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Original Paper

NSF Presidential Award Webinar

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Abstract

This paper presents a summary of a National Science Foundation Webinar on Supporting Student Research with methods of relevance to applied research applications. This Webinar featured invited Presidential Award (PAESMEM) winners Dominique Evans-Bye and Steve Oppenheimer and showcases selections done by K-12 students that are every bit as good as many from university level research programs. K-12 research is often belittled as not real research but this concept will be negated by reading the applied research presented here. Interesting data on ejecta pattern on Martian crater, adhesion peptides binding to hydroxyapatite, and population dynamics of Collembolans are presented here. Dominique Evans-Bye, a high school teacher, is one of two US Presidential Award winners in the area of student research in science, of hundreds at the university level. This paper will show why she was selected to receive this honor and what other teachers can do to lift the level of student research in their classes.

1. Introduction

The Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring (PAESMEM) is a Presidential award established by the United States White House in 1995 (Note 1). The program is administered by the National Science Foundation (NSF) (Note 2) on behalf of the White House Office of Science and Technology Policy (OSTP) (Note 3) to reward outstanding mentoring by individuals and organizations. PAESMEM is the highest national mentoring award bestowed by the White House (Note 4).

A National Science Foundation Webinar was presented on August 11, 2020 (Note 5) by invited Presidential Award winners Dominique Evans-Bye and Steve Oppenheimer on the topic Supporting

Student Research (Note 6). An abbreviated version of this Webinar is presented here as originally it was presented to a limited audience of Presidential Award winners.

The selections cited here were also presented in the New Journal of Student Research Abstracts (Note 7), a journal for K-12 teachers and their students and not for the general scientific community. Therefore, neither the Webinar or Journal were given the widespread coverage of this applied research paper. The material presented is applied research and the methods are of interest to applied research scientists and educators.

The Webinar started with a presentation by Steve Oppenheimer telling teachers how to submit their students' research to the journal. After reviewing and editing abstracts (the journal editors also review and edit the abstracts), teachers email the abstracts to steven.oppenheimer@csun.edu, usually by June 1 of each year (Note 8). Details and formats are given in each journal issue. All 25 annual issues are available for downloading free of charge world wide by clicking on:

http://scholarworks.csun.edu/handle/10211.3/125029 (Note 9). The sample selections from the journal show that K-12 student research can be every bit as good as university level research.

Also presented at the Webinar by Steve is the following National Science Teaching Association (NSTA) October 2019 Commentary read by hundreds of thousands (Note 9). It provides an important vision on the importance of recognizing all participating science students, if we are to increase the ranks of future research scientists.

The Value of Recognizing the Efforts of All Science Students By Steve Oppenheimer. Current education research (Note 10, Note 11) has shown that precollege science experiences substantially increase the number of students choosing a science major in college. However, science fairs usually select a relatively small number of winners from hundreds of participants, leaving most with little to show for their efforts, which can diminish those students' future interest. About 35 years ago, I established a research training program for K-12 teachers. After training many teachers in our labs, I developed the Journal of Student Research Abstracts (JSRA) to showcase and reward participating students with published abstracts in a free online journal. All students, not just the high achievers, should be encouraged to do precollege science research, as by the time they reach college, they often have decided on careers. The United States needs more research scientists, so we should encourage many more students, not just high achievers, to fall in love with science. Teachers across Los Angeles and across the U.S.A. submit abstracts on behalf of their middle and high school students to JSRA. Journal editors and teachers rigorously review abstracts, and students have the opportunity to correct any problems. Although this research is conducted by students, scientific rigor is expected. Abstracts document the use of appropriate controls, sufficient replications, and adequate numbers of samples. Accepted abstracts are published in the journal, and student authors receive a print copy of the journal containing their published research. (JSRA is available online at http://bit.ly/2kkE0Et.) One teacher said their students dance with joy upon seeing their work in print. Working with teachers like Greg Zem, Terri Miller, Stacy Tanaka, and Aphrodite Antoniou, my colleagues and I also created The Center for

Cancer and Developmental Biology Pre-College Research Poster Symposium, which also recognizes hundreds of middle and high school student scientists each year. The posters often are based on the reviewed project abstracts submitted to JSRA, and a cadre of advanced senior level university students trained in research science evaluate them. Students conduct their research at their schools and homes, and present their reviewed research in poster form at the symposium, held at California State University, Northridge (CSUN), where they receive medals and certificates recognizing their efforts. This really inspires them to continue in science. Former students who contributed to the journal and participated in the symposium have reported that their siblings “fight” to become involved. Students have been admitted to a spectrum of higher learning institutions, including the California State University system, University of California system, Drexel University, Oxford, Pepperdine, Stanford, Harvard, Penn State, and the University of Tokyo. Thousands of good precollege science experiences exist that can motivate students to choose science careers. Just having a great science teacher can spark students’ interest. Our journal and poster symposium recognize thousands of kids for their research work. A reward like a published abstract or a medal and certificate may be the first and often only recognition from a university many of these students receive. Following the most recent symposium, CSUN Vice Provost Matt Cahn noted, “This is one of those transformative opportunities that we hope all students have.” How often do hundreds of students receive university and parental recognition for science research work? The pride that families take in their children’s science work provides an extra push for them to choose a science career. These programs are replicable by teachers, schools, and school districts if they wish to encourage many more students to contemplate future science careers. I also suggest that science educators consider urging their middle and high school students to submit research abstracts to JSRA. l Author’s note I would like to thank Andrew Weiss, Elizabeth Altman, Mindy Berman, Alvalyn Lundgren, and Helen Chun for their work on JSRA. I have been fortunate to have support from CSUN leadership and staff in launching and running the symposium and the journal. Steve Oppenheimer, professor emeritus, CSUN, has received several awards, including the Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring and a CSU System Trustees Outstanding Professor award. He is an American Association for the Advancement of Science Fellow and serves as director of CSUN’s Center for Cancer and Developmental Biology. He was editor of Elsevier’s international journal Acta Histochemica, affiliated with the International Federation of Societies for Histochemistry and Cytochemistry. He has taught, conducted research, and worked with middle and high school students and teachers at CSUN for 48 years (Note 8).

We think that the selections from students and teachers presented here and at the Webinar confirm that K-12 applied research can be as good as university level research. This article helps in the recognition of an often under recognized segment of the world’s research efforts.

2. Experimental Procedure

In the Ejecta Pattern report, a Thermal Emission Imaging System (THEMIS) was used (Note 11). Peptide and hydroapatite slab structures were generated using peptide configuration software and molecular editing software in the Adhesion Peptide Interactions experiment (Note 12). In the Collembola (Onychiuridae encarpatus) experiment Petri dishes were used with experimental and control samples (Note 13).

