VIEW YOUR APPLICATION

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Name:	**SSN:**	**GSA Member No:**
Street Address:	**E-Mail Address:**	
University: University of Chicago	**Department:** Dept. of Geophysical Sciences	**Masters Degree?:** NO
Current Degree Program: Ph.D.	**Yrs. in Graduate School (Masters):** 0	**Yrs. in Graduate School (Ph.D):** 3rd Year
Minority Status: White/Caucasian	**Citizenship:** USA	**Gender:** Female
Are you a member of a GSA Division?: Sedimentary Geology	**Are you a member of a GSA Section?:** North-Central	**Did you attend the Grant Writing Workshop?:** No
Amount requested from GSA: $ 2463	**General field of this research project:** Paleontology	**Geographic focus, if any:** Rocky Mountain U.S.

Project Title:
How do hiatal type and nutrient enrichment affect macrofossil abundance and preservation? A case study in the Permian Phosphoria and Park City Formations

Project Supervisor:

Specialized Award(s):

This section should present the problem, hypotheses, and the overall objectives of the project. (1,000 character limit, including spaces).:
In upwelling zones, a delicate balance of O2 is required for life, but reducing conditions facilitate fossil preservation & phosphate concentration. Study of fossils in Phosphoria & Park City Fm facies will elucidate environmental conditions reflected by the biotic part of the record, how seawater nutrients impact preservation, & if these strata are the result of upwelling or purely sea-level changes & winnowing. Hypotheses include (1) a hump-shaped curve where moderate nutrients = denser bioclast packing, but too much depletes O2 & populations crash; (2) increasing nutrients buffers seawater with biominerals & bioclasts aren't degraded; (3) more bioclast damage with longer hiatuses, but phosphatic armoring limits destruction (Fig. 1); etc. I will evaluate sequence stratigraphic anatomy & distribution, close packing, shell bed type, & taphonomy (damage state, preserved mineralogy) of macrofossils as a function of proximity to upwelling cells, physical energy, & hiatal type & duration.

This section should discuss the scientific and societal significance; what is the importance of this project? (2,500 character limit, including spaces):
This study has implications for paleontologists and geologists, given the economic and environmental significance of coastal upwelling (Barber & Smith 1981), secular trends in Phanerozoic organic-rich & phosphatic rocks (Parrish 1987), and observed differences in fauna inhabiting upwelling zones vs. normal marine settings (Crawford et al. 1987). This will be the first parasequence-scale stratigraphic study of the western Phosphoria Basin, and one of the few studies to investigate macrofossil preservation as a function of upwelling conditions (e.g. Edelman-Furstenberg 2009). The Phosphoria Fm's unique situation in the Mid to Late Permian offers a novel view into preservation of pre-mass-extinction macrofauna and ichnofossils through 3 stratigraphic sequences that experienced spatially shifting upwelling cells. My first research season indicates that skeletal fossils may be most abundant in dysoxic facies along upwelling cell margins, where nutrient supply favors animal populations but anoxic events are sporadic rather than persistent and can enhance postmortem preservation. Stratigraphically significant surfaces (flooding, erosion, etc.) will likely have higher fossil abundances due to low dilution of macrofaunal input by siliciclastic sediments, but retarded burial may yield poorer taphonomic states of fossils. Species diversity and extinction have been tied to gradients in energy availability, which in marine ecosystems is a function of nutrients, primary productivity, & food availability (Budd 2000, Martin 2003, Valentine 1971). Increased cold water and turbidity tolerance of fauna during biotic turnovers is linked to upwelling, and high nutrient inputs on short time scales may destabilize ecosystems and uniquely influence diversity patterns (Budd 2000, Martin 2003). The spatiotemporal variation of the putatively cold-water, nutrient-enriched Phosphoria biota provides an ideal test case for these ideas. Understanding mode(s) of genesis and approximate amount of time represented by macrofossil accumulations in upwelling systems is vital for interpreting paleoecological and syn- and post-depositional processes. Results from this study will provide new insights into spatiotemporal trends in macrofossil assemblages preserved in these patchy upwelling zones or heterogeneous environments with a similar suite of facies, and potential ways that interpretations of diversity in the fossil record may be biased by nutrient enrichment of coastal waters via upwelling.

