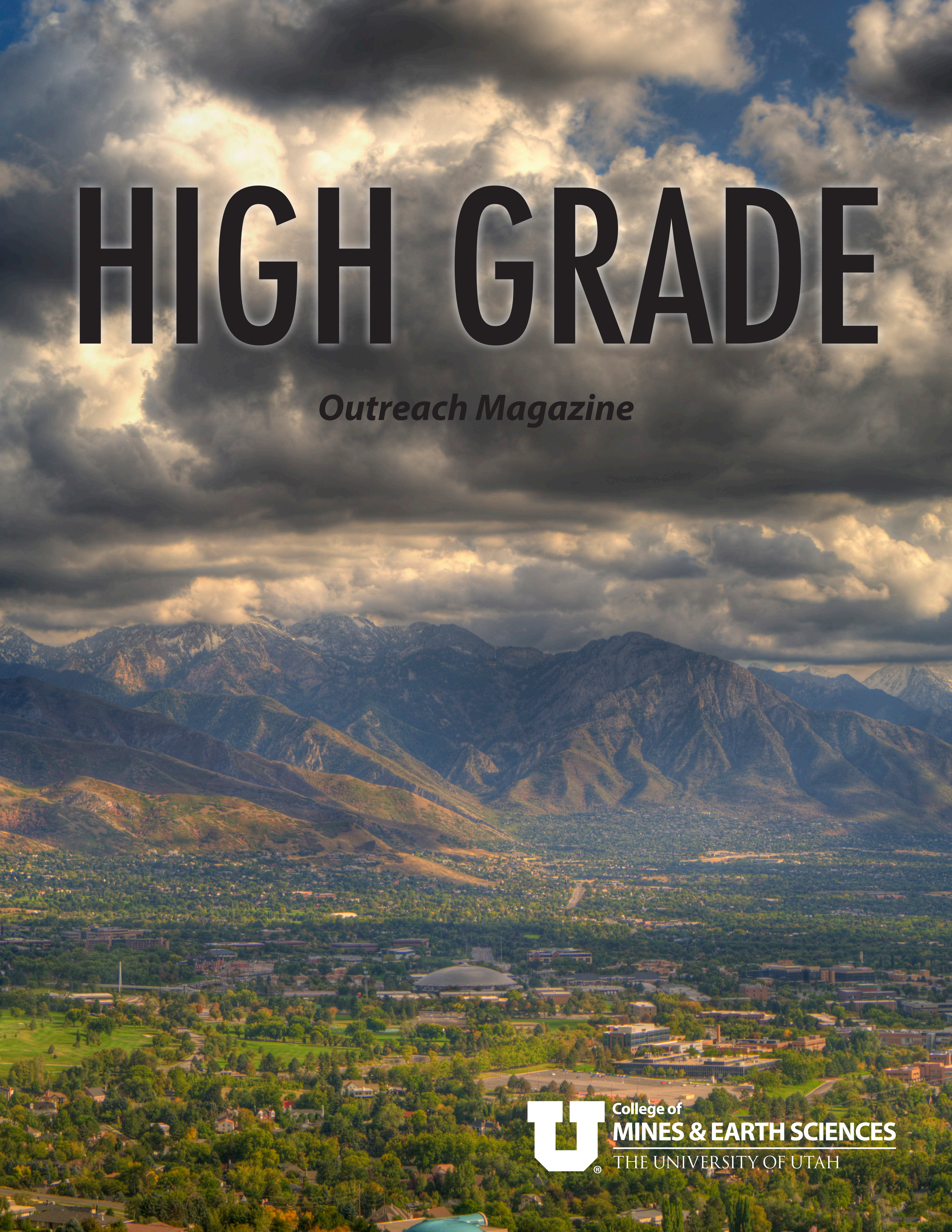
HIGH GRADE

Outreach Magazine



College of
MINES & EARTH SCIENCES
THE UNIVERSITY OF UTAH

THE UNIVERSITY OF UTAH

COLLEGE OF MINES & EARTH SCIENCES

Dear Educator,

We at the College of Mines and Earth Sciences invite you and your students to explore the exciting opportunities that exist in Atmospheric Sciences, Geosciences, Metallurgical Engineering, and Mining Engineering!

- Scholarships
- Small class sizes
- Field trips
- Undergraduate research
- Paid summer internships
- Actively recruited by industry
- High job placement upon graduation

Our *HIGH GRADE* magazine includes some helpful resources for your classroom. Among the pages you will find data about our College and insight about some of our research with demonstrations, activities, and information about our student experience.

It is our hope that you can use *HIGH GRADE* as a starting point to aid you in teaching your students interdisciplinary subjects. You will find that the disciplines in our College are applicable to multiple subjects including math, chemistry, physics, environmental sciences, and earth sciences and are appropriate for students from Junior High through High School.

This magazine can be used at your discretion in combination with the subjects and curriculum you are already teaching. Please feel free to contact me for more copies, materials, or any questions you have about using this resource.

In addition to this magazine, we would like you to consider having us come to your classroom or schedule an on-site visit at our College. For more resources, lesson plans, and an online version of *HIGH GRADE* visit our outreach website http://www.cmes.utah.edu/outreach/. To request materials or a visit contact me by phone at 801-585-5176 or by e-mail at samantha.j.davis@utah.edu.

Sincerely,

Samantha Davis

Outreach Coordinator
College of Mines and Earth Sciences
University of Utah

CONTENTS

HIGH GRADE

{definition}

of excellent or superior quality.

(of ore) yielding a relatively large amount of the metal for which is mined.

