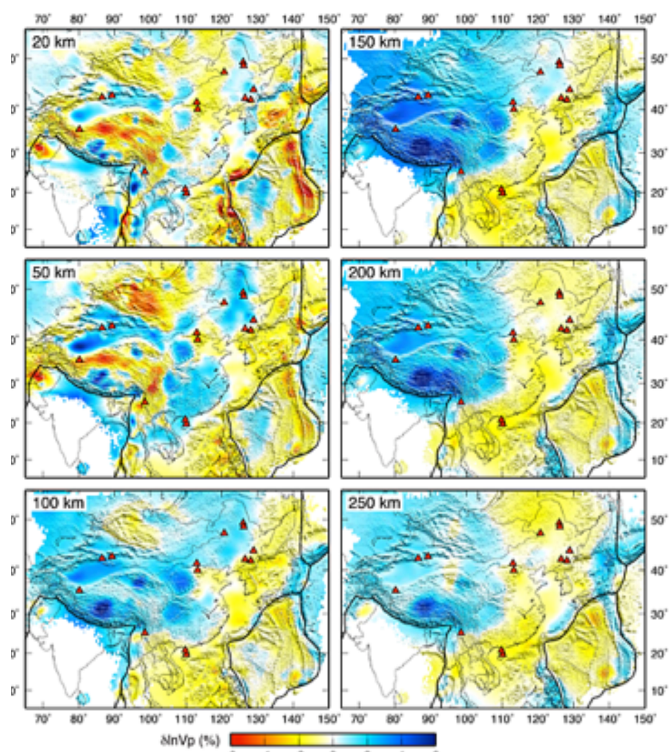
Research in the department 2015-2016

Research this past year took us on a wild ride, from deep within Earth's mantle, through the crust, into the oceans and atmosphere and onto other planets and beyond. Our research took us to almost all corners of our planet, leaving no stone unturned. Some of us studied rocks and volcanoes, while others studied the interactions between life and soils or simulated extreme conditions in our labs or on our computers. We investigated geologic processes on all timescales, from the billion year timescales of Earth's thermal evolution down to the rhythms of biological processes and earthquakes. We the editors have attempted to present a brief, but comprehensive overview of what our students, post-docs and faculty have been up to.

Deep lithosphere dynamics and the formation of continents

Formation and evolution of the crust and lithosphere appears to be a recurring theme among our faculty. Seismologists Alan Levander and Fenglin Niu have been actively writing up their results from seismic studies in Venezuela, western North America, China and the western Mediterranean. Jennifer Masy (PhD, '15) mapped out the deep lithospheric structure beneath the northeastern margin of Venezuela[1], Sally Thurner (PhD, '15) identified relic subduction structures beneath the Archean Trans-Hudson orogeny with US Array data[2], and post-doc Min Chen generated the most comprehensive and detailed tomographic map of the lithosphere beneath east Asia to date[3].

Graduate student Monica Erdman ('16), with Cin-Ty Lee and Alan Levander, reconstructed the density and compositional structure of the lower crust and lithospheric mantle beneath the Colorado Plateau in western USA and discussed implications for the rise of the Colorado Plateau[4]. Min Chen with Fenglin Niu reported a deep-seated origin for the high elevations of the Hangai Dome in Mongolia[5]. Graduate student Emily Chin ('13), with Cin-Ty Lee and Wiess visiting professor Janne Blichert-Toft, used Lutetium-Hafnium isotopes and modeling of diffusion kinetics to reconstruct the thermal evolution of the deep lithosphere beneath a continental arc. They showed that the tempo of arc magmatism is intimately tied to crustal and lithospheric thickening through effects on the thermal state of the asthenospheric mantle wedge[6]. Cin-Ty and former Wiess visiting professor Don Anderson also outlined the basic physics of how magmatic thickening of the crust and delamination feedback on each other[7].



P-wave velocity anomalies beneath China at different depths from Min Chen, Fenglin Niu and others[3]. Note the presence of large lateral variations in crustal velocity structure between the Tibetan plateau and eastern Asia. Note also the thick high velocity root beneath Tibet, corresponding to a thickened lithospheric root.