3. Results and Discussion

Here follow student research selections presented at the Webinar or in the journal described in the Webinar. IT IS IMPORTANT TO READ THE MARS PAPER BECAUSE IT PROVIDES A KEY CLUE ON WHY D.EVANS-BYE WAS SELECTED AS A PAESMEM RECIPIENT AND HOW OTHER TEACHERS CAN LIFT THE LEVEL OF THEIR STUDENT RESEARCH.

A Unique Ejecta Pattern: Erosion’s Effect on a Martian Dual Crater

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Eliza Petrosian, Sevak Vartanian, and D. Evans-Bye (teacher)

Anderson W. Clark Magnet High School

4747 New York Ave., La Crescenta, CA 91214 (Note 11)

I. Introduction

The research question that we investigated for this project was: “Has the ejecta pattern around the double crater in stamp V15272005 been modified by erosion?”

We found our research question interesting because as we were looking over Thermal Emission Imaging System (THEMIS) images, we noticed a double crater, which means there were two impacts. It appears the impacts were simultaneous, seeing as one crater does not overlap the other and the ridge cuts right in between the craters. The ejecta is unique because it does not match the shape of the other typical patterns such as butterfly, radial, or offset. The crater’s edges seem to be smoothed by erosion.

We came up with the following hypotheses for our project:

- If the ejecta has been modified, then we will find evidence of erosion.
- If the ejecta has been modified by water erosion, then we will find evidence of channels.

II. Background

Known as Earth’s sister planet, Mars is thought to have been very similar to present day Earth millions of years ago (Anderson, 2019). Surprisingly, both Mars and Earth have roughly the same amount of dry land surface area. This might seem like a strange claim when objectively looking at the two planets, but two-thirds of Earth’s surface is covered by water. Because the diameter of Mars is roughly half that of Earth, Mars’ gravity is much lower. The gravity of Earth is 2.66 times that of Mars. The composition of their atmospheres is greatly different. While they do share many of the same gases, the most abundant gas on Mars is carbon dioxide, with a whopping 95.32% compared to Earth's 0.038%. On Earth, the most prevalent gas is nitrogen with 77%, while on Mars it is 2.7%. Arguably the most important gas for the presence of life, oxygen, is 21% of Earth's atmosphere and only 0.13% of Mars'. The atmospheric pressure for Mars and Earth is 7.5 millibars (on average) and 1,013 millibars (at sea level), respectively (Phoenix Mars Mission, 2007).

In addition, Earth is much more geologically active than Mars. Earth has a "hot interior" with a core, mantle, and crust. Earth also contains a lithosphere, the rigid rock that forms the outer layer of a planet. These help with conducting heat flow around the planet, with gravity helping by sorting the materials in terms of density (McGrath, 2005). These differences in the two planetary bodies provide a reasonable explanation as to why it is less common for certain features to form, why they look different on Earth, or why they do not remain as long.

While there are a myriad of different features that form on both Mars and Earth, there are specific features that pertain to the stamp V15272005 (**Figure 1**). (See **Figures 1-8** on page 61.) These features include double craters, ejecta patterns, and channels (**Figure 2**). These features are thought to form the same way on Mars as they do on Earth. Craters are formed in three stages: compression, excavation, and modification (**Figure 3**). During the compression stage, the impact from the meteor causes a shock wave to pass around the area. The energy is converted into heat and kinetic energy. The impact causes solid materials to behave like fluids. During the next stage, excavation, the shock waves continue outward through the material surrounding the impact. The material then moves upward and outward, causing it to form an ejecta blanket. In the third and final stage, the loose debris will move and slide into the crater's walls.

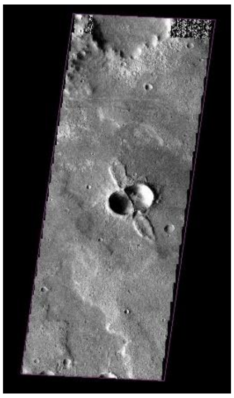

Figure 1. Our Study Area

Figure 2. Teal: Channels

Blue: Ejecta patterns

Purple Double crater

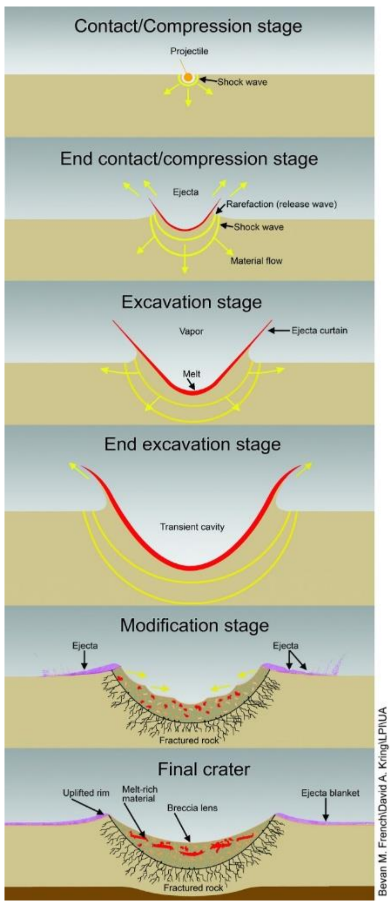

Figure 3. Formation of Craters

Source: Lunar and Planetary Institute

As seen in **Figure 4**, these ejecta blankets can be modified by erosion, future impacts, lava, or tectonic activity (Wiggins, 2017). Double craters form when a pair of meteorites simultaneously hit the ground next to each other. If both asteroids are comparable in size, the pair of craters they create may be the same size as well. If the impactors vary in size, they will also have different sizes for the resulting pair. If the two impact explosions occur simultaneously, the result would be the interconnected ejecta shooting debris sideways. Debris is the material that is formed during a meteor strike. Also as seen in Figure 4, debris is what creates "wings," or ejecta patterns, on the sides of the double craters (Arizona State University (ASU), 2020). There are three different types of ejecta patterns — radial, butterfly, and offset. Radial ejecta patterns are those with concentric shapes that extend outward (**Figure 5**). Butterfly ejecta patterns do not extend all around the crater. Instead, they are off to the sides of the crater (**Figure 6**). Offset patterns form when the ejecta branches out on a specific side of the crater. This occurs when the meteorite hits at an angle (**Figure 7**).