BY THE NUMBERS

Departments/Degree Programs

Atmospheric Sciences

- B.S. Atmospheric Sciences
  Minor : Atmospheric Sciences
- M.S. Atmospheric Sciences
- Ph.D. Atmospheric Sciences

Geology & Geophysics

- B.S. Earth Science Composite Teaching
- B.S. Geological Engineering
- B.S. Geosciences
  Minor: Earth Sciences
- M.S. Geology
- M.S. Geophysics
- M.S. Geological Engineering
- Ph.D. Geology
- M.S. Geophysics
- Ph.D. Geological Engineering

Metallurgical Engineering

- B.S. Metallurgical Engineering
- M.S. Metallurgical Engineering
- Ph.D. Metallurgical Engineering

Mining Engineering

- B.S. Mining Engineering
- M.S. Mining Engineering
- Ph.D. Mining Engineering

College of
MINES & EARTH SCIENCES
THE UNIVERSITY OF UTAH

Student Diversity

FEMALE STUDENTS
MALE STUDENTS

- CAUCASIAN
- UNKNOWN
- HISPANIC
- ASIAN
- BI-RACIAL/MULTI RACIAL
- HAWAIIAN/OTHER PACIFIC ISLANDER
- BLACK/AFRICAN AMERICAN

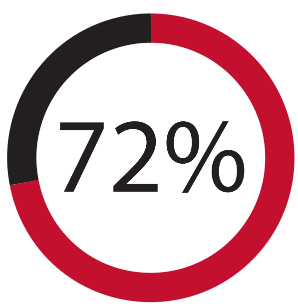
Enrollment/GPA

365
Undergraduate Students

187
Graduate Students

3.02
Average Undergraduate GPA

OF STUDENTS ARE WOMEN



OF STUDENTS HAVE SCHOLARSHIPS

Students Using TRAX

University of Utah researchers Logan Mitchell, Erik Crosman, John Horel and John Lin in the Department of Atmospheric Sciences are in the process of gathering air pollution data across the Wasatch Front with the help of the Utah Transit Authority light rail train (TRAX).

Using instruments installed on TRAX, which travels through the Salt Lake Valley, the team can collect spatial data of pollutants such as greenhouse gases. The team can then determine in real time how pollutants vary during the day and across various regions of the valley. Data is collected every one minute and archived in real time every five minutes.

Funded by the Utah Legislature, the 18-month project is the first of any major city to place air quality monitors on top of light rail trains.

For More Than Just Commuting

Two Atmospheric Sciences undergraduates involved in the research, senior Ben Fasoli and junior Luke Leclair-Marzolf, took some time to answer questions about their experience.

1 How did you get involved in this research and how long have you been involved?

Fasoli: I got involved over a year ago. I was initially working on other projects for professor John Lin's lab, but the projects slowly evolved into this one.

Leclair-Marzolf: I just got involved this summer through John Horel's lab.

2 What were your roles in this project?

Fasoli: We contributed to many different parts of this project. Looking back, I think we did a little bit of everything. Logan initially had the idea for the project back in February 2014. From September to November, we spent time in lab brainstorming how each individual piece of the project would work. From November to December, we put everything together and started figuring out how to code the data, and after December, we probably dedicated about four to five hours working on the project each day. After receiving clearance from the proper authorities, we designed the data collaboration system for the pilot program and figured out how to fit and organize everything into the box that collected air pollution data. Then we installed it all into the train and wrote the post-processing scripts for data.

Leclair-Marzolf: Over the summer during the pilot program, we both contributed to installing and maintaining the monitors. We'd have to do this at 3 a.m. during the train's off hours, so that was fun. Afterwards, Ben was more in charge of the post-processing code and I handled quality control issues.

3 What was your favorite part of this project?

Fasoli: The satisfaction of it all finally coming together and working. We went through so many leaps and hurdles to get this project going, so it's rewarding to see our hard work pay off. It's really exciting to have been part of this when it was only an idea to now seeing it as a physical, tangible thing. It's cool to be able to wake up and look at the air quality every morning before biking to class.

Leclair-Marzolf: I agree with Ben; seeing the project work after all of the time and effort we put into it is the best feeling.

4 How has conducting this research impacted your academic and professional development?

Fasoli: I would say that upon graduation, Luke and I will have an advantage over job and graduate school competitors because of all of the skills we've gained through our research. Instrumentation, coding, teamwork, leadership and organization are just a few of the things we've learned from working on this project. These are all transferable skills that will apply well in any academic or professional setting.

Leclair-Marzolf: There's a large gap between what you learn in school and what's out in the world. Hands-on experience is absolutely necessary to be successful post-graduation, whether you go on to graduate school or enter the workforce.

