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Lewis and Clark Fund for Exploration and Field Research in Astrobiology

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Measuring Polymorphism in Northern Hemisphere Snow Algae Populations

Team leader David J. Smith spent the first week of June 2009 completing preparations for the upcoming expedition to Mt. Baker (Fig. 1). Since participants Hunter Ferguson, Kelly Hillbun, and Tom Tobin (Fig. 2) already owned most of the personal clothing items necessary for early summer mountain conditions, Mr. Smith focused mostly on obtaining (through purchase or rental from retailers in Seattle and Mt. Vernon, Washington) technical climbing gear. One week prior to departure, Mr. Ferguson hosted a mountaineering training session in West Ewing Park, Seattle, where our group refreshed skills that would be critical the following week, including: rope handling, knots, belays, use of cordage and carabiners, harnesses, and other forms of snow and ice protection. The night before leaving for Mt. Baker, the team assembled at Mr. Ferguson's residence in Seattle to distribute group gear, personal items, food, and scientific equipment. Maps and field plans were reviewed in detail before night's end. Early the next morning, Mr. Smith's vehicle was loaded with backpacks and climbing gear and the team was on its way to Mt. Baker, approximately 3 hours to the north.

Upon arriving at the Mt. Baker – Snoqualmie National Forest, our team visited the ranger station to discuss our proposed route over Easton Glacier and inquire about snow and ice conditions, reported as deep and loose even at lower elevations. From the ranger station, it was a 30 minute drive on a dirt road to the trailhead for Easton Glacier access. Towards the end of this drive, it was clear that the reports of abundant snow at lower elevations were accurate. Eventually, our team was forced to park the vehicle about 1 mile from the trailhead due to the impassable roadway. This delayed our progress considerably. Knowing the ascent to Easton Glacier would be long and challenging – requiring an earlier start and fresher legs – Mr. Smith elected to establish camp at the trailhead; effectively postponing field activities until the following morning. The good news was the snowpack surrounding the team displayed bright hues of green and red; indicative of thriving snow algae populations (Fig. 3).

On June 12, after a restful night, the group packed up camp and started early on the trail. Our goal for the day was to gain elevation (approximately 3500 feet) and leave the alpine forest behind, targeting the terminus of Easton glacier by late afternoon to establish camp. During this transit, we would monitor the snow algae distribution and collect bulk samples – saving the detailed (more time-consuming measurements) for the glacier setting. With no human traffic this early in the season, the trail to Easton glacier was hidden by snowpack, and our team immediately relied upon the topographic maps and GPS units for navigation, which proved to be more challenging than expected. By noon, we had gained 2000 vertical feet and were heading up a boulder-studded ravine that was steep but seemed to offer a direct path to our destination. Each carrying at least 65 lbs in our backpacks, the pace was slow but steady. Above timberline our team noted the disappearance of snow algal populations, but we elected to continue upward for the afternoon to confirm the absence throughout higher elevations. Sure enough, as we continued our climb the snow showed no signs of coloration. More troubling to the team, however, was the increasing intensity of glacial runoff. What were merely streams at lower elevations were now steadily flowing rivers that we were forced to cross on several occasions in order to continue towards the glacier terminus (Fig. 4). After the second knee-deep crossing, our boots were soaking wet and morale was steadily dropping. With several hours of difficult climbing to go – but more importantly, with the science subject clearly behind us (at lower elevations) – Mr. Smith decided to turn the group around and return to the trailhead for safer camping and more reliable access to snow algae samples. After drying out and warming up, the new priority would be to characterize the snow algae populations at lower, alpine elevations where samples were readily available. With this pivotal decision made, our proposed transect across Mt. Baker was abandoned in order to achieve our stated scientific purpose.

Our final two days consisted of extensive sampling throughout the Heather Meadows interface (N 48°, W 121°, approximately 3000 ft elevation). Mr. Ferguson maintained the field notebook which described each sample locality (slope, GPS reading, etc.) and measurements taken by Mr. Tobin (snow density) and Ms. Hillbun (PAR and

UV irradiation) using handheld instruments (Figs. 5 and 6). Meanwhile, Mr. Smith collected and archived samples using aseptic techniques. Back at camp, pH, water content, and conductivity measurements were taken. Altogether, over 100 samples of germinated and sporulated algal cells from a variety of unique locations throughout Heather Meadows were collected and transported back to Seattle.

