JANUARY 2013 VOL 6 NO 1
www.nature.com/naturegeoscience

nature geoscience

Surface rupture by great Himalayan earthquakes

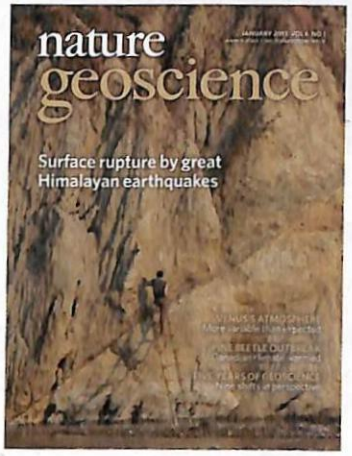
VENUS'S ATMOSPHERE
More variable than expected

PINE BEETLE OUTBREAK
Canadian climate warmed

FIVE YEARS OF GEOSCIENCE
Nine shifts in perspective

JANUARY 2013 VOL 6 ISSUE 1

nature geoscience



COVER IMAGE

The recurrence times of great Himalayan earthquakes are difficult to assess because they rarely rupture the surface. Field mapping and ^{14}C dating of offset fluvial deposits are used to identify two great Himalayan quakes that ruptured the surface along the main plate boundary fault in AD 1255 and 1934. The image shows the Sir Khola river-cut cliff looking east. Thrust fault F4, outlined by a narrow band of thin dark gouge, is seen to cut obliquely deformed grey Siwalik siltstones. Shyam Bogati, from Cheru village in southeastern Nepal, is refreshing the cliff face.

Article p71; News & Views p19

IMAGE: L. BOLLINGER

COVER DESIGN: DAVID SHAND

ON THE COVER

Venus's atmosphere
More variable than expected
Letter p25; News & Views p20

Pine beetle outbreak
Canadian climate warmed
Article p65; News & Views p21

Five years of geoscience
Nine shifts in perspective
Feature p7

Nature Geoscience is printed on paper recycled from post-consumer waste.

EDITORIAL

20 UK/3/13

CORRESPONDENCE

IN THE PRESS

FEATURE

SIKKIM UNIVERSITY सिक्किम विश्वविद्यालय LIBRARY पुस्तकालय GANGTOK गान्तोक
Dr. 20 15/3/13

BOOKS & ARTS

RESEARCH HIGHLIGHTS

NEWS & VIEWS

Sulphate concentrations in the ocean before 2.4 billion years ago were lower than today. The sulphur isotope systematics of 2.7-billion-year-old sulphide deposits suggests that these low concentrations were maintained by a balance between hydrothermal sources and microbial sulphate reduction. Image: © Mark D. Hannington. Letter p61

Every year, thousands of mesoscale storms (termed polar lows) cross the climatically sensitive subpolar North Atlantic Ocean. High-resolution numerical simulations of the ocean circulation, taking into account the effect of these storms on deep-water formation, suggest that polar lows significantly affect the global ocean circulation. Image: © NEODAAS Dundee Satellite Receiving Station. Letter p34

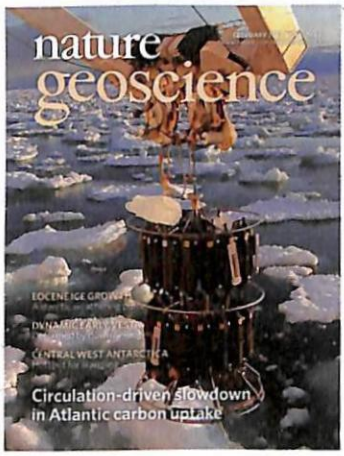
nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

FEBRUARY 2013 VOL 6 ISSUE 2

nature geoscience



COVER IMAGE

Uptake of atmospheric carbon dioxide in the subpolar North Atlantic Ocean declined rapidly between 1990 and 2006. An analysis of oceanographic data suggests that the slowdown of the meridional overturning circulation was largely responsible. The image shows sampling near the southeastern tip of Greenland aboard research vessel Thalassa, 18 June 2002.
Article p146

IMAGE: IFREMER-OVIDE

COVER DESIGN: DAVID SHAND

ON THE COVER

Eocene ice growth
Antarctic weathering pulse
Letter p121; News & Views p86

Dynamic early Vesta
Deformed by downwelling
Letter p93

Central West Antarctica
Hotspot for warming
Article p139; News & Views p87

Nature Geoscience is printed on paper recycled from post-consumer waste.

