SINUS INFECTION? TRY A BEER | GIFT GUIDE FOR GEO GEEKS

EARTH

HIGHLIGHTS OF 2010

Science and Law Clash

After the Spill: Oil, Water and Wind

What Does It Mean to Be Human?

a look back at all of the year's top stories

Plus:

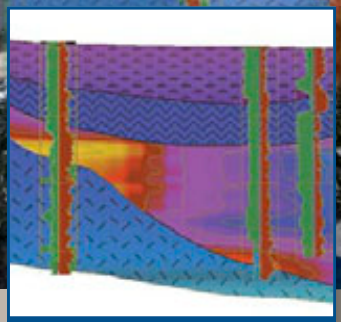
- Pele's wrath at Kilauea
- Dinner in a dinosaur
- Recalculating Greenland's ice loss
- China curtails rare earth minerals trade

SERVING THE GEOSCIENCES WORLDWIDE
AGI
THE AMERICAN GEOLOGICAL INSTITUTE

December 2010
www.earthmagazine.org

$5.99US $6.99CAN
12>
0 09281 01486 7

Not Just Software. . . .RockWare.
For Over 27 Years.



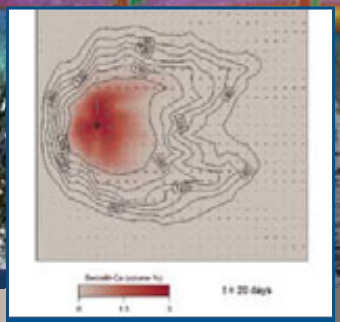
RockWorks®

3D Data Management, Analysis and Visualization

- Powerful measured-section/borehole database for managing:
  - Lithology
  - Stratigraphy
  - Hydrology
  - Hydrochemistry (e.g. Contaminants)
  - Geophysics
  - Fractures
  - and more
- Create striplogs, cross-sections, fence diagrams, and block models
- Contour data in 2D and 3D (isosurfaces)
- Extensive on-line help and sample data sets
- Includes RockWorks Utilities

Free trial available at www.rockware.com

$3,000



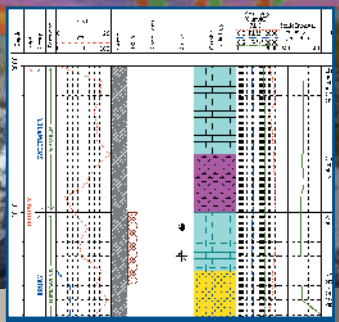
The Geochemist Workbench®

A Complete Set of Tools for Aqueous Geochemistry

- New GSS spreadsheet for storing water data, converting units and more.
- Water chemistry diagrams (Piper, Stiff, time series, series, ternary etc.)
- Eh/pH and activity diagrams
- Predict aqueous species, calculate mineral saturation and gas fugacities
- Reaction path modeling
- 1D and 2D reactive transport modeling

Free trial available at www.rockware.com

Starting at $999



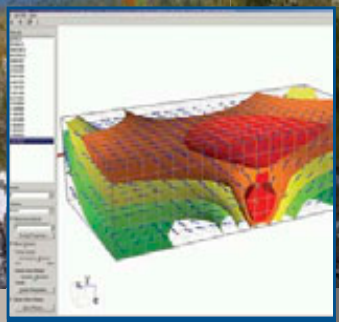
LogPlot™

Powerful, Flexible, Easy-to-Use Borehole Log Software

- Dozens of templates available or design your own in the drawing-style log designer window
- Tabbed data sheets
- Import/Export data from LAS, Excel, RockWorks
- Paginated and continuous logs at any vertical scale
- Export to a variety of formats
- Free viewer can be distributed to clients

Free trial available at www.rockware.com

$699



PetraSim™

A Preprocessor and Postprocessor for TOUGH2, T2VOC, TMVOC and TOUGHREACT and TOUGH-FX/HYDRATE

- Model multi-component fluid flow, heat transfer and reactive transport process
- Saturated and unsaturated conditions
- Fractured and porous media
- Mesh generation, parameter definition, and display of results
- Now supports TOUGH-MP (parallel version of the TOUGH2 simulator)

Free trial available at www.rockware.com

Call for pricing

RockWare®
Since 1983

303.278.3534 · 800.775.6745
RockWare.com

Follow us on:

YouTube

ESRI

MapInfo Professionals

This PDF is licensed for personal use only. MjAxMC0xMi0xMjky

One Man's Planet

Earth in Today's Political Culture

Stephen M. Testa

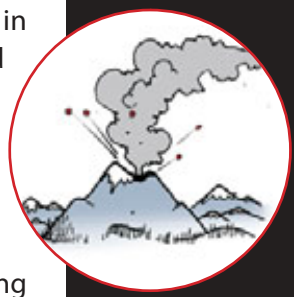
One Man's Planet is one slightly off-centered geologist's introduction to how politics, pop-culture and the earth sciences intertwine in our daily lives. It is a humorous look at a myriad of issues that grace the news and drive political debates from local councils to international discourse. *One Man's Planet* picks apart the rhetoric on all sides of these debates to look at how the science describes the issue, often to the nakedness of the opposing parties. Tackling topics like climate, energy, water, and hazards, Stephen Testa channels Pink Floyd, Mad Max, and Shakespeare among others to examine the latest scientific understanding of these issues. He deftly weaves all this into a very informative and entertaining tapestry on the planet today and the planet's tomorrow. Come tour the Earth with Testa as your guide!

Now Available From

SERVING THE GEOSCIENCES WORLDWIDE

AGI

THE AMERICAN GEOLOGICAL INSTITUTE



ISBN: 978-0-922152-85-8
$24.95
Softcover, Color
224 pages

www.agiweb.org/pubs

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

EARTH

DECEMBER 2010
vol. 55 ■ no. 12
www.earthmagazine.org

FEATURES

EARTH wraps up the year with a look at the events and findings that shaped the last year.

HAZARDS: Geologists on the Wrong Side of the Law
Stephen M. Testa p. 31

PLUS – Hazards of 2010

OFFSHORE ENERGY: After the Spill
Megan Sever p. 36

OFFSHORE ENERGY: A Tale of Two States: Offshore Wind in Texas and the Curious Case of Massachusetts
Sheril R. Kirshenbaum and Michael E. Webber p. 37

PALEONTOLOGY: What Does It Mean to Be Human?
Erin Wayman p. 40

PLUS – Favorite Paleo Finds of 2010

MAJOR RESEARCH TRENDS OF 2010
p. 46

Definitive Statements: A New Trend?

Beyond Mars: Water, magnetic fields, minerals and more on other planetary bodies

The Hunt for Other Earths

PLUS – Exoplanet Highlights of 2010

Major Quakes and Micro-Shakes in 2010

Twists and Turns in the Ocean Conveyor Belt

FEATURE

TRAVELS IN GEOLOGY: KILAUEA: EXPERIENCING PELE'S WRATH THROUGH THE EYES OF A YOUNG GEOLOGIST

No budding geologist could turn down the chance to spend a summer on Kilauea, working at the U.S. Geological Survey Hawaiian Volcano Observatory. And no geo-traveler should turn down the chance to see active volcanism in a glorious setting.
Zahra Hirji

56

ON THE COVER: A look back at the events of the past year. Design by Brenna Tobler, AGI.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

NEWS

8 NEWS SHORTS

9 PROJECTING TIPPING POINTS STAVES OFF EXTINCTION?

10 THE BEER THAT HEALS

12 ICELANDIC ERUPTION A BOON TO BRITISH ARCHAEOLOGISTS

13 FIELD STUDIES INDICATE GREATER EARTHQUAKE RISK IN SOUTHERN CALIFORNIA

14 EL NIÑO'S OCEAN ORIGINS ON THE MOVE

15 BLACK HOLE VOLCANO ALTERS GALACTIC EVOLUTION

15 NOAA: CORAL REEF BLEACHING LIKELY IN CARIBBEAN

16 GREENLAND NOT LOSING AS MUCH ICE AS THOUGHT

17 CHINA'S DOMINANCE OVER RARE EARTHS MARKET COULD BECOME A CRISIS FOR U.S.

18 BEFORE AND AFTER: A GLIMPSE INTO A POWERFUL QUAKE

19 DRY ROOTS KEEP CRATONS AFLOAT

20 SEEING BENEATH THE PACIFIC NORTHWEST

21 DRAGON DINOSAUR A STRANGE COUSIN OF *VELOCIRAPTOR*

22 ARCTIC OCEAN NOT THE HOPED-FOR CARBON SINK

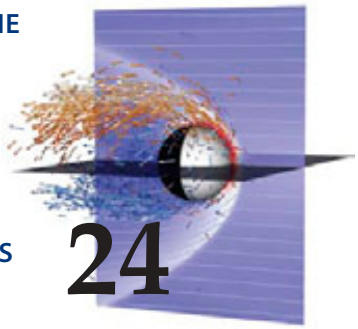
24 VENUS EXHALES ITS HYDROGEN AND OXYGEN

25 FIRES FUELED SPREAD OF FLOWERING PLANTS

25 WITH A LITTLE HELP FROM KELP

26 HUMANS, NOT CLIMATE, INITIATED THE DECLINE OF THE CAVE BEAR

27 MINERAL RESOURCE OF THE MONTH: CLAY MINERALS



VIEWS

87 A COMMENT
OBAMA'S MISSION TO AN ASTEROID: A PROTRACTED MISSION TO NOWHERE
When President Barack Obama cut the Constellation program, allowed the space shuttle program to end and announced the mission to an asteroid earlier this year, he hurt the hearts and pocketbooks of NASA communities.
Jonathan Gutheinz and Joseph Richard Gutheinz Jr.

88 GEOLOGIC COLUMN
A GEOLOGY CLUB FOR ALL SEASONS
A look back at the days of yore: The Branner Club helped bring geoscientists together throughout Southern California. Such personal contact isn't what it once was.
Lisa A Rossbacher

DEPARTMENTS

4 FROM THE EDITOR

6 LETTERS: PERSPECTIVES FROM READERS

64 GEOMEDIA
Books: Holiday On the Shelf
Gifts: Holiday Gift Guide

70 CROSS-SECTION: A PUZZLE

71 WHERE ON EARTH?

72 BENCHMARKS
December 31, 1853: Dinner in a Dinosaur

76 GEOMARKETPLACE

78 CLASSIFIEDS: CAREER OPPORTUNITIES

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

From the Editor

The devil is in the details.

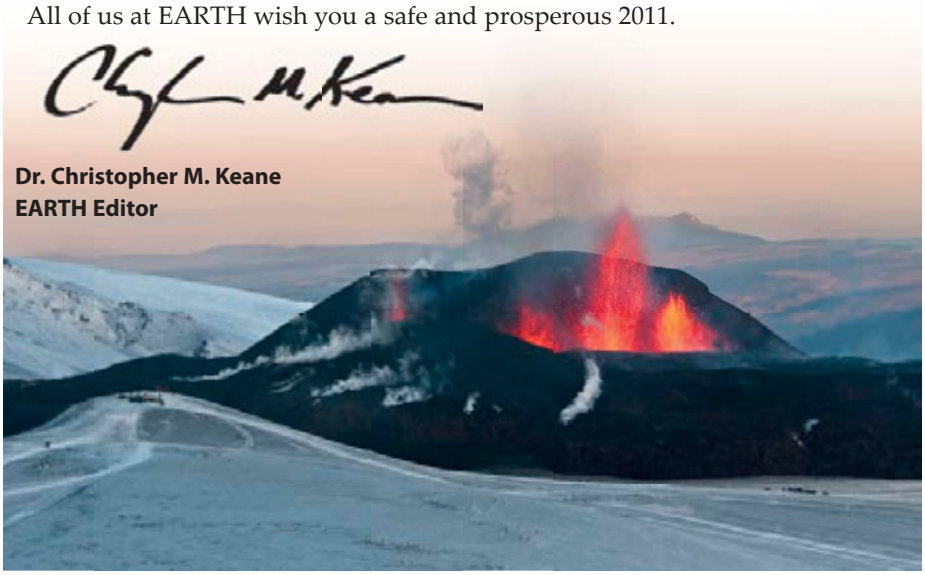
It's the end of another year. As usual, our December issue takes a look at the key stories of the past 12 months — research trends, hazards, commodities news and the like.

As usual, nature took its toll on humans, with several large and high-impact earthquakes, storms and volcanoes. Along with those events came the chorus of fear that these incidents are becoming worse. I don't mean to sound callous, but looking back at past year-end issues of EARTH and Geotimes (EARTH's predecessor) highlights instead how absolutely *usual* these events are: We see the same portfolio of events every year.

Yet our knowledge does continue to move forward. Science is an additive process; each piece of research adds to the knowledge base and none of it removes that information. To that end, this year EARTH takes a close look at highlights in the advancement of knowledge — from major exoplanet discoveries to new understandings of how ocean circulation works and impacts climate, and from new discoveries about our planetary neighbors (other than Mars) to new understandings about what it means to be human.

This year-in-review is a rich tapestry of what makes the geosciences so fascinating and dynamic, even if there is a familiar ring to it. The general picture isn't different this year, and I'd be willing to bet it won't be different next year either. But the details will vary — which volcano will erupt, where big earthquakes will hit, and how humans will never fully control the power of nature. Just as undoubtedly, 2011 will bring new knowledge and understanding of how humans can better coexist with our planet, which hopefully will lead to increased stewardship of the planet's fragile side and respect for its power.

All of us at EARTH wish you a safe and prosperous 2011.



Dr. Christopher M. Keane
EARTH Editor

EARTH (ISSN 1943-345X) is published monthly for a base subscription rate of $36.00 a year (single copies $5.99) by the American Geological Institute. © 2010 American Geological Institute. Standard mail, nonprofit postage paid at Denver, Colo., and at other mailing offices. Claims for missing issues will be honored only up to six months. Issues undelivered through failure to notify EARTH of address change will not be replaced.

Canadian Post Publications Mail Agreement Number 40065056; Canadian return address: DP Global Mail, 4960-2 Walker Road, Windsor, ON N9A 6J3.

EDITORIAL MATTER: We encourage readers to alert us to news and photos for possible publication. Opinions expressed by authors are their own and do not necessarily reflect those of AGI, its staff, its member societies, or its advertisers. The presence of an advertisement in this magazine does not constitute **EARTH** endorsement of the product.

REPRODUCTION: More than one photocopy of an item from **EARTH** may be made provided that fees are paid directly to the Copyright Clearance Center, 222 Rosewood Dr., Danvers, MA 01923, USA. Phone: (978)750-8400. Fax: (978)646-8600. Any other form of reproduction requires special permission from and is subject to fees by **EARTH.**

EARTH is sold on newsstands worldwide through the Curtis Circulation Company.

EARTH

4220 King Street
Alexandria, VA 22302-1502, USA
Phone: (703)379-2480 Fax: (703)379-7563
www.earthmagazine.org
earth@earthmagazine.org

PUBLISHER
P. PATRICK LEAHY

EDITOR
CHRISTOPHER M. KEANE

MANAGING EDITOR
MEGAN SEVER

WEB EDITOR
CAROLYN GRAMLING

ASSOCIATE EDITOR
ERIN WAYMAN

DESIGNER
BRENNA TOBLER

WEB PRODUCTION
MARY JO ALFANO

MARKETING/ADVERTISING
JOHN P. RASANEN

CONTRIBUTORS
CALLAN BENTLEY
NICOLE BRANAN
SAM LEMONICK
MEG MARQUARDT
PATRICK MORGAN
MARY CAPERTON MORTON
JOELLEN TALBOT
DAVID B. WILLIAMS

CUSTOMER SERVICE
NIA MORGAN

CONTRIBUTING EDITORS
SCOTT BURNS
(Portland State University)
SOLOMON HSIANG
(Columbia University)
RASOUL SORKHABI
(University of Utah)
MICHAEL WEBBER
(University of Texas at Austin)

DISPLAY/NATIONAL ADVERTISING
OEHLERMEDIA, INC.
GREGG R. OEHLER, PRESIDENT
RICH L. CORDERO, AD DIRECTOR
212-226-3955
GREGG@OEHLERMEDIA.COM

EARTH is printed by American Web, based in Denver, Colo. EARTH is printed on 20% recycled (10% post-consumer waste) paper. All inks used contain a percentage of soy base. Our printer meets or exceeds all federal Resource Conservation Recovery Act (RCRA) Standards.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

©David Karnå, Creative Commons Attribution 3.0 Unported

AMERICAN GEOLOGICAL INSTITUTE

SERVING THE GEOSCIENCES WORLDWIDE
AGI
THE AMERICAN GEOLOGICAL INSTITUTE

EXECUTIVE COMMITTEE

PRESIDENT
G. WARFIELD HOBBS IV, AMMONITE RESOURCES

PRESIDENT-ELECT
WAYNE D. PENNINGTON, MICHIGAN TECHNOLOGICAL UNIVERSITY

TREASURER
JAMES M. ROBERTSON, WISCONSIN GEOLOGICAL SURVEY

SECRETARY
BERRY H. TEW, JR., GEOLOGICAL SURVEY OF ALABAMA

MEMBER AT LARGE
JESSICA MOORE ALI-ADEEB,
CHEVRON ENERGY TECHNOLOGY COMPANY

MEMBER AT LARGE
DAVID W. BIEBER, GEOCON CONSULTANTS INC.

MEMBER AT LARGE
DONALD L. SPARKS, UNIVERSITY OF DELAWARE

PAST PRESIDENT
RICHARD M. POWERS, BCI ENGINEERS & SCIENTISTS

CHAIR OF AGI FOUNDATION
ROGER P. PINKERTON, MARATHON OIL COMPANY

EXECUTIVE DIRECTOR
P. PATRICK LEAHY

MEMBER SOCIETIES

AASP-The Palynological Society (AASP)
American Association of Petroleum Geologists (AAPG)
American Geophysical Union (AGU)
American Institute of Hydrology (AIH)
American Institute of Professional Geologists (AIPG)
American Rock Mechanics Association (ARMA)
American Society of Limnology and Oceanography (ASLO)
Association for Women Geoscientists (AWG)
Association of American State Geologists (AASG)
Association of Earth Science Editors (AESE)
Association of Environmental & Engineering Geologists (AEG)
Clay Minerals Society (CMS)
Council on Undergraduate Research, Geosciences Division (CUR)
Environmental and Engineering Geophysical Society (EEGS)
Friends of Mineralogy (FOM)
The Geochemical Society (GS)
Geo-Institute of the American Society of Civil Engineers (GI)
Geological Society of America (GSA)
The Geological Society of London (GSL)
Geoscience Information Society (GSIS)
History of Earth Sciences Society (HESS)
International Association of Hydrogeologists/U.S. National Chapter (IAH)
International Basement Tectonics Association (IBTA)
Karst Waters Institute (KWI)
Mineralogical Society of America (MSA)
National Association of Black Geologists and Geophysicists (NABGG)
National Association of Geoscience Teachers (NAGT)
National Association of State Boards of Geology (ASBOG)
National Earth Science Teachers Association (NESTA)
National Ground Water Association (NGWA)
National Speleological Society (NSS)
North American Commission of Stratigraphic Nomenclature (NACSN)
Paleobotanical Section of the Botanical Society of America (PSBSA)
Paleontological Research Institution (PRI)
Paleontological Society (PS)
Petroleum History Institute (PHI)
Seismological Society of America (SSA)
SEPM (Society for Sedimentary Geology) (SEPM)
Society for Mining, Metallurgy, and Exploration, Inc. (SME)
The Society for Organic Petrology (TSOP)
Society of Economic Geologists (SEG)
Society of Exploration Geophysicists (SEG)
Society of Independent Professional Earth Scientists (SIPES)
Society of Mineral Museum Professionals (SMMP)
Society of Vertebrate Paleontology (SVP)
Soil Science Society of America (SSSA)
United States Permafrost Association (USPA)

The American Geological Institute is a nonprofit federation of geoscientific and professional associations that represents more than 120,000 geologists, geophysicists, and other earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice of shared interests in our profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resilience to natural hazards, and the health of the environment.

www.agiweb.org

Clockwise from top right: Jennifer Kawata; AGI; Christopher Keane/AGI; Nicole Schlegel; AGI; ©iStockphoto.com/dwhob; center: AGI

This PDF is licensed for personal use only. MTcxMC0xMi0xMjkyOTE4OTEzLjQ3

Hannibal's march

ON HANNIBAL'S TRAIL:
THE CLUES ARE IN THE GEOLOGY

I can understand that in a magazine whose publisher is the American Geological Institute, one would seek to print articles with a geological twist; but your recent piece on Hannibal in the October issue is simply too much for me to take lying down.

First, what about the elephants? It seems that all 29 of those beasts that got across the Rhone, also descended into Italy, where their bones ended up mostly outside the walls of Piacenza. Therefore, despite the geology, Hannibal's route simply had to be "elephant friendly," not precipitate at any time or point, and any zookeeper could have told you that elephants just don't do steep terrain.

Furthermore, Hannibal was a superb commander, as the Romans found out over the next 20 years when he rampaged (mostly without his elephants) the length and breadth of Italy, while more than one Roman general (and one famous dictator) were powerless to contain or eliminate him. But no smart commander would force his weakened and hungry army to cross the exalted Col du Clapier when the vastly easier, and some hundreds of meters lower, Moncenisio was nearby. And the west approach to the Moncenisio is quite gentle, so gentle, in fact, that a non-cog railroad was actually built and operated across it prior to the opening of the Frejus Tunnel.

William Lowell Putnam
Flagstaff, Ariz.

Geologists and "plain talk"

I think that the Italian seismologists' statement, "it may or may not portend a larger quake," is about as "plain talk" as it's possible to get (as described in the September comment by John C. Mutter). If scientists admit they don't know something (which is what the Italian scientists said), then the relatively uneducated public believes it isn't happening and assumes the scientists don't know anything. This is so very true of climate change. It's complex and hard to make into a sound bite. Because of that, too many people choose to believe something simple: It's not happening.

The only way to bridge this communication problem is to create an intelligent public through the education system. But in America at least, that's a fairly broken system and in no way prepares people to deal with the complexities of science — whether it's climate change or vaccines.

If admitting you don't have all the answers means that people will assume you don't have *any* answers, plain talk isn't going to help.

Cassie Paslick
Rockford, Ill.

Where on Earth?

We enjoy the "Where on Earth?" quiz every month, and would like to recommend more input by local geologists in writing the clues. Regarding the September 2010 issue of EARTH, for example, we immediately recognized where this picture was taken and offer some additional information to the clues provided:

Your clue read: "The river cut into metamorphic rocks, including schists and gneisses, that date to the Precambrian (750 million years ago)." It could have read: "The view is to the northeast at the vertical metagraywacke beds of the Mather Gorge Formation. Ongoing uranium-lead analyses of detrital zircons suggest that the deposition of the protolith of these amphibolite-facies rocks likely occurred after approximately 600 million years ago, or during the Late Neoproterozoic. The rocks were metamorphosed and deformed during the Ordovician, at approximately 475 million years ago."

Where your clue read, "The waterfalls sit between two U.S. states and are part of a national park," it could have included more information, or been more specific. In truth, the waterfalls are in Maryland. The boundary between Virginia and Maryland is the low-water mark on the south wall of the Potomac River Gorge. Because the waterfalls are completely in Maryland, they are located in the Chesapeake and Ohio Canal National Historical Park. The picture was actually taken from an overlook in Great Falls Park, Va., which is part of the George Washington Memorial Parkway.

Scott Southworth
Reston, Va.
Aaron Martin
College Park, Md.

EARTH welcomes letters to the editor. All letters are subject to editing for length and clarity. Send letters to: earth@earthmagazine.org.

Visit our polls online at www.earthmagazine.org

Poll: Underground coal fires

In September, we asked our readers: Who do you think should be responsible for monitoring underground coal fires? Here are the results:*

Government agencies, including firefighting agencies	53%
Private mining and engineering companies	24%
Scientists and engineers in academia	15%
Don't know	5%
No one - we should let them burn out	3%

*This poll is not scientific and reflects the opinions only of those Internet users who have chosen to participate.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

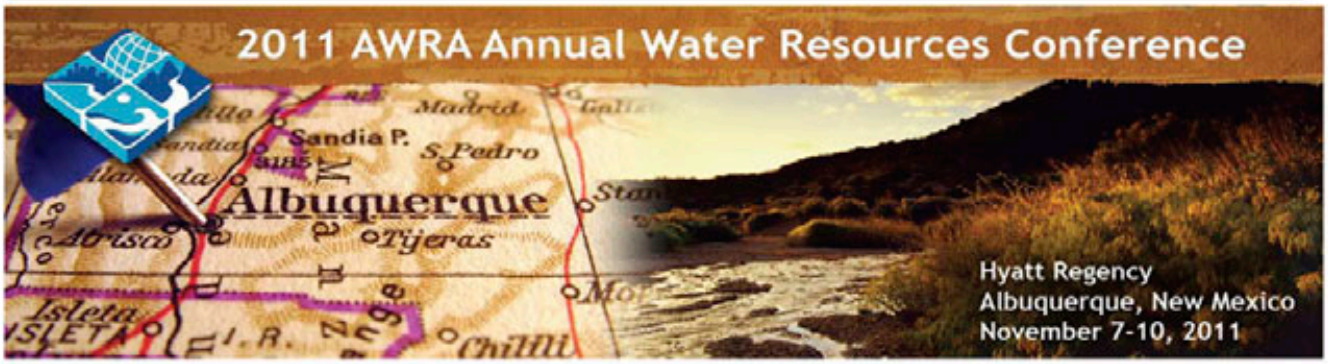
©AGI

Mark Your Calendars for these upcoming AWRA conferences!

Make your plans now to attend this American Water Resources Association (AWRA) specialty conference on the important topic ***of Managing Climate Change Impacts on Water Resources*** will bring together decision-makers, water managers and technical professionals from federal, state, and local agencies, academia, non-governmental organizations and the private sector to focus on the following key questions:

- What climate adaptation *strategies, decision-making approaches, planning and evaluation methods* do water managers and water professionals need to prepare for climate change impacts on water resources?
- What kinds of *assessment and planning approaches do we need*, what kind of *solutions may be available*, what kinds of *institutional adaptation may be necessary*, and what might be the *environmental and socioeconomic impacts and considerations* that need to be taken into account, and *how much will they cost*?

Registration is Open
Look for the Preliminary Program Online in December



Watch for the Call for Abstracts Online February 2011

The ***AWRA Annual Water Resources Conference*** brings together every year a multidisciplinary group of water resources professionals who will gather to present their latest research, discuss current hot topics, and share new ideas. The Southwestern locale provides an ideal backdrop for discussions of surface water and groundwater interaction, effects of natural and anthropogenic sources on water quality, water reuse and conservation, interstate and international transboundary issues, artificial recharge, stormwater management, desalination, and more.

Visit www.AWRA.org
for the most up-to-date conference info

AWRA
Community, Conservation, Connections

AMERICAN WATER RESOURCES ASSOCIATION

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Glaciers preserve Andes height

Rather than wearing the mountains down, glaciers in the southern Patagonian Andes have shielded the mountains from erosion over recent geological history, according to a new study. Researchers dated mineral samples from throughout the Patagonian Andes and found that the rocks increased in age farther south, indicating a decrease in the long-term efficiency of glacial erosion in the region.
Thomson et al., Nature, Sept. 16, 2010.

Mapping the carbon in trees

Scientists have mapped the amount of carbon in tropical forests in the Amazon and the amount of carbon released in the region by various types of land, including older and younger soils, and by various land-use practices, including logging and mining. They combined satellite mapping, airborne LiDAR technology and ground-based surveys to develop the new high-resolution maps, which they hope to use to track carbon emissions and storage.
Asner et al., Proceedings of the National Academy of Sciences, Sept. 21, 2010.

Southern Hemisphere warmed while Northern Hemisphere cooled

As the Northern Hemisphere was undergoing a significant cooling period about 13,000 years ago, called the Younger Dryas, Antarctica was warming. Now, glacial debris in New Zealand from that time period shows that New Zealand also warmed significantly, which indicates the warming was widespread across the Southern Hemisphere. The mechanisms behind the warming in the south and the cooling in the north are still up for debate.
Kaplan et al., Nature, Sept. 9, 2010.

Bark beetles expand as temperatures increase

Researchers recently found that two species of bark beetle that are common throughout spruce and pine forests in the western U.S. will expand in both numbers and northward range if regional temperatures warm as projected by the Intergovernmental Panel on Climate Change. There is little evidence, however, that the beetles will expand their range eastward.
Bentz et al., BioScience, September 2010.

Finding volcanoes on exoplanets

A new theoretical modeling study indicates that astronomers might be able to detect volcanic eruptions on exoplanets, even on small, rocky, Earth-like planets, well before the technology exists to image the planets' surfaces. If eruptions are strong enough — 10 to 100 times the size of the 1991 Mount Pinatubo eruption — they will throw enough gases into the air to be detectable by telescopes like the James Webb Space Telescope that will launch in 2014.
Kaltenegger et al., The Astrophysical Journal, in press.

Efficiency and conservation save water

A new study indicates that people can save more water through proper efficiency measures and conservation methods than can be added economically through new sources, such as building dams. The study looked at how California could save a million acre-feet of water annually; replacing inefficient water systems in homes, using drought tolerant plants in lawns and replacing flood irrigation with drip irrigation were some of the best practices.
Cooley et al., Pacific Institute's "California's Next Million Acre-Feet," September 2010.

Oil sands polluting Athabasca region

Despite previous statements to the contrary, new tests indicate that oil sands mining and processing in the Athabasca region in Alberta, Canada, are releasing large amounts of toxic metals — including mercury, arsenic, lead and cadmium — into the surrounding air and water. Metal levels are highest nearest industrial centers, researchers noted.
Kelly et al., Proceedings of the National Academy of Sciences, Sept. 14, 2010.

Utah approves oil sands project

In September, Utah's Division of Oil, Gas & Mining approved the first oil sands mining project in the U.S. The agency gave a permit to develop a 25-hectare site in eastern Utah to Canada-based Earth Energy. The company is raising funds to begin the project; meanwhile, environmentalists are opposing the ruling.
Associated Press, Sept. 13, 2010.

At EARTH online…

Follow EARTH online as we post new comments, blogs and tweets. Visit us online at www.earthmagazine.org, become fans on Facebook at www.facebook.com/earthmagazine, or follow us on Twitter @earthmagazine. Follow us on your Android phone too; check out the EARTH Magazine app on the Android Market. We tweet daily and blog at least once a week. Below are a few examples of things that tickled our fancy in recent months.

- **EPA has made Newtown Creek oil spill** in NYC a Superfund site. A history of the spill is at EARTH.
  Sep 29th
- **Mudslide buries 300-plus homes** in Oaxaca, Mexico; hundreds feared dead. Tropical storms exacerbating situation.
  Sep 28th
- **100-yr-old Wisconsin River levee** giving way - Portage and other towns and homes in the region in danger.
  Sep 27th
- **A magnitude-6.1 quake** hit southern Iran, killing at least 1 person.
  Sep 27th
- **World's largest offshore wind farm** opens off UK coasts in the North Sea.
  Sep 23rd
- **Treasure trove** of 1.4-million-year-old fossils found in cave in Los Angeles area; reveal 1500 bone fragments.
  Sep 21st
- **Ew! One occupational hazard** of being an astronaut: your fingernails fall off.
  Sep 16th

Clockwise from bottom right: ©iStockphoto.com/iofoto; ©George Denton; ©Stuart Thomson; Wade Henning

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

PROJECTING TIPPING POINTS STAVES OFF EXTINCTION?

Thousands of species around the world are threatened with extinction, from the Canadian lynx to the spotted owl to the desert pupfish. Scientists and conservation groups are monitoring these plants and animals, but forecasting when a population is so severely damaged that it is approaching a tipping point — where its demise becomes inevitable — has so far been impossible. Now scientists may have found a way to recognize the early warning signs that indicate the point of no return is right around the corner — allowing conservationists to take action before it is too late.

Many theoretical models of populations in the wild deal with stationary environments, devoid of any long-term trends, such as deforestation, says John Drake, an ecologist at the University of Georgia in Athens. "But we all know that this is plainly false, because we have things like climate change, deforestation, land conversion and so forth, and these are the primary threats to endangered species." So Drake and his team looked for ways to describe what happens to animals living in a steadily deteriorating environment.

To do that, they studied different populations of zooplankton that they reared in plastic tanks in their laboratory. They fed some of them continuously, but gave less and less food to others, simulating a deteriorating environment in the wild, eventually forcing these populations to go extinct. Along the way, the researchers periodically counted how many individuals were alive in each population.

In analyzing their data, the team found large spikes in some statistical properties of the datasets that occurred shortly before a population reached a tipping point, they reported in Nature. These spikes were caused by a phenomenon called critical slowing down, or CSD. CSD happens near a tipping point of a system and is coupled with "a decline in the resilience of a system," Drake says. For example, a healthy population of plants or animals recovers quickly from small disturbances, such as low food supply, but a population that is experiencing CSD is no longer able to bounce back quickly. Scientists have been using CSD in connection with systems outside of the field of ecology, such as shifts in climate, but no one had previously applied it to species extinction, he says.

By studying zooplankton's response to a lack of food, researchers found that there may be a statistical, somewhat predictable tipping point for when a species, such as the Canadian lynx (shown above), is about to go extinct.

Scientists could eventually use this technique in the wild, but "there are a couple of steps we need to take first," Drake says. For example, it is not clear yet whether the technique can signal the approach of a tipping point far enough in advance to allow interventions that would actually prevent it from happening.

The study "is a really nice demonstration" showing how statistical measures can be used to gauge extinction risk, says Bill Fagan, a biologist at the University of Maryland in College Park. However, data collected on populations of threatened species in the wild "are much more sporadic, fragmentary and subject to more observation error" than data collected in the lab, he adds. For example, for many species, "we might get an update on their estimated population size once every five years or once every 10 years." To see if this technique would work in the real world, researchers should "corrupt [lab data] in various ways to typify the challenges that are characteristic of real populations in the wild," Fagan says.

Drake and his team also plan to retrospectively look at data of species that have gone extinct in the past to see if they can identify CSD, Drake says, and to verify that "if we had known to look for this thing, we would have seen it."

Nicole Branan

Bottom: ©Paul Hebert; top: ©iStockphoto.com/Michael Olson

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

THE BEER THAT HEALS

Ancient Nubians brewed antibiotic beer

For ancient Nubians, sugar didn't help the medicine go down, but alcohol did. More than 1,500 years before modern medicine discovered antibiotics, researchers say, people living along the Nile River added tetracycline to their beer.

The discovery that ancient Nubians, who lived in northern Sudan between A.D. 350 and A.D. 550, medicated themselves with antibiotics dates back 30 years. Debra Martin, then a graduate student at the University of Massachusetts in Amherst, placed a sliver of bone from a Nubian mummy under an ultraviolet microscope. The bone glowed green. The same thing happens to bones of modern people who take tetracycline. The tetracycline binds with calcium in the body and then gets incorporated into new bone. The tetracycline emits a green fluorescence when exposed to UV light.

Beer in ancient Nubia probably had at least one ingredient not found in modern brews: antibiotics.

Finding signs of tetracycline in such old bones was unexpected, says George Armelagos, an anthropologist at Emory University in Atlanta, Ga. "It was as if you were unwrapping a mummy and found Ray Ban sunglasses," he says. But the mummy wasn't a fluke. In the past 30 years, Armelagos and colleagues have looked at 300 to 400 individuals from Nubia, Egypt and Jordan. About 90 percent of the Nubians have traces of tetracycline, he says, whereas the other populations have smaller percentages of tetracycline-marked individuals.

Initially, critics suggested the tetracycline came from microbes that invaded the bones after death. However, Armelagos says, none of the mummies shows any of the telltale signs of post-mortem microbe damage. Now, new research lends support to the idea that the tetracycline was stamped into the bones while people were alive.

Mark Nelson, a medicinal chemist at Paratek Pharmaceuticals in Boston, Mass., offered to verify the presence of tetracycline after he learned about the mummies in 2000. "It was one of the simpler experiments that I've ever conducted," he says. He took a bone sample from a Nubian child and dissolved it in hydrofluoric acid. If tetracycline were present in the bone, it would react to the acid in predictable ways — and that's just what Nelson found. He, along with Armelagos and others, published the results in the American Journal of Physical Anthropology.

The Nubians had a lot of tetracycline in their bones, Nelson says. "It wasn't a trace amount," he says, which indicates long-term exposure to the antibiotic. The finding fits with previous studies looking at osteons, tiny cylindrical structures that are the building blocks of bone, Armelagos says. If an osteon is uniformly saturated with tetracycline, it implies an individual must have been taking the antibiotic during the entire period the osteon formed, about 80 days. Looking at osteons, it appears Nubians were ingesting tetracycline as frequently as modern people who take the drug to clear up acne, he says.

The drug was likely mixed in with beer, Armelagos says. Ancient Egyptian and Nubian beer wasn't like the Miller High Life or Budweiser found in stores today. It was more of a soupy cereal, he says. The Nubians probably made beer in a process similar to baking bread: Bakers would make dough and let it sit outside to accumulate airborne yeast. The dough probably also collected the spores of *Streptomyces*, a type of soil bacteria that

©iStockphoto.com/Kevin Klöpper

The bones of some Egyptian and Nubian mummies contain tetracycline. Scientists think ancient people got the antibiotic from the beer they drank.

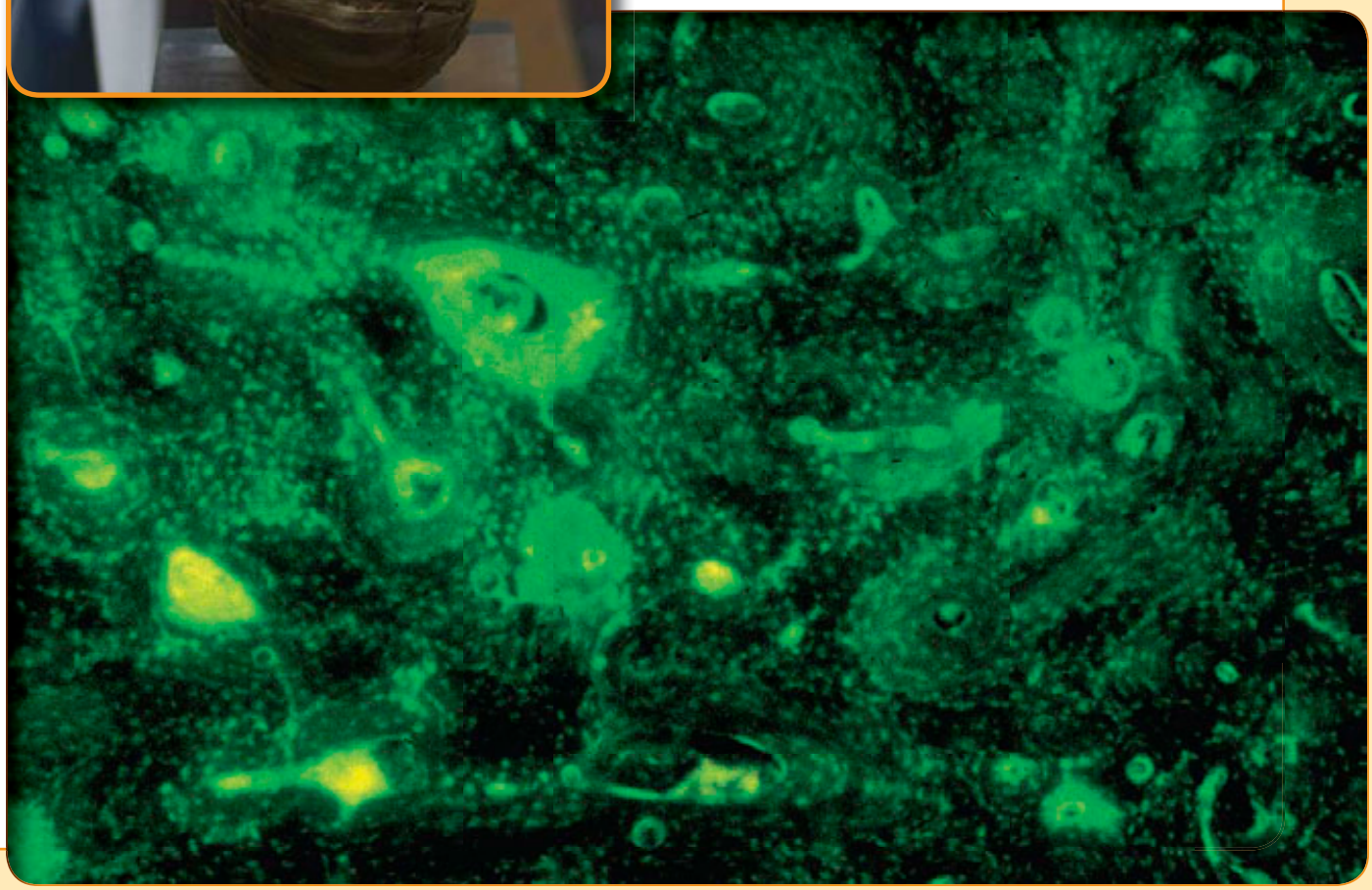
makes tetracycline. Then the dough would be partially baked and removed from the oven after a crust formed. The inside of the bread would still be raw, allowing the yeast — and the bacteria — to grow. Then the bread would be broken up and added to a mixture of malted grain to brew beer. Nubians probably added in leftover beer to new batches to ensure the tetracycline was present, Armelagos says.

"I don't think they understood they had discovered tetracycline," he says, "but they [realized] what they were doing made them feel better." Indeed, it appears the beer did keep the Nubians healthy. In a previous study, Armelagos only found minor infections in 6 percent of the Nubian bones he investigated. Furthermore, he says, it appears the tetracycline prevented bone loss in women, likely because it inhibits an enzyme that breaks down collagen.

Now that the researchers have confirmed the Nubians' long-term use of tetracycline, Armelagos is interested in figuring out the exact dosages they took. Nelson, on the other hand, wonders what other chemicals ancient Nubians may have discovered long before modern scientists. "I have started to think about what other molecules [ancient] people knew about," he says.