5 What are your post-graduation plans?

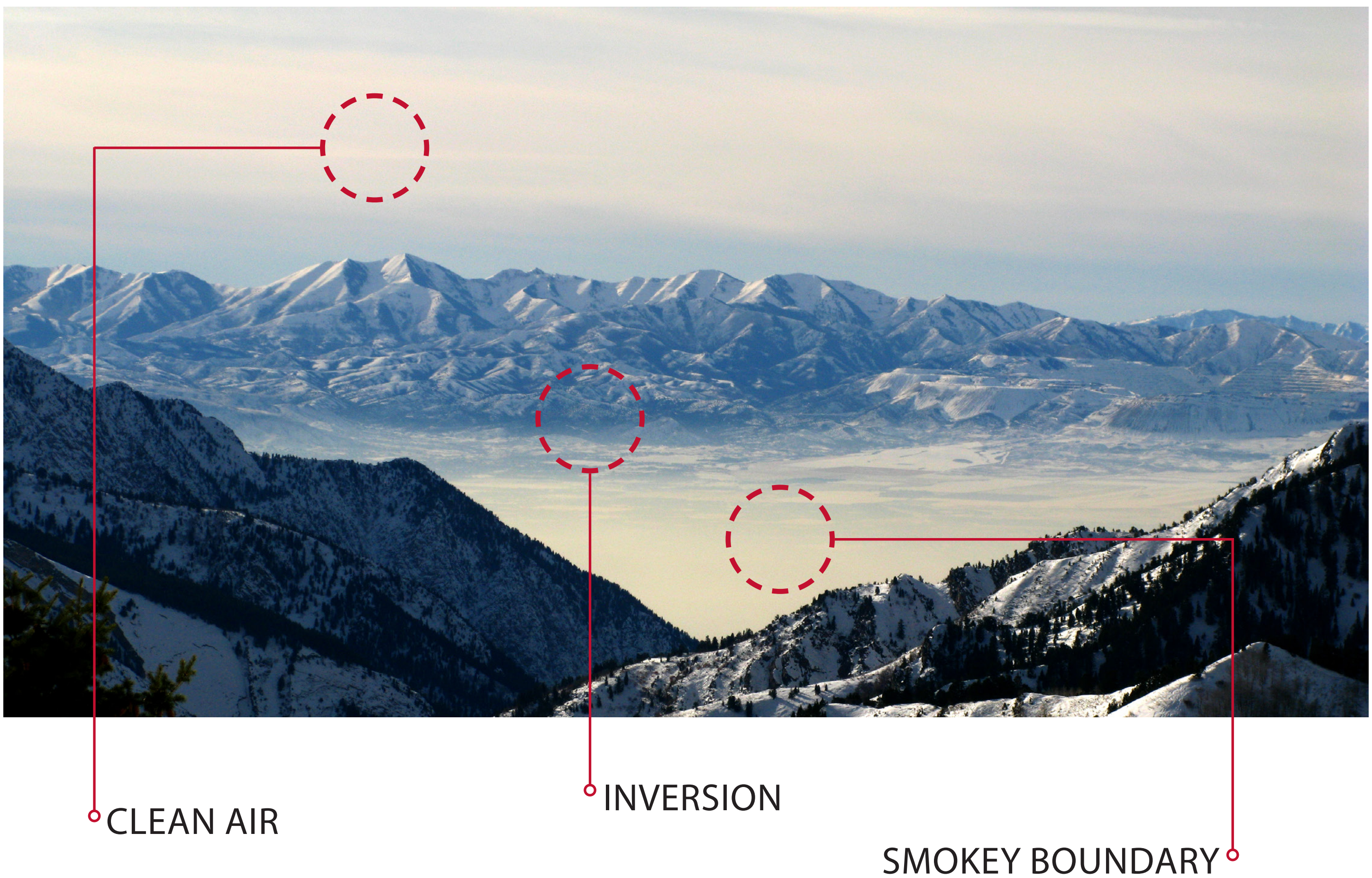
Fasoli: Continue my education at the U and earn a master's degree in atmospheric sciences. I'm currently involved in a lot of projects in the department and don't want to leave yet because I'm so invested in them.

Leclair-Marzolf: Hopefully get a job! Ideally, I'd like to work for Utah's Division of Air Quality.

This article originally appeared in @theU.

ABOUT INVERSION

Normally, air temperature decreases at a rate of 3.5°F for every 1000 feet (or roughly 6.4°C for every kilometer) you climb into the atmosphere. When this normal cycle is present, it is considered an unstable air mass and air constantly flows between the warm and cool areas. As such the air is better able to mix and spread around pollutants. We think of them as wintertime phenomena, but they can occur anytime of year. During an inversion episode, temperatures increase with increasing altitude. The warm inversion layer then acts as a cap and stops atmospheric mixing. This is why inversion layers are called stable air masses. Temperature inversions are a result of other weather conditions in an area. They occur most often when a warm, less dense air mass moves over a dense, cold air mass. Topography can also play a role in creating a temperature inversion since it can sometimes cause cold air to flow from mountain peaks down into valleys. This cold air then pushes under the warmer air rising from the valley, creating the inversion.



Discussion Questions

1. What are some advantages to collecting air pollution data across the Wastach front?
2. Why is the air quality in Utah so concerning?
3. What is an inversion?
4. What can be done to improve the valley's air quality?

Demonstration

Hot air rises and cold air sinks. In the winter the air is cold and sinks to the bottom of the valley, or in our case, to the bottom of the fish tank. The walls of the fish tank represent the mountains that trap the cold air in the valley. By pouring some warm water on the dry ice, we reveal the layer of cold air created by the dry ice. Pollution is emitted from the surface, in the cold air. The warm, clean air from outside the tank doesn't easily mix down into the tank to dilute the pollution. To show this is true, we blow bubbles over the tank. The bubbles float on top of the cold air pool. This shows that the clean air from outside can't get inside the tank to dilute the polluted valley. By blowing the cold air out of the valley we can remove the inversion. Air quality can also be improved by reducing pollution sources within the valley.

MINING ON MARS

Any attempt to establish a human presence on Mars will require mining for vital resources, most importantly, water, which is frozen beneath the planet's weathered surface.

That's part of the reason why NASA holds an annual competition in which teams of college students design and build robots that can crawl over chaotic terrain, excavate simulated Martian soil and carry payloads to a receiving port. Fresh ideas and technical solutions devised by the university teams have the potential to help NASA develop Martian excavation and hauling devices, the space agency says.

