95 Stirling Lane, Apt. 1113
Willowbrook, IL 60527

October 31, 2006

Jan P. Amend, Search Committee Chair
Department of Earth and Planetary Sciences
Washington University
C/B 1169
St. Louis, Missouri 63130

Dear Prof. Amend,

I am writing to apply for the position of Assistant Professor of low-temperature geochemistry as recently advertised in the American Geological Institute publication *Geotimes*. I completed my Ph.D. in Geological and Environmental Sciences at Stanford University in August 2004, and am currently the Harold Urey Postdoctoral Fellow at Argonne National Laboratory. I am attracted to this position because of the diverse array of faculty research interests in the Department of Earth and Planetary Sciences, the excellent facilities available on campus, the expressed interest in a scientist using modern, quantitative methods, and the opportunity to be part of a large, vibrant department.

My academic and scientific activities have prepared me to establish a world-class research program focused on fundamental aspects of mineral-water interface geochemistry. My Ph.D. dissertation research ranged from applied characterization studies of uranium speciation in contaminated sediments at the U.S. Department of Energy's Hanford site to fundamental studies of the geochemical processes occurring at the mineral-water interface that affect uranium mobility in the environment. Currently I am taking advantage of the independence provided by my postdoctoral fellowship to develop a research program focused on obtaining a thorough molecular-level understanding of mineral-water interface structure and reactivity. My recent studies have shown that well-established conceptual models of how contaminant ions like arsenic adsorb may be missing major, and sometimes dominant, mechanisms. In addition, I am beginning a series of studies that will provide the first measurements of how Fe(II) distributes itself on an Fe(III)-oxide surface at the atomic scale. This research is essential to understanding the processes that fractionate iron isotopes, transform contaminants, and play a role in iron biogeochemical cycling. At Washington University I intend to continue and expand this research program on the environmental and geochemical processes occurring at mineral-water interfaces, as describe in the attached Statement of Research Interests.

Past experiences have also prepared me to be an effective instructor at Washington University. During my graduate work at Stanford University I had the opportunity to serve as a teaching assistant for courses on earth materials (mineralogy and petrology) and environmental geochemistry as well as a mentor for undergraduate and graduate students. In addition, my experience working at the U.S. Geological Survey Water Resources Division provided me with an understanding of the skills needed by students interested in working for government agencies and environmental consulting firms concerned with water quality issues. I look forward to teaching both general courses and specialized courses in my area.

I would enjoy discussing this position with you in the weeks to come. I have attached my Curriculum Vitae, including the contact information for my references. Also included are Statements of Research and Teaching Interests. If you require any additional information, materials, or references, I would be happy to supply them. Thank you for your consideration.

Sincerely,

Dr. Jeffrey G. Catalano

JEFFREY G. CATALANO

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EDUCATION

Harold Urey Postdoctoral Fellowship, Argonne National Laboratory, Argonne, IL, September 2004 to present. Environmental Research and Chemistry Divisions. Research focuses on fundamental aspects of geochemical processes occurring at mineral-water interfaces. *Advisor:* Dr. Paul Fenter

Ph.D. in Geological and Environmental Sciences, Stanford University, Stanford, CA, August 2004. *Dissertation:* Molecular Scale Studies of Uranium Speciation in Contaminated Hanford, Washington Sediments and Related Model Systems. *Advisor:* Prof. Gordon E. Brown, Jr.

B.S. in Geology, cum laude with distinction, University of Illinois at Urbana-Champaign, Urbana, IL, May 1999. *Thesis:* Geochemical Investigation into the Source of Natural Arsenic Contamination in the Mahomet Valley Aquifer, East-Central Illinois. *Advisor:* Prof. Stephen P. Altaner

Wasatch-Uinta Geological Field Camp, Park City, UT, Summer 1998. Field training in geological mapping and structural, stratigraphic, geomorphologic, and petrologic analysis.

RESEARCH EXPERIENCE

Postdoctoral Fellow, Environmental Research and Chemistry Divisions, Argonne National Laboratory, Argonne, IL, 2004-Present. Current research is focused on fundamental studies of geochemical processes occurring at the mineral-water interface. Studies of arsenic and selenium adsorption to iron and aluminum oxides are revealing that decades-old conceptual models of these processes are missing key mechanisms, which we have now identified and are working to quantify. In addition, molecular-scale observations of interfacial redox reactions are being conducted that will provide a foundation for understanding these important environmental and biogeochemical processes.

Doctoral Candidate, Department of Geological and Environmental Sciences, Stanford University, Stanford, CA, 1999-2004. Studied the speciation of uranium in contaminated sediments from a nuclear waste site in Hanford, WA, revealing uranium occurs both incorporated into solid phases and adsorbed on the surfaces of clay particles. Examined how the adsorption of uranium on clay minerals may affect its distribution in the environment. In addition, compared the adsorption of uranium on isostructural surfaces of iron and aluminum oxide, revealing that fundamental chemical differences in these phases (likely the electronic structures) affects how uranium bonds to these minerals.

Undergraduate Research Assistant, Department of Geology, University of Illinois at Urbana-Champaign, Urbana, IL, 1998-1999. Investigated potential sources of natural arsenic contamination in an aquifer in East-Central Illinois using combined chemical and mineralogical methods. Concluded that it was unlikely a source existed in the glacially-derived aquifer material, with the arsenic instead coming from groundwater upwelling from underlying bedrock aquifers.

Student Assistant, National Water Quality Assessment Program, Water Resources Division, U.S. Geological Survey, Urbana, IL, 1997-1999. Assisted in data collection for the National Water Quality Assessment Program. Collected water samples, constructed/removed sampling wells, characterized well location land use, and maintained water quality database.