Erin Wayman

Many bones from Nubian mummies glow green when examined under an ultraviolet microscope because they contain tetracycline, which emits the green fluorescence.



Bottom: George Armelagos; top: ©iStockphoto.com/Floriano Rescigno

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

ICELANDIC ERUPTION A BOON TO BRITISH ARCHAEOLOGISTS

Last spring, while millions of air travelers were grounded by the eruption of Iceland's Eyjafjallajökull volcano, archaeologists took to the otherwise empty skies above England and photographed thousands of previously unknown archaeological sites from the air.

"Because England is a pretty small country, the four major airports restrict quite a lot of airspace to light aircraft," says David MacLeod, an archaeologist with English Heritage in York, who conducted the aerial survey last April. When the airspace was closed to commercial aircraft due to concerns about high-altitude ash, small, low-flying planes were still able to get into the air — something they normally have difficulty doing due to the busy airspace over England. "With commercial traffic grounded, we had a pretty rare opportunity to survey new areas, with fantastic results," MacLeod says.

Dry growing conditions in England reveal a wealth of information about this previously unknown 2,000-year-old Roman fort, photographed from the air in North Yorkshire in April. Ditches and pits are bright green while a road through the center of the fort is pale yellow.

Dave MacLeod/English Heritage

MacLeod estimates that "a large portion" of the newly photographed sites will prove to be undocumented, though he says checking records with local archaeologists has been time consuming. The sites have been overlooked until now because the kinds of features the researchers found — ditches, fence- and building-post holes and buried walls — have been buried by centuries of cultivation. Only by taking to the air and looking for crop marks — geometric patterns in wheat, barley and other cereal crops growing above buried ruins — can the sites be found.

These buried features create unique patterns in overlying crops due to the varied growing conditions for the plants. From the air, water and nutrient-trapping features like ditches and holes look brighter green, whereas plants growing over buried walls and foundations generally get less soil and moisture, and are stunted and yellower, says Kenneth Brophy, an archaeologist at the University of Glasgow in Scotland who was not involved in the English Heritage study.

Buried sites can also show up in fields as rectangles, circles and long, straight lines that represent structures, foundations, walls and ancient roads. "During a dry growing season, these crop marks will be even more stark," MacLeod says. "In an ideal year, like this one, the underlying archaeology is practically drawn on the surface by the plants, often quite clearly."

Aerial archaeology has been used over large swaths of Europe and parts of Asia, but it's limited to drier regions that grow large expanses of crops. "Great Britain is the classic site for crop mark aerial archaeology," Brophy says. "There you see a fantastic range of sites dating from World War II all the way back 6,000 years ago, when people first started farming and building more permanent structures."

One particularly exciting discovery made this year was a 2,000-year-old Roman fort, photographed for the first time near Tadcaster in North Yorkshire. Seen from the air as a large rectangle, the fort covered 7 hectares and boasted a 3-meter-thick wall and a 15-meter-wide moat. Another new site, a cluster of 60 small rectangles near East Yorkshire, is thought to be the buried remains of 2,500-year-old Iron Age farmhouse ruins.

Categorizing such archaeological sites from a two-dimensional aerial viewpoint has its limitations, but after 30 years of study, aerial archaeologists can glean "quite a lot of information from crop marks" Brophy says, without having to dig up each site to confirm what's buried.

English Heritage has no immediate plans to excavate any of the new sites, MacLeod says. With so many new sites and very little funding, MacLeod and colleagues will settle for making a catalog of the sites so that they can be protected from development, he says. "This way, if a new pipeline or housing development is proposed, we can put our finger on the map and say, 'Hang on, there might be something interesting here,' and then go digging."

Mary Caperton Morton

FIELD STUDIES INDICATE GREATER EARTHQUAKE RISK IN SOUTHERN CALIFORNIA

Seismologists have considered the Carrizo Plain section of the San Andreas Fault to be in a lull between major ruptures — but instead, it may be overdue. A new estimate of the likelihood of an earthquake in this region is likely to have serious impacts on earthquake forecasting in California, researchers say, and may force seismologists around the world to re-examine their predictions for other faults.

Current predictions of the probability of a rupture on the Carrizo Plain section of the San Andreas Fault, which runs from about Bakersfield through Santa Barbara, are based on models that suggest a large rupture occurs on average once every 235 years, with the last major earthquake happening in 1857. That would mean a major quake is not due for almost a hundred years.

Researchers led by Sinan Akciz, a seismologist at the University of California at Irvine, reconstructed the history of ruptures in the area by looking at excavations of deposits in dry streambeds, which showed how strata had been exposed during earthquakes and overlain in intervening years. Over the last 600 years, major ruptures in this region have occurred about every 88 years (give or take 40 years), rather than every 235 years, the team reported in Geology.

Past studies overlooked a number of smaller quakes within the "quiet" 235-year period, sometimes assigning a large shift to a single quake when it was in fact the result of two or three smaller ruptures, according to co-author Lisa Grant Ludwig, a public health professor in the School of Social Ecology at Irvine.

This is not the first study to re-evaluate this section of the fault this year, Grant Ludwig notes. Two previous studies in Science came to similar conclusions about the type of faulting that has occurred along the Carrizo Plain. Compared to previous studies, she notes, those papers found much less consistency in the way the fault slipped and how far it slipped during different earthquakes.

Taken together, however, the three studies indicate that there's greater complexity in the Carrizo Plain's earthquake ruptures than previously thought, Grant Ludwig says. "That makes it a little tricky to figure out what the next one would look like." One thing is for sure, she says: These papers are "going to lead to a re-evaluation of our models of faulting and a recalculation of probabilities in areas where the characteristic earthquake model was applied." Because so much research has been done on the San Andreas Fault, she says, many forecasters have applied the same models to faults worldwide.

Forecasts in California are almost certain to change too, according to Thomas Jordan, director of the Southern California Earthquake Center and a professor at the University of Southern California in Los Angeles. A revision of the Uniform California Earthquake Rupture Forecast is scheduled to be delivered in the summer of 2012. "This is the type of information that we can use to improve those types of models," he says.

Sam Lemonick

The Carrizo Plain section of the San Andreas Fault may be overdue for a large earthquake.

©lkluft, Creative Commons Attribution-ShareAlike 3.0 Unported

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

EL NIÑO'S OCEAN ORIGINS ON THE MOVE

The climate pattern known as the El Niño-Southern Oscillation, which occurs roughly every two to seven years, can have dramatic impacts on global weather patterns. After decades of measurements and observation, scientists are better able to anticipate these changes, allowing them not only to recognize the early signs of an El Niño year but to be able to incorporate those changes in models of future climate change. But El Niño itself may be undergoing changes, according to a new study.

El Niño, the oceanic part of the coupled atmosphere-ocean climate phenomenon known as the El Niño-Southern Oscillation, begins in the tropical Pacific Ocean. Abnormally warm sea-surface temperatures that are most intense in the eastern equatorial Pacific have been a well-known harbinger of El Niño, the result of lagging trade winds that normally drive upwelling of cold water in this region.

But in the past three decades, there has been a shift in the El Niño pattern: The warm sea-surface temperatures have been occurring farther west, in the central equatorial Pacific Ocean, says Tong Lee, an oceanographer at NASA's Jet Propulsion Laboratory at Caltech in Pasadena, Calif. These central Pacific El Niño events have occurred with increasing frequency and intensity, with the most intense event occurring in 2009-2010, he says.

Whether this shift is related to the anthropogenic warming over the past century is unclear, Lee says. So he and Michael McPhaden, an oceanographer at NOAA's Pacific Marine Environmental Laboratory in Seattle, Wash., used satellite and direct observations of sea-surface temperatures in the central equatorial Pacific Ocean over the past 30 years to distinguish between changes in El Niño intensity in the region and changes in overall background sea-surface temperatures.

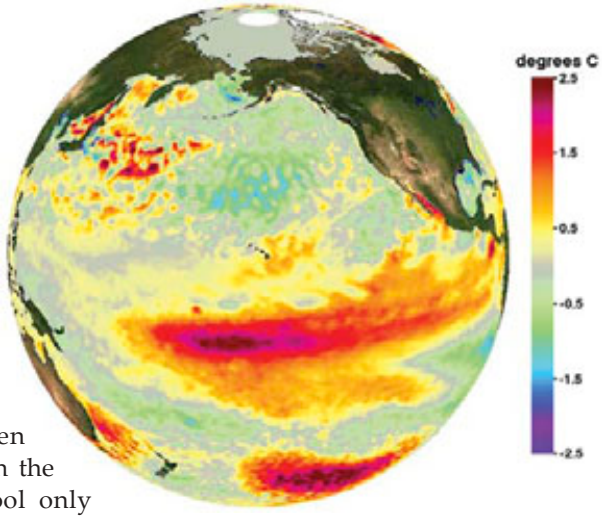
The central equatorial Pacific Ocean includes much of the western Pacific Warm Pool, a large section of ocean off the northeastern coast of Australia where sea-surface temperatures never dip below 28 degrees Celsius. The western Pacific Warm Pool has been of particular interest to researchers, who have found an increase in sea-surface temperatures there that some have attributed to global climate change.

But Lee and McPhaden found that temperatures in the western Pacific Warm Pool only seemed to increase during El Niño years, not during La Niña or neutral years, they reported in Geophysical Research Letters. Thus, Lee says, "this well-observed warming trend in the central Pacific has more to do with a more intense El Niño [there] than with the rise of background temperatures."

What is causing the shift in the El Niño from the eastern to the central Pacific is less clear, however. Global warming may be one reason; natural decadal to multidecadal variability is another possibility, Lee says. A study published in Nature last year by oceanographer Sang-Wook Yeh of the Korea Ocean Research and Development Institute in Ansan and colleagues found that increasing greenhouse gases in Earth's atmosphere tended to push El Niño's warming center westward, by altering the east-west tilt of the thermocline, the interface between warm surface water and cold deepwater, in the equatorial Pacific.

But although those models support the idea that greenhouse gas forcing can alter the frequency of central Pacific El Niño events, it is less clear whether this forcing would have a similar impact on the intensity of those events, Lee adds. "Climate models are not perfect and observations are still short. We have 30 years of high-quality observations, and that is not long enough to say for certain whether this is related to natural fluctuation or global warming."

An increase in more frequent and more intense central Pacific El Niño events would have big implications for climate, Lee says. "El Niño is the largest year-to-year fluctuation in Earth's climate system," he says. As such, "it has a powerful impact on weather patterns around the world, on flood and drought conditions on land, on fisheries in the ocean."



Sea-surface temperature anomaly during the peak of the 2009-2010 El Niño, the strongest central Pacific El Niño observed to date.

Image produced by Physical Oceanography Distributed Active Archive Centre (PO.DAAC) of NASA JPL

For example, recent publications have noted differences in tropical cyclones associated with El Niños that originate in the central rather than the eastern equatorial Pacific. Although the classic eastern equatorial Pacific El Niño tends to suppress Atlantic hurricanes, the central Pacific El Niño may produce more frequent Atlantic hurricanes, according to a study that appeared in Science last year by Georgia Tech atmospheric scientist Peter Webster and colleagues. In another paper published in Geophysical Research Letters, climate scientist Jin-Yi Yu of the University of California at Irvine and colleagues found that the central Pacific El Niño is also associated with more tropical cyclones in the northwest Pacific.

Lee and McPhaden's paper is an interesting and important hypothesis on the nature of the observed warming in the equatorial Pacific — but it is not entirely convincing, says Sophie Cravatte, an oceanographer at IRD/LEGOS in Toulouse, France. With only 30 years of data, she says, scientists are not able to unambiguously distinguish a long-term trend in El Niño-related or global-warming-related sea-surface temperatures, or to distinguish either from natural fluctuation. However, she notes, "one of the merits of this paper is to raise this possibility, even if we still miss data to firmly confirm this hypothesis."

Carolyn Gramling

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

BLACK HOLE VOLCANO ALTERS GALACTIC EVOLUTION

At the center of the Virgo Cluster, a galactic supervolcano is erupting. But instead of lava, the black hole-driven "volcano" is spewing highly energetic streams of particles, greatly disrupting the evolution of its home galaxy, M87.

In a galaxy like M87, stars form as the interstellar gas that accumulates in the galaxy begins to cool. The cooling gas cloud collapses under the pull of gravity from the center of the galaxy, and as the gas becomes denser, stars are born. But in M87, which is located only 50 million light-years from Earth, continuous shockwaves of energy from the black-hole volcano blasts the gas away from the center of the galaxy, beyond the reach of the galaxy's gravity, preventing the gas from condensing and developing into stars.

Scientists observed this black-hole volcano with NASA's Chandra X-ray Observatory and the National Radio Astronomy Observatory's Very Large Array in New Mexico. The observatories recorded shock waves traveling at supersonic speeds through the clouds of cool gas that were pushed out from the center of the galaxy by a single large blast some 150 million years ago. The study shows how much impact a single black hole can have on a galactic environment. The shock waves produced by the volcano have prevented some hundreds of millions of stars from forming, according to Evan Million, a graduate student at Stanford University in California and lead author of one of a pair of papers on the phenomenon that appeared in Monthly Notices of the Royal Astronomical Society.

Meg Marquardt

At the center of M87 a "volcano" is erupting. The galaxy's gas cloud (blue) is disrupted by waves of energetic particles (red) spewing from the black hole at the center of the galaxy.

NOAA: CORAL REEF BLEACHING LIKELY IN CARIBBEAN

In 2005, coral reefs in the Caribbean suffered severe bleaching damage. More than 80 percent of the corals were bleached and more than 40 percent died in many places across the Caribbean. Now NOAA says 2010 may be nearly as damaging for Caribbean corals. But full details of the damage won't be known until the end of the year.

Bleaching occurs when warmer than usual ocean temperatures cause the corals to expel the symbiotic algae, or zooxanthellae, that normally take shelter within the corals; prolonged loss of the zooxanthellae, which photosynthesize sunlight into sugars that feed the corals, can cause the corals to die. In September, NOAA reported that temperatures have been above-average all year in the Caribbean, and bleaching events have already been recorded at several Caribbean sites this year.

Carolyn Gramling

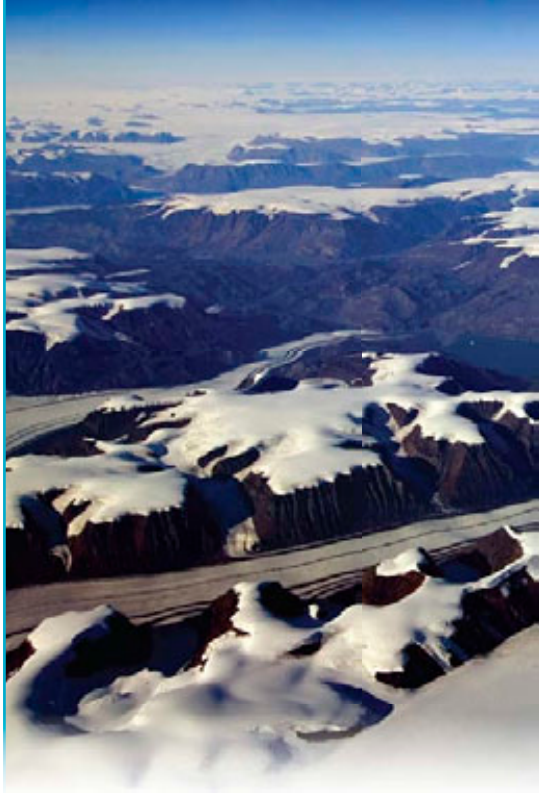
Bleached elkhorn coral.

Bottom: NOAA; top: X-ray: NASA/CXC/KIPAC/N. Werner et al., Radio: NSF/NRAO/AUI/W. Cotton

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

GREENLAND NOT LOSING AS MUCH ICE AS THOUGHT



For islands and coastal regions worldwide, one of the most pressing concerns regarding climate change is how much sea levels will rise in the future as the polar ice sheets melt. In the past several years, scientists have used satellites to estimate ice-loss rates — but a new study suggests researchers have been overestimating how much ice the planet is really losing.

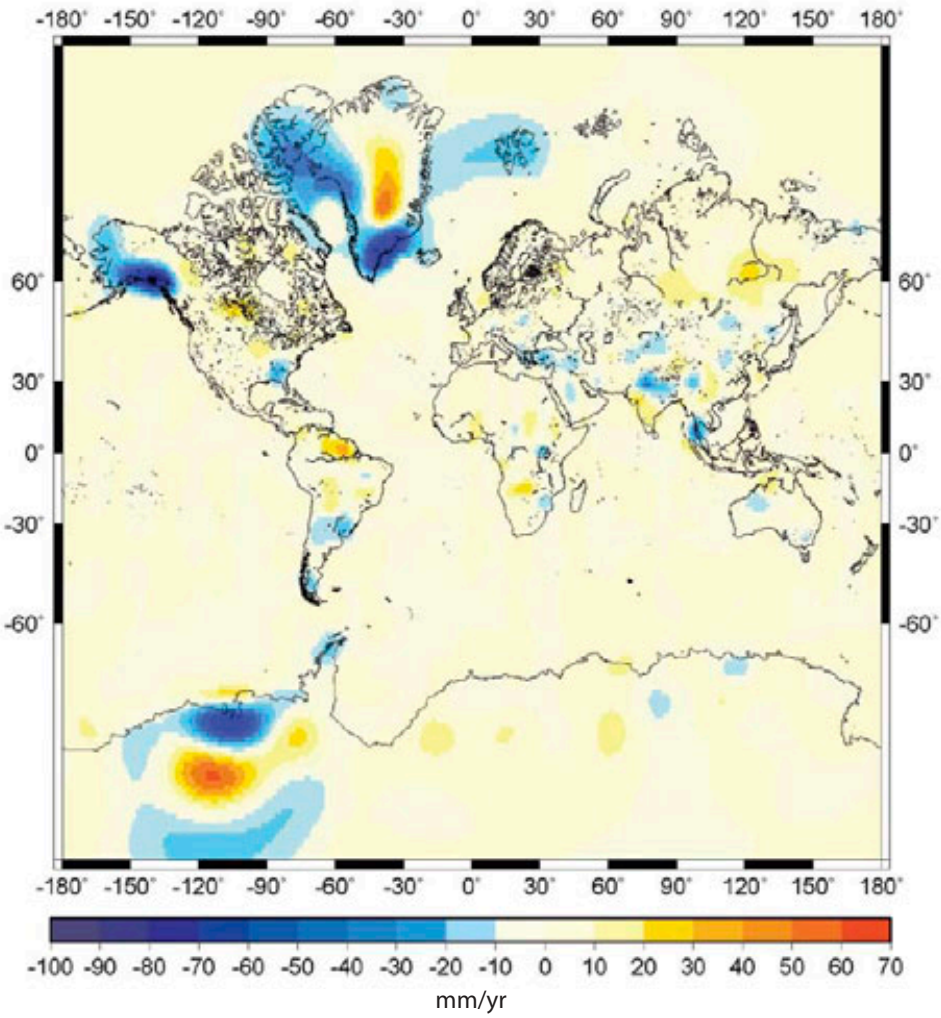
Scientists led by geophysicist Xiaoping Wu of NASA's Jet Propulsion Laboratory at Caltech in Pasadena, Calif., estimated global ice losses between April 2002 and December 2008. They determined Greenland lost about 104 gigatonnes of ice per year, the Alaska/Yukon region lost about 101 gigatonnes per year and West Antarctica lost about 64 gigatonnes per year. Two studies of Greenland and Antarctica published last year, however, found ice-loss rates that were twice as large, Wu and colleagues noted in Nature Geoscience.

The difference in numbers is due to how the melting ice was measured. Wu's team, like other researchers, started with data collected by NASA's Gravity Recovery and Climate Experiment (GRACE) satellites, which detect changes in Earth's gravity field. Because changes in Earth's mass affect the planet's gravity, GRACE data can be used to measure ice loss. For example, Greenland loses mass when its ice sheet melts and flows into the ocean.

But gravity is also affected by glacial isostatic adjustment, more commonly known as post-glacial rebound — a phenomenon that is similar to what happens to a mattress every morning when a person gets out of bed, Wu says. After the Laurentide Ice Sheet retreated at the end of the last glacial maximum 21,000 years ago, land began to rebound from the removal of the weight. The rebound is still ongoing, and the GRACE satellites can't tell the difference between mass changes caused by rebound and changes due to melting ice. "It's a fantastic, revolutionary tool to monitor Earth, but … [GRACE] is sensitive to any mass movement in or on top of Earth," he says.

Previous studies have dealt with this issue by modeling post-glacial rebound and then removing the effect from the GRACE data. But this method is problematic because there are "huge uncertainties"

This map shows areas with mass loss (cool colors) and mass gain (warm colors) from 2002 to 2008. Greenland, Alaska and Antarctica all lost ice during this time, but at a slower rate than previously thought.



Global Present-Day Surface Mass Trend (2002-2008) in Thickness of Water Equivalent

Bottom: NASA/JPL/Caltech; top: ©iStockphoto.com/Klaas Lingbeek-van Kranen

Antarctica and Greenland (pictured here) have both lost ice over the past several years.

surrounding these models, Wu says. Instead of using the rebound models, Wu and his team combined a range of datasets — GRACE data, GPS data and a model of ocean bottom pressure — to simultaneously estimate how much a region's change in mass was due to melting ice sheets versus post-glacial rebound. The team's lower ice-loss rates suggest that rebound is different than scientists had realized.

This won't be the last word on how much ice is melting, however. Although the new method is an improvement over other methods, it comes with its own uncertainties, wrote David Bromwich and Julien Nicolas, both of the Byrd Polar Research Center at Ohio State University in Columbus, in a commentary in Nature Geoscience. Part of the uncertainty comes from the small number of GPS stations that the team relied on. Since the data were collected, however, many more GPS stations have been installed across Greenland and Antarctica, so this won't be as much of a problem for future studies, Bromwich and Nicolas noted. Another consideration, Wu adds, is that his method is missing some important information recorded in historical relative sea-level records, which are used to make the typical post-glacial rebound models.

Despite these concerns, combining different datasets to answer the question of ice loss is "a very promising method," says Isabella Velicogna, a geophysicist at the University of California at Irvine who was not involved in the research. As the method is improved, scientists will continue to revise estimates of ice loss and projections of future sea-level rise.

Erin Wayman

CHINA'S DOMINANCE OVER RARE EARTHS MARKET COULD BECOME A CRISIS FOR U.S.

Rare earth elements, including neodymium, ytterbium and 16 other elements, are an essential component of many modern technological devices, from superconductors to magnets to hybrid cars to military weapons. But China's near-monopoly on the global supply of these elements has U.S. manufacturers — and the U.S. government — worried.

In response to a potential looming crisis, the U.S. government began to take action earlier this year: In March, the U.S. House Science and Technology Committee held a hearing on the rare earth supply shortage, during which experts suggested that the U.S. consider reopening a rare earths mine in California, closed since 2002. Shortly afterward, the Rare Earths Supply Technology and Resources Transformation Act of 2010 was introduced to the House of Representatives; in June, a similar bill was introduced to the Senate. Meanwhile, the U.S. Government Accountability Office prepared a report on rare earth materials in defense technologies, which was presented to the Armed Services Committees of the Senate and House of Representatives, suggesting that a shortage could threaten national security.

But in July, the situation became more urgent when China reduced its quota for rare-earth exports by 72 percent for the rest of the year, a move that resulted in a dramatic increase in the prices of these materials. Congress responded again: In September, a new bill called the Rare Earths and Critical Materials Revitalization Act of 2010 passed the House of Representatives and moved on to the Senate. The bill would establish a research, development and commercial application program within the Department of Energy to locate rare earths resources for U.S. needs.

Carolyn Gramling

The rare earth element lanthanum is a key ingredient in hybrid cars, such as Toyota's Prius.

Wikimedia Commons/S 400 HYBRID

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

BEFORE AND AFTER: A GLIMPSE INTO A POWERFUL QUAKE

Quakes as large as the magnitude-8.8 event that struck last February off the central Chilean coast are relatively rare. Having a comprehensive GPS network in place to measure ground deformation before and after such an event is even rarer. Now scientists are getting a first look at the before-and-after effects of a great quake — and the findings are confirming a long-held assumption that has never been tested in the field.

"Earthquake researchers have dreamed of doing a before-and-after comparison [of ground deformation] since the advent of GPS," says Matthias Rosenau, a geologist at the GFZ German Research Center for Geosciences in Potsdam and an author of the new study, published in Nature. "This earthquake was the first really great event that struck at a time and place where the instruments were already in place to make a detailed comparison."

By overlapping GPS data points taken before and after the Feb. 27 event, Rosenau and colleagues demonstrated that the sections of the fault that slipped during the earthquake were the same sections that were fully locked before the event.

The fracture pattern of the Chile quake, which lasted about 90 seconds, was "quite complex," Rosenau says. But the before-and-after comparisons of the quake demonstrate that the degree of rupture, and therefore the massive size of the event, should have been somewhat predictable. GPS measurements taken before the earthquake show the Nazca Plate sliding unevenly beneath the South American Plate. Some areas were sliding smoothly and others were locked. When the locked portions ruptured one after another, they produced the massive event.

This idea that locked sections are the sections that slip during earthquakes has long been a "fundamental assumption" of fault behavior, the authors noted. But before-and-after comparisons detailing exactly which areas are locked and which slip have been few and far between, says Thorne Lay, a seismologist at the University of California at Santa Cruz who was not involved in the new study. Thus, until this point, this theory was based "purely on logic," not on empirical data.

"If a fault has been stuck in a spot for 100 years since the last earthquake, you expect those areas will be the ones to release because they've accumulated the most stress," Lay says. Thus, "there are no real surprises in this study," he says, "It just reaffirms the validity of a previously untested, basic concept."

Whether this relationship between lock and slip will be observed on all faults remains to be seen, but Rosenau says it's "very likely." Scientists have observed some evidence to support the lock-slip theory in Sumatra, but the region still lacks the GPS coverage needed for confirmation. Networks are currently in place in Japan, northern Chile and Cascadia, all awaiting a large earthquake to supply the "after" portion of the data.

The magnitude-8.8 earthquake that struck off the coast of Chile last February was the seventh-largest earthquake ever recorded.

More GPS networks, also known as space-geodetic networks, would do more than just satisfy curiosity, Rosenau says. They could also help create better deformation maps, which are useful for pinpointing seismic hazards. Deformation mapping cannot predict when large earthquakes will strike, but it can help pinpoint where, he says. By studying where faults are locked, scientists can get a better idea of where they're most likely to rupture.

There ought to be GPS networks around all the subduction zones in the world, Lay says. "That would help draw attention to which regions are building up to large earthquakes."

The technique does have some limitations: Currently, GPS networks can only detect movement of a few millimeters a year or greater, restricting this kind of monitoring to plate boundaries that are moving relatively quickly. Furthermore, not all faults are ideal for GPS mapping. Subduction zones such as those off the coasts of Chile and Sumatra — places where one plate is diving beneath another — are most conducive to GPS monitoring, because the angle of the fault makes it easier to see the deformation on the surface. Strike-slip faults like the San Andreas Fault in California are harder to monitor using this method because the 90-degree angle makes it difficult to resolve exactly which areas on the vertical plane are locked.

Almost a year later, scientists are still learning from the Chile event, which is tied with three other magnitude-8.8 events for the seventh-strongest earthquake ever recorded. It was also possibly the best-recorded great earthquake, Lay says. "It's great to have so much instrumentation," he adds. "This study is a great example of what we can do with the right information."

Mary Caperton Morton

©Jorge Barrios, Creative Commons Attribution-ShareAlike 3.0 Unported

DRY ROOTS KEEP CRATONS AFLOAT

Earth's crust is in constant motion. Over geologic time, mid-ocean ridges give birth to new tectonic plates and subduction zones gobble them up. But there are a few ancient slabs of rock — called cratons — that have resisted these destructive forces. What makes them so resilient has been a mystery. But a new study provides a possible explanation: Parts of cratonic roots are almost devoid of water, making them exceptionally strong.

Cratons are pieces of crust and underlying mantle that have been around for up to 3.5 billion years. They are hundreds of kilometers wide, and with thicknesses of 200 kilometers or more, they are about twice as thick as the rest of the continental plates. Whereas most of Earth's crust floats on top of the asthenosphere — a portion of the upper part of the mantle — cratons have long roots that poke into the asthenosphere, "like an iceberg in an ocean," says Anne Peslier, a geochemist at Jacobs Technology at NASA Johnson Space Center in Houston, Texas, and lead author of the new study in Nature.

The hot asthenosphere is supposed to obliterate any rocks in its reach, "so a major question in geology and geophysics has long been 'How have [cratons] managed to be preserved over long periods of time with active mantle scraping away at them?'" says David James, a geophysicist at the Carnegie Institution in Washington, D.C., who was not involved in the new work.

Cratonic roots are colder and less dense than the mantle surrounding them, but models show that these characteristics alone are not enough to make them resistant to violent destruction in the mantle. Several researchers had suggested that their roots may also be drier than the rest of the asthenosphere, but no one had analyzed actual samples to see if that was true, Peslier says.

So she and her colleagues turned to ancient rocks that once were part of the root of the Kaapvaal craton, a 1.2-million-square-kilometer swath of ancient rock covering parts of southern Africa. The pieces of cratonic root the team analyzed were catapulted up to the surface by explosive magma shooting up from deep inside the planet and tearing off pieces of cratonic root along the way. These magmas, called kimberlites, are also rich in diamonds, which is why Peslier's team found their samples mainly in the tailings of the Kimberley diamond mine in South Africa.

"These kimberlites are great because they come to the surface at incredible speed," James says. "A rock picked up at 200 kilometers deep is probably brought to the surface in a couple of hours. In fact, people think that these kimberlites may blow out of the surface at supersonic speeds." Because they are getting carried up so fast, the picked-up rocks don't have time to react or change phases, "so you are basically getting the rock just as it was at that depth," James says.

Peslier and her team found that the water content of the rock's main mineral, olivine, decreased with depth (and thus with age), and the very bottom of the root — determined by the temperature and pressure at which they formed — was almost devoid of water. That may explain the craton's resilience. Dry olivine is much more resistant and harder to break up than its wet counterpart, Peslier says, because water molecules create defects in the mineral's structure, making it more prone to deformation and breakage. Why the bottom of the craton root dried up is not clear, she adds, and neither is whether other cratonic roots around the world have the same characteristics.

"I think this is an interesting explanation," James says, but he cautions that it's only a first step. "I really think this paper is one that will stand scrutiny, but it will now need more exploration to see whether or not it really works out," he says. "We need follow-up studies, including some modeling studies, to see if just a boundary layer [at the root] is sufficient to keep everything intact over billions of years."

Nicole Branan

Giant kimberlite hole in the ancient Kaapvaal craton in South Africa. Researchers studied rocks from the craton that were brought to the surface very quickly by kimberlites to determine how the craton survived for more than 3 billion years.

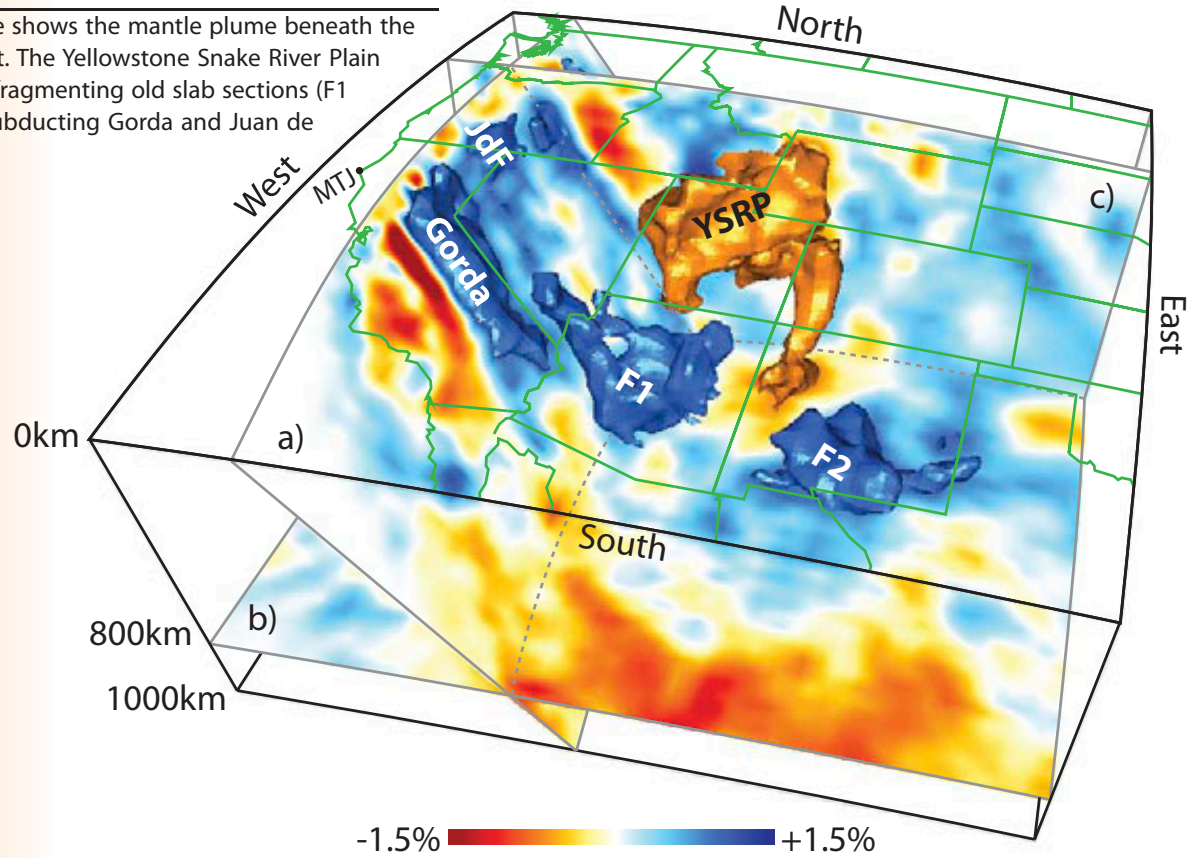
©iStockphoto.com/Daleen Loest

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

SEEING BENEATH THE PACIFIC NORTHWEST

Scientists have the ability to image the insides of the planet — at least down to 1,200 kilometers below the surface. And for the first time, researchers have gotten a glimpse of the mantle plume beneath Yellowstone National Park, which descends 1,000 kilometers into the lower mantle — and how that plume interacts with the rest of the complex tectonics beneath the U.S. Pacific Northwest. That enhanced imaging not only elucidates what happens when a cold tectonic plate clashes with a hot plume, researchers say, but it also puts to rest a 40-year-old debate over whether such deep-seated mantle plumes exist. The new images also shed light on why Oregon has fewer earthquakes than might be expected, given its tectonics.

But until the arrival of seismic tomography, an imaging technique that creates 3-D images of Earth's interior from recorded seismic activity, there wasn't direct evidence of the interior structure of the planet. And until even more recently, there hasn't been much direct evidence of such deep plumes, says Bob Smith, an emeritus professor of geology at the University of Utah in Salt Lake City who is unaffiliated with the study. "We only started doing tomography 20 years ago," he says, "and back then we could only see 5 to 20 kilometers under the Earth's surface." So scientists who argued that plumes did not exist were basing that largely on a lack of data, he says. But now, he adds, "we have wider capabilities, more resolution and deeper images." Past tomographic images had revealed a shallow mantle plume beneath Yellowstone, but the new images show direct evidence of a large mantle plume that extends down into the lower mantle.



A new 3-D image shows the mantle plume beneath the Pacific Northwest. The Yellowstone Snake River Plain (YSRP) plume is fragmenting old slab sections (F1 and F2) of the subducting Gorda and Juan de Fuca (JdF) plates.

Courtesy of Richard Allen/AGU

Researchers first proposed the idea of deep mantle plumes in the 1970s. Hot plumes of viscous mantle rising toward the crust are thought to be one way in which heat escapes from the interior of Earth, says Richard Allen, associate director of the seismological laboratory at the University of California at Berkeley, and a co-author of the new study in Geophysical Research Letters. Such plumes are thought to be the source of both the volcanic activity that formed the Hawaiian island chain and of Yellowstone's volcanic activity.

To "see" so far beneath Earth's surface, Allen and his team used data from the Earthscope-USArray project, which consists of a portable array of 400 seismometers that were first placed in the western U.S., but are gradually being shifted farther east, so that scientists will eventually be able to see into Earth's interior beneath the entire United States. These seismometers "make high-resolution, yet large-scale,

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

3-D models of Earth's interior possible," Allen says. They do this by creating images based on how seismic waves move through the subsurface. The waves move faster through denser material. Because colder material tends to be denser, researchers can infer the material's temperature.

The team's seismic data showed a "vertical conduit of low-velocity, high-temperature material upwelling beneath Yellowstone" — the mantle plume — but the data also showed high-velocity, cold material subducting off the West Coast of the U.S., which is probably the Juan de Fuca Plate. But that's where things get a little strange, Allen says.

The Juan de Fuca Plate has been subducting beneath the North American Plate off the coasts of Northern California, Oregon and Washington for about 150 million years, Allen says. Given such long-term stability, researchers expected the Juan de Fuca Plate to be quite homogenous. But the new images show that the plate is heterogeneous due to its interaction with Yellowstone's hot mantle plume. What's more, he adds, "our imaging results show that the plume has burnt a hole into the subducting slab and continues to interact with it."

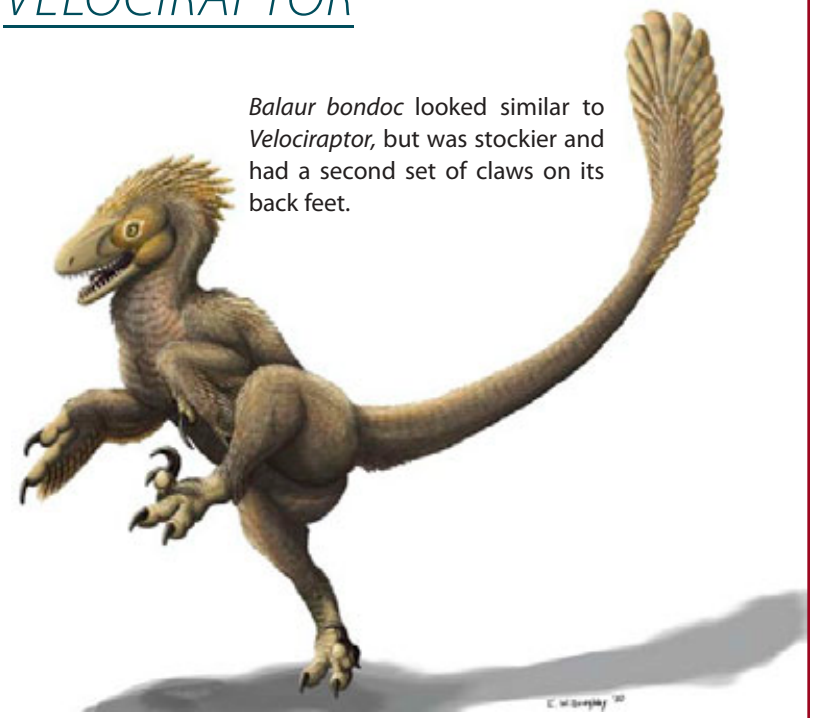
This unique glimpse into the subsurface may have solved another mystery: Oregon's lack of earthquakes. "We see very little evidence of the Juan de Fuca slab below Oregon, whereas it extends deeper beneath Northern California," Allen says, "and so we think Oregon is the region where a big chunk of the slab has been removed." Because the subducting plate is smaller in this region, the subduction itself is less influenced by the weight of the sinking slab, called "slab pull." This results in reduced stress on the shallower slab, which translates to fewer earthquakes on the surface, he adds.

As USArray's seismometers continue to provide data across North America, the researchers will add these data to their models of the subsurface, Allen says, creating a more expansive 3-D map of the mantle beneath the whole continent. Eventually, Smith adds, with technology such as this, "we'll be looking at the story of mantle geology below the whole western U.S., the whole North America, and — eventually — the whole globe."

Patrick Morgan

©Emily Willoughby, Creative Commons Attribution-ShareAlike 3.0

DRAGON DINOSAUR A STRANGE COUSIN OF *VELOCIRAPTOR*



Balaur bondoc looked similar to *Velociraptor*, but was stockier and had a second set of claws on its back feet.

Move over *Velociraptor*, there's a new terrifying dinosaur on the block. New fossils of *Balaur bondoc* (*Balaur* is the Romanian word for dragon, and *bondoc* means stocky) found in Romania reveal just how ferocious the dinosaur could be. The find also confirms that island-dwelling dinos were quite different from their mainland neighbors.

When *Balaur bondoc* roamed the Late Cretaceous period, a large portion of Europe was underwater, creating a series of islands. Scientists expect carnivorous dinosaurs on the islands to be smaller than their mainland counterparts because of different evolutionary demands of an island, including limited prey. Though *Balaur* has a stockier build than the mainland *Velociraptor*, it is approximately the same size — about 2 meters long from nose to the tip of its long tail. But incomplete skeletal evidence of *Balaur* has made the dinosaur something of a mystery for more than a decade.

After a fairly complete fossil was unearthed in Romania, a picture of the strange dinosaur has now come into focus. As previous fossil evidence had suggested, the new skeleton shows *Balaur bondoc* was stockier than *Velociraptor*, suggesting it was built for strength rather than speed. And instead of just one terrifying claw, the rear feet sport two massive claws. It also appears that the dino's arm bones were fused together to the point of being useless, implying that the dinosaur hunted and disemboweled its prey almost exclusively with its feet.

"*Balaur* is the size of an oversized turkey and unlike what we know of the large predators from other parts of the world at the same time period, like *Tyrannosaurus* or *Carnotaurus*," said Zoltán Csiki, a paleontologist at the University of Bucharest in Hungary and co-author of the new study in Proceedings of the National Academy of Sciences, in a press release.

