SURF Research Proposal Form
**This proposal form is for all students applying to: SURF L&S, SURF Rose Hills Independent, or SURF Rose Hills Experience. This is NOT the correct application form for the Math Team fellowships.

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Instructions: The SURF proposal has 5 sections. Each section specifies how long your response should be (approximate word number). Please keep your responses single space and use 12pt font. While it is useful and appropriate to use technical language in parts of your proposal (terms specific to your discipline), you should aim to have your proposal understandable to a more general academic audience. Avoid jargon or overly abstract phrasings. Type or paste in your responses to the 5 prompts below.

When you are finished, save the document as a PDF with a filename in this format: ***ProposalYourLastName.pdf (example: ProposalSmith.pdf)***
You will be asked to upload this completed PDF research proposal form when you submit your application online.

1. Research Statement: 150-200 words. What specific question will you pursue with your research and why is it important to the field? This section enables you to give the reviewers an overview of your project. Keep in mind that other sections give you an opportunity to develop more details around the background, methodology, and rationale for the project.

Glaciers are important freshwater sources around the world. They are especially significant during climate change because they serve as nature's drought buffer to balance years with less rain. Understanding previous global glacier melting events will help us understand how glaciers today will respond to global warming. Many mountain glaciers are not well constrained. The goal of this study is to provide more insights into the unsolved Tioga glacier melting patterns in Yosemite National Park (NP), located in the Sierra Nevada range in California, after the Last Glacial Maximum, the most recent global glacial maximum event. The main question I aim to answer is whether the glacier melted uniformly in a short period or altered between retreating and advancing during a longer melt period. Geochemical dating methods will aid in addressing questions related to the timing, rates, and patterns of Tioga glacier's glacial retreat and glacial thinning. With background research and connection to labs I developed last year, this summer, I will continue my fieldwork and create a geometry model of the glacier's response to warming temperatures and then predict the glacier's mass balance change under a warming climate. This will aid mountain glacier water budget planning around the world.

2. Background to the Topic and Rationale for Your Research: 300-400 words. What is already known about the field of research you will be working on? How does your research project fit in with what is being done currently in the field, and how does it build upon knowledge on the topic or fill in gaps in the field? Please cite references from the literature when applicable; these citations should be listed in #5 of this proposal.

Understanding deglaciation (large-scale glacier melting) after the Last Glacial Maximum (LGM) 22-12 thousand years (kyr) ago (Becker, 2018) will offer insight into current deglaciation dynamics related to climate change. Under the cold climate, the LGM had large northern hemisphere mountain glaciers. After the LGM, the deglaciation event started and the Pacific Ocean surface temperature rose (Clark et al., 2009), which is similar to today's global warming event.

The Tioga glacier at Yosemite is a well-mapped mountain glacier from the LGM (Wahrhaftig et al., 2019) and provides a foundation for studying its post-LGM deglaciation dynamics. Yosemite was only partially glaciated during LGM and now the park is almost fully deglaciated (Wahrhaftig et al., 2019), allowing me to study the full deglaciation process.

While some argue that the Tioga glaciation retreat was a short continuous event (Becker, 2018), other studies found that Yosemite underwent multiple warm-dry and cold-wet cycles from 19.7 to 10.7 kyr (Street et al., 2012), which can lead to glacier advance and retreat during a deglaciation event with longer duration. New geochemical bedrock exposure age dating methods can be used to capture information about the timing, rates, and thinning patterns of the Tioga deglaciation.

At Earth's surface, rocks are exposed to radiation coming from space (cosmogenic rays) that interact with the Oxygen element in quartz, forcing it to produce cosmogenic nuclides such as Beryllium-10 (^{10}Be) and Carbon-14 (^{14}C) on the rock surface. The longer time the rock is exposed to the atmosphere, the higher the concentration of cosmogenic nuclides will increase. Once the exposed rocks become covered by glaciers, cosmogenic nuclides will stop accumulating. Glaciers can erode the cosmogenic nuclides away, resetting the exposure age. ^{10}Be has a significantly longer half-life than that of ^{14}C (Godwin, 1962; Granger, 2006). ^{14}C is more effective for higher elevation samples around the predicted maximum glacial extent, which underwent minor glacier erosion and will inherit ^{10}Be from the deglaciation before LGM.

