RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Identifying the physical processes that control the stratigraphic record

The stratigraphic record, the sequential layers of sediment that geologists use to reconstruct the history of a landscape, has been described as "more gaps than record." The record, laid down over time as sediment settles out from flowing water, does not grow consistently. Pauses in sediment deposition can leave gaps, and periods of heightened erosion can wipe out sections. Although attempts have been made to identify the processes that control the completeness of the stratigraphic record, early analyses relied on parameters (such as the long-term sediment accumulation rate) that are not first-order physical landscape processes.

Building on that earlier work, *Straub and Esposito* used a series of laboratory experiments to identify the physical processes that are relevant to controlling the accumulating stratigraphic record and to determine the relationships between these processes. The authors built a series of artificial river deltas, each with varying water flow and sedimentation rates, and used time-lapse photography and topographic measurements to track how the stratigraphic record developed. They found that the stratigraphic record is most complete when the sediment deposition rate is high, when the water flow rate relative to the sediment flow rate is low, and when the river channel migrates slowly across the whole delta region. (*Journal of Geophysical Research-Earth Surface,* doi:10.1002/jgrf.20061, 2013) —CS

Detection of multiple small plasmoids in the magnetotail

Magnetic field lines in the Earth's dayside magnetic field can be broken down and swept to the Earth's nightside by the solar wind. The magnetic field lines reconnect in the magnetotail, in some cases triggering a magnetic substorm. During a substorm, plasma trapped in the magnetotail is sent flowing toward the Earth, and the magnetotail current sheet—the region where magnetic field lines from the Earth's North and South Poles come together—gets thinner.

This thinning of the current sheet can promote magnetic reconnection, drive a voltage potential known as the Hall effect to form across the sheet, and, scientists think, give rise to a structure known as a plasmoid. A plasmoid is a confined parcel of plasma and magnetic field lines. The magnetic field lines are closed off, encompassing the plasmoid. Plasmoids can take on various forms and can span a range of spatial scales.

Drawing on observations made using the European Space Agency's Cluster spacecraft, *Liu et al.* detected a number of small-scale plasmoids in the magnetotail, each about half the radius of the Earth in length. The authors detected for the first time three small plasmoids formed during a single magnetic substorm.

Using a magnetohydrodynamic model, the authors studied how the magnetic field properties in the magnetotail affected the formation of the plasmoids. From the modeled dynamics and the Cluster observations, the authors found that the occurrence of a cross-tail magnetic field in the magnetotail is important for the formation of plasmoids. They also found that multiple instances of magnetic reconnection and the Hall effect are particularly significant.

Hydrology affects carbon storage potential of prairie potholes

Prairie potholes, the small, dynamic, unconnected ponds that dot central Canada as well as parts of the north central United States, can store significant amounts of soil nutrients that can be transformed to carbon dioxide and other greenhouse gases. Scientists would like to better understand how these regions could contribute to climate warming, but there are challenges, given the large heterogeneity in greenhouse gas emissions over the prairie pothole landscape.

To help gain a better understanding of the factors that influence these emissions, *Creed et al.* measured fluxes of carbon dioxide, methane, and nitrous oxide from the soils in the prairie pothole region of central Canada, along with hydrologic properties such as soil moisture. They found that soil moisture was an important driver of the differences in carbon dioxide emissions. Controls of soil moisture occurred at multiple scales, from ridge to valley along individual potholes at the finest scale and from the southern limit to the northern limit of potholes in Canada at the coarsest scale. By integrating these soil moisture controls across fine-to-coarse scales, the authors were able to show the potential contribution of prairie potholes to warming changes across the region. Greenhouse gas emissions were smallest in the drier south, where the largest emissions came from the lowland area at the land-water interface, while in the north, large emissions came from a broader area of the hill slope.

Prairie pothole wetland in southern Saskatchewan.

The authors conclude that if hydrologic factors are not taken into account, studies could significantly underestimate or overestimate the potential effects of prairie pothole regions on warming. (*Journal of Geophysical Research-Biogeosciences,* doi:10.1002/jgrg.20050, 2013) —EB

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(*Journal of Geophysical Research-Space Physics,* doi:10.1002/jgra.50248, 2013) —CS

Sediment processes can be significant source of ambient noise

Many studies of ambient ocean noise have focused on anthropogenic, biological, and weather-related sources, but collisions of sediment grains can also generate a significant amount of background noise.

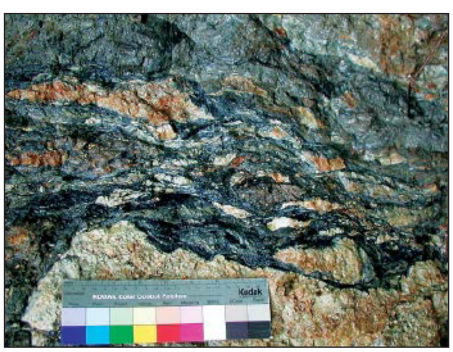
In an observational study linking noise and sediment processes, *Bassett et al.* measured sediment-generated noise in Admiralty Inlet, Puget Sound, Washington, a site where peak tidal currents exceed 3 meters per second. They found that sediment-generated noise is the dominant noise source with a frequency between 1 and 30 kilohertz during periods of strong currents. Peak sediment-generated noise levels from 4 to 20 kilohertz were associated with mobile gravel and pebbles.