Meg Marquardt

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

ARCTIC OCEAN NOT THE HOPED-FOR CARBON SINK

Researchers have long thought that there might be at least one benefit to the Arctic Ocean basin having less sea ice in summer: The ice-free and warmer conditions would lead to more biological activity and would remove a barrier for air-to-sea gas exchange, causing the ocean to soak up much of Earth's excess atmospheric carbon dioxide. But new research shows that the Arctic Ocean basin can easily reach its carbon dioxide limit — and thus will not be the great carbon sink that researchers had hoped.

In 2008, Wei-Jun Cai, a marine scientist at the University of Georgia in Athens, and his team traveled to the Canada Basin in the western Arctic Ocean, a place where summer sea ice has been retreating quickly in recent years. They measured how much dissolved carbon dioxide was in both surface waters and deeper waters in the basin to assess how much carbon dioxide was already in the water — and how much more carbon dioxide the ice-free areas of the Arctic would be able to take up in the future.

The team found that the region's surface water already contained a significant amount of carbon dioxide and was close to equilibration with the atmosphere, they reported in Science. The team thinks this is because the ice melt provides a shallow, 20-meter-deep "layer of very-light-density and low-salinity water, which floats on the surface," Cai says. This thin freshwater lens at the surface absorbs atmospheric carbon dioxide quickly, and the quick absorption then reduces the carbon dioxide concentration gradient from the air to the ocean, which blocks the further uptake of the gas. And that means that even with more ice-free areas in the future, the Arctic Ocean Basin is not going to be a big carbon dioxide sink, Cai says.

"It's like having oil floating on the top of the salad dressing," says Patricia Yager, an oceanographer at the University of Georgia who was not involved in the study. "You can't get the carbon dioxide past that freshwater layer," she says. In that case, the only way to absorb more carbon dioxide is to lower the gas' concentration at the surface by pumping the gas deeper into the ocean.

The most effective way to accomplish this is with the biological pump, Cai says, where phytoplankton take up extra carbon dioxide for photosynthesis; then when they die, that organic matter sinks deeper into the ocean, transporting carbon from the ocean's surface to its depths and sufficiently freeing the surface water of carbon dioxide so that it can absorb even more gas. But the Canada Basin, which lies far away from any nutrient-providing river outlet and the nutrient-rich Bering Strait, is essentially a wet desert and does not support a biological pump, Yager notes. Thus, Cai adds, although this part of the Arctic draws down carbon dioxide, it will not be as large of a sink as researchers had predicted.

Patrick Morgan

Researchers aboard the Chinese research vessel Xue Long measured the amount of carbon dioxide in the Arctic Ocean to see how much more of the gas the ocean could hold as ice melts and more water is exposed.

Yong Wang, State Ocean Administration of China - the Chinese Arctic and Antarctic Administration, Beijing, China

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

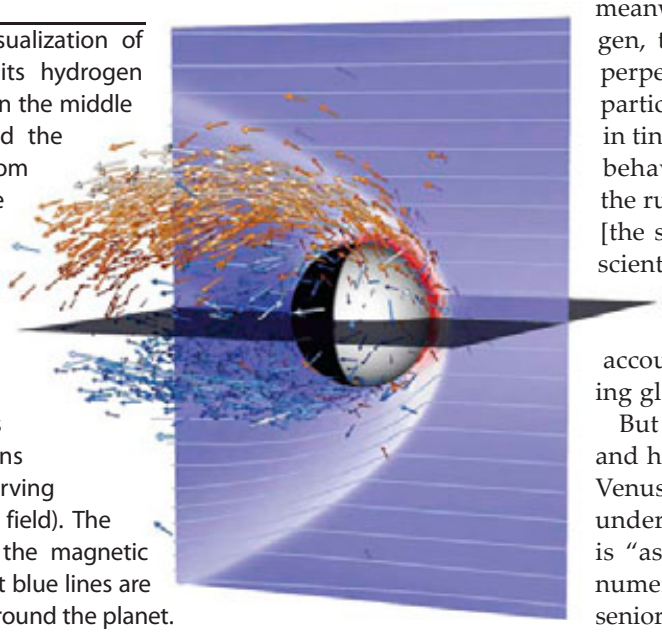
Researchers found that the now-exposed Arctic Ocean water may draw down less carbon dioxide than previously hoped.

Bottom: Zhongyong Gao, State Ocean Administration of China-Third Institute of Oceanography, Xiamen, China; top two: Jianfang Chen, State Ocean Administration of China - Second Institute of Oceanography, Hangzhou, China

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

VENUS EXHALES ITS HYDROGEN AND OXYGEN

Scientists studying how Earth's atmosphere formed spend a lot of time looking at the very different atmospheres of our planetary neighbors. Venus is similar to Earth in size and composition, but its dense atmosphere (primarily carbon dioxide, whereas Earth's is primarily nitrogen) is quite different. Scientists have known that the solar wind siphons hydrogen and oxygen out of Venus' atmosphere — but the escape route these ions take out of Venus' atmosphere and into space has been unclear until now.



Three-dimensional visualization of how Venus exhales its hydrogen and oxygen. Venus is in the middle with the sunlight and the solar wind arriving from the right. The orange arrows show how oxygen ions move when they leave the atmosphere (flowing straight back, perpendicular to the planet); the blue arrows show hydrogen ions (which follow the curving lines of the magnetic field). The vertical plane shows the magnetic field strength and light blue lines are the solar wind's flow around the planet.

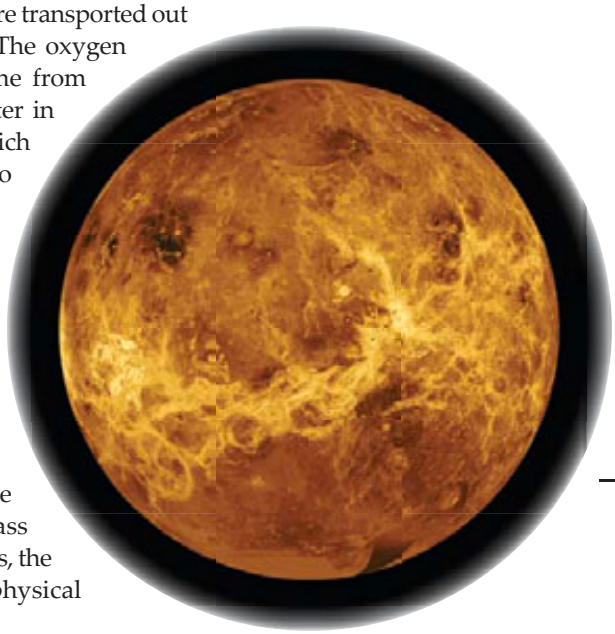
Riku Jarvinen, a graduate student and researcher at the Finnish Meteorological Institute in Helsinki, and his team used computer models to predict how oxygen and hydrogen ions are transported out of Venus' atmosphere. The oxygen and hydrogen ions come from carbon dioxide and water in Venus' atmosphere, which make their way up into the ionosphere — the second-to-last layer of the atmosphere before space, where atoms and molecules are ionized by the sun's energy. From there, they take very different routes away from the planet, primarily because of the difference in mass between the two elements, the team reported in Geophysical Research Letters.

Mass comes into play because of the weakness of Venus' magnetic field, Jarvinen says. On Earth, the strong magnetic field protects most of our planet from the sun's particles, but due to Venus' weak field, its atmosphere is much more exposed to the solar wind.

Jarvinen's team's simulations show that hydrogen is more influenced by the weak magnetic field, escaping the planet along the same path as the plasma generated by the interactions between Venus' atmosphere and the solar wind. Oxygen, meanwhile, which has 16 times the mass of hydrogen, tends to escape the planet along a nearly perpendicular path, Jarvinen says. When massive particles are placed in a magnetic field, they move in tiny, rigid orbits, he says, and this affects their behavior. "[Oxygen] basically wants to break the rules. It doesn't care about magnetic fields in [the same way] as hydrogen ions." This refines scientists' understanding of how ions escape, he says. Given that it's not uniform across the whole planet, researchers need to take into account how those ions are escaping before making global estimates of ion loss, he adds.

But it's still up for debate if knowing that oxygen and hydrogen have different escape routes from Venus' atmosphere will have much effect on our understanding of planetary evolution. The work is "as solid as it gets within the limitations of numerical simulations," says Janet Luhmann, a senior fellow at the Space Science Laboratory at the University of California at Berkeley. But it's more important just to know that oxygen and hydrogen ions do escape, which researchers already knew, she adds.

Sam Lemonick



New research details how hydrogen and oxygen escape from Venus' atmosphere.

Bottom: NASA; top: courtesy of Riku Jarvinen

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

FIRES FUELED SPREAD OF FLOWERING PLANTS

Flowers were a rare sight in the Early Cretaceous 135 million years ago. But by the time the Cretaceous ended 70 million years later, flowers were everywhere. A pair of scientists has a new idea of how flowering plants took over the botanical world: fire.

It wasn't an act of arson, but flowering plants likely benefited from frequent fires during the Cretaceous, say botanist William Bond of the University of Cape Town in South Africa and paleobotanist Andrew Scott of Royal Holloway, University of London in England.

Fires may have helped flowering plants become the dominant plant life by the end of the Cretaceous period.

Climatic conditions and high oxygen levels in the Cretaceous would have made forest fires a common event, they say. Fires that cleared swaths of forests dominated by nonflowering plants like pine and ginkgo trees would have been good news for early flowering plants — small trees and shrubs that preferred open conditions and unobstructed sunlight. Furthermore, because flowering plants grow and reproduce faster than nonflowering plants, flowering plants would have recovered more quickly after the fires subsided.

In turn, Bond and Scott wrote in the journal New Phytologist, the speedy buildup of flowering vegetation would have provided the fuel to allow even more fires to burn — creating a positive feedback cycle that gave flowering plants an edge over their nonflowering plant competitors.

Erin Wayman

WITH A LITTLE HELP FROM KELP

How did the sea spider cross the ocean? On a raft, of course.

Scientists have used the concept of ocean rafting to explain how animals colonized a variety of isolated landmasses, including how monkeys from Africa arrived in South America 35 million years ago. But evidence that creatures can survive long ocean voyages on chunks of floating vegetation has been sparse — until now. Researchers have learned that giant tangles of kelp can carry tiny invertebrate passengers hundreds of kilometers across the ocean.

Ceridwen Fraser, a postdoctoral researcher at the University of Otago in New Zealand, and colleagues studied six samples of bull kelp that they found on St Clair Beach in mainland New Zealand in February 2009 and May 2010. The kelp was home to more than 10 species of invertebrates, including crustaceans, a sea spider, mollusks and a sea star. The researchers knew that the kelp must have been at sea for a long time because the tangles were covered in goose barnacles, which attach to floating ocean debris. By measuring the size of the barnacles and knowing their growth rate, the team estimated the age of the barnacles and thus determined the minimum amount of time the kelp had been floating in the ocean: 20 to 65 days, they reported in Proceedings of the Royal Society B.

Kelp can carry tiny crustaceans, mollusks and other invertebrates hundreds of kilometers across the ocean.

The researchers pinpointed the origins of the kelp through genetic analyses. The kelp's DNA most closely matched the DNA of kelp from the Snares Islands and the Auckland Islands — subantarctic islands that are, respectively, 390 kilometers and 600 kilometers south of New Zealand. DNA from one of the crustaceans clinging to the kelp confirmed these findings.

But surviving the journey at sea doesn't guarantee a successful colonization; luck also plays a role. The researchers noted that the animals they found would probably not have survived in the long term because they ended up on a sandy beach, not the rocky shores they are used to.

Erin Wayman

Bottom: ©Erasmo Macaya, Creative Commons Attribution-ShareAlike 3.0 Unported; top: ©iStockphoto.com/Pgiam

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

HUMANS, NOT CLIMATE, INITIATED THE DECLINE OF THE CAVE BEAR

Ursus spelaeus, commonly known as the cave bear, became extinct during the last glacial maximum about 20,000 years ago, but the reason for the extinction has never been clear. New research shows that the decline of the great European bear, which weighed about 500 kilograms and was primarily an herbivore, had less to do with climate change and more to do with the introduction of humans.

Mathias Stiller, a biologist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and colleagues examined the mitochondrial DNA of 17 bear fossil samples found in caves stretching across Europe, from Siberia to the Iberian Peninsula. By tracing the genetic diversity in the samples, researchers found that the cave bear began its decline 50,000 years ago, a date that coincides with modern human expansion into Europe, but does not coincide with any major change in climate, they reported in Molecular Biology and Evolution.

Though humans may have initiated the decline, multiple factors likely drove the bear to full extinction, the authors noted. As the cold of the last glacial maximum crept over northern Europe, the cave ecosystems began to degrade. This led to heightened competition with humans for safe habitats and enough food, and likely sealed the fate of the already-declining species about 24,000 years ago. At that time, researchers consider the species extinct, though they note that in some regions, the bears may have lived for a few thousand years longer. The survival of Europe's brown bear, which does not depend solely on caves for hibernation spots, supports these findings, the researchers suggest.

Meg Marquardt

The cave bear, *Ursus spelaeus,* would have weighed up to 500 kilograms. Despite its size, it couldn't compete with humans for habitat space.

Smectite clays help give toothpaste its squeezability.

Clay varieties and uses

There is a large number of clay minerals, which vary widely in mineral composition and other properties. Manufacturers use clays in a large number of products. Some of the more visible products are brick, pottery, roofing tile and the almost-ubiquitous fill dirt at construction sites. But for every visible clay application, there are hundreds of uses of which the public may not be aware.

For example, clays make cooking oils clear: The electric charge on the surface of montmorillonite clays allows the clay to bind with chlorophyll and other colored organics in semi-processed oil; the clays are later removed. Bentonite is used in hand lotions and paints to prevent other solid components from settling to the bottom of the container after sitting on the shelf for extended periods of time. Smectite clays make toothpaste thick enough to stay on the toothbrush, but still allow it to be soft enough to flow from the tube when the tube is squeezed.

Here are a few other uses of clays:

- Bentonite and fuller's earth are used in some waterless shampoos, as absorbents (oil and grease) and in kitty litter.
- Bentonites are also used in some laundry detergent, foundry sand bond and iron ore pelletizing.
- Kaolin is used as an all-natural dust coating on certain crops, principally fruits, to control bugs and prevent sunburn. It is also a component in anti-diarrhea remedies. Its primary use is in the paper industry as a filler and a paper coating; it gives paper a glossy surface by forming a smooth, thin, ink-receptive film over the rough cellulose paper surface.
- Special clay products made from fuller's earth, kaolin and expanded shale, rather than common clay, may be used on baseball fields to prepare infields, pitcher's mounds and outfield warning tracks.
- Concrete ships were built using lightweight aggregates (calcined clay, shale and slate) during World Wars I and II to conserve steel.
- Ball clay is used mainly in floor and wall tile, pottery and toilets.
- Common clay and shale are used in manufacturing brick, cement and lightweight aggregate. Fire clay is used in common brick production as well as refractory applications.

Bottom: Aurora Grandal-D'Anglade; top: Scott Ehardt

MINERAL RESOURCE OF THE MONTH: CLAY MINERALS

USGS
science for a changing world

Robert Virta, mineral commodity specialist for the U.S. Geological Survey, prepared the following information on clays, one of the more multifaceted mined mineral commodities.

Clays were one of the first mineral commodities used by people. Clay pottery has been found in archeological sites that are 12,000 years old, and clay figurines have been found in sites that are even older. One of the most famous examples is the 2,200-year-old army of terracotta (clay) warriors — 8,000 of them — found in Shaanxi Province, China. Today, the production of clays is among the largest of the world's minerals industries, exceeding 1 billion metric tons per year. Clays are used in everything from shampoo to kitty litter to pottery to cement.

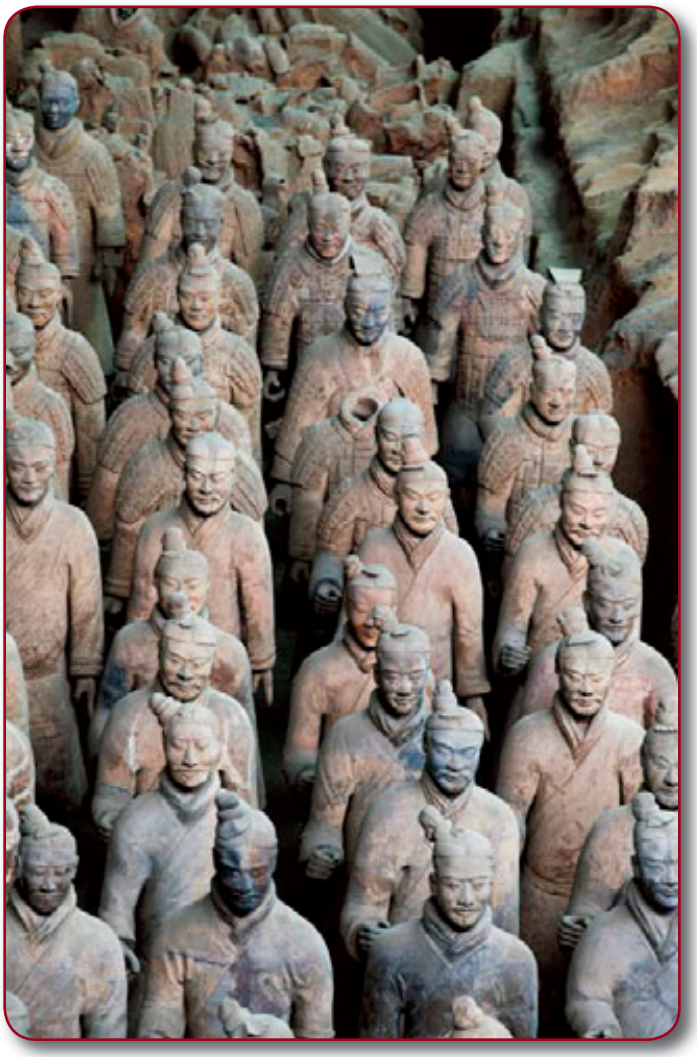
Bentonite and fuller's earth are used in kitty litter.

The term "clay" generally is applied to soil (mineral) particles with diameters less than 2 micrometers. "Clay minerals" can have particle sizes ranging from tens of angstroms to several millimeters. There are many distinct clay minerals, but commercial clays generally include ball clay, bentonite, common clay and shale, fire clay, fuller's earth and kaolin.

Mineral composition, particle size, plasticity, absorption qualities, firing properties and oil clarification properties are a few of the major characteristics used to distinguish between the six industrial clay categories. Bentonite is composed of smectite minerals, clays that swell in varying amounts when exposed to polar liquids such as water; it is further subdivided into sodium-rich (or swelling) bentonite and calcium-rich (or nonswelling) bentonite. Common clay and shale are composed mainly of illite and chlorite; fire clay is composed mainly of kaolinite, gibbsite and/or diaspore; and fuller's earth consists primarily of palygorskite and/or montmorillonite clays. Kaolin is composed primarily of kaolinite or kaolin-group minerals whereas ball clay consists primarily of finely crystalline kaolinite.

Most clays are mined worldwide, but some commercial clays are mined in only a few locations. Most of the world's supply of halloysite, a variety of kaolin, is mined in New Zealand, for example. And nearly 70 percent of the world's supply of palygorskite, a form of fuller's earth, is mined in the United States; the U.S. is also the world's leading producer of bentonite and kaolin. Spain provides the bulk of the world's supply of sepiolite (another clay mineral).

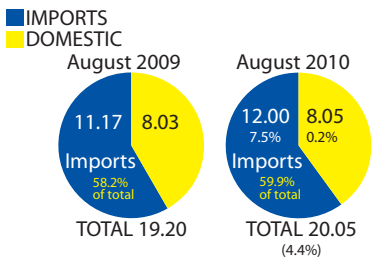
About 25.3 million metric tons of clays were sold or used in the United States in 2009, half of which was common clay and shale. This equates to a per capita use of clay and shale of about 82 kilograms per year.



The 2,200-year-old terracotta warriors found in Emperor Qin Shi Huang's tomb in China are made of clay.

For more information on commercial clays and other mineral resources, visit http://minerals.usgs.gov/minerals.

ENERGY NOTES



U.S. Oil & Petroleum Imports (millions of barrels per day)

Oil and petroleum imports data are preliminary numbers taken from the American Petroleum Institute's Monthly Statistical Report. For more information visit www.api.org.

Visit the EARTH Energy Notes online archive, www.earthmagazine.org/Res_index.html for Energy Information Administration consumption and production data.

Bottom: ©iStockphoto.com/Nina Shannon; top: ©iStockphoto.com/xxapril

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

AGI GeoRef

WWW.GEOREF.ORG

PROVIDING FAST, EASY ACCESS TO THE GEOSCIENCE LITERATURE OF THE WORLD

3 Million References and Growing

- Search GeoRef online, on the Worldwide Web or on CD-ROM.
- Current, worldwide coverage includes the Geology of North America from 1669 and the rest of the world since 1933.
- 3,500 journals in more than 40 languages.
- New books, maps, reports, symposia, and theses from U.S. and Canadian universities.
- Regular updates totaling more than 100,000 new references each year.

GeoRef Providers

GeoRef is made available through many vendors:

- World Wide Web
  Dialog/DataStar
  Ebsco
  Engineering Village
  GeoScienceWorld
  Ovid Technologies
  ProQuest
- CD-ROM
  Ovid Technologies
- Traditional Online Services
  Dialog/DataStar
  STN International
- Current Awareness
  NERAC

GeoRef Document Delivery Service

Available exclusively from AGI, this service enables you to obtain copies of hard-to-find documents, maps or theses cited in the GeoRef database. AGI has access to documents from sources throughout the world including the U.S. Geological Survey, the Library of Congress, and various organizations in Germany, China, the Russian Federation, and other countries. For information, contact dds@agiweb.org or visit: www.agiweb.org/georef/dds/index.html.

AGI GEO REF

- For information on the content of GeoRef, licensing the database, and on methods of access, contact Monika Long at AGI headquarters, **ml@agiweb.org.**

SERVING THE GEOSCIENCES WORLDWIDE
AGI
THE AMERICAN GEOLOGICAL INSTITUTE

This PDF is licensed for personal use only. MjAxMC0xMjkyOTE4OTEzLjQ3

GEOREF SERVICES

• GeoRef Search Aids

GeoRef Thesaurus, Eleventh Edition

Edited by Barbara A. Goodman
The Thesaurus is the guide to the 30,800 controlled vocabulary terms used in GeoRef — indispensable for efficient searching of the GeoRef database. ISBN 978-0-922152-82-7. Paperback, 8.50"x11.00" 833 pp. Item # 140337 $139.95 (*AGI Member Society price $111.96); 6 lbs.

• GeoRef Custom Searches & Alerts

Need an occasional search of the GeoRef database? Do you have an ongoing interest in a specific research area? Check out GeoRef's Custom Search option at www.agiweb.org/georef/access.html#custom or the GeoRef Alert Service at www.agiweb.org/georef/alert.html

• GeoRef Preview Database

Want to check on new references even before they're available in GeoRef? Check out the GeoRef Preview Database at no charge at: www.agiweb.org/georef/onlinedb/preview.

This database, updated weekly, contains unedited references that have not yet been completed. Get a sample of the types of publications included in the GeoRef database or keep up with new publications!

• Other GeoRef Databases

Groundwater and Soil Contamination Database

This highly specialized database provides coverage of literature on the contamination of groundwater and soil. It includes over 127,000 bibliographic references to the worldwide literature on this subject.

Documents cited in the database are primarily related to geology, hydrology, and the environment.

For further information visit: www.agiweb.org/georef/onlinedb/gscweb

Antarctic Bibliography

The Antarctic Bibliography covers all scientific disciplines related to the region. The Antarctic Bibliography is produced with support from the National Science Foundation with contributions from the Scott Polar Research Institute, University of Cambridge.

For further information visit: www.coldregions.org/antinfo.htm

Bibliography on Cold Regions Science and Technology

The Bibliography on Cold Regions Science and Technology includes references to scientific and engineering research related to material and operations in a winter battlefield, the nature and impact of cold on facilities and activities, cold-related environmental problems, and the impact of human activity on cold environments. The Bibliography on Cold Regions Science and Technology is funded in part by the National Science Foundation and the U.S. Army Cold Regions Research and Engineering Laboratory.

For further information visit: www.coldregions.org/coldinfo.htm

AusGeoRef

This bibliographic database, produced in cooperation with Geoscience Australia and drawn from GeoRef, contains information on Australian geoscience publications, both published in Australia or about Australia.

AusGeoRef includes over 180,000 bibliographic references on geology in Australia back to 1840, drawn from journal literature, meeting proceedings and abstracts, books, reports and maps.

For further information visit: www.agiweb.org/georef/ausgeoref

WWW.GEOREF.ORG

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Highlights of 2010

The earth sciences dominated global headlines a number of times during 2010. The year started with the devastating magnitude-7.0 earthquake in Haiti that killed more than 200,000 people and left millions homeless. Then a magnitude-8.8 quake struck Chile just over a month later. These and other notable temblors grabbed headlines and fascinated the public, prompting questions of whether they were related and whether they were anomalous ("no" to both). Then in April, the Deepwater Horizon drilling rig exploded, setting off the largest oil spill in U.S. history and turning public attention to the mess in the Gulf.

But if you put aside these headline-grabbing disasters for a moment, you'll see that there were many other notable stories in the earth sciences this year as well.

When the EARTH staff sat down late last summer to discuss what we wanted to cover in this issue, one theme kept coming up: paradigm shifts. There seems to be a growing trend in many fields of overturning long-held paradigms. More often than not these days, scientific papers end with the conclusion "what we thought we knew was incorrect." We are seeing an increasing appreciation for the complexity of earth systems, from how faults slip aseismically to how ocean conveyor belts transport salt and heat around the world, to what it means to be human. Likewise, we are seeing rapid breakdowns and changes in models accompanying the new research. It seems that scientific inquiry is beginning to catch up with technology, and it's opening up new sets of questions about fields we thought we had mastered.

We at EARTH find these trends fascinating, and look forward to seeing how they are fleshed out over the coming years. In the meantime, we hope you enjoy this month's look back at the events and research trends over the past year.

HAZARDS

Last year, a geologist was brought to trial for inducing earthquakes during the enhanced geothermal energy process. Although he was cleared, the repercussions of the trial are still being felt and the future of enhanced geothermal energy is unclear.

Could the devastation and deaths caused by the earthquake in L'Aquila, Italy, have been prevented if geologists had warned residents that the quake was coming? A court case looked into that prospect this year.

An American geologist was sentenced to eight years in a Chinese prison for allegedly stealing state oil secrets.

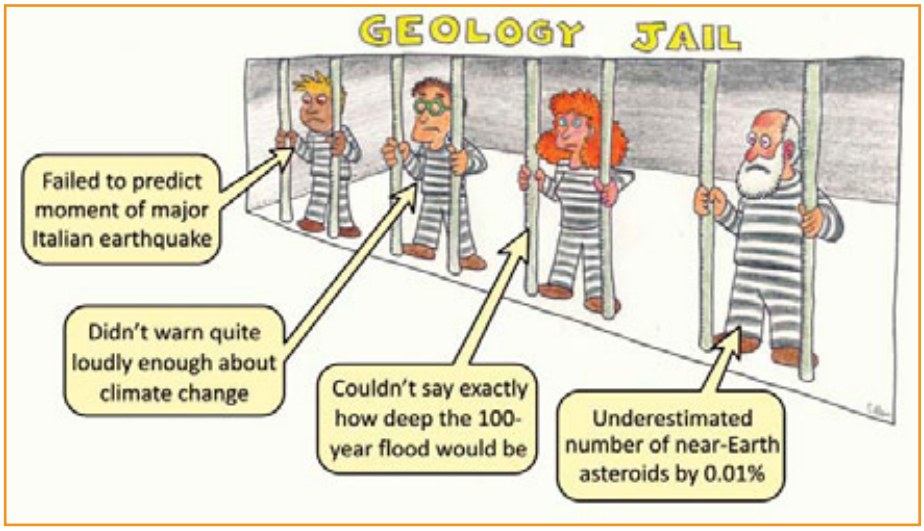
Bottom to top: ©iStockphoto.com/Robert Ellis; ©iStockphoto.com/Juri Pozzi; Gretar Ívarsson

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Geologists on the Wrong Side of the Law

Stephen M. Testa

We live in a litigious society. Engineering and environmental geologists are no strangers to the legal system. They frequently deal with issues relating to geologic hazards such as active faults and unstable ground, the release of contaminants into the environment and numerous other circumstances. But for the most part, geoscientists tend to avoid legal battles. Is that changing?



Callan Bentley

In the last couple of years, several events have brought geologists into new legal territory. Geologists have recently been accused of potentially inducing earthquakes, of not predicting natural hazards, of potentially adversely impacting water quality, of spying and of engaging in indelicate e-mail discussions and alleged misdealings with climate change data.

The question of whether geologists can be held responsible for inducing earthquakes is a bit different from the question that arose in Italy late last spring: Can a geologist be held liable for *not* predicting an earthquake or any other natural hazard that occurs?

ARE GEOLOGISTS AT FAULT?

On more than one occasion in the pursuit of energy, geologists have been cited for inducing earthquakes. First was a case of enhanced geothermal development in Switzerland that came to a head last December. Enhanced geothermal essentially fractures bedrock and then circulates water through the cracks to produce steam, which in turn is utilized to produce electricity. However, by its very nature, fracturing creates earthquakes, albeit mostly of small magnitude. Last year, a case was brought against geologist Markus Haring for inducing some 30 earthquakes, the largest a magnitude 3.4, through drilling and injecting pressurized water into rocks 5 kilometers below the surface to generate electricity. Damage to buildings in the region was estimated at $9 million. Although Haring was acquitted last December, the enhanced geothermal project was terminated.

The Swiss case had significant ramifications, and sent a shot over the bow to those in favor of enhanced geothermal, considered a clean and virtually limitless energy source. In the U.S., the Department of Energy had provided more than $100 million for enhanced geothermal. One of the big projects was the AltaRock Energy project in an area called The Geysers, about 160 kilometers north of San Francisco, Calif. The Geysers comprise the largest complex of geothermal power plants in the world, and supply one-fifth of the renewable energy produced in California. The AltaRock project is — actually was — President Obama's first major test to advance geothermal energy generation.

But in December 2009, immediately following the shutdown of the project in Switzerland, AltaRock Energy removed its drill rig and informed the government that the project would be abandoned. The Geysers' geothermal fields are lined with active faults, and minor earthquakes have been induced by the geothermal operations there; it appears that the potential reward just wasn't worth the risks for AltaRock. The liabilities associated with the subsurface fracturing of rock present a significant setback in our search for renewable energy. Thus the efforts for more renewable energy will obviously be hampered and derailed with these legal setbacks.

Geothermal isn't the only form of energy under attack. Another recent case centers on whether drilling a natural gas well caused four small earthquakes — none above magnitude 2.8 — in the vicinity of Cleburne, Texas, near Dallas-Fort Worth. It did not help that one of the earthquakes occurred during the meeting of the city council while the council was holding an emergency session to discuss this very topic. This part of the Lone Star State had not had an earthquake in its 140-year history. The alleged culprit is either a practice called fracking — which is the injection of water, with added chemicals, at high pressures in order to fracture the underlying shale layers and release natural gas trapped in the rocks — or the reinjection of wastewater back into a depleted well, which

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Engineering and environmental geologists are no strangers to the legal system. They frequently deal with issues relating to geologic hazards such as active faults and unstable ground, the release of contaminants into the environment and numerous other circumstances. But for the most part, geoscientists tend to avoid legal battles.

is what one study found, as EARTH reported in June.

For now, gas production continues in Texas, but this issue and the issue of how fracking affects groundwater are in the headlines elsewhere, including in Pennsylvania, New York and other parts of the Northeast. As of 2005, fracking was deemed exempt from federal regulation under the Safe Drinking Water Act, but renewed interest on the impact of fracking on water quality is being re-evaluated by the Environmental Protection Agency. We haven't heard the end of this issue.

The question of whether geologists can be held responsible for inducing earthquakes is a bit different from the question that arose in Italy late last spring: Can a geologist be held liable for *not* predicting an earthquake or any other natural hazard that occurs? Italian geologists, seismologists, volcanologists, engineers and the like were threatened with charges of manslaughter for failing to predict the magnitude-6.3 earthquake in L'Aquila on April 6, 2009. The following statement was provided by the Major Risk Committee, an advisory group to the Civil Protection Agency, in reference to tremors that preceded the April 6 seismic event: "The scientific community tells us there is no danger, because there is ongoing discharge of energy." This was followed by such statements as "a major earthquake in the area is unlikely but cannot be ruled out" and "Because L'Aquila is in a high-risk zone it is impossible to say with certainty that there will be no large earthquake."

Whether these and other statements offered prior to the earthquake were adequate, appropriate or sufficient became questionable in the eyes of blind justice. Do the Italian geologists deserve to be under investigation for manslaughter for failure to forecast the earthquake? My opinion: No. We will see how it plays out in the courts.

ARE GEOLOGISTS THE NEW JAMES BOND?

Last summer, American geologist Xue Feng was sentenced to eight years in a Chinese prison for alleged oil espionage. Apparently Feng received documents on the geological conditions of onshore oil wells and a database on some 30,000 oil and gas wells. The wells belonged to China National Petroleum Corporation and listed subsidiary PetroChina, Ltd. Feng's behavior was not unusual, except that China contends that the information was obtained illegally and allegedly sold to IHS Energy, a U.S. consultancy firm and Feng's employer. On July 5, 2010, China ignored a personal appeal from President Obama and sentenced Feng to prison for buying confidential information about China's oil industry. Feng was also fined $30,000 for attempting to obtain and traffic state secrets.

But regardless of the eventual outcome — assuming China has an appeal process or can be persuaded by Feng's supporters to reconsider its verdict — there is little doubt that we will be seeing more of this type of behavior as certain countries and companies become ever more aggressive about obtaining available resources and supply lines to fulfill their growth and expansion plans. The Feng incident, which dragged on in the courts for more than two and a half years, also sent warning signals to foreign businesses that may not be familiar with security laws germane to other countries and jurisdictions.

Despite China's displeasure with Feng's alleged misbehavior, China was alleged to be behind several spying events of its own, in the form of cyber-attacks. Last January, the Christian Science Monitor reported that at least three U.S. oil companies — Marathon Oil, ExxonMobil and ConocoPhillips — were the target of a series of previously undisclosed cyber-attacks. There is a growing level of sophistication in the global war of Internet espionage. These new types of attack include custom-made spyware that is virtually undetectable by anti-virus and other electronic defenses traditionally used by corporations. These new cyber-burglary tools pose a serious threat to corporate America and the long-term competitiveness of the nation, according to experts in this field. We will need to stay tuned for the sequel in these unfolding cyber-spies reports.

And in the realm of cyber-spying, there was Climategate, although the emphasis has not been on the cyber-thieves who stole the information but rather the information itself. Late in 2009, hackers released a thousand private e-mails written by prominent climatologists. The case threatened to discredit the Intergovernmental Panel on Climate Change's Fourth Assessment Report, and threatened the integrity of the scientific process as a whole. The e-mails exposed the hyper-political nature of the debate on climate change, and caused the general public to be more confused than ever. In the past year, a series of independent reviews of the e-mails and of the situation has cleared the climatologists of any real legal wrongdoing, but damage to the integrity of climate science remains. Interestingly, the cyber-thieves appear to have made their getaway without legal repercussions.

Amid the ongoing pursuit of resources and clean energy, as well as public perception on what we do or don't know, we will undoubtedly see more geologists involved in legal wrangling in the future. Thus, what we do, how we do it, how we document it and how we relate it to the public becomes increasingly important.

Testa is an environmental geologist and serves as the executive officer of the California State Mining and Geology Board.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

HAITI QUAKE

The magnitude-7.0 earthquake that struck Haiti Jan. 12 killed more than 200,000 people, injured another 300,000 and left more than 2.3 million people (a quarter of Haiti's population) homeless, according to the United Nations Development Programme. Geologists originally thought the quake occurred on the Enriquillo-Plantain Garden Fault, a strike-slip fault that runs east-west through Hispaniola, but satellite and GPS evidence indicate that the event happened on a previously unknown, 30-kilometer-long fault.

CHILE QUAKE AND TSUNAMI

The fifth-largest earthquake recorded since 1900 struck offshore Chile Feb. 27. The magnitude-8.8 quake generated a tsunami that ravaged parts of the Chilean coastline; the event killed at least 500 people and damaged or destroyed about 370,000 houses, according to the U.S. Geological Survey. The tsunami also damaged several thousand boats.

ICELAND ERUPTION

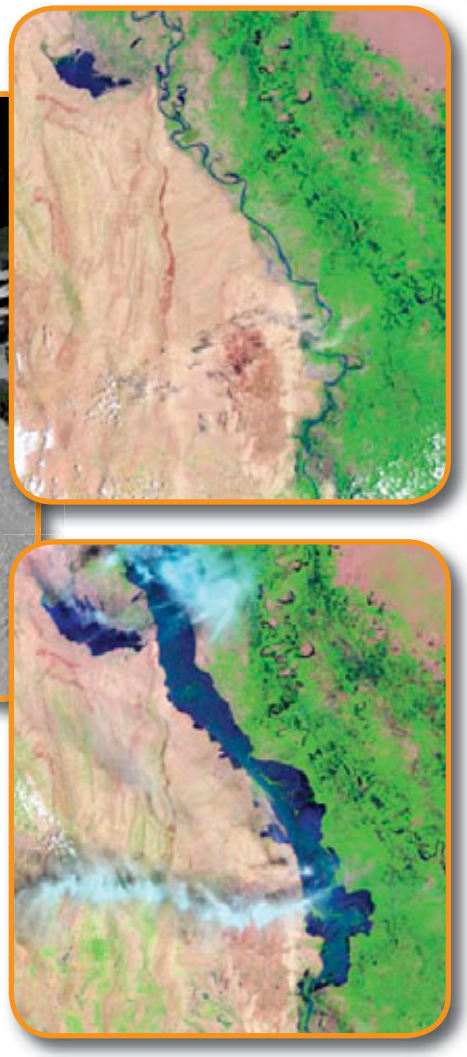
Iceland's Eyjafjallajökull volcano roared back to life March 20, erupting for the first time since 1823. Jets of lava, called fire fountains, spewed into the air, creating steam plumes as the lava flowed down the glacier that sits atop the volcano. The eruption stopped April 12, but picked up again two days later when Eyjafjallajökull unleashed a massive ash plume that reached a height of 11 kilometers. The ash closed European airspace for several days, stranding millions of travelers. By late May, the eruption had waned, but officials are still monitoring the volcano for signs of future activity — as well as signs that the unrest could trigger eruptions at nearby volcanoes.

Bottom to top: ©David Karnå, Creative Commons Attribution 3.0 Unported; Walter Mooney, U.S. Geological Survey; ©United Nations, Creative Commons Attribution 2.0 Generic

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

PAKISTAN FLOODING

This bridge was destroyed during the summer floods in Pakistan, which were brought on by monsoonal rains in late July. Flooding of the Indus and other rivers affected almost 21 million people, ruined more than 1.8 million houses and sickened millions of Pakistanis with diarrhea and other waterborne diseases, according to the World Health Organization.



A satellite view of Pakistan's Indus River in July 2009 (top) and a view of flooding in the same region in August 2010.

RUSSIAN WILDFIRES

The streets of Moscow were darkened last summer from the thick smoke of hundreds of wildfires burning across Russia. The wildfires were the result of a drought and a record-breaking heat wave that dried out forests and peat land. Temperatures reached as high as 40 degrees Celsius. At the height of the fires, Moscow's daily death rate doubled to 700, in part due to increased levels of air pollution — carbon monoxide levels were as much as 6.5 times greater than safe levels and particulate levels were as much as 2.5 times higher. The fires also ruined a third of Russia's wheat crops, causing the government to ban wheat exports for the rest of the year.

This July 29 satellite image captures plumes of smoke wafting over several hundred kilometers of Russia. The smoke originated from burning peat fields and forest fires.

Clockwise from bottom right: ©Shutterstock.com/vicspacewalker; ESA; DoD photo by Staff Sgt. Horace Murray, U.S. Army; top right set: NASA image by Robert Simmon, based on Landsat 5 data from the USGS Global Visualization Viewer

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

GULF OIL SPILL

The explosion on the Deepwater Horizon drilling rig in the Gulf of Mexico April 20 led to a leak in BP's Macondo exploratory well off Louisiana. Federal scientists estimate the well released 4.9 million barrels of oil into the Gulf (seen here May 24), making it the world's largest unintentional offshore oil spill.

Controlled burns removed 5 percent of the oil that leaked into the Gulf of Mexico, according to a federal report released in August.

Frank Minter, an oil recovery technician, sifts through tarballs at a beach in Mississippi in July.

Bottom to top: U.S. Coast Guard photo by Petty Officer 3rd Class Brandyn Hill; U.S. Coast Guard photo by Lt. Cmdr. Paul Rooney; NASA image by Jeff Schmaltz, MODIS Rapid Response Team

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

After the Spill

Megan Sever

In late March, much to the chagrin of environmentalists and to the cautious delight of the energy industry, President Barack Obama announced that he was in favor of oil and gas exploration and production off U.S. coasts. To limit U.S. dependence on foreign oil and to generate revenue, the administration proposed opening vast parts of the Atlantic coastline from Florida to Delaware, the eastern Gulf of Mexico and the northern coast of Alaska to drilling — much of this area for the first time ever. But less than a month later, the Deepwater Horizon drill rig exploded in the Gulf of Mexico, beginning what would become the largest oil spill in U.S. history and changing the landscape for offshore oil and gas activities in the U.S.

Firefighters try to put out the fire on the Deepwater Horizon, which exploded in the Gulf of Mexico on April 20.

U.S. Chemical Safety Board

In May, as the oil was spreading, Obama announced a six-month moratorium on current deepwater drilling in the Gulf (deeper than 150 meters) and a six-month moratorium on any new offshore leases anywhere in the U.S., pending an investigation into how to improve safety and operations offshore. After legal challenges and court decisions, the administration reissued the moratorium in July and expanded its reach to any offshore drilling, regardless of depth. In September, the Senate Committee on Small Business and Entrepreneurship stated that safety considerations had been met and that companies operating in the Gulf ought to be allowed to continue exploration and production. The moratorium, which was set to expire Nov. 30, was lifted in early October.