I discovered a gap in the current ^{10}Be exposure age data in Yosemite's Lyell Canyon: there is no data in the vertical glacier thickness dimension. Using both ^{14}C and ^{10}Be analyses on samples collected from vertical transects on valley walls, combined with previous data from the valley floor (Dühnforth et al., 2010; Becker, 2018), will allow me to assess my hypotheses about the thinning and retreating relationship of mountain glaciers. My result will be informational for managing glacial meltwater under global warming.

3. Research Plan - Methodologies and Timeline: 450-700 words. Please define the main challenges of your project and what research methods you will use to address these challenges. Describe your research plan for the summer in chronological order - either use a week-by-week timeline or phases approach (i.e. week 1, week 2…or phase 1, phase 2…). Each week/phase should specify goals, action items, and methods. Please include in your plan information about exactly how/when you will check in with your research mentor.

The study area focuses on Yosemite's Lyell Canyon because of its accessible trails, clear topographical indication for past glacier head, and lack of influence of large tributary glaciers, which can provide a simple case for modeling. The glacier in Lyell Canyon originated from Mount Lyell, the highest peak of Yosemite. The local glacier of Lyell Canyon retreated from 16 kyr to 3 kyr, from the north to the south of the canyon (Dühnforth et al., 2010; Becker, 2018; Wahrhaftig et al., 2019).

Bedrock samples for cosmogenic nuclide dating will be collected across Lyell Canyon perpendicular to the glacier flow/retreat direction to capture the glacier thinning in the valley (Fig.1a&b). The majority of the bedrock within the canyons is granodiorite (Huber et al., 1989), which contains abundant quartz and is well-suited for ^{14}C and ^{10}Be cosmogenic nuclide analysis. The exposure age can inform us of when the glacier melted away from the underlying bedrock. With these new data, combined with previous ^{10}Be data from the study location (Dühnforth et al., 2010; Becker, 2018), we will examine the relationship between the glacier's vertical thinning and its horizontal retreat. Three vertical transects, consisting of six sample sites in each transect, will be collected within the valley (Fig. 1a). Also, I will collect a vertical transect with two samples at a higher elevation than previous studies at Mount Lyell to better constrain the maximum glacier elevation. This transect will allow me to compare and quantify the difference in thinning at the head of the glacier versus the ice body in the valley.

Using these new results, together with previous studies' data (Dühnforth et al., 2010; Becker, 2018) and the local topography data, I will be able to construct the volume change of the Tioga glacier overtime during the deglaciation event (Fig. 1c) using Python. The modeled glacier surface altitude and glacier's length will be used to estimate the glacier mass balance changes after the LGM (Cuffey and Paterson, 2010; Faraoni, 2016; Roe et al., 2017). Additionally, current deglaciation models in Sierra Nevada (Kessler et al., 2006) will be used to examine how climate change will result in glacial mass balance change.

I will perform the following phases in the summer of 2021 (Fig. 2):

1. Data Analysis and Field Sampling Phase (May - June): the goal of this phase is to use the received data to revise and carry out further fieldwork collecting 14 samples. Prof. Shuster and I will use the cosmogenic online calculator (Balco et al., 2008) and Python to analyze the trend in the data, which will help revise the sampling location and logistics of the fieldwork. Following COVID-19 regulations, I will recruit voluntary field assistants to conduct a week-long sampling trip at Yosemite. I will also document the fieldwork using an action camera.