2015/3/13

SIKKIM UNIVERSITY LIBRARY GANGTOK 2015/3/13

Deposits of highly vesicular pumice that blanket submarine volcanoes are often attributed to explosive eruptions. Density and textural analysis of clasts dredged from the submarine Macauley Volcano in the southwest Pacific Ocean, however, reveal an eruptive style that is neither explosive nor effusive, with clasts instead forming from buoyant detachment of a magma foam.
Letter p129

The subsurface of Mars could potentially have contained a vast microbial biosphere. An evaluation of the possibility of groundwater upwelling, which might provide clues to subsurface habitability, reveals evidence in the deep McLaughlin crater for clays and carbonates that probably formed in an alkaline, groundwater-fed lacustrine setting.
Article p133

ARTICLES

CLASSIFIEDS

See the back pages

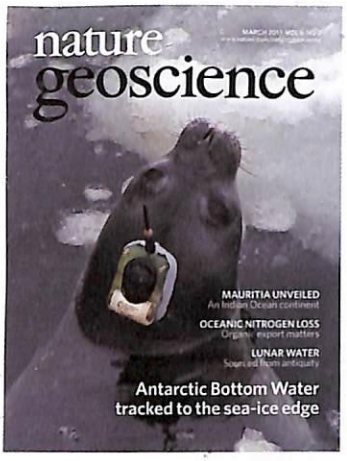
nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

MARCH 2013 VOL 6 ISSUE 3

nature geoscience



COVER IMAGE

Antarctic Bottom Water fills much of the global abyssal ocean, and is known to form in three main sites in the Southern Ocean. Data from instrumented elephant seals and moorings suggest an additional source of bottom-water formation in the Cape Darnley polynya that is driven by sea-ice production. The image shows an instrumented Weddell seal, deployed together with the Southern elephant seals in the study.

Article p235: News & Views p166

COVER IMAGE: IAIN FIELD

COVER DESIGN: DAVID SHAND

ON THE COVER

Mauritia unveiled
An Indian Ocean continent
Letter p223; News & Views p165

Oceanic nitrogen loss
Organic export matters
Article p228; News & Views p160

Lunar water
Sourced from antiquity
Letter p177; News & Views p159

Nature Geoscience is printed on paper recycled from post-consumer waste.

EDITORIAL

CORRESPONDENCE

COMMENTARY

IN THE PRESS

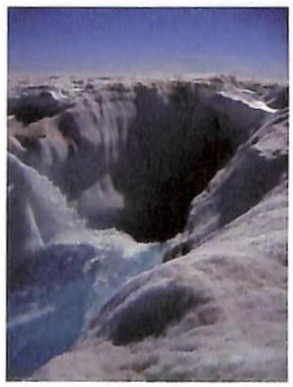
RESEARCH HIGHLIGHTS

NEWS & VIEWS

REVIEW ARTICLE

LETTERS

Coccolithophores are a key component of the oceanic food web, and may be sensitive to environmental changes. Modern experiments and an assessment of the fossil record suggests that the response of individual species to a period of ocean acidification in the past may have affected the evolutionary success of these species' lineages.
Letter p218; News & Views p164



The fast flow of glaciers in Greenland during the summer season has been attributed to seasonal increases in subglacial melt water. Tracking the flow of subglacial water using geochemical tracers reveals the establishment of an increasingly efficient drainage network as the melt season progresses. Image © Dave Chandler
Letter p195

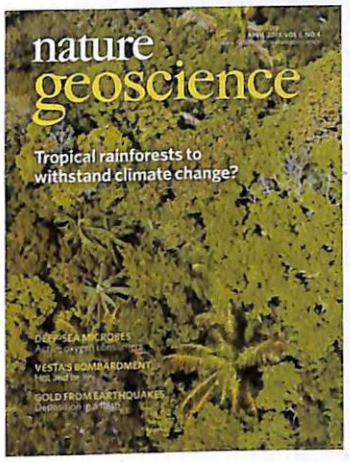
ARTICLES

CLASSIFIEDS

See the back pages

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA. UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA. Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience. © 2013 Macmillan Publishers Limited. All rights reserved.