Meanwhile, in May, the Department of the Interior dismantled its troubled Minerals Management Service — the agency that had been in charge of regulating the offshore oil industry as well as offering leases and collecting lease monies. The department set up two new agencies: the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), which will develop offshore energy options and ensure the safety of that production, and the Office of Natural Resources Revenue, which will collect royalty revenues. "With this restructuring, we will bring greater clarity to the roles and responsibilities of the [Interior] Department while strengthening oversight of the companies that develop energy in our nation's waters," said Interior Secretary Ken Salazar in a statement.

One of BOEMRE's first acts was to mandate that all nonproducing wells that have been inactive for more than five years in the Gulf of Mexico be permanently plugged and that all nonproducing offshore platforms in the Gulf be decommissioned and dismantled. That involves some 3,500 wells and 650 platforms. The mandate "is something we have been expecting and working with BOEMRE on a reasonable timeframe for implementation," says Carlton Carroll, a spokesperson for the American Petroleum Institute in Washington, D.C. Despite concern about the ability of companies to obtain the permits necessary for the decommissioning, Carroll says, "we believe that for most operators, compliance with the rule will not be an issue."

One issue that hasn't been addressed yet, however, is that many of these platforms act as artificial reefs in the Gulf. Removing them will affect marine life in the region, but exactly how is not yet known.

Despite the government's call for reform, however, "the business-as-usual outcome is, in some form, most probable," wrote Michelle Foss, chief energy economist and head of the Center for Energy Economics at the Bureau of Economic Geology at the University of Texas at Austin, in Foreign Affairs LatinoAmérica. "The value of oil and natural gas for both energy and materials is beyond measure," she wrote. "Thus, behind the [political] posturing statement lies a very hard equation: The amount of effort, time and money to shift the global economy away from hydrocarbons is harder, more expensive and more complex than is politically acceptable to admit."

> **When all is said and done, "the business-as-usual outcome is, in some form, most probable."**
> **- Michelle Foss, University of Texas at Austin**

Any changes that result from this spill, Foss wrote, are likely to be changes to the regulation of offshore development. How and when that will all play out is anybody's guess. But for a nation dependent on offshore oil and gas — some 30 percent of all U.S. oil production and 10 percent of U.S. gas production comes from offshore locations — the longer the drilling ban stays in place, the more it will negatively impact U.S. energy security, oil and gas prices, jobs and overall economic recovery, she wrote.

Obama, for his part, has not sworn off all offshore exploration. In a press conference in late May, he said, "Where I was wrong was in my belief that the oil companies had their act together when it came to worst-case scenarios." He still thinks that domestic offshore oil production should be part "of our overall energy mix" — there just needs to be more regulation and oversight. The administration released its new offshore drilling rules on Sept. 30. Companies will be required to meet the new regulations before continuing offshore development.

Sever is the managing editor of EARTH.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

A Tale of Two States: Offshore Wind in Texas and the Curious Case of Massachusetts

Sheril R. Kirshenbaum and Michael E. Webber

Humans have harnessed wind energy throughout history for milling, pumping and transportation — in a way you could say it's the "original" form of industrial energy. But only recently have we built massive, powerful turbines to convert that wind into electricity. As concerns about pollution, carbon emissions, resource depletion and energy security mount, wind farms are an increasingly attractive alternative for meeting growing energy demand. Unlike many other "solutions," capturing the wind's potential emits no hazardous wastes or greenhouse gases, and is an inexhaustible energy source. A boom in development has also created thousands of new jobs during a period when most industries are letting workers go. In 2009 alone, the American wind power industry grew by 39 percent and now accounts for 2 percent of electricity produced in the United States. The total resource in the U.S. central wind corridor could satisfy our total demand for electricity. In the last year, although many renewable technologies have taken a hit as the global economy continued to struggle, wind power — especially offshore wind power — seemed to do all right.

Offshore wind projects are particularly attractive because coastal wind tends to blow more reliably than onshore winds, especially in times of greater demand, such as hot summer afternoons. In addition, a significant fraction of the U.S. population lives near the coasts, so coastal wind farms are close to demand centers, obviating the need for transmission lines that are hundreds or thousands of kilometers long. Ideal conditions involve relatively shallow water, low wave heights and high-speed winds. Development has been rapid, but not uniform because each state must work within its own governance framework to establish the institutions to support them. In 2010, things have progressed in intriguing ways in Massachusetts and Texas, two states with very different perspectives on energy.

CAPE WIND MOVES AHEAD

In Massachusetts, the road to offshore wind power development has been long and arduous. Local and political opposition has bogged down the permitting process for years while misinformation continues to plague plans due to mismatched priorities of developers and residents.

The primary hurdles have finally been cleared to allow Cape Wind to put a wind farm, similar to this one, in Nantucket Sound.

Siemens

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLTQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Those seeking to build the wind farms in Massachusetts have set their sights on a region known as Horseshoe Shoal in Nantucket Sound, where scientific studies have shown physical conditions are ideal. Wind farms at this location would not interfere with bird flight paths, shipping channels or ferry routes. The sound is also in close proximity to homes so transmission would be relatively easy and inexpensive.

The wind farm would reside in federal waters, with a transmission line crossing state boundaries as well. When the U.S. Army Corps of Engineers compared Horseshoe Shoal to 16 other regions in New England, they reported that the sound would be economically, environmentally and technically superior to every other option. With that in mind, in 2001, Cape Wind Associates, the developers of the project, began planning to construct 130 turbines that would each produce up to 3.6 megawatts and sell electricity to consumers on Martha's Vineyard, Nantucket and Cape Cod.

If the project had been proposed elsewhere, an offshore wind farm might have been up and running by now. But Cape Wind Associates did not account for perhaps the most important piece of the puzzle: people. Early on, they mistakenly assumed local residents would embrace the offshore farm simply because it produces clean energy, improves air quality and creates jobs. They even predicted that the project would attract tourists as other offshore farms around the world have, boosting the local economy.

However, when the project started nine years ago, offshore wind was a poorly understood new technology with no predecessor in the U.S. (despite its success in other countries, such as Denmark). Poor efforts by Cape Wind to educate the local population on the project and its economic benefits opened the door for key wealthy residents to support efforts to stall Cape Wind's development, citing environmental, safety and aesthetic concerns as well as noise. Lawsuits to stop the permitting process were filed by fishermen, residents and local Native American tribes. Complicating matters was the absence of an established regulatory framework to manage the use of ocean space in federal waters. Additional pressure mounted from powerful politicians, who did not want to see a wind farm from their own backyard.

After more than eight years of federal review by the U.S. Department of the Interior through two administrations, Cape Wind was finally approved last spring by Interior Secretary Ken Salazar. More lawsuits were filed, but on Aug. 31 a Massachusetts Supreme Judicial Court ruled against community opposition and granted the Cape Wind energy project the permits to begin construction. Many community members have pledged to keep fighting, suggesting that the wind farm sets a dangerous precedent for private developers who want to open the area to drilling rigs or nuclear power plants. The wind farm is anticipated to be fully operational by late 2012 and is estimated to cost at least $2 billion. It will have the capacity to power about three-quarters of Cape Cod's residents — many of whom continue to fight Cape Wind Associates.

Texans have long been accustomed to large oil and gas rigs speckling the landscape, so they associate energy with income; wind farms just replace pump jacks with turbines and oil or gas leases with wind leases.

Texas has the capacity to produce 10,000 megawatts of wind power annually on land.

Edward Jackson

OIL RIGS TURN INTO WIND FARMS

The story of wind off Texas' coast will be written very differently from that of Massachusetts. The Lone Star State already has the capacity to produce 10,000 megawatts of wind power on land, making it by far the nation's leading producer of wind energy. With dramatic irony, many tapped-out oilfields have been resurrected as wind farms. Today, if Texas were a nation, it would be the sixth-largest wind producer in the word.

Texas has a long-established positive relationship with energy — including wind. Residents have long

Wind farms are replacing oil derricks across the West Texas landscape.

©iStockphoto.com/Mooneydriver

been accustomed to large oil and gas rigs speckling the landscape, so they associate energy with income; wind farms just replace pump jacks with turbines and oil or gas leases with wind leases. Furthermore, in areas where wind farms have been established, residents have watched as property values increased from the farms, reminiscent of oil and gas booms — the difference is, unlike oil and gas, the wind won't run out after a few decades. Meanwhile, wind companies have already rejuvenated towns, restored abandoned buildings and brought wealth to communities. The wind farms have also helped Texas reduce its electricity prices and carbon emissions, and created thousands of jobs. As a result, turbines have been welcomed onshore, and viewed as a strategy for economic development.

Because of the positive experience with land-based wind farms, Texans have embraced opportunities to develop turbines offshore as well. Therefore, coastal wind will complement the thriving wind industry already established throughout the western part of the state.

There are other reasons why wind is flourishing, and will continue to, in Texas. Unlike in Massachusetts, developers in Texas do not face strong environmental opposition to turbines. Although a few lawsuits have been filed to halt development because of aesthetic concerns about views, Texas is a state that highly values private property rights. Because the wind farms are on private property in rural parts of the state, developers don't need a permit to build them, and so, in large part, the onshore projects have proceeded.

Also, by a fluke of Texas' unique history, the state controls offshore lands out to nine nautical miles (16.7 kilometers), whereas all the other states in the nation only control three nautical miles (5.6 kilometers). (Because Texas was once its own nation, it negotiated for these extra nautical miles as a condition of joining the United States.) The state can thus move forward more readily — with fewer permitting issues — than places like Massachusetts where parts of the offshore projects will be in federal waters.

Texas' long history of autonomy also comes into play in electricity transmission issues: There are three electric grids in the United States — East, West and Texas. Because Texas controls its own grid, it has the freedom to make the grid competitive (which it did, starting in 1999) and to build transmission lines for wind (which the state started in 2007). Consequently, wind can more readily compete in Texas than in most places.

Finally, in Texas, the permit process for offshore development only takes weeks to months, and the General Land Office has already issued eight leases covering more than 570 square kilometers along the Texas coastline from Port Arthur on the Louisiana border to Port Isabel at the Rio Grande. The first test turbine will be operational in 2011, and offshore wind farms are expected to produce more than 3,500 megawatts of power by 2020.

It appears that Texas will benefit from offshore development quicker than the traditionally "green" state of Massachusetts. Will other coastal states follow suit?

Kirshenbaum is a research associate at the Center for International Energy and Environmental Policy (CIEEP) at the University of Texas at Austin and co-author of "Unscientific America: How Scientific Illiteracy Threatens Our Future" (with Chris Mooney). Webber is associate director of CIEEP, where he trains a new generation of energy leaders through research and education. Visit the Webber Energy Group at www.webberenergygroup.com.

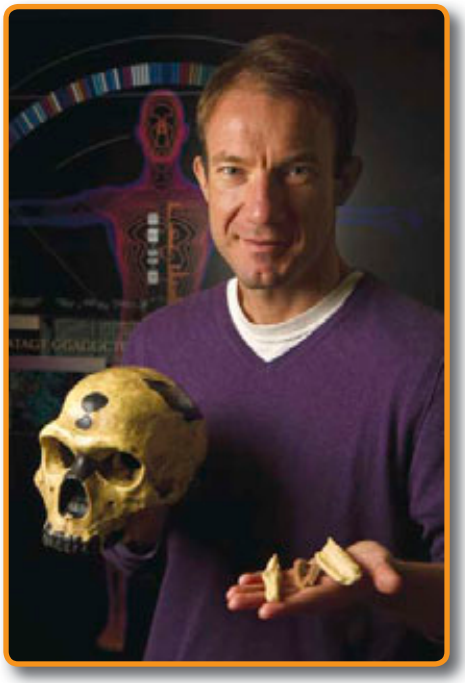
This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTE2ZLJQ8

What Does It Mean to Be Human?

The sequencing of the Neanderthal genome in 2010 helps scientists answer the age-old question

Erin Wayman

Calling someone a "Neanderthal" in the heat of an argument may not be such an insult after all. Last May, scientists announced they had completed a draft sequence of the Neanderthal genome, and found evidence that Neanderthals and modern humans interbred, likely sometime 80,000 to 50,000 years ago when modern humans left Africa and ventured into Eurasia — Neanderthal territory. Those encounters left a mark in the modern gene pool: As much as 4 percent of the DNA in people with European or Asian ancestry may be Neanderthal DNA, the researchers reported in Science.



Richard Green holds replicas of a Neanderthal skull and the bones from which Neanderthal DNA was extracted for genome sequencing.

The discovery of our intimate history with Neanderthals received tremendous press last spring, but another implication of the sequencing of the Neanderthal genome also deserves attention, says the study's lead author, Richard Green, a genome biologist now at the University of California at Santa Cruz. "The hope is to be able to use the Neanderthal [genome] to shine a flashlight on recent evolution in humans," he says.

Until now, scientists had been limited to comparing human DNA to the DNA of our closest living relative, the chimpanzee. It was impossible to know, however, when any detected difference arose in our evolutionary history: Did it occur right after the split with the chimp lineage (sometime about 8 million years ago), in australopithecines, in other now-extinct species in the genus *Homo*? Or is it a change only found in *Homo sapiens*? By comparing our genome to that of Neanderthals, researchers can now look for the genetic changes that make modern humans unique among all hominins.

DNA for sequencing the Neanderthal genome was retrieved from these three bones, all from Vindija Cave in Croatia.

GENOMICS 101

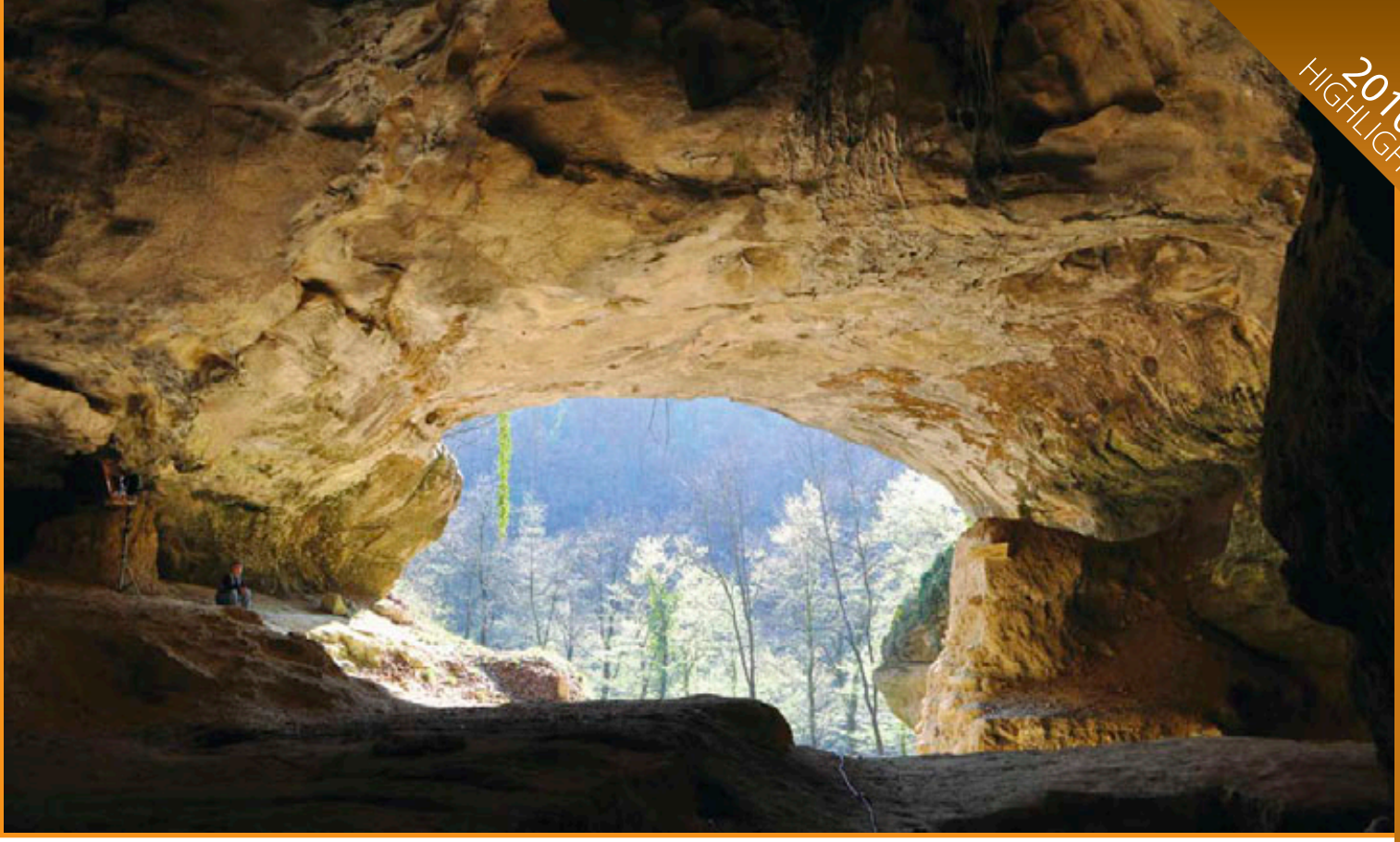
Three Neanderthals "volunteered" their DNA for genome sequencing. Green and colleagues, including geneticist Svante Pääbo of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, extracted the genetic material from three bone fragments dating to more than 38,000 years ago that were found in Croatia's Vindija Cave. Because the bones were buried in a cool, dry environment, minute amounts of DNA were preserved, Green says.

After collecting the DNA and separating the Neanderthal DNA from microbial DNA that had accumulated in the bones over time, the researchers had to "read" the DNA sequence. DNA is made up of smaller subunits called nucleotides. Each nucleotide has a different chemical base: adenine (A), guanine (G), cytosine (C) or thymine (T). Reading DNA means figuring out which chemical base occurs at each nucleotide location. The sequence of chemical bases is important because different sequences of bases, called genes, code for different proteins in the body, such as collagen in skin or hemoglobin in blood.

The Neanderthal genome consists of roughly 3 billion nucleotides. It took the team three years to identify all those A's, G's, C's and T's. The feat was made possible by advances in techniques that allow for faster, more efficient sequencing, Green

Bottom: courtesy of Jim MacKenzie/UC Santa Cruz; top: courtesy of the Max Planck Institute EVA

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3



The Neanderthals whose DNA was sequenced lived in Vindija Cave more than 38,000 years ago.

Courtesy of Johannes Krause MPI-EVA

says. The technology has come so far in the past few years, he says, that if the team were to begin the genome project today, it would probably only take a matter of months.

Reading the Neanderthal's genetic blueprints was only half the battle. The next crucial step was to compare the extinct hominin's genetic code to that of modern humans and chimpanzees.

WHAT MAKES US DIFFERENT?

Humans and chimpanzees share many of the same genes. But over the past 8 million years, genetic mutations have cropped up, changing how these genes function. For example, consider a hypothetical gene that codes for hairiness. At some point in human evolution, a mutation — say, an "A" replaced a "C" — altered that gene, causing humans to be less hairy than chimpanzees.

One task in the Neanderthal genome project was to look for such changes. In some instances, for a gene in which humans are different from chimpanzees, Neanderthals have the human version of the gene. Scientists assume that such gene variants must have evolved in the hominin lineage sometime after the split with the chimp lineage — but when those changes happened in hominin evolution can't be inferred, Green says.

In other instances, chimpanzees and Neanderthals share the same version of a gene and modern humans are different. In these cases, scientists think the gene must have stayed the same throughout most of hominin evolution until modern humans split from Neanderthals (our closest hominin relative) sometime between 440,000 and 270,000 years ago, according to the team's estimates. After the split, humans evolved the new version of the gene. Such changes are what make modern humans unique.

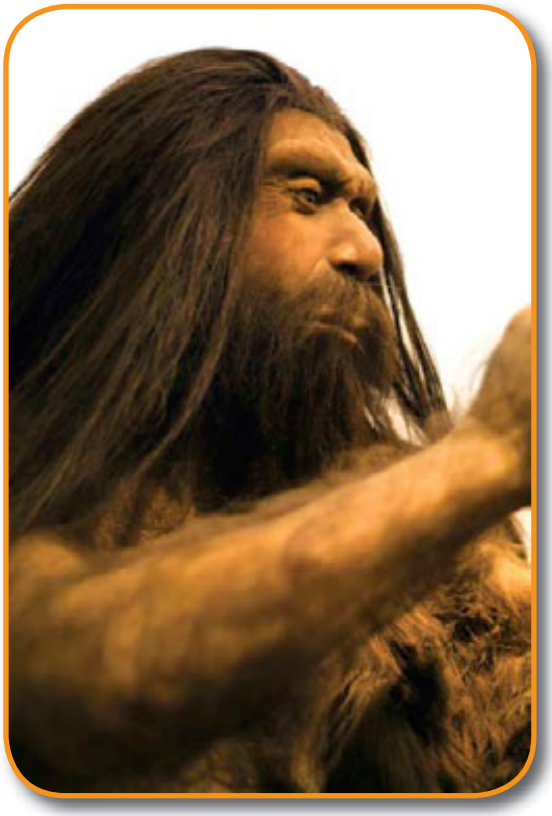
In all of their searching, the team found very few differences between humans and Neanderthals, Green says. Only 73 human genes have mutations that probably make the genes function differently from genes shared by Neanderthals and chimpanzees. Some of these differences, for example, occur in genes that code for characteristics related to skin, such as wound healing. But exactly how these changes affect the function or appearance of skin among the species is unknown.

"That's a little bit frustrating," Green says. "It's very suggestive that maybe there would be some phenotypic difference, but we don't know right now what that difference would be." But the researchers do have a hunch on why these things changed: genetic drift — random evolutionary changes not directed by natural selection. "Mostly when you look at things that are different it's just random background [changes]," he says, "which happen all the time."

Other parts of the genome, however, point to regions that were shaped by natural selection. To look for such areas, the researchers studied parts of the genome that vary between modern people — spots, perhaps, where you might have a "T" but your neighbor has a "G." Then they looked at these

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

areas in Neanderthals to see if they also varied in these positions. The idea is that modern humans and Neanderthals both acquired certain genetically variable areas from their common ancestor. But some of this shared variation may have been "wiped clean" if a beneficial mutation arose in humans, such as a change that helped us to develop language or engage in complex social interactions, Green says. Over many generations, this particular genetic change would "sweep" through humans, erasing any genetic variability we had in this particular section of the genome. This is an example of natural selection in action. Then over time, new genetic variation would pop up in humans due to random changes; this genetic variability, however, would not be shared with Neanderthals, he says. This non-shared variation, therefore, marks areas previously affected by natural selection.



The Neanderthal genome will help scientists better understand what Neanderthals looked like and how they were different from modern humans.

The team found 212 regions in the modern human genome that may have been shaped by natural selection. Some of these regions appear to be related to cognition and metabolism, Green says. In genetic studies of modern people, genetic changes to these regions have been associated with cognitive and metabolic abnormalities, such as autism, schizophrenia and diabetes. Therefore, some geneticists think these parts of the genome must somehow relate to cognition and metabolism because when something "goes wrong" in these areas, these abilities are affected.

But it may be premature to link these 212 regions to any particular function, notes Erik Trinkaus, an anthropologist at Washington University in St. Louis, Mo. "The reality is, with few exceptions … [the correlation between certain] genetic variants and medical issues [like autism] are just statistical associations," he says — it's not clear how those genetic variants are related to the abnormalities or how they actually work. Before scientists can figure out what genetic differences between modern humans and Neanderthals mean, he says, they need to better understand how the modern human genome itself works.

It gives us the opportunity to look … at components of our biology that we had no ability to investigate before.
– John Hawks, University of Wisconsin at Madison

Another issue with identifying instances of natural selection is that it's hard to find evidence for it in complex genetic traits, says Tim Weaver, a paleoanthropologist at the University of California at Davis. For example, some traits such as height are influenced by many parts of the genome, each having a small effect. "Selection may not strongly influence any single [part of the genome], and hence would not leave a detectable signature," he says. Therefore, he says, the researchers' list of 212 regions affected by natural selection is likely an underestimate.

Despite all of the challenges that lie ahead, many researchers are excited about the prospects of working with Neanderthal DNA. "It's the beginning stages of this," says John Hawks, a paleoanthropologist at the University of Wisconsin at Madison. "It gives us the opportunity to look … at components of our biology that we had no ability to investigate before." Weaver agrees. "The most interesting genetic studies of human uniqueness are those that address aspects … for which we have no direct fossil or archaeological evidence," he says. Now researchers can investigate the evolution of human physiological systems, language and even cognition in new ways.

Perhaps the next step is to bring together the range of scientists who study human evolution — paleoanthropologists, archaeologists and geneticists — so the various lines of evidence can be integrated. "There needs to be a synthesis of what [paleoanthropologists and archaeologists] have done and what [geneticists] have done," Green says. "We know in broad strokes what has happened in Neanderthal history, from what bones were found, where and from what time. The genetics now adds a wrinkle to this, and putting it together is something that needs to be done."

Wayman is the associate editor of EARTH.

©Shutterstock.com/Marcio Jose Bastos Silva

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Favorite Paleo Finds of 2010

Dinosaurs, hominins, trilobites, oh my! Paleontologists were hard at work in the past year, digging up some amazing discoveries. Here's a look at some of the EARTH staff's favorite paleo finds of 2010.

PUSHING BACK THE AGE OF DINOSAURS

Who: *Asilisaurus kongwe*

Where: Found in the Ruhuhu Basin, Tanzania

When: Lived 243 million years ago during the Middle Triassic

Claim to fame: *Asilisaurus* — a type of silesaur — predates the oldest-known dinosaur by at least 10 million years. Because silesaurs and dinosaurs are thought to have shared a common ancestor, *Asilisaurus*' antiquity suggests that the dinosaur lineage must have also been present 243 million years ago, *Asilisaurus*' discoverers say.

Source: Nesbitt et al., Nature, March 4, 2010.

BRIDGING THE *AUSTRALOPITHECUS-HOMO* GAP

Who: *Australopithecus sediba*

Where: Found in the Malapa cave site, South Africa

When: Lived 1.95 million to 1.78 million years ago during the Pliocene

Claim to fame: *Australopithecus sediba* is a new species of hominin. The species shared several cranial and dental features, such as small molars, with the genus *Homo*. Its discoverers say these similarities make *Australopithecus sediba* a good candidate for ancestor of the *Homo* lineage.

Source: Berger et al., Science, April 9, 2010.

Bottom: photo by Brett Eloff, courtesy of Lee Berger and the University of Witwatersrand; top: Marlene Donnelly, Field Museum

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

A CROC WITH AN IDENTITY CRISIS

Who: *Pakasuchus kapilimai*

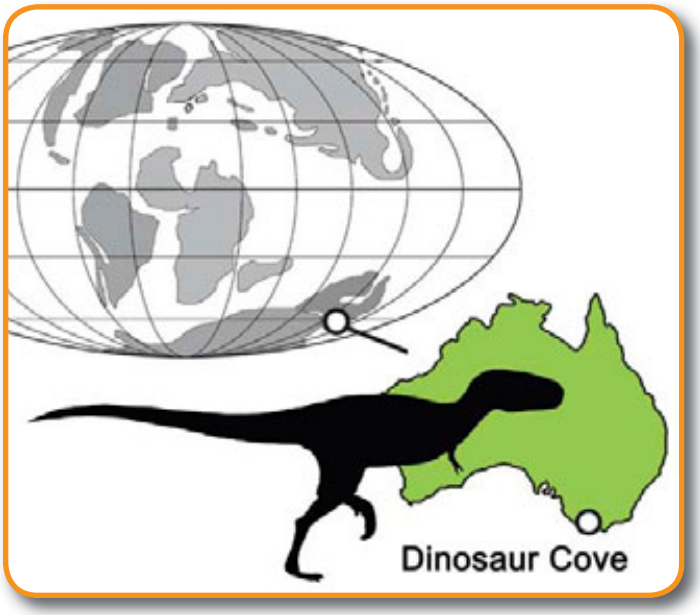
Where: Found in the Rukwa Rift Basin, Tanzania

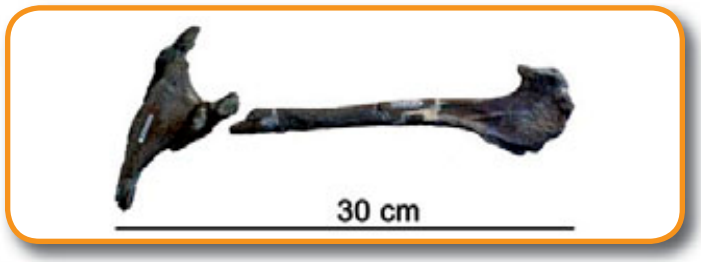
When: Lived 105 million years ago during the Early Cretaceous

Claim to fame: The cat-sized crocodile-like reptile *Pakasuchus* had teeth that resembled the canines, premolars and molars found only in mammals. Mammals use their specialized dentition to chew grub, unlike crocodiles, which swallow their prey whole. *Pakasuchus*' discoverers say the diminutive croc's unusual features indicate it probably behaved more like a mammal than a reptile.

Source: O'Connor et al., Nature, Aug. 5, 2010.

A TYRANNOSAUR ON THE WRONG SIDE OF THE PLANET





Who: Pubis bone belonging to an unknown tyrannosauroid

Where: Found in Dinosaur Cove, Victoria, Australia

When: Lived 110 million years ago during the Early Cretaceous

Claim to fame: The fossil is the first evidence that tyrannosauroids (the superfamily that includes *Tyrannosaurus rex*) lived in the Southern Hemisphere. The 30-centimeter-long pelvic bone indicates small tyrannosauroids probably lived all across the planet early in tyrannosauroid history.

Source: Benson et al., Science, March 26, 2010.

Bottom to top: ©Dr. Roger Benson, Cambridge; ©Dr. Roger Benson, Cambridge; Zina Deretsky, National Science Foundation; Mark Witton, University of Portsmouth; John Sattler, Ohio University College of Osteopathic Medicine

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

FOSSILS CAST DOUBT ON ORDOVICIAN EXTINCTION

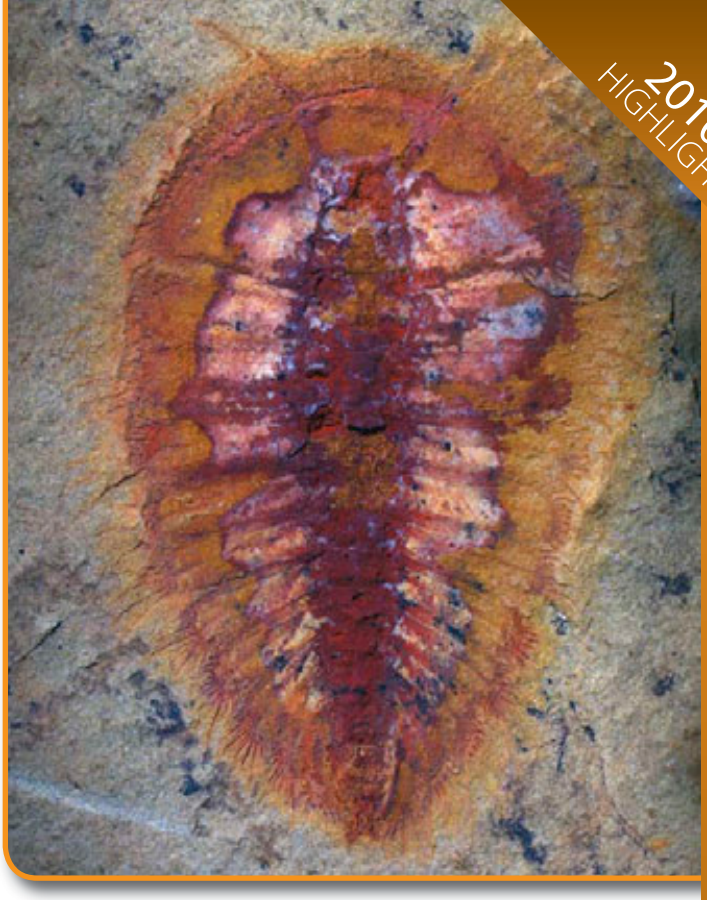
Who: More than 1,500 fossils of soft-bodied marine creatures, including arthropods and mollusks

Where: Found in the Lower and Upper Fezouata Formations, Morocco

When: Lived 480 million to 472 million years ago during the Ordovician

Claim to fame: Some of the soft-bodied animals in the assemblage resemble the famous fossils of the Burgess Shale. Burgess Shale-type animals arose during the Cambrian explosion, but then disappeared by the Ordovician; therefore, the discovery of similar animals living during the Ordovician suggests poor preservation, not a mass extinction, better explains the dearth of soft-bodied fossils from this time, the researchers say.

Source: Van Roy et al., Nature, May 13, 2010.



DINOSAURS IN COLOR

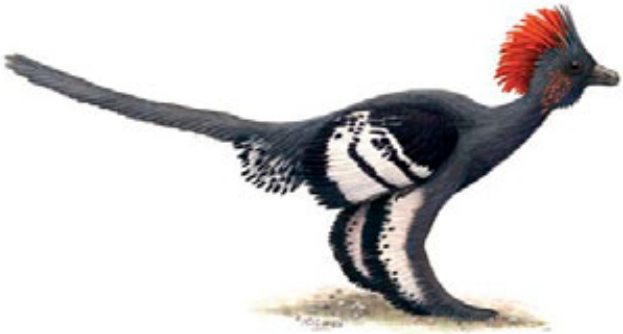
Who: *Sinosauropteryx*; *Anchiornis huxleyi*

Where: Both found in Liaoning Province, China

When: *Sinosauropteryx* lived 131 million to 120 million years ago during the Early Cretaceous; *Anchiornis* lived 160 million to 150 million years ago during the Late Jurassic

Claim to fame: These feathered dinosaurs aren't new to science, but this year two teams studied these species to determine for the first time the color of dinosaurs. Both teams studied melanosomes in the dinos' fossilized feathers, which give cells their pigment. *Sinosauropteryx* had an orange tail with white stripes; *Anchiornis huxleyi* had black and white wings, gray legs and orange-brown feathers sprouting from its head.

Source: Zhang et al., Nature, Feb. 25; Li et al., Science, March 12, 2010.



Bottom left: Chuang Zhao and Lida Xing; bottom right: Michael DiGiorgio/Yale University; top: Peter Van Roy

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

A Comment

Definitive Statements: A New Trend?

Megan Sever

"This *is* the way it was." Or: "This *is* what is happening." Hmmm. Scientists don't usually make such definitive statements, given that in science, there are almost always caveats. Yet in the last year, such statements have been issued by several large groups of scientists who have come together to support a certain point of view. Are scientists feeling the need to dig in their heels because of public pressures? Or are we actually reaching some consensus?

In particular, one wonders what brought about the sudden interest in making such blanket statements on two of arguably the most contentious issues in the geosciences: mass extinctions and climate change. Scientific societies have been making those consensus statements for a couple of years now about climate change, in an effort to present a united front to naysayers — so that's not entirely surprising. As for extinctions, large groups of scientists have made several definitive statements this year: that the end-Cretaceous extinction event was caused by an asteroid impact; and then groups came down on both sides of the debate about whether a comet caused the Younger Dryas cold spell.

In the March 5 issue of Science, a team of 41 scientists from institutions around the world published a paper that reviewed all the available evidence over the past 30 years and concluded that an asteroid that struck the Yucatán Peninsula in Mexico 65 million years ago killed off half of all species on the planet, including the dinosaurs. The impact theory is the "only plausible" explanation of the end-Cretaceous mass extinction, they wrote.

The asteroid impact theory was first published by Luis and Walter Alvarez and colleagues in Science in June 1980. They hypothesized that a 6- to 14-kilometer-wide asteroid struck Earth with a force a billion times more powerful than the atomic bomb that hit Hiroshima. The impact sent out a ball of fire and tremendous amounts of dust and material into the atmosphere, choking out life and collapsing the food chain.

Since that theory was presented, others have also been floated — most notably that massive volcanic activity caused the extinction. The Deccan Traps in India formed during an eruption of some 1.1 million cubic kilometers of basalt over a period of about 1.5 million years. Researchers have reported that this eruption would have cooled the atmosphere and produced enough acid rain to choke out life.

However, the March paper in Science stated that all of the geological evidence suggests that the extinction event occurred too rapidly to have been caused by the Deccan Traps eruption. Plus, the scientists wrote, models and data agree that the amount of poisonous gases released by the eruption would not have caused enough widespread and long-lasting damage to have created a rapid mass extinction.

> **The impact theory is the "only plausible" explanation of the end-Cretaceous mass extinction.**
> **– Schulte et al., Science, March 5, 2010**

Will this "consensus statement" end the debate about what killed the dinosaurs? Not a chance. But on the 30th anniversary of the original theory's presentation, it's nice to know a lot of people do still agree with it.

Over the past couple of years, scientific meetings of the American Geophysical Union (AGU) and the Geological Society of America (GSA) have hosted multiple sessions — often highly contentious — on the cause of the Younger Dryas cold period and the megafauna extinctions, both of which occurred roughly 12,900 years ago. The issue at hand is whether a comet hitting the planet or exploding in the atmosphere could have caused the cold period and the extinctions, or whether it was something else (the leading thought is that melting ice sheets produced a catastrophic discharge of freshwater into the Atlantic Ocean, shutting down ocean circulation).

Some researchers say they have definitively found all the telltale evidence of an impact: nanodiamonds, microspherules, "fullerenes" with extraterrestrial helium and elevated iridium levels, and charcoal, black mats and other signs of widespread fires. Meanwhile, other papers have discounted each piece of that evidence.

©AGI/Meteor Studios

No matter how strong the scientific consensus is, it doesn't seem to change people's minds if it conflicts with personal beliefs.

Both sides have presented strongly worded statements supporting their points of view.

Who's right? No one knows for sure. But as freelance writer David B. Williams wrote in the June EARTH, only one thing was clear after multiple sessions on the topic at last year's AGU and GSA meetings: No one had changed anyone else's mind.

But if you want to get into a real battle, bring up climate change. Assessments by the National Academies of Science in 2005, the National Research Council in 2006 and the Intergovernmental Panel on Climate Change in 2007 found that the global climate is changing and that human activities are at least in part to blame. In 2008, AGU released a similar consensus statement. In April 2010, GSA published its own consensus statement, also stating that the evidence suggests that human activities account for most of the warming since the mid-20th century. The American Association of Petroleum Geologists issued its statement in 2007, noting that although its members were "divided on the degree of influence that anthropogenic carbon dioxide has on recent and potential global temperature increases," the members still supported more research on the topic. In May, the National Research Council issued three more reports emphasizing why the U.S. should act now to reduce greenhouse gas emissions and why the U.S. needs to "develop a national strategy to adapt to the inevitable impacts of climate change."

Several researchers undertook a study this year to determine whether consensus statements actually change anyone else's mind, and to understand why the public remains sharply divided even when expert scientists largely agree. Law professors Dan Kahan of Yale University and Donald Braman of George Washington University worked with political science professor Hank Jenkins-Smith of the University of Oklahoma to study topics as varied as climate change, nuclear waste disposal and gun control. They found that people's own cultural values trumped "expert opinions," they reported in September in the Journal of Risk Research. No matter how strong the scientific consensus is, it doesn't seem to change people's minds if it conflicts with personal beliefs.

"The problem won't be fixed by simply trying to increase trust in scientists or awareness of what scientists believe," Braman said in a press release accompanying the paper. "To make sure people form unbiased perceptions of what scientists are discovering, it is necessary to use communication strategies that reduce the likelihood that citizens of diverse values will find scientific findings threatening to their cultural commitments."

Perhaps "extinctions" and "climate change" have joined "religion" and "politics" on the list of topics "not to be discussed in mixed company."

Sever is the managing editor of EARTH.

Beyond Mars

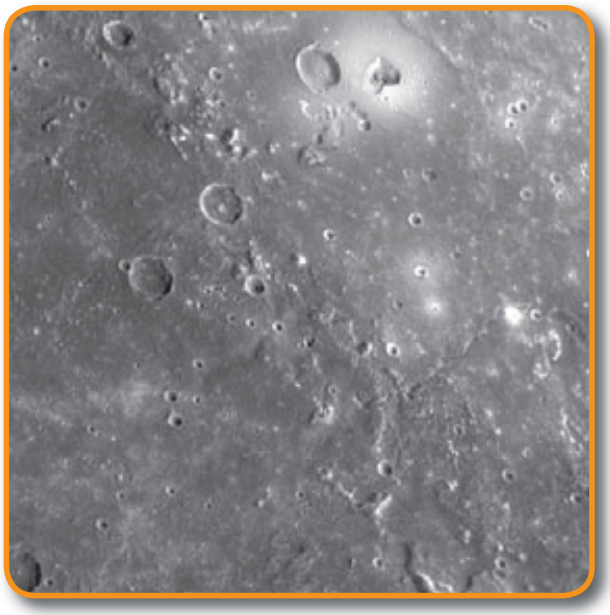
Water, magnetic fields, minerals and more on other planetary bodies

Carolyn Gramling

The ongoing search for evidence of water and signs of life — whether in the present or in the past — on Mars continues to captivate. But the Red Planet wasn't the only planetary body of interest in the inner solar system this year. New observations of Mercury and the moon are inching us closer to understanding the origin and makeup of our solar system — and perhaps a deeper understanding of the ancient history of our own planet.