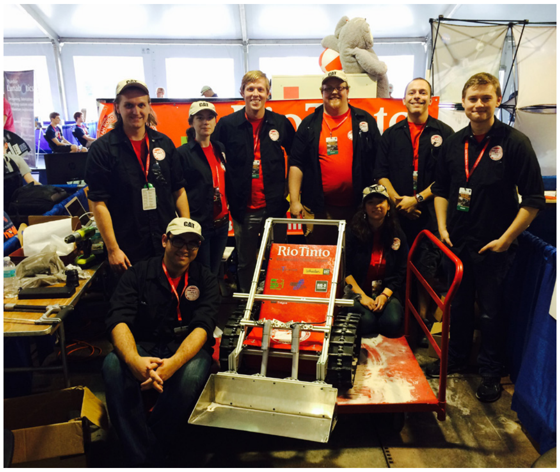
The University of Utah fielded its first-ever team this year and took home third place honors in the sixth annual robotic mining competition in May, a week long event at NASA's Kennedy Space Center in Florida. A total of 49 teams competed. Robots have to be able to withstand operating in a harsh, simulated Martian landscape covered with a dusty, abrasive volcanic grit. Strict rules limit the weight and size of robots, just as they would if designed for interplanetary transport. Scoring takes into account not just the total mass of material robots dig and deliver, but also factors such as dust tolerance, communications effectiveness, energy use and how independently the robot operates.

George Kevin Chapin, a mining engineering major and project manager for the U's robotic mining team, says careful planning and committing to hard deadlines helped his rookie crew advance into the top ranks. Being on the team meant giving up many Saturdays over the past year to work on the project. "But it was a lot of fun," Chapin says. "Designing the robot. Building it from the ground up. Seeing it succeed."

The most valuable take-home, though, was gaining the practical experience and chance to apply and develop real engineering skills, Chapin says. The team had to imagine the range of possible problems, decide which were the most likely to threaten the mission, prioritize them to tackle the most critical issues and, of course, develop solutions or alternatives.

"Seeing potential problems down the road and taking steps to prevent them before they occur – that's the essence of engineering," Chapin says. "If you have a problem on Mars, it's too late to fix it."

Outreach and sponsorship are a significant part of the competition. During the year, the team visited community schools to educate students about careers in engineering and mining. Local companies contributed to the financial success of the project. Rio Tinto/Kennecott Utah Copper was the primary financial sponsor of the project. Other local sponsors included Wheeler Machinery, BIG-D Construction and the Utah Mining Association.



The U team's robot moved more material than all but one of the other competitors, but lost points because it required remote direction by a human operator. Only the two top teams, Purdue University and the University of Alabama, fielded robots that navigated the course autonomously.

Come next year, the U team intends to be back in the fray with a fully autonomous robot. But first, Chapin says, "We're going to take a little break."

Other team members are assistant project manager Clayton Sanders, software engineer John Robe, mechanical unit manager Aaron Young, system integration manager Teresa Petty, electrical and controls unit manager Jack Petersen, drive train optimization David Denson, Abigail Campbell, Chelsea Gibbs, Derek Jensen, Becca Novy, Matt Sheridan, Artem Simonyan, Max Stocking and faculty advisor Michael Nelson. *This article originally appeared in @theU.*

See discussion questions on page 11

All about **MINING**

Every American born will need **3.11 million pounds of minerals, metals, and fuels** in their lifetime.

A television requires **35** different minerals; **40** minerals are used to make phones, and **15** minerals are needed to make a car.

If all of the copper wiring in an average car were laid out, it would stretch **0.9 miles**.

Kennecott Utah Copper has produced more copper than any mine in history, about **18.1 million tons**.

Sustainable energy from **solar panels requires the mining of 16 minerals** including copper, gallium, and indium.

Many **ski resorts** in Utah and Colorado started as **mining towns**.

and U®

What's Yours is Mined

Activity

Minerals are made up of elements, and rocks are made up of minerals. Knowledge about this information makes it possible for the mineral to be refined so the elements become available for use in everyday products.

In this activity, students will learn how products used every day contain elements that we mine. Students will match the mineral or rock to the product it is used to create. The College of Mines and Earth Sciences has created 10 kits that are available to be checked out and used in the classroom. We can also send representatives to present and facilitate the lab. Please contact Samantha Davis at 801-585-5176 or samantha.j.davis@utah.edu for more information.