TEACHING EXPERIENCE

Teaching Assistant, Environmental Geochemistry (GES 170), Stanford University, 2000
Co-wrote and graded problem sets. Assisted students individually and during review sessions with homework problems and course material. Organized midterm and final exam review sessions. Implemented the use of geochemical modeling software in coursework.

Teaching Assistant, Earth Materials (GES 80), Stanford University, 1999
Responsible for lecturing in one-third of the twice-weekly laboratory sessions. Organized additional, optional laboratory sessions weekly to provide hands-on assistance with mineralogical and petrological methods. Co-wrote laboratory final exam. Organized midterm and final exam review sessions. Graded problem sets.

ADVISING EXPERIENCE

Undergraduate Academic Advisor, Undergraduate Advising Center, Stanford University, 2001-2003

Graduate Student Mentor, Department of Geological and Environmental Sciences, Stanford University, 2000-2004

HONORS, AWARDS, AND FELLOWSHIPS

- Harold Urey Postdoctoral Fellowship, Argonne National Laboratory, 2004-Present
  One of four postdoctoral fellowships awarded internationally on an annual basis to outstanding doctoral scientists and engineers who are at early points in promising careers. The fellowships are named after scientific and technical luminaries who have been associated with the laboratory, its predecessors and the University of Chicago.
- APS Annual Report Science Highlight, *Assessing Strategies for Uranium Contamination Remediation*, 2004
- SSRL Science Highlight, *Chromium Speciation and Mobility in a High Level Nuclear Waste Vadose Zone Plume*, 2004
- Student Travel Grant, 40th Annual Meeting of the Clay Mineral Society, 2003
- Outstanding Student Presentation, Volcanology, Geochemistry, and Petrology Section, American Geophysical Union Fall Meeting, 2002
- Graduate Student Poster Prize, Environmental Sciences, 29th Annual Stanford Synchrotron Radiation Laboratory Users Meeting, 2002
- Corning Foundation Science Fellow, Stanford University, 2000-2001

Awarded yearly to one graduate student in the Department of Geological and Environmental Sciences

- USGS STAR Award, Water Resources Division, U.S. Geological Survey, 1999
  STAR (Special Thanks for Achieving Results) awards recognize one-time acts of service or accomplishments that are noteworthy
- Geology Alumni Award for the Outstanding Senior in Geology, University of Illinois, 1999
- Rocky Mountain Alumni Field Camp Scholarship, University of Illinois, 1998
- Estwing Award, University of Illinois, 1998
  Awarded to the top junior in the Department of Geology

PROFESSIONAL SOCIETY MEMBERSHIPS

- American Chemical Society
- American Geophysical Union
- Clay Mineral Society
- Geological Society of America
- International XAFS Society
- Mineralogical Society of America
- The Geochemical Society

REVIEWER FOR SCHOLARLY JOURNALS

- *Environmental Science & Technology*
- *Chemical Geology*
- *Geochemical Journal*
- *Geochimica et Cosmochimica Acta*
- *Geology*
- *Journal of Colloid and Interface Science*
- *Journal of Environmental Radioactivity*
- *Journal of Hazardous Materials*
- *Science of the Total Environment*
- *Thermochimica Acta*

UNIVERSITY SERVICE - STANFORD

- School of Earth Sciences Academic Programs Committee, 2004
- University Committee on Graduate Studies, 2003-2004
- Graduate Student Academic Life Survey Development Committee, 2003-2004
- Administrative Panel on Radiological Safety, 2002-2003
- University Committee on Health and Safety, 2002-2003
- Stanford Student Enterprises Board of Directors, 2002-2003
- Graduate Student Council, Elected Member and Financial Officer, 2002-2003
- School of Earth Sciences Graduate Student Advisory Committee, 2001-2002

OTHER PROFESSIONAL ACTIVITIES

Session Co-Chair, Synchrotron-Based Analytical Techniques for Nuclear and Environmental Sciences, *225th National Meeting of the American Chemical Society*, March 2003.

Reviewer, U.S. Civilian Research and Development Foundation

REFEREED PUBLICATIONS

1. Tanwar K., Lo C., Eng P.J., Catalano J.G., Brown G.E., Jr., Waychunas G.A.., Chaka A.M., Trainor T.P. (2006) Surface diffraction study of the hydrated hematite $(1\bar{1}02)$ surface. *Surface Science*, in press.

2. Zhang Z., Fenter P., Kelly S.D., Catalano J.G., Bandura A., Kubicki J.D., Sofo J., Wesolowski D.J., Machesky M.L., Sturchio N.C., and Bedzyk M.J. (2006) Structure of Zn^{2+} at the TiO_2 (110) – aqueous solution interface: Comparison of X-ray standing wave, X-ray absorption spectroscopy and density functional theory results. *Geochimica et Cosmochimica Acta* **70**, 4039-4056.

3. Fenter P., Catalano J.G., Park C., Zhang Z. (2006) On the use of CCD area detectors for high resolution specular X-ray reflectivity. *Journal of Synchrotron Radiation* **13**, 293-303.

4. Catalano J.G., Park C., Zhang Z., Fenter P. (2006) Termination and water adsorption at the α-Al_2O_3 (012)-aqueous solution interface. *Langmuir* **22**, 4668-4673.

5. Catalano J.G., McKinley J.P., Zachara J.M., Heald S.M., Smith S.C., and Brown G.E., Jr. (2006) Changes in uranium speciation through a depth sequence of contaminated Hanford sediments. *Environmental Science & Technology* **40**, 2517-2524.

6. Catalano J.G., Zhang Z. Fenter P., and Bedzyk M.J. (2006) Inner-sphere surface complexation of Se(IV) on the hematite (100) surface. *Journal of Colloid and Interface Science* **297**, 665-671.