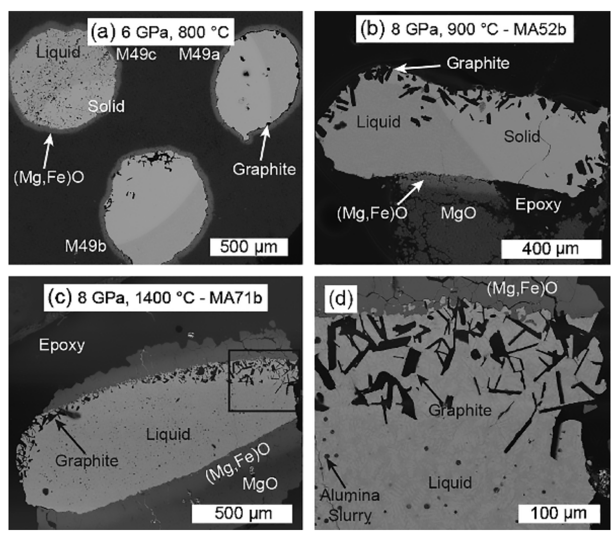
Oceanic lithosphere

Our faculty also found themselves investigating the structure of oceanic crust and basins. Emeritus professor Manik Talwani led a new tectonic model for the origin of the Bay of Bengal and Bangaladesh in the Journal of Geophysical Research. Specifically, Manik suggests that much of the basement beneath Bangaladesh is oceanic crust, on top of which lies thick sediments derived from the Himalayan orogeny. Thus, the ocean-continent basement transition here lies well inboard of the current passive margin. Visiting professor Jianping Huang, with Fenglin Niu and Richard Gordon in a creative paper, used water column reverberations to map out the focal depth of earthquakes in the oceanic crust to show that the stress state of the crust changes with depth[8], in apparent support of Richard Gordon's hypothesis that thermal contraction plays an under-appreciated role in internal deformation of oceanic plates[9]. Richard Gordon and Gregory Houseman used finite element modeling of thin viscous sheets to simulate the nature of deformation in diffuse oceanic plate boundaries, arriving at an improved view of the rheology of the oceanic lithosphere[10].

Dale Sawyer and Julia Morgan are writing up results of a large seismic study of the Galicia margin, an amagmatic continental rift in the eastern Atlantic, off the coast of Spain. Sarah Dean ('14) reported the results of seismic reflection experiments, showing that the structure of this amagmatic continental rift resembles a metamorphic core complex[11]. Dale and Juli, with international colleagues, also published a paper in Nature that showed that much of the lithosphere had been serpentinized, and with these constraints on the extent and nature of serpentinization, they offered new insights into how much water might be fluxed into oceanic lithosphere during continental rifting[12], which in turn has implications for how water gets recycled back into the Earth by subduction.

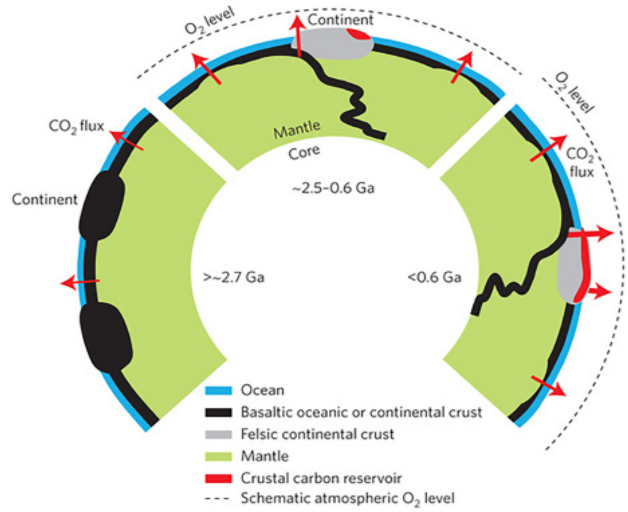
Whole Earth volatile cycling and the evolution of planetary atmospheres

And that brings us to our research on whole Earth volatile cycling. Rajdeep Dasgupta's group continues to be one of the world's leaders in this theme. Megan Duncan ('16) calibrated how the solubility of carbon dioxide varies with pressure and temperature in rhyolitic melts[13], which may have profound implications for the fate of carbon in subduction zones. Along these lines, current student Laura Carter published on the interaction between basaltic magmas with limestones, quantifying how much carbon dioxide might be released under such conditions[14]. Cin-Ty Lee and Jade Star Lackey at Pomona College described the implications of magma-wallrock interaction in continental arcs for long term climate evolution[15]. These works represent part of an ongoing 4 million dollar National Science Foundation funded project on the importance of continental arc magmatism on driving greenhouse conditions led by Cin-Ty Lee, Rajdeep Dasgupta, Adrian Lenardic, Gerald Dickens, and colleagues at Pomona College, University of Hawaii and UT Austin (arc2climate.org). Over the last year, they extended the project beyond its initial objectives. For example, Kyusei Tsuno and Raj dove into the deep carbon cycle, exploring equilibrium phase relations in the upper mantle for systems containing Fe, Ni, C, S and Cu[16]. This work led to a better understanding



Examples of experimental run products from Dasgupta's high pressure petrology laboratory. These are electron back-scattered images of experimental runs at 6 and 8 GPa (or 180 and 240 km depth), showing phase assemblages in a system containing Fe, C, Ni and S[16].

of the genesis of certain types of diamonds and their inclusions. Cin-Ty Lee, with Laurence Yeung and Adrian Lenardic, in a paper published this year in Nature Geoscience, zoomed outwards to present a new model for the whole Earth carbon and oxygen cycles, which explains how the Earth's atmosphere became oxygenated[17]. Finally, Echo Ding, with Rajdeep and Cin-Ty, re-examined the behavior of S in Martian meteorites of igneous origin to show that S contents reflect mixing between magmas and cumulates, hence caution is warranted when estimating the flux of mantle-derived S to the Martian surface from meteorites[18].

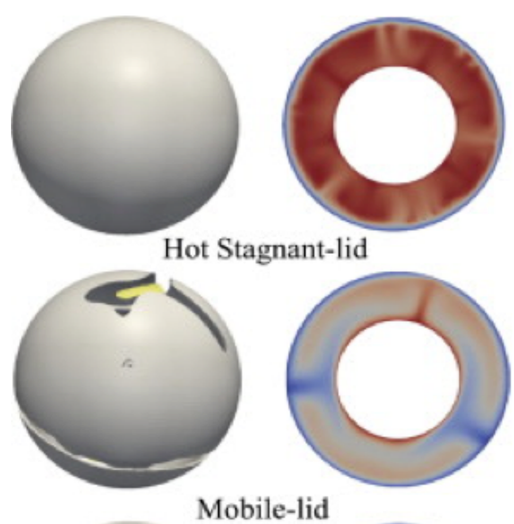


One explanation for the rise of atmospheric oxygen from Lee, Yeung and Lenardic[17]. A change in crustal composition around 2.5 Ga resulted in a decrease in the efficiency of the oxygen sink, allowing atmospheric oxygen to rise. Build-up of carbonate on the continents through time led to an increase in metamorphically derived degassing of carbon dioxide, resulting in more burial of organic carbon and production of oxygen.

