, B. L. Isacks and M. Barazangi, (1990) Seismicity and crustal structure of the Fiji Platform, Southwest Pacific. *J. Geophys. Res.*, **95**, 2553-2573.

Hamburger, M. W. and J. A. Rupp, (1988) The June, 1987 southeastern Illinois earthquake: Possible tectonism associated with the LaSalle anticlinal belt. *Seismol. Res. Lett.*, **59**, 151-157.

Hamburger, M. W. and B. L. Isacks, (1988) Diffuse back-arc deformation in the Southwest Pacific. *Nature*, **332**, 599-604.

Meyerholtz, K. A., G. L. Pavlis, and S. A. Szpakowski, (1989). Convolutional quelling in seismic tomography, *Geophysics*, **54**, 570-580.

Pavlis, G. L., P. Anderson, and B. Kaplan (1990). Visualization technique for seismic array data *Leading Edge*, **9**, 26-29.

Pavlis, G. L. (1986). Appraising earthquake hypocenter location errors: a complete, practical approach for single event locations. *Bull. Seis. Soc. Amer.*, **76**, 1699-1717.

Pavlis, G. L., M. W. Hamburger, and I. L. Nersisov (1989). Anomalies in the magnitude-frequency relation of earthquakes in the Garm region, Soviet Central Asia, *Bull. Seism. Soc. Amer.*, **79**, 1913-1926.

Pavlis, G. L. and M. W. Hamburger (1991). Aftershock sequences of intermediate-depth earthquakes in the Pamir-Hindu Kush Seismic Zone, *Journal of Geophysical Research*, **96**, 18,107-18,117.

Ranganathan, V. (in press 1992) Basin dewatering and formation of brine plumes near salt domes. *Journal of Geophysical Research*.

Rudman, Albert J., (1982) Interrelationship of resistivity and velocity logs, in Developments in Geophysical Exploration Methods, Vol. 3 Editor A.A. Fitch, Published by Applied Science Publishers (Elsevier), P. 33-59.

Rudman, Albert J., and David Epp, (1983) Conduction models of the temperature distribution in the east rift zone of Kilauea Volcano, Jour. of Volcanology and Geothermal Res., Vol. 16, P. 189-203.

Rudman, Albert J., with L. Neil Frazer and D. L. Bates, 1985, Generation of vertically incident seismograms, Indiana Geol. Surv. Occasional Paper 49, Geophysical Computer Program Series 10, 13 Figs., 61 Pages.

Rudman, Albert J., with A. K. M. Sarwar, 1985, Inversion of a normally incident reflection seismogram by the Gopinath-Sondhi integral equation, *Geophys. Journ. Roy. Astro. Soc.*, **81**, 551-562.

Rudman, Albert J., with L. Neil Frazer, (1988) Seismic Modeling in the Tau-p Domain, Indiana Geological Survey Occasional Paper 54, Geophysical Computer Program Series 12.

## RESEARCH GRANTS

**A. Basu** (NASA) - "Petrologic evolution of lunar and meteorite parent body regolith."

**S. Brassell** (PACKARD FDN) - "Molecular organic geochemical research studies of climatic variations over geological time."

**J. Brophy** (NSF) - "A petrologic and ion-probe study of hornblende gabbro cumulates from Medicine Lake volcano: an evolution of competing mechanisms of calc-alkaline fractional/crystallization."

**J. Brophy** (TEXAS A&M) - "Ocean Drilling Program, Leg 142 (Engineering Test Leg III)."

**J.R. Dodd** (MARATHON OIL) - "Carbonate stratigraphy project".

**M. Dorais** (NSF) - "An ion and electron microprobe study of apatite in the Red Hill Complex, New Hampshire."

**J. Dunning** (DOW CHEMICAL) - "Ceramic research (PAR project)."

**J. Dunning** (BUREAU OF MINES) - "Single crystal studies of the role of electrostatic potential and PZC in chemical weakening".

**M. Hamburger** (USGS) - "Seismicity and crustal structure in an active collisional orogen, Soviet Central Asia".

**M. Hamburger** (NSF) - "Tectonics of subduction zone terminations: a case study in northernmost Tonga".

**M. Hamburger** (NSF) - "Application of global positioning system measurements to continental collision in the Pamir-Tien Shan Region, USSR."

**M. Hamburger** (Dept. Interior) - "Collaborative research: multidisciplinary study of geodynamics in an active collisional orogen, Soviet Central Asia."

**M. Hamburger** (NSF) - "Seismic monitoring of Mt. Pinatubo, Luzon, Philippines."

**J. Hayes** (UNIV.CALIF.-DAVIS) - "Midwestern Regional Center of the National Institute for Global Environmental Change: studies of the biogeochemical cycle of carbon relationships between pCO<sub>2</sub> and the <sup>13</sup>C sedimentary organic matter."

**J. Hayes** (UNIV.CALIF.-DAVIS) - "Midwestern Regional Center of the National Institute for Global Environmental Change: isotopic studies of the biogeochemical cycle of carbon."

**N. Krothe** (WESTINGHOUSE) "Spectrofluorophotometer analysis of fluorescent dyes injected into groundwater wells in local landfills."

**N. Krothe** (WESTINGHOUSE) "Investigation of epikarst for groundwater storage in the drainage basin of the Quarry Spring system."

**G. Lane** (NSF) "Paleobiogeography of Late Devonian and Carboniferous echinoderms from the Peoples Republic of China."

**E. Merino** (NSF) - "Self-organization in agate: textures, compositions, and dynamic crystallization modelling."

**E. Merino** (NSF) - "Self-organization origin of fibrous texture and twisting of agate quartz: dynamic crystallization model."

**H. Murray** (UNION FNDN) "Industrial Minerals Research."

**G. Olyphant** (NOAA) University of Illinois, "Contemporary and historical eolian sand transport in a coastal dune environment, South Shore, Lake Michigan, IN."

**G. Pavlis** (IRIS) - "Use of a small aperture seismic array for earth structure, seismotectonic and earthquake prediction studies in the United States with the Soviet Academy of Sciences."