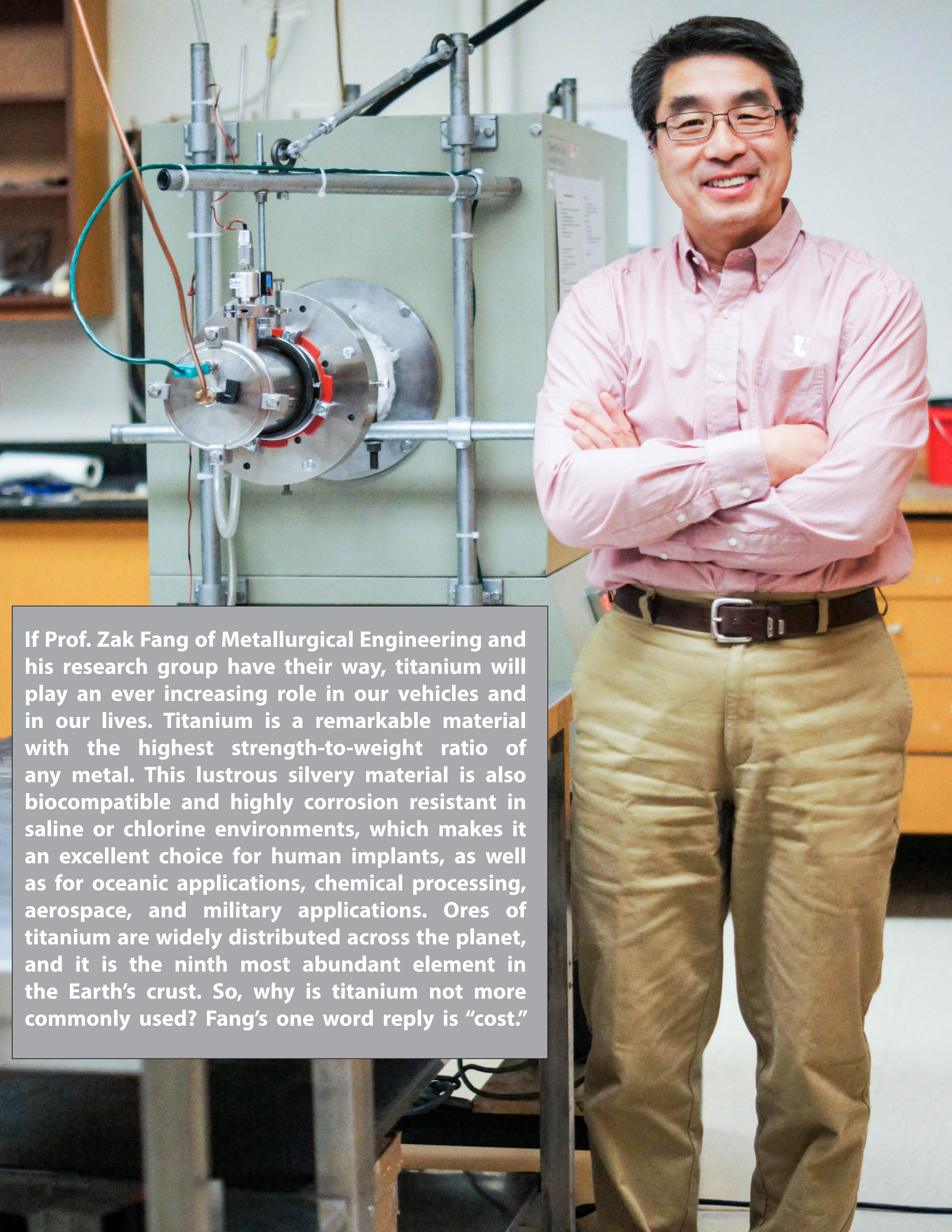
Discussion Questions

What is mining engineering?

Why should we explore space for mining?

Why is it important for the robot to operate independently?

Name one thing you own that is mined
and one thing that is not mined.



If Prof. Zak Fang of Metallurgical Engineering and his research group have their way, titanium will play an ever increasing role in our vehicles and in our lives. Titanium is a remarkable material with the highest strength-to-weight ratio of any metal. This lustrous silvery material is also biocompatible and highly corrosion resistant in saline or chlorine environments, which makes it an excellent choice for human implants, as well as for oceanic applications, chemical processing, aerospace, and military applications. Ores of titanium are widely distributed across the planet, and it is the ninth most abundant element in the Earth's crust. So, why is titanium not more commonly used? Fang's one word reply is "cost."

TITANIUM in our FUTURE

In addition to cost, titanium is also very reactive and is not easily purified into its metallic form. Although, once produced, it readily forms a protective passivated oxide layer on its surface, the process of converting it from its ores of ilmenite and rutile to a pure metal is complex and very expensive. Prof. Fang, along with Co-P.I. Mike Free who is also in the Dept. of Metallurgical Engineering, have recently won a $3 million DOE grant to investigate an innovative, and potentially much less expensive, method to produce titanium metal directly from titanium slag.

The standard method for producing titanium is by use of the Kroll process, which processes the ore with coke over a fluidized bed at high temperature. The material is then combined with chlorine gas and the resulting $TiCl_4$ is removed by fractional distillation and reduced using magnesium. After removing the resulting $MgCl_2$ and obtaining what is referred to as titanium sponge through this process, the metal must then be sent through repeated refining steps using vacuum arc remelting. Although complex and energy intensive, the Kroll process accounts for nearly all of the current global titanium production.

The new process, however, bypasses several of these expensive steps by using hydrogen to form titanium hydrides directly from slag, then refining the material through a series of leaching steps. Early analyses indicate the potential for cutting the production energy and the cost of titanium by more than half. If realized, this would be a boon for industry, increasing the use of titanium across a broad spectrum of applications. Fang states that, "One noble goal is to replace steel components in transportation vehicles, especially automobiles."

Fang's group is not only addressing the production of metallic titanium, but is also pursuing research investigating the reduction of energy for making titanium components from metal powders. This new process also uses hydrogen, but this time during the high temperature consolidation of the powder into fully dense solid parts. The hydrogen aids in Ti self-diffusion, lowers porosity, and the phase changes during processing give smaller grain sizes in the resulting materials, which improves mechanical properties.

The Fang research group is pursuing this work as part of a DOE grant through the Office of Energy Efficiency and Renewable Energy (EERE), a project they are working on in conjunction with Co-PI Prof. Ravi Chandran and his students, as well as Research Assist. Prof. Mark Koopman, all in the Dept. of Metallurgical Engineering.