COVER IMAGE

Assessing potential future carbon loss from tropical forests is important for evaluating the efficacy of programmes for reducing emissions from deforestation and degradation (REDD). An exploration of results from 22 climate models in conjunction with a land surface scheme suggests that in the Americas, Africa and Asia, the resilience of tropical forests to climate change is higher than expected, although uncertainties are large. The image shows a tropical rainforest canopy.
Letter p268

IMAGE: THINKSTOCK/ PHOTODISC

COVER DESIGN: DAVID SHAND

ON THE COVER

Deep-sea microbes
Active oxygen consumers
Letter p284; News & Views p252

Vesta's bombardment
Hot and heavy
Article p303

Gold from earthquakes
Deposition in a flash
Letter p294; News & Views p248

Nature Geoscience is printed on paper recycled from post-consumer waste.

EDITORIAL

CORRESPONDENCE

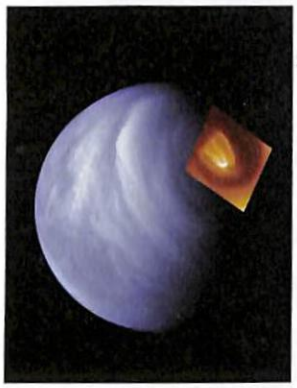
IN THE PRESS

RESEARCH HIGHLIGHTS

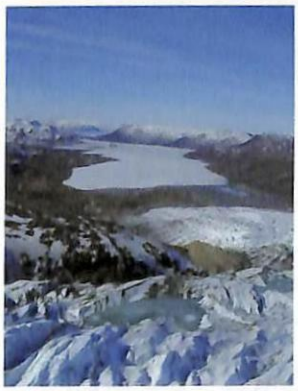
SIKKIM UNIVERSITY सिक्किम विश्वविद्यालय LIBRARY GANGTOK 8/5/13

NEWS & VIEWS

LETTERS



A whirling vortex has been observed in the atmosphere at the south pole of Venus. Cloud motions tracked by the Venus Express spacecraft suggest that the south polar vortex is long-lived, erratic and baroclinic in character.
Image © ESA/VIRTIS-Venus Express and VMC teams
Letter p254



The micronutrient iron is thought to limit primary production in large regions of the global ocean. Meltwater measurements suggest that the Greenland ice sheet serves as a significant source of potentially bioavailable iron to the surrounding coastal ocean.
Image © Sarah Das
Letter p274; News & Views p251

ARTICLES

CLASSIFIEDS

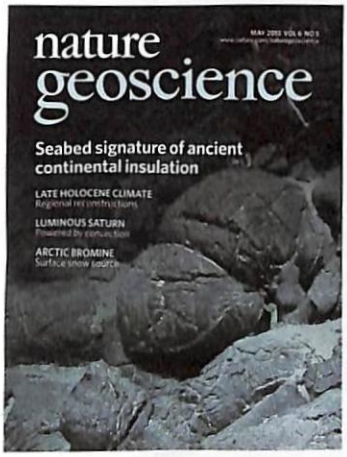
See the back pages

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience. © 2013 Macmillan Publishers Limited. All rights reserved.

MAY 2013 VOL 6 ISSUE 5

nature geoscience



COVER IMAGE

The continents are thought to insulate and heat the underlying mantle. Geochemical analyses of lava samples formed at a mid-ocean ridge in the Atlantic Ocean immediately after continental break-up show that the mantle was up to 150 °C hotter than today and took about 70 million years to cool. The image shows pillow lavas — which record the chemical composition of the melts — at the southern Mid-Atlantic Ridge at 9°34′S.

Letter p391; News & Views p332

IMAGE: © MARUM, UNIV. BREMEN, GERMANY

COVER DESIGN: DAVID SHAND

ON THE COVER

Late Holocene climate
Regional reconstructions
Progress Article p339

Luminous Saturn
Powered by convection
Letter p347

Arctic bromine
Surface snow source
Letter p351; News & Views p331

Nature Geoscience is printed on paper recycled from post-consumer waste.