This section should concisely state your research plan and how it will test your hypothesis stated above. (2,500 character limit, including spaces):
I will develop a sequence stratigraphic framework at a parasequence scale within the three transgressive-regressive sequences. Using that, I will assess the distribution and abundance of skeletal remains of both macrobenthic and fish fossils (using taxonomy of Yochelson, 1968). At multiple localities spanning southeastern Idaho through southwestern Montana (to capture the spatial variation in upwelling cells), I will measure stratigraphic sections to recognize bed-scale patterns, and then subsample these to evaluate skeletal macrofossil assemblages using standard methods (Kidwell 1991) for: sedimentological features (size sorting, close-packing, bioclast orientations); preservational features (articulation, fragmentation, biogenic modification, molds or replaced mineralogy); and stratigraphic features (sedimentary matrix, contacts, ichnofabric). I will use standard multivariate methods (e.g., Edelman-Furstenberg, 2008) to test for covariation in close-packing, shell bed type, damage state, and preserved mineralogy (calcite, phosphate, silica, mold) of macroinvertebrates and fish as functions of lithology (a proxy for proximity to upwelling cells); sedimentary structures and ichnology (proxies of physical energy & oxygenation); flooding and other stratigraphic surfaces (proxies of hiatal type & duration); and stratigraphic position (variation in sedimentation rate & type, transgressive vs. highstand systems tracts). Most fossils are degraded, so specific taxonomic identification is impossible; examining preservational quality and distribution

offers a window into an otherwise-obscure biotic portion of the economically important Phosphoria Sea's paleoenvironmental story. Finally, while the entrenched idea of Phosphoria upwelling may offer a ready context for understanding taphonomic & sedimentary patterns, careful investigation of fossil & sedimentary characteristics is warranted to determine if this is the best explanation, or if alternative scenarios are more viable.

Duration of investigation (dates):
May 20-June 20 and August 20-September 20, 2015

This section should have an itemized budget and detailed justification for each item listed. MAXIMUM of $2,500 to be requested from GSA. List in order of priority and be sure to total up each column of budgeted item costs.

	Title of Category	Total Amount Budgeted	Amount Requested from GSA	Amount Requested from Other Sources
1.	Fuel to drive from Chicago to Idaho, around field sites, and back	$625	$325	$300
2.	Fuel to drive from Chicago to Montana, around field sites, and back	$600	$300	$300
3.	Thin sections of rock & fossil samples (36 total)	$1038	$838	$200
4.	Campground fees ($10/night for 10 nights)	$100	$100	$0
5.	Motel fees (~$80/night for 5 nights for storm emergencies during fieldwork)	$400	$400	$0
6.	Food while camping in the field (2 people for 8 weeks)	$600	$500	$0
7.		$	$	$
8.		$	$	$
	TOTAL:	$3363	$2463	$800

Budget justification:
The key Phosphoria and Park City Fm outcrops for my study in Idaho & Montana are accessible on US Forest Service land and at inactive phosphate mines near Soda Springs, Idaho. I will spend 6 weeks measuring stratigraphic sections, sampling, and scoring macrofossils exposed in outcrop. Fuel expenses to drive between Chicago, IL and Soda Springs, ID or Dillon, MT, and around my field areas are estimated at $600-625 per trip (~5,000 miles round-trip, $3.00/gal). While most camping areas on USFS land that I use are free, two of my sites have fees of $10/night ($100 for 10 nights). I am also budgeting $400 for 5 nights in a motel (for storm emergencies during fieldwork, based on multiple occurrences during 2014 field season). I will have an undergraduate field assistant from Macalester College with me, and food expenses for two people while camping for eight weeks will total $600 (based on my August 2014 fieldwork). Thin sections of fossiliferous layers for fine-scale taphonomic analysis using a petrographic microscope will be made for $27 each (30 total of carbonates and cherts, from Spectrum Petrographics) and $38 each (6 total of shales, from Wagner Petrographics).