7. Waychunas G.A., Trainor T.P., Eng P.J., Catalano J.G., Brown G.E., Jr., Davis J.A., Rogers J., and Bargar J.R. (2005) Surface complexation studied via combined grazing-incidence EXAFS and surface diffraction: Arsenate on hematite (0001) and $(10\bar{1}2)$. *Analytical and Bioanalytical Chemistry* **383**, 12-27.

8. Pierce E.M., Icenhower J.P., Serne R.J., and Catalano J.G. (2005) Experimental determination of UO_2 (cr) dissolution kinetics: effects of solution saturation state and pH. *Journal of Nuclear Materials* **345**, 206-218.

9. Wellman D.M., Catalano J.G., Icenhower J.P., and Gamerdinger A.P. (2005) Synthesis and characterization of sodium meta-autunite, $Na_2[(UO_2)(PO_4)]_2 \cdot 3H_2O$. *Radiochimica Acta* **93**, 393-399.

10. Catalano J.G, Trainor T.P., Eng P.J., Waychunas G.A., and Brown G.E., Jr. (2005) CTR diffraction and grazing-incidence EXAFS study of U(VI) adsorption onto α-Al_2O_3 and α-Fe_2O_3 $(1\bar{1}02)$ surfaces. *Geochimica et Cosmochimica Acta* **69**, 3555-3572.

11. Catalano J.G., and Brown G.E., Jr. (2005) Uranyl adsorption onto montmorillonite: Evaluation of binding sites and carbonate complexation. *Geochimica et Cosmochimica Acta* **69**, 2995-3005.

12. Wang Z., Zachara J.M., Gassman P.L., Liu C., Qafoku O., Yantasee W., and Catalano, J.G. (2005) Fluorescence spectroscopy of U(VI)-silicates and U(VI)-contaminated Hanford sediment. *Geochimica et Cosmochimica Acta* **69**, 1391-1403.

13. Catalano J.G., Warner J.A., and Brown G.E., Jr. (2005) Sorption and precipitation of Co(II) in Hanford sediments and alkaline aluminate solutions. *Applied Geochemistry* **20**, 193-205.

14. Brown G.E., Jr., Catalano J.G., Templeton A.S., Trainor T.P., Farges F., Bostick B.C., Kendelewicz T., Doyle C.S., Spormann A.M., Revill K., Morin G., Juillot F., and Calas G. (2005) Environmental interfaces, heavy metals, microbes, and plants: Applications of XAFS spectroscopy and related synchrotron radiation methods to environmental sciences. *Physica Scripta* **T115**, 80-87.

15. Trainor T.P., Chaka A.M., Eng P.J., Newville M., Waychunas G.A., Catalano J.G, and Brown G.E., Jr. (2004) Structure and reactivity of the hydrated hematite (0001) surface. *Surface Science* **573**, 204-224.

16. Catalano J.G., and Brown G.E., Jr. (2004) EXAFS study of uranyl adsorption on Wyoming montmorillonite. In: *Water-Rock Interaction, Proceedings of the 11th International Symposium on Water-Rock Interaction, Saratoga Springs, NY, June 27-July 2, 2004* (eds. R.B. Wanty and R.R. Seal II). A.A. Balkema Publishers, Leiden, The Netherlands. Vol. 1, pp. 665-670.

17. Catalano J.G., and Brown G.E., Jr. (2004) Analysis of uranyl-bearing phases by EXAFS spectroscopy: Interferences, multiple scattering, accuracy of structural parameters, and spectral differences. *American Mineralogist* **89**, 1004-1021.

18. Catalano J.G., Heald S.M., Zachara J.M., and Brown G.E., Jr. (2004) Spectroscopic and diffraction study of uranium speciation in contaminated vadose zone sediments from the Hanford Site, Washington State. *Environmental Science & Technology* **38**, 2822-2828.

19. Zachara J.M., Ainsworth C.C., Brown G.E., Jr., Catalano J.G., McKinley J.P., Qafoku O., Smith S.C., Szecsody J.E., Traina S.J., and Warner J.A. (2004) Chromium speciation and mobility in a high level nuclear waste vadose zone plume. *Geochimica et Cosmochimica Acta* **68**, 13-30.

20. Helean K.B., Navrotsky A., Lumpkin G.R., Colella M., Lian J., Ewing R.C., Ebbinghaus B., and Catalano J.G. (2003) Enthalpies of formation of U-, Th-, Ce-brannerite: implications for plutonium immobilization. *Journal of Nuclear Materials* **320**, 231-244.

21. Helean K.B., Navrotsky A., Vance E.R., Carter M.L., Ebbinghaus B., Krikorian O., Lian J., Wang L.M., and Catalano J.G. (2002) Enthalpies of formation of Ce-pyrochlore, $Ca_{0.93}Ce_{1.00}Ti_{2.035}O_{7.00}$, U-pyrochlore, $Ca_{1.46}U^{4+}{}_{0.23}U^{6+}{}_{0.46}Ti_{1.85}O_{7.00}$ and Gd-pyrochlore, $Gd_2Ti_2O_7$: Three materials relevant to the proposed waste form for excess weapons plutonium. *Journal of Nuclear Materials* **303**, 226-239.

22. Chambers S.A., Farrow R.F.C., Maat S., Toney M.F., Folks L., Catalano J.G., Trainor T.P. and Brown G.E., Jr. (2002) Molecular beam epitaxial growth and properties of $CoFe_2O_4$ on MgO(001). *Journal of Magnetism and Magnetic Materials* **246**, 124-139.

PUBLICATIONS IN REVIEW

1. Catalano J.G., Zhang Z., Park C., Fenter P., and Bedzyk M.J. (2006) Bridging arsenate surface complexes on the hematite (012) surface. *Geochimica et Cosmochimica Acta*, submitted.