SIKKIM UNIVERSITY ... LIBRARY ... GANGTOK ... 3/7/13

The Antarctic Peninsula is one of the most rapidly warming regions on Earth. A reconstruction of ice melt over the past 2,000 years from an ice core taken near the northeastern tip of the peninsula shows that surface melt has accelerated during the twentieth century. Image © Nerilie Abram

Article p404; News & Views p334

Lavas erupted from individual volcanic centres often have one of two distinct compositions. High pressure and temperature experiments on lava samples collected from St Vincent Volcano in the Caribbean, combined with thermal modelling, show that this compositional bimodality is generated by volcanic systems with low heat and water content. Image © Richard J. Arculus

Letter p385

ARTICLES

CLASSIFIEDS

See the back pages

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

JUNE 2013 VOL 6 ISSUE 6

nature geoscience

COVER IMAGE

Carbon is carried into the Earth at subduction zones. Geochemical analysis of subducted sediments now exhumed in Alpine Corsica, France, reveal the formation of graphite during shallow subduction, implying that carbonate transformation to graphite aids transport into the deeper Earth. This image shows a contact between hydrothermally altered mantle rocks and blueschist metasediments in Alpine Corsica, France.
Letter p473

IMAGE: ALBERTO VITALE BROVARONE

COVER DESIGN: DAVID SHAND

ON THE COVER

Slow lunar impacts
Asteroid survival
Letter p435; News & Views p422

Biogenic aerosols
Increase following warming
Letter p438

Pacific hydroclimate
Glacial sea-level control
Article p485

Nature Geoscience is printed on paper recycled from post-consumer waste.

SIKKIM UNIVERSITY LIBRARY GANGTOK

Earth's inner core rotates at a different rate than the mantle, and discrepancies exist between rotation rates derived from geophysical observations and geodynamical simulations. An inverse analysis of seismic data from repeating earthquakes over the past 50 years suggests that the rotation rate of the inner core fluctuates on decadal timescales.
Article p497; News & Views p424

Hydrogen is commonly produced during the high-temperature hydration of mafic and ultramafic rocks. Laboratory experiments suggest that water–rock reactions also generate hydrogen at lower temperatures, potentially fuelling microbial life in ultramafic aquifers in oceanic and terrestrial crust.
Article p478; News & Views p426

ARTICLES

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

JULY 2013 VOL 6 ISSUE 7

nature geoscience

COVER IMAGE

Flow in the deep mantle is thought to create textures in the high-pressure mineral post-perovskite. Laboratory simulations of the transformation between lower-pressure perovskite and post-perovskite show that post-perovskite can also inherit textures from the perovskite phase, and vice versa. This image shows an electron diffraction pattern with strong crystallographic alignment between perovskite and post-perovskite.
Letter p575; News & Views p516

IMAGE: DOBSON *ET AL.*

COVER DESIGN: DAVID SHAND

ON THE COVER

Ocean oxygen minima
Intensified by vertical migrators
Letter p545; News & Views p515

Deglacial oceans
Accelerated nitrogen loss
Article p579

Violent early Solar System
Bombardment unravelled
Progress Article p520

Nature Geoscience is printed on paper recycled from post-consumer waste.

EDITORIAL

CORRESPONDENCE

COMMENTARY

SIKKIM UNIVERSITY Library GANGTOK Dt. 20/8/13

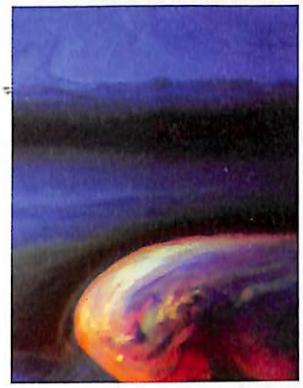
IN THE PRESS

RESEARCH HIGHLIGHTS

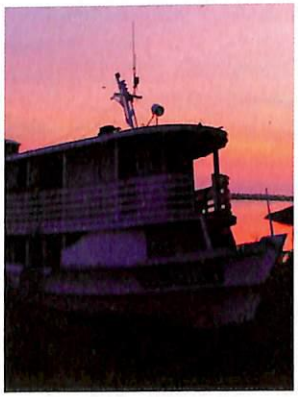
NEWS & VIEWS

PROGRESS ARTICLE

LETTERS



A Great White Spot — a rare planet-encircling storm — raged on Saturn in 2010–2011. Analyses of high-resolution spacecraft imagery and numerical modelling reveal a dynamic storm head powered by sustained convection in the zonal flow of Saturn's atmosphere. Image: © NASA/JPL-Caltech/SSI and Universidad del País Vasco
Letter p525



Temperate and tropical rivers serve as a substantial source of carbon dioxide to the atmosphere. Measurements of organic matter breakdown in the Amazon River suggest that terrestrial macromolecules contribute significantly to this outgassing. Image: © Jeff Richey
Letter p530

ARTICLES

CLASSIFIEDS

See the back pages

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA. Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

AUGUST 2013 VOL 6 ISSUE 8

nature geoscience

COVER IMAGE

The Lusi mud eruption in Indonesia has been ongoing since 2006. Numerical simulations show that a parabolic-shaped layer in the rock surrounding the site of the Lusi eruption could have amplified and focussed incoming seismic energy from an earthquake, which then triggered the mud eruption. The image shows mud oozing out of the Lapindo well in the district of Sidoarjo, Indonesia, on Monday, 18 September 2006.

