THE KECK "MARS 2000" PROJECT: USING MARS ORBITER LASER ALTIMETER DATA TO ASSESS GEOLOGICAL PROCESSES AND REGIONAL STRATIGRAPHY NEAR ORCUS PATERA AND MARTE VALLIS ON MARS.

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INTRODUCTION During five weeks in the summer of 2000 the Keck Geology Consortium sponsored a planetary geology undergraduate research project (the "Mars 2000" project), which was hosted by the Geodynamics Branch at NASA's Goddard Space Flight Center in Maryland. The consortium consists of twelve strong geology departments at small, geographically distributed liberal arts colleges in the United States. Operating on the premise that active participation in scientific research is a fundamental component of undergraduate student education and training, each summer the consortium members pool their faculty, students and resources to run a diverse array of research projects. Funding for these projects is provided by the Keck Foundation and the National Science Foundation (the latter specifically to promote involvement of groups traditionally underrepresented in the sciences), and in this instance supplemental funds were also generously provided by the MOLA Science Team.

On the "Mars 2000" project, ten students preparing to enter their junior year of college participated; on average each student had completed four geology courses, three additional science courses and one math course above pre-calculus, but only two students had taken planetary geology and none had completed a computer science class. After selecting an area to study (2-21°N, 176-190°W; the region contains Marte Vallis and Orcus Patera, and was chosen in part for its potential as a future landing site) the students were divided into five teams, each of which formulated an original, independent research question to explore using Mars Orbiter Laser Altimeter (MOLA) data and available imagery. Taken together, the five projects began to assess the regional stratigraphy and the complex interplay among several of the geologic processes responsible for shaping this portion of the Martian surface; the teams' science results are presented elsewhere in this conference volume [1-5]. The goal of this abstract, building in part upon previous experience [6], is to explain the "Mars 2000" project organization and activities in order to help facilitate development of similar undergraduate projects elsewhere—and we also hope to promote discussion about how formulation of such projects might be improved in the future.

PROJECT ORGANIZATION & ACTIVITIES The "Mars 2000" project was organized into three primary phases. In the first, several days of intensive lecture introduced students to basic image analysis techniques, the geology of Mars, existing (Mars Surveyor 2001) landing site selection criteria, and the origin of ancient microbial life on Earth. Using principally *Gridview* [7], Adobe's *Photoshop* and *Illustrator*, and Synergy's *Kaleidagraph*, students also learned the basic skills required to load and manipulate MOLA data and both Mars Orbiter Camera (MOC) and Viking images. Then, using online landing site selection resources and USGS 1:2,000,000 controlled photomosaics, the students collectively examined the entire near-equatorial region of Mars in order to select a single region for detailed study. Finally, once the target area was chosen, faculty and students worked together over a two-day period to define five student teams and formulate each team's research project. The first phase of the project ended with each team submitting a formal 1-2 page proposal to the faculty defining a research question, the steps necessary to resolve it within the available time, and the potential significance of the outcome.

During the second phase of activity, which lasted approximately three weeks, each student team focused upon (1) exploring the literature to learn about and absorb lessons from previous research efforts, (2) collecting the data required to address their research question, and (3) analyzing the data, a process which in all cases involved a quantitative component. Throughout this phase of the project, each team also wrote the bulk of an iterative research paper—i.e. after meeting an initial deadline by submitting its Introduction, each team met a second deadline by handing in a revised version of the Introduction and a new section describing Methods, and so on. This process was of necessity very fluid as ideas changed and evolved during the course of the research activity, but it helped faculty identify potential difficulties on an ongoing basis and kept each project focused and moving forward by periodically encouraging team members to submit their ideas in writing for discussion and evaluation.