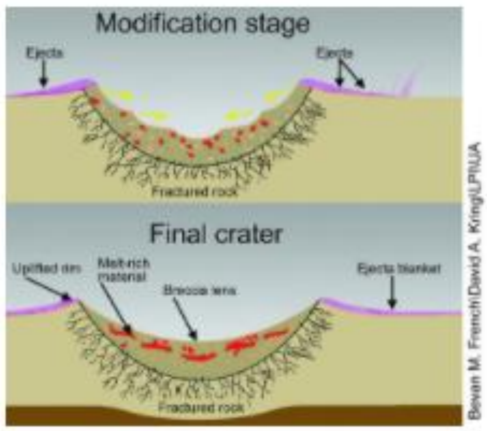

Figure 4. Formation of Ejecta Blankets and Patterns

Source: Lunar and Planetary Institute

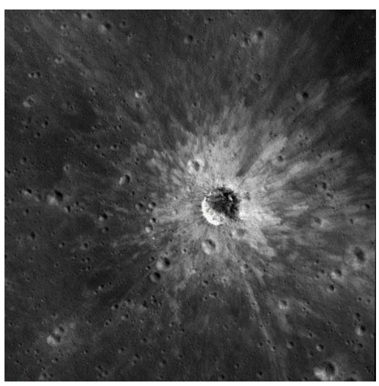

Figure 5. Radial Ejecta Pattern

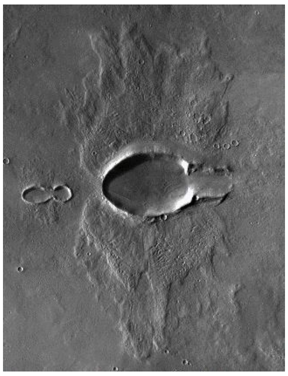

Figure 6. Butterfly Ejecta Pattern

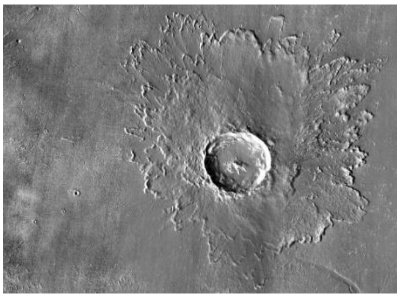

Figure 7. Offset Ejecta Pattern

Channels form through flowing water (**Figure 8**). Today, it is impossible for water to flow through channels on Mars. Because of Mars' thin atmosphere, water would evaporate or freeze before traveling anywhere (ASU, 2020). However, scientists hypothesize that Mars had a much warmer and wetter climate when it had an atmosphere up to five times thicker than Earth's current one (Redd, 2018). This atmosphere would have made it very possible for water to flow and create channels. It is a common belief among scientists that Earth's thick atmosphere causes meteorites to burn up before they can hit Earth's surface (NASA, 2015). Because of this theorized thicker atmosphere, it is very likely that there were fewer craters on the surface of Mars in the past than now.

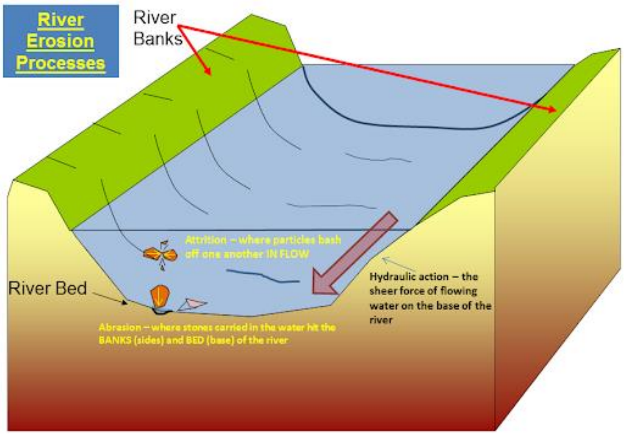

Figure 8. Channel formation

Source: Coolgeography.co.uk

III. Methods

We used the THEMIS camera on the Mars Odyssey spacecraft to collect data for our research. We chose THEMIS stamp V15272005 to be the focus of our research, noting the double crater, its ejecta pattern, as well as the banks on either side of the crater. We used JMARS (Java Mission-planning and Analysis for Remote Sensing) to find images of craters with different ejecta patterns, and also referred to the Mars Image Analysis Feature ID Charts to identify the geological features we were observing on Mars.

We obtained our research image using the THEMIS stamp tool in JMARS. We rendered a CTX (Context Camera) stamp to provide the highest-resolution image available. We used the MOLA (Mars Orbiter Laser Altimeter) color over THEMIS Day (plus MOLA Numeric Elevation Layer) to not only visualize the changes, but to obtain graphs of each of the different types of ejecta patterns. We used the Elevation Profile Tool to record the elevation change and to determine the direction water would flow through our study area. We worked on the premise that if ejecta has been eroded, then the elevation change would be lessened. To investigate this, we used the Elevation Profile Tool to measure the change in elevation in one radial, butterfly, and offset crater ejecta sample. To support our claim of a water channel eroding away some ejecta, we measured the elevation changes from our study area down what appeared to be a floodplain, to a well-defined channel.

IV. Data

We collected four THEMIS images of craters, one of each crater type.

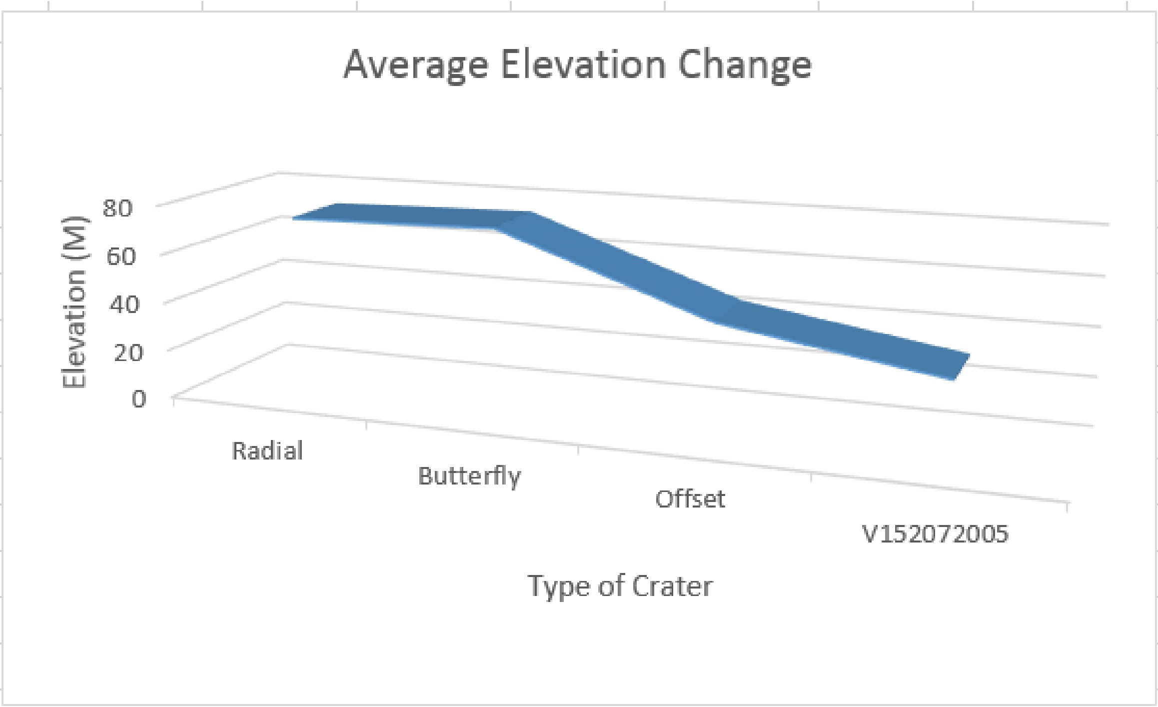

Figure 9. This Three-dimensional Graph Shows the Different Average Elevation Changes of the Ejecta Patterns of Each Type of Crater