Into the deep Earth

No understanding of whole Earth volatile cycles would be complete without constraints on the composition, structure and dynamics of the deep Earth. Post-doctorate Yuan Li, with Rajdeep Dasgupta and Kyusei Tsuno, were hard at work mapping out carbon solubility and partitioning in iron metals, with implications for the formation of the Earth's core and early degassing of the Earth's mantle, just after planetary accretion[19]. Fenglin Niu and colleagues continue to investigate the topography of the 660 km depth discontinuity, this time beneath northeast China, where they map out regions of slab stagnation and associated gaps and discuss potential links with volcanism[20].

On a much larger scale, Adrian Lenardic, our resident geodynamicist, has been mapping out the variable space over which different types of convective states can exist on Earth, ranging from plate tectonics to a stagnant lid regime to a regime in which heat is lost via heat "pipes" through the lithosphere[21]. Matt Weller ('15) and Adrian explored the role of internal heating and climate on the nature of convection, specifically showing that the Earth could be characterized by more than one type of steady state[22]. The implication is that Earth's current state of plate tectonics need not have been inevitable. If its starting conditions were different, it may have ended up in a different convective state; specifically, plate tectonics may be an intermediary phase, not an endmember state[23,24]. Adrian, with colleagues, continued exploring the role of different variables, such as the Urey number and lateral variations in stress state on the initiation of plate tectonics[25]. We have much to learn about how Earth's thermal state evolved and how it differentiated, but these works provide us with important new directions to follow.



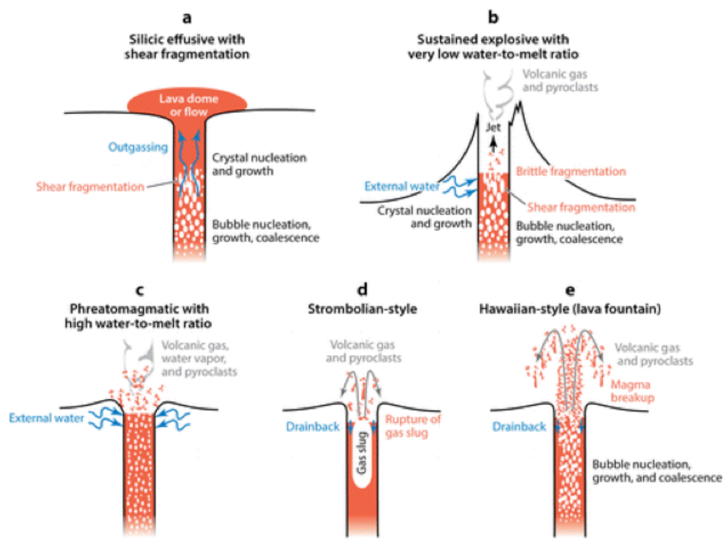
Numerical modeling results of three different types of mantle convection regimes. The mobile lid regime is akin to plate tectonics. However, a convecting mantle does not necessarily guarantee plate tectonics. Stagnant lids, e.g., a one plate planet, are permissible under certain conditions[22].

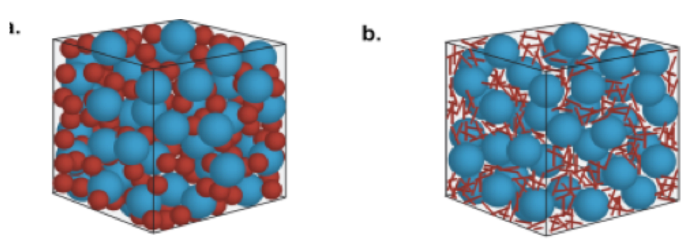
Magmas, plutons and volcanoes

Traveling from the deep mantle to the surface falls in the realm of magmas and volcanoes. Although to first order, we know how the mantle melts and how melts are transported, our faculty continue to ask new questions and push the boundaries. Ananya Mallik ('14) with Rajdeep Dasgupta explored the reaction of hydrous rhyolitic melts with ultramafic mantle, showing that such interaction can lead to flux melting and the generation of the unusually potassium rich magmas that are occasionally found in arc settings[26]. The passage of melts through the asthenosphere and lithosphere leads to refertilization, which Cin-Ty Lee and visiting scientist Jianping Zheng showed could destabilize continental lithosphere[27]. Exactly how much of the mantle is composed of unusually fertile domains is unclear, but past post-doctoral fellow Veronique Le Roux, with Rajdeep and Cin-Ty, proposed a systematic way of identifying such lithologies from the transition element compositions of lavas[28].

