Department of Geology

Graduate Application Package

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Introduction and Facilities

Washington State University, student population 18,600, is located in eastern Washington on the edge of the Columbia River Basalt plateau only eight miles from the Idaho state line and the University of Idaho. The geology in the region is extremely varied with the rocks of the Idaho and Wallowa batholiths to the east and south, the Columbia River basalts and Cascade volcanics to the west, and the highly deformed and mineralized rocks of the Kootenai arc and the Coeur d'Alene and Republic mining districts to the north. Much faculty and student research takes advantage of this proximity to excellent field sites. In addition, a number of current projects are larger in scope and include economic mineral deposits in western North America, Asia, and South America, volcanology of the Canary Islands, tephra stratigraphy of the western United States, and studies of greenhouse gases in past atmospheres.

The Geology and Physics departments share a 12 story teaching and research complex. Graduate students and faculty have access to a wide range of state of the art equipment, and a technical staff of four to support their research activities. The department's GeoAnalytical Laboratory houses an automated Cameca electron microprobe for quantitative elemental micro-analysis and element mapping, a Siemens X-ray powder diffractometer for phase identification; an automated Rigaku X-ray fluorescence spectrometer and HP inductively coupled plasma mass spectrometer (ICP-MS) for major, trace and rare earth elemental analysis; and a Finnigan-MAT gas source mass spectrometer for oxygen, carbon and hydrogen isotope ratio determinations. Recent additions include a high resolution Thermo-Finnigan ICP-MS for ultra low trace element analysis, a multicollector Thermo-Finnigan ICP-MS for radiogenic and stable isotope ratios and a clean room for sample preparation. Other departmental equipment includes modern research quality microscopes equipped for cathodoluminescence, reflected light photometry, and fluid inclusion examination; an atomic absorption spectrophotometer and three gas chromatograghs with ECD, FID and TCD detectors; field hydrology equipment including an auger drilling rig; and mineral separation facilities. Other equipment is available via cooperative arrangements with the Department of Geology at the University of Idaho and the USGS Spokane Office.

Computing facilities include a student microcomputer laboratory equipped with 12 microcomputers, and printers, color flat bed and slide scanners, GeoRef database, large digitizing tablet and an extensive collection of geological software including ARCinfo and AutoCad. In addition, all graduate student offices are equipped with ethernet hubs. University facilities include an IBM 3090 mainframe computer, a Digital Image Analysis Laboratory, and a Scanning Electron Microscope Center. Thus, the students and faculty have excellent access to a wide variety of analytical equipment used in modern geological research.

The Department maintains close research ties with federal agencies, mining, oil, and environmental companies, and regional consulting companies. Strong ties with Hanford Nuclear Reservation and Battelle Pacific Northwest Laboratories offer additional, unique research opportunities for student research.

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Franklin F. (Nick) Foit, Jr., Professor

PhD (1968) University of Michigan foit@mail.wsu.edu (509) 335-3093

Professional Experience: Consultant for numerous companies and federal agencies. Former associate editor of American Mineralogist and currently associate editor for Canadian Mineralogist.

Awards/Honors/Memberships: Fellow of the Mineralogical Society of America, President's Award from Energy Minerals Division, American Association of Petroleum Geologists (AAPG) for best paper at annual meeting, foitite and magnesiofoitite, alkali-deficient end members of the tourmaline group, are named in recognition of my contributions to the understanding of tourmaline group crystal chemistry.

Research Interests: My research interests are currently focused in two areas: 1) Tephra chemistry, distribution and stratigraphy in the Pacific Northwest. Tephra deposits from Quaternary volcanic eruptions are useful time stratigraphic markers over much of the western United States. My research involves chemical and mineralogical characterization and dating of these deposits to establish not only the timing of eruption and distribution of airfall deposits from a particular eruptive center but also to provide an understanding of magma genesis and evolution. Much of the data collected forms a database which is also supports archaeological and paleoclimatological studies. Thus, much of my research on tephras is interdisciplinary and has both applied and basic aspects. 2) Crystal chemistry. The tetrahedrite group of mineral is extremely tolerant of chemical substitution. Studies of the chemistry, structure and occurrence of the mercurian and argentian members of this group are now being undertaken in an effort to better understand how the structure accommodates such an extensive and diverse substitutional chemistry.

Representative Publications:

Negrini, R.M., Erbes, D.B., Faber, K., Herrera, A.M., Roberts, A.P. Cohen, A.S., Wigand, P.E., and Foit, Jr., F.F., 2000, A paleoclimate record for the last 250,000 years from Summer Lake, Oregon, U.S.A.: I. Age control and magnetic lake level proxies, J. of Paleolimnology 24, 125-149.

Hallett, D. J., Mathews, R., and Foit, Jr., F.F. (2001) Mid-Holocene Glacier Peak and Mount St Helens We tephras found in lake sediments from southern Bristish Columbia, Canada using high resolution sampling, magnetic susceptibility, and electron microprobe analysis. Quaternary Research, 55, 284-292

King, M., Busacca, A.J., Foit, Jr., F.F., and Kemp, R.A. (2001) Identification of the Trego Hot Springs tephra in the Palouse, Washington State, U.S.A., Quaternary Research, 65, 165-169.

Gaylord, D.R., Foit, Jr., F.F., Schatz, J.K., and Coleman, A,J. (2001) Smith Canyon dune field history and paleoclimate, Washington, U.S.A.: Relations to glacial outburst floods and the Mazama eruption, Journal of Arid Environments, 47, 403-424.*

Foit, Jr., F.F. and Ulbricht, M.E. (2001) Compositional variation in mercurian tetrahedrite-tennantite from the hydrothermal deposits of the Steens-and Pueblo Mountains, Harney County, Oregon. Canadian Mineralogist, 39, 819-830.*

Kuehn, S.C. and Foit, Jr., F.F. (2001) Tephra stratigraphy at Summer Lake, a subbasin of pluvial Lake Chewaucan, Oregon in Quaternary Studies near Summer lake, Oregon, Guidebook for the Friends of the Pleistocene Annual Pacific Northwest Field Trip, pp.SK1-SK8 .*

Ertl, A., Hughes, J.M., Pertlik, F., Foit, Jr,, F.F., Wright, S.E., Brandstetter, F., and Marler, B. (2002) Polyhedral distortions in tourmaline. Canadian Mineralogist, 40, 153-162

Teaching Responsibilities: Introductory Mineralogy (undergraduate), Optical Mineralogy (undergraduate) Advanced Mineralogy (graduate), X-ray Analysis in Geology (graduate)

Recent Graduates:

Mary Ulbricht, M.S. (1997). Present employment: Community College Instructor

Steven Kuehn Ph.D. (2002). Present employment: College Professor

Potential Research Projects: Although a great deal of effort has been devoted over the past several decades to unraveling the tephra stratigraphy of the Pacific Northwest, much remains to be done. There are a large number active and dormant volcanic centers in this region which have contributed to its tephra stratigraphy about which very little is known. Thus, there is ample opportunity for the student to combine field and laboratory (electron microprobe, whole rock X-ray fluorescence analysis, X-ray diffraction) studies to gain a better understanding of tephra distribution and the volcanic history of the region. Other projects include integrated field and laboratory studies of sulfosalt group mineral deposits in the Pacific Northwest many of which are associated with ore deposits. The Department is very well-equipped to carry out these as well as other geochemical investigations.

David R. Gaylord, Professor
Ph.D. (1983) University of Wyoming gaylordd@wsu.edu (509) 335-8127

Professional Experience: Registered professional geologist (Wyoming, Washington). Consultant to mining and environmental geology companies Associate Editor, Northwest Science.

Memberships: American Association of Petroleum Geologists, American Geophysical Union, Society for Sedimentary Geology, International Association of Sedimentologists, Geological Society of America, International Association of Volcanology and Chemistry of the Earths Interior, Northwest Association for Science, Sigma Xi.