**G. Pavlis** (IRIS) - "Joint US-USSR Program: Kirghizia seismic network and small aperture seismic array studies".

**G. Pavlis** (NSF) - "Appraisal of relative earthquake location errors."

**L. Pratt** (DOE) - "Gas chromatograph-mass spectrometer for organic geochemical research."

- L. Pratt** (Dartmouth College) "Mesozoic-Cenozoic evolution of northern South America."
- L. Pratt** (NSF) - "Geochemical and stable isotopic study of the C<sub>org</sub>-S-Fe-Mn system in anoxic paleoenvironments."
- L. Pratt** (NSF) - "Cooperative study of Cretaceous black shales in Benue Trough, Nigeria."
- L. Pratt** (Various Petroleum Grants) "Sedimentary organic geochemistry research."
- V. Ranganathan** (AM CHEM) - "The dynamics of groundwater flow associated with perched brine plumes above salt domes."
- V. Ranganathan** (NSF) - "Basin dewatering near salt domes in the U.S. Gulf Coast."
- E. Ripley** (NSF) - "Mechanisms of platinum-group element enrichment and the nature of the hydrothermal system at the Babbitt Deposit, Duluth Complex, Minnesota."
- M. Savarese** (NOAA) University of North Carolina, "Detection of algal symbiosis in fossil reef builders via stable carbon isotopic signatures: a test of the method's applicability using modern scleractinian corals."
- M. Savarese** (AM CHEM) "A paleoecological field test of the functional interpretation of archaeocyathan paleobiology using lower Cambrian reefal carbonates from South Australia."
- L.J. Suttner** (NSF) - "Regional chronostratigraphic and sequence stratigraphic analysis of central cordilleran foreland basin."
- R. P. Wintsch** (NSF) - "Thermochronology and thermobarometry in lithotectonic zones in eastern New England."
- R. P. Wintsch et al.** (NSF) - "Acquisition of an electron probe microanalyzer."

## DEPARTMENT OF GEOLOGICAL SCIENCES FACULTY AND STAFF

### Professor:

**Abhijit Basu, Simon Brassell, James Brophy, J. Robert Dodd, John Droste, Jeremy Dunning, Michael Hamburger, Donald Hattin, John Hayes, Norman Hester, Noel Krothe, N. Gary Lane** (Associate Chair), **Enrique Merino, Haydn Murray, Greg Olyphant, Lawrence Onesti, Gary Pavlis, Lisa Pratt, Vishnu Ranganathan, Edward Ripley, Albert Rudman, Michael Savarese, Lee Suttner** (Chair), **David Towell, Robert Wintsch**

### Part-Time Professors:

**Ned Bleuer** (Survey), **Donald Carr** (Survey), **Gordon Fraser** (Survey), **Henk Haitjema** (SPEA), **Brian Keith** (Survey), **Peter Ortoleva** (Chemistry), **Carl Rexroad** (Survey), **Jeff White** (SPEA)

### Professors Emeritus:

**Robert Blakely, Judson Mead, Robert Shaver, Charles Vitaliano**

### Research Scientists:

**Haydar Al-Shukri, Michael Dorais, Bruce Douglas, David Hollander, Alan Horowitz, John Jasper, Fabien Kenig, Tian-Min Xie**

### Visiting Research Associates:

**Silvana Bertolino, Peter Braendlein, Jae-III Chung, Colin Harvey, Eva Kocsardy**

### Librarian: **Lois Heiser**

### Staff:

**Sarah Burton**, Administrative Assistant, Chair's Office  
**Patty Byrum**, Administrative Secretary, Chair's Office  
**Lorie Canada**, Faculty Secretary, Fifth Floor  
**Ruth Droppo**, Research Secretary, Third Floor  
**Mark Gilstrap**, Analytical Chemist  
**Gary Hinton**, Resident Manager, Field Station  
**Mary Iverson**, Student Records, First Floor  
**Charles Miller**, Machinist  
**Elaine Oehmich**, Secretary, Business Office  
**Jean Reese**, Research Secretary, Third Floor  
**Kim Schulte**, Secretary, Geologic Field Station  
**Brian Snow**, Computer Systems Manager  
**Kimberly Sowder**, Cartographic/Photographic Specialist  
**Terry Stigall**, Electronics Technician  
**Steven Studley**, Mass Spectrometer Manager  
**James Tolen**, Senior Cartographic Specialist  
**Rodney Ward**, Faculty Secretary/Software Support Asst., Fourth Floor



## STUDENT AWARDS AND GRANTS

1991:

### Undergraduate

Senior Faculty Award- **Brian Towell**, Bloomington, IN

Junior Scholarship Award-

**Michael Delgass**, West Lafayette, IN

N. Gary Lane Award (Beginning Major)-

**Rebecca Robinson**, Kennesaw, GA

Chevron Scholarship in Geology-

**Eric Shock**, Tipton, IN

Chevron Scholarship in Geophysics-

**Mark Dustman**, Merrillville, IN

Minority Achiever's Program Scholarship-

**Andrea Foster**, Flint, MI

Arts and Sciences Alumni Association Award-

**Joseph Callis**, Madison, IN

### Field Station Scholarships (I.U. Students)

Charles Deiss Field Station Scholarship-

**Susan McDonald**, Freedom, IN

Field Station Scholarships-

**Ana Maria Carmo**, Salvador, Bahia, Brazil

**Jane Hultberg**, Ontario, NY

**Terri Keith**, Bloomington, IN

**Scott Szentes**, Indianapolis, IN

### Graduate

John B. Patton Award (Indiana Geology)-

**Karl Leonard**, Palouse, WA

Estwing Award- **Mark Schult**, Norfolk, VA

Graduate School Alumni Assoc. and Dept. of Geological Sciences Honors- **John Holbrook**, Denton, KY

Outstanding Associate Instructor (Beginning Level)-

**Matthew Averill**, Knox, IN

Outstanding Associate Instructor (Upper Level)-

**John Holbrook**, Denton, KY

Cumings Award- **Dennis Sponable**, Mechanicsville, NY

Chevron Oil Company Fellowship in Geophysics-

**Robert Mellors**, New Royalton, OH

Shell Oil Company Fellowship-

**Mark Williams**, Norristown, PA

University Graduate School Fellowship-

**Jane Hultberg**, Ontario, NY

Grassmann Fellowship- **Clifford Ambers**, Polk, OH

Oil Dri Fellowship- **Karan Keith**, Leawood, KS

Geochemistry Fellowship-

**Glenn Hieshima**, Mill Valley, CA

Horton Research Fellowship-

**Barbara Lakey**, Mt. Pleasant, MI

Brazilian Government Fellowship-

**Ana Maria Carmo**, Salvador, Bahia, Brazil

University Graduate School Summer Research

Fellowship- **John Holbrook**, Denton, KY

Grants-in-Aid of Research:

**Clifford Ambers**, Polk, OH (Clay Minerals Society)

**Matthew Averill**, Knox, IN (Geol. Soc. America)

**Michael May**, Evansville, IN (Univ. Graduate School)

**Michael Stewart**, Bloomington, IN (Geol. Soc. America and Sigma Xi)

Department of Geological Sciences Summer Research Grants-

**Suzanne Kairo**, Plymouth, PA

**Michael May**, Evansville, IN

**Mohammad Iqbal**, Dhaka, Bangladesh

Sigma Xi Initiates-

**Wesley Boberg**, Warwick, RI

**Barbara Lakey**, Mt. Pleasant, MI

**Clay Harris**, Evansville, IN

**Calvin R. Johnson**, Daderville, AL

**Patricia Merkley**, Huntingburg, IN

**Mark Schult**, Norfolk, VA

**Doreen Zaback**, Peabody, MA

1992:

### Undergraduate

Senior Faculty Award-

**Michael Delgass**, West Lafayette, IN

Junior Scholarship Award-

**Rebecca Robinson**, Kennesaw, GA

N. Gary Lane Award (Beginning Major)-

**Deborah Reas**, Indianapolis, IN

Chevron Scholarship in Geology-

**Michael Delgass**, West Lafayette, IN

Chevron Scholarship in Geophysics-

**Kathleen Dull**, Huntington, IN

Minority Achiever's Program Scholarships-

**Andrea Foster**, Flint, MI

**Amanda Hopkins**, Valparaiso, IN

Junior Professional Development Awards (Society membership and journal)-

**Louis Bucklin**, Media, PA

**Christopher Dintaman**, Bloomington, IN

**Dana Strength**, Valparaiso, IN

Field Station Scholarships (I.U. Students)

Charles Deiss Field Station Scholarship-  
**Michael Delgass**, West Lafayette, IN  
Field Station Scholarships-  
**Amanda Austin**, Cincinnati, OH  
**Julie Blue**, New Haven, CT  
**Jamie Budak**, Griffith, IN  
**Joseph Callis**, Madison, IN  
**Jennifer Curtis**, Louisville, KY  
**Christopher Dintaman**, Bloomington, IN  
**Kevin Ellett**, Bloomington, IN  
**Joseph Fisher**, Warsaw, IN  
**Andrea Foster**, Flint, MI  
**Khaireddine Sakrani**, Znati, Guelma, Algeria  
**Eric Shock**, Tipton, IN

Graduate

Estwing Award- **Steven Bennett**, Cedar Falls, IA  
Department of Geological Sciences Honors-  
**Mohammad Iqbal**, Dhaka, Bangladesh  
Outstanding Associate Instructor (Beginning Level)-  
**Amanda Austin**, Cincinnati, OH  
Outstanding Associate Instructor (Upper Level)-  
**Nur Iskandar Taib**, Selangor, Malaysia  
Cumings Award- **Patricia Merkley**, Huntingburg, IN  
Chevron Oil Company Fellowship in Geophysics-  
**Glenn Bear**, Fostoria, OH  
Shell Oil Company Fellowship-  
**Cara Davis**, Honolulu, HI  
University Graduate School Fellowship-  
**Huitang Zhou**, Shanxi, China  
Grassmann Fellowship- **Clifford Ambers**, Polk, OH  
Oil Dri Fellowship- **Karan Keith**, Leawood, KS  
Geochemistry Fellowships-  
**Dorothy Payne**, Berkeley, CA  
**Ruiliang Wang**, Yunnan, China  
SEPM Student Excellence Development Award-  
**Yifeng Wang**, Linbai, Zhejiang, China  
Brazilian Government Fellowship-  
**Ana Maria Carmo**, Salvador, Bahia, Brazil  
Friday Harbor Marine Laboratory Fellowship-  
**Barbara Grehl**, Nanuet, NY  
Grants-in-Aid of Research-  
**Clifford Ambers**, Polk, OH (Geol. Soc. America)  
**Glenn Bear**, Fostoria, OH (Soc. of Exploration  
Geophysicists)  
**Julie Boyd**, Kingwood, TX (Geol. Soc. America)  
**Mohammad Iqbal**, Dhaka, Bangladesh (University  
Graduate School)  
**Matthew Paige**, Pasadena, CA (Geol. Soc. America)

Department of Geological Sciences Summer Research  
Grants-

**Clifford Ambers**, Polk, OH  
**Barbara Grehl**, Nanuet, NY  
**Mohammad Iqbal**, Dhaka, Bangladesh  
**Matthew Paige**, Pasadena, CA

Sigma Xi Initiates-

**Barbara Grehl**, Nanuet, NY  
**Karl Leonard**, Palouse, WA  
**George Yu**, Beijing, China

## STAFF PROFILES

### INTRODUCING . . . The Support Staff

The Department staff contributes substantially to our educational mission by its spirit of team effort, dedication to purpose and loyalty. These combined factors are geared toward achieving the high standards set in the Department. We thought you'd be interested in catching up on the news of those staff whom you may remember as well as learning about newer members of the staff who have joined us since you left.

**Charles Miller** has been with the university for 40+ years, all of which have been spent either in the Geological Survey or with the Department. His understanding of and experiences with designs of a wide variety of machinery certainly defines him as a master craftsman. **Charles** enjoys classical music, stereoscopic photography, traveling, antique clocks, and woodworking, but the delight of his life is his four-year-old grandson, **Cormack**, who lives in Indianapolis.

**Mary Iverson** recently completed twenty-nine years in the Department, so is known to many of you. **Mary's** cheerful and helpful attitude continues to be appreciated by students as they face the increasingly complicated maze of requirements they must meet in order to obtain their degrees. **Mary** enjoys her grandchildren, activities at her church where she takes care of the nursery, and, of course, Indiana University Basketball! **Mary** received one of the university's Staff Merit Awards in 1989 which recognized her service to the Department and Indiana University.

**Jim Tolen** is also another long-time employee; he has been with the Department since June, 1964. As our Senior Cartographic Specialist, **Jim** has diligently and

quietly increased his skills and experience in his special area which is so critical to the materials that are produced for research papers, proposals, and presentations at professional meetings. **Jim** has been an active numismatist for more than thirty years. He and his wife, Ramona, have two daughters, both of whom are pursuing Ph.D. degrees in anthropology, though at different universities.

**Steve Studley** began working in the department in August 1970, as a lab assistant for Warren Meinschein. He later became the lab technician for John Hayes which has meant moves to the Chemistry building, then back to Geology. **Steve** also received one of the I.U. Staff Merit awards in 1984. **Steve** and his wife, Penny, enjoy traveling via railroad. He is also an avid hobbyist in model railroading.

**Mark Gilstrap**, our resident analytical chemist, continues to manage the geochemical laboratories as he has since 1980. **Mark** also has been instrumental with helping to set up and maintain safety standards throughout the Department. He keeps pretty busy outside the Department, too, as the father of four children. This year he was ordained in the Russian Orthodox Church. His interests include gardening, fishing and lapidary, as time permits.

Since 1981 **Terry Stigall** has shared her electronic expertise with many others throughout the department. Although she is primarily the geophysics technician she has been the resident troubleshooter for almost every electronics area. As the mother of three young children **Terry** has plenty of opportunity for recreation outside the department. She is involved in a choral group and is a member of an extension homemaker's club. She was named 1991 Extension Homemaker of the year for Monroe County. Whenever she can take a break from work in the Department and homemaking and housework, she enjoys getting outside.