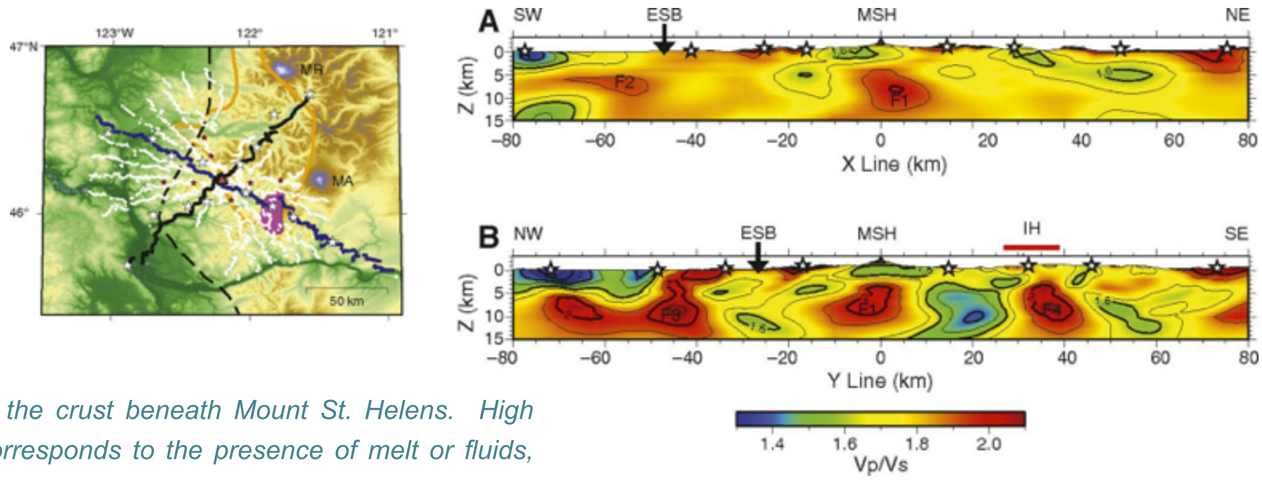
How these magmas make it out and erupt to form volcanoes or segregate to form plutons and batholiths may seem obvious. Melts are low density so they rise, but the devil is in the details. Not surprisingly, Helge Gonnermann presented definitive reviews, in the Encylopedia of Volcanoes and Annual Reviews of Earth and Planetary Sciences, of how magmas dike their way up[29] and then fragment[30]. Pranabendu Moitra ('15) and Helge, through analog fluid dynamic experiments and models, developed comprehensive parameterizations describing the role of non-uniform shaped and sized crystals on the rheology of magmas, a fundamental parameter in controlling magma flow and bubble dynamics[31].

Also important for understanding how magmas erupt is the role of degassing and bubble formation, which depend on the initial volatile content of the magma. Post-doctorate Thomas Giachetti and Helge conducted thermogravimetric analyses of pyroclasts to develop criteria for distinguishing between primary and secondary water contents, possibly forcing reinterpretation of past studies from the community[32]. On the plutonic side, Cin-Ty along with graduate students Michael Farner and Pranabendu Moitra showed how nonlinear latent heat release buys time, at the right time, for viscous silicic melts, like granites, to segregate from crystal-rich magmas[33]. Cin-Ty's group also developed new ways to determine the critical melt porosity for crystal-liquid segregation during crystallization of a magma and during partial melting of metamorphic rocks[34, 35]. Finally, one of the most recent developments in our departments is the I-MUSH seismic experiment centered on Mount St. Helens in the Washington Cascades led by Alan Levander's group. Post-doctoral fellow Eric Kiser, along with Alan and Colin Zelt, published results of their seismic survey in Geology, where they showed that the magmatic plumbing system beneath Mount St. Helens is a complicated network of magmatic mushes and cumulate bodies, the latter of which may influence the direction of magma transport[36]. All in all, we clearly have quite an interdisciplinary team at Rice working on magmatic systems.





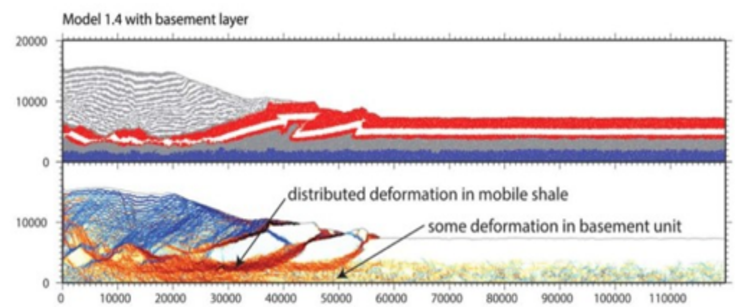
Above: Different styles of volcanic eruptions, summarized by Gonnermann[30]. Below: Analog models for crystal suspensions in magmas. Maximum packing efficiency is sensitive to particle size distribution and shape. Rheology of the magma is highly dependent on the nature of packing and particle shape/size[31].