The Chandran group is primarily investigating the mechanical properties of the new materials, particularly fatigue properties, which are critical for many transportation applications. "We expect significant savings in terms of energy and cost on the productions side," says Koopman, "but, the truly profound energy savings will come from replacing heavier steel components in automobiles and trucks with lighter titanium parts that have comparable strength and fatigue properties." A 1% decrease in the mass of an automobile results in approximately a 0.7% increase in fuel efficiency. The conversion of only 12 lb of steel components to titanium in US automobiles would result in a savings of 486 million gallons of gasoline per year, and a reduction in carbon dioxide emissions of 3.6 million metric tons.

See discussion questions on page 14

"The new process developed at the U has proved to be able to manufacture Ti materials with superior mechanical properties, which are stronger and more ductile than those made by using the conventional vacuum sintering method and also comparable with costly wrought titanium." says Pei Sun, doctoral candidate studying the process.

Discussion Questions

1. What is a Metallurgical Engineer?
2. What is the Kroll Process?
3. Why is it important to develop a new process?
4. What is titanium used for?
5. What are some uses for nitinol? What could be some new uses?

Nitinol Demonstration

Nitinol is a shape memory alloy that exhibits a solid state phase change with interesting and useful properties.

Ni = nickel
Ti = titanium

Straighten or deform a piece of shape memory metal. Dip the distorted wire into a beaker of water at approximately 70° C (or higher based on the alloy you have). It will return to its original "trained" shape. Test different samples and shapes. A hair dryer may also be used as a source of heat. Hold the metal in the warm water using pliers on each end. Deform the metal and release the wire from one of the pliers - it will be elastic and not pliable.

A solid state phase change occurs at specific transition temperature. A crystal structure change occurs - more pliable structure at cooler temperatures and an elastic structure at warmer temperatures. By varying the percentage of nickel and titanium in the alloy, different transition temperatures can be achieved.

Contact Samantha Davis at 801-585-5176 or samantha.j.davis@utah.edu for shape memory alloy

Elements currently or formerly extracted or refined in Utah

PERIODIC TABLE OF THE ELEMENTS

GROUP NUMBERS IUPAC RECOMMENDATION (1985)

GROUP NUMBERS CHEMICAL ABSTRACT SERVICE (1986)

13 IIIA

ATOMIC NUMBER — 5 | 10.811 — RELATIVE ATOMIC MASS (1)

SYMBOL — B

BORON — ELEMENT NAME

PERIOD	GROUP 1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 (VIIIB)	9 (VIIIB)	10 (VIIIB)	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 1.0079 H HYDROGEN																	2 4.0026 He HELIUM
2	3 6.941 Li LITHIUM	4 9.0122 Be BERYLLIUM											5 10.811 B BORON	6 12.011 C CARBON	7 14.007 N NITROGEN	8 15.999 O OXYGEN	9 18.998 F FLUORINE	10 20.180 Ne NEON
3	11 22.990 Na SODIUM	12 24.305 Mg MAGNESIUM											13 26.982 Al ALUMINIUM	14 28.086 Si SILICON	15 30.974 P PHOSPHORUS	16 32.065 S SULPHUR	17 35.453 Cl CHLORINE	18 39.948 Ar ARGON
4	19 39.098 K POTASSIUM	20 40.078 Ca CALCIUM	21 44.956 Sc SCANDIUM	22 47.867 Ti TITANIUM	23 50.942 V VANADIUM	24 51.996 Cr CHROMIUM	25 54.938 Mn MANGANESE	26 55.845 Fe IRON	27 58.933 Co COBALT	28 58.693 Ni NICKEL	29 63.546 Cu COPPER	30 65.38 Zn ZINC	31 69.723 Ga GALLIUM	32 72.64 Ge GERMANIUM	33 74.922 As ARSENIC	34 78.96 Se SELENIUM	35 79.904 Br BROMINE	36 83.798 Kr KRYPTON
5	37 85.468 Rb RUBIDIUM	38 87.62 Sr STRONTIUM	39 88.906 Y YTTRIUM	40 91.224 Zr ZIRCONIUM	41 92.906 Nb NIOBIUM	42 95.96 Mo MOLYBDENUM	43 (98) Tc TECHNETIUM	44 101.07 Ru RUTHENIUM	45 102.91 Rh RHODIUM	46 106.42 Pd PALLADIUM	47 107.87 Ag SILVER	48 112.41 Cd CADMIUM	49 114.82 In INDIUM	50 118.71 Sn TIN	51 121.76 Sb ANTIMONY	52 127.60 Te TELLURIUM	53 126.90 I IODINE	54 131.29 Xe XENON
6	55 132.91 Cs CAESIUM	56 137.33 Ba BARIUM	57-71 La-Lu Lanthanide	72 178.49 Hf HAFNIUM	73 180.95 Ta TANTALUM	74 183.84 W TUNGSTEN	75 186.21 Re RHENIUM	76 190.23 Os OSMIUM	77 192.22 Ir IRIDIUM	78 195.08 Pt PLATINUM	79 196.97 Au GOLD	80 200.59 Hg MERCURY	81 204.38 Tl THALLIUM	82 207.2 Pb LEAD	83 208.98 Bi BISMUTH	84 (209) Po POLONIUM	85 (210) At ASTATINE	86 (222) Rn RADON
7	87 (223) Fr FRANCIUM	88 (226) Ra RADIUM	89-103 Ac-Lr Actinide	104 (267) Rf RUTHERFORDIUM	105 (268) Db DUBNIUM	106 (271) Sg SEABORGIUM	107 (272) Bh BOHRIUM	108 (277) Hs HASSIUM	109 (276) Mt MEITNERIUM	110 (281) Ds DARMSTADTIUM	111 (280) Rg ROENTGENIUM	112 (285) Cn COPERNICIUM	113 (. . .) Uut UNUNTRIUM	114 (287) Fl FLEROVIUM	115 (. . .) Uup UNUNPENTIUM	116 (291) Lv LIVERMORIUM	117 (. . .) Uus UNUNSEPTIUM	118 (. . .) Uuo UNUNOCTIUM