Images were taken of four distinct cell morphologies (Fig. 7), later identified as *Chloromonas nivalis*, *Chloromonas brevispina*, *Chlainomonas rubra*, *Chlamydomonas nivalis*. Species and phylogenetic assignments will be confirmed by subsequent DNA analysis (pending). Polymorphism measurements on non-vegetative samples are ongoing and will provide critical comparisons to Southern Hemisphere populations sampled in February 2009 by Mr. Smith and Mr. Tobin. Using the in-situ data collected, bioreactors at the University of Washington and NASA Ames Research Center (PI: Dr. Nathan Bramall) were calibrated to maintain vegetative populations for detailed growth studies. Keeping the cells active in the laboratory satisfied a major goal of this field research and will provide significant insight into the snow algae life cycles. This curious dormancy pattern, which has allowed populations to adapt to extremely cold, oligotrophic, high-radiation environments, will be an important terrestrial analog for astrobiologists exploring Mars over in the years ahead. Our team was very grateful for the opportunity to contribute to this effort thanks to the generous support provided by the American Philosophical Society on behalf of the Lewis and Clark Fund for Exploration and Field Research in Astrobiology.

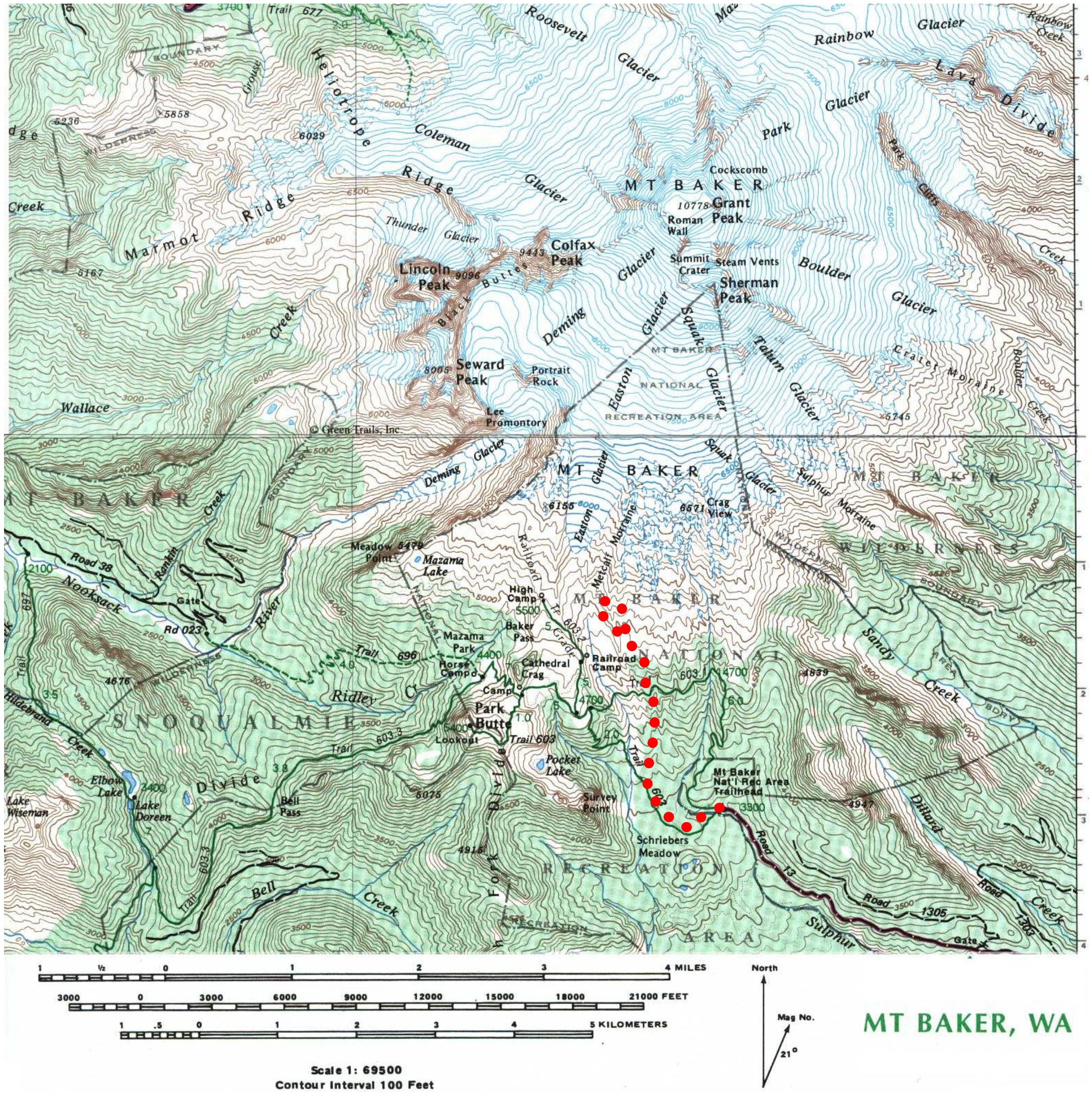

Fig. 1. Map of Mt. Baker with Smith team route depicted in red.

