

RUI Impact Statement

This is a collaborative RUI project that proposes to conduct both field and laboratory investigations that will engage undergraduates in all facets of the research. The inclusion of undergraduates supports the goal of both PIs' departments of providing undergraduates with meaningful research experiences and is consistent with both Buffalo State College's and Oswego State University's campus-wide programs designed to increase the participation of undergraduates in research. The following section is a description of the departments' and colleges' undergraduate research programs and the structure of student research experiences previously undertaken by students mentored by the PIs. The impact of undergraduate research experiences and decisions made by students to continue their education at the graduate level are also described.

Buffalo State College's Mission and the Office of Undergraduate Research (PI Solar)

Buffalo State has long been known for its teaching of educational foundations and its preparation of teachers. The College recently underwent an extensive strategic planning process and adopted a five-year plan designed to help the College achieve its vision of becoming a nationally recognized leader in public higher education. Since adopting the plan in October 2002, the Office of Academic Affairs completed and had endorsed by the College Senate an Academic Plan that supports several academic initiatives, including: 1) building a diverse and intellectually vital faculty through increased Provost's Faculty Development Incentive Grant allocations and recruitment of full-time faculty; 2) engaging students in a community of learners through a new general education program that emphasizes common learning outcomes and a shared intellectual foundations course; 3) establishing organizational structures and administrative systems to ensure academic success and responsiveness (including the creation of a new unit more responsive to first-year experiences and academic support needs). The Buffalo State College guidelines for promotion and tenure decisions clearly articulate expectations of faculty scholarship and research. Within the Department of Earth Sciences and Science Education, this expectation is also part of faculty appointments and reviews prior to tenure and promotion. Partial support is provided through the department and the Dean's office to support faculty travel to professional meetings and the College has made a strong commitment to providing matching money to grants (e.g., NSF-CCLI).

The College has also made undergraduate research a priority area in its academic plan and recently established an Office of Undergraduate Research and appointed a half-time director. This office facilitates the coordination and promotion of undergraduate research in all academic disciplines. Buffalo State has enjoyed a long tradition of research with undergraduates. The science faculty annually sponsored the Sigma Xi Student Paper Day until 1999 when the event was combined with a college-wide event known as the Student Research and Creativity Celebration. Currently, in addition to the annual Student Research and Creativity Celebration (now in its seventh year), there are a variety of programs to support undergraduate research (<http://www.rf.buffalostate.edu>) including a summer fellowship program (also in its seventh year) and an undergraduate travel program (in its fourth year) to provide support to students giving presentations at professional meetings. In 2003, a small grants program was introduced to support student research during the academic year, and there is a program to support faculty revising introductory or advanced courses to add a significant research component. With recent funding through the NSF-STEP (STEM Talent Expansion Program) program and with additional support through the Office of Academic Affairs, the Office of Undergraduate Research is establishing a Sophomore Research Program (open to students that completed their first year in a STEM major) in an effort to provide students early mentored research experiences.

Buffalo State College has a campus-wide Honors program and academic departments offer students an option for graduating with honors. The All-College honors program does not require a formal thesis, although nearly all of the students graduating with college honors participate in undergraduate research. Students graduating with departmental honors are required to complete a minimum of 6 credit hours (equivalent to two semesters) of research, and each of the four students whom have completed this program with the PI (Solar) have produced Honors theses as part of their required components (**Table 1**).

Whereas the College provides opportunities for selected students to participate in the All-College and departmental honors programs, many more students participate in undergraduate research through independent

Table 1: Undergraduate student research under the supervision of PI Solar, Buffalo State.