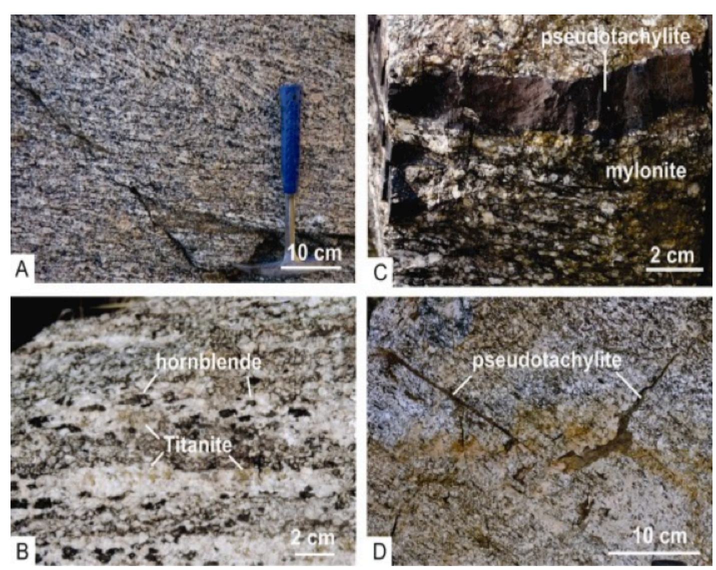
Vp/Vs structure of the crust beneath Mount St. Helens. High Vp/Vs generally corresponds to the presence of melt or fluids, such as might characterize a magmatic mush. Low values may correspond to cumulates[36]

Building mountains and following the sediments to the ocean

Mountains are transient. Their elevations are a balance between mountain building forces and the processes that take them down, from erosion to lower crustal gravitational collapse. Much excitement followed an interdisciplinary seminar on mountain building in the spring of 2014, which brought students together with John Anderson, Rajdeep Dasgupta, Cin-Ty Lee, Alan Levander, Carrie Masiello, Julia Morgan, Fenglin Niu, Laurence Yeung, and Wiess visiting professors Francis Albarede, Janne Blichert-Toft, Onno Oncken, and Yusuke Yokoyama to tackle the big problems in the origin and evolution of mountains. Cin-Ty Lee, Sally Thurner ('14) and post-doctoral fellow Wenrong Cao outline the feedbacks between magmatism, uplift, erosion and isostasy in controlling the rise and fall of volcanic arcs, discussing also how chemical weathering and climate respond[37]. Sarah Dean ('14) and Julia Morgan used discrete element numerical modeling to investigate the role of weak zones, such as layers of shale, in modulating the dynamic morphology of mountain belts in fold-and-thrust regimes[38]. Hehe Jiang, Cin-Ty Lee, Julia Morgan and visiting undergrad Catherine Ross investigated pseudotachylites – paleo-earthquakes- from a Cretaceous continental arc to track the interplay between thrust faulting, magmatism and erosion in the building of a magmatic arc[39].

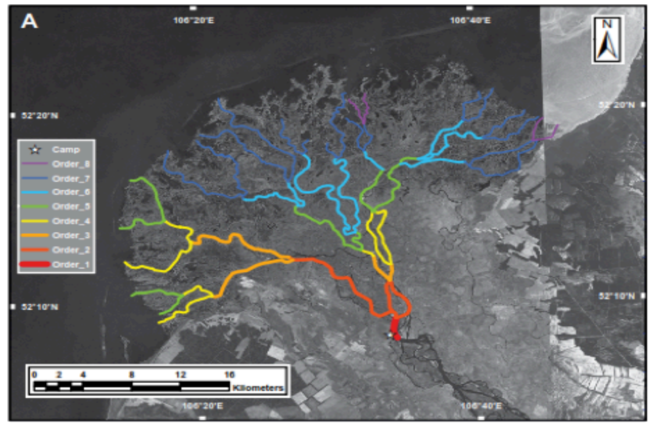


Results of discrete-element modeling of an orogen with an initially weak shale layer (gray in top figure). Bottom figure shows magnitude of strain, corresponding to faults and ductilely deformed regions[38]*.*



Right: Mylonites and pseudotachylites from the eastern Peninsular Ranges Batholith, California. Composition of the pseudotachylite indicated that they represent preferential melting of biotite-rich layers[39]*.*

As the sediments move down, we enter the realm of sedimentology. Graduate student Tian Dong and Jeff published a paper in the Geological Society of America Bulletin on the morpho-dynamics of the Selena river[40], which flows into Lake Baikal in eastern Siberia, the deepest freshwater lake in the world. This area is the best modern analog for deltaic evolution during sea level regressions, owing to the tectonic down-dropping of the Baikal rift. Tian and Jeff tracked gravel transport and may have come up with the definitive explanation for what controls gravel terminations in rivers: bifurcation in deltaic systems results in a rapid drop in the flow energy of higher order channels, resulting in rapid decline in gravel carrying capacity of rivers[40]. Jeff was also part of a study investigating flow and sediment transport in the Mississippi river in the vicinity of bedrock to alluvial transitions, with implications for engineering man-made structures in the river[41]. Finally, Andre Droxler was part of a study investigating sediment delivery off the continental margin and into the deep sea of the Gulf of Papua, the receiving basin for massive sedimentation coming off the actively uplifting Papua New Guinean orogeny[42]. From source to sink, our faculty are providing a comprehensive view of our surface environment.



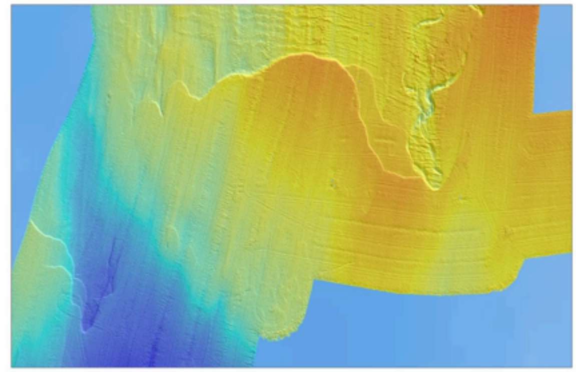
Tian Dong and Jeff Nittrouer showed that channel order in deltaic systems plays a key role in sedimentary transport dynamics[40].