Research Interests: Current research concentrated in three areas: 1) Quaternary sedimentology and paleoclimatic studies in the western interior of the U.S. (eolian and outburst flood deposits), 2) modern and ancient sedimentary volcanic research near Mt St. Helens, northern Washington, southern British Columbia, Taranaki, New Zealand, and Vanuatu, and 3) hazardous waste-related sedimentology and stratigraphy research at and near the Hanford Site, Washington and Borden Site, Canada.

Representative Publications/Presentations:

Gaylord, D.R., Busacca, A.J., and Sweeney, M.R., 2003, The Palouse loess and the Channeled Scabland: A paired Ice-Age geologic system in Easterbrook, D.J., ed., Quaternary Geology of the United States, INQUA Field Guide Volume, p. 123-134.

Gaylord, D.R., Price, S.M., and Suydam, J.D.,2001, Volcaniclastic lacustrine deposits in the Republic Basin, northern WA: (White, J.D.L.and Riggs, N. eds.) IAS Sp. Publ. No. 30, Volcaniclastic Lacustrine Sedimentation, p. 199-222.

Gyalord, D.E., Foit, F.F., Schatz, J.K., Coleman, A.J., 2000, Smith Canyon dune field, Washington, U.S.A: relation to glacial outburst floods, the Mazama eruption, and Holocene paleoclimate, v. 47, p. 403-424.

Allen-King, R. M., Halket, R.M., Gaylord, D.R., 1998, Characterizing the heterogeneity and correlation of perchloroethene sorption and hydraulic conductivity using a facies-based approach: Water Resources Research, v. 34, p. 385-396.

Suydam, J.D., and Gaylord, D.R., 1997, The Toroda Creek half-graben, northeast Washington: Late stage sedimentary infilling of a synextensional basin: Geological Soc. Am. Bull., v. 109, p.1333-1348.

Stetler, L.D., and Gaylord, D.R., 1995, Evaluating eolian-climatic interactions using a regional climate model from Hanford, Washington (USA), J. of Geomorphology, v. 17, p. 99-113.

Gaylord, D.R., and Stetler, L.D., 1994, Eolian-climatic thresholds and sand dunes at the Hanford Site, south-central Washington, USA: Journal of Arid Environments, v. 28, p. 95-116.

Gaylord, D.R., Neall, V.E., and Palmer, A.S., 1993, The Maitahi Formation, A Mid-Pleistocene volcanic debris avalanche assemblage, Taranaki, New Zealand. (IAVCEI) Congress, Abs. with Programs.

Stokes, S., and Gaylord, D.R., 1993, Geochronology of the Clear Creek area: Ferris dune field: A test of optical dating: Quaternary Research, v. 39, p.274-281.

Teaching Responsibilities: Sedimentology and Sedimentary Petrology, Field Camp, Clastic Depositional Systems, Advanced Topics in Sedimentology, Environmental Geology, Petrology.

Some Recent Graduates:

Jason D. McClaughry MS (2003) Middle Eocene sedimentary and volcanic infilling of an evolving supradetachment basin: White Lake Basin, south-central British Columbia. Present employment as Independent Geologist, Missoula, MT.

Angela J. Coleman MS (2002) Sedimentology, stratigraphy, and paleoclimates of the St. Anthony Dune Field, eastern Idaho. Present employment, National Forest Service.

Jeremy Coughlin MS (2000). Sedimentology and geomorphology of the St. Anthony Dune Field, eastern Idaho. Present employment: Consulting firm in Minneapolis.

Scott Meyer MS (1999) Latah Creek pre-Late and Late Wisconsin glacial outburst flood depositional history. Present employment: U-Calif Sacramento.

Michelle Bart MS (1999) Recent evolution and recovery of the N.Fork Toutle River, Mount Saint Helens. Presently employment: teaching in Philadelphia area.

Jeff Matthews, PhD (1996) Stratigraphy and Sedimentology of the Eocene O'Brien Creek Formation, Okanogan Highlands, NE Washington, USA. Present employment: Director, Center for Advanced Spatial Computing & Distributed Education, Lewis Clark State College, Idaho.

Potential Research Projects: Currently funded projects are: 1) eolian-climatic interactions in the western U.S. (NSF), 2) sed and strat influences on contaminant sorption at Borden Site, Canada (NSF), Funding being sought for volcanic hazards research in New Zealand and Vanuatu as well as dispersal patterns of glacial outburst flood sediment on Columbia Plateau.

C. Kent Keller, Professor

Ph.D. (1987) University of Waterloo ckkeller@wsu.edu (509)335-3040

Research Interests: The interest underlying my research is understanding the relationships between physical processes and biogeochemical environments in vadose (unsaturated) zones. The occurrence and rates of many geologic processes -- carbon cycling, weathering, contaminant attenuation, microbial respiration -- depend on these relationships. My work aims to test our presently vague ideas about these dependencies, and develop practical predictive relationships emphasizing the control exerted by geologic settings. Almost all of this work involves innovative instrumentation for making in situ geochemical measurements, as well as physical and geochemical modeling.

An equally compelling line of research, quite different from that described above, is aimed at understanding the sustainability of our groundwater resource here on the Palouse of southeast Washington. We have here a classic instance of the semi-arid West problem: depletion of high-quality sole-source groundwater, with attendant questions about how serious the situation is, and what if anything should be done. Research in this area (collaborative with R. Allen-King) involves isotope-geochemical constraints on groundwater ages and recharge rates, and assessment of occurrence and fate of agricultural chemicals (applied to more than 90% of the land area). We collaborate in these studies with counterparts at the University of Idaho.

Representative Publications:

Bormann , B.T., C.K. Keller, D. Wang, and F.H. Bormann, 2002. Lessons from the Sandbox – Is undexplained nitrogen real? Ecosystems, in press.

Larson, K.R., C.K. Keller, P.B. Larson, and R.M. Allen-King, 2000. Stable isotope evidence for low recharge rate to a confined basalt aquifer: Implications for water resource development. J. Ground Water 38:947-953.

Keller, C.K., R.M. Allen-King, and R. O'Brien, 2000. A framework for integrating quantitative geologic problem-solving into courses across the undergraduate geology curriculum. J. Geosci. Education 48:459-463.

Selker, J.S., C.K. Keller, and J.T. McCord, 1999. Vadose Zone Processes. Lewis, 339 pp.

Keller. C.K., and D.H. Bacon, 1998. Soil respiration and georespiration distinguished by transport analysis of vadose CO_2, $^{13}CO_2$, and $^{14}CO_2$. Global Biogeochem. Cycles 12:361-372.

Bacon, D.H., and C.K. Keller, 1998. Carbon dioxide respiration in the deep vadose zone: Implications for groundwater age dating. Water Resour. Res. 34:3069-3077.

Berner, R.A., Rao, J-L., O'Brien, R., and C.K. Keller, 1998. Seasonal variability of adsorption and exchange equilibria in soil waters. Aquatic Geochem. 4:273-290.

O'Brien, R., C.K. Keller, and J.L. Smith, 1996, Multiple tracers of shallow groundwater flow and recharge in hilly loess. Ground Water 34:675-682.

Keller, C.K., and B.D. Wood, 1993, Possibility of chemical weathering before the advent of vascular land plants. Nature 364: 223-225.

Selected recent Graduates:

Tim White, MS (2001) Soil respiration in an experimental forest ecosystem. Present employment: groundwater consulting, Seattle, WA.

Rachel O'Brien, PhD (2000) Unsaturated flow and hydrogeochemistry beneath different plant covers: Field observations from the Hubbard Brook Sandbox Experiment. Present employment: Assistant Professor, Allegheny College, Meadville PA.

Kathryn Larson, MS (1998) Stable isotopes in the Pullman-Moscow basin, eastern Washington and north Idaho: Implications for the timing, magnitude and distribution of groundwater recharge. Present employment: groundwater consulting, Minneapolis, MN.