year	student(s)	title	funding *
2000-2001	Bestine, J. (<i>Honors thesis</i>)	Structural analysis of preferred orientations of kyanite in the "log-jam" schist, western Connecticut.	NEGSA, NEIGC
	Chmura, S. (<i>Honors thesis</i>)	An analysis of structures in contrasting migmatite outcrops, western Maine.	NEGSA, NEIGC, Sigma Xi, BSC Undergraduate Summer Research Fellowship; Dean's Minigrant
	Kerr, S. (<i>Honors thesis</i>)	Detailed mapping of the boundary between two zones of different finite strain, Roxbury, Maine.	NEGSA, Dean's Minigrant, Sigma Xi
	Klauk, E.	An analysis of the strain record in metaconglomerate in the basal Rangeley formation, near Rangeley, Maine.	NEGSA, Sigma Xi
2001-2002	Crosset, J.	Rock fabric analysis in the Piseco Notches, Adirondacks.	
	Perlman, I.	Fracture patterns and density according to stratigraphic horizon in rocks of the Buffalo Southtowns, NY.	
	Foster, S.	Fabrics in rocks of the Ohio Gorge, West Canada Ck., SW Adirondacks.	
	Zaprzal, A.	A detailed analysis of fabric variations in quartzofeldspathic and ferromagnesian gneisses, Piseco Lake tectonite zone, southern Adirondacks.	NEGSA, BSC Undergraduate Summer Research Fellowship
2002-2003	Fissler, D.	Structural analysis of porphyroblast-matrix relations in rocks in an abandoned garnet quarry, W. Connecticut.	NEGSA
	Ribiero, A.	A comparative analysis of fabrics in rocks associated with the Sebago pluton and its surrounding migmatitic rocks, southern Maine.	NEGSA
	Thompson, L.	Petrography of staurolite-matrix relations in rocks of W. CT.	NEGSA
2003-2004	Charney, K.	Textural Documentation of Metagabbro, Southern Marcy Massif, Eastern Adirondacks.	
	Goodrow, K.	A Look at Mineral Reactions in the Metamorphic Rocks around Wissahickon Creek, Philadelphia, PA.	
	Reynard, M.	Mapping Metamorphic Zones in Fairmount Park, Philadelphia, PA.	
2004-2005	Burke, C.	Fabric analyses in garnet-mica schist of the Rowe formation, western Connecticut.	BSC Minigrant
	King, M.	Interpretation of migmatitic fabrics associated with the Sebago body, southern Maine.	
	Shaw, N.	Calc-silicate rock migmatite structures in the southern Adirondacks, Indian Lake, NY	BSC Minigrant
	Skotnicki, S. (<i>Honors thesis</i>)	An analysis of petrofabric variations in metagabbro of the abandoned Hooper garnet mine, southeastern Adirondacks.	NEGSA, BSC Undergraduate Summer Research Fellowship
	Thorington, P.	Fabric analysis of quartzofeldspathic gneisses, Piseco tectonite zone, S. Adirondacks.	

* NEGSA is Northeastern Section of the Geological Society of America, NEIGC is the Billings Fund of the New England Intercollegiate Geological Conference

study (IS) courses. At Buffalo State, students may enroll multiple times in IS, and the assigned credit hours may vary between 1 and 6. The PI (Solar) has had 12 IS students complete projects, and 4 with projects in progress, over the last five years (see **Table 1**). These students are engaged in various scopes of projects that may include some combination of field work, laboratory sample preparation, laboratory measurements and analyses, data

analysis and map interpretation, depending upon the size (and credit total) of the IS. Generally, students conducting undergraduate research enroll in two semesters of IS, up to a total of 6 credit hours. Because many of the undergraduates enrolled at Buffalo State work jobs twenty or more hours per week, research activities take place both during the summer months and during the academic year. One of the motivations for introducing the Office of Undergraduate Research's Undergraduate Summer Research Fellowship (USRF) program in 1999 was to provide funding for students so that they could either not work at all during the summer and devote full-time to their research project, or, at least take part of the summer off to focus on conducting field and laboratory studies. In the years since the program was introduced, over fifty students have participated and most have been able to substantially reduce their hours at work and/or not work for a period of two months in order to concentrate on their research. A measure of the success of the USRF program is that nearly all of the students have indicated their desire to continue their education at the graduate level. The PI has had 3 students awarded this fellowship (**Table 1**).

Undergraduate Research in the Department of Earth Sciences, Buffalo State College (Solar). The Department of Earth Sciences is part of a combined unit with the Department of Science Education. The Science Education side of the department is responsible for teaching a sequence of courses required for all secondary education majors seeking New York State certification in biology, chemistry, Earth science and/or physics. These courses include an early field experience course, laboratory techniques for teaching sciences, and teaching methods; Science Education faculty also coordinate the placement and supervision of all students enrolled in chemistry, physics, biology and Earth science education programs.

The Earth Sciences side of the department offers two undergraduate degree programs: B.S. Earth Sciences and B.S. Education (Earth science education). Within the B.S. Earth Sciences program there are three concentrations (environmental Earth science, geology, and Earth science education) designed to help students take a sequence of courses most appropriate to prepare them for either entry level employment (e.g., environmental consulting), secondary Earth science certification, or to pursue advanced degrees. Earth Science faculty teaching loads are three courses per semester, and, depending on whether or not the course includes associated labs, this translates to between nine and approximately twelve contact hours each week. Currently, no mechanism exists for counting the mentoring of undergraduates conducting research in-load, so this activity is done in addition to normal teaching loads.