Letter p642; News & Views p592

IMAGE: BLOOMBERG, GETTY IMAGES

COVER DESIGN: DAVID SHAND

ON THE COVER

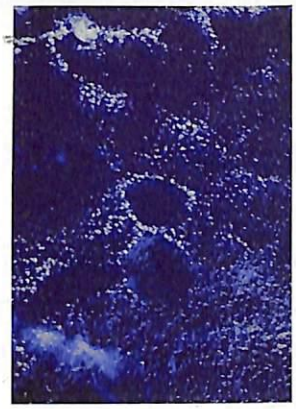
Carbon continuum
From land to ocean
Review Article p597

Cretaceous ocean anoxia
Fast continental weathering
Article p668

Australian vegetation shift
Caused by megafauna extinction
Letter p627; News & Views p595

Nature Geoscience is printed on paper recycled from post-consumer waste.

SIKKIM UNIVERSITY ... GANGTOK



Owing to the turbulent nature of the ocean, mesoscale eddies are omnipresent. An analysis of atmospheric conditions associated with several hundred thousand eddies in the Southern Ocean suggests that the transitory sea surface temperature fronts associated with these eddies alter near-surface winds, clouds and rainfall.
Letter p608; News & Views p594

The precise location of the mantle plume upwelling beneath Hawaii is debated. Seismic data reveal a thick layer of melt in the mantle beneath western Hawaii, implying that the upwelling plume may be deflected around an ancient, resistive root beneath the island.
Image: © Gabi Laske
Letter p657

ARTICLES

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

INSIGHT
MARINE CYCLES
IN FLUX

SEPTEMBER 2013 VOL 6 ISSUE 9

nature geoscience

COVER IMAGE

The remote detection of surface water indigenous to the Moon has proved difficult because of alternative sources, such as the solar wind. Spectroscopic observations of hydroxyl-bearing materials in Bullialdus Crater by the Chandrayaan-1 spacecraft are consistent with indigenous magmatic water that was excavated by impact from the lunar interior. The image shows an oblique view of Bullialdus Crater, taken from the west, about 74 km above the lunar surface, and looking east at the eastern crater wall (north is to the left). The central peak towers 1.1 km above the flat crater floor.

Letter p737

IMAGE: NASA

COVER DESIGN: DAVID SHAND

ON THE COVER

East Antarctica
Pliocene ice retreat
Letter p765; News & Views p680

Mountain building
More deformation on old plates
Letter p785

Marine nitrogen fixers
Selection by CO_2 level?
Article p790

Nature Geoscience is printed on paper recycled from post-consumer waste.

EDITORIAL

CORRESPONDENCE

IN THE PRESS

RESEARCH HIGHLIGHTS

NEWS & VIEWS

INSIGHT: MARINE CYCLES IN FLUX

EDITORIAL

COMMENTARY

REVIEW ARTICLES

The thawing and decomposition of carbon stored in permafrost generates greenhouse gases that could further intensify global warming. However, the storage and burial of thawed carbon in long- and short-term reservoirs is likely to attenuate greenhouse gas emissions. Image © Jorien E. Vonk
Correspondence p675

ARTICLES

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience. © 2013 Macmillan Publishers Limited. All rights reserved.

OCTOBER 2013 VOL 6 ISSUE 10

nature geoscience

COVER IMAGE

During glacial periods, ice sheets covered continental margins through much of Arctic North America, Greenland and western Eurasia. Marine structures suggest that an ice sheet up to a kilometre in depth periodically covered the East Siberian continental shelf as well. The image shows the Korean icebreaker *Araon* conducting a swath bathymetric survey on the Arctic Ocean.
Letter p842; News & Views p807

IMAGE: SEUNG PIL HAN

COVER DESIGN: DAVID SHAND

ON THE COVER

Volcanic eruptions
Cyclicity from gas pulses
Letter p856

Ingredients for martian life
No limit on phosphorus
Letter p824; News & Views p806

Marine methylmercury
Subsurface source
Article p879; News & Views p810

Nature Geoscience is printed on paper recycled from post-consumer waste.