2. Sample Processing Phase (July): the goal of this phase is to finish processing the collected samples at UC Berkeley. I will use the rock-crushing room at McCone Hall, UC Berkeley to crush the bedrock samples and separate them into different grain sizes. I will actively communicate through email with Prof. Shuster, as well as the point of contact in Tulane Cosmogenic Nuclide (TCN) Lab and the Purdue University's PRIME Lab. Finally, the samples will be ready for sending to the TCN Lab and PRIME Lab in the fall.

3. Model Designing Phase (August): the goal of this phase is to start modeling the glacier geometry in Lyell Canyon. With the exposure age data from fall 2020 samples and summer 2021's field observations, I will design a glacier model using Python with Prof. Shuster. The phase will continue through the fall semester until I receive the summer samples' data.

4. Science Communication Phase (July - August): the goal of this phase is to produce science communication projects related to this research. I will compile footage from the field to produce a short documentary to be posted on YouTube. I will also write a science communication article to encourage public learning about scientific research at Yosemite and its significance for understanding current climate issues. Prof. Shuster will advise me to produce clear and engaging science communication projects.

4. Your Qualifications and Project Affiliations: 150-250 words. What experiences have prepared you to carry out this research project, including coursework, previous research experiences, and other relevant skill building? If your project involves access to people and/or institutions to support your work (i.e. interviewing subjects or partnering with institutions), please describe the affiliations, permissions and agreements you have already established as part of your plan.

As a Geology major, I have backgrounds in chemistry, calculus, glaciology, geochemistry, geomorphology, field geology, and computer science. I collected samples in the backcountry from Juneau Icefield Research Program and presented research at conferences (Reahl et al., 2019). Also, I was a student sample preparation technician at the Berkeley Geochronology Center (BGC).

I am also a passionate science communicator. I produced three short films during high school. I volunteer as a picture editor for the Institute of Geology and Geophysics of the Chinese Academy of Science and an ambassador for the NASA Lucy Mission.

This project was initiated last fall and I will carry it on to next year as my thesis. I have conducted some background research and performed field trips to Yosemite where I collected six samples. I processed the samples at UC Berkeley and sent them to Dr. Brent Goehring at the TCN Lab and PRIME Lab for further analysis, which should return me results before May 2021. We have agreed to run the future ~14 samples that I will collect. I also delivered three online presentations about my Yosemite fieldwork to students and educators around the world.

I plan to have weekly zoom meetings with my advisor Prof. David Shuster and collaborate online with Dr. Greg Balco and Dr. Alyssa Abbey at BGC, and Dr. Greg Stock from Yosemite. I also received the Free Seed Sample program from PRIME Lab. With strong academic and project management background, I believe I will carry out this project successfully.

5. Citations and Core Texts: No longer than 1 page. This section should contain citations for any references you made in your proposal, and you are welcome to list any additional texts that you feel are central to your project.

Balco, G., Stone, J.O., Lifton, N.A., and Dunai, T.J., 2008, A complete and easily accessible means of calculating surface exposure ages or erosion rates from 10Be and 26Al measurements: Quaternary Geochronology, v. 3, p. 174–195, doi:10.1016/j.quageo.2007.12.001.

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Clark, P.U., Dyke, A.S., Shakun, J.D., Carlson, A.E., Clark, J., Wohlfarth, B., Mitrovica, J.X., Hostetler, S.W., and McCabe, A.M., 2009, The Last Glacial Maximum: Science, v. 325, p. 710–714, doi:10.1126/science.1172873.

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Dühnforth, M., Anderson, R.S., Ward, D., and Stock, G.M., 2010, Bedrock fracture control of glacial erosion processes and rates: Geology, v. 38, p. 423–426, doi:10.1130/G30576.1.

Faraoni, V., 2016, Volume/area scaling of glaciers and ice caps and their longitudinal profiles: Journal of Glaciology, v. 62, p. 928–932, doi:10.1017/jog.2016.79. Godwin, H., 1962, Half-life of Radiocarbon: Nature, v. 195, p. 984–984, doi:10.1038/195984a0.