As described in the section above, qualified students (e.g., meeting the GPA requirements) may elect to apply to the department's honors program. In order for a student to graduate with honors in Earth Sciences, they must maintain a GPA of >3.5 and complete a research project (minimum of three credit hours). Only a few students in any given year apply for, and, graduate with departmental honors. One reason for this is lack of promotion of the program among our undergraduates. In recent years, this situation is changing as the department replaces retiring faculty that were not research-active with faculty that are expected to build research programs that include opportunities for students to conduct meaningful research.

A track record of undergraduate student research under the supervision of PI Solar. PI Solar has been a faculty member at Buffalo State since Fall 2000. His research activities in understanding regional tectonic controls using petrographic signatures has supported many undergraduate research opportunities across New York state, Pennsylvania, and parts of New England (**Table 1**). He established the Laboratory for Orogenic Studies focused upon understanding problems in structural, petrological and petrographical research within the Department of Earth Sciences and renovated a space within the department that now contains a research petrographic microscope, faculty and student research space, computing technology, and thin sectioning and sample handling equipment. Over the past four and a half years, the PI has advised 16 Buffalo State undergraduate students. **Table 1** summarizes information on student researchers and their activities. The last column in **Table 1** provides information about funding sources. In the past four years, three of the PI's students have been recipients of Undergraduate Summer Research Fellowships and many have received support from the Northeast Section of GSA, among other sources. All of the students carrying out research projects are expected to present their findings at appropriate professional meetings.

Oswego State University's Mission and the undergraduate research program (PI Tomascak)

Undergraduate research at Oswego State University is promoted actively and supported internally by a variety of sources (<http://www.oswego.edu/academics/opportunities/research.html>). The Office of Research and Sponsored Programs and the Scholarly and Creative Activities Committee disperse funds yearly in support of undergraduate student research. The University showcases the products of institutional research with the annual *Quest* symposium.

The Earth Sciences Department (comprising BS major programs in Geology, Geochemistry and Meteorology) has been at the forefront of student research activity on campus. To this end, the Geology program has instituted a required Capstone Experience for all BS graduates. Most students fulfill this requirement by completing a research project that involves the production of a thesis.

Track record of undergraduate student research -- PI Tomascak. PI Tomascak has spent most of his professional career in predominantly research environments, where close contact with undergraduate students has not always been possible. Even so, he has demonstrated a commitment to undergraduate research: as a postdoctoral research fellow at the Lamont-Doherty Earth Observatory (Columbia University) he hosted undergraduate summer intern H. Myvonwynn Hopton on a cross-disciplinary research project, examining Pb isotopes in tree rings. As research faculty at the University of Maryland (2001 to 2003) he was laboratory manager of the Isotope Geochemistry Laboratory, where he was instrumental in attracting undergraduate lab assistants (a total of 5 in three years). In 2002 he supplemented his research role with the additional duty of Director of Undergraduate Studies (at no extra compensation). This position permitted hands-on mentoring of a group of ~30 undergraduate Geology and Environmental Sciences majors. During this period he directed the undergraduate research thesis of Tracey Centorbi on Pb isotopes from granites in western Maine. The student presented her findings at national GSA in 2002 and the results were important to the completion of a journal article (Tomascak *et al.*, in press). The student involved in the project was so enthusiastic about research in geochemistry that she stayed on for a M.S. under the direction of Dr. Richard Walker.

Since arriving at Oswego State in January 2004 he has begun the process of rebuilding a long-dormant Geochemistry program (a Geochemistry major is offered but virtually abandoned in previous years). The anticipated completion of a geochemical sample preparation laboratory in early 2005 will bolster the potential of attracting undergraduate researchers. One upside to this rebuilding is the recent hires of faculty with parallel interests in Biology (limnology/hydrogeochemistry) and Chemistry (mineralogy/crystal chemistry), with whom future collaborations would be profitable, and students with interdisciplinary interests might be attracted.

Outcomes and expectations of undergraduate research

Consistent with the philosophy of both PIs' institutions, that students learn best when provided opportunities to explore through active learning, students mentored by the PIs receive significant support early in their research experience and are encouraged to become progressively more independent through later stages in their research. Even students that initially express reservations about their knowledge and preparation to undertake independent research projects have enjoyed a high level of success and emerge as confident researchers. Evidence of this includes the desire to go on at the graduate level (currently 4 Buffalo State graduates whom have conducted undergraduate research with Solar are in graduate programs; 3 current students are applying to graduate programs). Through working with these students, the PIs note that one of the outcomes from an undergraduate research experience has been the confirmation of a student's commitment to the discipline and continuation of their education at the graduate level. Nearly 60% of Buffalo State Earth Sciences majors are preparing to become secondary Earth science teachers. For this population of students, an undergraduate research experience may be their first and only opportunity to directly apply their understanding of geological processes and principles to answer a challenging research question. An undergraduate research opportunity is invaluable to these future teachers as they can bring their personal experiences into the classroom as they describe to their students the scientific method, the realities of conducting scientific research, and what it takes to make scientific discoveries.