Diana Holford-Bacon, PhD (1997) Turnover and residence time of labile carbon in the vadose zone. Present employment: Senior Scientist, Battelle Pacific Northwest National Laboratory.

Potential Research Projects: organic carbon turnover rates in the vadose zone and relationship to global warming; controls on rates of silicate weathering and implications for the history of Earth's climate; water resources of the basalt aquifers of eastern Washington; pollution of sole-source aquifers by agricultural practices in southeastern Washington; the hydrogeology of chemical weathering.

Peter B. Larson, Professor and Chair
PhD (1984) California Institute of Technology plarson@wsu.edu (509) 335-3095

Professional Experience: Four years experience as an exploration geologist with various mining companies; Faculty of Geology at Washington State Univ. since 1983 (Chair in the Department of Geology since 1998); Two summers as a summer faculty at Lawrence Livermore National Laboratory, California; Sabbatical leaves at Centre de Recherches Petrographiques et Geochimiques, Nancy, France, Universite de Lausanne, Switzerland, and the Open University, Milton Keynes, UK.

Awards/Honors/Memberships: Past and present research funding from the National Science Foundation; Member of Society of Economic Geologists (Fellow), the Geochemical Society, the Geological Society of America, and the American Geophysical Union.

Research Interests: My major research interests include investigation of the processes of water/rock interaction in hydrothermal environments, and the sources of continental granites and ocean island magmas. I direct a stable isotope geochemistry laboratory at WSU. Recently, we have begun investigating variations in Cu isotope ratios in hydrothermal environments, an exciting new application of stable isotopes. Other current research topics include the application of stable isotope ratios in weathered basalts to Pliocene paleoclimatic reconstructions of the Pacific northwest.

Representative Publications:

Larson, P.B., Maher, K., Ramos, F.C., Chang, Z., Gaspar, M., and Meinert, L.D., In Press, Copper Isotope ratios in magmatic and hydrothermal ore forming environments: Chemical Geology.

Cole, D.R., Larson, P.B., Riciputi, L.R., and Mora, C.I., In Press, Oxygen isotope zoning profiles in altered feldspars and limits on the duration of convective hydrothermal circulation: Geology.

Rosenberg, P.E., and Larson, P.B., 2000, Isotope geochemistry of ankerite-bearing veins associated with the Coeur d'Alene Mining District, Idaho, Economic Geology, v. 95, pp. 1689-1700.

Wolff, J.A., Grandy, J.S., and Larson, P.B., 2000, Interaction of mantle-derived magma with island crust? Trace element and oxygen isotope data from the Diego Hernandez Formation, Las Cañadas, Tenerife, Canary Islands, Journal of Volcanology and Geothermal Research, v. 103, pp. 343-366.

Larson, P.B., and Sharp, Z.D., 1998, Mineral oxygen isotope ratios for the Boehls Butte-Goat Mountain metamorphic complex, Idaho: Evidence for fast cooling: American Journal of Science, v. 298, pp. 572-593.

Campbell, A.R., and Larson, P.B., 1998, Introduction to Stable Isotope Applications in Hydrothermal Systems: Chapter in "Reviews in Economic Geology", Society of Economic Geologists, v. 10, pp. 173-193.

Teaching Responsibilities: Undergraduate courses include Introduction to Geology (Geology 101), Field Petrology (Geology 206), a hand-sample lithology course; Graduate courses include Geochemistry of Hydrothermal Ore Deposits (Geology 571), Isotope Geochemistry (Geology 584).

Recent Graduate Students:

H. Hickes, Ph. D.(in progress) TOPIC: Stable isotope investigations of Tenerife magmatism, Canary Islands

A. Takeuchi, M.S. (in progress) TOPIC: Paleoclimate indicators in paleosols in eastern Washington

K. Maher, Ph.D. (in progress) TOPIC: Cu isotope ratios in hydrothermal systems

R. Lee, M.S. (in progress) TPIC: Tectonic and magmatic evolution of the Cretaceous suture zone in west-central Idaho

J. Thompson, M.S. (2001) An Oxygen Isotope Investigation of Hydrothermal Alteration in the Castle Mountain Mining District, Montana, M.S.

J. Grandy, M.S. (2000) Multiple Assimilants in Ocean Island Magma: O Isotope and Trace Element Evidence from Tenerife, Canary Islands, M.S.

Nevada.

Current and Potential Research Projects: Hydrothermally altered and mineralized rocks in the San Juan Mountains, Colorado, are continually being investigated. Many additional aspects of water/rock interaction in the San Juan hydrothermal systems are suitable for MS and PhD research projects. Other current research projects are investigating Cretaceous and Eocene tectonism, magmatism, and metamorphism in the inland Northwest Cordillera; cu isotope ratios in hydrothermal environments, magma/wall rock interaction and hydrothermal alteration on Tenerife, Canary Islands; and paleoclimatic reconstruction of the Columbia River Plateau.

Michael C. Pope, Assistant Professor

PhD (1995) Virginia Tech. mcpope@wsu.edu (509)335-5989

Professional Experience: Sr. Carbonate Geologist, Mobil Technology Corp., Dallas, TX, 1998-1999; Research Scientist, Massachusetts Institute of Technology, 1995-1998; Staff Geologist, Raney Geotechnical, W. Sacramento, CA 1989-1991; Staff Geologist, M.V. Engineering, Escondido, CA, 1985-1987.

Awards/Honors/Memberships: American Association of Petroleum Geologists, Geological Society of America, Society for Sedimentary Geology, International Association of Sedimentologists.

Research Interests: 1) Carbonate sequence stratigraphy – specifically the role that tectonics, climate and eustasy exert on the sedimentary rock record; 2) The record of carbonate deformation fabrics in meteorite or cryptoexplosive structures – what do they tell us about the mode and degree of deformation.

Representative Publications:

Pope, M. C., Bartley, J. K., Knoll, A. H., and Petrov, P. Y., 2003, Molar tooth structures in calcareous nodules, early Neoproterozoic Burovaya Formation, Turukhansk region, Siberia: Sedimentary Geology, v. 158, p. 235-248.

Pope, M.C., and Steffen, J. B., 2003, Widespread, prolonged Late Middle to Late Ordovician upwelling in North America: A proxy record of glaciation?: Geology, v. 31, p. 63-66.

Myrow, P.M., Pope, M.C., Goodge, J. M., and Fischer, W., 2002, Depositional history of pre-Devonian strata and timing of Ross orogenic tectonism in the central Transantarctic Mountains, Antarctica: Geological Society of America Bulletin, v. 114, p. 1070-1088.

Pope, M. C., and Grotzinger, J. P., 2000, Controls on fabric development and morphology of tufa and stromatolites, uppermost Pethei Group (1.8 Ga), Great Slave Lake, northwest Canada: in Grotzinger, J.P. and James, N. P. eds., Carbonate Sedimentation and Diagenesis in the Evolving Precambrian World, SEPM Special Publication 67, p. 103-121.

Pope, M. C., Grotzinger, J. P., and Schreiber, B. C., 2000, Evaporitic subtidal stromatolites produced by *in situ* precipitation: Textures, facies associations and temporal significance, Journal of Sedimentary Research, v. 70, p. 1139-1151.

Pope, M.C., and Read, J.F., 1998, Ordovician meter-scale cycles: implications for climate and eustatic fluctuations in the central Appalachians during a global greenhouse, non-glacial to glacial transition: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 138, p. 27-42.

Pope, M.C., and Read, J.F., 1997a, High-resolution stratigraphy of the Lexington Limestone (Late Middle Ordovician), Kentucky, U.S.A.: A cool-water carbonate-clastic ramp in a tectonically active foreland basin: in James, N.P., and Clarke, J.F., eds. Cool-Water Carbonates, SEPM Special Publication 56, p. 411-429.