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Kessler, M.A., Anderson, R.S., and Stock, G.M., 2006, Modeling topographic and climatic control of east-west asymmetry in Sierra Nevada glacier length during the Last Glacial Maximum: Journal of Geophysical Research, v. 111, p. F02002, doi:10.1029/2005JF000365.

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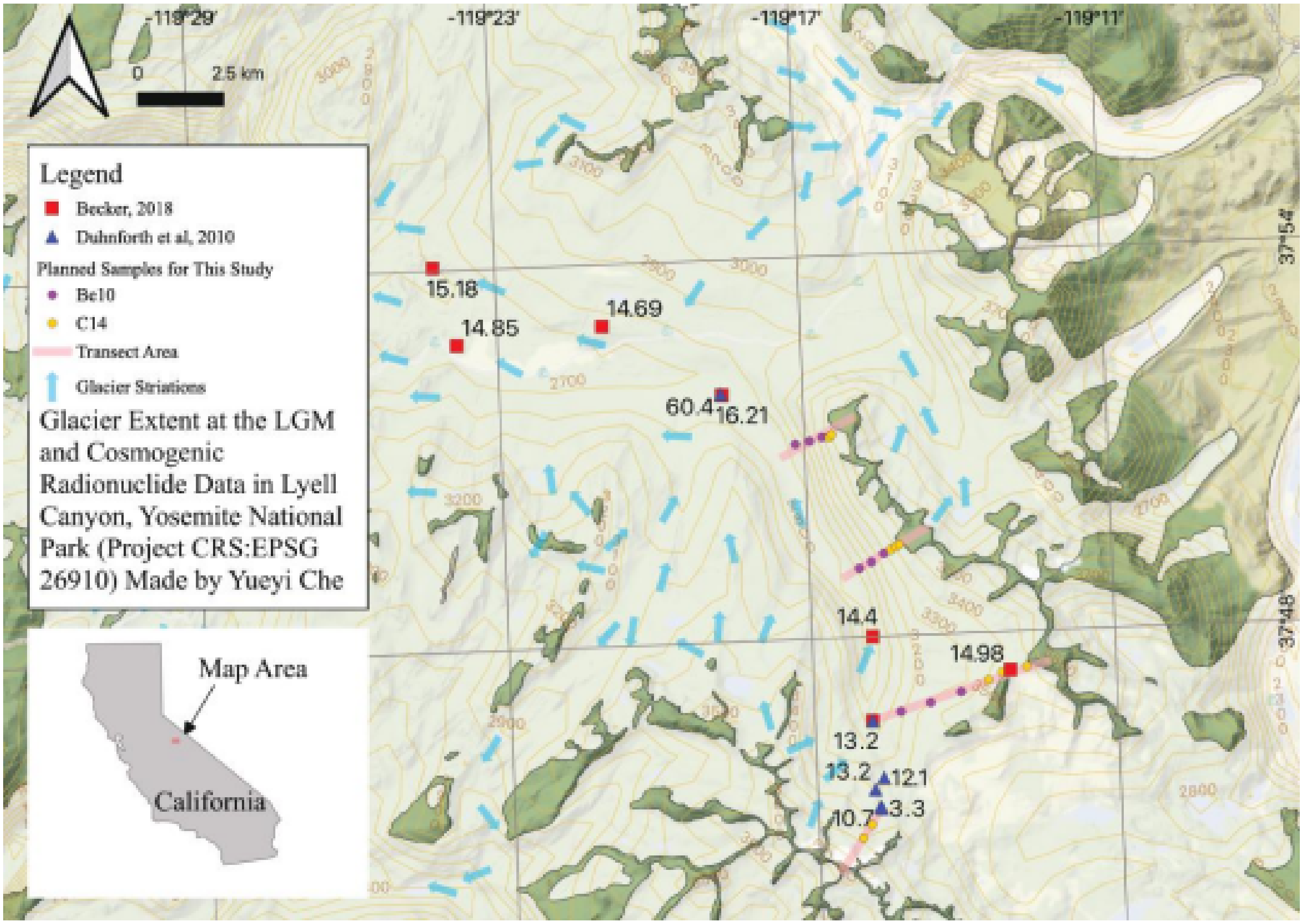
Roe, G.H., Baker, M.B., and Herla, F., 2017, Centennial glacier retreat as categorical evidence of regional climate change: Nature Geoscience, v. 10, p. 95–99, doi:10.1038/ngeo2863.