Throughout the second phase, the regular schedule of project activity at Goddard was punctuated by a variety of events. Most significantly, students interacted with a diverse array of talented scholars and scientists who took the time to visit, tell us about their careers/research, and in some cases work with the teams on their projects. These visitors included (in alphabetical order): Phil Armstrong (CSU Fullerton), Marcelino Bedolla (MD Science Center), Harvey Cohen (S.S. Papadopulos), Orlando Figueroa (NASA HQ), Herb

Frey (GSFC), Jim Garvin (NASA HQ), Steve Korpon (Severn High), Laurie Leshin (ASU), Mellie Lewis (Balt. Public Schools), Brian McAdoo (Vassar), Jerry Soffen (GSFC), Don Wise (Franklin & Marshall), Martin Wong (USRA) and Jim Zimbelman (NASM). Additionally, the project members visited the Center for Earth and Planetary Studies at the National Air & Space Museum (Host: Jim Zimbelman), NASA Headquarters (Hosts: Phillip Sakimoto, Joe Boyce, Julius Dasch), the National Museum of Natural History (Host: Ed Venzke), and the NEAR mission at the Applied Physics Laboratory (Host: Noam Izenberg); on each trip we learned about the site's activities/facilities and interacted with several resident scientists.

In the third phase of the project the teams completed their research efforts and finalized their research papers. In addition, the project members invited the community of scientists at Goddard's Geodynamics Branch to a set of talks in which the students presented their results. Finally, each team designed and constructed a poster detailing the results of its research. These posters have subsequently been displayed at the students' home institutions, and all five teams will present their research results at this year's 32nd Lunar and Planetary Science Conference.

STUDENT PROJECTS In order to learn as much as possible about the geology and history of the targeted area (2-21°N, 176-190°W) within the time available, the project members worked together to identify the key geological features/processes in need of detailed study. Prioritized on the basis of geological significance and student interest, the most important five processes were then examined by the student teams.

One of the teams, ***Dolores van der Kolk*** (California State University, Fullerton) and ***Krystal Tribbett*** (Vassar College), studied Orcus Patera, a large, elliptical depression of uncertain origin located several hundred kilometers north of the dichotomy boundary. By comparing geometric parameters (e.g. flank slopes, plan view ellipticity) obtained from MOLA data with values from similarly shaped features on Earth, Mars and the Moon, they explored whether Orcus Patera is best ascribed to an impact or volcanic origin.

Two teams examined different aspects of the intriguing Marte Vallis channel system. ***Sven Moller*** (Pomona College) and ***Kate Poulter*** (Colorado College) used cross-channel MOLA profiles, MOC images and regional mapping to assess the evolution of the fluvial channel system, in particular whether it was shaped by catastrophic floods or multiple, lower energy fluvial events. The channel system was subsequently occupied by what have been interpreted as exceptionally young lava flows [8], and ***Jes Therkelsen*** (Amherst College) and ***Sara Santiago*** (Arizona State University) used MOLA profiles, MOC images and a numerical channelized flow model [9] to assess flow rate, volume and duration near the terminus of one example.

Complementing study of fluvial and volcanic processes within the region, ***Matthew Silver*** (Whitman College) and ***Andrew Gendaszek*** (Carleton College) used MOLA profiles to characterize the geometry of several prominent tectonic wrinkle ridges within the plains north of Orcus Patera. They then used these geometric data to explore the validity of several different mechanical models for wrinkle ridge formation.

Finally, providing a crucial framework within which to integrate the project's research results, ***Jesse Yoburn*** (Franklin & Marshall College) and ***Roderick Yazzie*** (Crownpoint Institute of Technology) used Viking and MOC images to define regional map units and assess relative stratigraphy. In addition, this team used crater counting to assign absolute ages to most of their units.

EVALUATION OF IMPACT It is difficult to evaluate the immediate educational impact of a single student research project, but one key element—the students' continued participation in the research process—can already be inferred. All five teams opted to write and submit LPSC abstracts, and most students acquired the funds necessary to attend the meeting on their own. Ultimately, if one can judge from the students' voluntary participation in this conference then one main objective for the "Mars 2000" project, using planetary geology to promote undergraduate interest in scientific research, was successfully achieved.

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