LANTHANIDE

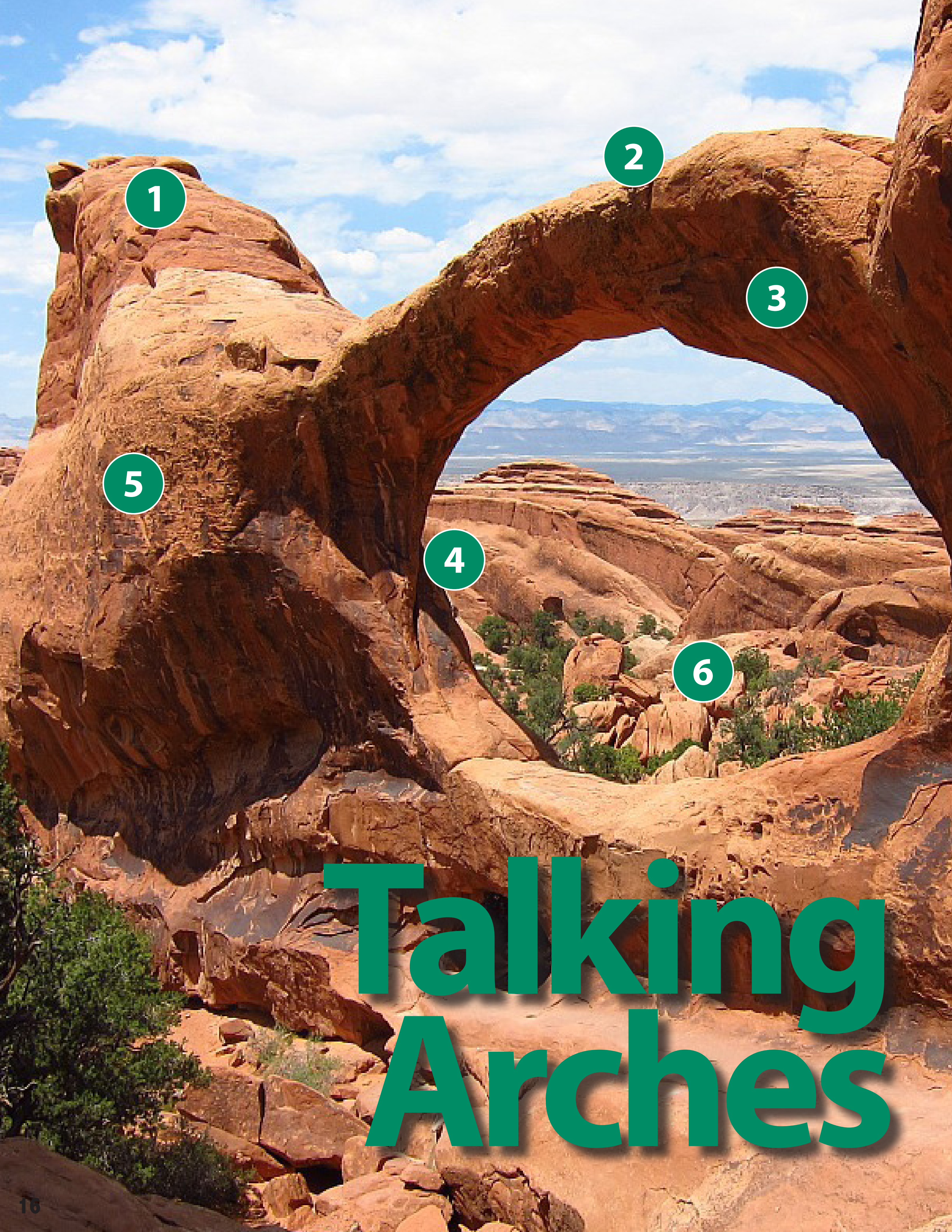
57 138.91 La LANTHANUM	58 140.12 Ce CERIUM	59 140.91 Pr PRASEODYMIUM	60 144.24 Nd NEODYMIUM	61 (145) Pm PROMETHIUM	62 150.36 Sm SAMARIUM	63 151.96 Eu EUROPIUM	64 157.25 Gd GADOLINIUM	65 158.93 Tb TERBIUM	66 162.50 Dy DYSPROSIUM	67 164.93 Ho HOLMIUM	68 167.26 Er ERBIUM	69 168.93 Tm THULIUM	70 173.05 Yb YTTERBIUM	71 174.97 Lu LUTETIUM

ACTINIDE

89 (227) Ac ACTINIUM	90 232.04 Th THORIUM	91 231.04 Pa PROTACTINIUM	92 238.03 U URANIUM	93 (237) Np NEPTUNIUM	94 (244) Pu PLUTONIUM	95 (243) Am AMERICIUM	96 (247) Cm CURIUM	97 (247) Bk BERKELIUM	98 (251) Cf CALIFORNIUM	99 (252) Es EINSTEINIUM	100 (257) Fm FERMIUM	101 (258) Md MENDELEVIUM	102 (259) No NOBELIUM	103 (262) Lr LAWRENCIUM

(1) Pure Appl. Chem., 81, No. 11, 2131-2156 (2009) Relative atomic masses are expressed with five significant figures. For elements that have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element. However three such elements (Th, Pa and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Talking Arches



University of Utah geologists are using sensors to measure movement of the Southwest's famed red-rock arches. This movement can then be accelerated to create sound.