The research projects described within this research proposal are designed to be primarily carried out during the summer months, with laboratory work and analysis and interpretation of field data taking place during the fall and spring semesters. Because of the modest size of the research program and the fact that the PIs do not receive

a reduction in teaching load during the academic year, the projects are designed to complement each other and contribute to a regional understanding of petrological and geochemical problems in the northeastern US (focusing primarily on rocks in Maine and New Hampshire). This structure allows the students to work in teams while conducting field and laboratory work and see how their individual project is an important component in the larger effort. For some of these students, additional experience will be gained by visiting other facilities in order to perform some of the geochemical and geochronological work. Certainly, the collaborative nature of this project will support students from both institutions exchanging ideas and learning from one another that may not have been possible otherwise. This arrangement has also been highly effective in helping the students interact as part of a research group—modeling the experience of most graduate students working in a research group.

Students recruited for this project will be Earth Sciences and Geology majors from across the concentrations completing their second years of courses. The background and skill set of these students varies considerably, and experience has shown that many students with average grades in geology courses excel when offered an opportunity to conduct research. The PIs will continue to recruit students with this in mind and make every effort to ensure that each selected student is closely mentored so that they are able to attain a high level of independence on their project. Recognizing that it takes time for students to attain a high level of independence and ownership over the design and direction of their project, most of the student projects described within this proposal are fairly modest in scope and complexity. Because each undergraduate requires a significant amount of mentoring to learn the necessary field and laboratory techniques and understand the underlying geological framework within which their particular problem relates, it requires several years of student-mentored projects to contribute sufficient data to allow for a publishable dataset. Thus, compared to the publication rate for research done with Masters and Doctoral students, this model of research results in a longer period of time between research and publication. It should be noted though, that while the pace may be slower compared to that at a research university, the overall quality of the research is as high and that the questions being addressed are meaningful to the research community.

**PI-mentored Student Presentation Abstracts for the Geological Society of America
(BSC student authors indicated in italics, OSU student authors indicated by underline)**

- Bauer, M., Valentino, D.W., Chiarenzelli, J.R. and **Solar, G.S.**, 2004. Metamorphic petrology and unit distribution in the Oliver Hill dome, eastern Adirondack mountains, New York. *Geol. Soc. of America, Abstracts with Programs*, **36**.
- Bestine, J.P.* and **Solar, G.S.**, 2002, Structural analysis of preferred orientations of kyanite in the "log-jam" schist, western Connecticut. *Geological Society of America, Abstracts with Programs*. **34**.
- Centorbi, T.L., **Tomascak, P.B.**, Brown, M., **Solar, G.S.** and Tian, J., 2002, Nature of the crust near the Grenville border in northern New England: New Pb isotope data from the Mooselookmeguntic Igneous Complex, Maine. *Geological Society of America, Abstracts with Programs*, **34**.
- Chmura, S.M.* and **Solar, G.S.**, 2001, The record of granite magma flow through deforming rocks, comparative meter-scale mapping of contrasting types of migmatite in western Maine. *Geol. Soc. of America, Abstr. w/Progs.*, **33**.
- Kerr, S.D.* and **Solar, G.S.**, 2001, Documentation of the transition between contrasting structural zones in western Maine, USA: testing a model. *Geological Society of America Abstracts with Programs*, **33**.
- Klauk, E.E.* and **Solar, G.S.**, 2001, Quantifying the strain record in naturally deformed conglomerate, Silurian Rangeley Formation, western Maine. *Geological Society of America Abstracts with Programs*, **33**.
- Fissler, D.A.* and **Solar, G.S.**, 2004. Variations in porphyroblast-matrix fabrics associated with high-temperature deformation, Roxbury, Connecticut, USA. *Geological Society of America, Abstracts with Programs*, **36**.
- Freyer, P., Valentino, D.W. and **Solar, G.S.**, 2003. Deformation spanning high- to low-grade in the Piseco Lake shear zone, Speculator, New York. *Geological Society of America, Abstracts with Programs*, **35**.
- Price, R.E., Valentino, D.W., **Solar, G.S.** and Chiarenzelli, J.R., 2003. Greenschist facies metamorphism associated with the Piseco Lake shear zone, central Adirondacks, New York. *Geol. Soc. of America, Abstr. w/Progs.*, **35**.
- Smith, N., Valentino, D.W., Chiarenzelli, J.R. and **Solar, G.S.**, 2004. Distribution of L- and L-S tectonite in the Oliver Hill dome, eastern Adirondack mountains, New York. *Geol. Soc. of America, Abstracts with Programs*, **36**.