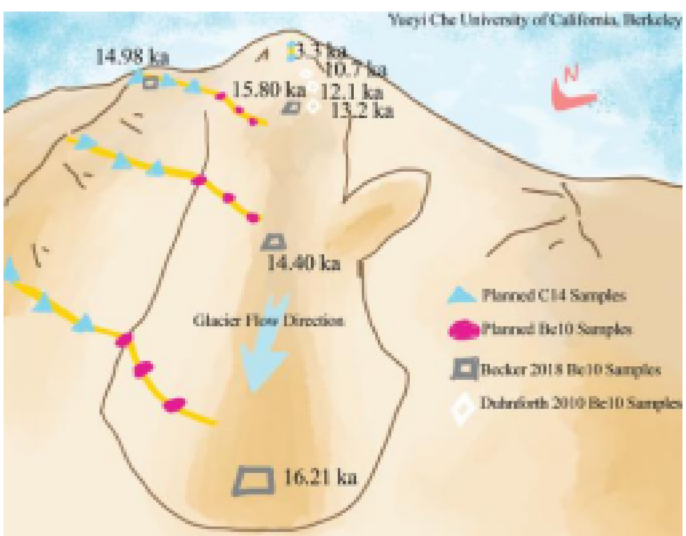
Street, J.H., Anderson, R.S., and Paytan, A., 2012, An organic geochemical record of Sierra Nevada climate since the LGM from Swamp Lake, Yosemite: Quaternary Science Reviews, v. 40, p. 89–106, doi:10.1016/j.quascirev.2012.02.017.

Wahrhaftig, C., Stock, G.M., McCracken, R.G., Sasnett, P., and Cyr, A.J., 2019, Extent of the Last Glacial Maximum (Tioga) glaciation in Yosemite National Park and vicinity, California: U.S. Geological Survey Scientific Investigations Map, p. 3414, pamphlet 28 p., 1 sheet, scale 1:100,000, 2 appendixes, doi:10.3133/sim3414.



-119°29'
-119°23'
-119°17'
-119°11'
0
2.5 km
37°54'
37°48'
Legend
Becker, 2018
Duhnforth et al, 2010
Planned Samples for This Study
Be10
C14
Transect Area
Glacier Striations
Glacier Extent at the LGM and Cosmogenic Radionuclide Data in Lyell Canyon, Yosemite National Park (Project CRS:EPSG 26910) Made by Yueyi Che
Map Area
California
15.18
14.85
14.69
60.4
16.21
14.4
14.98
13.2
13.2
12.1
10.7
3.3

(a)



Yueyi Che University of California, Berkeley
14.98 ka
3.3 ka
10.7 ka
15.80 ka
12.1 ka
13.2 ka
N
14.40 ka
Glacier Flow Direction
16.21 ka
Planned C14 Samples
Planned Be10 Samples
Becker 2018 Be10 Samples
Duhnforth 2010 Be10 Samples

(b)