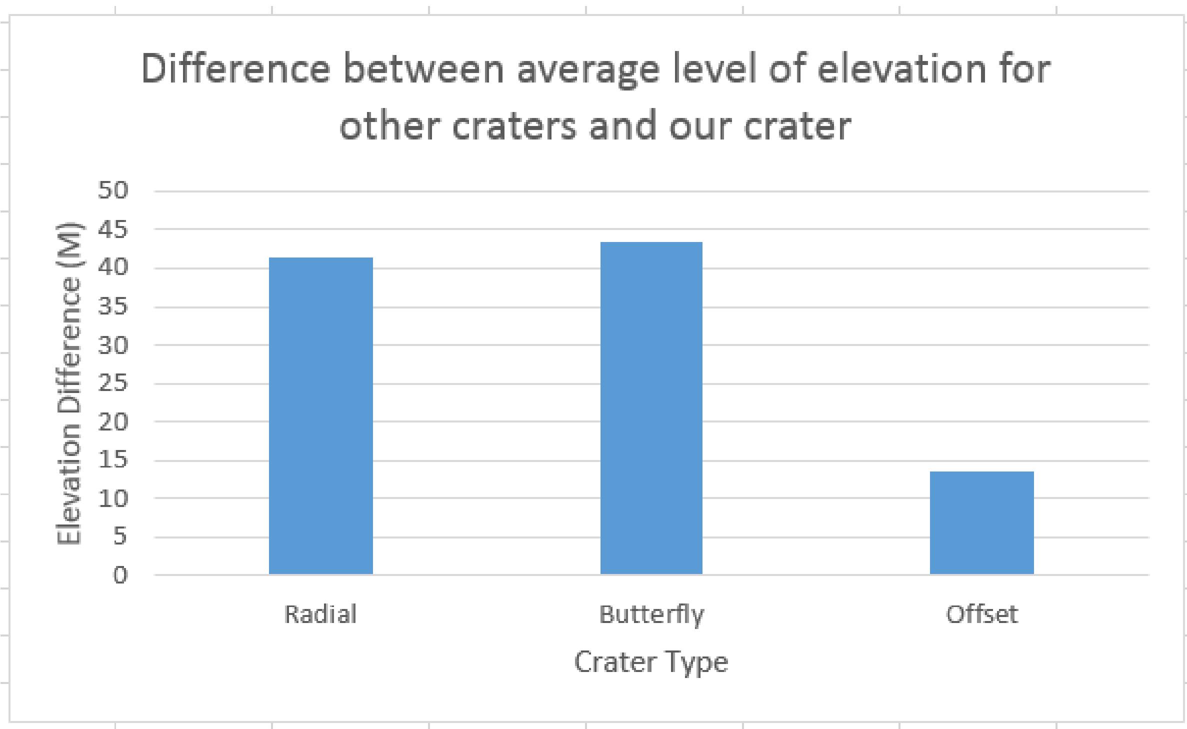

Figure 10. This Is a Graph of the Differences between the Average Levels of Elevation Change. The Offset Crater and Our Crater have the Least Difference in Value