Sikkim University Library Gangtok
Dt 18-11-13

The buoyancy of magma should cause it to rise into the crust, preventing it from ponding in the uppermost mantle. Magnetotelluric data from the Dabbahu rift segment, Ethiopia, identify a magma reservoir that extends well into the mantle beneath the rift, and is so large that it should persist for thousands of years. Image: Graham Dawes
Letter p861; News & Views p811

Anthropogenic aerosols are highly spatially variable, whereas greenhouse gases are largely well-mixed at the global scale, but both affect climate. Nevertheless, climate simulations suggest that regional changes in sea surface temperature and precipitation in response to changes in greenhouse gas and aerosol forcings are similar. Image: © Frontfoto.com
Letter p828

ARTICLES

nature publishing group

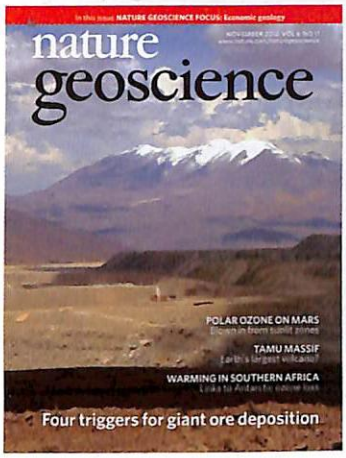
Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

FOCUS
ECONOMIC GEOLOGY

NOVEMBER 2013 VOL 6 ISSUE 11

nature geoscience



COVER IMAGE

Porphyry ore deposits supply much of the copper, molybdenum, gold and silver used by humans. A review of the main processes that trigger porphyry ore formation suggests that sulphide saturation of the magmas that supply the metals could be the overriding mechanism that helps control the temporal and spatial distribution of the ore deposits. The image shows the view across the Ujina porphyry copper deposit, Collahuasi district, Chilean Andes, looking towards the Bolivian border.
Review Article p917

IMAGE: JAMIE WILKINSON

COVER DESIGN: DAVID SHAND

ON THE COVER

Polar ozone on Mars
Blown in from sunlit zones
Letter p930

Tamu Massif
Earth's largest volcano?
Article p976; News & Views p902

Warming in southern Africa
Links to Antarctic ozone loss
Letter p934

Nature Geoscience is printed on paper recycled from post-consumer waste.

University ... Dt 8/5/14

Palaeoclimate records indicate lower El Niño/Southern Oscillation (ENSO) variance during the middle Holocene compared with today, but the mechanisms leading to this muted variability are not clear. A 175-year oxygen isotope record from a Porites coral microatoll in the NINO3.4 region records persistently reduced ENSO variance about 4,300 years ago, and season-specific analyses of the record suggest that insolation played an important role in this change.
Letter p949

Subglacial meltwater channels beneath the Antarctic Ice Sheet have been reported, but the nature and distribution of these meltwater pathways are unclear. Remote sensing observations reveal persistent channelized features beneath the Filchner Ronne Ice Shelf in West Antarctica, suggesting widespread channelized flow driven by melting.
Letter p945

ARTICLES

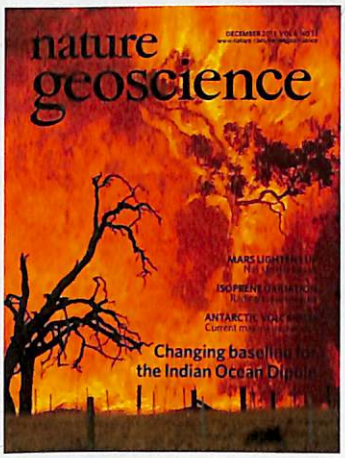
nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.

DECEMBER 2013 VOL 6 ISSUE 12

nature geoscience



COVER IMAGE

The Indian Ocean Dipole is a key mode of interannual climate variability influencing much of Asia and Australia. A Review suggests that in response to greenhouse warming, mean conditions of the Indian Ocean will shift towards a positive dipole state, but with no overall shift in the frequency of positive and negative events as defined relative to the mean climate state. The image shows a devastating bushfire in the small township of Tonimbuk, 90 km east of Melbourne, Australia, in February 2009, following severe austral spring rain deficits between 2006 and 2008, three consecutive years of positive Indian Ocean Dipole events.