EACH OF THESE THINGS IS NOT LIKE THE OTHERS

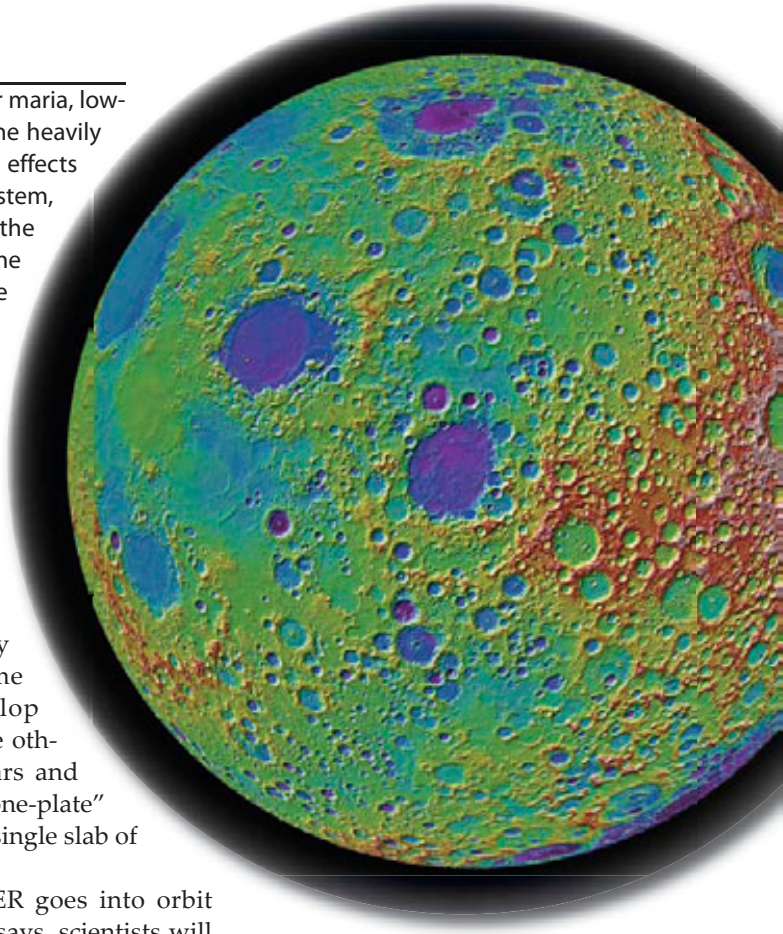
The four planets in the inner solar system are all terrestrial, and each is differentiated into crust, mantle and core. But beyond that common ground, Mercury, Venus, Earth and Mars have each gone their own way. Mercury has remained the most mysterious. Until NASA's MESSENGER mission — launched in



When the MESSENGER spacecraft flew by Mercury in October 2008, it discovered that previously uncharted regions of the planet had large craters. The smoothness of the craters suggests they were later flooded with lava, indicating Mercury had active volcanism for billions of years. MESSENGER completed its third and final flyby in September; scientists anticipate more surprises when MESSENGER enters into orbit around Mercury in March 2011.

NASA/JHU-APL/CIW

This PDF is licensed for personal use only. MjAxMC0xMjkyOTE4OTEzJQ3



Most of the dark blue areas in this lunar topographic map are lunar maria, low-lying regions composed of volcanic lava flows that formed after the heavily cratered lunar highlands. The large, near-circular basins show the effects of the early impacts on early planetary crusts in the inner solar system, including Earth. The light blue region in the middle-left part of the moon is Mare Tranquillitatis, the site of the Apollo 11 landing. The dark blue oval-shaped region above it is Mare Serenitatis, where Apollo 17 landed.

2004 — everything scientists knew about Mercury came from telescopes and a single probe, Mariner 10, which flew by the planet three times in the 1970s.

Mariner 10 mapped about 45 percent of the planet's surface, offering tantalizing tidbits of information: The planet appeared to have a very large core, a helium-rich atmosphere and a weak magnetic field. Some highly cratered regions on the planet's surface contained smooth deposits — possibly lava. But planetary geologists at the time were wary of assuming that the deposits were volcanic because of false positives on the moon, says Sean Solomon, a planetary geologist at the Carnegie Institution of Washington in Washington, D.C., and lead scientist on the MESSENGER mission.

Now, MESSENGER has flown by Mercury three times, snapping images of the planet's surface, and is on a trajectory to enter into orbit around Mercury in March 2011. The first two flybys, in January and October 2008, confirmed the early suggestions of widespread volcanism on the planet's surface. Images also suggested that volcanism has occurred throughout much of the planet's history. "Rocks have erupted many times over the history of the planet," Solomon says. "It provides an important window into the interior heat budget and history of the cooling of the planet."

The third flyby, in September 2009, revealed a large impact basin, dubbed Rachmaninoff, that also seemed to show volcanism: The images revealed that the floor of the basin was a smooth plain that had once been liquid, Solomon says. Several lines of evidence pointed to the material being the result of volcanism — making it the youngest volcanic material yet found on Mercury, probably "as recently as the second half of the solar system's history," he says.

The confirmation of volcanism "places Mercury more squarely in the family of other inner planets that have had extensive, widespread, protracted volcanism," Solomon notes. The finding also gets at larger questions of how terrestrial planets evolve, how they cool and why some (like Earth) develop plate tectonics while others (like Venus, Mars and Mercury) become "one-plate" planets with only a single slab of lithosphere.

Once MESSENGER goes into orbit next year, Solomon says, scientists will be able to glean more about the planet's geologic history, including the composition of the rocks and minerals on its surface. Mercury — which has an elliptical orbit that takes it between 46 million and 70 million kilometers from the sun — also appears to have icy deposits within the permanently shadowed craters at its poles. "That's one mystery that we would love to solve," he says.

Another mystery involves the planet's unusually large and molten core — it comprises 60 percent of the planet's volume — and its weak magnetic field. That Mercury, the smallest of the inner planets, has a molten core and a planetary magnetic field at all is surprising, Solomon says. Venus doesn't have one, and Mars did but no longer does. Earth's magnetic field is generated by convection in its liquid metal outer core. How tiny Mercury still has a molten core that generates a magnetic field isn't clear. Once MESSENGER goes into orbit, it will be in a better position to sketch out the geometry of the core and assess the variability of the magnetic field strength over time.

The flybys have kicked off a period of rapid hypothesizing about Mercury, Solomon says. And the best part, he adds, is that planetary geologists will soon have data to begin to test their ideas.

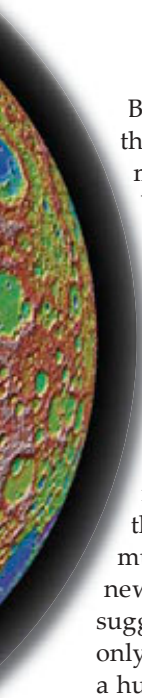
TO THE MOON

Like Mars, the moon dominated many headlines over the past year. And as on Mars, much of the interest was in the search for water. Deep craters at the moon's poles remain in permanent shadow, never seeing the light of the sun; previous missions have suggested that these deep craters may contain some amount of water-ice.

This year, a number of studies suggested the moon contains more water than once thought. For example, a NASA radar instrument on the Indian Chandrayaan-1 lunar satellite found evidence of as much as 600 metric tons of water-ice in 40 craters at the lunar north pole, reported scientists in Geophysical Research Letters in March. Meanwhile, a re-analysis of moon rocks collected by the Apollo missions, as well as of a lunar meteorite from Africa, suggested the moon contains as much as 100 times more water than previously estimated, according to research published in Proceedings of the National Academy of Sciences in June. The new estimate, by scientists at the Carnegie Institution of Washington, was based on the amount of hydroxyl in grains of apatite found in the rocks; the hydroxyl can only form if the apatite crystallizes from water-rich magma.

NASA/Goddard/MIT/Brown

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3



But other studies this year suggested that although the surface of the moon may contain water, its interior is bone-dry. That, in turn, suggests that whatever water the moon has came from comet impacts. In August, another re-analysis of Apollo moon rocks looked at the chlorine isotopes contained in the rocks. The ratio of two isotopes, chlorine-37 to chlorine-35, is an indicator of the presence of water in the primitive moon, because that ratio varies depending on how much hydrogen is in the rocks. The new analyses, published in Science, suggested the moon's interior contains only a fraction — a ten-thousandth to a hundred-thousandth — of the water in Earth's interior.

Detecting evidence of water is one of the goals of NASA's Lunar Reconnaissance Orbiter (LRO) mission, which launched in 2009. In September, LRO completed the first phase of its mission, a yearlong exploration of the lunar surface, from which LRO produced a detailed map of the moon's poles, as well as data on temperatures and radiation levels.

LRO is also mapping the dozens of scarps — raised cliffs caused by a fault near the moon's equator — found by astronauts on the Apollo 15, 16 and 17 missions between 1971 and 1972, and has found even more, spread farther across the moon's surface, all from within the last billion years or so. What the scarps may show, scientists suggest, is that the moon is actually shrinking as its interior cools. As the interior contracts, the crust cracks to adjust to the smaller volume.

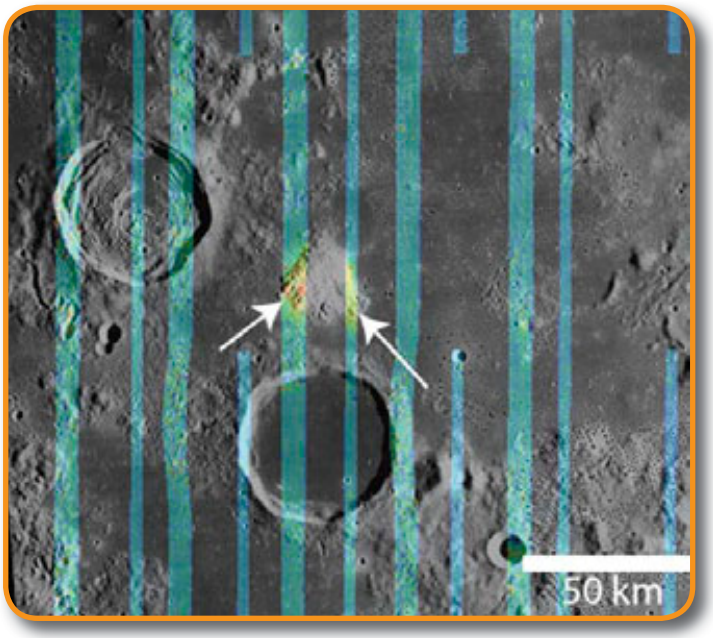
Other landforms on the moon are telling more of its story. The moon's pockmarks record billions of years of bombardment by meteorites — bombardment that likely struck Earth as well. On Earth, however, the constant recycling of the crust due to plate tectonics has long since erased evidence of the oldest impacts, as well as how those impacts might have affected life on Earth at the time. Because the moon has no plate tectonics and older craters are only erased by younger craters, lunar bombardment can act as a proxy for ancient bombardment on Earth. In September, scientists used the new LRO data to construct a topographic map of the moon, finding two distinct groups of craters: older, larger craters later filled in with lava, and younger, smaller craters. The transition from these giant craters to smaller craters occurred about 3.8 billion years ago, they found — a transition that likely affected all of the planetary bodies in the inner solar system.

In addition, new data have emerged on the moon's chemical makeup, suggesting a surprisingly complicated geologic and chemical history. A longstanding hypothesis for the origin of our closest neighbor is known as the "magma ocean" hypothesis, which suggests that the moon is made up of material ejected from Earth after a huge, Mars-sized object slammed into our own planet about 4.5 billion years ago. In June, this hypothesis got a boost from findings by the Japanese lunar explorer SELENE/Kaguya. The lunar explorer had found outcrops of olivine, a common mineral in Earth's mantle, exposed in impact craters at the moon's surface. If the olivine did originate in the moon's mantle before exposure by bombardment, that would support the idea that the moon was once a molten magma ocean, researchers reported in Nature Geoscience.

Meanwhile, LRO provided even more insights into the rocks and minerals on the moon's surface. Scientists have long known that the moon's maria — the dark patches once imagined by Earth-bound astronomers to be lakes — were actually regions of iron- and magnesium-rich basalt. The lighter-colored highlands, meanwhile, were considered to be largely composed of anorthosite, a rock rich in calcium and aluminum.

But the new LRO data revealed that each of these terrains contained within them more complexity than once thought. The orbiter's Diviner Lunar Radiometer Experiment instrument took spectral measurements of the surface minerals, each of which absorbs and emits energy with a unique spectral signature. Using these data, scientists created a global, high-resolution infrared map of the minerals on the lunar surface, with some surprising results, they reported in September in Science. For example, in several locations, Diviner found highly silica-rich minerals, including quartz and potassium- and sodium-rich feldspar. These minerals — unlike the minerals that make up basalt — only form after a significant amount of chemical differentiation, a gradual process during which minerals in magma slowly cool and solidify; their presence thus suggests that the moon's geologic history may be much more complex than once thought.

LRO's Diviner instrument allows scientists to spot silicic minerals in the moon's crust. Hansteen Alpha (arrows) is believed to be a silicic volcano. Red and orange indicate highly silicic compositions.



NASA/Goddard/UCLA/Stony Brook

Gramling is a reporter and Web editor at EARTH.

This PDF is licensed for personal use only. MjAxMC0xMlcxMjkyOTE4OTEzTjQ3

The Hunt for Other Earths

Meg Marquardt

In 1992, astronomers made an amazing announcement: For the first time, they had spotted planets orbiting a distant star. Discoveries of more extrasolar planets — exoplanets — went from a slow trickle to a steady stream as technology improved. By 2010, more than 300 exoplanets had been identified. But last spring, that stream turned into a deluge: NASA announced that the telescope at the heart of the Kepler mission had identified 700 new stars that likely have orbiting planets — and some of these planets may be in the so-called habitable zone. The holy grail is to find Earth-like planets that might harbor life. But that's proven to be quite a challenge.

Most of the exoplanets that astronomers have identified are not Earth-like at all. Most are "hot Jupiters," large gassy planets that orbit closely to their stars. Researchers have also found hot super-Earths (planets that have a mass larger than Earth, but smaller than a gas giant) and large, icy planets. Ground-based observatories have found many of these planets using the "transit method."

When an orbiting planet moves in front of its star relative to an observatory, the brightness of the star appears to briefly dim. The bigger the planet and the closer it is to the star, the larger the dimming effect. This is why scientists have largely identified gas giants — Earth-sized planets produce such a small dimming effect that it's extremely difficult to detect. From ground-based observatories, the effect is nearly impossible to see, because Earth's atmosphere distorts the light arriving from distant stars. Only stars that are relativity close to Earth can be closely studied by a ground-based observatory.

That's where Kepler comes in. The mission, named for Johannes Kepler, the German astronomer who first described the laws of planetary motion in the early 17th century, was launched on March 6, 2009, and is using the transit method to examine a 3,000-light-year-wide section of the Milky Way, inspecting more than 100,000 stars for changes in apparent brightness. Because Kepler is in the same orbit around the sun as Earth is, but is trailing the planet, the mission's telescope won't be blocked by Earth or affected by the light that reflects off the planet's surface. And unlike Hubble, which has its targets occasionally blocked by Earth because it is in a low-Earth orbit, Kepler will be able to keep a star in focus for an extended period of time, allowing scientists to watch a possible planet transit in front of its star multiple times.

As of this fall, Kepler had already investigated 156,000 stars and found at least 700 that are likely to have planets. It will take a while for Kepler to measure the precise size and orbits of all the planets, but there's time. The mission is expected to run until at least November 2012. Researchers say it'll probably take that long to locate and verify any Earth-sized planets within a habitable zone: Transits of planets orbiting stars like our sun in habitable zones only happen about once a year, and to verify the data, scientists require at least three transits.

Besides hunting for Earths, Kepler is also compiling data on what types of stars have orbiting planets and at what distance from the star the planets are in orbit. These data will help scientists pare down targets for future missions.

"This is the most precise, nearly continuous, longest and largest dataset of stellar photometry ever," said David Koch, deputy principal investigator of the Kepler mission at NASA's Ames Research Center in Moffett Field, Calif., in a press statement in June. "The results will only get better as the duration of the dataset grows with time."

In September, as Kepler's data were coming in, Samuel Arbesman, a computational social scientist and a postdoctoral researcher at Harvard Medical School in Boston, Mass., and Gregory Laughlin, an astrophysicist at the University of California at Santa Cruz, predicted that scientists would find the first Earth-like habitable exoplanet in May 2011. Their study, published at arXiv, was based on scientometrics — the science of measuring the progress of science itself and predicting how a given field might grow and expand. Based on math and science trends as well as the rate of exoplanet discoveries since 1995, Arbesman and Laughlin estimated that if discoveries continue at their current rate, we'll find an Earth in the first half of 2011, "with the likeliest date being early May," they wrote.

That discovery may have come sooner than predicted — although the jury is still out. On Sept. 29, researchers led by Steven S. Vogt of the University of California at Santa Cruz announced that the W.M. Keck Observatory in Hawaii had found Gliese 581g, a rocky planet only three times more massive than Earth — large enough to maintain a watery atmosphere. Gliese 581g appears to orbit its star in the so-called Goldilocks zone — that perfect place where a planet could have surface temperatures that allow for the existence of liquid water and where a planet could retain an atmosphere. But in October, a team of Swiss astronomers led by Francesco Pepe of the Geneva Observatory announced at the Astrophysics of Planetary Systems meeting in Turin, Italy, that based on their own data, they saw no evidence of a planet in star Gliese 581's habitable zone — although they could not disprove it either. Several more years of data may be necessary to confirm the presence of such a small planet.

If it does exist, whether Gliese 581g can support life bears further scrutiny. The planet's calculated year is only 37 Earth-days long, and it appears to be tidally locked — meaning it doesn't rotate. The side that faces the sun would be too hot for life, and the side that faces away too cold. But life could exist in perpetual twilight, along the transition zone between light and dark. To learn more about planets like Gliese 581g, more powerful, dedicated telescopes like Kepler and Europe's CoRoT will be called into action. Stay tuned.

Marquardt is a freelance writer in Omaha, Neb.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

EXOPLANET HIGHLIGHTS OF 2010

Kepler has already spotted a handful of planets this year, and ground-based telescopes identified more than two dozen. Some of them had strange surprises to share.

Kepler 9b and 9c orbit the same star. A smaller Earth-sized planet may also orbit the star.

HOTTER THAN HADES

When the first data from Kepler were announced in January, the five newly discovered planets were extra hot. Called Kepler 4b, 5b, 6b, 7b and 8b, these planets have surfaces that are thought to be between 1,090 and 1,650 degrees Celsius — hotter than molten lava. Kepler 7b is especially weird. Astronomers think it has one of the lowest densities of any planet discovered to date: It has only half the mass of Jupiter, but has twice Jupiter's diameter. 4b orbits its star at the closest distance of the five new planets; its orbit is only 3.2 days long. By comparison, Mercury, our sun's closest neighbor, has an orbit that lasts 87.9 days.

In August, Kepler added two more hot Jupiters to its discovery list. Kepler 9b and 9c are unique because they are the first confirmed exoplanets to orbit the same star. And that might not be the only surprise the system holds: Calculations suggest a smaller, super-Earth planet just 1.5 times larger than Earth may also be in the system. But don't expect this super-Earth to have life. Preliminary data suggest the planet is close enough to its star to have a lightning-fast orbit of 1.6 days.

THE BACKWARD PLANETS

Scientists have long assumed that planets orbit around stars in the same direction as their star rotates. In our solar system, for example, the sun rotates clockwise, and all of the planets orbit in a clockwise direction. This synchronicity is attributed to how large gas planets form out of the dust clouds that surround stars in the infancy of solar systems.

But in late 2009, an exoplanet was spotted orbiting in the opposite direction of its star's rotation. Scientists thought it was an anomaly, but then a second was found. And then a third. And in April 2010, when researchers at the Observatory of Geneva in Switzerland announced that six more planets had been found orbiting the "wrong" way, scientists were forced to rethink how gas planets evolve and move.

One new hypothesis is that as planets move closer to their star during formation, the pull of gravity from other nearby stars and planets can affect the plane of the planets' orbit, sometimes causing a tilt.

Most known planets orbit in the same direction as their star rotates. However, some orbital paths are tilted to such an extreme degree that the planet begins to orbit backward.

Another hypothesis is that stars in newly forming solar systems may actually tilt and flip themselves as the planet-forming disc influences the dynamics of the star's magnetic field. Or it could be some combination of many unusual interactions. In the end, most planets still keep an orbit that is close to 90 degrees. But some of the planets end up with an orbit with such an extreme tilt — 150 degrees relative to the normal plane — that they begin to move in reverse to the star's rotation.

A FAMILIAR FACE

In March, the CoRoT satellite, run by the French Space Agency and the European Space Agency, picked up a familiar face: a planet that is similar to the gas giants found in our solar system. CoRoT-9b is a "cool" Jupiter. It orbits its star, in the constellation Serpens, at almost the same distance that Mercury orbits the sun. That distance makes it the exoplanet with the longest "year" known to date, with an orbital period of 95 days. Because the planet is so far out, its transit period across its star lasts for eight hours, giving scientists ample time to study its properties. They've learned that CoRoT-9b, because it's so far away from its star, is practically frigid compared to hot Jupiters: Its temperatures range from minus 20 to 160 degrees Celsius. And it's similar to Jupiter and Saturn in having a composition of primarily helium and hydrogen.

The European satellite CoRoT spotted a planet that is similar to the gas giants in our own solar system. The planet's composition is primarily helium and hydrogen, and it has a relatively temperate climate of minus 20 to 160 degrees Celsius.

Bottom to top: Gabriel Pérez – Instituto de Astrofísica de Canarias; ESO/L. Calçada; NASA/Ames/JPL-Caltech

This PDF is licensed for personal use only. MjAxMC0xMjkyOTE4OTEzJQ3

Major Quakes and Micro-Shakes in 2010

Mary Caperton Morton

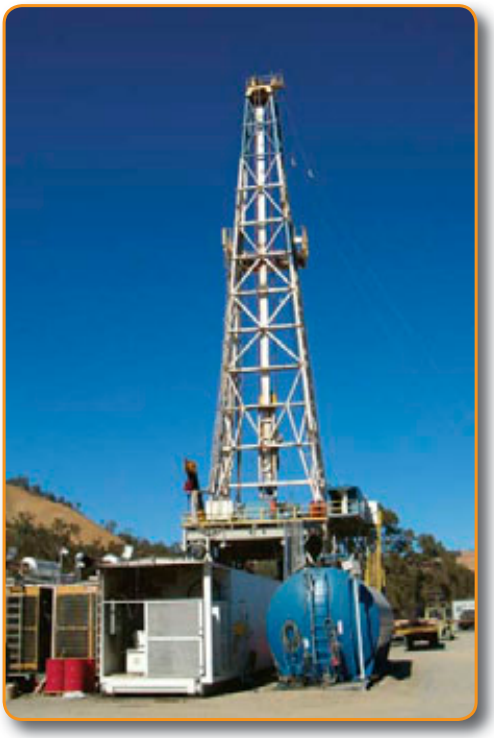
At times in 2010, it seemed the world was shaking itself to pieces. A barrage of headline-grabbing earthquakes in the Solomon Islands, Haiti, Chile, Turkey and Baja California had the public asking whether the planet's plates were moving more vindictively than usual.

Major earthquakes did cause tremendous damage and untold suffering in places like Port-au-Prince, where more than 200,000 Haitians were killed in a magnitude-7.0 quake in January, but a look back at seismicity trends over the past few decades shows that 2010 was nothing more than an average year.

"When you get a few big earthquakes in quick succession, people start to worry," says Chris Rowan, a geophysicist at the University of Edinburgh in Scotland. Last summer, in the wake of several devastating earthquakes, Rowan drew upon the global seismic records compiled since the 1960s by the U.S. Geological Survey (USGS) and graphed earthquakes year by year according to frequency and energy released.

"With all the buzz out there, I thought it would be interesting to use the USGS earthquake catalogs to show people why they shouldn't be worrying about some sort of seismic apocalypse," he says.

Researchers are studying movement deep belowground at the San Andreas Fault Observatory at Depth (SAFOD).



Ben vander Pluijm

Rowan's graphs, embedded in an entry entitled "The Seismic Non-pocalypse" on his geoscience blog, Highly Allochthonous, show that despite the headlines, 2010 was on par with the USGS estimated annual average of 13 magnitude-7.0 quakes, with a magnitude-8.0 event occurring every year and a half.

A graph depicting the amount of energy released by quakes over the past 50 years shows a spike attributed to Chile's colossal magnitude-8.8 event in February, but 2010 is still dwarfed by Sumatra's magnitude-9.1 event in 2004 and two magnitude-9.0 events in Alaska and Chile in the early 1960s. The moment magnitude scale is logarithmic so a magnitude-9.0 quake releases 32 times more energy than a magnitude 8.0 and more than 1,000 times more energy than a magnitude 7.0.

"If there was ever a time to announce the oncoming seismic apocalypse, the early 1960s would have been the time to do it (of course, you would then have had to cope with the embarrassment of us still being here)," Rowan wrote in EARTH in July.

Rowan cautions against drawing too many conclusions from earthquake records, however. "Looking at events over one year or even a few decades can't tell you much about earthquake cycles, which happen over timescales of hundreds of years," he says.

In the future, public anxiety about earthquakes should be channeled into better disaster preparation, he says. Despite being 500 times stronger, Chile's massive quake in February had far fewer casualties than the Haitian earthquake, in large part due to Chile's experience with strong earthquakes and widely enforced quake-resistant building standards.

"Large earthquakes happen all the time," Rowan says. "But sometimes you get the tragic coincidence of a large earthquake occurring near a poorly built city. That's what makes the newspapers and gets people's attention."

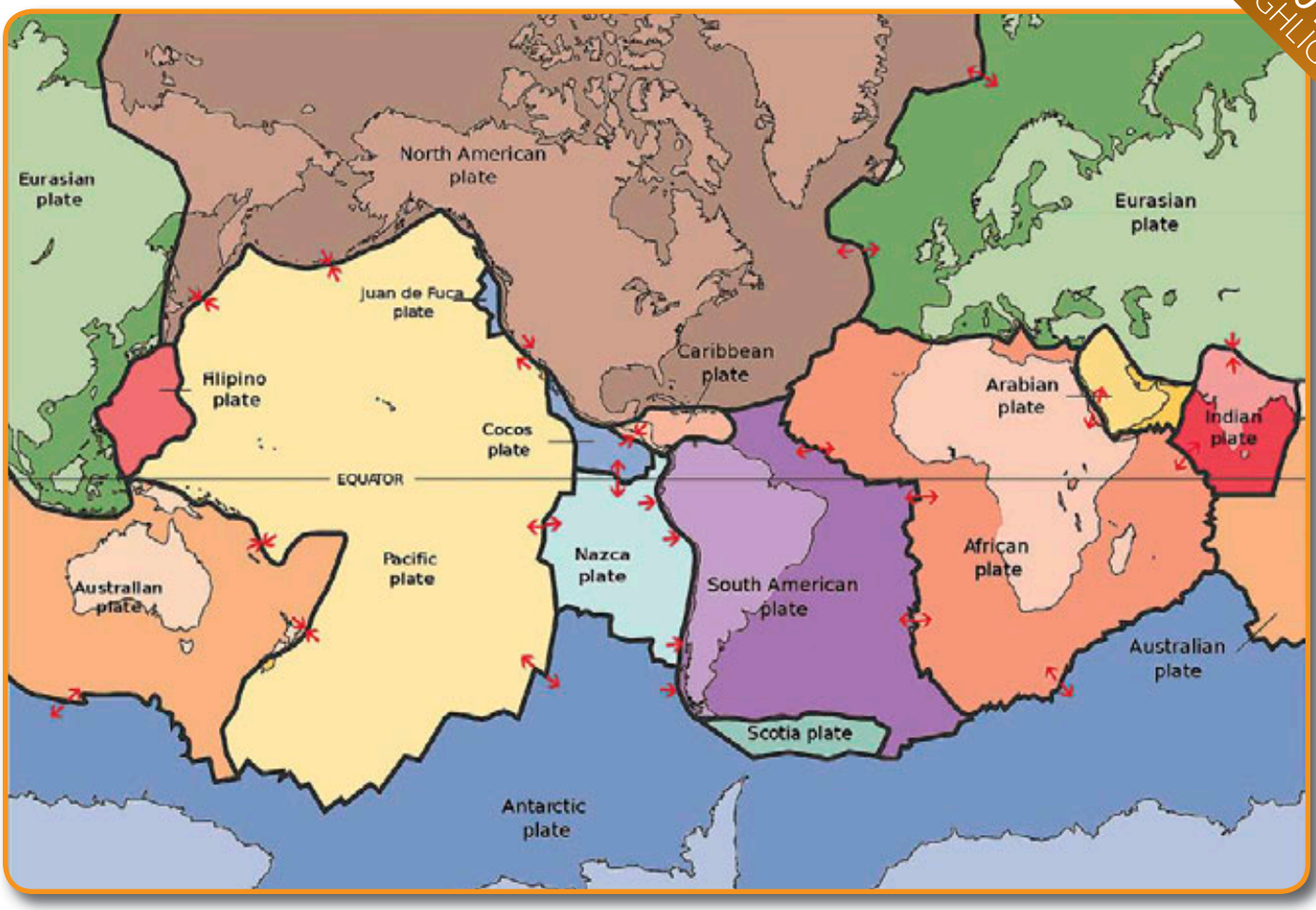
TINY QUAKES REVEAL BIG CLUES

While earth-shattering quakes were making all the headlines this year, seismologists and geophysicists were increasingly interested in shaking on the other end of the seismic scale. Aseismic slip, microquakes and tremors garnered more research attention than ever, but how these tiny events fit into the grand scheme of planetary quaking remains a mystery.

People who only know about earthquakes from the headlines may be surprised to learn that the Richter scale goes into negative numbers and that some faults move without producing any shaking at the surface. Research on the San Andreas Fault in California, along the coast of Peru and elsewhere is demonstrating that these benign events can reveal important information about their destructive counterparts.

"We have found that the tiniest earthquakes, many of which are smaller than magnitude zero, share important characteristics with the big earthquakes," says William Ellsworth, a geophysicist and seismologist at USGS in Menlo Park, Calif. By studying how these small events are triggered and how they propagate along meter-long mini-faults, scientists are hoping to better understand how huge, earth-shaking events take place.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3



Recent research at some of the world's subduction zones, such as where the Nazca Plate dives beneath the South American Plate, shows how energy moves aseismically.

U.S. Geological Survey

Scientists divide small, nondestructive events into three categories: aseismic slip, microquakes and tremors. Aseismic slip occurs when plates move past each other smoothly, without producing a seismic signal. Microquakes operate in much the same manner as earthquakes, but generally have a magnitude less than 2.0 and have been measured as small as magnitude negative 4.5. Tremors usually appear as a series of tiny earthquakes that occur deeper than normal earthquakes and often show periodicity, recurring in cycles every few months or years.

Unlike larger quakes, which occur a handful of times a year, these tiny perturbations are almost constant along active faults, giving scientists a stream of valuable data. Studying such tiny events presents unique challenges, however. Aseismic slip can only be detected through GPS networks, while tremors and microquakes are best studied with specialized, underground seismic instruments.

One project that is studying the small end of the earthquake scale is the San Andreas Fault Observatory at Depth (SAFOD) joint venture between USGS and the National Science Foundation, which has monitored seismic instruments installed 2.5 kilometers underground, beneath Parkfield, Calif., since 2008.

"At the surface, we can only record very limited data about small, high-frequency events because we lose the signal as it propagates through the earth," says Ellsworth, who oversees the seismic division of SAFOD. SAFOD's underground seismometers have now been in operation for two years, and Ellsworth says the project is now entering "a very scientifically exciting time" as the first round of seismic studies nears completion. Evidence of clay-lubricated aseismic creep along the fault, covered in EARTH in October, and several seismic studies are slated for presentation at the 2010 American Geophysical Union meeting this month in San Francisco, Calif.

Other projects aimed at studying nondestructive plate movements are currently under way in several other locations around the world.

In Peru, a team using GPS instruments to track aseismic ground movements found that more than half the movement along the central Peru megathrust fault takes place aseismically. Measuring aseismicity is an important step in assessing seismic risk, says team leader Hugo Perfettini, a geophysicist at the Institut de Recherche pour le Développement in Grenoble, France, because the size, location and frequency of earthquakes that a fault can generate depends in part on how much movement occurs between seismic events as aseismic creep, though to what extent, scientists don't yet fully understand.

Studies of tremors occurring deep beneath Vancouver Island, British Columbia, are revealing patterns of strict periodicity, where identical tremors reoccur every 14 months like clockwork. The apparent predictability of these events has allowed scientists to monitor the tremors more closely than ever, and in

This PDF is licensed for personal use only. MjAxMC0xMjkyOTE4OTEzLTQ3

the past two years, evidence has emerged to support the idea that water seeping into the fault zone may lead to tremors. Further observation is needed to confirm this idea and determine whether it applies to all tremor events, or is unique to this region.

And a SAFOD-inspired drilling project is currently under way along Japan's Nankai Trough, where the Philippine Sea Plate is being forced beneath the Eurasian Plate, creating one of the most active earthquake and tsunami zones on the planet. Drilling started in August of this year, and researchers eventually plan to drill five to seven kilometers below the seafloor into the seismogenic region of the subduction zone to take rock samples and place seismic instruments.

All of these projects are adding up to a deeper understanding of the behaviors and the mechanisms of aseismic slip, microquakes and tremors, says David Shelly, a geophysicist at USGS in Menlo Park, who studies tremors along the San Andreas Fault.

But more work is needed to determine how they fit into the bigger, more hazardous picture of earthquake cycles. "Do they trigger bigger quakes? Or help relieve stress? These are not easy questions to answer," Shelly says.

One thing that is clear is that microevents aren't just an oddity in one location, but a fairly pervasive global phenomenon, Shelly says. "Fortunately, this seems to be an ever-growing field of earthquake research," he says. "With this kind of burgeoning interest, we must be getting closer to answers than ever."

Morton is a freelance writer and photographer in Tenant's Harbor, Maine. Her website is www.marycapertonmorton.com.

Twists and Turns in the Ocean Conveyor Belt

Carolyn Gramling

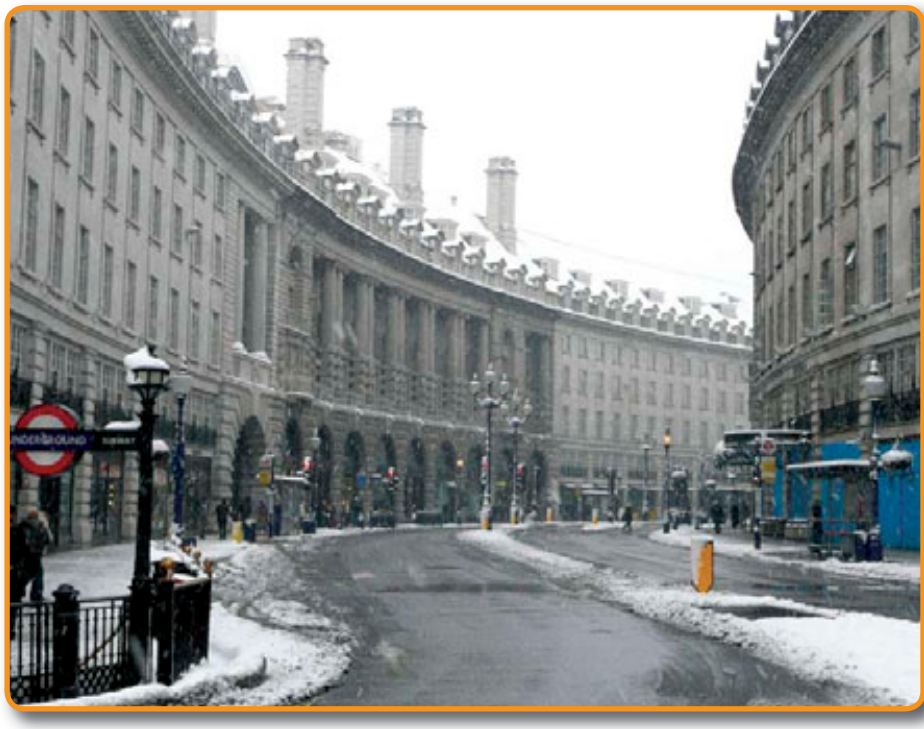
Fifty years ago, physical oceanographer Henry Stommel proposed the existence of huge currents of water flowing southward along the basin of the Atlantic and later upwelling to the surface, from where it is transported northward — sketching out a large-scale "overturning" of water in the oceans. In the 1970s, geochemist Wally Broecker coined the term the Great Ocean Conveyor Belt to describe the global network of currents that redistribute heat and salt throughout the world's oceans. Changes to the conveyor, he argued at the time, could trigger abrupt changes in climate, such as the sudden cold spell that occurred during the Younger Dryas between about 12,900 and 11,500 years ago.

As Broecker, of Columbia University's Lamont-Doherty Earth Observatory in Palisades, N.Y., noted in his 2010 book "The Great Ocean Conveyor: Discovering the Trigger for Abrupt Climate Change," it took a few years, but the concept of such a conveyor eventually became the dominant paradigm. It fundamentally altered the way people thought about what triggers abrupt climate change and the role the ocean plays in the process, Broecker told EARTH in August. Now, decades later, oceanographers are not only learning a whole lot more about how the conveyor works, but are also reexamining how useful the paradigm still is as a simplified model of the complex process of ocean circulation.

In 1985, Broecker and colleagues proposed that the Younger Dryas cold period was triggered by an influx of freshwater from melting glaciers in the North Atlantic, which made the waters too buoyant to sink. That effectively shut off a key part of the conveyor, which then was unable to transport heat globally. But new research has shown that there may be backup switches elsewhere in the conveyor system.

About 17,000 years ago, as the last glacial maximum was waning, an influx of freshwater prevented water in the North Atlantic from sinking, effectively shutting off the conveyor. That should have triggered a return to glacial conditions,

Without the ocean conveyor belt bringing warmer waters northward from the tropics, snow in England would be a much more common sight.



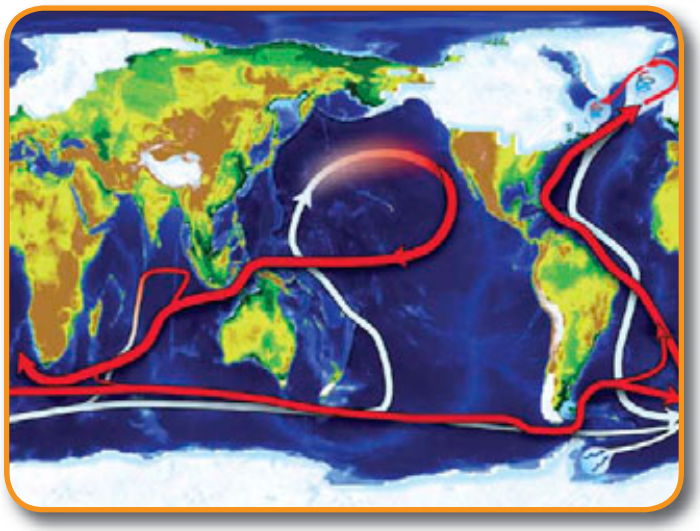
©Jon Curnow, Creative Commons Attribution 2.0 Generic

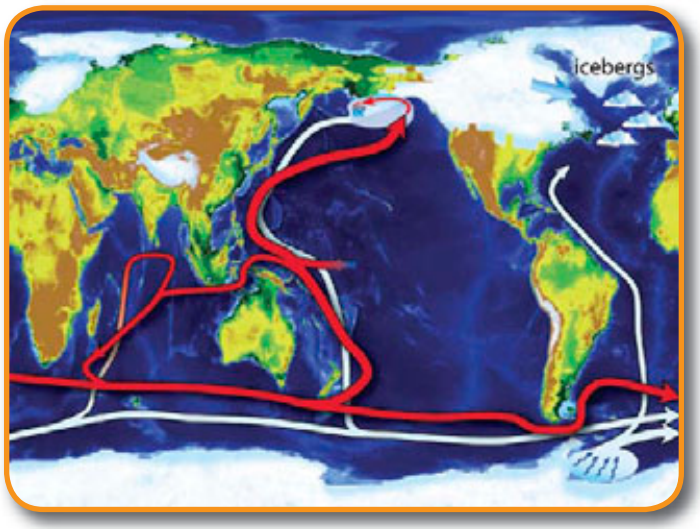
This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

as it did during the Younger Dryas a few thousand years later. But that didn't happen, and new data from the northern Pacific Ocean suggest why. Paleontologist Yusuke Okazaki of the Japan Agency for Marine-Earth Science and Technology in Yokosuka and colleagues radiocarbon-dated tiny carbonate-shelled creatures called foraminifera in sediment cores from the North Pacific and found that the water had adjusted to the shutdown of the conveyor in the North Atlantic, they reported in Science in July. The North Pacific water became saltier and thus denser; as it sank, warmer water from the tropics rushed in to fill the void. That effectively started up a new system of currents that kept the world from returning to a glaciated state.

Due to concerns about the link between ocean circulation and abrupt climate change, the U.S. National Science and Technology Council's Joint Subcommittee on Ocean Science and Technology has made understanding another key part of the conveyor system, the Atlantic meridional overturning circulation (AMOC), a research priority. AMOC is a system of currents that brings warm surface water from the tropics north to the North Atlantic. From there, the water cools, sinks and flows southward again.

Whether or not this part of the conveyor is slowing down in recent years has been a question: Climate models indicate that the overturning circulation will slow down as greenhouse gases warm the atmosphere and melting ice adds freshwater to the ocean. Such a slowdown would significantly impact the climate of Europe, North America and North Africa: The heat transported by AMOC is a key player in the climate of those regions; without that heat, they would likely be much colder. In March, NASA measurements of AMOC collected using ocean-observing satellites and profiling floats found no signs of a slowdown, and even a slight increase in overturning since 1993, which may be related to a decades-long pattern of heating and cooling in the Atlantic Ocean, oceanographer Josh Willis of NASA's Jet Propulsion Laboratory in Pasadena, Calif., and colleagues reported in Geophysical Research Letters.





Since the Great Ocean Conveyor Belt was first described in the mid-20th century, researchers have learned a lot about how global currents redistribute heat and salt throughout the world's oceans, and thus how they affect global climate. A 2010 study determined that the conveyor belt reorganized itself to prevent an ice age. The top panel shows the ocean conveyor belt flow 21,000 years ago. The bottom panel shows a reorganized conveyor belt flow from 17,500 to 15,000 years ago, with dense water sinking in the North Pacific.