Antarctic ice sheets and far-field signals of glacial cycles near the equator

For several decades, John Anderson's group has been investigating the history of the Antarctic ice sheet by studying the sedimentary record on the Antarctic shelf. Anna "Ruthie" Halberstadt ('15), along with post-doctorate Lauren Simkins and John Anderson used high resolution multibeam bathymetry data to map ancient glacial landforms in the Ross sea, showing that bed physiography played a key role in ice sheet dynamics[43]. Becky Minzoni ('15) and John Anderson compared for the first time the glaciomarine sedimentary record in the Antarctic Peninsula to local ice core records of temperature to reconstruct the history of the Antarctic ice sheet in the context of temperature[44]. Rodrigo Fernandez ('13) and John Anderson used sedimentary and marine geophysical data to reconstruct alpine glacial erosion rates from Patagonia, South America and the Antarctic peninsula[45]. They showed that glacial erosion, averaged over millennial timescales, decreases with increasing latitude, which they attribute to a general decrease in temperature and water availability.

This past year was also graced by the first application of compound-specific carbon 14 dating on glaciomarine sediments off of Antarctica. Published in the Proceedings of the National Academy of Sciences, Yusuke Yokoyama, 2014 Wiess visiting professor, worked with John Anderson to precisely date the collapse of the Ross Sea ice shelf to 5 ka, providing much needed chronological constraints on paleo-ice sheet dynamics[46]. Brandon Harper ('14) and Andre Droxler teased out the intricacies of carbonate platform development and sediment composition during glacial and interglacial cycles along the Great Barrier Reef off of northeast Australia[47]. Perhaps the most impressive piece of work from our faculty this past year might well be John Anderson's monumental summary of all the work he and his students over several decades have done on Quaternary sediments along the edge of the Gulf of Mexico. Together with Davin Wallace, Alex Simms, Antonio Rodriguez, Robert Weight, and Patrick Taha, all graduate students of John's from the last 15 years, John laid out in Earth-Science Reviews how sediments are recycled between source and sink during eustatic cycles[48]. This work will undoubtedly serve as the seminal text for future students of sedimentology and lays the framework for understanding how human-induced climate change may influence our coastlines.

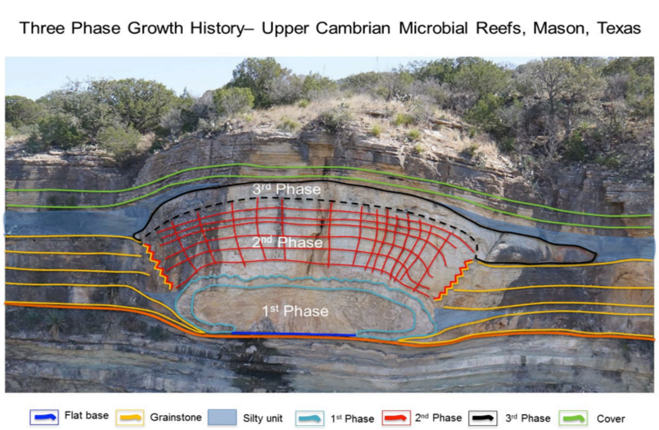
Anna Ruth Halberstadt (L), Lindsay Prothro, Lauren Simkins, and Brian Demet (R) during an expedition to the Ross Sea off of Antarctica. Right panel shows high resolution seafloor bathymetric map, which reveals numerous morphological structures left behind by the Antarctic ice sheet[43].

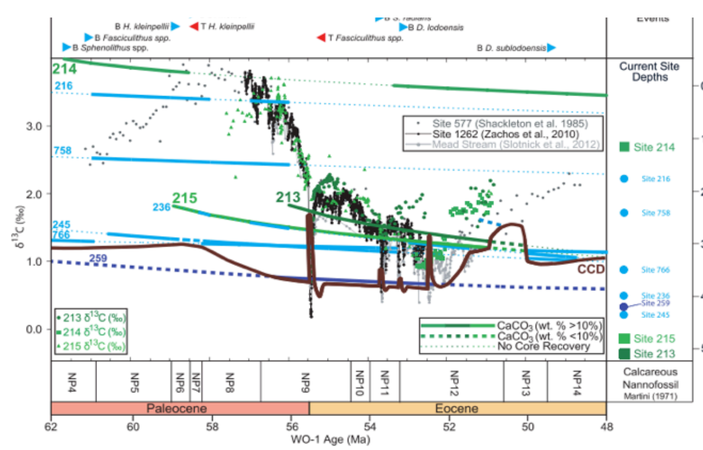


Climates and environments of the past

It would seem that Texans are always trying to get away from the heat, but Gerald "Jerry" Dickens seems to always find himself in hot water. Jerry continues to return to Paleocene-Eocene times, which were characterized by several climatic excursions to hothouse conditions, specifically the Paleocene-Eocene Thermal Maximum (PETM). Ben Slotnick and Jerry reconstructed a high resolution carbon isotopic and lithologic record of Early Eocene marine sediments in New Zealand to show that hyperthermals, identified by extreme carbon isotopic excursions, coincided with massive terrigenous influx, which they attribute to increased seasonality during these climatic excursions[49]. Ben and Jerry also reconstructed the depth of the carbonate compensation depth (CCD) during the early Paleogene from sedimentary cores on Ninetyeast Ridge in the Indian ocean; although on short timescales, increases in atmospheric CO_2 concentrations acidify the ocean and cause the CCD to shoal, increases in carbon fluxing on long timescales causes the CCD to deepen[50]. This study represents a potential approach for reconstructing long term inputs and outputs of carbon into the Earth's exogenic system and dovetails nicely with the work that Rajdeep Dasgupta's and Cin-Ty Lee's groups are doing on quantifying long term volatile fluxing between the deep and surface Earth.