Until recently **Patty Byrum** was the first person that anyone calling or coming into the Department would see. Her smile and helpful attitude has certainly smoothed the way for many faculty, staff and students in the Department since she began working here in February, 1984. Last year **Patty** moved from the front office to become the secretary to the Chair, Dr. Suttner. **Patty** and her husband, Roy, live in Martinsville; the activities of their three children keep her pretty busy -- her son Brian, a junior at Indiana State, will be married this summer, her older daughter will enroll at IU this fall and her younger daughter will enter high school.

**Kim Sowder** has a joint appointment with the Department and the Indiana Geological Survey. She is the Senior Cartographic/Photographic Specialist in the Drafting Section

of the Survey. **Kim** joined the staff in March 1984, as a cartographer/photographer; the position developed into one with much greater responsibility due to the increased activity connected with the publications produced by the faculty. In addition to her job responsibilities, **Kim** and her husband, Mike, have two young and active sons, Joshua and Jacob, who keep them busy. She enjoys spending time with her family and includes gardening among her interests.

**Sarah Burton** became part of the support staff in May 1986, after five years in other departments at Indiana University. She is the Administrative Assistant to the Chair and her duties include anything having to do with budgets, monetary requests, funding, development, and any other category that isn't named or can't be identified. **Sarah** and her husband enjoy traveling, especially via train although trips by car also are a favorite form of travel. Four of their five children are in various stages of university studies, while their youngest will be a high school junior in the fall. **Sarah** also maintains student status at IU by taking one class each semester. She is currently working on a Master's Degree in Library and Information Science.

**Kim Schulte** has held three different positions since joining the Department in February 1987. She was first hired to be the third floor secretary, then became payroll and clerical assistant in the Chair's office. Last summer she accepted the very busy position of senior secretary for the Geologic Field Station. Each position has offered increased challenges and **Kim** has effectively used her organizational skills to bring order to each set of responsibilities. She lives in Bloomfield where she is active in her church. She is the mother of two teenage sons; her oldest will pursue an engineering degree at Purdue this fall while her youngest will be a sophomore at Bloomfield High School.

**Ruth Droppo** began her appointment in the Department in July 1989, as the secretary for the biogeochemistry program. She often has demonstrated a capacity to deal with the wide-ranging set of responsibilities for that research group. One special project in which she applied multiple talents was the soft sculpture she designed depicting the activities of the Sequence Stratigraphy class conducted in May 1991. This mixed-media sculpture is displayed on the north wall of the Geology Lobby. **Ruth** also is the owner/designer of Jessica's Closet, Inc. This fall she will be devoting some of her free time as instructor at the Waldron Arts Center in Bloomington. She is active in youth group projects at her church and has

published applique patterns. She has two daughters, one a high school freshman, the other a student at Indiana University.

**Brian Snow** joined the Department in November 1990, as the Computer Systems Manager. With the increased number of computers for faculty and staff during the past few years, **Brian's** addition to the support staff was critically important. Having taught computer related courses at Ivy Tech, **Brian** very quickly applied his experience and computer knowledge to our equipment environment. He enjoys spending time with his children outside the daily work routine. He also enjoys classical music and the opportunity to attend some of the School of Music's performances. He appreciates the variety of cultural and educational activities available at Indiana University and in Bloomington.

**Elaine Oehmich** joined us in September 1991. She has been able to apply a wide range of job experiences to the multiple and diversified tasks of her front office position. **Elaine** has many talents and enjoys a variety of activities outside the office. She is an artist and has been busy producing canvases. She hopes to exhibit some of these at a showing in Paris, where she lived prior to returning to Bloomington last year. In her spare time, **Elaine** plays classical piano, sings and plays guitar and attends the opera and ballet performances in Bloomington.

**Rodney Ward** joined the staff in December, 1991, coming to Bloomington from the University of California-Berkeley. His office is located on the fourth floor. He also assists the staff with various software information/problems. His outgoing personality and interest in a wide variety of subjects quickly has enabled him to feel at home here in the Department. **Rodney** has a number of outside interests and activities which include environmental issues and social justice concerns. His interests also extend to music and comedy.

**Lorie Canada** is one of the newer staff members in the Department; she joined us this past January. She was the payroll assistant at the University Computing Services Department just prior to her appointment here. She moved to Bloomington from Shoals in 1989. **Lorie** and her husband, Jeff, a Bloomington police officer, have a four-year-old son, Jordan. She enjoys spending time with her family and cooking.

**Jean Reese** joined our staff in July. She is the research secretary for Simon Brassell; she has a few other faculty assignments as well. She is from Oak Ridge, Tennessee,

but lived in Bloomington a few years ago while working on a B.A. in journalism and political science. Her husband, Vance, is a doctoral candidate in the I.U. School of Music. **Jean** enjoys the cello, bike riding and vegetarian cooking.



*Peggy Cox Gilmour (B.A. 1973; M.A.T. 1978)*

### **ADVISORY BOARD (formerly Alumni Council)**

At its annual meeting in Bloomington in February, the Department's Alumni Council approved a new set of bylaws which in effect formalized the organization's purpose, structure, and membership selection. In the process, the Council changed its name to the Advisory Board, Department of Geological Sciences, Indiana University, Bloomington. This action is intended to permit the Board to play a more active role in aiding and advising the Department, largely in aspects of long-range planning and program and resource development, and in promoting closer ties between the Department and its alumni and other individuals and organizations outside the University community.

The concept of the Department's Alumni Council was conceived by Professor John B. Patton during his chairmanship in the 1960's. In the early years after it was formed, the Council would meet annually with Dr. Patton, usually at national AAPG or GSA meetings, to discuss various matters related to the Department's curriculum, long-range planning and its research program, but it never had an officially defined status and mission. When Professor Haydn Murray became Chair of the Department in 1972, the Council, usually consisting of up to 15 alumni, began to meet once each year for 1 1/2 days in Bloomington. Members of the Council were selected by the Chair from informal nominations submitted by faculty and alumni.

The new Advisory Board may include up to 21 regular members, at least two-thirds of whom must be alumni of Indiana University. Selection of the members will be made by the Board's Executive Director (i.e., the Department Chairperson) from nominations made by the faculty and other members of the Board. If you know someone who would make a good candidate, you are encouraged to submit that person's name to Lee J. Suttner or a member of the Board. Qualifications for membership include a commitment to the well-being and mission of the Department, leadership and organizational skills, high professional stature and wide acquaintanceship, and a willingness to play an active role in securing financial support for the Department.