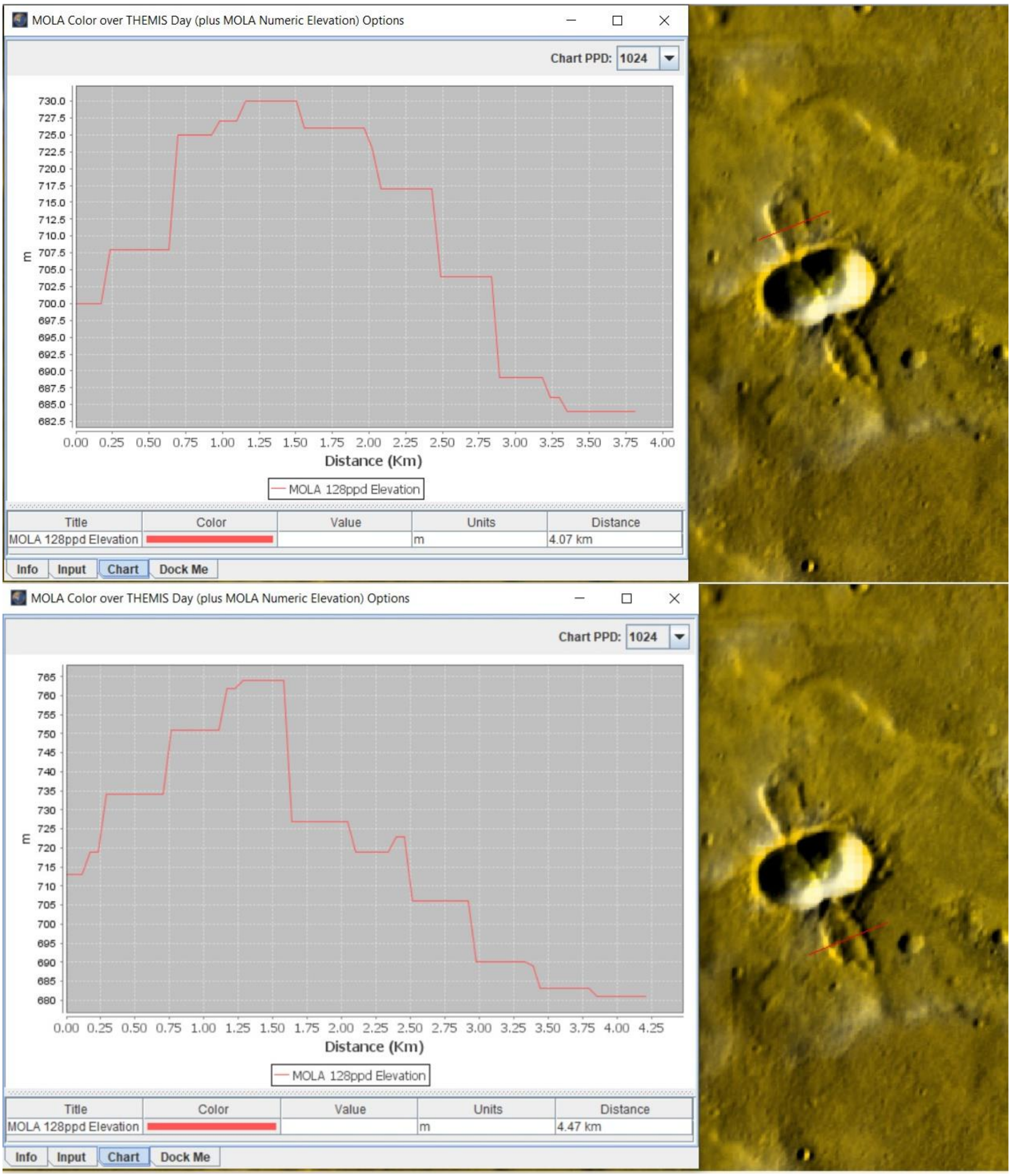

Figure 11. Elevation of Cross-sections of Ejecta Patterns for Our Study Area

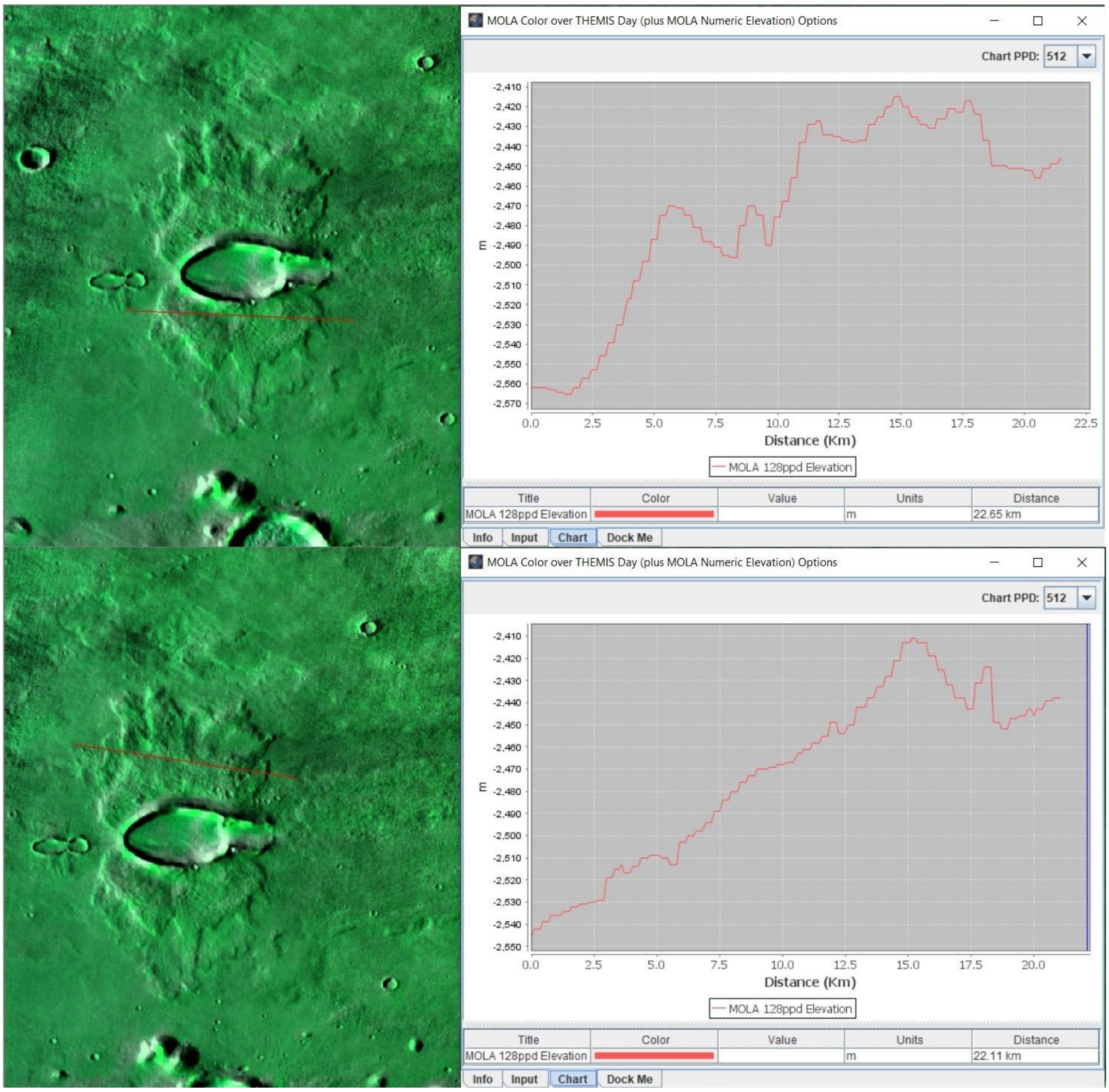

Figure 12. Elevation of Cross-sections of Ejecta Patterns for a Butterfly Crater

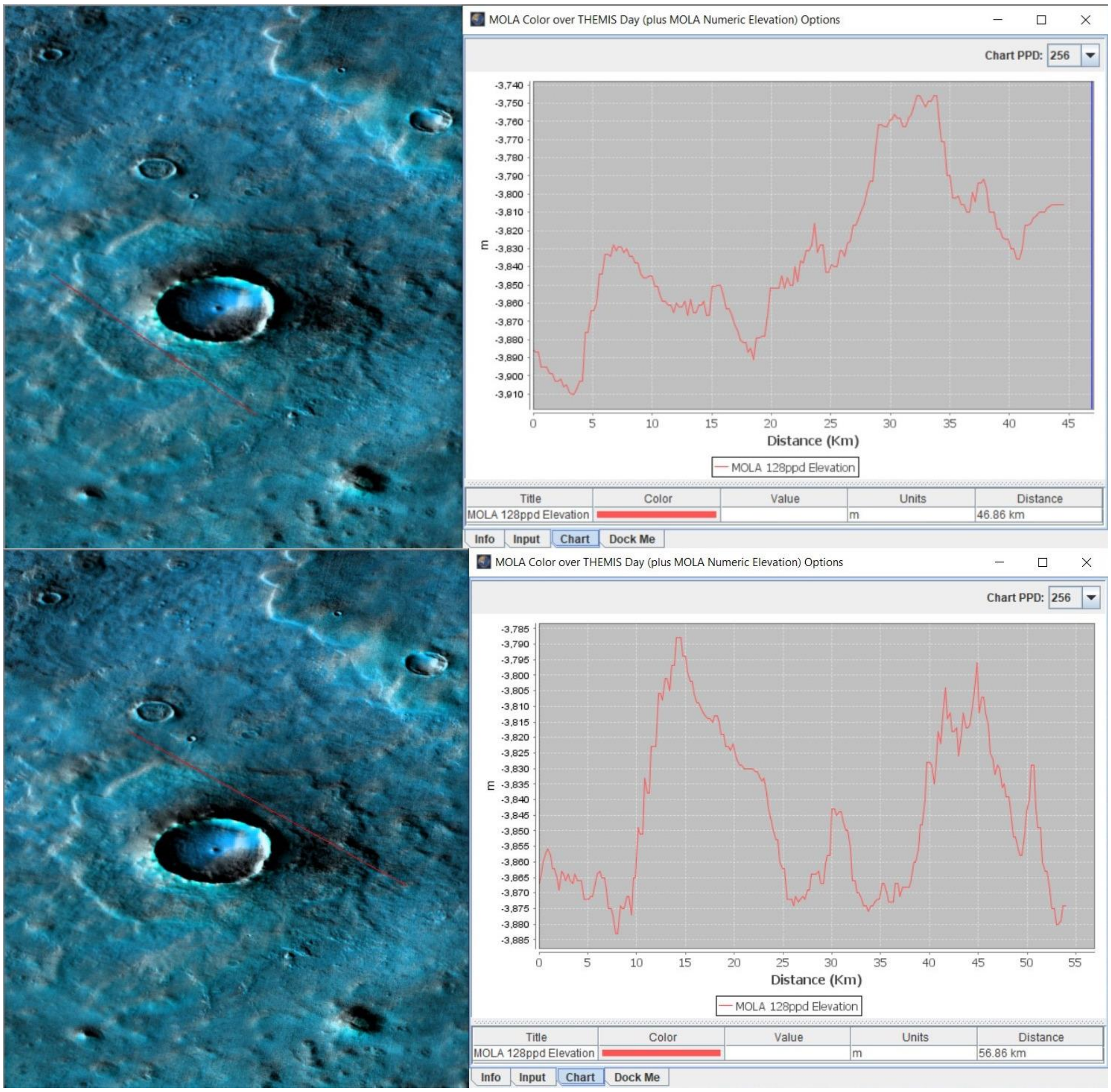

Figure 13. Elevation of Cross-sections of Ejecta Patterns for an Offset Crater

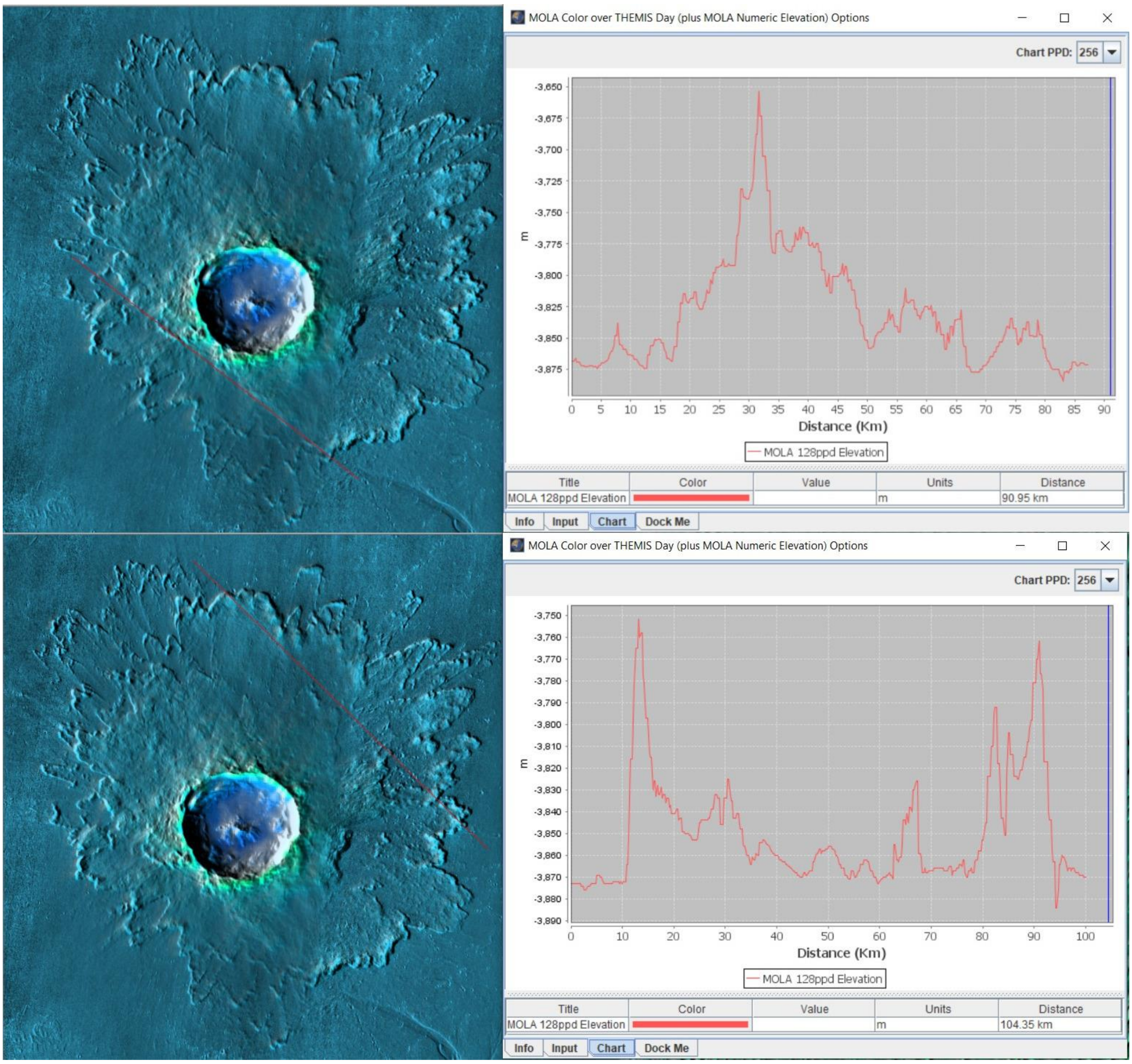

Figure 14. Elevation of Cross-sections of Ejecta Patterns for a Radial Crater

Table 1. Data Collected and Tool Used for Each Crater Type

Type of crater	Data collected	Tool we used
Radial crater with ejecta	Average elevation change: 73 m	Elevation Profile tool
Butterfly crater with ejecta	Average elevation change: 75 m	Elevation Profile tool
Offset crater with ejecta	Average elevation change:	Elevation Profile tool

	45 m	
Our crater with ejecta	Average elevation change: 31.5 m	Elevation Profile tool

Table 2. Elevation Level Information for Each Crater Type

Type of crater	Difference between average level of elevation for other craters and our crater
Radial crater	41.5 m
Butterfly crater	43.5 m
Offset crater	13.5 m

V. Discussion

Table 1 shows the type of object that was studied, the data we collected from that object, and the tool we used to get the information. Data collected show the average elevation change. Finally, the "tool used" column shows which tool in JMARS was used to find the information. In this case, we used the Numeric Profile Tool for all parts of the table. In the second table we have two sections: the "type of crater" and the "difference between average level of elevation for ejecta around other craters and the ejecta around our crater." The "type of crater" shows which crater we are studying and the "difference between average levels" shows an estimate of the average elevation change of the ejecta.