Going back in time to the Cambrian, we find Andre Droxler with his graduate students Pankaj Khanna, Heath Hopson, and Jacob Proctor scrambling over ancient carbonate bioherms (stromatolites), photomapping them with the aid of drones at an unprecedented level of resolution. These bioherms are exposed on a central Texas ranch and represent one of few ancient bioherms in which one has a three-dimensional perspective. We hope to see these results published soon: preliminary data are already adding to our understanding of the 3-D architecture of algal colonies.





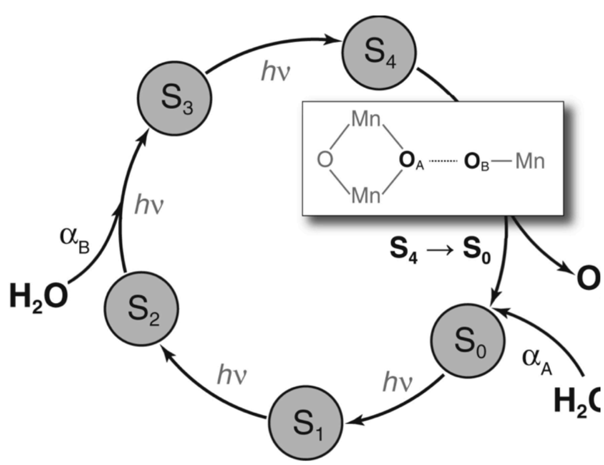
Left: 2D cross section of Upper Cambrian Microbial Reef, Pointpeak Member of Wilberns Formation, Zesch Cliff, along the Llano River, Mason, Texas (Pankaj Khanna, Andre Droxler). Right: Constraints on the depth of the carbonate compensation depth (CCD) in the early Eocene (brown line) based on different sites around the world[50].

Dynamics of the ocean, atmosphere and biosphere

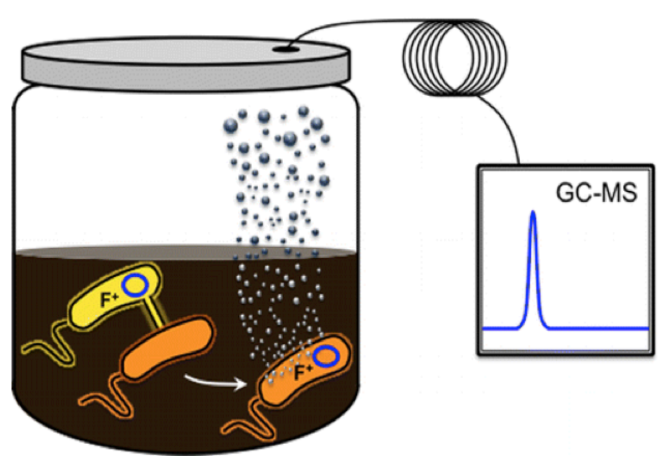
Our most recent faculty, Laurence Yeung, arrived in 2014 and has been rapidly building state of the art facilities for high resolution stable isotope ratio mass spectrometry. We now have three gas source isotope ratio mass spectrometers on the third floor. Laurence is one of the leaders in clumped isotope geochemistry, a relatively new application which takes advantage of the preference for rare isotopes to clump together in a molecule, resulting in slight deviations from random or stochastic combination of isotopes. These deviations have only recently been explored. Clumping is now being used to extract paleo-temperatures without the need of thermometry pairs or assumptions about the composition of reservoirs, such as the ocean through time. But even in this rapidly evolving field of clumped isotopes, Laurence is on the forefront. Last year, in a paper published in Science magazine, Laurence and Jeanine Ash showed using terrarium experiments that biological cycling of oxygen drives clumping away from equilibrium, thus not all clumping signatures reflect temperature[51]. This work significantly expands the applications of clumped isotopes to environmental problems, and may provide a unique way to unambiguously detect and quantify biological processes back in time or on other planets. As a follow-up to this paper, Laurence has laid out the basic principles and theory of interpreting clumped isotopes in Geochimica Cosmochimica Acta, which will likely serve as the official text for future students[52]. Laurence is currently measuring in his lab the clumped isotopic signatures in gases trapped in Greenland ice cores to unravel atmospheric dynamics back in time.

Biochar and biosensors

Our department is also making headway in truly interdisciplinary studies. Carrie Masiello continues her investigations on the prospects and limitations of using biochar as a soil amendment and vehicle for long term carbon sequestration. Her range of applications, building on numerous cross-departmental collaborations, was wide. These include studies of the hydrologic properties of biochar-amended soils with graduate student Zuolin Liu, Brandon Dugan and Helge Gonnermann[53,54], dynamics of nutrient transport in biochar-amended soils with Kyriacos Zygourakis in the Chemical Engineering department[55], carbon and nitrogen isotopic constraints on the nature of pyrolysis with former graduate student Morgan Gallagher and post-doctorate Bill Hockaday[56] and biochar effects on micronutrient availability[57]. With Bill Hockaday, Carrie also outlined how changes in CO_2 availability influenced the oxidative ratio of biological productivity, an important quantity necessary for quantifying global carbon cycle models[58].