Review Article p999

IMAGE: ANDREW BROWNBILL/AAP

COVER DESIGN: DAVID SHAND

ON THE COVER

Mars lightens up
Not strictly basalt
Letters p1008 and p1013; News & Views p991

Isoprene oxidation
Radicals regenerated
Letter p1023; News & Views p995

Antarctic volcanism
Current magma movement
Letter p1031; News & Views p990

Nature Geoscience is printed on paper recycled from post-consumer waste.

EDITORIAL

Sikkim University Library Gangtok
दि .....
Dt 29.01.14

IN THE PRESS

RESEARCH HIGHLIGHTS

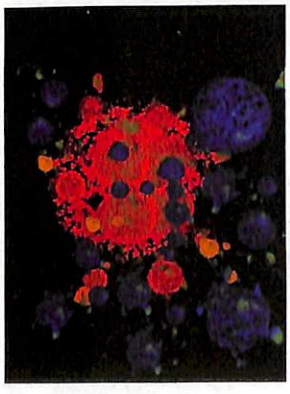
NEWS & VIEWS

REVIEW ARTICLE

LETTERS

Modern grasslands are dominated by grasses that use the C_4 photosynthetic pathway, and were established about 8 million years ago. A sediment record suggests that in southwestern Africa, the expansion of grasslands was associated with increasing aridity and fire activity, both of which favour grasses that use the C_4 pathway. Image © Paulus de Wilt

Letter p1027



The pressures and temperatures experienced by material flung from craters following impact events are expected to preclude survival of organics. The preservation of biomarkers in impact glass from the Darwin crater in Tasmania suggests that organic matter can survive in the distal products of meteorite impact. Image © Kieren Howard and Deborah Berhanu

Letter p1018; Editorial p987

ARTICLES

nature publishing group

Nature Geoscience (ISSN 1752-0894, USPS 025065) is published monthly by Nature Publishing Group, Porters South, 4 Crinan Street, London N1 9XW, UK. Editorial Office: Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4563. Email: naturegeoscience@nature.com. North American Advertising: *Nature Geoscience* 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 212 726 9200. Fax: +1 212 696 9006. European Advertising: *Nature Geoscience*, Porters South, 4 Crinan Street, London N1 9XW, UK. Telephone: +44 (0)20 7833 4000. Fax: +44 (0)20 7843 4749. New subscriptions/renewals/changes of address/back issues and all other customer service questions should be addressed to: North America: Nature Publishing Group, Customer Services Department, 75 Varick Street, 9th Floor, New York, NY 10013-1917, USA. Telephone: +1 (866) 363 7860. Fax: +1 (212) 334 0879. Outside North America: Nature Publishing Group, Subscriptions Department, Brunel Road, Houndmills, Basingstoke, Hants, RG21 6XS, UK. Telephone: +44 (0)1256 329242. Fax: +44 (0)1256 812358. The 2013 US annual subscription price is $4677 (Full), $152 (Personal 1 year). Airfreight and mailing in the USA by agent named Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA; UK/Rest of World (excluding Europe and Japan) £2400 (institutional/corporate), £78 (individual making personal payment); Europe €3713 (institutional/corporate), €121 (individual making personal payment). Japan: contact Nature Asia-Pacific, Chiyoda Building, 2-37 Ichigayatamachi, Shinjuku-Ku, Tokyo, 162-0843, Japan. Telephone +81 3 3267 8751. For single back issue prices contact the publisher. Periodicals postage paid at Jamaica NY 11431. *Nature Geoscience* is published monthly by Nature Publishing Group, The Macmillan Building, 4 Crinan Street, London N1 9XW, UK. US Postmaster: Send address changes to *Nature Geoscience*, Air Business Ltd, c/o Worldnet Shipping Inc., 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA Distributed in the USA by Mercury Intl 365 Blair Rd, Avenel, NJ 07001. Reprints: *Nature Geoscience* Reprints Department, Porters South, 4 Crinan Street, London N1 9XW, UK. Subscription records are maintained at Nature Publishing Group, Brunel Road, Basingstoke, Hampshire RG21 6XT, UK. Air Business Ltd is acting as our mailing agent. Subscription information is available at the *Nature Geoscience* homepage at http://www.nature.com/naturegeoscience.

© 2013 Macmillan Publishers Limited. All rights reserved.