All active members of the Alumni Council automatically assumed three-year terms on the new Advisory Board. Elected officers of the Board are: President, Robert Boyer, Dean, College of Natural Sciences, University of Texas at Austin, and Vice-President, Michael Graham, Chief Scientist, Battelle Northwest Laboratories. Three standing committees were appointed by the new President. They include the Educational Planning Committee (Thomas Straw (Chair), Frank Pruett, Steve Young, Stephan Graham and Judson Mead); Industrial Liaison Committee (Michael Graham (Chair), Kim Thomas, Ann Petricca, Wayne Bundy and Robert Blakely); and Development Committee (Marcia Engle (Chair), Daniel Tudor, Richard Gibson, George Nevers, and Don Six).

The Educational Planning Committee has included a questionnaire in this newsletter to solicit your thoughts on the strengths and weaknesses of your education at Indiana University and to request recommendations for ways in which the Department can improve its curriculum. The Industrial Liaison Committee will be working with alumni employed in the general area of environmental geology to

identify avenues leading toward careers in this sector for future graduates of the Department. And thanks to a giant effort on the part of Marcia Engle, with generous help from the Development Office of the College of Arts and Sciences, the Development Committee recently completed a mailing to non-Indiana alumni of the Geologic Field Station in order to solicit contributions for maintenance of the Station. The Development Committee also is in the process of organizing Fall social functions for alumni in several major metropolitan areas. The thrust of the social events will be to re-establish contact and re-acquaint alumni with one another and to help them know first-hand what is going on within the Department. A faculty member likely will be present at each event.

## ALUMNI NEWS

In the last Newsletter, a call went out for identification of at least three of the geologists shown in Figure 3, page 20, participants on an April 15-16, 1950 field trip at Tunnel Mill, Indiana. Several persons responded and **Jim Stanley** (A.B., '50) wins a modest prize by identifying Pat Arken standing, facing the photographer and Dennis Lucas, Shorty Carpenter, and Bill Crites from right-to-left facing the outcrop. Others are not identified. A second prize, however, is being awarded to **Robert A. Bieberman** (A.B., '48; M.A., '50) who correctly pointed out that we made a stratigraphic blunder in stating that the students were looking at the New Albany Shale and instead suggests that they were looking at the Waldron Formation. Professor Don Hattin, our resident stratigrapher, when he first saw the issue, called Chairman Lee Suttner -- at home over dinner -- and admonished him. Suttner weakly blamed the error on our past editor who is a geophysicist. This year's editor was on sabbatical leave and pleads ignorance. In any case, Robert, thank you for catching us on this. You and Jim Stanley will each receive, in due course, a stylish Cross pen bearing the I.U. logo courtesy of the I.U. Alumni Association.

**Alawi, Jomaah** - M.A.(1979) Ph.D. (1986)  
Jomaah has been promoted to Professor of Economic Geology at King Saud University, Riyadh, Saudia Arabia.

**Al-Jassar, Tariq** -M.A. (1981) Ph.D. (1986)  
is employed with the Geological Survey of Iraq.

**Armstrong, Cecilia** - B.S. (1988)  
is employed as an environmental geologist in Houston,



Texas. She is working on site cleanup and design of remediation systems for underground gasoline storage.

**Ausich, William I** - M.A. (1976) Ph.D. (1978)  
now holds the rank of Full Professor at the Ohio State University, Columbus.

**Ballard, Wm. Turpin** - M.S. (1985)  
is a Remedial Project Manager in the Superfund Program with the U.S. Environmental Protection Agency, based in Chicago.

**Becker, Michael** - M.S. (1988) is a hydrogeologist at ERM-Northeast in Albany, New York.

**Boyer, John E.** - B.S. (1986)  
is currently a project geologist for the environmental consulting firm, IT Corporation, Chicago, Illinois.

**Bork, Kennard B.** - M.A. (1964) Ph.D. (1967)  
has been conferred with the Denison College Alumni Chair. He also continues as Secretary of the Earth Sciences Society.

**Brown, Josh** - B.A. (1990)  
is currently working with Osborne Incentive Company in Atlanta. He designs and implements sales incentive and marketing programs for major corporations.

**Bruns, Thomas M.** - M.A.T. (1979)  
left the Indiana Department of Natural Resources in May 1989, to become Principal Hydrologist with the Indianapolis Water Company. He is responsible for the company's groundwater development projects and for preparing a well head protection plan for new fields.

**Cameron, Donald K., Jr.** - M.A. (1954)  
has been Manager of Stratigraphic Sciences for Chevron Overseas Petroleum, Inc. in San Ramon, California, where he has supervised the bio/lithostratigraphic staff responsible for overseeing Chevron's worldwide stratigraphic projects.

**Chew, Brian E., Sr., P.G.** - B.A. (1979)  
was recently promoted to Assistant Vice President of Law Environmental in Charlotte, North Carolina. He is a principal hydrogeologist specializing in remediation of petroleum-contaminated sites.

**Clements, Edward J.** - B.S. (1983)  
is currently pursuing a master's degree at Indiana University. He is a geologist with AMAX Coal Industries in Indianapolis.

**Coe, E. Arnold** - M.A.T. (1966)  
is currently superintendent/principal of an eastern Oregon school district. He visited the Geologic Field Station in June 1990. He was a student there in 1966 as a member of the National Science Foundation Academic Year Institute of 1965-66 and served as a teaching assistant at the Station in 1967.

**Deputy, Tom** - B.S. (1964) joined Handex of Maryland, Inc. as Operations Manager.

**Dombrowski, Thomas** - M.A. (1982) Ph.D. (1992)  
is now in the Research Department at Engelhard Minerals and Chemicals Corporation in Edison, New Jersey.

**Duc, Aileen Wojtal** - M.A. (1975)  
has been living in Surrey, England, since 1987 with her husband, a geophysicist with Arco British, and their three children.

**Elzea, Jessica** - M.S. (1987) Ph.D. (1990)  
is in charge of the Industrial Minerals Analytical Section at McCrone Laboratories in Chicago, Illinois.

**Farley, Martin** - M.A. (1982)  
is a senior research geologist with Exxon Production Research Co. in Houston. He is part of the Global Tectono-Stratigraphic Framework Group.

**Fields, Rudy** - B.A. (1982)  
is currently employed by the Indiana Department of Environmental Management where he works as a geologist in the Technical Support Section of the Office of Environmental Response.

**Friberg, James** - M.A. (1967) Ph.D. (1970)  
**Friberg, Kathy (Sommer)** - A.B. (1967) M.A.T. (1969)  
are now making their home in Sunbury, England, where Jim is Exploration Manager for the United Kingdom Division of Unocal.

**Georgesens, Kurt** - B.S. (1985) is with G.E. Aircraft Engines in Madisonville, Ky. He works in the Chemical/Metallurgical Laboratory.

**Gerkie, Tammie** - B.S. (1988)  
is a Ph.D. student at the University of Cincinnati.

**Gosine, Rajindra** - M.S. (1989)  
is an engineering geologist with the Division of Water, Indiana Department of Natural Resources in Indianapolis.