O_2 formation in one part of the photosynthetic process. A five-step cycle is involved in splitting water to make O_2: $2H_2O + 4hv \rightarrow O_2 + 4H^+ + 4e^-$. Transitions between intermediate oxidation states in the cycle (S_0 to S_4) occur upon absorption of visible light. Clumping and anti-clumping of rare isotopes were shown by Yeung to be sensitive to these biological processes[51].



Dynamic gene expression in a microbial population in soil can be expressed by the production of methyl halides gases. Gas reporting of gene expression will enable dynamic studies of natural and engineered microbes within many hard-to-image environmental matrices (soils, sediments, sludge, and biomass)[59].

This past year was also a windfall for Carrie. In collaboration with George Bennett and Jonathan Silberg from the department of Biochemistry, Carrie was awarded a 1 million dollar grant from the Keck Foundation to develop biosensors as a tool for interrogating microbial processes in soils and other natural environments. Most approaches used to detect microbial activity are based on visual signatures of gene expression, which are difficult to see in soils. Carrie and her collaborators are bioengineering microbes to release gases under specific conditions, which they hope to be able to detect in soils in real time. Graduate student Hsiao-Ying Cheng led their first paper, a proof-of-concept study published in Environmental Science and Technology[59]. Stay tuned to next year for more results of this innovative study.

Exploration and environmental geophysics

Colin Zelt continues to develop methodologies for interpreting seismic data. With graduate student Jianxiong Chen, they are developing frequency-dependent traveltime tomography with full waveform inversion for application to environmental problems[60,61]. William Symes, joint with the Computational and Applied Math department, worked with graduate student Jie Hou on improving methods of least square migration of seismic data[62].

Undergraduates lead in research and graduate students and post-docs move on to the real world

Our senior undergraduate honors thesis program began last year. Our first seniors to graduate under this program were Maya Stokes (Synsedimentary deformation in prodelta sedimentary deposits), Michelle Muth (Compositional controls on CO_2 solublity in rhyolitic melts) and Rachel Marzen (Modeling effects of cohesion on interactions between erosion and exhumation in bivergent orogens). Our 2016 honors graduates were Adeene Denton (Ice deformation on Enceladus), Larisa LaMere (Effects of goethite on biochar porosity), Emily Paine (Origin of orbicular granitoids), and Elli Ronay (Characterization of volcanic ash in the Eagle Ford formation). Maya, Michelle, and Rachel are in PhD programs at MIT, University of Oregon, and Columbia, respectively. Adeene and Elli will start their PhDs this fall at Brown and Vanderbilt Universities.

Emily is working for the National Institute of Standards and Larisa is continuing at Rice as a research assistant and co-editor of this journal, and beginning full time work with a Houston non-profit this fall! We are proud to also announce that both Maya Stokes and Elli Ronay are recipients of the much coveted National Science Foundation Graduate Research Fellowship. Finally, we are proud of our recent graduates and post-doctoral fellows. Jianxiong Chen is now at Anadarko, Emily Chin went to Brown University as a post-doctorate and is starting an assistant professorship at the Scripps Oceanographic Institute at the University of California in San Diego, Sarah Dean is at Shell, Monica Erdman is working at Hess, Megan Duncan is a post-doctorate at the Geophysical Lab at the Carnegie Institution of Washington, Rodrigo Fernandez is a research associate at the University of Texas Institute of Geophysics, Brandon Harper is at Conoco-Phillips, Ananya Mallik is a post-doctorate at the Institute of Geosciences in Bayreuth. In Germany, Jennifer Masy is at Osprey Energy, Becky Minzoni is an Assistant Professor at the University of Alabama, Ben Slotnick is at BP, Sally Thurner is at Noble Energy, and Matt Weller became a post-doctorate at the Lunar and Planetary Institute in Houston and is starting this fall as a post-doctorate at UT Austin. Post-doctoral fellows Thomas Giachetti is now an assistant professor at the University of Oregon, Wenrong Cao is starting as an assistant professor at the University of Nevada, Reno, Eric Kiser is starting as an assistant professor at the University of Arizona, Tucson, and Yuan Li is starting as an assistant professor at the Guangzhou Institute of Geochemistry, Chinese Academy of Sciences. Congratulations to all!

1. Masy, J., Niu, F., Levander, A. & Schmitz, M. Lithospheric expression of Cenozoic subduction, Mesozoic rifting and the Precambrian Shield in Venezuela. Earth and Planetary Science Letters 410, 12-24 (2015).

2. Thurner, S., Margolis, R., Levander, A. & Niu, F. PdS receiver function evidence for crustal scale thrusting, relic subduction, and mafic underplating int he Trans-Hudson orogen and Yavapai province. Earth and Planetary Science Letters 426, 13-22 (2015).

3. Chen, M., Niu, F., Liu, Q., Tromp, J. & Zheng, X. Multi-parameter adjoint tomography of the crust and upper mantle beneath East Asia - Part I. Model construction and comparisons. Journal of Geophysical Research 120, 1762-1786 (2015).

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