Courtesy of Axel Timmermann

Another study of the AMOC this year delved further into how it works. Oceanographer Susan Lozier of Duke University in Durham, N.C., and colleagues studied changes in pressures, temperatures and salinity in the Atlantic Ocean over the second half of the 20th century and found that instead of being one large circulation cell — water flowing northward along the surface, then sinking, then flowing southward along the bottom — the AMOC varies in strength between low and high latitudes. Although the Atlantic circulation has become weaker in the subtropics over this period, it has become slightly stronger farther north, they reported in Nature Geoscience in September. The researchers also suggested that these changes were related to climate variability, rather than being part of a larger trend.

Lozier raised another question in a paper published in Science in June: Recent studies, she noted, have suggested that other forces, including fields of eddies within the ocean and wind forcing, can have as significant an impact on the shallower portions of ocean circulation — such as AMOC — as density-driven forcing due to heat and salt content. Given those findings, Lozier asked, is the oversimplified ocean-conveyor paradigm still a useful way to think about circulation — and, of course, to assess its impact on climate? Among the still-lingering questions about circulation are the spatial and temporal variability of the circulation, the impact of wind forcing — and how much that variability can affect the transport of heat and future climate change. New research studying these questions may reveal that the ocean's movements are considerably more complex than thought even a decade ago.

Gramling is a reporter and Web editor at EARTH.

This PDF is licensed for personal use only. MjAxMC0xMlcxMjkyOTE4OTEzZTJQ3

KILAUEA: Experiencing Pele's Wrath Through the Eyes of a Young Geologist

Kilauea's 3-kilometer-by-5-kilometer caldera sits in the middle of Hawaii Volcanoes National Park. The Halema`uma`u crater located within the caldera is currently erupting.

Zahra Hirji

This past summer, I lived a geologist's dream: residing in a national park and getting up close and personal with Hawaii's infamous Kilauea volcano. For hundreds of thousands of years, Hawaii's Kilauea has been erupting on and off. But on Jan. 3, 1983, the volcano began one of its longest (and largest) eruptions, shooting a fountain of lava hundreds of meters into the air. Twenty-seven years later, the volcano is still alive and kicking — in fact, it's the most active volcano in the world. For volcanologists, Kilauea is a mecca: an accessible active volcano in a picturesque location. So when I landed an opportunity to volunteer at the U.S. Geological Survey (USGS) Hawaiian Volcano Observatory near Kilauea, I couldn't refuse.

THE CREATION OF HAWAII

Kilauea is located on Hawaii's Big Island, one of the eight major islands that make up the Hawaiian chain. The islands were formed by a volcanic "hot spot," where a large mantle plume brings magma up through the center of the Pacific Plate. As the Pacific Plate moves over the hot spot, new volcanoes (and thus new islands) pop up.

Right now the Big Island sits atop the hot spot. The island has been growing for a little over a million years. It was born from Kohala volcano, which started out as a small vent on the ocean floor. Over hundreds of thousands of years of

©iStockphoto.com/joeygil

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

When Kilauea's lava flows into the ocean, it cools and solidifies, adding new land to the Big Island.

repeated eruptions, this shield volcano grew into the immense mountain it is today. When land created by the volcano broke through the sea surface, it officially created Hawaii's Big Island. Since then, the younger Mauna Kea, Hualalai, Mauna Loa and Kilauea volcanoes have all followed the same gradual shield-building process, each adding to the Big Island's size.

Today, Kilauea is most actively building up the island. When Kilauea's flows reach the ocean, the lava cools and solidifies, creating new real estate.

The Hawaiian island chain was formed by a volcanic hot spot.

But the buildup of land is slow because some of the unstable fresh land occasionally breaks off into the ocean, similar to how glaciers calve off icebergs. As of January 2007, Kilauea's currently ongoing, multidecadal eruption had added 201 hectares to the island's southern shore, although some of that land has been lost to the ocean.

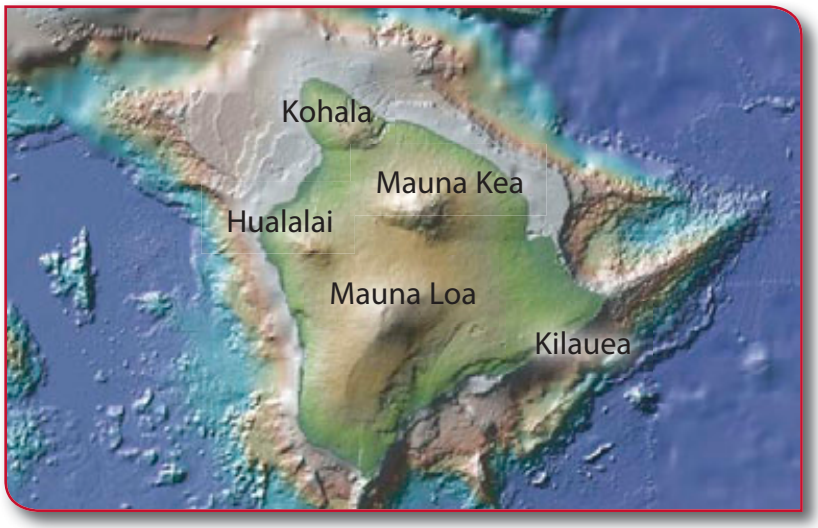
Some of Kilauea's volcanic neighbors also have the potential to expand the size of the Big Island. Although Hualalai has not erupted since 1801 and Mauna Loa has not erupted since 1984, they are far from extinct (see sidebar). If and when these volcanoes blow, they will likely cause much more damage than Kilauea's eruptions. Past lava flows from Mauna Loa — which encompasses half of the Big Island and is the world's largest volcano — have extended as far as Kona and Hilo, located on opposite sides of the island.

A WALK IN THE PARK

From the sky, Kilauea does not look like much, with a peak only 1,277 meters above sea level. The volcano is nearly invisible, tucked away in the southeast corner of the Big Island, as its four older, more massive volcanic siblings compete for the horizon.

Driving down the one-lane Highway 11 on my way to the volcano observatory last April, I did not even realize that I was on the volcano until I saw a big wooden sign announcing the entrance to Hawaii Volcanoes National Park. Once inside the park, however, the evidence is everywhere: Huge, scattered igneous boulders serve as remnants of past explosive eruptions and steam vents line the road, while gassy, yellowish brown tinted plumes snake high up into the atmosphere.

The 5-kilometer-long drive from the front gate to the observatory offers glimpses of the volcano's caldera, hidden behind a vegetated wall of red lehua-flowered `ohi`a trees. The real breathtaking view, however, is saved for the observatory, which is precariously perched on the edge of the northern caldera rim, only a stone's throw from the pond of lava that sits deep inside the caldera's Halema`uma`u crater, one source of Kilauea's current eruption.



Bottom to top: AGI/GeoMapApp, Ryan et al., 2009; AGI/NASA; Zahra Hiriji, USGS

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTE

During the last couple of hundred years, the Kilauea landscape has changed dramatically due to the near-constant level of volcanic activity. Eruptions have lasted from only a few hours to a few decades, with each new layer of lava making its mark on the land.

Visitors to the national park can bear witness to these previous eruptions as well as observe the ongoing one. The park encompasses more than 93,000 hectares, with Kilauea's 3-kilometer-by-5-kilometer caldera standing at its center. Crater Rim Drive encircles the caldera and the adjacent Kilauea Iki crater, making many of the park's highlights easily accessible by car. However, the section of Crater Rim that goes past Halema`uma`u crater is currently closed due to the buildup of dangerous levels of sulfur dioxide gas, and will likely remain closed as long as the crater is active.

Hiking is probably the best way to experience Kilauea. Kilauea's caldera used to host vibrant volcanic entertainment: In the 1800s and early 1900s, according to observers' reports, the caldera put on shows of dancing lava fountains and transient lava lakes. Today, much of the caldera is a dry, barren, rocky place, with only a few stubborn `ohi`a trees sprinkling the floor with color.

An `ohi`a tree with red lehua flowers grows up through old lava inside the park.

Kileaua has been continuously erupting since 1983. The eruption began south of the caldera in the Pu`u `O`o crater, pictured here.

Many of the trails that line the perimeter of the caldera, such as the Byron Ledge Trail and the Crater Rim Trail, provide breathtaking views, where you can see the carnage of historic magmatic events visible in the crater walls and the caldera floor. If you close your eyes, it is easy to imagine the place when it was alive, pulsing with red hot lava, glowing throughout the night.

However, the trails won't get you close to the center of the caldera's current action — the small Halema`uma`u crater, located in the caldera's southern corner. The crater, which has existed for hundreds of years, nearly doubled in size to its present dimensions (900 meters across) during a 1924 explosive eruption. The crater's most recent eruptive phase began in 2008 (Kilauea's ongoing

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Bottom: ©iStockphoto.com/Hoerold Photography; top: ©iStockphoto.com/photo75

THE SLEEPING GIANTS

After you've gotten a taste of what Kilauea has to offer, consider taking the time to travel to the rest of the Big Island's volcanoes.

Mauna Loa, the island's second-youngest volcano, last erupted in 1984, and is likely to erupt again in the next 100 years, according to the USGS Hawaiian Volcano Observatory. With a summit at 4,170 meters above sea level, the massive volcano (the largest in the world if you include its base below sea level) offers a variety of challenging hikes. Technically within Hawaii Volcanoes National Park, the volcano also hosts cabins near its summit that are open to the public (just make sure you get a permit ahead of time).

Not far from Mauna Loa is Mauna Kea. At 4,205 meters, Mauna Kea is the island's tallest volcano and is known more today for its must-see astronomy observatory than for its long volcanic history. The observatory is about an hour drive from Hilo or a two- to three-hour drive from Kona. Many tour companies offer trips that include a day drive to the summit where the observatory is located. Near sunset, descend down to the visitor's center, where multiple telescopes are available for viewing the observatory's "constellation tour." If you get cold, venture inside the visitor's center for some hot chocolate and interact with the sky above through the center's computer stations.

The island's remaining volcanoes, Hualalai and Kohala, are less accessible. Hualalai last erupted in 1801, but it's still considered active. Climbing this volcano is discouraged because much of it is located on private land. The long-quiet Kohala, on the other hand, is frequently visited because of its spectacular lush greenery and amazing black sand beaches.

ZH

The Big Island's tallest volcano, Mauna Kea, is home to astronomical observatories.

eruption initially began in the Pu`u `O`o crater, located south of the caldera in the East Rift Zone). Although the Halema`uma`u Crater Overlook, a 10-minute walk from Crater Rim Drive, is currently closed, you can still see the crater's erupting plume from the lookout point near the volcano observatory, just off Crater Rim Drive.

The observatory is not generally open to the public. But if you call ahead of time, you may be able to arrange a quick tour to see what the geologists do there. If that doesn't work out, you can still visit the nearby Jaggar Museum, named for Thomas Jaggar, the MIT geology professor who founded the observatory in 1912. The museum describes the development of the volcano observatory and provides a comprehensive history of Kilauea's evolution. You can also watch video footage of the Halema`uma`u crater's active lava pond.

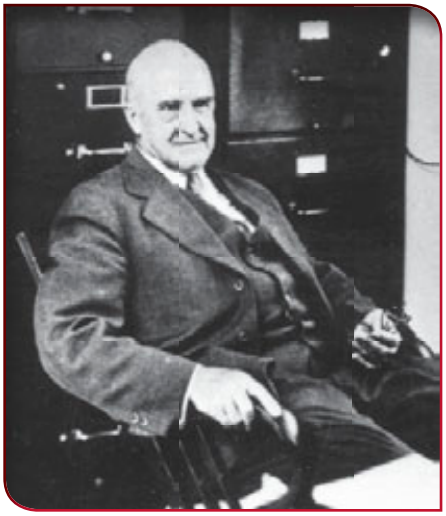
The museum also explains that Kilauea often hosts more than one active crater. For example, the Pu`u `O`o crater in the East Rift Zone is still active. Although the crater is closed to visitors, various trails along the southern part of the park, such as the Napau Trail, provide panoramic views of the beautiful, remote Pu`u `O`o crater.

MEETING PELE

Hawaiians believe the impetuous Kilauea is embodied by the goddess Pele, a fiery lady with a hot temper. When she gets angry, destruction plagues the land in the form of lava flows, earthquakes and the release of noxious volcano smog, called vog.

Kilauea's repeated eruptions and displays of power keep the observatory geologists (which included me for the summer) very busy. I had many run-ins with danger and learned firsthand just how powerful the goddess could be. Within 24 hours of landing on the Big Island, I got my first encounter with Pele. Active lava flows were threatening the town of Kalapana, which had last been inundated with lava during the 1990s. As a result, Tim Orr, my boss and the observatory's head operational geologist for

Thomas Jaggar opened the Hawaiian Volcano Observatory in 1912. He was the observatory's director until 1940.



Bottom: USGS; top: Gro Birkefeldt

This PDF is licensed for personal use only.

A bird's-eye view of the lava flow field that threatened the town of Kalapana in June. By the end of July, the entire road (shown here) was covered in lava.

over the lava because much of it had cooled, hardening into a dark crust. But the heat emanating from the still-liquid, glowing red parts was staggering — fresh lava can be as hot as 1,050 degrees Celsius. And the fact that we were covered head to toe in protective gear did not help with the heat.

Kilauea's lava flows reach a road near Kalapana on July 17.

Kilauea, had to pull weekend duty, and I tagged along.

Our task was to map the growth of the lava flow and see just how close it was to a small road that cuts through a residential neighborhood in Kalapana. Using a GPS device, we followed the sinuous margins of the lava. Walking next to a slow, barely moving flow of lava may seem simple, but it's not. At all. Our journey involved wading through thick brush, navigating around cracked, hot flows (and sometimes on top of flows when other routes proved too precarious), and generally abusing my poor quads. We managed to walk

Left: Kilauea research geologist Matt Patrick takes a lava sample while wearing full-body protective gear. Below: Kilauea geology technician Kelly Wooten changes a webcam camera card at Halema`uma`u crater.

Hiking around the flows, Tim pointed out the difference between pahoehoe (pronounced pa-hoy-hoy) and `a`a (pronounced ah-ah) flows, the two main types of basaltic lava on land. Both types of lava have the same chemical composition, but differ in viscosity and temperature. Pahoehoe flows are smooth or ropey layered lobes of lava, whereas `a`a flows have a rougher, blocky texture and can look like a rolling wave of lava. They also flow much faster than pahoehoe flows. In one of Kilauea's prior eruptions, for example, `a`a flows traveled 12 kilometers in less than a day; it took pahoehoe flows about three months to cover the same distance.

During my first three weeks on the job, I went to these flow fields multiple times a week. The hot lava field became my second office, and I got to know the layout of the place fairly well. In addition to the lava, I encountered methane bursts. When lava ignites vegetation, methane builds up. These methane bubbles randomly burst with a resounding pop. I also had my fair share of run-ins with trees and plants suddenly lighting on fire, trees falling down and lots of smoke. Each time I emerged from a burning "kipuka," the Hawaiian term for an island of vegetation surrounded by lava, I was covered in sweat and black scratches from brushing up against burning, ashy vegetation.

My last two weeks on the job during the end of July were entirely different. With little warning,

Bottom two and top: Zahra Hirji, USGS; middle: Jeanette Renee Bachland

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

a new, larger, faster surge of lava erupted from Kilauea. On July 17, lava finally hit the road I had been monitoring all summer. When lava eats up asphalt, thick, noxious black smoke clogs the air. We wore gas masks when maneuvering around the melted road. Then on July 26, Pele took her first victim, a house. This was the first time in a few years that Kilauea's flows had consumed an occupied structure. Two more houses were nearly enveloped by the lava, but fortunately there were no other casualties. Since then, Kilauea's tempestuous flow has calmed down.

At the beginning of my time at the volcano observatory, I was a young geologist with eyes only for the Hollywood version of volcanoes: the smoking craters and the flowing lava. Three months living on Kilauea taught me to open my eyes, and when I did, it was impossible not to see evidence of the volcano in every inch of the island.

Hirji is a freelance writer in Boston, Mass. To read more about her adventures in Hawaii, visit her blog: writteninlava.blogspot.com.

The author, Zahra Hirji, maps an active lava toe at the Kalapana flow fields.

GETTING THERE AND GETTING AROUND

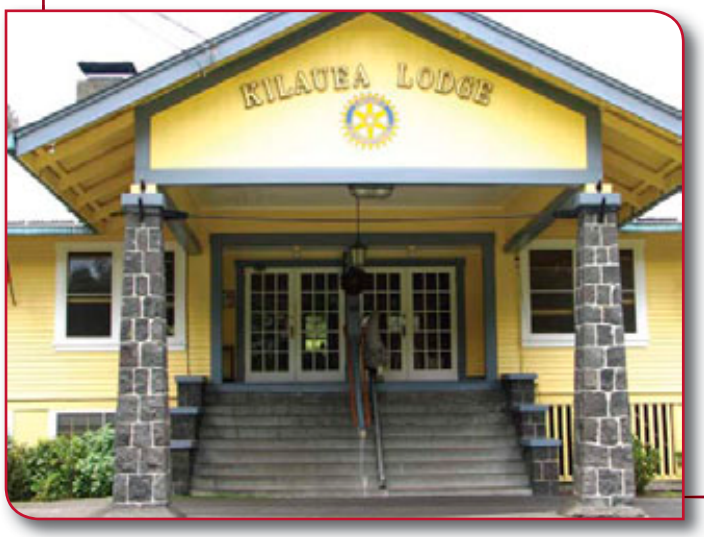
Many trips to Hawaii's Big Island involve island-hopping. From the U.S. mainland, you'll most likely fly through Honolulu on Oahu or Kahului on Maui on your way to either of the Big Island's airports — Hilo on the east side or Kona on the west side. However, some airlines fly directly to Kona. Once on the Big Island, renting a car is your best bet for getting around because public transportation, albeit free, is virtually nonexistent: Buses run a handful of times a day during the week, but not at all on Sundays. From Hilo, getting to Hawaii Volcanoes National Park is a 30-minute drive straight up Highway 11. Getting to the park from Kona is more of a trek, a two- to four-hour scenic drive depending on which route you take.

The Big Island has two airports: Hilo on the east side (pictured here) and Kona on the west side.

Visitors to the park must pay a $10 per vehicle fee that offers access for one week. Volcano Village, a small community a few kilometers outside of the park, offers a range of accommodations, from luxury hotels (Kilauea Lodge) to economy options (Volcano Bed & Breakfast) to hostels. And if you are in the mood for the full outdoor experience, you can pick up camping permits at the park's visitor's center for the numerous campsites scattered around the park, most of which are equipped with toilets.

For more information about visiting the park, check out www.nps.gov/havo.

ZH



Visitors to Hawaii Volcanoes National Park often stay at Kilauea Lodge.

Bottom to top: ©Luis Argerich, Creative Commons Attribution 2.0 Generic; ©Shutterstock.com/Shawn Zhang; Ryan Ferguson, USGS

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEz-IQ3

AAG SESSIONS & WORKSHOPS

Environment. Energy. Disasters. Natural Resources.

Attend the Annual Meeting of the Association of American Geographers in Seattle to learn more about these and other related topics:

Challenges of Natural Hazards & Disasters: Haiti and the Gulf of Mexico Oil Spill

Global Environmental Change • Climate Policy • Renewable Clean Energy

Natural Resources • And More!

AAG ANNUAL MEETING

Seattle, WA • April 12-16, 2011

About the Meeting

The AAG Annual Meeting will be held April 12-16, 2011, in Seattle, WA, at the Washington State Convention Center and the Seattle Sheraton Hotel. Sessions and workshops will feature presentations from many leading scholars and experts on the latest in research, policy, and scientific applications.

The meeting also will feature a large Jobs in Geography Career Center, an International Networking Reception, and exhibits showcasing the latest scholarly publications and advanced geographic technologies. Many educational field trips will explore the rich cultural and physical geography of Seattle and the surrounding Pacific Northwest region.

The AAG Annual Meeting is an interdisciplinary forum open to anyone with an interest in geography and related disciplines.

Register to Attend
www.aag.org

AAG
Association of American Geographers
1710 16th St. NW • Washington, DC 20009
202-234-1450 • www.aag.org

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

2011 GEOSPATIAL SOLUTIONS CONFERENCE

gita GEOSPATIAL INFORMATION & TECHNOLOGY ASSOCIATION®

Intelligent Infrastructure for a Sustainable Future

APRIL 10-14, 2011
Grapevine (Dallas), TX

JOIN US

With investments in geospatial technology maturing, this year's conference will address key issues across all sectors, with a focus on integration, in order to achieve greater efficiency and productivity.

Discover the latest innovations, ideas and solutions that will help you to contribute to a sustainable future.

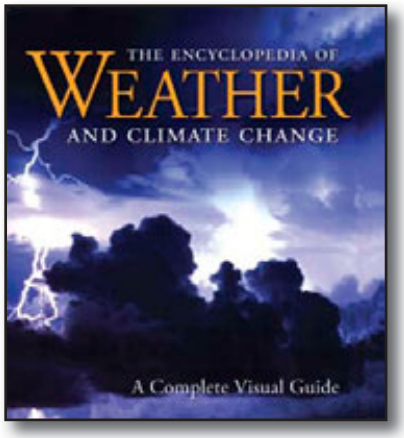
REGISTER TODAY
www.gita.org/gsc

GEOSPATIAL INFORMATION & TECHNOLOGY ASSOCIATION
303-337-0513 - info@gita.org - www.gita.org
14456 East Evans Ave., Aurora, CO 80014

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

BOOKS: HOLIDAY ON THE SHELF

An earth science-themed book is a great holiday gift for diehard rock hounds and budding geo-enthusiasts alike. The EARTH staff has rounded up some of our favorite geoscience books from the past year or so to help you find the perfect present for the science buff on your gift list.

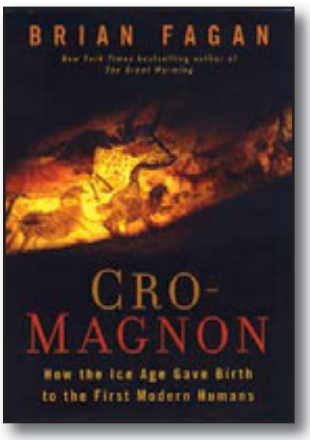


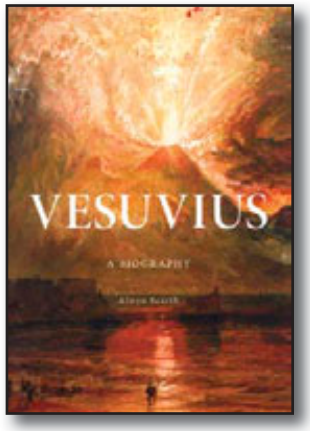
"The Encyclopedia of Weather and Climate Change," by Juliane L. Fry, Hans-F Graf, Richard Grotjahn, Marilyn N. Raphael, Clive Saunders and Richard Whitaker. University of California Press, 2010. ISBN 9780520261013. Hardcover, $39.95.

Brought to you by a team of earth scientists, "The Encyclopedia of Weather and Climate Change" is a colorful reference book that makes for a great introduction to the science of meteorology and climate. Divided into six sections, the 512-page book is filled with diagrams, maps and photos that help explain everything from how clouds form to why climate varies by region.

"Cro-Magnon: How the Ice Age Gave Birth to the First Modern Humans," by Brian Fagan. Bloomsbury Press, 2010. ISBN 9781596915824. Hardcover, $28.00.

In "Cro-Magnon," archaeologist Brian Fagan explores the glaciated world of the first modern humans living in Europe (the Cro-Magnons) and their Neanderthal neighbors. Fagan pulls together evidence from the archaeological and fossil records, genetics and paleoclimate research to tell the tale of how these early Europeans survived in a harsh, changing environment.



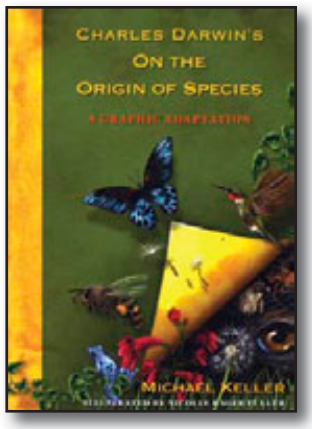


"Vesuvius: A Biography," by Alwyn Scarth. Princeton University Press, 2009. ISBN 9780691143903. Hardcover, $29.95.

True to its name, "Vesuvius: A Biography" covers the history of one of Italy's most famous volcanoes, from its birth to its infamous eruption in A.D. 79 that buried Pompeii to what the future holds — with dozens of eruptions in between. "Vesuvius" will captivate volcano experts with its discussions of how the volcano has affected Italy's history and culture, and will educate novices about the basics of volcanology.

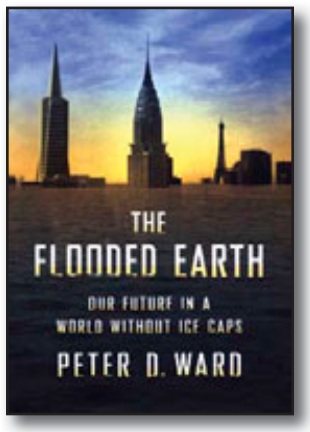
"Charles Darwin's On the Origin of Species: A Graphic Adaptation," by Michael Keller and illustrated by Nicolle Rager Fuller. Rodale Books, 2009. ISBN 9781605299488. Paperback, $14.99.

Writer Michael Keller and illustrator Nicolle Rager Fuller have created a Charles Darwin comic book. Divided into three parts, their book recounts the events that led to Darwin's theory of natural selection, provides an abbreviated version of his "On the Origin of Species" and ends with a brief look at the development of evolutionary theory post-Darwin. The comic book style is a great way to pique kids' and teens' interest in the science of evolution.

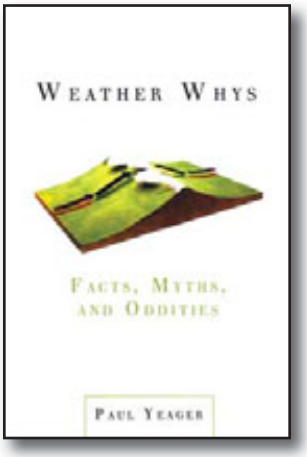


"The Flooded Earth: Our Future in a World Without Ice Caps," by Peter D. Ward. Basic Books, 2010. ISBN 9780465009497. Hardcover, $25.95.

Paleontologist Peter Ward presents his take on what the future will look like as sea levels rise due to a warming climate in "The Flooded Earth." In addition to discussing how the melting of polar ice caps and the subsequent sea-level rise will affect different regions of the world (including sea dwellers), Ward outlines the factors that have led to recent climate change and what can be done to prevent further warming.



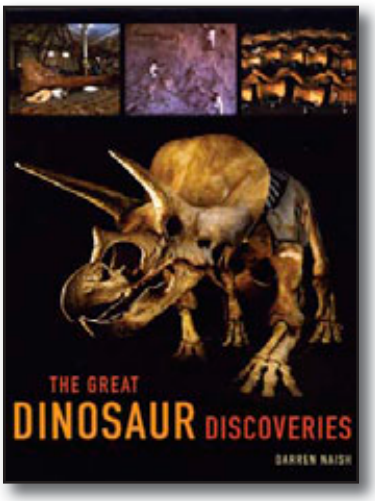
This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3



"Weather Whys: Facts, Myths, and Oddities," by Paul Yeager. Perigee Books, 2010. ISBN 9780399535703. Paperback, $14.95.

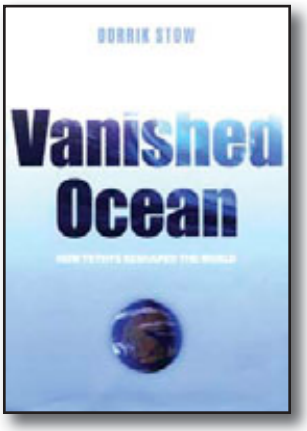
"Weather Whys: Facts, Myths, and Oddities" is packed with weather trivia. Meteorologist Paul Yeager describes everything from how cold weather contributed to the Challenger disaster in 1986 to why bridges freeze before roadways to why California is raisin country. It's the perfect gift for someone who can't get enough of the Weather Channel.

"The Great Dinosaur Discoveries," by Darren Naish. University of California Press, 2009. ISBN 9780520259751. Hardcover, $29.95.

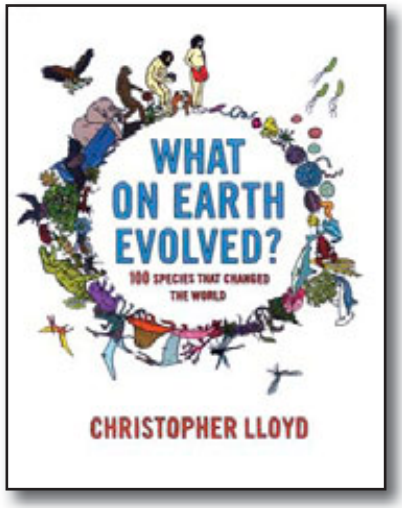


Science writer and paleozoologist Darren Naish highlights the history of dinosaur paleontology in "The Great Dinosaur Discoveries," beginning with the unearthing of *Megalosaurus* (the first dinosaur to be named, in 1824). Naish focuses on the personalities behind the discoveries as much as he does on the dinosaurs themselves. Photographs of fossils and illustrations of what dinosaurs might have looked like in the flesh help tell the story.

"Vanished Ocean: How Tethys Reshaped the World," by Dorrik Stow. Oxford University Press, 2010. ISBN 9780199214280. Hardcover, $29.95.

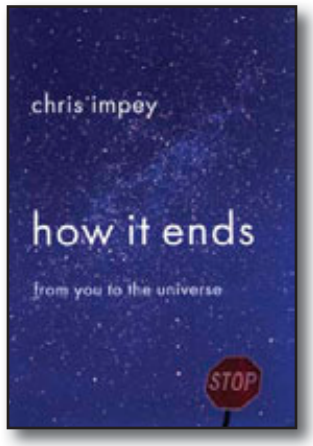


"Vanished Ocean" chronicles the story of the Tethys Ocean, which lasted 250 million years before it vanished 5.5 million years ago. Geologist and oceanographer Dorrik Stow draws upon his own work and that of others to describe how the Tethys formed, how it affected life on Earth and how geological forces led to its eventual demise. Stow also discusses the Tethys' legacy, including its role in creating the wealth of oil in the Middle East.



"What on Earth Evolved? 100 Species That Changed the World," by Christopher Lloyd. Bloomsbury USA, 2009. ISBN 9781596916548. Hardcover, $45.00.

Writer Christopher Lloyd offers his picks for the more important species on Earth in his fun and colorful "What on Earth Evolved?" Lloyd cruises through the 50 "most successful life forms" (dubbed "species" for the sake of the book) and then follows up with the 50 most successful species that have been shaped by humans, such as cotton, cows and cannabis. Lloyd ends by ranking the importance of each species (earthworms top the list).



"How It Ends: From You to the Universe," by Chris Impey. W.W. Norton & Company, 2010. ISBN 9780393069853. Hardcover, $26.95.

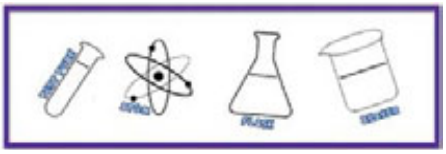
"Nothing lasts forever" is the take-home message of astronomer Chris Impey's "How It Ends." Impey uses the death of individuals, the extinction of species, the burnout of the sun and the fading of the Milky Way to expound on a range of science topics, from biology to astrophysics. Interesting anecdotes throughout the book lighten the grim subject matter.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

GIFTS: HOLIDAY GIFT GUIDE

Oh, iThis and iThat. So predictable. But that's what everyone *else* is giving this year. May we suggest instead treating your friends and family to some of the more interesting and unusual geogadgets these holidays?

Home Decorating



Science Lab Cookie Cutters
Box of 4 cutters $14.95 at
www.sciencecookiecutters.com

Yum. These chemistry-themed cookie cutters come in four shapes familiar to anyone who's spent time in a lab: test tube, atom, flask and beaker. They're 25 millimeters deep, so you can make nice thick cookies. They also come with a "scientifically tested" recipe for yummy cutout cookies.

TV Rock
$6.00 at www.copernicustoys.com

Ulexite — also called "TV rock" — is a milky-white mineral of hydrated sodium calcium borate hydroxide that is deposited in arid regions by evaporating lakes. What's more fun is that this mineral also has interesting fiber-optic properties: The needle-shaped crystals in ulexite grow in parallel and transmit light along their lengths — so that a polished ulexite specimen can display an image of whatever happens to be beneath it. Copernicus Toys sells its "TV Rock" ulexite pieces as part of its Compact Curiosity line.

Desktop Dinosaur Plant
$7.99 at www.thinkgeek.com

Well, sort of. It's not a dinosaur, but it did outlive them by millions of years. The "dinosaur plant" is actually a *Selaginella lepidophylla,* an evergreen plant that grew during the Carboniferous period about 290 million years ago and is still around today. Back then, these plants may have grown more than 35 meters tall, but the desktop version only grows to about 10 centimeters tall — when watered. When not watered, the plant curls up into a tight ball, but "comes back to life" each time you water it. The plant comes with a display bowl … and for some reason, with a bag of volcanic rocks. Available for shipping in the U.S. only.

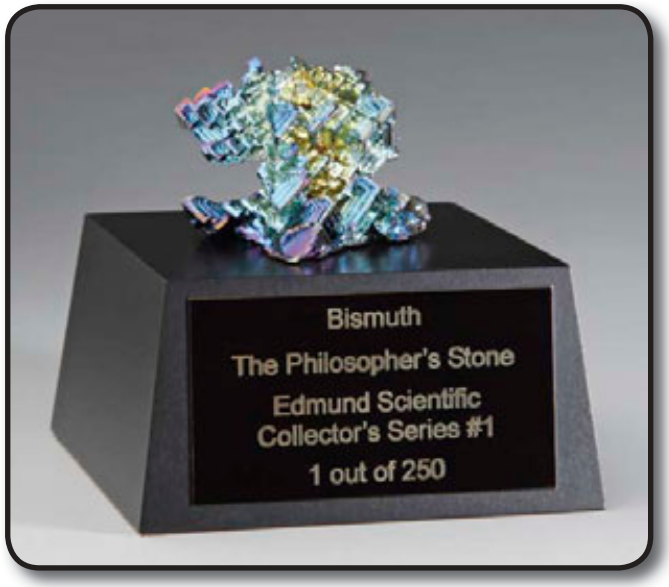
This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Cabinet of Curiosities: Peculiar Minerals
$16.00 at www.copernicustoys.com

Copernicus Toys also sells a set of five minerals that do interesting things. In addition to a TV Rock, you get a whole geode that you can crack open yourself (rock hammer not included), a Buoyant Rock that floats in water (it's actually pumice), a Grow Crystal that creates a rock garden in days (actually calcium carbonate) and "Flash Rocks" — a pair of piezoelectric rocks such as quartz (when struck together, they produce flashes of light, similar to chewing a certain wintergreen-flavored candy).

Solar Radiometer
$11.95 at scientificsonline.com

Prop this clear glass bulb on your windowsill or under a lamp and watch the delicate windmill inside rotate. This is a "Crookes radiometer," a device invented in 1873 by chemist Sir William Crookes. In addition to being pretty, it provides an intro to the study of thermodynamics: It consists of four vanes, each with a black and a silver side. The black sides of the vanes absorb energy and heat up the air molecules next to them, which bounce off the black sides more quickly — in effect, giving them a push.



The Philosopher's Stone
$49.95 at scientificsonline.com

No, not from the Harry Potter books; the true philosopher's stone turned out to be the rare element bismuth. Although medieval alchemists searched in vain for a material that would transmute base metals into gold — the so-called philosopher's stone — Nobel prize-winning chemist Glenn Seaborg managed the feat in 1980, by removing neutrons and protons from bismuth, thus synthesizing it into gold. Edmund Scientific is offering a limited-edition collectible of this fragile piece of history, mounted on a black base.

Rock Tumbler & Polishing Kits
3-pound single-barrel polishing kit (pictured) $119.95 at scientificsonline.com
6-pound double-barrel polishing kit $139.95 at scientificsonline.com

If you're the kind of tourist who brings back a heavy bag full of rough, unpolished "souvenirs" from all of the cool places you've been, now's your chance to prove toting them around was worth it. Edmund Scientifics sells assorted tumbling and polishing kits to turn your rough stones into shiny décor or jewelry pieces.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Electronics

BONE Dinosaur Flash Drives
$29.95 at www.x-tremegeek.com

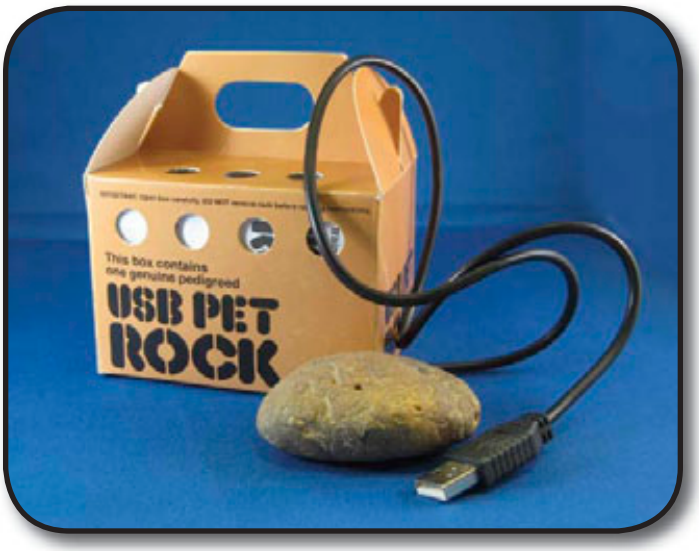
OK, so these "dinosaurs" are breathing a little fire, but that's just a minor paleontological inaccuracy. And it could be symbolic: These fierce little drives are fired up and ready to store your data or help you finish your dissertation. Each 4-gigabyte drive is encased in a soft silicone shell, available in light or dark green, pink and blue. The shells are also removable: As your attitude toward your dissertation evolves, pop out the drive and dress it up in a new (perhaps darker) dino suit. Windows/Mac/Linux compatible.

Tech 21 iBand
$28.99 at
www.expansys.com

British company Tech 21 has designed a wraparound band for the iPhone that protects it from damage due to being dropped, kicked, thrown or otherwise abused. The case is made of a super-shock-absorbing, flubber-like material called d3o, also used for impact protection in multiple types of sports gear. The iBand includes cutouts for the on/off and volume switches. Available in white and black.

USB Pet Rock
$9.99 at www.giftsforageek.com

Yep, the Pet Rock is back — now with cable. Instead of sitting innocently on your coffee table and acting as a conversation piece, this one hooks up to your computer. What does it do? Exactly what a Pet Rock has always done: Nothing. It's 100 percent environmentally friendly, in that it draws no power from your computer. Thus, it is also compatible with all types of software.



Corsair Flash Survivor
$27.99 to $199.99 at www.amazon.com

Speaking of wear-and-tear in the field, this flash drive is nearly indestructible: Made of anodized aircraft-grade aluminum, water-resistant down to 200 meters depth and protected from vibration or impact thanks to a molded shock-dampening collar, this flash drive can take just about any abuse a field geologist throws at it, and then some. In order of increasing durability, the Flash Survivor, Survivor GT and Survivor GTR are available with 8- to 64-gigabyte capacity.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

For Kids

Bag of Prehistoric Fossils
$5.99 at www.thinkgeek.com

Forget coal: Here's a much more exciting stocking-stuffer for the kids. Each bag contains four types of prehistoric fossils: crinoids, ammonites, gastropods and clams. You also get a bonus shark tooth and a magnifying glass to examine your treasures from every angle.

Hatchling Dino Pals
$14.99 at
www.thinkgeek.com

Rawr. This collection of plushy dinosaurs (not to be confused with similarly plushy Evolvems, featured in our April issue) comes in six different species, including *Triceratops*, *T. rex* and the obsoletely named *Brontosaurus* (we know what they mean). These dinos don't just sit there and look cute: Pet a dino's back and it comes to life, wagging its tail or flapping its wings or roaring, depending on the species. For ages 3 and up.

Giant Evolution Timeline
Book/Playmat
$19.00 at
www.charliesplayhouse.com

This accordion-folded timeline by the award-winning evolution toy, game and learning tool company Charlie's Playhouse is a colorful, easy-to-read trip through 600 million years of evolution. Designed with the help of scientists for ages 4 and up, the timeline has plenty of information, pictures and even an activity guide offering artistic, active, competitive and noncompetitive games. The timeline can expand to 5 and a half meters across the floor or collapse into the size of a picture book — so kids can sit quietly and read or jump and hop along it … fortunately, it's also waterproof and easy to clean with a damp cloth.