Pope, M.C., and Read, J.F., 1997b, High-resolution surface and subsurface sequence stratigraphy of Late Middle to Late Ordovician (Late Mohawkian-Cincinnatian) Foreland Basin Rocks, Kentucky and Virginia: AAPG Bulletin, v. 81, p. 1866-1893.

Teaching Responsibilities: Physical Geology, Evolution and Earth History, Stratigraphy, Field Camp, Carbonate Depositional Systems

Potential Research Projects: 1) Sequence stratigraphic framework of Chesterian (Late Mississippian) rocks of southern Idaho and western Montana. 2) Calcite deformation studies of carbonate rocks from meteorite craters and cryptoexplosive structures: field based studies—Sierra Madera structure, west Texas; many sites in the U.S. Midcontinent. 3) Sequence stratigraphic framework of Pennsylvanian rocks of southern Idaho and western Montana. 4) Detrital zircon analyses of Neoproterozoic-Cambrian rocks of Washington, Idaho and Utah.

Philip E. Rosenberg, Professor

PhD (1960) Pennsylvania State University rosenberg@wsu.edu (509) 335-4368

Professional Experience: Postdoctoral Fellow, Princeton University - Visiting Scientist, U.S.G.S - Senior Fellow, University of Manchester, England - Visiting Professor, University of Manchester, England and University of Paris, France.

Awards/Honors/Memberships: NRC and Smithsonian Lecturer, India and China. Past research funding from National Science Foundation, American Chemical Society (PRF), Battelle-PNL, Westinghouse-Hanford. Member of Mineralogical Society of America, Geochemical Society, Clay Minerals Society and Societe Francaise de Mineralogie et de Cristallographie.

Research Interests: Experimental mineralogy and geochemistry; currently (1) the nature and stability of clay minerals and (2) the geology and geochemistry of geothermal systems in the Idaho batholith and geochemistry of quartz-carbonate veins associated with the Coeur d'Alene Mining District.

Representative Publications:

Rosenberg, P.E., 2002, The nature, formation and stability of end-member illite: A hypothesis. American Mineralogist, 87, 103-107.

Druschel, G.K. and Rosenberg, P.E., 2001 Non-magmatic fracture-controlled hydrothermal systems in the Idaho batholith: South Fork Payette geothermal system. Chemical Geology, 173, 271-291.

Rosenberg, P.E. and Larson,P.B., 2000, Isotope geochemistry of ankerite-bearing veins associated with the Coeur d'Alene Mining District, ID. Economic Geology, 95, 1689-1699.

Yates, D.M. and Rosenberg, P.E., 1998, Characterization of neoformed illite from hydrothermal experimens at 250°C and Pv = PH2O: An HRTEM/ATEM study. American Mineralogist, 83.1199-1208.

Yates, D.M. and Rosenberg, P.E., 1997, Formation and stability of end-member illite. II. Solid equilibration experiments at 100-250° c and Pv,soln. Geochem. et Cosmochim. Acta, 61, 3135-3144.

Rosenberg, P.E. and Hooper, R.L., 1997, The effect of chemical pretreatments on the composition of natural illite. Clays and Clay Min., 45, 486-488.

Yates, D.M. and Rosenberg, P.E., 1996, Formation and stability of end-member illite: I. Solution equilibration experiments at 100-250°C and $P_{V,H2O}$. Geochim. et Cosmochim. Acta 60, 1873-1883.

Rosenberg, P.E. and Hooper, R.L., 1996, Determination of the chemical composition of natural illites by analytical electron microscopy. Clays and Clay Min., 44, 569-572.

Teaching Responsibilities: Introduction to Geochemical Thermodynamics and Phase Diagrams, Metamorphic Petrology.

Recent Graduates:

Druschel, Gregory K., MS (1998) Geothermal Systems in the Idaho Balholith: Geology and Geochemistry. Present Position: Ph.D candkdate, University of Wisconsin, Madison WI

Zimmer, Michael, MS (1996) Geology and Geochemistry of the Boiling Springs Geothermal Area, Valley County, Idaho. Present employment: Computer Software Engineer, Portland, Oregon.

Krahmer, Michael, MS (1995) Geology and Geochemistry of Thermal Springs near Stanley, Idaho. Present employment: Senior Geologist, Karaha Bodas Co., LLC, Jakarta, Indonesia.

Douglas Yates, PhD (1993) Experimental investigation of the formation and stability of the end-member illite from 100° to 250°C and $P_{V,H2O}$. Present employment: Director, Materials Characterization Laboratory, Dept. of Materials Science and Engineering, University of Pennsylvania, Philadelphia, PA.

Wen Yang, PhD (1990) Solubilities of selected borosilicate minerals between 25° and 250°C and $P_V = P_{H2O}$. Present employment: Geochemist, EPA, California.

Potential Research projects: Geochemistry of clay minerals; experimental investigations in hydrothermal systems at elevated temperatures and pressures; mineralogical studies using instrumental methods; geothermal systems in or near the Idaho batholith ; Geochemistry of hydrothermal ore deposits.

Jeffrey D. Vervoort, Assistant Professor

PhD (1994) Cornell University vervoort@wsu.edu (509) 335-5597

Professional Experience: Ten years as a research scientist at the University of Arizona; Faculty member, Dept. of Geology, Washington State University since 2002.

Awards/Honors/Memberships: Past and present research funding from the National Science Foundation; Member of the Geochemical Society, the Geological Society of America, the American Geophysical Union, and the American Association for the Advancement of Science.

Research Interests: My area of research is radiogenic isotope geochemistry. Within this broad subject area my interests fall into two categories: using natural isotopic variations of elements such as Hf, Nd, Sr, and Pb to understand the origin and chemical evolution of the Earth and using radiogenic isotopes to determine the ages of rocks and geological events. In the first area, I have been examining geochemical problems in both ancient and modern rocks. Some specific projects include: 1) Hf-Nd-Pb isotopic evolution in the early Earth to determine the formation of the earliest continental crust and differentiation of the mantle; 2) Sm-Nd and Lu-Hf isotopic composition of chondritic meteorites to constrain the isotopic composition of the Earth; 3) determining the ^{176}Lu decay constant by comparative U-Pb and Lu-Hf studies of terrestrial magmatic rocks; 4) Hf-Nd isotopic and trace-element composition of subducting sediment and its contribution to subduction zones magmas; 5) the influence of subducted sediment on mantle composition and evolution; 6) high precision analysis of high field strength elements by isotope dilution to constrain their geochemical behavior in subduction zones; 7) Hf, Nd, and Pb isotopes as petrogenetic tracers in igneous rocks; 8) Sm-Nd and Lu-Hf isotopic constraints on middle and lower crustal melting, assimilation and differentiation; 9) provenance of sediments using Sm-Nd and Lu-Hf isotopes in whole rocks and U-Pb and Lu-Hf in detrital zircons. Projects in the region that I have been involved in have been centered around geochronological applications: 10) age fingerprinting of zircons in the sediments of the catastrophic flood deposits from the last glacial period in order to determine their source regions; 11) age and petrogenesis of the Idaho batholith and rocks of the cratonal margin; 12) age relationships between magmatism and mineralization in skarn deposits; 13) using Lu-Hf and Sm-Nd isotopes to date garnet growth/closure in metamorphic rocks; and 14) using Lu-Hf isotopes to date magmatic and biogenic apatites.

There are two critical elements in place at WSU for my research: a clean lab to dissolve samples and chemically separate the elements of interest in ultra-clean, contaminant-free environment and a multicollector-inductively coupled plasma-mass spectrometer (MC-ICP-MS) that can produce high precision isotopic measurements on a wide range of elements and isotopic systems. In addition, I have been developing procedures for U-Pb geochronology of zircons with laser ablation in conjunction with our high resolution ICP-MS. This new technique allows the rapid determination of zircon ages and is a useful geochronological tool that will be used by many members of the department.