Jeff Moore, a U assistant professor of geology and geophysics, and his geohazards research group have developed "ambient resonance monitoring," a noninvasive diagnostic process to monitor the status of arches' structural integrity. Tracking the changes could help alert the U.S. National Park Service about when or if arches might collapse. *This article originally appeared in the University of Utah Continuum.*

1 GOOD VIBRATIONS

Moore and his team have placed clusters of small sensors—seismometers, tilt-meters, and temperature probes—on the surface of some of Utah's most spectacular arches (including the Landscape, Mesa, and Double-O arches) in Arches and Canyonlands national parks.

2 DAILY MOVEMENT

One broadband seismometer is placed on or near the arch, and the other is placed about 100 meters away for reference. The seismometers are placed in cases along with a data logger and GPS clock. An electrolytic tilt-meter helps measure daily movement of the arch, while data loggers measure temperature and relative humidity.

3 QUICK TEMPO TESTING

The sensors remain on the surface for a few hours so that the vibrations and other parameters can be recorded, and then all the instruments are removed.

4 EARTH, WIND, AND HUMANS

The sensors measure the arches' natural vibration frequencies, which are influenced by the structures' mass and stiffness. Those vibrations shift with rain and snow loads, thermal cycles, and internal structural damage. Moore and his team have found that each rock structure has its own characteristic resonance patterns.

5 CHANGING FREQUENCIES

The scientists repeat their measurements with the sensors to note changes in the rock structures' frequencies over time, to help determine whether the structural integrity has changed. If an arch develops a crack, it changes the vibrational characteristics of the structure.

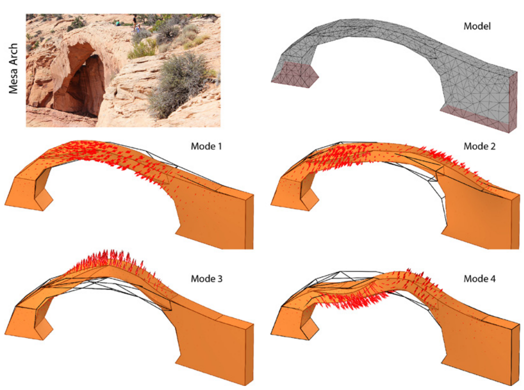
6 WALL CAME TUMBLIN' DOWN

Wall Arch, in Arches National Park, collapsed in 2008 due to stress fractures that occurred over time. Moore and his team believe Landscape Arch, in the same park, is close to falling down. The 88-meter-long arch—the longest in North America—has a fundamental resonant frequency of about 1.8 Hz. If it sustains further damage, the arch's resonant frequency would drop, and Moore and his team could measure that.

Arches are always moving, though we can't see it with the naked eye. Data collected so far show that they rock back and forth, expand and contract, twist and contort constantly. All this movement produces sound waves.

At the core, resonant frequencies are simply a function of two material properties: mass and stiffness, we try to sense damage by searching for changes in the stiffness of the rock; the rock becomes softer as it accumulates damage. We track changes in the stiffness of the rock by listening to changes in the sound of the arch over time.

And what do those sounds mean? Well, if they change in tone over time, it could signal that the arch itself is cracked or getting weaker.



For more information about this study, explore 3-D images or the arches, and hear sound clips of arch movement please visit our Geohazards website at http://geohazards.earth.utah.edu/arch.html

Examples

If we pluck a guitar string, we hear primarily the sound it generates at the first resonant frequency, but there are many modes to that. And Mesa Arch (as well as the others) is doing the same thing. As a wind gust comes through, it actually plucks Mesa Arch.

Another example is a cracked dinner plate. If you have two identical and one has developed a crack. The one without a crack will give a nice high pitched ring when set on the counter, the one with the crack will give a dull thud.

Information for this article was collected from geohazards website and ksl.com

Discussion Questions

How were the arches formed in southeast Utah?
Watch this video to learn more
http://www.nps.gov/arch/learn/photosmultimedia/geologyvideo.htm

Why is it important to monitor arch movement?

What other ways can "ambient resonance monitoring" be used?

Instagram

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The University of Utah
College of Mines and Earth Sciences

uofucmes #BreakingtheStereotypes

Follow us @ufoucmes and @uofucmes

BREAKING THE STEREOTYPES

True

If you get an Atmospheric Sciences degree, you will end up on TV as the weather person.

But, you can also do a lot more! Our Alumni have gained employment in a variety of settings including: federal agencies such as the National Weather Service, NASA, National Oceanic and Atmosphere Administration, Bureau of Land Management, state agencies such as transportation and air quality, private employers such as consulting firms, aviation, insurance, and agriculture, and the military.

False

Geosciences is not real science.

Geoscience degrees combine knowledge from disciplines such as math, biology, chemistry, and physics to study the earth. Geoscientists are problem solvers, addressing issues related to energy & water resources, natural disasters, and environmental protection.

False

Metallurgical Engineering is a narrow degree with not many career options.

Metallurgical engineers play an important role in providing solutions to problems in today's society. The metallurgical profession is extremely diverse with applications in industries such as biotech, mineral processing, computer technology, and aeronautics, to name a few. Metallurgical engineers are employed in every industry that produces, buys, sells refines or manufactures metals or metallic products.

False

If you get a Mining Engineering degree, you will have to work underground.

Most Mining Engineers will spend their careers "above ground" as a majority of U.S. mineral production is from surface operations. Career paths include mine design using sophisticated software to health and safety to government and state agencies like the BLM and MSHA. Mininig Engineering continues to be ranked in the top 10 of the highest paying college majors with starting salaries between $65,000 and $85,000.

College of
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