Philanthropy

GoodSearch and GoodShop
www.GoodSearch.com

Consider doing your holiday shopping via www.GoodSearch.com, a Yahoo-powered search engine that will donate one penny for every search you do through the site to the charity of your choice (money is generated from the site's advertisers). GoodSearch also hosts GoodShop, an online shopping mall affiliated with more than 1,300 retailers, including Amazon, Target, Apple and Macy's, that will donate a percentage of every purchase to the designated charity. Tens of thousands of nonprofits are currently participating in the program; you can also add the charity of your choice, provided it is a registered nonprofit.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

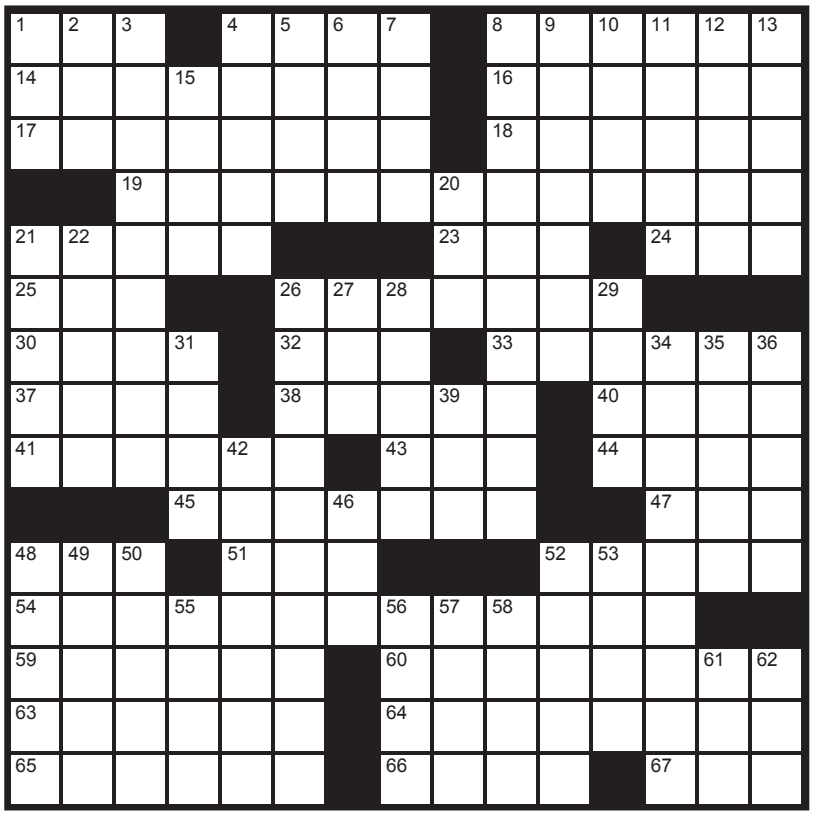
Cross-Section: A Puzzle

Across

1. Infomercials, e.g.
4. Holds up
8. Brunch beverage
14. In the recent past
16. Inner selves
17. Top soil
18. Tally
19. Yeah, whatever...
21. Frets
23. Clear
24. D.C. bigwig
25. "___ what?"
26. Struts
30. All excited
32. Sue Grafton's "___ for Lawless"
33. Iridescent?
37. Roll up
38. Hiked
40. Autumn tool
41. Not Wall Street
43. Bank offering, for short
44. "Beowulf," e.g.
45. Doctor related
47. Biochemistry abbr.
48. Any car, affectionately
51. "___ lost!"
52. Science
54. Small dog breed
59. Wired
60. Time for a drink
63. Less of a mess
64. Famous singer
65. Dimethyl sulfate and others
66. Signs, as a contract
67. #13

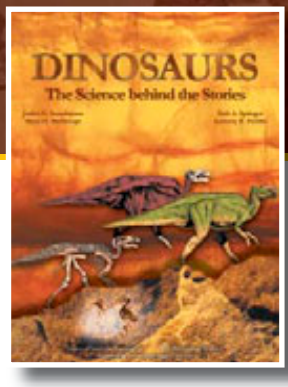
Down

1. ___ king
2. Code word
3. Carbonate-encrusted algae
4. Control, symbolically
5. Ricelike pasta
6. Alliance
7. Harmony
8. Angry at mom?
9. Called for
10. Bit
11. ...
12. Booze
13. Colorado resort
15. Think
20. Ashes holder
21. Big mess
22. Get dressy
26. Pirates
27. Cheat, slangily
28. Jellied garnish
29. "Your majesty"
31. Grab (onto)
34. Rotted rock
35. Squeezing (out)
36. Break down
39. Victorian, for one
42. Geo puzzler
46. "___ alive!"
48. Bakery treat
49. Fine-tunes
50. Pomp
52. Pen sounds
53. "___ go!"
55. Toy with a tail
56. "Frasier" actress Gilpin
57. Shakespeare, the Bard of ___
58. Adam's apple spot
61. Calendar square
62. "... ___ he drove out of sight"



Puzzle solution will appear in next month's issue of EARTH.

Dinosaurs: The Science behind the Stories



Edited by Judith G. Scotchmoor, Dale A. Springer, Brent H. Breithaupt, and Anthony R. Fiorillo.

Dinosaurs: The Science behind the Stories illustrates the nature and methods of science. Dinosaur paleontology provides an excellent opportunity to illustrate how science works and this collaborative effort of leading paleontologists focuses on how we know what we know. This 186 page book is perfect for the teacher, parent or grandparent looking to help that eager child move beyond the visual portrait of a dinosaur to the science behind that image.

Available from the American Geological Institute at www.agiweb.org/pubs
(703)379-2480; fax: (703)379-7563; pubs@agiweb.org
This and other AGI titles are also available at amazon.com.

Solution to the November 2010 crossword

N	A	R	C	S		C	O	M	B		A	N	O	A
I	D	I	O	M		L	E	E	R		C	U	R	D
P	I	C	N	I	C	A	R	E	A		A	M	I	D
S	T	E	T	T	E	D		D	E	S	C	E	N	T
			R	E	D					L	I	N	G	O
A	S	E	A		E	L	K		A	O	A			
S	H	E	I	K		A	L	O	N	G		F	R	O
P	A	R	L	I	A	M	E	N	T	A	R	I	A	N
S	H	Y		K	R	A	I	T		N	E	R	V	Y
			O	U	T		N	O	T		A	M	E	X
U	N	I	F	Y					I	T	S			
S	U	B	F	U	S	C		A	P	O	S	T	L	E
E	R	S	E		C	O	N	T	I	N	U	O	U	S
U	S	E	R		O	L	I	O		A	M	A	S	S
P	E	N	S		T	A	M	P		L	E	T	H	E

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

WHERE ON EARTH?

...was this picture taken?

CLUES

1. Thousands of years of freezing and thawing cycles during the last ice age broke a nearby rock formation into these large chunks of red sandstone and conglomerate, which are strewn across a relatively flat valley. These stones, ranging in size from 1 meter across to more than 8 meters across, have remained in this valley, relatively unchanged, for more than 20,000 years.

2. A nearby terminal moraine marks the southernmost extent of the Wisconsinan ice sheet to the north and east of the valley, and provided a clue that periglacial activity was responsible for the field of stones.

3. The site is a designated national natural landmark, one of about 600 geologic or biotic features in its host country with that designation.

Name this feature and its location.

Enter at www.earthmagazine.org, where you can also see previous Where on Earth? contests.

HOW TO PLAY

Where on Earth was this picture taken? Use these clues to guess and send your answer via mail or e-mail by the last day of the month (December 31). From those who answer correctly, **EARTH** staff will randomly draw the names of 10 people who will win Where on Earth? T-shirts. Enter the contest at www.earthmagazine.org. You can also submit entries to Where on Earth? EARTH, 4220 King Street, Alexandria, VA 22302 (postmarked dates on letters will be used).

EARTH also welcomes your photos to consider for the contest. If we print your photo in **EARTH**, you'll receive a free one-year subscription or renewal and an **EARTH** T-shirt.

WHERE ON EARTH? PLAY NOW!

September answer

The Great Falls of the Potomac River are located about 24 kilometers west of Washington, D.C., in Maryland near the border with Virginia. In 1853, the U.S. Army Corps of Engineers began constructing a dam near Great Falls for the Washington Aqueduct, which provides water to the residents of the Washington, D.C., metropolitan area. Photo is by Patrick Rodgers.

September winners

Eugene Aleshin (Smithsburg, Md.)
George E. Beetham Jr. (Glenside, Pa.)
Mark Duigon (Baltimore, Md.)
Maria G. Gerber (Clifton, Va.)
Dave Kuentz (Oxford, Ohio)
Bret Leslie (Vienna, Va.)
Debia McCulloch (Lilburn, Ga.)
Diane OKunewick (Idaho Springs, Colo.)
Christopher J. Roll (Gansevoort, N.Y.)
Shuang-Ye Wu (Beavercreek, Ohio)

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

December 31, 1853: Dinner in a Dinosaur

On New Year's Eve, 1853, Benjamin Waterhouse Hawkins hosted a formal dinner in the mold of an *Iguanodon*.

The weather in London on Saturday, Dec. 31, 1853, could not have pleased Benjamin Waterhouse Hawkins. After a relatively warm Friday, the temperature had plummeted, snow had begun to fall, and for the first time in more than a decade, masses of ice floated down the Thames River. The snow made the streets so slippery that injured pedestrians filled the hospitals.

For New Year's Eve, Hawkins was hosting an elaborate feast at his sculpting studio in Sydenham, 11 kilometers south of London. Would his guests be able to find transportation out to Sydenham and then across the pastures of muddy swamp that surrounded the wooden building where the dinner would be held? Hawkins hoped so; he had been planning the meal for more than a month. It would be the first time that most of his dinner-mates had seen the incredible life-sized dinosaurs that he was building for the Crystal Palace Exhibition, which Queen Victoria and Prince Albert would open to the public in June.

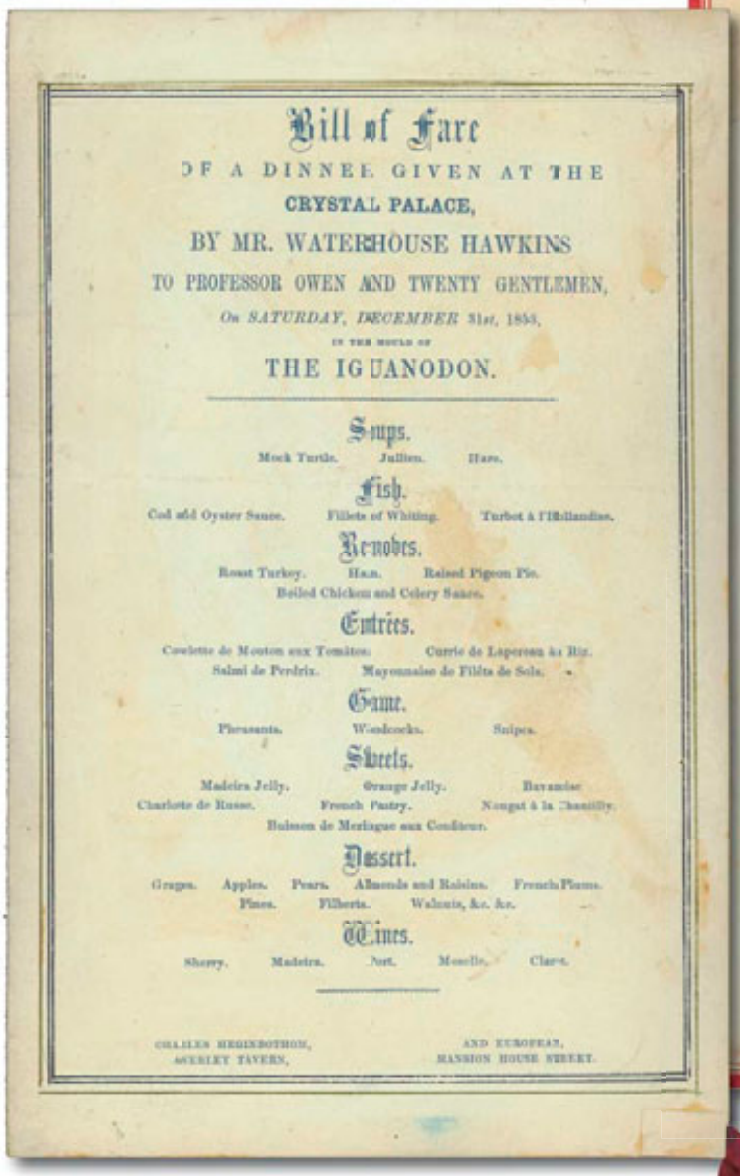
The previous year, a group of investors had bought the Crystal Palace, an ornate cast-iron and glass edifice that had housed the Great Exhibition of 1851 (London's first World's Fair). The investors moved the building to Sydenham, where they planned to celebrate the "triumphs of industry and art," and hired Hawkins to direct the "Fossil Department." They tasked him with populating a vast geologic display with giant monsters of the ancient world, including the first three dinosaurs ever described: *Megalosaurus*, *Iguanodon* and *Hylaeosaurus*.

Hawkins was uniquely qualified to bring these great animals to life. He had initially achieved fame for his detailed illustrations of animals collected by British explorers, including the still relatively obscure naturalist Charles Darwin. Subsequently, Hawkins started to sculpt, and to write and illustrate books on animal anatomy. For his efforts in taking new scientific findings and translating them into words and images accessible to the general public, Hawkins earned membership into the most exclusive science clubs of the era — the Royal Society, the Geologic Society of London and the Linnean Society.

In early December 1853, Hawkins sent out invitations for his New Year's Eve bash. For one guest, he sketched the profile of

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Academy of Natural Sciences, Ewell Sale Stewart Library and the Albert M. Greenfield Digital Imaging Center for Collections



Bill of Fare

OF A DINNER GIVEN AT THE

CRYSTAL PALACE,

BY MR. WATERHOUSE HAWKINS

TO PROFESSOR OWEN AND TWENTY GENTLEMEN,

On SATURDAY, DECEMBER 31st, 1853,

IN THE MOULD OF

THE IGUANODON.

Soups.

Mock Turtle. Julien. Hare.

Fish.

Cod and Oyster Sauce. Fillets of Whiting. Turbot à l'Hollandise.

Remobes.

Roast Turkey. Ham. Raised Pigeon Pie.

Boiled Chicken and Celery Sauce.

Entrées.

Cowlette de Mouton aux Tomates. Currie de Lapereau à la Riz.

Salmi de Perdrix. Mayonnaise de Filets de Sole.

Game.

Pheasants. Woodcocks. Snipes.

Sweets.

Madeira Jelly. Orange Jelly. Bavaroise

Charlotte de Russe. French Pastry. Nougat à la Chantilly.

Buisson de Meringue aux Confiture.

Dessert.

Grapes. Apples. Pears. Almonds and Raisins. French Plums.

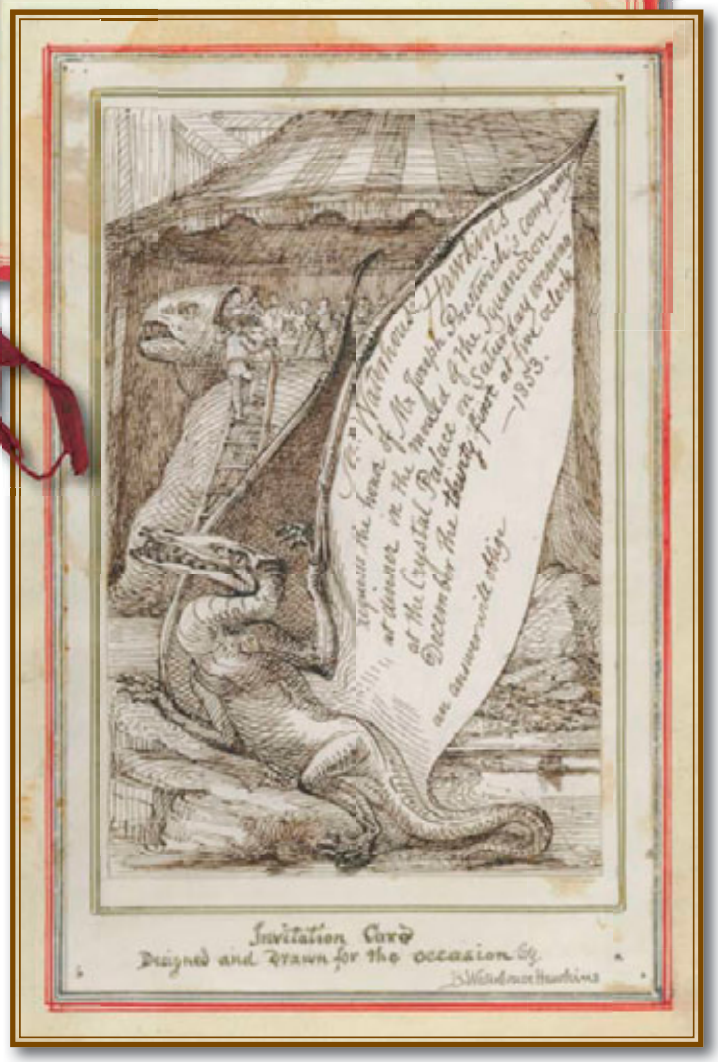
Pines. Filberts. Walnuts, &c. &c.

Wines.

Sherry. Madeira. Port. Moselle. Claret.

CHARLES HEGINBOTHOM, ACCRLEY TAVERN,

AND EUROPEAN, MANSION HOUSE STREET.



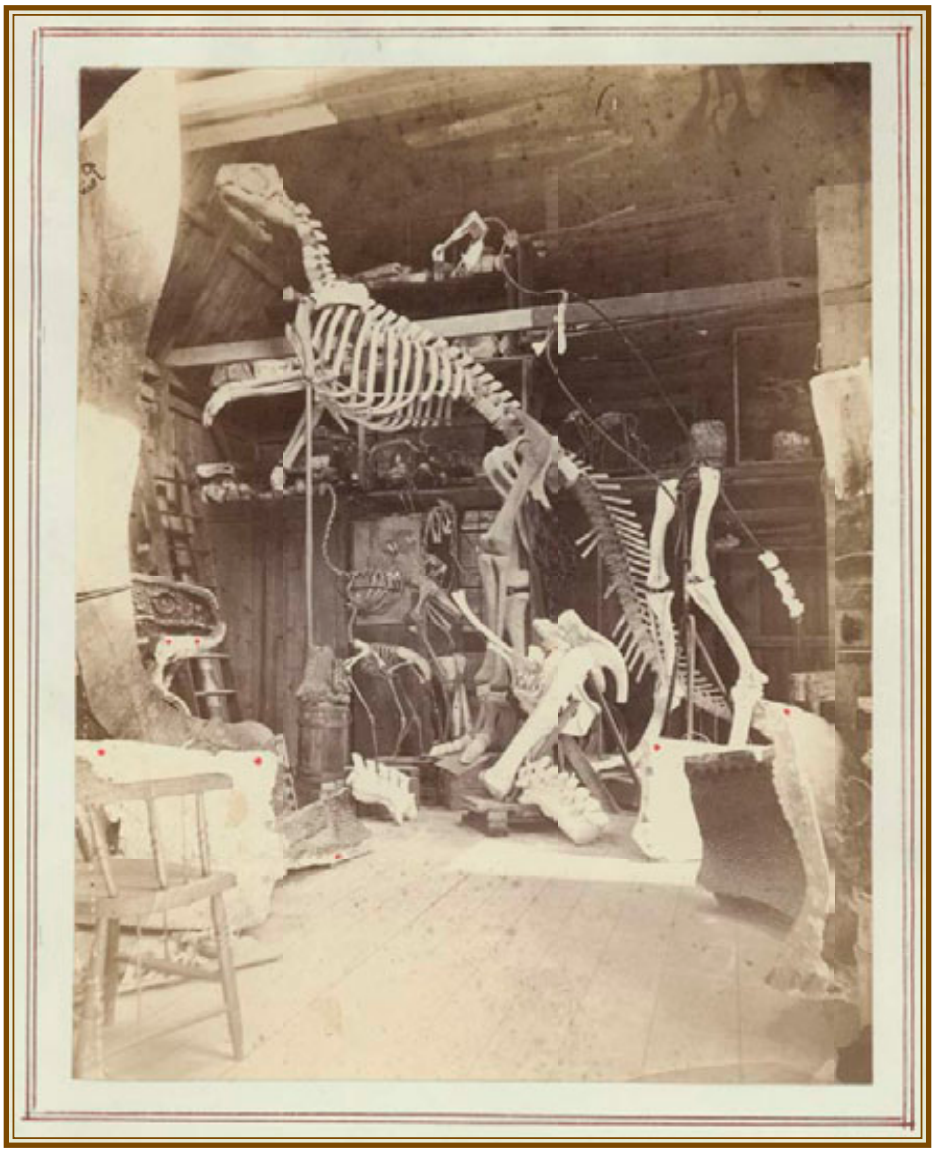
Hawkins hand-drew the invitations to his dinner in an *Iguanodon*. Twenty prominent men accepted the invitation.

the giant herbivorous *Iguanodon* with a feast table in its body. In front of it, he added a *Pterodactyl*, its mouth filled with pointed teeth. For another guest, he turned the *Iguanodon* to face the viewer with the table still inside the body. In the foreground, a wine-sipping participant rides the neck of a *Plesiosaur*, on which stands a *Pterodactyl*. On both cards, Hawkins carefully penned on the *Pterodactyl*'s outstretched wing "Mr. Waterhouse Hawkins requests the honor of --------'s company at dinner in the mould of the Iguanodon at the Crystal Palace on Saturday evening December the thirty first 1853 at five o'clock. An answer will oblige."

Hawkins chose his guests carefully. They included Richard Owen, Hawkins' scientific adviser and the man who coined the term dinosaur in 1842; Francis Fuller, the managing director of the Crystal Palace; Edward Forbes, a jovial, irreverent paleontologist who mentored Thomas Huxley and advised Darwin; Joseph Prestwich, winner of the Geological Society of London's highest award, the Wollaston Medal, and a man

All: Academy of Natural Sciences, Ewell Sale Stewart Library and the Albert M. Greenfield Digital Imaging Center for Collections

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3



Hawkins' studio circa 1869.

well-liked for his propensity to end geology walks at vineyards; and ornithologist John Gould, who in 1837, identified the finches collected by Darwin on the Galapagos. Because Hawkins viewed the feast as a publicity stunt, he also invited Herbert Ingram, publisher of The Illustrated London News, a paper with a circulation of more than 150,000.

Twenty men accepted the invitation. Despite the snow and ice, they donned formal attire and traveled by train from London and tromped to Hawkins' studio. Inside the large warehouse, the men found an unimaginable menagerie of creatures sculpted by Hawkins. Largest was the *Hylaeosaurus*, with thick stippled skin and a single row of spikes down its back. Near it rested an amphibian known as a *Labyrinthodon* and a curious beast that looked like a turtle with a pair of tusk-like teeth. In another corner, a tapir-like *Paleotherium* poked its head out from under a wooden scaffold.

To reach their dining table inside the *Iguanodon* mold, the guests ascended a short flight of steps to a platform built around the massive model. Above them rose a pink and white tent, which helped keep out the cold wind that snuck in through the wooden walls of the building. Additional heat and light came from a crystal chandelier and brass candelabras. For the final touch, Hawkins hung banners bearing the names of the paleontologists who had pioneered the study of dinosaurs: Georges Cuvier, Gideon Mantell, William Conybeare and William Buckland.

Each guest had an assigned seat at the table inside the body of the *Iguanodon*. Owen had the presiding seat, tucked into a nook formed by the dinosaur's head. In the roomier rear end sat Fuller and Forbes and a musician "whose delightful singing greatly increased the pleasure of the evening," Hawkins wrote in a description of the night in 1872. Hawkins placed his friends Prestwich and Gould on either side of him and filled in the sides with the rest of the men. Certainly no other dining table in England was so unusual nor held such an esteemed group. A team of liveried servants brought in the food — a trio of soups, three varieties each of fish and fowl, a quartet of meats and luscious sweets — and copious amounts of wine on silver platters.

The conversations, especially ones lubricated by generous glasses of wine, must have been vivid. They probably discussed Mantell's recent death (was it a suicidal drug overdose or an accident?), Buckland's erratic slipping into dementia and those young upstarts Darwin and Huxley (both of whom had just won the prestigious Royal Medal). And what did the royal couple say when they visited Hawkins' studio in November? Fossils may also have come up a time or two.

Eventually, Owen asserted his role at the head of the dinosaur table and offered a round of toasts. Finally, around midnight, Forbes stood before the group, noting that he was indebted to Mr. Waterhouse Hawkins for providing the opportunity to spend the evening in "an antediluvian dragon." He then launched into an elaborate poem.

A thousand ages underground
His skeleton had lain;
But now his body's big and round,
And he's himself again!
Beneath his hide he's got inside
The souls of living men,
Who dare our Saurian now deride
With life in him again?

Encouraging the revelers to join him, Forbes offered a chorus.

The jolly old beast
Is not deceased,
There's life in him again. (A roar.)

As Forbes continued through his verses, the men became "so fierce and

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Academy of Natural Sciences, Ewell Sale Stewart Library and the Albert M. Greenfield Digital Imaging Center for Collections

The First Dinner in a Beast

Surprisingly, there is precedence for eating dinner in the body of a massive beast. In February 1802, Rembrandt Peale, an early American painter best known for his portraits of George Washington and Thomas Jefferson, invited 12 friends and family to dine under the rib cage of a mammoth, which had recently been erected in his father's museum in Philadelphia.

The bones of what were called the American *incognitum* had come from the Hudson River Valley, a few kilometers west of the town of Newburgh. First discovered in1790, the mammoth fossils had attracted the attention of Thomas Jefferson, who, despite the controversy over his presidential election in 1800, took the time to inquire about buying the specimens. He was unsuccessful, but in 1801, artist and museum owner Charles Willson Peale bought the bones for $200, plus $100 for any new ones he could dig up. He eventually collected enough bones from a variety of bogs and marl pits to assemble two nearly complete mammoth skeletons. (The remains were later identified as mastodons.)

Rembrandt, Charles' son, staged his dinner to celebrate his upcoming trip to Europe, where he would display one of the family's mammoths. Thirteen men, including Rembrandt's siblings Rubens and Raphaelle, sculptor William Rush, botanist William Darlington and inventor John I. Hawkins, sat at a round walnut table beneath the bones. As would happen almost 52 years later, much frivolity ensued followed by solemn toasts such as "All Honest Men — If they cannot feast in the *Breast of a Mammoth*, may their own breast be large enough … Success to these boney parts in Europe," as described in The Port Folio, a Federalist, anti-Jefferson journal, on Feb. 20, 1802.

In the same issue, Samuel Ewing, a Philadelphia lawyer, lampooned the dinner with lines such as "What toasts roar'd loudly thro' the Mammoth's ear, or,/Were sweetly sounded thro' his wide posterior."

DBW

enthusiastic, as almost to lead to the belief that a herd of iguanodons were bellowing," as described in "Routledge's Guide to the Crystal Palace and Park at Sydenham." Eventually the roaring ended, the men climbed out of the *Iguanodon*, fumbled past the other beasts, donned their overcoats, and made their ways back through the cold to the train station and returned to London. It was "a good wind-up for a geologist's year," Forbes is quoted as saying in Archibald Geikie's "Memoir of Edward Forbes."

As Hawkins hoped, his New Year's Eve publicity stunt fostered keen interest in what The Times of London described as the "gigantic tenants of … the earliest and sublimist pages in the history of creation." Charles Dickens mentioned the meal in his newspaper, and Herbert Ingram, in The Illustrated London News, concluded that the guests were "evidently well pleased with the modern hospitality of the *Iguanodon*, whose ancient sides there is no reason to suppose had ever before been shaken with philosophic mirth."

Six months later, more than 40,000 people attended the opening of the Crystal Palace and saw Hawkins' beasts. His dinosaurs quickly became icons of Victorian England, launching the world's first wave of dinomania.

David B. Williams

Hawkins with his statue of the Irish elk, *Megaloceros*, circa 1853.

Academy of Natural Sciences, Ewell Sale Stewart Library and the Albert M. Greenfield Digital Imaging Center for Collections

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

American Petrographics Inc.

THIN SECTIONS ● POLISHED SECTIONS

40 Appletree Lane
Roslyn Heights. NY 11577
(516) 625-9162
Fax: (516) 625-5804

Leonard J. Cannone. PRESIDENT

PRICE LIST SENT ON REQUEST

BURNHAM PETROGRAPHICS LLC
(The new home of Palouse Petro Products.)

Preparation of thin sections for all methods of analysis.
Petropoxy 154 Thin Section Epoxy
Petrographic Slide Boxes

www.burnhampetrographics.com
artisans@burnhampetrographics.com

(800) 772-3975
(208) 687-5951
Fax (208) 687-0232

5029 W. Lodestar Ave., Rathdrum, ID 83858 USA

National Petrographic Service, Inc.

Palynology
Paleontology
Forams Nannos

Thin and polished sections
Kerogen slides
Vitrinite Reflectance

www.nationalpetrographic.com

5933 Bellaire Blvd. Suite 108
Houston, Texas 77081
(713) 661-1884 Fax (713) 661-0625
E-mail npsinc@flash.net

Texas Petrographic Service Inc.
Polish/Thin Section
12520 Market Street Houston, TX 77015
Phone: (713)330-1018 Fax: (713)330-8186
E-mail: texasrocks1@gmail.com
www.texaspetrographic.com

www.tasagraphicarts.com
Tasa Graphic Arts, Inc.
Educational software for the Earth Sciences
1-800-293-2725

Before any major commitment, be sure to have all the information.

The GEM family of ground conductivity instruments offers a highly portable, flexible and versatile solution to engineering and environmental challenges in a wide variety of applications. The systems are designed to provide sensitivity to, and discrimination of, a broad range of targets and environments. The GEM technology is scalable and can be carried or mounted on a cart or vehicle for custom applications. From site assessments to military applications the versatility of the GEM instruments has driven their success. As part of the AEROQUEST Group of Companies, Aeroquest Sensortech (formerly Geophex) continues to offer R&D services for improvement of existing systems and development of new ones.

AEROQUEST offers airborne geophysical surveys and services on a turn-key basis worldwide. Visit us online at www.geophex.com / www.aeroquestsensortech.com or call (919) 839-8515.

Mining Exploration Services
Petroleum Exploration Services
Environmental Engineering Services

AEROQUEST SENSORTECH

A member of the AEROQUEST International Group of Companies
© Copyright Aeroquest International Limited

TECHNOLOGY OF MATERIALS

X-Ray Powder Diffraction Analysis

• Qualitative and quantitative I.D.
- Reitveld analysis
- Structural characterization
• Soil/Clay analysis -
www.xraydiffrac.com
sam@xraydiffrac.com
Phone: 1(951) 471-8194
Wildomar, Calif.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

GSW® GeoScienceWorld

Explore deeper, faster

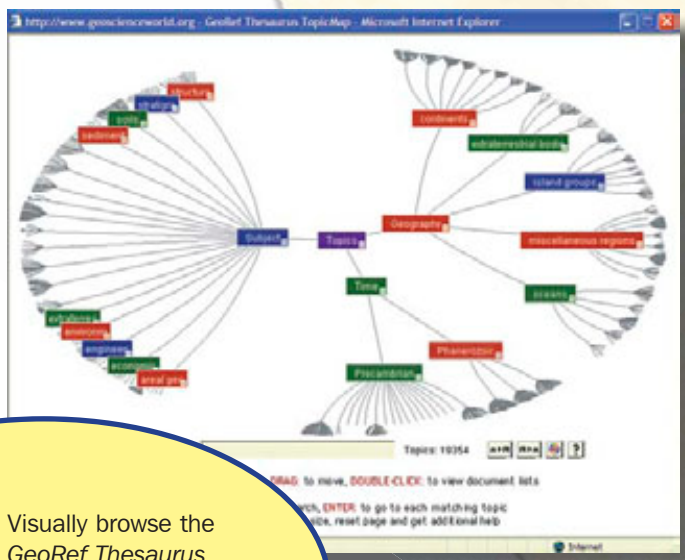
The GSW home page, showing a reader's favorite journals list

We're Still Growing!

GSW's online service, the *GSW Millennium Collection*, includes peer-reviewed articles and other materials with linked reference lists from over 30 high-impact journals in a broad range of geoscience areas. The digital collection is updated continuously with the most current journal issues. All journals have a minimum of one back year, and most in the database start with the year 2000. A Literature Archive of pre-2000 articles enhances the *Millennium Collection*.

Readers may sign-up for free e-mail alerts for the contents of their favorite journals and results of saved search parameters. Extensive reference linking enables researchers to readily trace their way through the literature.

For information about subscribing, please visit:
www.geoscienceworld.org/subscriptions/subscribe.dtl



Visually browse the *GeoRef Thesaurus* using the TopicMap.

GeoRef

A primary strength of GSW is the ability to search full text in a linked collection. GSW is also integrated with GeoRef, the premier abstracting and indexing database in our field. GSW's fully-searchable version of GeoRef is updated weekly, making it the most current version of GeoRef available anywhere.

GeoRef searching includes authors and their affiliations, titles, keywords, meeting information, publication date, language, and document types.

Unique features

Users may search using geographic coordinates, entering boundaries for latitude and longitude for an area of interest.

A data-visualization tool called the TopicMap provides a graphical interface for browsing the *GeoRef Thesaurus.*

30-day free trials available
Check it out at: www.geoscienceworld.org

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

CAREER OPPORTUNITIES

ASSISTANT PROFESSOR PALEOCLIMATOLOGY SYRACUSE UNIVERSITY

The Department of Earth Sciences at Syracuse University seeks applicants for a tenure-track position in paleoclimatology. The successful candidate will balance an active research program with both graduate and undergraduate teaching responsibilities (e.g., Climate Change, Paleolimnology/Paleoceanography, Isotope Geochemistry). We seek a physical scientist willing to collaborate within the Department of Earth Sciences and across campus (e.g., SUNY College of Environmental Science and Forestry), and participate in an emerging University-wide initiative in Clean Water. Potential fields of study might include, but are not limited to, recovering, analyzing, and integrating records of paleotemperature, ocean/atmosphere chemistry, or biogeochemical cycles. Current Department resources include extensive geochemical, sedimentological, and paleobiological analytical facilities, as well as sediment sampling equipment and portable research vessels. More information is available at http://earthsciences.syr.edu.

Applicants must attach their curriculum vitae, statements of teaching and research interests, and the names and contact information for three referees to https://www.sujobopps.com. The search will remain open until the position is filled. Review of applications will begin December 1, 2010. Syracuse University is an equal opportunity employer. Minorities and women are encouraged to apply.

ASSISTANT PROFESSOR, GEOPHYSICS SYRACUSE UNIVERSITY

The Department of Earth Sciences at Syracuse University seeks applicants for a tenure track position in geophysics. The successful candidate will balance an active research program with both graduate and undergraduate teaching responsibilities (General/Applied Geophysics, as well as introductory courses in Earth Sciences). We seek a geophysicist willing to collaborate within the Department of Earth Sciences and across campus (e.g., L.C. Smith College of Engineering, SUNY College of Environmental Science and Forestry), and participate in emerging University-wide initiatives in Water Resources, Energy and/or Forensic Sciences. Current Department resources include a LINUX computing network for processing and interpreting seismic reflection data (PROMAX,

UNIVERSITY OF DELAWARE

One of the oldest institutions of higher education in this country, the University of Delaware today combines tradition and innovation, offering students a rich heritage along with the latest in instructional and research technology. The University of Delaware is a Land-Grant, Sea-Grant, and Space-Grant institution with its main campus in Newark, DE, located halfway between Washington, DC and New York City. Please visit our website at **www.udel.edu**.

Director and State Geologist, Delaware Geological Survey

The College of Earth, Ocean, and Environment at the University of Delaware is seeking an individual to serve as the Director of the Delaware Geological Survey (DGS) and as Delaware State Geologist. The DGS is a highly regarded research and service unit of the University of Delaware. As a university-based State agency, the DGS plays a unique role in the application of high-quality science to public needs issues in geology, water resources, natural hazards, and geospatial data. Located in a modern, well-equipped building on the University of Delaware campus in Newark, Delaware, the DGS has an annual direct State appropriation of $1.6 million and employs a permanent full-time staff of 16 scientists and support staff.

We seek an energetic and visionary Director with a record of scientific accomplishment, strong management and interpersonal skills, and the ability to effectively communicate about science with a variety of constituencies. Applicants should have a doctoral degree in the geosciences (exceptional candidates with a master's degree may be considered) and a minimum of seven years of post-graduate professional experience in the geosciences. At least three years of administrative experience is required; strong interpersonal skills and a collegial management and leadership style are essential. We encourage applications from scientists with national recognition in a field of geoscience research, experience in delivery of public-service-directed science, and a record of obtaining and managing external financial support for research and service. Additional information on the position and required qualifications can be found at www.udel.edu/udjobs

Founded in 1743, the University of Delaware combines tradition and innovation, offering a rich heritage along with the latest in technology. Located in scenic Newark, Delaware, halfway between New York and Washington, D.C., the University is a state-assisted, privately governed institution. Review of applications will begin February 1, 2011 and continue until the position is filled. Position is available on July 1, 2011. Candidates should submit a letter of interest, curriculum vitae, and the names and contact information for five references. Applications and requests for information should be directed to dgs-directorsearch@udel.edu or to Dr. Daniel Leathers 111 Robinson Hall Newark, Delaware 19716.

The UNIVERSITY OF DELAWARE is an Equal Opportunity Employer which encourages applications from Minority Group Members and Women.

University of Massachusetts UMASS Lowell

Careers with **Mass Appeal**

Department of Environmental, Earth and Atmospheric Sciences

Tenure-Track Position in Quaternary Geology/Hydrogeology

The Department of Environmental, Earth and Atmospheric Sciences at the University of Massachusetts Lowell invites applications for a tenure-track faculty position in Quaternary geology/hydrogeology.

Applicants must have a strong general background in the prescribed area and a significant, demonstrated record of funded research and publication in either Quaternary geology, hydrogeology or a closely related field. The successful applicant will be expected to help support an undergraduate program in environmental geosciences, develop a new MS program in environmental geosciences and work with the PhD program in the UMass School of Marine Sciences. Courses offered might range from general geology to geomorphology, hydrogeology, glacial and Pleistocene geology plus any other advanced courses relevant to environmental studies in the Northeast. The successful candidate will join with atmospheric scientists and other geoscientists in the Department to develop a PhD program in global change. A strong, well-funded research program and the mentoring of graduate students are extremely important. The teaching workload, according to University and College policy, will be calibrated to research productivity as befitting a research university. Outstanding applicants with previous research and teaching experience are encouraged to apply and will be offered a rank commensurate with experience. Appointment is anticipated to be at the Associate level for a senior person but all levels, including that of Assistant Professor for promising young investigators, will be considered. The starting date is anticipated to be Fall semester 2011.

Minimum Requirements:

- Candidates must have earned a PhD in earth science or a closely related field by the position starting date.
- Candidates must have a demonstrated record of externally-funded research which supports the Department's mission, and provide evidence for high competence in teaching.
- Candidates should be able to speak and write English clearly and have excellent interpersonal skills.

How to apply: Interested applicants should apply online at https://jobs.uml.edu. Thank you for considering the University of Massachusetts Lowell as an employer of choice. We look forward to receiving your application.

The University of Massachusetts Lowell is committed to increasing diversity in its faculty, staff, and student populations, as well as curriculum and support programs, while promoting an inclusive environment. We seek candidates who can contribute to that goal and encourage you to apply and to identify your strengths in this area.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Please visit our website, www.earthmagazine.org/classifieds, for these and many other current career opportunities.

SEISWORKS software), and marine seismic imaging instruments. More information is available at http://earthsciences.syr.edu.

Applicants must attach their curriculum vitae, statements of teaching and research interests, and the names and contact information for three referees to sujobopps.com. The search will remain open until the position is filled. Review of applications will begin December 1, 2010. Syracuse University is an equal opportunity employer. Minorities and women are encouraged to apply.

TWO POSITIONS AVAILABLE COASTAL GEOLOGY AND SEDIMENTARY GEOLOGY

The Department of Geography and Geology at the University of North Carolina Wilmington (http://www.uncw.edu/earsci) invites applications for two tenure-track positions to begin August 2011:

1) Coastal Geology at the rank of Assistant or Associate Professor. We seek an individual with demonstrated expertise in coastal geologic processes, and research interests in a related area such as coastal geomorphology, monitoring and modeling of surface processes, coastal evolution, or coastal hazards and engineering.

2) Sedimentary Geology at the rank of Assistant Professor. We seek an individual with demonstrated expertise in sedimentary petrology, and research interests in a related area such as sequence stratigraphy, carbonate or clastic sedimentation, geochronology, or basin analysis.

Primary responsibilities for both positions include teaching and advising students at the undergraduate and graduate levels, directing student research, and developing a vigorous research program with the potential to attract external funding. We especially encourage applicants who will actively engage students in field research. A Ph.D. in the geosciences or related discipline is required.

The department offers B.S. and M.S. degrees in geology, B.S. in oceanography, B.A. in geosciences, and B.A. in geography. UNCW maintains a wide range of research laboratories on the main campus and at the Center for Marine Science (http://www.uncw.edu/cmsr), including facilities for isotope ratio mass spectrometry, x-ray diffraction, scanning electron microscopy, preparation of petrographic samples, sedimentology, and geospatial analysis.

To apply, complete the online application at http://consensus.uncw.edu. A letter of application, brief statements of teaching and research interests, a curriculum vitae and contact information, including e-mail addresses, for three professional references should be uploaded as MS Word or PDF files. For questions about the Coastal Geology position contact search committee chair Dr. Nancy Grindlay, grindlayn@uncw.edu, (910)962-2352. For questions about the Sedimentary Geology position contact search committee chair Dr. Michael Benedetti, benedettim@uncw.edu. For questions about the online application process contact Ms. Cathy Morris, morris@uncw.edu, (910)962-3736. Priority consideration will be given to applications received by December 15, 2010, but applications will be accepted until the position is filled.

UNC Wilmington actively fosters a diverse and inclusive working and learning environment and is an equal opportunity employer. Qualified men and women from all racial, ethnic, or other minority groups are strongly encouraged to apply.

LOW TEMPERATURE GEOCHEMIST

The Geology Program of the Department of Geography and Geology at Sam Houston State University wishes to appoint at the Assistant Professor level a Low Temperature Geochemist with research interests in the broad field of either Aqueous Geochemistry (surface or groundwater) or Petroleum Geochemistry. The candidate will already hold the Ph.D. and will be in process

MARK YOUR CALENDARS...

And join thousands of industry professionals at this year's recovery 2011 convention in Calgary May 9 - 13, 2011 at the Calgary TELUS Convention Centre.

- Submit your abstract for oral presentation, poster presentation or core presentation
- Increase your company's brand visibility among thousands of industry professionals - sponsor or advertise in our official publications
- Earn up to 6 PDH credits each day you attend
- Bring your company to the show floor. Space is limited, so book now.
- Re-connect with friends, meet new contacts and take advantage of the opportunity to network with industry professionals at various social events including Luncheons and the Core Meltdown

FOR MORE INFORMATION visit us online at www.geoconvention.com

recovery energy environment economy

2011 CSPG CSEG CWLS Convention

Produced by:

www.geoconvention.com

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

UF UNIVERSITY of FLORIDA

DEPARTMENT OF GEOLOGICAL SCIENCES, UNIVERSITY OF FLORIDA

Thompson Chair of Geological Sciences

The Department of Geological Sciences, University of Florida, invites applications for the **Thompson Chair of Geological Sciences**, an endowed position at the rank of **Associate or Full Professor** with tenure. The successful candidate will be expected to teach at the undergraduate and graduate levels, mentor students for M.S. and Ph.D. degrees, and conduct a dynamic, externally funded research program in an area of globally significant earth science that is relevant to geological problems within Florida and the surrounding region. Areas of expertise may include, but are not limited to: basin analysis, regional tectonics, carbonate and/or siliciclastic stratigraphy and sedimentology, biostratigraphy, karst geology, hydrogeology, coastal processes, sea level change, and environmental geophysics. Ph.D. required. Salary will be competitive and commensurate with experience.