Representative Publications:

Patchett, P. J., Vervoort, J. , Söderlund, U., and Salters, V.J.M., in review, Lu-Hf and Sm-Nd isotopic systematics in chondrites and constraints on the Lu-Hf properties of the Earth, Earth Planet. Sci. Lett.

Söderlund, U., Patchett, P. J., Vervoort, J. and Isachsen, C., in review, The ^{176}Lu decay constant determined by Lu-Hf and U-Pb isotope systematics of Precambrian mafic intrusions, Earth Planet. Sci. Lett.

Vervoort, J.D., Patchett, P.J., Blichert-Toft, J., and Albarède, F., Downes, H. and Rudnick, R., 2000, Hf-Nd isotopic evolution of the lower crust. Earth and Planetary Science Letters, v. 181, p. 115-129.

Vervoort, J.D., Patchett, P.J., Blichert-Toft, J., and Albarède, F., 1999, Relationships between Lu-Hf and Sm-Nd isotopic systems in the global sedimentary system. Earth Planet. Science Letters, v. 168, p. 79-99.

Vervoort, J.D. and Blichert-Toft, J., 1999, Evolution of the depleted mantle: Hf isotope evidence from juvenile rocks through time. Geochimica et Cosmochimica Acta, v. 63, p. 533-556.

Vervoort, J.D. and Patchett, P.J., 1996, Behavior of hafnium and neodymium isotopes in the crust: constraints from Precambrian crustally derived granites. Geochim. Cosmochi,/ Acta, v. 60: 3717-3723.

Vervoort, J.D., Patchett, P.J., Gehrels, G.E., and Nutman, A.P., 1996, Constraints on early Earth differentiation from Hf isotopes. Nature, v. 379, p. 624-627.

Vervoort, J.D., White, W.M., and Thorpe, R.I., 1994, Nd and Pb isotope ratios of the Abitibi greenstone belt: new evidence for very early differentiation of the Earth. Earth Planet. Sci. Lett., v. 125: 215-229.

Teaching Responsibilities: Undergraduate courses: Introductory Geochemistry (Geology 480), Radiogenic Isotopes and Geochronology (Geology 483); Graduate courses: Igneous Petrogenesis (Geology 563) Radiogenic Isotopes and Geochronology (Geology 583); Graduate seminar (Geology 598).

Current Graduate Students: Julie Prytulak, Megan Gerseny, Chunjiang Yu

Anthony J. Watkinson, Professor
PhD (1972) Imperial College, London watkinso@mail.wsu.edu (509)335-2470

Professional Experience: United Nations Geologist, South America; Research Fellow, Trinity College, Dublin; Maitre de Conference Associé, Rennes, France; Consultant, WGM, Echo Bay Mines, etc. Mapping experience in Western Alps, Scottish Highlands, New Zealand, and NW USA. Special Editor of Journal of Structural Geology, 1993.

Awards/Honors/Memberships: Invited lecturer; Penrose Conference, Alps, Switzerland. J.G. Ramsay Meeting, Zurich, Switzerland. Funding from the National Science Foundation (NSF). Member - Geological Society of America, Structural Geology and Tectonics Division, Tectonic Studies Group, Geological Society-London.

Research Interests: The principal theme underlying my research is to understand the mechanics of the physical process of how rocks fold, fracture and how mountain belts evolve. The basis of this process begins with detailed mapping in the best examples of well-exposed regions of deformed rocks. Analogues are then constructed using analytical models [e.g. Watkinson & Cobbold 1981, James & Watkinson 1993], physical models [e.g. Watkinson 1981, Watkinson 1993], computer simulation [e.g. Watkinson & Thiessen 1988] and strain constraint models [e.g. Ellis & Watkinson 1987]. The aim is to integrate all of these approaches to understand the birth, growth, and decay of mountain belt systems. Exciting new research is the rational mechanical analysis of the ductile/brittle transitions: we believe we have the first formulation using a viscoelastic rheology to deal with this transition[Patton & Watkinson, in press].

Representative Publications:

Patton, R., Watkinson, A.J. & Manoranjan V.S. 2000. Plate Formation at the Surface of a Convecting Fluid. J. Int Congress of Rheology, v.13.

Patton, R. and Watkinson, A.J., 1998, A continuum model for the Transition from flow to fracture in the Lithosphere. Journal of Conference Abstracts, vol 3[1],121.

James, A., and Watkinson, A.J., 1994, Initiation of folding and boudinage in wrench shear and transpression: J. Struct. Geol. v. 16 883-893.

Watkinson, A.J., 1993, A footwall system of faults associated with a foreland thrust in Montana: J. Struct. Geol., v. 15, p. 335-342.

Watkinson, A.J., and Thiessen, R.L., 1988, Geometric models of folding at Loch Monar, Scotland using computer simulation: Tectonophysics, v. 149, p. 1-15.

Ellis, M.A., and Watkinson, A.J., 1987, Orogen-parallel extension and oblique tectonics: The relation between stretching lineations and relative plate motions: Geology, v. 15:11, p. 1022-1026.

Watkinson, A.J., and Cobbold, P.R., 1982, Axial directions of folds in rocks with linear/planar fabrics: J. Struct. Geol., v. 3:3, p. 211-217.

Teaching Responsibilities: Introduction to Structures and Structural Analysis at both the undergraduate and graduate levels; Advanced Topics in Structure, i.e. Fracture Mechanics, Fold Theories, Rheology; Graduate level Tectonics co-taught with Prof. John Oldow [U. Idaho]; Honors Science and Mathematical Geology.

Recent Graduates:

Geraghty, Emily, MS: Reactivation of Mesoscale Structures in Strike-Slip and Thrust Faulting Regimes: Evidence from Les Matelles, France and the Sawtooth Range, Northwestren Montana. Present employment: NSF Ph.D. Fellowship, University of Montana.

James, Andrew, PhD: Mathematical models of folding in shear zones and transpressional regimes. Present employment: Assistant Professor U. of Florida, Mathematical Modelling of Groundwater Contaminants.

Patton, Regan, PhD: Continuum Models of Crustal Deformation. Present employment: Adjunct Assistant Scientist, WSU.

Koerber, Sarah, MS: Comparison of fault morphology and geometry in different rock types. Present employment: Consultant, Environmental Geologist.

Ellis, Michael A., PhD: Structural morphology and associated strain within parts of the U.S. section of the Kootenay Arc, NE Washington. Present employment: Associate Professor, Univ. Memphis Tn, Earthquake Hazard Reduction Center..

Price, Edwin H., PhD: Structural geometry, strain distribution, and mechanical evolution of Eastern Umtanum Ridge and a comparison with other selected localities within Yakima fold structures, South-Central Washington. Present employment: Senior Hydrogeologist, Geotrans, Inc., Las Vegas, Nevada.

Potential Research Projects: MS student projects are primarily field based, principally in NE Washington and the NW USA (e.g. Kootenay Arc, Kettle/Okanogan Core Complexes, Yakima Folds). I prefer PhD projects that involve at least some detailed mapping and can be region oriented or theme oriented. Some PhD projects have been predominantly theoretical and some have involved working in the the Alps and Scottish Highlands.

John A. Wolff, Professor
PhD (1983) University of London, United Kingdom jawolff@mail.wsu.edu (509)335-2825

Professional experience: Assistant and Associate Professor at the University of Texas at Arlington, 1983-1997; Associate and full Professor, WSU, 1997 – date. 15 months (cumulative) as visiting scientist at Los Alamos National Laboratory, 6 months as visiting scientist at the Institute of Earth Sciences, Barcelona, Spain; field experience on igneous rocks in the U.S., Canary Islands, Cape Verde Islands, New Zealand, Greenland, and U.K. Director of the WSU GeoAnalytical Lab.