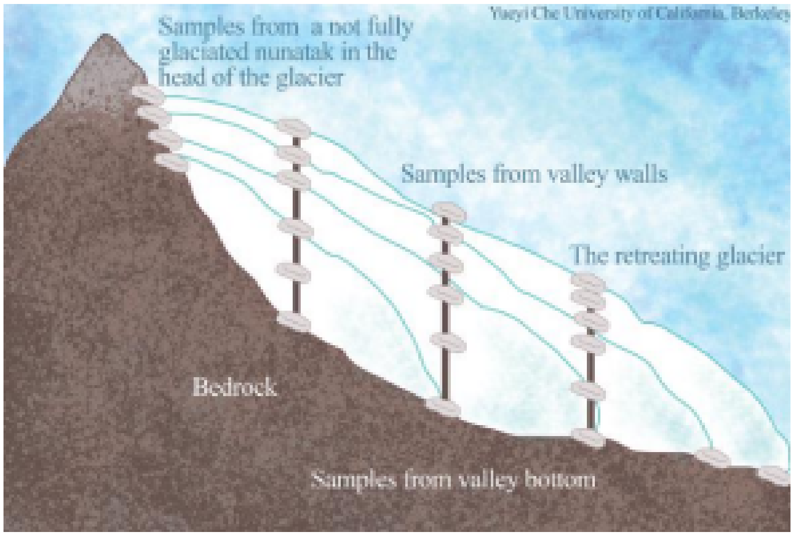


Figure 1. Proposed Sample Locations. (a) is the proposed sample locations on a map view. Six ^{10}Be and ^{14}C samples will be collected along each transect line. Red squares and blue triangles show previous studies' 10Be sample locations and data (Becker, 2018; Duhnforth et al, 2010). The base map is from Stamen Terrain and the LGM glacial maximum extent marked by white polygon, as well as the blue arrow glacier striation (glacier flow direction), is based on the Wahrhafting et al, 2019 map. (b) shows the transects in the u-shaped valley with the previous studies' data. (c) shows the ideal 2-D geometric shape our new data with previous studies' data can yield.

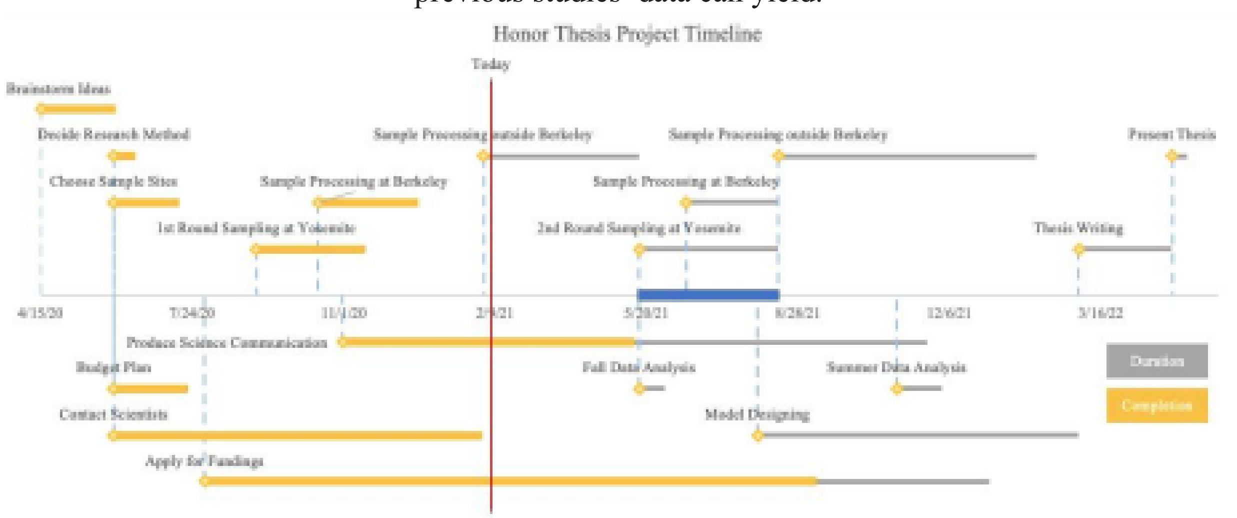


Figure. 2. Honor Thesis Project Timeline. "Today" in the figure is Feb. 6th, 2021. The grey bars show the duration of the phases. The yellow bars show the percent completion of the phases. The blue bar on the time axis shows the summer of 2021.