For additional information or nominations please contact **Dr. Jonathan B. Martin, Thompson Chair Search Committee, Department of Geological Sciences, University of Florida, P.O. Box 112120, Gainesville, FL 32611-2120 (jbmartin@ufl.edu)**. Review of applications will begin January 14, 2011 and will continue until the position is filled. **To ensure full consideration please apply online at http://jobs.ufl.edu (requisition # 0806180)**. For full consideration, the application should include: (1) cover letter, (2) curriculum vitae, (3) statement of research, teaching, vision, and goals; (4) reprints of no more than three publications, and (5) the names of three colleagues who might be contacted for letters of recommendation. *The University of Florida is an Equal Opportunity Institution. If an accommodation due to a disability is needed to apply for this position, please call (352) 392-2477 or the Florida Relay System at (800) 955-8771 (TDD). The selection process will be conducted under the provisions of Florida's "Government in the Sunshine" and Public Records laws.*

UF UNIVERSITY of FLORIDA

FLORIDA MUSEUM OF NATURAL HISTORY, UNIVERSITY OF FLORIDA

Thompson Chair of Invertebrate Paleontology

The Florida Museum of Natural History, University of Florida, invites applications for the **Thompson Chair of Invertebrate Paleontology** to be hired at the level of **Associate or Full Curator** (equivalent to Associate or Full Professor) with tenure. The successful candidate will be expected to conduct a dynamic research program and develop the museum's extensive collection of primarily Cenozoic invertebrate fossils that includes five million specimens. The collection is assigned two full-time staff responsible for its operations. A substantial endowment is associated with this position.

This position requires a strong commitment to university education, field work, museum-based research, and outreach. Interactions with allied academic departments include affiliate professorship status with responsibility for supervision of graduate students and teaching two formal courses per year. Minimum qualifications: Strong externally funded research, collections experience, and tenure or at least seven years of post-Ph.D. professional experience (i.e., in academic, research, or related position[s]). The start date is open. The salary is competitive and commensurate with experience.

The search committee will begin reviewing applications on January 14, 2011 and will continue to receive applications until the position (requisition # 0806086) is filled. **To ensure full consideration please apply on-line at http://jobs.ufl.edu.** The application should include: (1) cover letter, (2) curriculum vitae, (3) statement of research, collections, teaching, and outreach experience, vision, and goals; (4) reprints of no more than three publications, and (5) the names of three colleagues who might be contacted for letters of recommendation. Any questions regarding this position or nominations may be directed to the search committee chair **Dr. Bruce J. MacFadden, Thompson Chair Search Committee, Florida Museum of Natural History, University of Florida, P.O. Box 117800, Gainesville, FL 32611-7800 (bmacfadd@flmnh.ufl.edu).**

The University of Florida is an Equal Opportunity/ Affirmative Action Employer. If an accommodation due to a disability is needed to apply for this position, please call (352) 392-2477 or the Florida Relay System at (800) 955-8771 (TDD). The selection process will be conducted under the provisions of Florida's "Government in the Sunshine" and Public Records laws.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

of developing a strong research program with the likelihood of external funding. Primary teaching responsibilities will include an upper level course in Geochemistry to be taught each year; an upper level course related to the candidate's research field to be taught alternate years; plus coverage of sections of an introductory level Geological/Environmental Hazards course designed to attract majors. It would be particularly advantageous if the candidate could offer a general survey course in Hydrology (surface and groundwater) that includes modeling.

At the present time, Geology and Geography form a combined department with separate degree programs. The Geology curriculum is deliberately generalist but rigorous and we have success in placing our graduates in entry level positions in both environmental and petroleum-related fields, as well as in good graduate programs. It is probable that in the relatively near future Geology will become an independent department and will begin the process of building a focused graduate program of its own. We seek a geologist who would enjoy full participation from the start of this building process. This includes making funds available to the successful candidate to design and equip a research lab that will support the candidate's research agenda.

The start date for this position will be August 2011. A letter of interest, vita, e-mail addresses of referees and a statement of research interests should be e-mailed or mailed to Dr. Chris Baldwin (baldwin@shsu.edu) Department of Geography and Geology, Sam Houston State University, Box 2148, Huntsville, TX 77341-2148.

In addition, candidates should go online and apply at https://shsu.peopleadmin.com/.

Sam Houston State University is an Equal Employment Opportunity/Affirmative Action Plan Employer and Smoke/Drug-Free Workplace and a Member of The Texas State University System.

FACULTY OPENING
ECONOMIC GEOLOGY AND GEOTHERMAL SYSTEMS
RESEARCH ASSISTANT PROFESSOR
UNIVERSITY OF NEVADA, RENO

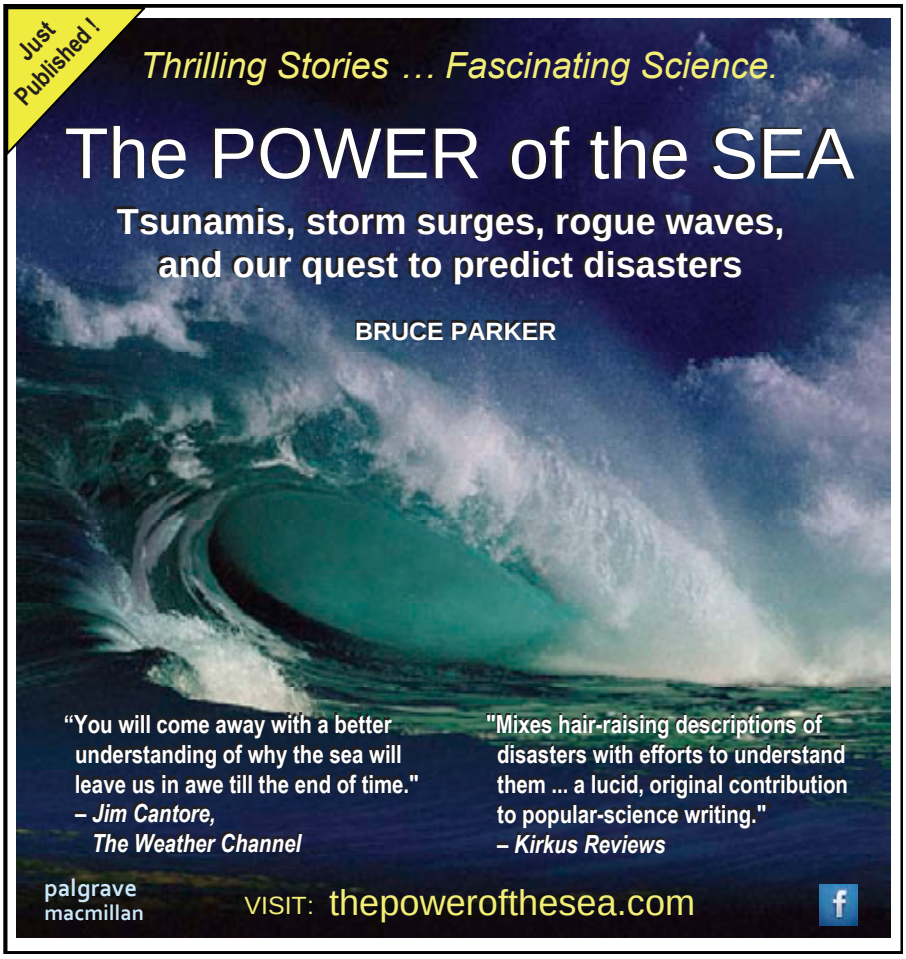
The Nevada Bureau of Mines and Geology (NBMG), University of Nevada, Reno (UNR), seeks applicants for a tenure-track, Research Assistant Professor faculty position beginning on or after July 1, 2011, with interests in research on both mineral deposits and geothermal systems. Doctoral research must include one or more of the following disciplines: economic geology, structural geology, igneous petrology, geochemistry, exploration geophysics, and hydrogeology. Nevada is one of the most exciting regions in the world to do research in the geosciences and the best in the US for the study of metallic mineral deposits and geothermal energy. For a complete position description and requirements, view the position announcement at http://www.nbmg.unr.edu and https://www.unrsearch.com/postings/8202 or contact Geoscience Search, NBMG, Mail Stop 0178, UNR, Reno, NV 89557-0178. Applications received through - https://www.unrsearch.com/postings/8202 by December 23, 2010 will receive full consideration. EEO/AA. Women and under-represented groups are encouraged to apply.

PALEONTOLOGY/STRATIGRAPHY

University of Wisconsin Oshkosh, Department of Geology, seeks field-oriented geologist for full-time, tenure-track assistant professor position starting September 1, 2011. Specialty area should complement existing faculty expertise. Ph.D. required; prior college/university teaching experience preferred. Successful candidate is expected to develop a vigorous research program, which includes publishing peer-reviewed papers. Teaching responsibilities include historical geology, paleontology, stratigraphy, field trips and advising majors. Submit letter of application, concise statement of teaching and research interests and experience, curriculum vitae, and undergraduate and graduate transcripts (original or photocopy) by December 31, 2010 to Dr. William Mode, Chair, Department of Geology, University of Wisconsin Oshkosh, Oshkosh, WI 54901. Have three current letters of reference sent directly to Department by that date. For additional information see www.uwosh.edu/departments/geology/. Employment requires criminal background check. AA/EOE.

PETROLOGY

University of Wisconsin Oshkosh, Department of Geology, seeks hard rock, field-oriented geologist for full-time, tenure-track assistant or associate professor position starting September 1, 2011. Specialty area should complement existing faculty expertise. Ph.D. required; prior college/university teaching experience



This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Please visit our website, www.earthmagazine.org/classifieds, for these and many other current career opportunities.

preferred. Successful candidate is expected to develop a vigorous research program, which includes publishing peer-reviewed papers. Teaching responsibilities include introductory courses, lithology, economic geology, geochemistry, field trips, and advising majors. Submit letter of application, concise statement of teaching and research interests and experience, curriculum vitae, and undergraduate and graduate transcripts (original or photocopy) by December 31, 2010 to Dr. William Mode, Chair, Department of Geology, University of Wisconsin Oshkosh, Oshkosh, WI 54901. Have three current letters of reference sent directly to Department by that date. For additional information see www.uwosh.edu/departments/geology/. Employment requires criminal background check. AA/EOE,

DEPARTMENT OF GEOSCIENCES SEARCH FOR TENURE-TRACK STRUCTURAL GEOLOGIST

Smith College invites applications for a tenure-track Assistant Professor position in the Department of Geosciences specializing in structural geology with knowledge in the use of Geographic Information Systems (GIS). The successful candidate will be expected to teach courses in structural geology, GIS, and other subjects that can support our Geoscience majors and Environmental Science and Policy majors. Applicants must demonstrate a strong interest in teaching. In addition, the successful candidate will be expected to maintain an active research program that encourages collaborative research with Smith College undergraduate students. A Ph.D. in the geosciences is required.

Submit application at http://jobs.smith.edu with uploaded letter of application, C.V., statement of research interests, and the names and contact information of three references. Review of applications will begin on December 30, 2010.

Smith College is a member of the Five College Consortium with Amherst, Hampshire, and Mount Holyoke Colleges and the University of Massachusetts Amherst. Smith College is an equal opportunity employer encouraging excellence through diversity.

SCOTT RUDOLPH CHAIR IN EARTH AND PLANETARY SCIENCES WASHINGTON UNIVERSITY IN ST. LOUIS

The Department of Earth and Planetary Sciences at Washington University in St. Louis invites applications for a tenure-track associate professor or full professor in the area of planetary petrology to fill the new Scott Rudolph Chair in Earth and Planetary Sciences. We seek outstanding candidates with expertise in the petrologic evolution of Earth and other terrestrial planets, satellites, meteorites, and/or cosmic dust. The successful candidate will be responsible for teaching undergraduate and graduate courses in petrology and other topics in the area of his or her expertise. The individual must have an outstanding teaching record or otherwise show promise of excellence in teaching and mentoring of students. The candidate must also develop and sustain a vigorous research effort in petrology, maintain a strong publication record, and be active in student advising and university service. We are seeking individuals who will greatly strengthen our efforts in cosmochemistry and planetary sciences, both within the Department of Earth and Planetary Sciences and the McDonnell Center for the Space Sciences. Candidates must have a Ph.D. with a focus in petrology, or a related field, at the time of appointment, and should send a letter of application, curriculum vitae, statement of teaching and research interests, and names and contact information of at least four references to Professor Raymond Arvidson, Search Committee Chair, Washington University, Campus Box 1169, 1 Brookings Drive, St. Louis, MO 63130, or via e-mail: srcfacsearch@levee.wustl.edu. Women and minorities are encouraged to apply. Washington University is an equal opportunity/affirmative action employer. Employment eligibility verification required upon employment. Applications will be considered until the position is filled, but priority will be given to those received by December 31, 2010.

SERVICES AND SUPPLIES

ANYPLACE AMERICA offers free, printable topographic maps of any place and geological feature in America, including latitude and longitude, nearest city, and elevation. www.anyplaceamerica.com

IGNEOUS AND CONTACT METAMORPHIC ROCK SUITES from the Gettysburg and Newark Basins of Pennsylvania. Including newly discovered Olivine Zones rocks and Monocacy Hill Xenoliths. For price and information contact RRK_ANISE_PA@yahoo.com

Digital Vector Maps — Offers royalty-free & cartographically accurate Adobe Illustrator maps for use in print, web and multimedia design projects. Hundreds of editable maps including: world vector maps, United States vector maps, Europe vector maps and many more. Visit http://digital-vector-maps.com or call 1-800-928-6851.

PROSPECTING MAPS WWW.GOLDMAPS.COM

OnlyGlobes.com offers a huge selection of maps and globes.

World globes www.1worldglobes.com and globe gifts www.1worldglobalgifts.com - the largest selection in the world. Classroom maps, history map sets, raised relief maps -www.worldmapsonline.com

GEOLOGY SUPPLIES — field books, maps, tools and more www.geology.com

TOPO MAPS — mapping software, GPS and aerial photos www.digital-topo-maps.com

ROCK TUMBLERS
Get rock tumblers and supplies at www.rock-tumbler.com

WATERPROOF CASES
Protect your gear with a waterproof case. www.waterproof-paper.com/cases/

WATERPROOF PAPER — field books, waterproof pens www.waterproof-paper.com

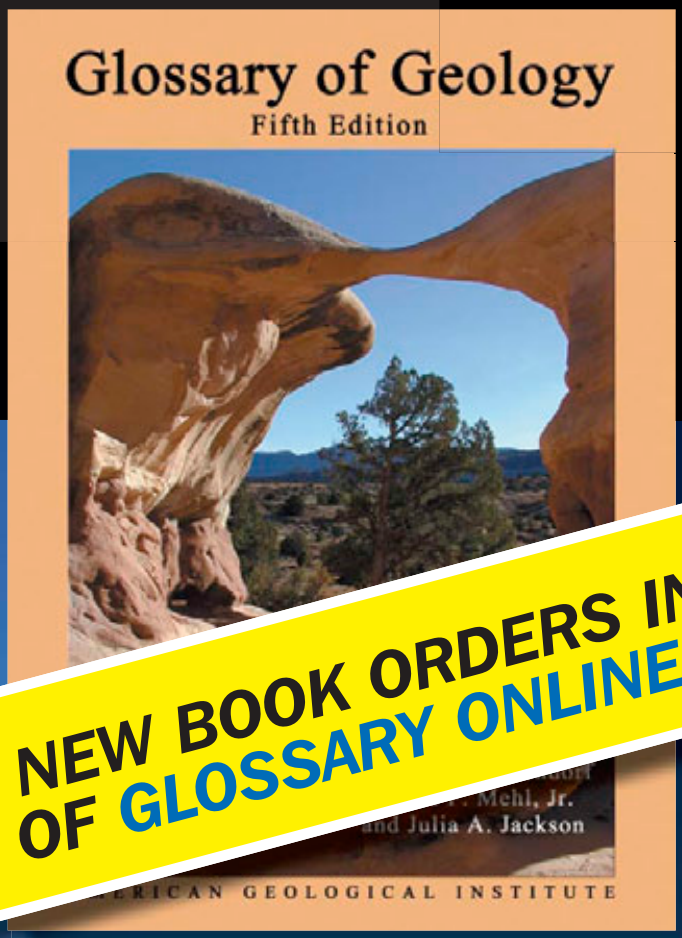
RECENT, RARE, AND OUT-OF-PRINT BOOKS
Find our catalogs at http://booksgeology.com for books on geoscience, paleontology, mineralogy, mining history, ore deposits, USGS publications, petroleum, remote sensing and metallurgy. E-mail: msbooks@booksgeology.com. We purchase books and entire collections. MS Book and Mineral Company, P.O. Box 6774, Lake Charles, LA 70606-6774 USA.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Glossary of Geology

Fifth Edition

Klaus K.E. Neuendorf
James P. Mehl, Jr.
Julia A. Jackson



NEW BOOK ORDERS INCLUDE 6 MONTHS OF GLOSSARY ONLINE ACCESS FOR FREE!

The fifth edition of the *Glossary of Geology* contains nearly 40,000 entries, including 3,600 new terms and nearly 13,000 entries with revised definitions from the previous edition. Additions and changes reflecting both advances in scientific thought and changes in usage make this 800+ page hardbound reference tool indispensable to professional earth scientists and students. In addition to definitions, many entries include background information and aids to syllabication. The *Glossary* draws its authority from the expertise of the more than 100 geoscientists in many specialties who reviewed definitions and added new terms.

American Geological Institute
4220 King Street
Alexandria, VA 22302 U.S.A.
Tel. (703)379-2480
Fax (703) 379-7563
E-mail: pubs@agiweb.org
ISBN 0-922152-76-4. Hardcover, 8.75"x11.25" 800 pp. Item #300154. Shipping and handling charge is additional. Please contact AGI for details. Free 6-month *Glossary Online* offer is for single-user access. Offer applies only to new book sales with purchases made directly from AGI.

Order online at:

www.agiweb.org/pubs

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

www.agiweb.org/pubs/glossary

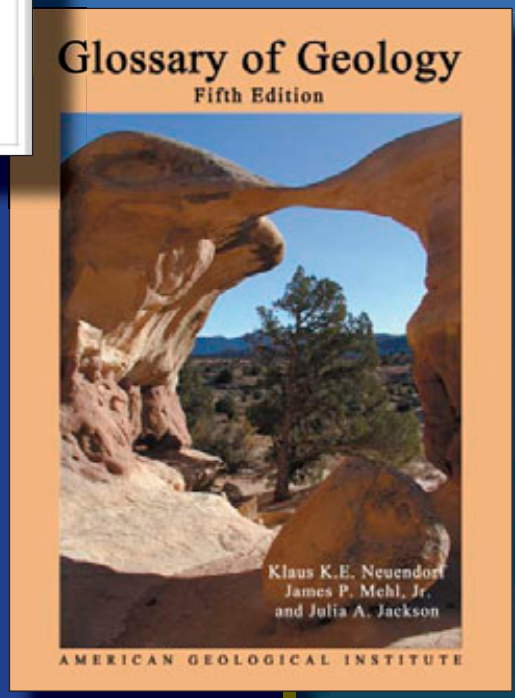
GLOSSARY ONLINE!

Free Trial!

Check out the *Glossary of Geology* online!

- Almost 40,000 searchable entries and definitions.
- Hyperlinked synonyms and related words.
- Enhanced with Spanish translations and color images.
- Based on the 2005 Fifth Edition of the *Glossary*.
- Produced with the assistance of more than one hundred subject specialists.

30-day free trial available.
Individual access fee just **$30.00** per year.
Contact **jr@agiweb.org** for details.



This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

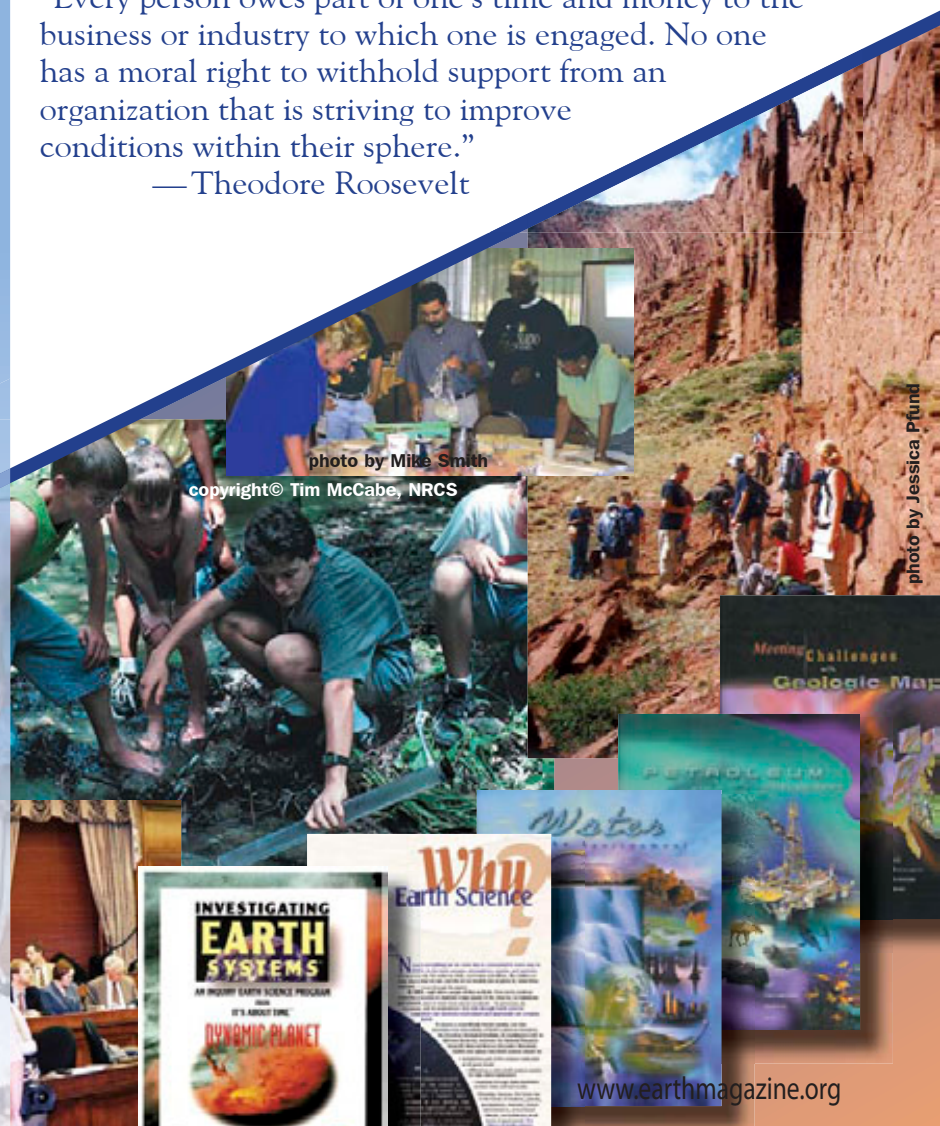
The American Geological Institute FOUNDATION

The AGI Foundation supports programs that assist researchers, educators, policy-makers, and young people—the geoscientists and informed citizens of tomorrow. Invest in the geosciences by supporting the AGI Foundation's efforts.

Some of the programs the AGI Foundation is working to fund are the following:

* Develop national geoscience curricula.
* Support a national teacher enhancement program.
* Establish a Congressional Geoscience Fellowship endowment.
* Produce environmental geoscience publications.
* Develop web-based training materials for geoscience students and professionals.

"Every person owes part of one's time and money to the business or industry to which one is engaged. No one has a moral right to withhold support from an organization that is striving to improve conditions within their sphere."
—Theodore Roosevelt



AGI Foundation Trustees

Chair: Roger P. Pinkerton, Marathon Oil Co.
Vice Chair: William A. van Wie, Devon Energy Corp.
Secretary: William L. Fisher, Univ. of Texas, Austin
Treasurer: William E. Gipson, Gas Investments/Gas Fund Inc.
Executive Director: Jan F. van Sant, Pennzoil Co. (Ret.)

Hisham Alqassab, ExxonMobil • John J. Amoruso, Amoruso Petroleum Co. • Bruce S. Appelbaum, Mosaic Resources • Michael J. Baranovic, Shell Exploration and Development Co. (Ret.) • Stephen J. Barberio, Vulcan Materials Co. • William N. Barkhouse, ABC-GEO, Inc. • William J. Barrett, Bill Barrett Corp. (Ret.) • Thomas D. Barrow, T-Bar-X Limited Co. (Ret.) • Annell R. Bay, Marathon Oil Co. • R. Michael Beathard, Bechtel Corp. • Steven R. Bell, Remora Energy • C. Scott Cameron, Shell Energy Resources Co. • Peter D. Carragher, Rose & Associates • Stephen M. Cassiani, ExxonMobil (Ret.) • Kenneth W. Ciriacks, Amoco (Ret.) • William E. Crain, Chevron Corp. (Ret.) • Robert P. Daniels, Anadarko Petroleum Co. • Peter A. Dea, Cirque Resources • David DeFelice, Occidental Oil and Gas Co. • James W. Farnsworth, Cobalt International Energy • Michael C. Forrest, Consultant • James M. Funk, Equitable Production Co. (Ret.) • James A. Gibbs, Five States Energy Co. • Howard R. Gould, Exxon (Ret.) • Arthur R. Green, ExxonMobil (Ret.) • Priscilla C. Grew, Univ. of Nebraska State Museum • Elwyn C. Griffiths, ExxonMobil • Charles G. Groat, Univ. Texas, Austin • Thomas M. Hamilton, Medora Investments LLC • James W. Handschy, ConocoPhillips • Frank W. Harrison Jr., Optimistic Oil Co. • John D. Haun, Colorado School of Mines (Ret.) • G. Warfield Hobbs IV, Ammonite Resources • Paul R. Koeller, Halliburton • Gregory M. Larberg, Burlington Resources • Ernest A. Mancini, Univ. of Alabama • Richard E. Migues, Bechtel Corp. (Ret.) • James C. Patterson, Conoco (Ret.) • Donald L. Paul, E&T Strategies • Alan S. Pennington, Meridian Resource Corp. • Richard M. Powers, BCI Engineers & Scientists • Floyd R. Price, Apache Corp. • Robert N. Ryan Jr., Chevron Corp. • John N. Seitz, Endeavour Intl. Corp. • Russell G. Slayback, Leggette Brashears & Graham, Inc. • Daniel L. Smith, Sandalwood Energy L.L.C. • Harvey A. Smith, Consultant • Donald L. Sparks, Univ. of Delaware • James V. Taranik, Univ. of Nevada, Reno • M. Ray Thomasson, Thomasson Partner Associates • Jack C. Threet, Shell Oil Co. (Ret.) • Scott W. Tinker, Texas Bureau of Economic Geology • Frederick F. Weber, ExxonMobil • Kane C. Weiner, Texas Crude, Inc. • Lawrence P. Wilding, Texas A&M Univ. • John Willott, ExxonMobil (Ret.) • David F. Work, BP Amoco (Ret.)

AGI Foundation
J.F. (Jan) van Sant
Executive Director
10777 Westheimer, Suite 250
Houston, TX 77042-3453
www.agifoundation.org
Tel: (713) 787-6767
Fax: (713) 787-6772

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

Obama's Mission to an Asteroid: A Protracted Mission to Nowhere

Jonathan Gutheinz and Joseph Richard Gutheinz Jr.

Disasters at NASA affect more than just astronauts and their families. They affect entire communities. Of course, the heartbreak at the loss of life is first and foremost on everyone's minds. But while the dust settles and NASA figures out how best to continue with manned spaceflight, the communities that depend on NASA for their economic livelihood experience a crippling loss that locals describe as a slow death.

Following the Space Shuttle Challenger disaster in 1986, residents of Titusville, Fla., located at the doorstep of the Kennedy Space Center, waited two years and eight months to see another manned mission. During this timeframe, the community was gripped by fear of economic calamity. For two and a half years after the Space Shuttle Columbia catastrophe in 2003, residents of Clear Lake, Texas — home of the Johnson Space Center, mission control and some of the primary contractors for the space shuttle program — worried aloud what the future of shuttle contract employees and NASA mission control specialists might be until finally, once more, NASA re-engaged and launched a shuttle flight.

This year, the Obama administration dealt a similarly tough blow to the hopes and dreams of NASA employees working on the agency's manned missions and those who depend on the agency's commerce. The administration announced in April that it was scrapping plans to return astronauts to the moon. NASA and the administration instead are opting for limited goals and meager efforts. This year marked a sad time for the once-vaunted U.S. space program.

At a speech at the Kennedy Space Center, President Obama announced that NASA would be canceling the troubled Constellation program — a program designed to rocket American astronauts back into space after the shuttle fleet is finally retired following the final launch of the space shuttle sometime next year. Constellation would have ultimately returned America to the moon and led to the creation of a permanent colony there. Instead, Obama announced that after the space shuttles stop flying, NASA astronauts will continue to go into space — aboard the Russian Soyuz spacecraft. Furthermore, Obama announced his administration's goals of missions beyond the moon, first to an asteroid in about 2025, and then to Mars by the mid-2030s. All of that would be accomplished through public-private partnerships, as EARTH reported in July.

This is a short-sighted and ill-advised plan. For one thing, why are we putting our astronauts' lives in Russian hands? Officials within NASA have long been critical of the Russian space program due to its antiquated technology, relatively lax safety regimen and lack of candor with NASA when it comes to safety-related incidents — such as the 1997 fire aboard the Mir Space Station. The Russians concealed the fire for hours and then lied about the risks associated with it, even though a NASA astronaut was onboard.

Obama's olive branch to NASA was his mission to an asteroid. We polled a lot of our friends in NASA for this column, and discerned that NASA employees and enthusiasts have different perspectives when it comes to this mission. Some told us that a commitment to any type of manned missions was better than nothing. Thus we should find encouragement in the fact that President Obama was scaling back manned space missions, not eliminating them.

But more say it is too little and too late, too costly, too distant an object — and why go to an asteroid anyway? Is it a mission to save the planet? We hope not. More likely, it won't save anything but a few NASA jobs within a sea of NASA layoffs in other programs. In fact, in October 2010, a special workforce office opened in Clear Lake, Texas, to find work for displaced NASA workers, perhaps the prelude to things to come.

In the process of studying the new space direction proposed by the president, we looked for the silver lining that would make an asteroid mission worthwhile to the NASA community and to America. Sadly, we found none, and instead found a state of malaise has encompassed NASA as the employees are left adrift, devoid of goals and direction. However, this fall, in a pre-election compromise between the administration and both Republicans and Democrats in Congress, a small amount of funds have been preserved for the Constellation program. But that action is best suited to save a few jobs as opposed to impacting NASA's mission for the better.

It seems that the proposed asteroid mission is just an abstract proposal. All that we know now are the unknowns: What will astronauts do on an asteroid? How much will it cost to get there? Which asteroid will they go to? Such an uncertain mission may be the death of meaningful American manned missions into space. Let's hope the new year brings better news for our space program.

Joseph R. Gutheinz Jr. is a retired senior special agent with NASA's Office of Inspector General, a criminal defense attorney and an instructor at both the University of Phoenix and Alvin Community College in Texas. While at NASA, he investigated the Russian space program and the Russian Mir Space Station fire and collision. Jonathan Gutheinz, Joseph's nephew, is a junior at the University of Texas at Arlington, majoring in broadcast management. He plans to go to law school and join Joseph's law firm. The views expressed are their own.

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

A Geology Club for All Seasons

Lisa A. Rossbacher

As 2010 draws to a close, I find myself thinking about how people and organizations change and evolve over time. Some come and go out of our lives while others persist. Some are perfect for their moment, but then the environment around them changes. The Branner Club is one of these entities. It no longer exists, but it was exactly right for its time.

> In a world of Internet, e-mail, Twitter, groupware, Basecamp, wikis, Facebook, Google docs, Google maps, FTP sites, MobileMe, text messaging and file sharing, the importance of face-to-face social gatherings is not what it once was.

The Branner Club was founded in 1921 by geologists who wanted to honor their mentor J.C. Branner. Most had been Branner's students at Stanford University in Northern California, but after school, they found themselves in Southern California, looking for personal and professional connections with colleagues. The purpose of the club was straightforward, as noted in its founding document: "In order to foster the study of Geology in Southern California and to stimulate good fellowship among Geologists the undersigned do hereby form a club."

At a time when petroleum companies were competing with each other and relatively few colleges and universities had established geology departments, this organization played an important role in developing friendship, partnerships and a sense of community throughout the Los Angeles area. The Branner Club brought together geologists from a variety of specialties, although petroleum geologists and seismologists figured prominently at first. Over time, they were joined by engineering geologists in industry and geoscientists of all sorts in academia and state and federal government positions.

For most of its existence, the Branner Club met at the Athenaeum, the storied faculty club and dining facility on the Caltech campus in Pasadena. The group met three or four times a year to socialize, have dinner and listen to a speaker — not unlike many of our current societies and clubs. Spouses were always welcome. No doubt, stories about Branner filled some of the early gatherings, like how he introduced his senior student assistant and future U.S. president, Herbert Hoover, to Hoover's future wife, Lou Henry, a freshman who decided to major in geology after attending one of Branner's lectures. Occasional sightings of Nobel Prize-winner Linus Pauling on the Caltech campus were also a highlight of these gatherings.

Speaking at the Branner Club was more like telling stories around a campfire than a formal presentation. Certainly, the talks were well-illustrated, but they were usually aimed at a general audience. The result was that even the guests and spouses usually understood the presentation and enjoyed the slides and stories. Because the setting was intimate, some of the speakers were refreshingly honest and open in their remarks. No one ever had to assure them that they could speak freely because they were "among friends." They knew. The feeling in the room was like a department seminar, in which people could share their passion for the science and explore ideas, rather than a formal presentation in which the speaker had to defend a theory.

Over nine decades, some of geology's leading figures spoke at the Branner Club — from William Morris Davis to Ian Campbell to Harrison Schmitt. But by the 1970s, attendance at the meetings began to dwindle. The increasing cost of the dinners may have led to the downfall, or perhaps as the group became diversified in age and occupation, the members lost some of the basic links — especially the relationship with a shared mentor. Ultimately, changing times were probably the major contributor to the Branner Club's fate. The last meeting of the club was held in 2008.

And times *have* changed since 1921. Southern California geologists are no longer isolated. They collaborate with geoscientists all over the world. People from anywhere can attend the frequent global professional conferences in person and, increasingly, electronically. In a world of Internet, e-mail, Twitter, groupware, Basecamp, wikis, Facebook, Google docs, Google maps, FTP sites, MobileMe, text messaging and file sharing, the importance of face-to-face social gatherings is not what it once was. Perhaps it should be, but it's not.

Mark Boryta of Mt. San Antonio College in Walnut, Calif., was the last president of the Branner Club. Since the organization's last formal gathering in 2008, he and others have dreamed of resurrecting it, although the meeting location will almost certainly be different and the attendees will not share a common mentor. And yet, the original goals, set out 90 years ago, are still valid. Even in a world of constant connectivity, the time is always right to "foster the study of Geology … and to stimulate good fellowship among Geologists." I hope Mark and his colleagues are successful.

For now, as we head into a new year, all of us can contribute to the same overall goals through our own connections with local scientific organizations, sharing our understanding of the region, the state, Earth and other planets. And don't forget that good fellowship part.

If J.C. Branner were still around, he would probably tweet his approval and set his Facebook status to "Ready!"

Rossbacher, a geologist, is president of Southern Polytechnic State University in Marietta, Ga. She served as president of the Branner Club in 1990. E-mail: rossbach@spsu.edu. The views expressed are her own.

Lisa A. Rossbacher

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

EnviroTech℠ ◆ Suppliers of Field Instrumentation ◆

Did You Know...

Enviro-Tech Rental Program

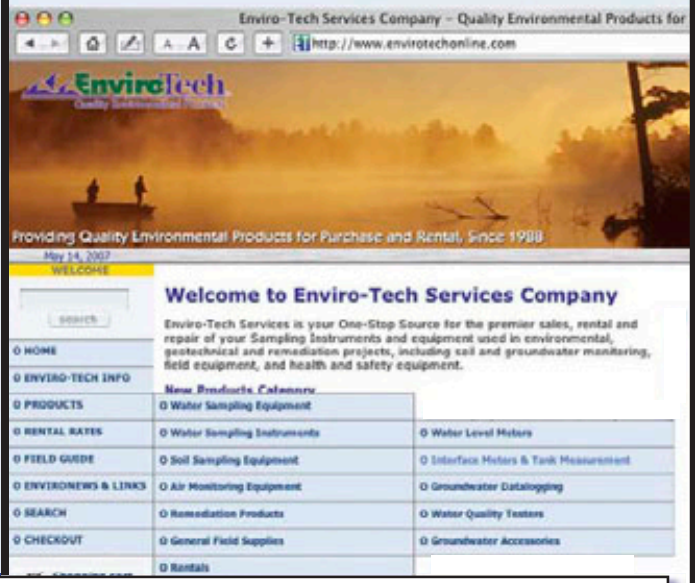
It Looks Sharp and Professional

Our Quality Guarantee – If we fail to provide any of this, your rental is FREE* until we fix it.

*The only condition is you need to notify us immediatley.

We Rent Instruments

Visit Our Website
Purchase with Only A P.O. #
No Credit Card Needed!



MasterCard VISA American Express Cards DISCOVER NOVUS

Call Toll Free **1-800-468-8921**

BOREHOLE GEOPHYSICAL LOGGING SYSTEMS

*EXPLORATION & PRODUCTION * GROUND WATER * UNIVERSITY RESEARCH*

MOUNT SOPRIS INSTRUMENTS

Optical & Acoustic Televiewer
- fracture characterization
- borehole wall imagery
- casing inspection
- rock integrity

High Resolution Spectral Gamma
- rock typing, lithology
- uranium exploration
- lithostratigrapic facies analysis

Borehole Flow Meters
- hydraulic conductivity
- flow from individual fractures

Water Quality
- in-situ pH,FEC,Redox, NO_3

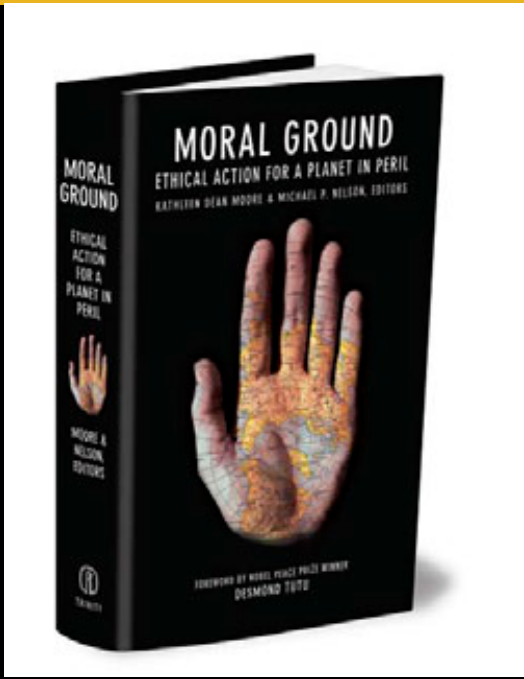
Petrophysical Properties
- density, porosity, mag. Suscep.
- galvanic resistivity

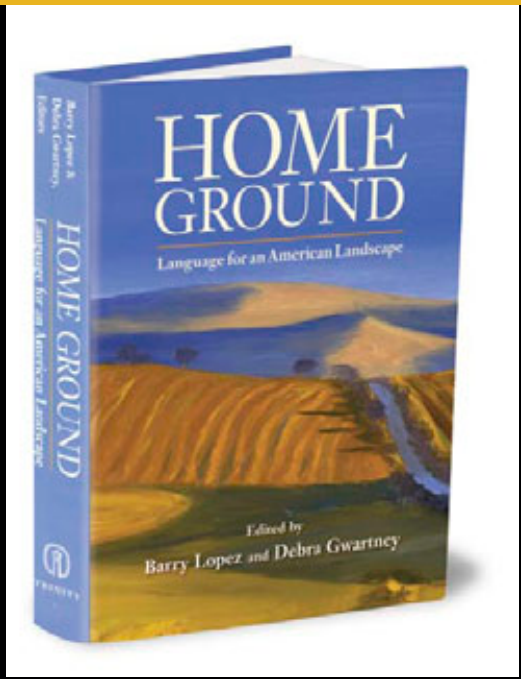
MATRIX Portable Logger

Mount Sopris Instruments * 4975 E. 41st Avenue * Denver, CO 80216 * ph.303.279.3211
Email: sales@mountsopris.com **www.mountsopris.com**

This PDF is licensed for personal use only. MjAxMC0xMi0xMjkyOTE4OTEzLjQ3

STAND YOUR GROUND





"A clear call to action."
—Archbishop Desmond Tutu

"*Moral Ground* will light a righteous fire."
—*Utne Reader*

Over 80 visionaries present challenging and inspirational testimonies on our moral obligation to address climate change, species endangerment, and environmental degradation.

www.**moralground**.com

$24.95 hardcover

MORAL GROUND @moralground

"Fabulously well-executed, a gift in every sense of the word."
—*Chicago Tribune*

"A civilized pleasure, in the way great reference books can be."
—*San Francisco Chronicle*

Over 850 original and stylistic definitions about our shared geography created by 45 of our most loved writers. Edited by Barry Lopez and Debra Gwartney.

www.**ourhomeground**.com

$19.95 paperback

HOME GROUND

At bookstores now TRINITY UNIVERSITY PRESS www.tupress.org