Awards/Honors/Memberships: Funding from Department of Energy and National Science Foundation; invited lecturer, GSA, AGU and IAVCEI meetings; member of AGU, GSA, and MSA.

Research Interests: My broad interest is the behavior of magma in and on the Earth's crust, as deduced from physical and chemical analysis of volcanic rocks and minerals. Most of my research has focussed on the establishment and evolution of differentiated magmas in crustal reservoirs, and their behavior during volcanic eruptions. Methods typically used are detailed field description, followed by petrographic and geochemical analysis and microanalysis for major, trace elements and isotopes, and radiometric dating. Increasingly, I rely on microanalysis of rock components such as phenocrysts to yield petrogenetic information.

Representative recent publications:

Wolff, J.A. and Ramos, F.C., 2003. Pb isotope variations among Bandelier Tuff feldspars: no evidence for a long-lived silicic magma chamber. Geology 31, 533-536.

Strong, M. and Wolff, J.A., 2003. Compositional variations within scoria cones. Geology 31, 143-146.

Sumner, J.M. and Wolff, J.A., 2003. Petrogenesis of mixed-magma, high-grade, peralkaline igniumbrite 'TL' (Gran Canaria): diverse styles of mixing in a replenished, zoned magma chamber. J. Volcanol. Geotherm. Res. 126, 109-126.

Wolff, J.A., Balsley, S.D. and Gregory, R.T., 2002. Oxygen isotope disequilibrium between quartz and sanidine from the Bandelier Tuff, New Mexico, consistent with a short residence time of phenocrysts in rhyolitic magma. J. Volcanol. Geotherm. Res. 116, 119-135.

Teaching Responsibilities: Volcanology, igneous petrology and petrogenesis at both graduate and undergraduate levels, plus an introductory course in solar system science.

Potential Research Projects: Graduate research projects under my direction may be either field- or laboratory-based, or, preferably, combine both aspects. Specific NSF-supported projects currently underway include the following: (1) Insights into the dynamic behavior of large rhyolitic magma bodies through continuing studies of isotopic disequilibrium among phenocrysts and matrix in rhyolitic tuffs and lavas associated with the Valles caldera, New Mexico. (2) Mechanisms of caldera formation deduced from lithic fragment types and pumice compositions, also at the Valles caldera. (3) Crustal transport history of Columbia River flood basalts revealed by crystal isotope zoning studies.

Facilities in the GeoAnalytical Lab include XRF, electron microprobe, quadrupole, high-resolution magnetic sector, and multicollector ICP-MS instruments, and a 213 nm laser ablation system. We are performing a wide range of isotopic and elemental analyses on geological samples, including in-situ analysis using laser ablation. I anticipate that much of the research carried out under my direction over the next several years will exploit the analytical capabilities of these instruments.

HOW TO APPLY

Please complete each of the following steps:

_____ **Application Form**. Mail the yellow copy to the Department of Geology; mail the green copy to the Graduate School. If you are applying on-line using a credit card payment, both the Graduate School and the Department of Geology will receive a copy of the application form. If you are using an on-line form, you will need to print off two copies: one for the Graduate School and one for the Department of Geology.

_____ **Application Fee**. Attach the fee to the green copy of the application form. ***PLEASE NOTE: THE $35 APPLICATION FEE CANNOT BE WAIVED OR DEFERRED.***

_____ **Application for Assistantship**. Mail this form to the Department of Geology.

_____ **Official Transcripts** or attested mark sheets from all university-level institutions that you have attended (including field camp). Two sets are required as follows: one set must be mailed directly to the Department of Geology from the Registrar; one set must be mailed directly to the Graduate School directly from the Registrar.

_____ **Basic GRE Scores** (verbal, quantitative, and analytical). An official copy must be provided to the Department of Geology. Scores should not be more than 5 years old.

_____ **TOEFL Scores** (international applicants only). An official copy must be provided to both the Department of Geology and the Graduate School. Minimum score required is 550. Scores cannot be more than 2 years old.

_____ **Certificate of Financial Responsibility** (international applicants only). Return the completed form to the Graduate School. Evidence of financial independence is required before a Certificate of Eligibility can be issued (for immigration purposes). *Note: Decisions regarding aid begin February 1 for Fall semesters and December 1 for Spring semesters.*

_____ **Three Letters of Recommendation**. Please use the forms provided.

_____ **Statement of Intention**. Please submit a one-page statement of your intentions relative to graduate studies to the Department of Geology. Please address such issues as geologic interests, anticipated thesis research, career objectives, experience in geological research and teaching.

_____ **Email Release Form**. Please submit this form with an original signature if you wish to correspond via email with regards to your application.

Please ensure that all of the above information is provided. We are unable to evaluate your file if any of the above information is missing.

Department of Geology
Washington State University
Pullman, WA 99164-2812
(509)335-3009
(509)335-7816 FAX

Graduate School
Washington State University
Pullman, WA 99164-1030
(509)335-3535

Financial Aid Note *(domestic applicants only): Free application forms for Federal Student Aid (FAFSA--same form used nationwide) are available at all colleges and universities. Please contact your local institution to obtain this form. If this is not possible, please phone and we will gladly send you a copy.*

Application Deadlines for Department of Geology

	FALL SEMESTER	SPRING SEMESTER
DOMESTIC		
with aid	**February 1***	**December 1***
without	July 1	December 1
INTERNATIONAL		
with aid	**January 15***	**August 15***
without	January 15	August 15

***Department evaluation regarding assistantships generally <u>begins</u> February 1 for Fall semesters and December 1 for Spring semesters. Inasmuch as these dates are not absolute, please aim to complete your application as close to these dates as possible.**

<u>International Students outside the USA:</u>

The Graduate School maintains early deadlines for issuing I-20's (required by his/her country to receive exit visa--sometimes a lengthy process). This deadline precedes the department's date of decision regarding aid. Therefore, we recommend international students complete their application/file one semester prior to that they wish to attend.

Recommendation for Graduate Studies

Graduate Admissions
Department of Geology
Washington State University
Pullman, WA 99164-2812

_____
Name of Applicant

NOTICE TO WRITER OF STATEMENT AND APPLICANT: Public Law 93-380, Educational Amendments Act of 1974, grants students and graduates the right of access to letters of recommendation in their placement files. The opportunity to waive one's right to inspect such letters is also provided by the law.

I, the undersigned, hereby waive my right of access to the letter of recommendation written about me by _____.
Name of Referee

_____ _____
Signature of Applicant Date

How well do you know the applicant?

How does this student compare to his/her peers or graduating class? To other students you have recommended to WSU? To all students you have known?

Would you accept this student into your graduate program?

How would you rate the applicant's oral and written communication skills?

How well do you think the applicant would perform as a teaching or research assistant?

Overall recommendation: _____strongly recommend _____recommend with reservation
_____recommend _____do not recommend

Please add any additional comments about the applicant on the back of this form or in a separate letter and return to the address above. Thank you.

_____ _____ _____ _____
Signature of Referee Title/Dept. Organization Date

Recommendation for Graduate Studies

Graduate Admissions
Department of Geology
Washington State University
Pullman, WA 99164-2812

_____
Name of Applicant

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How well do you think the applicant would perform as a teaching or research assistant?

Overall recommendation: _____strongly recommend _____recommend with reservation
_____recommend _____do not recommend

Please add any additional comments about the applicant on the back of this form or in a separate letter and return to the address above. Thank you.

_____ _____ _____ _____
Signature of Referee Title/Dept. Organization Date

Recommendation for Graduate Studies

Graduate Admissions
Department of Geology
Washington State University
Pullman, WA 99164-2812

_____
Name of Applicant

NOTICE TO WRITER OF STATEMENT AND APPLICANT: Public Law 93-380, Educational Amendments Act of 1974, grants students and graduates the right of access to letters of recommendation in their placement files. The opportunity to waive one's right to inspect such letters is also provided by the law.