Amount and nature of other available funds, facilities, materials, etc.:
I have already purchased all necessary field equipment, using funds from previous research grants. I also still have a limited amount of research money remaining from grants I received in 2014 (~$800), which is listed in the matrix above. I will use this to cover a portion of my fieldwork expenses this summer (primarily, funding fuel expenses to allow me to make a second trip from Chicago to work at new sites in southwest Montana), as well as having several additional thin sections made. I have access without fees to petrographic microscopes and basic rock preparation facilities at both the University of Chicago and Macalester College (my undergraduate institution). Additionally, I have gained access without fees to the X-ray diffractometer, X-ray fluorescence spectrometer, and scanning electron microscope at Macalester College for analyzing a subset of my samples. Finally, curation fees have been waived by the Idaho Museum of Natural History for my fossil samples, and the U.S. Forest Service has waived my permit fees as well.

Other grants that (a) have supported this project, (b) are currently supporting this project, and (c) are being applied for. This list should include funds available to or applied for by the thesis supervisor, if these can support the proposed work:

	Year Applied	Agency Title Applied to	Amount Requested	Amount Granted or Date Decision Expected	Amt. remaining as of March 30 this year (projected)
1.	2014	International Association of Sedimentologists	$1146	$1146	$0
2.	2014	Paleontological Society	$800	$800	$0
3.	2014	American Association of Petroleum Geologists	$2000	$1500	$200
4.	2014	American Museum of Natural History: Theodore Roosevelt Memorial Grant	$2000	$1500	$200
5.			$	$	$

Have you ever received a GSA graduate student research grant?	**Related to this project?**	**Year(s) applied:** **Year(s) granted:**
NO		

Progress Report:

Abbreviated Resume:
B.A., Geology, Macalester College (2012); Wasatch-Uinta Field Camp (2013). POSITIONS: TA, Univ. of Chicago Dept. of Geophysical Sciences (Fall 2012–Spring 2013, Fall 2014); TA, Macalester College Geology Dept. (Fall 2011–Spring 2012); Research Assistant for Prof. Ray Rogers, Macalester College (May 2010–June 2012). AWARDS: G. Arthur Cooper Award (2014 Paleontological Society research grant); Donald & Mary O'Nesky Grant (2014 AAPG research grant); Theodore Roosevelt Memorial Grant (2014 AMNH research grant); International Association of Sedimentologists post-grad research grant (2014); National Science Foundation Graduate Research Fellowship (2013); McCormick Fellowship (Univ. of Chicago Dept. of Geophysical Sciences, 2012–2014); MN Space Grant NASA Summer Research Award (Macalester, 2012 & 2011); Barry M. Goldwater Scholar (2011); Student Faculty Summer Research Collaboration Award (Macalester, 2010). PUBLICATIONS: Rogers, R.R., D.W. Krause, S.C. Kast, M.S. Marshall, L. Rahantarisoa, C.R. Robins, & J.J.W. Sertich, 2013, A new, richly fossiliferous member comprised of tidal deposits in the Upper Cretaceous Maevarano Formation, northwestern Madagascar. Cretaceous Research, v. 44, p. 12-29. Marshall, M.S., & R.R. Rogers, 2012, Lungfish burrows from the Upper Cretaceous Maevarano Formation, Mahajanga Basin, Northwestern Madagascar. Palaios, v. 27, p. 857–866. Marshall, M.S., 2014, Variation in macrofossil abundance and preservation under upwelling conditions: A case study in the Permian Phosphoria Formation. GSA annual meeting. Rogers, R.R., M.T. Carrano, K. Curry Rogers, B. Faulkner, A. Lawrence, M.S. Marshall, & M. Perez, 2012, Taphonomy of vertebrate microfossil bonebeds in the Upper Cretaceous (Campanian) Judith River Formation of Central Montana. GSA annual meeting. Marshall, M.S., & R.R. Rogers, 2011, Exceptional record of lungfish burrows from the Upper Cretaceous Maevarano Formation, Mahajanga Basin, Northwestern Madagascar. GSA annual meeting. SELECTED FIELD EXPERIENCE: 2014 dissertation fieldwork, SE Idaho;