PUBLICATIONS IN PREPARATION

1. Catalano J.G., Park C., Fenter P., Zhang Z. (2006) Rethinking arsenic adsorption: Simultaneous inner- and outer-sphere arsenate complexation.

2. Singer D.M., Johnson S.B., Catalano J.G., Farges F., and Brown G.E., Jr. (2006) Sequestration of Sr(II) by calcium oxalate.

TECHNICAL REPORTS

1. Catalano J.G., Zachara J.M., and Brown G.E., Jr. (2002) *X-ray Spectroscopic Investigation of the Distribution and Speciation of Uranium in Samples from the BX-102 Borehole.* B-BX-BY FIR: Digest of S&T Evaluations. United States Department of Energy, Richland Operations, Richland, WA 99352.

2. Wang Z., Zachara J.M., Gassman P.L., Liu C.X., and Catalano J.G. (2002) *Fluorescence Spectroscopic Studies of Uranium-Bearing Vadose Zone Sediments.* B-BX-BY FIR: Digest of S&T Evaluations. United States Department of Energy, Richland Operations, Richland, WA 99352.

3. Serne R.J., Brown C.F., Schaef H.T., Pierce E.P., Lindberg M.J., Wang Z., Gassman P., and Catalano J.G. (2002) *300 Area Uranium Leach and Adsorption Project Report.* ERC FY01-02 Final Report. United States Department of Energy, Richland Operations, Richland, WA 99352.

4. Catalano J.G., Warner J.A., Chen C.-C., Yamakawa I., Newville M., Sutton S.R., Ainsworth C.C., Zachara J.M., Traina S.J., and Brown G.E., Jr. (2001) *Speciation of Chromium in Hanford Tank Farm SX-108 and 41-09-39 Core Samples Determined by X-ray Absorption Spectroscopy.* S-SX FIR Appendix E: Digest of S&T Evaluations. United States Department of Energy, Richland Operations, Richland, WA 99352.

INVITED PRESENTATIONS

1. Catalano J.G. (2006) Mineral-water interface processes affecting contaminant fate and biogeochemical cycling. Invited oral presentation at the *Johns Hopkins University, Department of Earth and Planetary Sciences*, November 2006, Baltimore, MD.

2. Catalano J.G. (2006) Mineral-water interface processes affecting contaminant fate and biogeochemical cycling. Invited oral presentation at *Stony Brook University, Department of Geosciences and the Center for Environmental Molecular Science*, October 2006, Stony Brook, NY.

3. Catalano J.G. (2006) Mineral-water interface processes affecting contaminant fate and biogeochemical cycling. Invited oral presentation at the *University of Miami, Department of Geological Sciences*, May 2006, Coral Gables, FL.

4. Catalano J.G. (2006) Using molecular geochemistry to affect cleanup decisions at the Hanford site. Invited oral presentation at the *University of Miami, Center for Ecosystem Science and Policy*, May 2006, Coral Gables, FL.

5. Catalano J.G. (2006) Molecular-level geochemical processes controlling the fate of uranium in the environment. Invited oral presentation at the *University of Tennessee, Department of Earth and Planetary Sciences*, February 2006, Knoxville, TN.

6. Catalano J.G. (2005) Interactions of environmental contaminants with metal oxide surfaces. Invited oral presentation at *Northwestern University Center for Catalysis and Surface Science Seminar Series,* September 2005, Evanston, IL.

7. Catalano J.G. (2005) Molecular-level geochemical processes controlling the fate of uranium in the environment. Invited oral presentation at *University of Illinois at Chicago Earth & Environmental Sciences Department Seminar*, September 2005, Chicago, IL.

8. Catalano J.G., Wang Z., McKinley J.P., Zachara J.M., Heald S.M., Brown G.E., Jr. (2005) Probing uranium speciation in contaminated Hanford sediments. Invited oral presentation at *The 15th Annual Goldschmidt Conference*, May 2005, Moscow, ID.

9. Catalano J.G. (2005) Molecular-level geochemical processes controlling the fate of uranium in the environment. Invited oral presentation at the *University of Colorado, Department of Geological Sciences*, February 2006, Boulder, CO.

10. Catalano J.G. (2004) Probing uranium speciation in contaminated sediments and at the mineral-water interface. Invited oral presentation at *University of Illinois at Urbana-Champaign Geology Department Colloquium*, October 2004, Urbana, IL.

11. Catalano J.G., Heald S.M., Zachara J.M., Trainor T.P., Eng P.J., Waychunas G.A., Brown G.E., Jr. (2004) Synchrotron-based studies of uranium speciation in contaminated sediments and related model systems. Invited oral presentation at *Actinide-XAS-2004: 3rd Workshop of Speciation, Techniques, and Facilities for Radioactive Materials at Synchrotron Light Sources*, September 2004, Berkeley, CA.

12. Catalano J.G. (2004) X-ray spectroscopic studies of uranium speciation in 300 Area samples. Invited oral presentation at *Workshop on Conceptual Model Development and Reactive Transport Modeling for the 300 Area Uranium Plume in 300-FF-5*, May 2004, Richland, WA.

13. Catalano J.G., Zachara J.M., McKinley J.M., Heald S.M., and Brown G.E., Jr. (2003) X-ray spectroscopic and diffraction study of the distribution and speciation of uranium in contaminated sediments from the DOE's Hanford site. Invited oral presentation at the *30th Annual Stanford Synchrotron Radiation Laboratory Users' Meeting*, October 2003, Menlo Park, CA.