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How would you rate the applicant's oral and written communication skills?

How well do you think the applicant would perform as a teaching or research assistant?

Overall recommendation: _____strongly recommend _____recommend with reservation
_____recommend _____do not recommend

Please add any additional comments about the applicant on the back of this form or in a separate letter and return to the address above. Thank you.

_____ _____ _____ _____
Signature of Referee Title/Dept. Organization Date

GEOLOGY GRADUATE PROGRAM REQUIREMENTS
AT WASHINGTON STATE UNIVERSITY

The Geology graduate program requirements are in accordance with the Graduate School Policies & Procedures manual found at http://www.wsu.edu/~gradsch/polproc.html#categories. However, further departmental requirements are outlined below. Additionally the Graduate Student Code can be found at http://www.wsu.edu:8080/~gradsch/stdtcode.html.

All graduate students are required to choose an area of specialization in Geology (see attached). The area of specialization should be one of, or a combination of not more than two areas. Students should select a committee consisting of an advisor and two faculty members; they will also serve as your examining committee. Program forms must be filled out, with the help of your advisor, and filed with the Graduate School as follows: M.S. - prior to the end of 1st semester; Ph.D. - prior to end of 2nd semester. Students whose programs are not filed with the Graduate School by the end of the second semester of residence will not be reappointed. Additionally, a 1-2 page thesis, non-thesis, or dissertation proposal must accompany your program. The choice of course options and electives on the program will be based on the student's research interest and needs. Undergraduate prerequisites must be satisfied for all courses within the selected program, and will not count for graduate credit.

Assuming one-half time employment, the normal time for completion of graduate degrees is as follows:
M.S.--2 calendar years; Ph.D. with previous M.S.--3 calendar years; Ph.D. without previous M.S.--4 calendar years. Departmental financial support will ordinarily not extend beyond these time limits.

Departmental program requirements for 500-level graded major course work is as follows:

M.S. thesis/non-thesis	15 hours instead of 9 as required by the Graduate School
Ph.D.	30 hours instead of 17 as required by the Graduate School

One of the following is also required of all Ph.D. candidates.
1. Two courses in computer science and/or statistics, meeting thesis committee approval.
2. Math through differential equations (Math 315) or a committee approved equivalent.
3. Passage of the WSU Graduate Foreign Language Translation Exam in languages other than native tongue. For foreign students, passage of the English Proficiency Exam would satisfy this requirement.
4. Two courses in chemistry or physics at or above the WSU 300 level.

Note that these are minimum departmental requirements. In some Ph.D. programs of study a higher level of proficiency in more than one of these supporting subjects (for example, math and chemistry) may not only be desirable but required by the thesis committee.

In addition to the aforementioned program requirements:
1. All graduate students must enroll in Geology 598 (seminar) for two semesters.
2. All graduate students should register for sufficient Geology 700, 702 or 800 to bring their total semester load to 14-16 credit hours when on appointment. All graduate students with office space and/or using departmental facilities, and/or expecting supervision must enroll for a minimum of 2 credit hours/semester of Geol 700, 702, or 800 (1 credit hour/Summer Session--*when not enrolled in Geol 508*). Further specific enrollment requirements are outlined in the Graduate School Policies & Procedures manual.

Annual review of the student's progress will be conducted each Spring.

The M.S. thesis is expected to be a publishable contribution to the science of geology (in this option the problem and research program culminating in a thesis are more comprehensive than those in the non-thesis option). A final oral exam is required to test the candidate's knowledge of geology with emphasis on the work presented in the thesis. In the M.S. non-thesis option, a formal written project report as well as an oral exam are required. The oral exam is not intended to be a defense of the special project report but will focus on the candidate's general knowledge of geology.

The Ph.D. dissertation should be a significant contribution to the science of geology, worthy of publication in refereed international journals. Preliminary and final exams will be in accordance with the Graduate School Policies & Procedures manual.

Scheduling final exams: In addition to the requirements set forth in the Tabular Summary, the Dept. of Geology requires a complete, typed copy of the thesis/dissertation (to include abstract, table of contents, text, figures, tables, references, appendices, and maps) be submitted to the Department Chair by April 1 for Spring graduation and November 1 for Fall graduation.

Two unbound copies of the completed thesis or dissertation must be turned in to the Geology Office the same day they are submitted to the Graduate School (one for the advisor, one for the thesis cabinet). Two copies of the special project report must be turned in to the Geology Office within 5 days of the oral exam.

SEDIMENTOLOGY-STRATIGRAPHY-PALEONTOLOGY

Core Courses:

511	(3)	Advanced Topics in Paleontology
520	(3)	Advanced Topics in Sedimentary Rocks
521	(3)	Clastic Depositional Systems
523	(3)	Advanced Topics in Stratigraphy
525	(3)	Carbonate Depositional Systems

Additional Courses:

428 ID	(3)	Geostatistics
508	(3)	Advanced Field Methods
515 ID	(3)	Paleoecology
528 ID	(3)	Petrology of Carbonate Rocks
529 ID	(3)	Geologic Development of North America
540	(3)	Tectonics
541	(3)	Structural Analysis
552	(3)	X-ray Analysis in Geology
571	(3)	Geochemistry of Hydrothermal Ore Deposits
577	(3)	Advanced Groundwater Hydraulics
591	(3)	Remote Sensing and Geologic Applications

Designing a Graduate Course Program:
Graduate study in sedimentology, stratigraphy, and paleontology requires a fundamental knowledge of the principles of each of these areas. For the graduate program the student will select a research project in one of, or any combination of, the general areas of sedimentology, stratigraphy, or paleontology for the thesis or dissertation topic.

M.S. students are required to include 521, 523, 525, and one additional core course within their program.

Ph.D. students are required to include four of the five core courses within their program.

STRUCTURAL GEOLOGY - TECTONICS

Required Courses, M.S.:

Geol	540	(3)	Tectonics
Geol	541	(3)	Structural Analysis
Geol	592	(V)	Adv. Topics in Structural Geol.

Recommended Course, M.S.:

Geol	591	(3)	Remote Sensing and Geologic Applications
Geol	505	(3)	Geophysics

Ph.D. Program:
In addition to the above, the following course is required:

Geol	428	(3)	Geostatistics (UI) or an advanced math course (Diff. Equations or above)

Modern structural geology and tectonics is becoming increasingly quantitative. Therefore, we strongly recommend that you take advanced mathematics and computer courses, e.g. Math 440, Math 570.

Designing a Graduate Course Program:
Because structures and tectonics are frequently related to most other branches of geology, the additional courses in your program will be selected according to your interests.

Examples: (if you are interested in)

Structural Control of Economic Deposits

Geol	470	(4)	Intro. to Econ. Geol.
Geol	551	(3)	Ore Microscopy & Fluid Inclusion Anayl
Geol	571	(3)	Geochem. Hydrotherm. Ore Depos.
Geol	573	(3)	Adv. Topics Econ. Geol.
Geol	584	(3)	Stable Isotope Geochemistry

Deformation Mechanisms

Geol	550	(3)	Adv. Mineralogy
Chem	331	(3)	Physical Chemistry
MSE	413	(3)	Mechanics of Solids
Math	440	(3)	Applied Math.
Math	570	(3)	Found. Cont. Mech. I
Math	571	(3)	Found. Cont. Mech. II

Igneous and Metamorphic Petrology

Geol	480	(3)	Introductory Geochemistry
Geol	552	(2)	X-ray Analysis in Geology
Geol	582	(3)	Petrologic Phase Equilibria
Chem	331	(3)	Physical Chemistry

Stratigraphy/Sedimentology

Geol	320	(3)	Sed. Petrol. & Sedim
Geol	421	(3)	Princ. of Stratigraphy
Geol	521	(3)	Clastic Dep. Systems
Geol	529	(3)	Geol. Devp. N. America