- Hamilton, Michael** - B.S. (1969) M.A. (1975)  
is employed as a geologist with the U.S. Bureau of Mines in Spokane, Washington and is currently engaged in a three-year program to evaluate the mineral resources of the Toiyabe National Forest in central Nevada.
- Henry, Gary E.** - M.A. (1958)  
continues as an independent geologist out of Wichita Falls, Texas. He recently completed a term as President of the Southwest Section of AAPG, was chosen as the Southwest Section representative to the AAPG Advisory Council for a three-year term, and has been appointed to the AAPG Nominating Committee.
- Houck, Karen** - M.A. (1982) is a Ph.D. student at the University of Colorado, Boulder.
- Keener, Charles** - B.S. (1988)  
has received his Master's Degree from the University of New Orleans and is now working for Applied Earth Sciences, Richardson, Texas.
- Kopec, Charistopher J.** - B.S. (1985)  
is currently employed as an Environmental Specialist with Southwestern Laboratories, Dallas, Texas.
- Kottlowski, Frank** - B.A. (1947) M.A. (1949) Ph.D. (1951) retired on April 30, 1991, after nearly forty years of distinguished work as an economic geologist with the New Mexico Bureau of Mines and Mineral Resources, the last 18 years as Director and State Geologist.
- Kring, David** - B.S. (1984) is on the research faculty at the University of Arizona.
- Lane, Mike** - M.A. (1967) Ph.D. (1970)  
is a geological consultant with the Research Center, SUNY College at Oswego. The group specializes in providing solid waste management information to citizens' groups and local governments.
- Loretto, Thomas M.** - M.A. (1984)  
has continued working in geophysics with Texaco since receiving his masters degree from I.U.
- MacDaniel, Edward** - B.S. (1988)  
is a staff geologist with an environmental engineering company in the San Francisco area.
- Mangold, Kent** - B.S. (1979) M.A. (1980)  
Kent and his wife Sherry are living and working in Sumatra, Indonesia, for Caltex Pacific Indonesia, near the town of Pekanbaru in central-East Sumatra.
- Merkel, Roland** - M.S. (1985) Ph.D. (1989)  
is in the Research Department at Sud-Chemie in Moosbary, Germany.
- Merkley, Patricia** - M.S. (1992) is working for Exxon in Midland, Texas.
- Middleman, Bruce** - M.S. (1987)  
is a hydrogeologist for McLaren/Hart Environmental Engineering Corporation in Philadelphia.
- Moreau, Peter A.** - M.A. (1978)  
is now a Senior Geophysicist in the Mapping and Graphics Group, Union Pacific Resources, Fort Worth, TX.
- Mound, Michael** - M.A. (1961) Ph.D. (1963)  
is now employed by Gamma-Metrics of San Diego, California, where he is Director of Sales for Analytical Instrumentation.
- Nelson, Allen** - M.A. (1971) lives in Tacoma, Washington, and is a geological engineer for Weyerhaeuser.
- Nieman, Sam** - B.S. (1988) is a project geologist with Farlow Environmental Engineers in Indianapolis.
- Olson, Carolyn** - M.A. (1977) Ph.D. (1979) is a hydrologist with the U.S. Geological Survey in Reston.
- Oslund, Jeff** - M.S. (1979)  
has become Senior Staff Geophysicist in the Offshore Exploration District of MAXUS Energy in Dallas.
- Pirie, Gordon** - B.S. (1958) M.A. (1961) Ph.D. (1963)  
continues as Senior Geologist with Schlumberger Well Services in the Interpretation Development Group in Houston. His wife, **Deborah**, is finishing her doctoral degree in statistics.
- Porter, Elise** - M.A. (1979) Ph.D. (1983)  
has completed her law degree at the Ohio State University.
- Proctor, Paul** - Ph.D. (1949)  
is currently an adjunct professor at Brigham Young University in Provo. Two projects have been published recently -- his contributions to a color-illustrated Mineral-Rock Handbook by Macmillan and a second via Paulmar Publishers in Provo: Silver, Sinners and Saints (A History of Old Silver Reef, Utah). Paul is still active in mining

exploration and is currently President of a small gold mine development company.

**Pruett, Robert - M.S. (1988)**  
is in the Research Department at English China Clay America at Sandersville, Georgia.

**Reisch, Franz - M.S. (1991)**  
has joined the research group at Oil-Dri Corporation at Vernon Hills, Illinois.

**Robertson, Rebecca - B.S. (1983)**  
is finishing her third year teaching physical, historical, and environmental geology at Virginia Western Community College in Roanoke, Virginia.

**Rooney, Carol Bangs - M.S. (1988)** is working with Texaco in New Orleans.

**Rousch, Susan - B.S. (1976)**  
lives in Calgary, Alberta, Canada, and is busy with family and community activities which includes serving as Head of the Advisory Planning Commission for fundraising for the Alberta Children's Hospital.

**Salter, Timothy - B.S. (1978) Ph.D. (1988)**  
is working in the Minerals Institute at the University of Kentucky.

**Seelen, Mark A. - M.A. (1981)**  
is now in Portland, Maine, where he has been a project manager for ABB Environmental Services.

**Schultz, Wendy Ray - M.S. (1986)**  
is with Texaco-Western Exploration Division in Denver.

**Shaffer, Elizabeth - B.S. (1990)**  
is a Ph.D. student at the California Institute of Technology.

**Sieverding, Jayne - M.A. (1981)**  
is an exploration geologist with Chevron in Houston.

**Smith, Carl - A.M. (1969)**  
is Deputy Director for West Virginia Geological Survey.

**Smith, Synthia - B.S. (1978)**  
Geoscience Training Coordinator for Exxon Company, USA, has been very active with the AAPG-sponsored group of managers working on industry training issues.

**Stanley, James - B.A. (1950)**  
retired several years ago from evaluating oil and gas properties and examining drilling ventures for the IRS. He and his wife live north of Atlanta, Georgia. He pursues his hobbies of writing science fiction and making silver jewelry, with emphasis on Herkimer diamonds.

**Stellavato, Nick - M.A. (1974)**  
is currently working for Science Applications International Corporation in Las Vegas, Nevada, which is the integrating contractor to the DOE on the high level radioactive waste disposal project at Yucca Mountain. He is manager of the project's Sample Management Facility.

**Tank, Ron - Ph.D. (1962)**  
is retired from his Professor of Geology position at Lawrence University in Appleton, Wisconsin.

**Trowbridge, Andrew - B.S. (1986)**  
is a staff environmental geologist with ATEC Environmental Consultants in Indianapolis, Indiana.