2012 paleontology & stratigraphy expedition, Mahajanga & Morondava Basins, Madagascar, led by Dr. David Krause (SUNY Stony Brook) & Dr. Joseph Sertich (Denver Museum of Nature & Science); 2011 vertebrate microfossil bonebed taphonomy, Judith River Fm, Montana, led by Dr. Ray Rogers; 2010 paleontology & stratigraphy expedition, Mahajanga Basin, Madagascar, led by Dr. Ray Rogers (Macalester) & Dr. David Krause (SUNY Stony Brook)

References cited in proposal:

Barber, R.T., and Smith, R.L., 1981, Coastal Upwelling Ecosystems, in Analysis of Marine Ecosystems, p. 31–68. Budd, A.F., 2000, Diversity and extinction in the Cenozoic history of Caribbean reefs: Coral Reefs, v. 19, p. 25–35. Crawford, R.J.M., Shannon, L.V., and Pollock, D.E., 1987, The Benguela Ecosystem. Part IV. The Major Fish and Invertebrate Resources (M. Barnes, Ed.): Oceanography and Marine Biology – An Annual Review, v. 25, p. 353–505. Edelman-Furstenberg, Y., 2009, Cyclic upwelling facies along the Late Cretaceous southern Tethys (Israel): taphonomic and ichnofacies evidence of a high-productivity mosaic: Cretaceous Research, v. 30, no. 4, p. 847–863. Edelman-Furstenberg, Y., 2008, Macrobenthic community structure in a high-productivity region: Upper Campanian Mishash Formation (Israel): Palaeogeography, Palaeoclimatology, Palaeoecology, v. 261, no. 1-2, p. 58–77. Hiatt, E.E., 1997, A paleoceanographic model for oceanic upwelling in a Late Paleozoic epicontinental sea: A chemostratigraphic analysis of the Permian Phosphoria Formation: Univ. of Colorado, 294 p. Hiatt, E.E., and Budd, D.A., 2003, Extreme paleoceanographic conditions in a Paleozoic oceanic upwelling system: Organic productivity and widespread phosphogenesis in the Permian Phosphoria Sea, in Chan, M.A. and Archer, A.W. eds., Extreme depositional environments: Mega end members in geologic time (Special Paper 370), GSA, p. 1-20. Kidwell, S.M., 1991, The Stratigraphy of Shell Concentrations, in Allison, P.A. and Briggs, D.E.G. eds., Topics in Geobiology: Taphonomy: Releasing the Data Locked in the Fossil Record, Plenum Press, p. 211–290. Martin, R., 2003, The fossil record of biodiversity: nutrients, productivity, habitat area and differential preservation: Lethaia, v. 36, no. 3, p. 179–193. Maughan, E.K., 1984, Geological setting and some geochemistry of petroleum source rocks in the Permian Phosphoria Formation, in Hydrocarbon Source Rocks of the Greater Rocky Mountain Region, Rocky Mountain Assoc. of Geologists, p. 281–294. Parrish, J.T., 1987, Palaeo-upwelling and the distribution of organic-rich rocks: GeoL. Soc., London, Special Pub., v. 26, no. 1, p. 199–205. Valentine, J.W., 1971, Resource supply and species diversity patterns: Lethaia, v. 4, p. 51–61. Yochelson, E.L., 1968, Biostratigraphy of the Phosphoria, Park City, and Shedhorn Formations: U.S.G.S., p. 571–660.

Images On File:

Yes