Our project consists of 10 graphs. Our data map (**Figure 15**) shows the crater in stamp V15272005, as well as a water channel flowing toward a water bank. By using the tool, we saw that the elevation was decreasing as the channel was getting closer toward the bank (**Figure 16**).

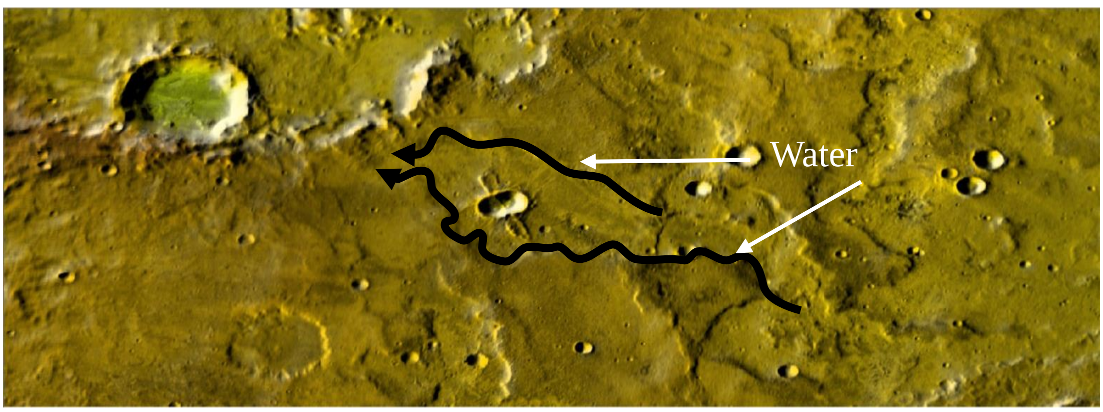

Figure 15. Map of Two Water Channels Showing Water Flow from Our Study Area

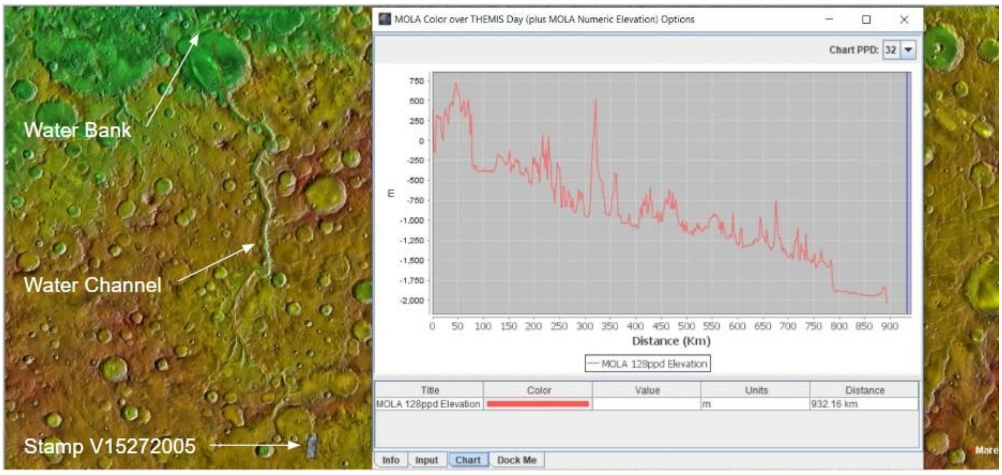

Figure 16. Map of a Floodplain Flowing from Near Our Study Area to a Water Channel

During our research we also found potential errors for the data collected. Because we were able to analyze only one crater of each type, that left some room for inaccuracies. It also was difficult to find craters with the same radius. In addition, there is a possibility of misinterpretations in this project. Because the edge of the ejecta is sometimes hard to define, it’s difficult to determine where it starts. Additionally, we need to find craters that are younger, because in that case the average elevation changes would be greater than those of ones that were already eroded. An original ejecta pattern would have more fluctuation in the change of elevation, since erosion blows off parts of the ejecta pattern, thus smoothing the surface and decreasing the change in elevation.

VI. Conclusions

Our research question was: “Has the ejecta pattern around the double crater in stamp V15272005 been modified by erosion?” and we found that yes, the ejecta pattern has been modified by erosion because we found evidence of a bank formed from a water body. Using the Elevation Profile Tool, we were able to find the direction the water would flow based on changes in elevation (**Figure 15**), with our ejecta pattern being right in the middle of the flow path.

Our hypothesis was: “If the ejecta has been modified by water erosion, then we will find evidence of channels.” We want to continue this project on ArcGIS to create a watershed and do a downstream water trace. Additionally, we still need to do statistical analysis to find out if our data show significant differences in erosion levels.

We would like to acknowledge our GIS & Remote Sensing teacher, Ms. Dominique Evans-Bye; Don Boonstra with Arizona State University (ASU) for his helpful suggestions on the Mars Student Imaging Project (MSIP) program; ASU and NASA/Jet Propulsion Laboratory (JPL) for developing the project; and the National Science Foundation for funding the MSIP. A key take-home lesson is funding and consultations, just as university faculty often require funding and consultations for doing high level research. The Mars paper shows how Evans-Bye and her students went after funding and consultations

to accomplish this monumental Mars paper. If one looked at her other papers, the same pattern of funding and consultations would be evident. That's one major reason that Evans-Bye was one of only a couple of high school teachers in many years who won a U.S. Presidential Award and why she was selected for this NSF Webinar.