Fig. 2. (*left to right)* Team members David J. Smith, Tom Tobin, Hunter Ferguson, and Kelly Hillbun at Heather Meadows in Mt. Baker – Snoqualmie National Forest

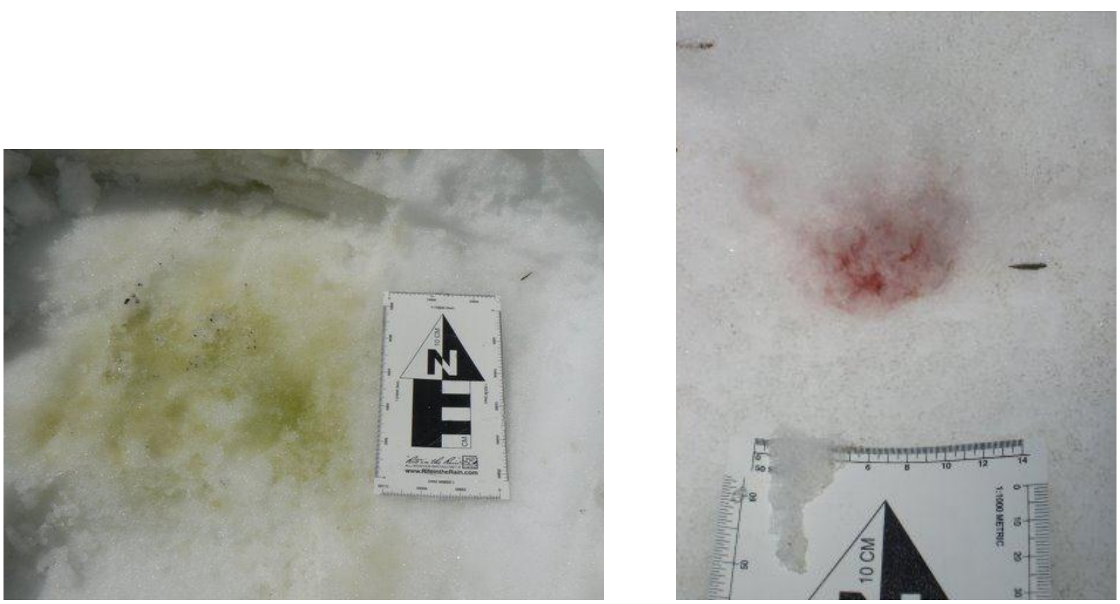

Fig. 3. Germinated snow algae population (green coloration) and sporulated snow algae population (red coloration)

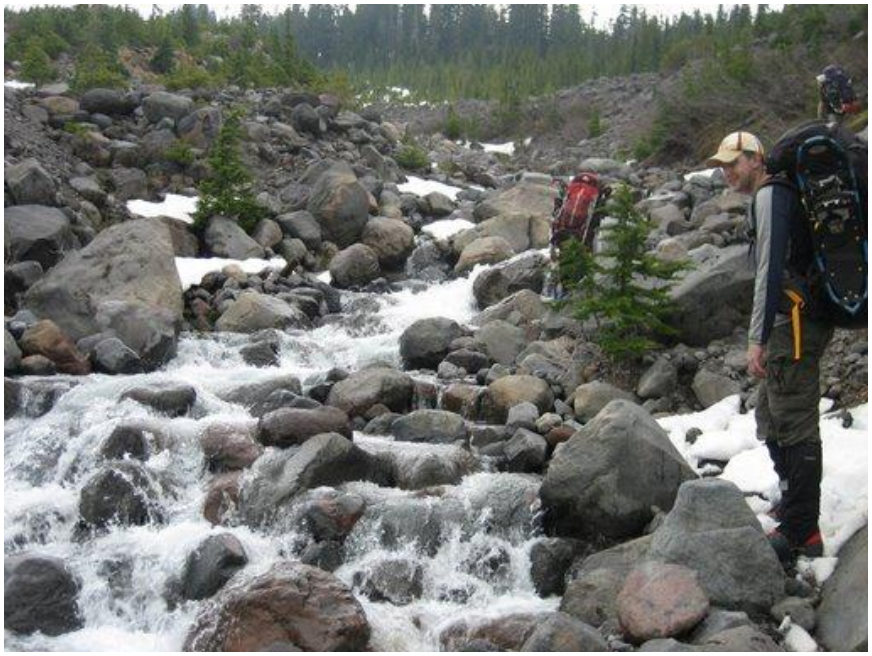

Fig. 4. Tom Tobin pictured in front of the glacial runoff on the attempted ascent toward the Easton terminus

Fig. 5. (*left to right)* Smith, Ferguson, and Hillbun sampling algae in the snowpack of Heather Meadows and characterizing the radiation environment.

Fig. 6. (*left to right)* Smith and Tobin collecting samples and measuring snow density.

Fig.7. Representative sample of snow algae cells at 400 X magnification