14. Catalano J.G., Warner J. A., Brown G.E., Jr. (2001) Spectroscopic Studies of Radionuclide Speciation in Model Systems and Contaminated Sediments. Invited oral presentation at the *Conference of the 2000-2001 Corning Foundation Science Fellows*, May 2001, Corning, NY.

VOLUNTEERED PRESENTATIONS

1. Catalano J.G., Park C., Zhang Z., Fenter P. (2006) Simultaneous inner- and outer-sphere arsenate adsorption on iron and aluminum oxide surfaces. Oral presentation at the *2006 GSA Annual Meeting*, October 2006, Philadelphia, Pa.

2. Catalano J.G., Park C., Zhang Z., Fenter P. (2006) Simultaneous inner- and outer-sphere As(V) adsorption on iron and aluminum oxide surfaces. Oral presentation at the *19th General Meeting of the International Mineralogical Association*, July 2006, Kobe, Japan.

3. Catalano J.G., Park C., Zhang Z., Fenter P. (2006) Resonant anomalous x-ray reflectivity studies of As(V) adsorption on iron and aluminum oxide surfaces. Oral presentation at the *13th International Conference on X-ray Absorption Fine Structure (XAFS13)*, July 2006, Stanford, CA.

4. Catalano J.G. (2006) X-ray scattering studies of the interactions of environmental contaminants with metal oxide surfaces. Oral presentation at the *Advanced Photon Source, Surface & Interface Scattering Science Interest Group*, May 2006, Argonne, IL.

5. Catalano J.G., Park C., Zhang Z., Fenter P. (2006) Resonant anomalous x-ray reflectivity studies of As(V) adsorption on iron and aluminum oxide surfaces. Poster presentation at the *2006 Users' Meeting for the Advanced Photon Source*, May 2006, Argonne, IL.

6. Catalano J.G., Park C., Zhang Z., Fenter P. (2006) Simultaneous inner- and outer-sphere As(V) adsorption on α-Al_2O_3. Oral presentation at the *231th National Meeting of the American Chemical Society*, March 2006, Atlanta, GA.

7. Catalano J.G., Zhang Z., Fenter P., Bedzyk M.J. (2005) XSW studies of oxoanion adsorption at the hematite-water interface. Poster presentation at the *Workshop on In-Situ Characterization of Surface and Interface Structures and Processes*, September 2005, Argonne, IL.

8. Catalano J.G., Trainor T.P., Eng P.J., Waychunas G.A., Brown G.E., Jr. (2005) Surface x-ray scattering and spectroscopy studies of U(VI) adsorption on corundum and hematite single-crystal surfaces. Oral presentation at the *229th National Meeting of the American Chemical Society*, March 2005, San Diego, CA.

9. Catalano J.G. and Brown G.E., Jr. (2004) EXAFS study of uranyl adsorption on Wyoming montmorillonite. Oral presentation at *WRI-11: The 11th International Symposium on Water-Rock Interaction*, June/July 2004, Saratoga Springs, NY.

10. Catalano J.G., and Brown G.E., Jr. (2003) Spectroscopic study of uranyl adsorption on Wyoming montmorillonite: Factors affecting surface complexation. Oral presentation at *Classic Clays and Minerals: The Clay Minerals Society 40th Annual Meeting and Mineralogical Society of America Spring Meeting*, June 2003, Athens, GA.

11. Catalano J.G., Zachara J.M., McKinley J.M., Heald S.M., and Brown G.E., Jr. (2003) X-ray spectroscopic and diffraction study of the distribution and speciation of uranium in contaminated sediments from the DOE's Hanford site. Oral presentation at the *225thNational Meeting of the American Chemical Society*, March 2003, New Orleans, LA.

12. Catalano J.G., Zachara J.M., McKinley J.M., Heald S.M., and Brown G.E., Jr. (2002) X-ray Spectroscopic Investigation of the Distribution and Speciation of Uranium in Contaminated

Sediments From the DOE's Hanford Site. Oral presentation at the *American Geophysical Union 2002 Fall Meeting*, December 2002, San Francisco, CA.

13. Catalano J.G., Zachara J.M., and Brown G.E., Jr. (2002) X-ray Spectroscopic Investigation of the Distribution and Speciation of Uranium in Contaminated Sediments From the DOE's Hanford Site. Poster presentation at the *29th Annual Stanford Synchrotron Radiation Laboratory Users' Meeting*, October 2002, Menlo Park, CA.

14. Catalano J.G., Warner J.A., Ainsworth C.C., Zachara J.M., Traina S.J., and Brown G.E., Jr. (2002) XAFS studies of chromium and uranium speciation in Hanford vadose zone sediments. Oral presentation at the *223rd National Meeting of the American Chemical Society*, April 2002, Orlando, FL.

15. Catalano J.G., Warner J.A., Ainsworth C.C., Zachara J.M., Traina S.J., and Brown G.E., Jr. (2001) X-ray Spectroscopic Study of the Speciation Of Chromium in Hanford S-SX Tank Farm Core Samples. Poster presentation at the *28th Annual Stanford Synchrotron Radiation Laboratory Users' Meeting*, October 2001, Menlo Park, CA.

16. Catalano J.G. and Brown G.E., Jr. (2001) XAFS Spectroscopic Investigation of Co and U Speciation in Model Hanford Tank Waste Systems. Poster presentation at the *28th Annual Stanford Synchrotron Radiation Laboratory Users' Meeting*, October 2001, Menlo Park, CA.