Remote Sensing

SoilS	374	(3)	Remote Sensing & Airphoto Interpretation	
Geol	575	(1)	Seminar in Remote Sensing	
ES/RP	586	(4)	Intro. to Geographic Info. Systems (WSU)	) one of
ES/RP	575	(3)	Geographic Info. Systems (UI)	) these two

MINERALOGY-PETROLOGY-GEOCHEMISTRY

M.S. Core Courses:

Geol	550	(3)	Advanced Mineralogy
Geol	560	(3)	Advanced Igneous Petrology
Geol	582	(3)	Petrologic Phase Equilibria*

Ph.D. Core Courses:
In addition to the above, the following are required:

Geol	552	(3)	X-ray Analysis in Geology
Geol	563	(3)	Igneous Petrogenesis
Geol	584	(3)	Stable Isotope Geochemistry

Additional Recommended Courses:

Geol	362	(2)	Metamorphic Petrology
Geol	470	(4)	Introduction to Economic Geology
Geol	480	(3)	Introductory Geochemistry
Geol	540	(3)	Tectonics
Geol	551	(3)	Ore Microscopy and Fluid Inclusion Analysis
Geol	552	(3)	X-ray Analysis in Geology
Geol	554	(3)	Physical Petrology (UI)
Geol	557	(3)	High Temperature Aqueous Geochemistry I (UI)
Geol	558	(3)	High Temperature Aqueous Geochemistry II (UI)
Geol	561	(3)	Advanced Topics in the Geochemistry of Hydrothermal Ore Deposits (UI)
Geol	563	(3)	Igneous Petrogenesis
Geol	567	(3)	Volcanology
Geol	571	(3)	Geochemistry of Hydrothermal Ore Deposits
Geol	573	(2)	Advanced Topics in Economic Geology
Geol	583	(3)	Radiogenic Isotopes and Geochronology (UI)
Geol	584	(3)	Stable Isotope Geochemistry
Geol	588	(4)	Isotope Geology (UI)
Chem	331/ 332	(3)	Physical Chemistry

*Additional chemistry may be required in some programs.

Designing a Graduate Course Program:
An undergraduate program comparable to that at Washington State University, including a course in geochemistry, is prerequisite to graduate study in these areas of specialization. The Ph.D. program will include at least 18 hours of core courses; the M.S. program at least 9 hours of core courses. The remainder of the program will consist of courses selected from the above list and/or departmental or interdepartmental graduate-credit courses. Individual programs will be designed to provide the background and proficiency appropriate to the area of specialization and degree sought.

HYDROGEOLOGY

Students pursuing an advanced degree with specialization in hydrology should have completed an undergraduate program that includes course work having a content analogous to that in:

Geol	206	(3)	Field Petrology
Geol	340	(4)	Geologic Structures
Geol	350	(4)	Mineralogy & Crystallography
Geol	308	(6)	Geology Field Camp
Geol	320	(3)	Sedimentary Petrology and Sedimentation
Geol	475	(3)	Groundwater
CE	315	(3)	Mechanics of Fluids
Math	315	(3)	Differential Equations

In addition, many students find the following course work beneficial?

CE	315	(3)	Mechanics of Fluids

Required Courses, M.S.:

Geol	569	(2)	Field Methods in Hydrogeology
Geol	577	(3)	Advanced Groundwater Hydraulics
Geol	582	(3)	Petrologic Phase Equilibria

Two of the following:

Geol	428 ID	(3)	Geostatistics
Geol	521	(3)	Clastic Depositional Systems
Geol	570	(V)	Advanced Topics in Hydrogeology (Organic Contaminants)
Geol	584	(3)	Stable Isotope Geochemistry
CE	518	(3)	Hazardous Waste Engineering
		or	
		(4)	
CE	576	(3)	Dynamics of Groundwater Contamination

Required Courses, Ph.D.:

Students pursuing the Ph.D. degree should have completed <u>all</u> of the courses listed under the requirements of the M.S. program and, in addition, are expected to take:

CE	550	(3)	Intermediate Fluid Mechanics

Additional Courses:

Depending upon the individual student's major interest within the ground-water discipline, additional studies will be selected from the following list:

Geol	480	(3)	Introductory Geochemistry
Geol	505	(4)	Geophysics
Geol	520	(3)	Advanced Topics in Sedimentary Rocks
Geol	523	(3)	Advanced Topics in Stratigraphy
Geol	525	(3)	Carbonate Depositional Systems
Geol	540	(3)	Tectonics
Geol	541	(3)	Structural Analysis
Geol	552	(3)	X-ray Analysis in Geology
CE	515	(3)	Environmental Measurements
CE	518	(3) or (4)	Hazardous Waste Engineering
CE	519	(3)	Hazardous Waste Treatment
CE	540	(3)	Instrumental Analysis of Environmental Contaminants
CE	560	(3)	Advanced Hydrology
CE	576	(3)	Dynamics of Groundwater Contamination
CE	584	(2)	Engineering Aspects of Aquatic Biology
Chem	527	(2)	Environmental Chemistry

Additional courses:

Math	441	(3)	Applied Math II
Math	448	(3)	Numerical Analysis
SoilS	513	(2)	Advanced Soil Physics
SoilS	521	(3)	Advanced Soil Chemistry
SoilS	537	(3)	Soil Biochemistry
SoilS	551	(3)	Advanced Pedology

WASHINGTON STATE UNIVERSITY

THE GRADUATE SCHOOL

P.O. BOX 641030
PULLMAN, WASHINGTON 99164-1030

APPLICATION FOR FELLOWSHIP AND/OR ASSISTANTSHIP

This application is to be completed by assistantship and fellowship applicants only and mailed to the chair of the department. Washington State University is an Equal Opportunity Employer.

Name in Full _____
(Last) (First) (Middle)

Social Security# _____ Telephone _____
(Area Code)

Present Address _____
(Street) (City) (State) (Zip Code)

Are you a citizen of the U.S.A.? Yes ☐ No ☐ Country _____ Type of Visa _____
(if other than U.S.A.)

How do you plan to finance your education at WSU?
☐ Personal Funds ☐ Teaching Assistantship
☐ Research Assistantship ☐ Staff Assistantship ☐ Classified Staff ☐ Other, Specify: _____

Major and minor subjects in undergraduate work: _____ _____
(Major) (Minor)

Major and minor subjects in graduate work: _____ _____
(Major) (Minor)

Describe any teaching, research, or other work in which you have been engaged that contributes to your qualifications for the position for which you are applying. _____

List academic honors you have received. _____

List any documents sent in support of this application (publications, important papers, etc.)

List three persons whom you have asked to write in support of this application. (Letters of recommendation must be sent by the writers to the chair of the department concerned. The Graduate School does not need letters of recommendation.)

Name	Address	Position

State the period for which you are applying for an assistantship. _____

I hereby certify that the above information is complete and correct.

_____ _____
Signature of Applicant Date

7/2001

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PULLMAN, WASHINGTON 99164-1030

E-MAIL RELEASE FORM

The Federal Education Rights and Privacy Act prevents Washington State University from discussing the status of graduate applications with friends, relatives, or other associates of the applicant. WSU also cannot respond to e-mail requests for specific information regarding application status unless an e-mail release form is on file in the Graduate School. If you have a current e-mail address you would like to have the Graduate School and/or department use to correspond with you, please complete the following form.

Last Name: _____

First Name: _____

Birthdate: _____ Social Security Number: _____

WSU ID Number if known: _____

Mailing Address: _____

City: _____ State: _____

Zip: _____ Country: _____

E-Mail Address to be used for correspondence: _____

Certification: I herby request that the Graduate School at Washington State University and the department to which I am applying accept this authorization to release confidential information to me via the e-mail address listed above. I understand that electronic mail is a less secure environment than the postal service.

Submission of this form requires a written, original signature.

Signature: _____

Date Signed: _____