**Tudor, Daniel - B.S. (1955), M.S. (1957), Ph.D. (1972)**  
retired from Chevron Exploration and Production Services on July 31, 1992. He was named President of CEPS in 1984, after having been Vice-President of the Exploration Services for Chevron Geosciences since 1981 (which later reorganized and was renamed CEPS). Dan joined Chevron in 1956 and has enjoyed a long and distinguished career there.

**Tweddale, John B. - M.S. (1987)**  
is now Project Hydrogeologist for Environmental Resources Management, North Central, Inc., Deerfield, Illinois.

**Vandrey, M. Ross - B.S. (1989)**  
completed his M.S. degree at the University of Wisconsin, Madison in 1991 and began employment as a production geologist with the Offshore Division of Exxon Company, USA in New Orleans, Louisiana.

**Wang, Peggy - B.A. (1982)**  
has her own graphic design business, Middle Mountain Designs. Her company was awarded a Silver Medal in the 1991 Neographics Competition for a full-color direct mail piece done for Douglass College in New Brunswick.

**Wiley, Richard - B.S. (1958)** has sold his business and home and moved to Veracruz, Mexico.

**Wilson, Michael A.** - B.A. (1986)  
has moved to Colorado to work for Groundwater Technology's Government Services Division as a project manager/hydrogeologist.

**Woodfork, Larry** - B.S. (1964) M.A. (1965)  
Director and State Geologist of the West Virginia Geological and Economic Survey has been named the 1992 recipient of the Richard Owen Award. (See elsewhere under Departmental News.)

\* \* \* \* \*

*The deaths of the following alumni have been reported to us since the last Alumni Newsletter.*

- Axenfeld, Sheldon**  
(M.A. 1952) August 1988.
- Bates, Robert**  
(M.A. 1932) of Santa Rosa, California,  
July 8, 1991.
- Fidlar, Marion M.**  
(B.A. 1934; M.A. 1936; Ph.D. 1942),  
retired Chairman of the Board of Mountain Fuel Supply Company and a recipient of the Department's Richard Owen Award, April 9, 1991.
- Green, Thomas E.**  
(B.A. 1946) April 17, 1991.
- Jacques, David**  
(M.S. 1990) December 5, 1991.
- Kiper, Ruth**  
(B.A. 1942) November 22, 1990.
- Logue, Lester**  
(A.B. 1938) long-time member of the Department's Alumni Council, June 16, 1991.
- Reno, Robert G.**  
(B.A. 1941) November 6, 1991.
- Rogers, Benjamin Franklin**  
(B.A. 1935) February 19, 1990.
- Woodfork, Myra Fox**  
(M.A. 1964) July 8, 1991.

*We would like to extend our deepest sympathy to family and friends of the deceased.*

\* \* \* \* \*

## QUESTIONNAIRE

Please note the enclosed questionnaire and letter from Steven Young (Ph.D., 1975). We hope you will help us by completing the questionnaire and returning it to us as soon as possible in the envelope provided.



*Puzzler-of-the-year. A modest prize will be awarded to the first person to correctly identify all the persons in the above photo.*

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Haydn Murray  
James Murray  
George Nevers  
Sybil Nieman

Carolyn Olson  
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We hope that you will consider making a donation to the Department of Geological Sciences. Please make your check payable to:

#### I.U. FOUNDATION

You may specify that your donation go to any of the various funds which are maintained by the I.U. Foundation for the Department of Geological Sciences. You may specify a particular fund: Geological Sciences (department's general account); Ralph E. Esarey (geological research in Indiana); Galloway/Perry (research/educational needs of graduate students in paleontology, stratigraphy and paleoecology); Judson Mead Field Station (student/faculty support at the Field Station); John B. Patton (research on geology in Indiana); William Thornbury (student research in physical geology, with preference for geomorphology and glacial); Cumings/Malott (to encourage superior work by staff/students in geological sciences); Charles Deiss (to support scholarships to Field Station); Arch McPheeter's Student Loan (short-term, no-interest loans to geology majors); Excellence in Geology (undergrad scholarships, graduate research, summer field training), or the Geologic Field Station Maintenance Fund (improvements to physical facilities).

In 1988 a university account was established in memory of John B. Patton which specifies funds for the Library. Contributions to this fund should be made to Indiana University rather than the Foundation.

Mail your gift c/o:

Lee J. Suttner, Chair  
Department of Geological Sciences  
Indiana University  
1005 East 10<sup>th</sup> Street  
Bloomington, IN 47405

## ACKNOWLEDGMENTS

The Newsletter was compiled and edited by David Towell with major assistance from Sarah Burton and Kim Schulte. Help from Lee Suttner, Noel Krothe, and Barbara Hill is also appreciated. The College of Arts and Sciences Alumni office contributed partially to offsetting the printing expenses as well as mailing costs. The Alumni mailroom handled distribution. We appreciate their assistance.



*We need your help in identifying the location,  
date and people in the above photo.  
How many can you identify?*

Please fill out this sheet and return it to us so we have your news for the next newsletter. If you have a change of address, be sure to include it.

NAME:	DEGREE(S):	YEAR(S):
ADDRESS:		
MY NEWS IS:		

Please check if you would be willing, if contacted, to consult with our graduates concerning employment, career choices, etc., in your geographic area and/or with your company:

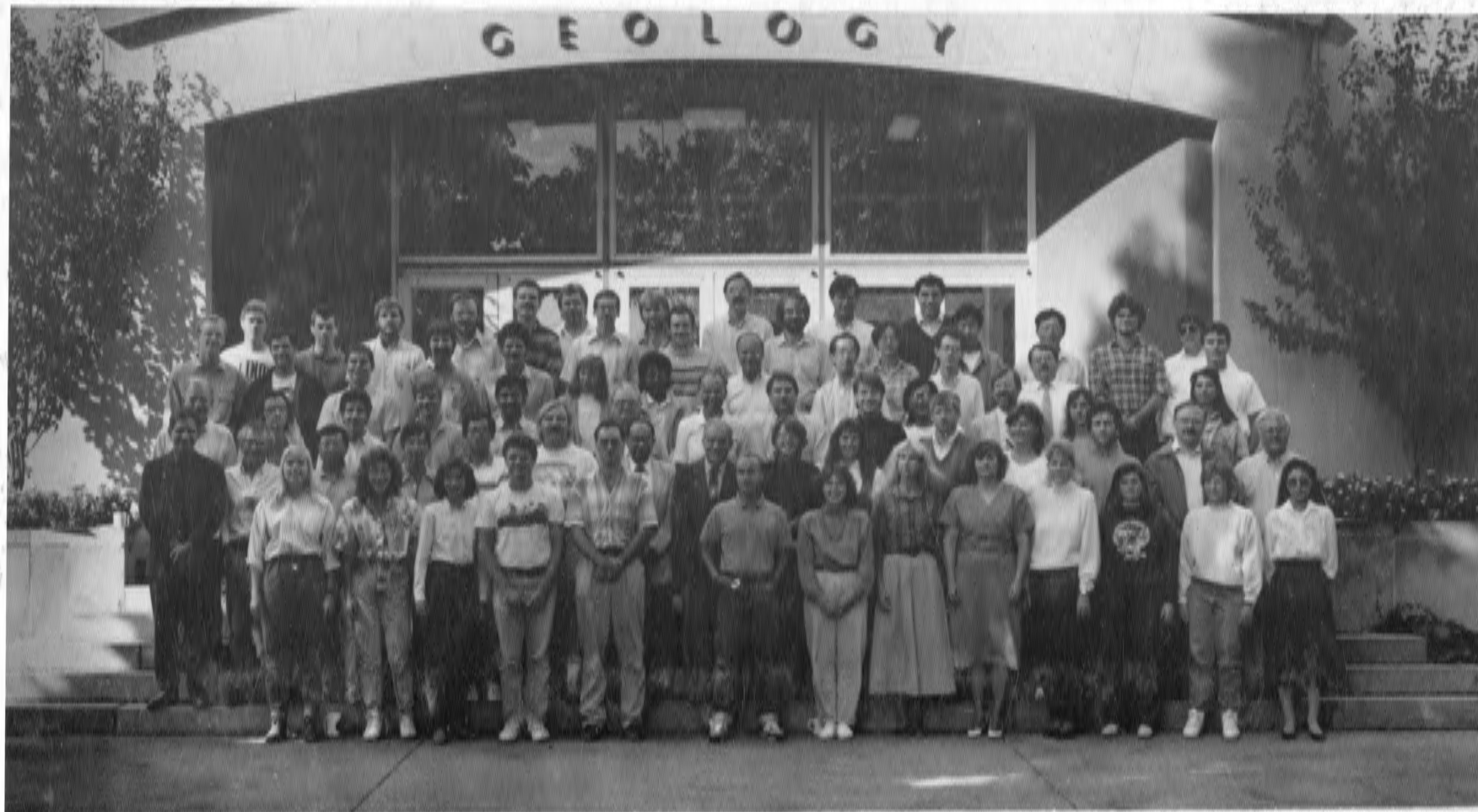
Please mail this sheet to:

Lee J. Suttner, Chair  
Department of Geological Sciences  
Indiana University  
1005 East 10<sup>th</sup> Street  
Bloomington, IN 47405



ADVISORY BOARD MEETING, FEBRUARY 14-15, 1992

Front Row (left to right): *Thomas Straw, Ann Petricca, Marcia Engle, Abhijit Basu, Robert Boyer, George Nevers, Lee J. Suttner, Kim Thomas*  
Back Row (left to right): *Richard Gibson, Steven Young, Judson Mead, Daniel Tudor, Robert Blakely, Frank Pruett, Michael Graham*



**BACK ROW**—*John Guthrie, Karl Leonard, John Holbrook, Bruce Douglas, John Jasper, and Mike Dorias*  
**FIFTH ROW**—*Michael Smith, Timothy Eckert, Mark Williams, Robert Wintsch, John Hohman, Steven Bennett, Mark Schult, Jane Hultberg, Changxing Qin, Yueting Chen, Brian Towell, and Janice Harste*  
**FOURTH ROW**—*Scott Wendorf, Michael Stewart, Glenn Bear, James Fitch, Michael May, Doreen Zaback, Ana Maria Carmo, Lee J. Suttner, Jon Fong, David Hirt, Nelson Shaffer, and David Newton*  
**THIRD ROW**—*John Hayes, Jeff Cutright, Katherine Freeman, James Collister, Mohammad Iqbal, John B. Droste, J. Robert Dodd, Michael Savarese, Matthew Averill, Glenn Hieshima, John Comer, Karan Keith, and Linda Pride*  
**SECOND ROW**—*Norman Hester, Albert J. Rudman, In Sung Lee, Yifeng Wang, Hai Chao George Yu, David Millen, Abhijit Basu, Charles Vitaliano, Andrea Koziol, Barbara Gruver, James Brophy, Eva Kocsardy, Raul Lira, Brian Keith, and N. Gary Lane*  
**FRONT ROW**—*Patricia Merkley, Yvonne Huff, Lisbeth Kovach, Clifford Ambers, Clayton Harris, Eric Lichtfouse, Suzanne Kairo, Ruth Droppo, Kim Schulte, Patty Byrum, Terry Stigall, Susan McDonald, and Xujia Weng*

**GEOLOGICAL SCIENCES SENIORS, GRADUATE STUDENTS, FACULTY, AND STAFF**

October 1, 1990



INDIANA UNIVERSITY

DEPARTMENT OF GEOLOGICAL SCIENCES  
1005 East Tenth Street  
Bloomington, Indiana 47405  
FAX: (812) 855-7899

July 1, 1992

Dear Alumni,

As you will soon learn from your Alumni Newsletter, the Alumni Council of the Department of Geological Sciences at Indiana University has adopted bylaws which formalize this organization into a new Advisory Board. The Board will serve as the primary link between the Department, its Alumni, and other organizations and individuals in advising the chairperson and faculty on long-range planning, policy, and program development. To that end we are writing to give you the opportunity, as a former student in the Department, to assist the Board in advising the Department.

The Department is examining its program in many areas; we would like your aid in helping the Board evaluate the Department's curriculum and course requirements for both undergraduate and graduate degrees. Specifically, we ask that you reflect on your geoscience education at Indiana University and identify aspects of your education which proved most and least valuable in your professional life. Also, with the benefit of 20/20 hindsight, what would you have done differently in your education and how could the Department have helped you to do so?

You are an important resource for the Department of Geological Sciences; your post-graduate "Life Experience" can provide valuable insight into how the curriculum could be improved. Would you please take some time and fill out the enclosed form and return it in the envelope provided.

We thank you in advance for your input. We hope to see you at one of the regional get-togethers for Indiana University alumni or at an upcoming meeting of one of our professional societies.

Sincerely,

A handwritten signature in cursive script that reads "Steven W. Young".

Steven W. Young, Ph.D. '75  
For the Advisory Board  
Department of Geological Sciences  
Indiana University





NAME \_\_\_\_\_

Current Employer \_\_\_\_\_ Position \_\_\_\_\_

Degree(s)    Year(s)

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Major Area of Study Within the Department

What aspects of your geoscience education were of most and least benefit (e.g. specific courses, certain teaching techniques, special projects)? Please be as detailed as you wish.

How could the Department have better prepared you to more adequately meet your post-graduate professional career needs?

Additional Comments:



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DEPARTMENT OF GEOLOGICAL SCIENCES  
INDIANA UNIVERSITY  
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