17. Catalano J.G., Warner J.A., Chen C.-C., Yamakawa I., Newville M., Sutton S.R., Ainsworth C.C., Zachara J.M., Traina S.J., and Brown G.E., Jr. (2001) X-ray spectroscopic and fluorescence study of the speciation and distribution of chromium in Hanford S-SX Tank Farm core samples. Oral presentation at the *222nd National Meeting of the American Chemical Society*, August 2001, Chicago, IL

18. Catalano J.G., Warner J.A., and Brown G.E., Jr. (2001) Spectroscopic investigation of Co and U speciation in model leachate-solid systems. Poster presentation at the *222nd National Meeting of the American Chemical Society*, August 2001, Chicago, IL

19. Catalano J.G., Altaner S.P., and Warner K.L. (1999) Geochemical Investigation of the Source of Natural Arsenic Contamination in the Mahomet Valley Aquifer, East-Central Illinois. Poster presentation at the *Geological Society of America, North-Central Region Spring Meeting 1999*, April 1999, Champaign, IL.

REFERENCES

Prof. Gordon E. Brown, Jr. (Ph.D. Advisor)
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Statement of Research Interests

Dr. Jeffrey G. Catalano

Introduction

My research program is focused on investigating the geochemical processes that occur at mineral-water interfaces. Such processes affect contaminant fate, the composition of natural waters, and biogeochemical element cycling (**Fig. 1**). At the Hanford Site in Washington State, where massive amounts of high-level nuclear waste have been spilled, uranium transport in groundwater is controlled primarily through adsorption to and desorption from clay minerals **[1]**. The origin of arsenic in Bangladesh well water is arsenic sorbed to iron oxides minerals, which is released during reductive dissolution **[2]**. Trace element concentrations in seawater are thought to be partially controlled by adsorption onto mineral surfaces and water-rock interactions between seawater and basaltic glass at ocean floor spreading centers **[6-8]**. Adsorption reactions can even generate YREE patterns, and may be an important YREE removal mechanism in estuaries **[3,9]**. Iron isotope fractionation in modern and ancient systems has been used to infer microbial activity, primarily dissimilatory iron reduction **[10]**. Recent results show that this fractionation may be produced through electron and atom exchange between aqueous Fe(II), the product of dissimilatory iron reduction, and Fe(III) at the surface of iron oxides minerals **[4]**, and not by the microbial iron reduction process.

At Washington University, I intend to build a research program that will examine the important geochemical processes described above. The main goal of my program is to establish the fundamental mechanisms of interfacial adsorption and redox processes in order to provide a foundation for understanding these processes in diverse modern and ancient low-temperature systems. This program applies the principles of physical chemistry to investigate these processes in detail, and relies on a combination of traditional laboratory methods with synchrotron-based diffraction, spectroscopy, and microscopy techniques.

Areas of Research Interests

My interest in studying the nature of mineral-water interfaces stems from my belief that studying the earth and the environment requires a fundamental understanding of the important processes operating, and that such an understanding is lacking in this area. My research program aims to address this critical shortcoming in our current knowledge through studies in the following related, complimentary areas:

Structure of Mineral-Water Interfaces

The mineral-water interface is not an abrupt transition between solid and liquid, but a region where the ordering of a mineral structure induces ordering in near-surface water that gradually decays towards normal, disordered bulk water (see review by Fenter and Sturchio **[11]**). Functional groups on a mineral surface may obtain a pH-dependent charge and react with aqueous species. In order to study how mineral surfaces react with geological and environmental fluids, a fundamental understanding of the structure of the mineral-water interface is needed. My recent work in this area has involved investigating the structure of iron and aluminum oxide surfaces **[12-14]**, important environmental substrates used to study many of the important geochemical processes described below. In the future I intend to extend these studies to manganese oxides, important phases in soil, sedimentary, lacustrine, and oceanic systems, and uranium oxide, a major component of spent nuclear fuel and a common uranium ore deposit mineral.