In fact, the researchers found that during periods of strong currents, sediment-generated noise actually exceeded the noise from local ship traffic and that intermittent events can increase noise levels by more than 10 decibels over periods of seconds. (*Journal of Geophysical Research-Oceans,* doi:10.1002/jgrc.20169, 2013) —EB

Graphite lubricates fault zones

Graphite is known to be a low-friction material, and rocks rich in graphite are often found in fault zones. *Oohashi et al.* conducted laboratory studies to determine how much graphite is needed to reduce the frictional strength of a fault. Their experiments included samples with various mixtures of graphite and quartz, as well as pure quartz and pure graphite, and they covered large displacements (up to 100 meters), a range of slip rates (from 200 micrometers per second to 1.3 meters per second), and a range of shear strains (up to several tens of thousands).

The authors found that the coefficient of friction decreases nonlinearly with increasing graphite fraction for any given shear strain and slip rate. Friction decreases quickly as graphite fraction increases between 5 and 20% by volume; at concentrations of 30–50% graphite, frictional levels were similar to that of pure graphite. They suggest that graphite in natural fault zones can effectively reduce the fault strength. (*Journal of Geophysical Research-Solid Earth,* doi: 10.1002/jgrb.50175) —EB



Graphite-bearing, blackish fault zone along the Atotsugawa fault system, Japan. Color scale is 20 centimeters.

Coupled model boosts reproduction of inner magnetosphere ring current

The inner magnetosphere ring current, which circles the Earth a few Earth radii above the surface, consists of energetic ions and electrons and plays an important role in the space environment. During geomagnetic storms the flow in the ring current rises dramatically. The behavior of the ring current and other features of the inner magnetosphere depend strongly on conditions in other regions of the magnetosphere. The small scale of the particle dynamics that drive the ring current, compared to the vast spatial scale of the entire magnetosphere, makes it difficult to represent both the nuance of the inner magnetosphere and the full scope of the magnetospheric system.

By tying two models together, *Glocer et al.* developed a coupled model that can represent the complex inner magnetosphere while also accounting for broader magnetospheric behavior. The authors used the Comprehensive Ring Current Model (CRCM) for the inner magnetosphere and the Block-Adaptive-Tree Solar-wind Roe-type Upwind Scheme (BATS-R-US) for the global magnetosphere. In the authors' scheme, BATS-R-US is used to set the magnetic field and boundary conditions for CRCM, and CRCM's results feed back into the wider model.

The authors' model takes more magnetospheric dynamics into account, and it runs more smoothly on powerful supercomputers than previous similar setups. Comparing their model against reference geomagnetic storms, the authors found that their model reproductions of the magnetosphere's behavior compared well with satellite and ground-based observations. (*Journal of Geophysical Research-Space Physics,* doi:10.1002/jgra.50221, 2013) —CS

Studying how flocculation affects acoustic reflection

In inland estuaries and shallow coastal waters, small particles of organic matter, such as organic waste and debris or bacteria, clump together to form an aggregate known as floc. Flocculated particles can span a range of sizes, from a few micrometers to a few millimeters, and the properties and concentration of floc have a strong influence on water quality. To infer the properties of floc particles, researchers have proposed using acoustic backscatter measurements, a common technique for estimating sediment concentrations. To do so, however, requires an understanding of how the properties of floc particles affect acoustic wave reflection.

To find out, *MacDonald et al.* conducted a series of controlled laboratory experiments studying how high-frequency acoustic waves reflect off floc particles of differing composition, density, and size. They found that floc particles reflect acoustic signals differently from particles of the component organic material alone. The reflected signal depends on the base material and also on the degree of flocculation and the size of the particle. Previous research found that as floc particles grow larger, they become less dense, so that very large floc has nearly the same density as the surrounding liquid. The authors suggest that the flocculation process itself alters the particle's reflection profile.

The authors' study explored how acoustic waves scatter off floc particles and detailed how sound can be used to study floc. They found that theoretical models using conventional scattering assumptions were capable of only partially describing the observed scattering properties. They suggest that future models should better align with the observed scattering characteristics, therefore allowing acoustic observations to be used to routinely measure sediment properties in flocculating marine environments. (*Journal of Geophysical Research-Oceans,* doi:10.1002/jgrc.20197, 2013) —CS

A fix to modeled biases in rainfall microphysical process rates

Much of the uncertainty in global climate models stems from issues involved in accurately representing cloud properties. The difficulty arises in parameterizing the small-scale physical interactions that turn water vapor to cloud to rain.

The two main microphysical interactions that drive precipitation are autoconversion, the process of collision and coalescence that turns water vapor into tiny rain droplets, and accretion, the growth of droplets into raindrops. Because global models have spatial resolutions that are too coarse to fully represent these microphysical properties, they typically use assigned microphysical process rates. Often missing from these parameterizations is a consideration of cloud precipitation covariance, a representation of how the water stored in clouds varies with the water falling as rain.

Using satellite observations of the partitioning of water between cloud and rain across the planet and an analytical assessment, *Lebsock et al.* found that ignoring cloud precipitation covariance causes global models to systematically underrepresent the rates of autoconversion and accretion for

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low-altitude marine clouds. The extent of the biases varies regionally, changing with the amount of water stored in the clouds.

Based on their global analysis, the authors found that the cloud water variance is higher in the tropics than at the poles, and as a result, the microphysical process bias is stronger. Using their analytical framework, the authors suggest that some, though not all, of this bias could be corrected. (*Journal of Geophysical Research-Atmospheres,* doi:10.1002/jgrd.50347, 2013) —CS

—Ernie Balcerak, Staff Writer, and Colin Schultz, Writer

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