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Investigation of Adhesion Peptide Interactions With Hydroxyapatite Through Computational Molecular Dynamics

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Objectives: Nanomedicine revolutionizes treatment of cardiovascular disease through the design of peptide-labelled nanoparticles that bind to hydroxyapatite (HA), the form of calcium in atherosclerotic plaques. This project evaluated binding efficacies of broad-range adhesion peptides (SVSVGMKPSPRP, STLPIPHEFSRE, and VTKHLNQISQSY) to hydroxyapatite through the use of molecular dynamics (MD) software. **Methods:** Peptide and hydroxyapatite slab structures were generated using peptide configuration software PEP-FOLD3 and molecule editing software Avogadro, respectively. Three 5 ns simulation trials were run for each peptide using MD software GROMACS to model atomic force-field interactions between the peptide and the hydroxyapatite in water solvent. Binding efficacy was evaluated through visual observation and calculation of the surface separation distance (SSD) between the peptides and the HA slab. Binding is indicated by a separation of less than 1 nm between the amino acid binding site and HA slab. **Results:** SVSVGMKPSPRP exhibited binding at its lysine (K) and arginine (R) residues. STLPIPHEFSRE exhibited binding at its first serine (S), and VTKHLNQISQSY exhibited binding at lysine (K) and histidine (H). Consistent adhesion interactions were evident in all three trials of SVSVGMKPSPRP, two trials of VTKHLNQISQSY, and one trial of STLPIPHEFSRE. **Conclusions:** The simulations confirmed that all three peptides possess binding capabilities and identified the specific binding sites. SVSVGMKPSPRP exhibited the smallest surface separation distance from hydroxyapatite over multiple trials, thereby demonstrating the greatest binding efficacy, and suggesting the greatest potential for clinical use. These results are contingent upon the initial peptide structures and would benefit from extended simulation periods and in vitro confirmation.

Will a Population of Collembolans Increase If Dawn® Dishwashing Foam Soap Is Placed in Their Environment?

Nathaniel Cruz, Gavin Decker, Justin Decker, Angela Sorensen, and T. Miller (retired teacher)
Laughlin Library
2840 S. Needles Hwy., Laughlin, NV 89029 (Note 13)

The purpose of this experiment was to determine if Dawn Dishwashing Foam Soap will harm a population of Collembolans (*Onychiuridae encarpatus*). The hypothesis was that a population of Collembolans would decrease if Dawn Dishwashing Foam Soap was added to their environment. Collembolans are tiny insect-like animals that have a springtail for jumping and feed on mold. For the procedure, one part charcoal was measured and placed in a container. Nine parts plaster of Paris also were measured and placed into the container, and the lid was tightly closed. It was shaken until the ingredients were completely mixed. The mixture was placed in a different plastic container and water was added while the mixture was stirred to make it the consistency of yogurt. The liquid was poured into eight Petri dishes and tapped on the table until it was spread out evenly in each Petri dish. It was allowed to dry for a few days. Half of the Petri dishes were labeled control and half labeled experiment. Water drops were added to make a moist environment. Equal numbers of Collembolans were added to

the eight control and experiment Petri dishes. Dawn Dishwashing Foam Soap was added to the four experiment Petri dishes. Yeast was added to all of the Petri dishes for the Collembolans to eat, and drops of water were added daily. The Collembolans and their eggs were counted and graphed. After 35 days, a total of 1,208 Collembolans were counted: 39% in the experiment and 61% in the control. A total of 623 Collembolan eggs were counted on Day 35: 105 (17%) in the experiment and 518 (83%) in the control. The hypothesis was correct. Dawn Dishwashing Foam Soap decreased a population of Collembolans.

4. Conclusion

- The National Science Foundation Webinar on supporting student research showed that K-12 applied student research is as good as some university level research. The research selections presented on ejecta patterns on a Mars crater, adhesion peptide interactions with hydroxyapatite, and population dynamics in Collembolans are examples of what can be done by students. It is important for the continued excellence of applied research that journals such as this one showcase what the next generation of future scientists can do. NSF selected this work as being important for the future health of science research worldwide. The U.S. Presidential Award for student research mentoring is usually given to university professors like Steve. The fact that Dominique received this award suggests that NSF and the White House Office of Science and Technology Policy recognize that pre-college student research and mentoring deserve a place in the annals of research excellence (Note 14, Note 15). But how can high school teachers like Dominique achieve such a high level of sophisticated student research with their massive teaching workload? Part of the answer is that they go after funds just like university professors. In Dominique's case:

  The Mars Ejecta project was developed with the help of Arizona State University, NASA and the Jet Propulsion Laboratory and funded by the National Science Foundation. Dominique also received support from:
- Toyota Tapestry Large Grant recipient, 2008
- Robert and Karen Newcomb Graduate Scholarship recipient, 2009
- Marine Technical Society Student Scholarship recipient, 2009
- University of California Los Angeles Teacher Initiated Inquiry Project grant recipient, 2010 and 2012
- Chevrolet Green Educator Award, 2012
- Presidential Innovation Award for Environmental Educators, 2013
- Steve Allen "Excellence in Education Award," 2013
- Verdugo-Montrose Chamber of Commerce Educator of the Year, 2013
- California Geographic Society Distinguished Teaching Award, 2014
- Totaling over $500,000.

- It should be noted that like in college not all pre-college submissions are of the high level of sophistication as the selections presented here. Fostering interest in science is most important even if the students' work with far less sophisticated materials and mentors who are far less trained and motivated than Dominique. What Dominique has accomplished is legendary.
- What is presented here is the only material by Evans-Bye and Oppenheimer presented at the Webinar. No other student research papers were presented. This presentation was invited by NSF and what is in this paper is a model for all teachers for enhancing their student research. A key take-home lesson is funding, funding, funding…just as university faculty often require funding for doing high level research. We see in this paper exactly how Evans-Bye obtained funding to help do the high quality of research presented in the Mars paper. The Mars paper is an example of what can be done at the pre-college level.

Notes

Note 1. https://paesmem.net

Note 2. info@paesmem.net

Note 3. https://obamawhitehouse.archives.gov/administration/eop/ostp/about

Note 4. www.paesmem.net

Note 5. Alumni Webinar: Preparing for Fall Online Learning, Supporting Student Research, www.paesmem.net

Note 6. PAESMEM_AY2021_Alumni_ Engagement_Webinar.pdf

Note 7. http://scholarworks.csun/handle/10211.3/125029

Note 8. Oppenheimer, S. The Value of Recognizing the Efforts of All Science Students, NSTA Reports, October 2019, p. 3.

Note 9. http://bit.ly/2kkE0Et

Note 10. Dou, R., Hazari, Z., Dabney, K., Sonnert, G., Sadler, P., 2019, Early informal STEM Experiences Identity: The Importance of Talking Science, Sci.Edu. 10. 1002/sce.21499.

Note 11. The New Journal of Student Research Abstracts, vol. 25, 2020, p. 57.

Note 12. The New Journal of Student Research Abstracts, vol. 25, 2020, p. 48.

Note 13. The New Journal of Student Research Abstracts, vol. 25, 2020, p. 15.

Note 14. Oppenheimer, S., Berman, M., Chun, H., Lundgren, A., Tanaka, S., Antoniou, A., Miller, T., Zem, G. Applied Science Research for All Part 1 Pre-College Level. American Journal of Applied Scientific Research, vol 6, pp. 72-75, 2020.

Note 15. Oppenheimer, S., et al. Applied Science Research for All Part 2 College Level, American Journal of Applied Scientific Research, vol 7, pp. 1-7, 2021.