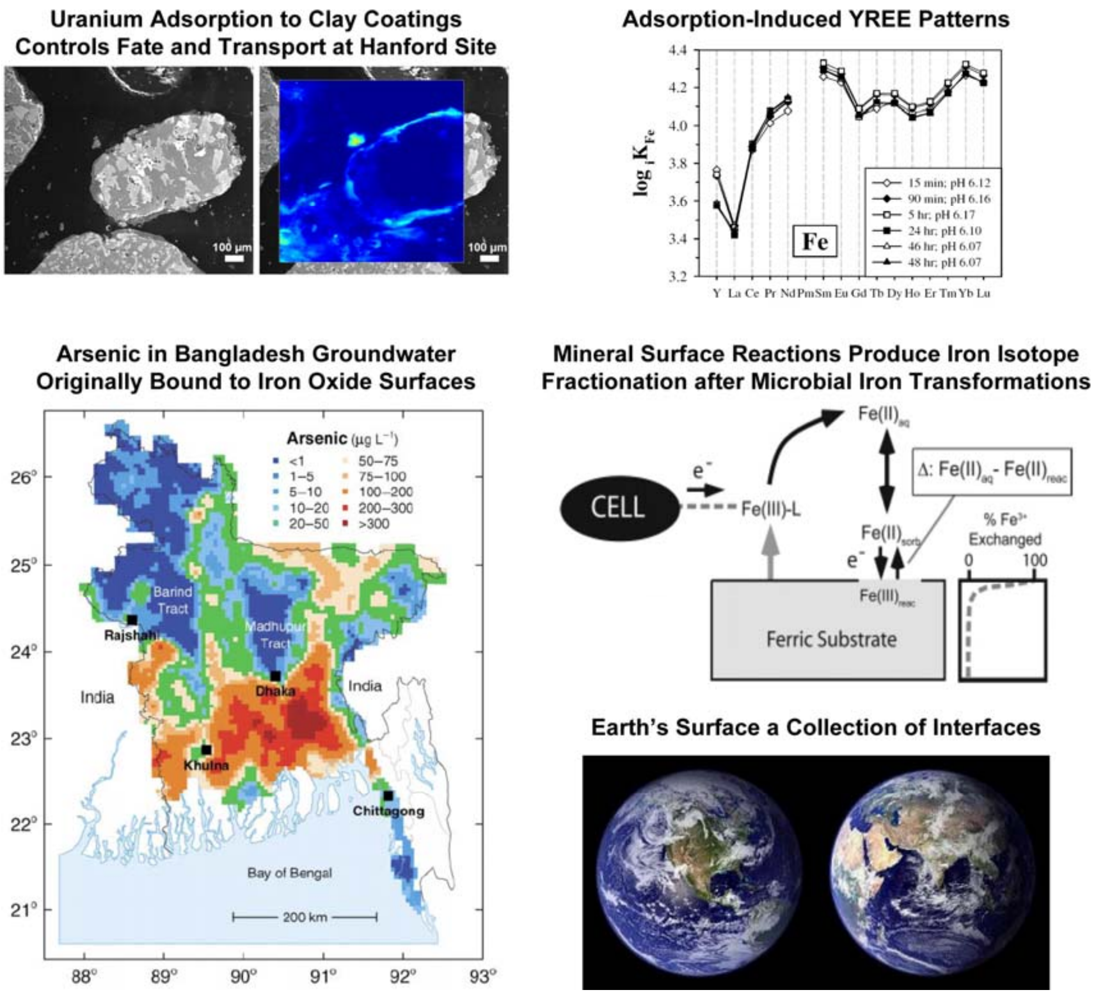

Figure 1. Processes occurring at the mineral-water interface affect contaminant fate, the composition of natural waters, and biogeochemical metal cycling. Many of the important reactions on the Earth's surface occur at interfaces. Images from **[1-5]**.

Contaminant Adsorption Processes

Adsorption of aqueous contaminants onto mineral surfaces affects their fate and transport in aquatic environments and is one of the major processes involved in water treatment systems. Currently I am investigating arsenic(V) and selenium(IV) adsorption processes, which past research has suggested form strong, direct chemical bonds (inner-sphere complexation) to mineral surfaces. My initial studies in this area found that there is a pool of adsorbed arsenic and selenium not bonded to the mineral surface **[15,16]**. I have now found that, in the case of arsenic(V), 30-60% of adsorbed arsenic(V) does not bond directly to iron oxide surfaces (**Fig. 2**), but instead retains its hydration shell (outer-sphere complexation) **[17]**. Such species are expected to be bound much more weakly and, as they have been previously unreported, their identification may force earth and environmental scientists to significantly alter their conceptual models of how arsenic and other oxoanions behave in the environment. In the future I intend to continue my studies of oxoanions adsorption processes on iron and aluminum oxide surfaces in order to define under what range of conditions these outer-sphere species exist and to identify how they are bound to minerals. Ultimately, I would like to develop a surface complexation model (SCM) for oxoanion adsorption to a specific mineral surface, as my unique ability to identify and quantify the types and distribution of adsorbed species provides a previously unavailable dataset that can help constrain SCM parameters that typically are determined empirically. If successful, these studies will be extended to cationic contaminants such as cobalt, nickel, zinc, lead, and mercury, as well as to examining how organic ligands and natural organic matter modify this behavior.

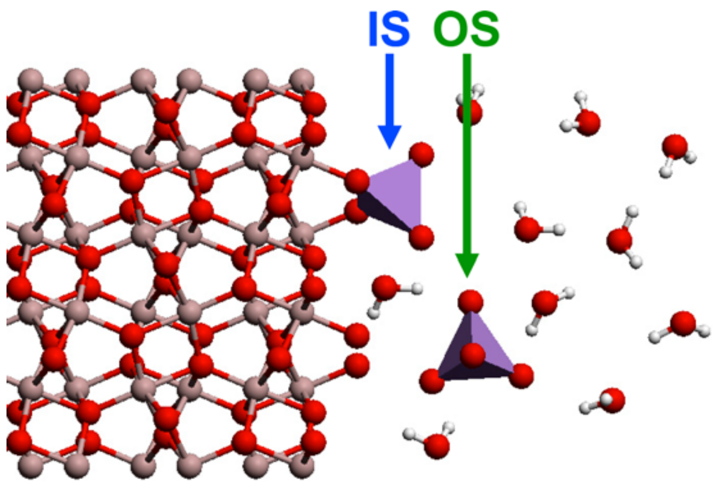

Figure 2. All previous studies have concluded As(V) adsorbed to minerals as a strongly-bound, inner-sphere complex (IS). My current research has shown that 30-60% of adsorbed As(V) occurs as a weakly-bound, outer-sphere (OS) species.

Interfacial Redox Phenomena

Redox processes at mineral surfaces may promote dissolution, induce phase transformations, and affect the fate of environmental contaminants. Such processes play roles in the biogeochemical cycling of elements such as iron, manganese, and sulfur, as many of the products of microbial element transformations go on to react abiotically with other aqueous species and solid phases present in the environment. Interest in using iron isotopes to identify signatures of modern and ancient microbial activity requires an understanding of the processes that induce fractionation. Recent studies have demonstrated that aqueous Fe(II) exchanges electrons with Fe(III)-oxide surfaces, and that this may generate the fractionation seen during dissimilatory iron reduction **[4,18]**. I am currently investigating the reaction of aqueous Fe(II) with Fe(III)-oxide surfaces using new methods that allow me to observe the atomic-scale distribution of Fe(II) at the mineral surface. Preliminary results indicate two pools of Fe(II) are present: adsorbed on the surface and in Fe(III) lattice sites in the top atomic layers of the mineral. Once I better quantify this distribution, I will examine how it varies with solution conditions and what transformations occur upon reoxidation. In the future I intend to study how redox-sensitive contaminants such as arsenic, chromium, and uranium may transform on these Fe(II)-reacted mineral surfaces, and how other reduced aqueous species, such as manganese(II) and sulfide, react with iron oxide surfaces. Ultimately I would like to extend these studies to other mineral surfaces, such as manganese oxides, iron sulfides, and uranium oxide, to obtain a broad understanding of mineral surface redox processes.

Other Interests

While the above areas will comprise the core of my research program over the next 5-10 years, I have interests in related areas that may be pursued if opportunities arise or appropriate collaborations develop. In the past I have investigated chromium and uranium speciation in contaminated sediments at the Hanford site **[19-21]**, and I may be involved in future environmental characterization studies that build on my major research areas. Geomicrobiology is another area where I have a strong interest because of the major role microorganisms play in controlling geochemical conditions and transforming many contaminants. I am interested in examining how biofilm formation affects the way contaminants adsorb to mineral surface and comparing the composition and structure of microbially- and abiotically-reduced iron oxide surfaces. I may address these questions in the future if a collaboration with a geomicrobiologist with similar interests develops. I am also fascinated by the apparent changes in physical and chemical properties that occur in nanoscale solid phases. As these changes likely modify the redox potentials of nanominerals compared to bulk phases, a logical offshoot of my work on interfacial redox phenomena is to examine how such processes change as a function of particle size. Finally, the renewed interest in nuclear power generation may open up new areas of research related to separation science that require the study of interfacial reactions; I may become involved in such work if the processes involved overlap with my areas of interest.

Student Involvement in Research Program

This research program is intended to be implemented with the major involvement of graduate students and postdoctoral researchers. However, projects are potentially available for undergraduate and masters students interested in conducting research. While inclusion of undergraduate and masters students into this research program will require added effort on my part, this provides additional educational opportunities for such students, and fits well into the educational mission of a university.

Facilities Needs

My planned research program requires a wet chemistry laboratory furnished with standard equipment (reagents, glassware, benches, fume hoods, etc.). Other examples of necessary equipment include a high-speed centrifuge, deionized water system, an anaerobic chamber for O_2-free studies, pH meters and probes, ovens, a muffle furnace, a controlled-temperature bath, and a UV/Vis spectrometer. An FTIR spectrometer with ATR attachment and an AFM are desired equipment, but are not needed in my laboratory if access is available on campus. I intend to utilize existing shared equipment in the Department of Earth and Planetary Sciences and elsewhere on campus. Portions of this research program rely on method only available at synchrotron light sources such as the Advanced Photon Source (APS) at Argonne National Laboratory; occasional travel to such facilities will be necessary.

Potential Sources of Funding

Financial support from relevant agencies would be explored to fund this research, including the US Department of Energy (DOE), Offices of Basic Energy Sciences (BES) and Biological and Environmental Research (BER) and the National Science Foundation (NSF). DOE-BES or -BER would be appropriate funding sources for my studies of fundamental contaminant adsorption processes. The studies of interfacial redox phenomena could be funded by the NSF, DOE-BES, or possibly the Environmental Protection Agency. In addition, the ACS Petroleum Research Fund may provide some initial funding opportunities for my program. As a graduate student and postdoctoral fellow I was an active contributor to successful funding proposals submitted to DOE-BES and -BER, and am confident I will be able to obtain funding from similar sources in the future. Access to synchrotron light source facilities such as the APS is awarded based on the results of peer-reviewed proposals. I have submitted twelve successful proposals to such facilities in the past (all have been approved), and expect to continue doing so in the foreseeable future.

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Statement of Teaching Interests

Dr. Jeffrey G. Catalano

My educational and research experiences have prepared me to teach a number of courses at Washington University. My primary teaching interest is a low-temperature aqueous geochemistry course, with the following possible course description:

> **Low-Temperature Aqueous Geochemistry:** An introduction to the chemical process controlling the composition of natural waters. Topic covered include: thermodynamics of aqueous systems, acid and bases, carbonate equilibria, ion complexation, precipitation and dissolution, oxidation and reduction reactions, clays and environmental minerals, mineral-water interface geochemistry, and aqueous kinetics. Open to graduate students and undergraduate students with senior standing.

I am also capable and willing to teach introductory courses as needed (e.g., physical geology), as well as geochemistry or mineralogy for undergraduate majors. Other courses I would teach depend on the interests and needs of the department and/or students. Some possible courses (with example course descriptions) include:

> **Minerals, the Environment, and Human Health:** A survey of minerals and their effect on the environment and human health. Topics include: acid mine drainage, asbestos and other inhalants, nuclear waste disposal, groundwater contamination. Open to undergraduate non-majors.

> **Clay Mineralogy and Chemistry:** Composition and classification of various types of clay minerals. Clay mineral structure, properties, origin, and occurrence. Identification of clay minerals by X-ray diffraction. Open to graduate students.

> **Environmental Geochemistry and Mineralogy:** Introduction to common solid mineral (crystalline and amorphous) and organic phases occurring in the environment. Geochemical processes that affect the fate of contaminants, including adsorption/cation exchange, precipitation, complexation by aqueous ligands, and oxidation/reduction reactions. Microbial effects on geochemical conditions. Kinetics of environmental processes. Open to graduate students.

> **Characterization Methods in Geochemistry and Mineralogy:** An introduction to various spectroscopic, microscopic, and diffraction methods encountered in geochemical and mineralogical research. Lectures introducing individual methods are followed by student-led discussions of examples from the recent scientific literature. Open to graduate students.

> **Seminar on Mineral Surface Chemistry:** A graduate seminar covering a topic in mineral surface chemistry. Example topics include: electrical double layer theory, surface characterization methods, colloid chemistry, surface redox processes. Open to graduate students.