When I finished studying stratigraphy in graduate school, I saw a lot of stratigraphers, but not many people studying how stratigraphy and fluid flow couple. So began a 20-year journey that I am still on.

Today I study how fluids impact geological systems. My research spans the applied and the fundamental. I run UT-GeoFluids, an industry-sponsored consortium that explores flow and overpressure in sedimentary basins. We do field studies of overpressured systems, we develop models of how stress and pressure interact, and we perform geomechanical experiments in the lab. Two summers ago I put all these ideas to work as part of the government's well-integrity team on the BP Macondo well blowout.

I love to drill wells, and, as an academic, I do that through the Ocean Drilling Program. I've drilled wells to study shallow pressure in the Gulf of Mexico, how flow drives landslides on the Atlantic margin, and how pore pressure impacts development of large earthquakes in offshore Japan. There is nothing so satisfying or so frustrating as testing your ideas with the drill bit.

The best part of my day is watching our research group work together to discover new things. We've got postdocs, research scientists, project managers, technicians, and graduate and undergraduate students all asking questions, learning new techniques, and making new discoveries. At the root of every question is the study of fluid flow in stratigraphy. These folks teach me things every day, and I try to keep up.

I bring our discoveries to the classroom. I teach undergraduates petroleum geology, and I stress the enormous importance of fluids. I teach graduate students how flow drives faults, landslides, deep-sea vents, hydrate formation, and compaction. I love to mix the classroom with the field through trips to west Texas and California.
I employ geomechanical models that couple stresses and pore pressures so as to improve borehole stability calculations in complex geologic environments, such as around salt or close to dipping structures.

When designing a borehole, we need to ensure that fluids inside the well will balance against pressures from the Earth to prevent collapse of the borehole and a violent escape of fluids. We cannot be too conservative, however, because high mud pressures in the well can fracture the surrounding formations and lead to the loss of circulation. Two values are critical to borehole stability: pore pressure and minimum principal stress of the formation. In an undisturbed sedimentary basin, these values are relatively straightforward to predict. In contrast, pressure anomalies are often encountered near and below salt bodies, resulting in numerous borehole failures.

Salt, which appears as a solid rock formation in the subsurface, is present throughout the world. The main mechanical characteristic of salt is that because it cannot sustain any differential loading, it deforms (relaxes) so as to achieve an isostatic state. As salt is buried among other sediments, this relaxation process loads the neighboring formations, resulting in elevated pressures and stress levels around the salt that are different from the general stress state of the basin. More than 70 percent of deep-water oil reserves worldwide are found below salt bodies; therefore, salt must be drilled through so that the hydrocarbon reservoirs can be reached.

Consequently, an understanding of the stresses and pore pressures around salt bodies is critical to the design of safe drilling operations. Previously published results show that simple models have been unable to capture the complexity of salt-sediment interaction. At the Bureau, we use coupled models developed specifically for earth materials to simulate how stresses evolve around salt.

Our key results, summarized in the AAPG Bulletin (v. 96, no. 1, 2012) are: (1) salt affects stresses in sediments miles away from the salt body, (2) the shape and extent of the salt play a key role in the dominant direction of stress/pressure changes, and (3) because pore pressures due to salt relaxation require millions of years to dissipate, they may still be present today.

Another example of the importance of coupled geomechanical analyses is trap integrity (how much oil or gas a reservoir can hold). Reservoirs often span hundreds of feet in elevation, establishing a preferred flow path, and this fluid flow changes the stresses at the crest of the reservoir. Typical noncoupled industry workflows often conclude that the caprock must be fractured and leaking; hence, drilling of the reservoir has no value. However, a simple coupled analysis reveals a different pattern of stress changes in both vertical and horizontal directions and shows that either the horizontal or the vertical stress, or both, can be greater than the overburden. As we discuss in our 2012 ARMA publication, these results offer greater confidence in the trap integrity of inclined reservoirs.
My research is focused on flow and deformation in porous media. In my studies, I am trying to understand the underlying mechanics of observed macroscale behavior of porous media, both in the laboratory and in the field.

One question I have been pursuing is how much natural gas we can produce from virtually tight gas shales. For this question to be answered, the mechanics of gas transport in these rocks need to be understood. I conduct permeability experiments in the laboratory on shale-core samples at stresses similar to those of in situ conditions and investigate gas-flow behavior. Understanding the flow through nanopores requires subnanoscale thinking! And this is what draws me to this research.

Why is it that natural slopes, boreholes, fault gouges, earth dams, building foundations, retaining walls, etc. sometimes fail? An answer to this question requires an understanding of the microscopic physics of deformation and fluid-flow behaviors in soils and rocks. In another technical area of my research, I develop digital image-based techniques for characterizing the evolution of grain-scale processes governing deformation of nonuniformities and their evolution. I also characterize internal microstructures using microscopy and elastic and plastic mechanical properties of earth materials in the triaxial cell.
Several questions have captured my interest in subsurface processes such as deformation and fluid flow: How does squishy mud from the ocean floor become a hard rock? How does composition affect physical and mechanical properties, as well as the microstructure of these rocks? How do fluids move through soft muds, and how is gas transported through tight-gas shales—by connected pore throats and/or a fracture network? If through fractures, are these real or coring induced? I study materials ranging from shallow, soft muds to deeply buried, low-permeability, hard rocks. This type of research is important for prediction of overpressure and geological hazards (for example, submarine landslides), geological CO₂ storage and sequestration, hydrocarbon trapping, and production from unconventional oil and gas reservoirs. The processes involved in transforming a mud to a hard rock are complex. As a mud becomes weighed down by overlying sediments, it reaches larger subsurface depths and experiences higher temperatures and different fluids, resulting in a microstructure and physical properties that evolve with depth. By performing a multidisciplinary study on (1) intact mudstone cores from various depths and (2) synthetically prepared mudstones of various compositions and consolidated to various stresses, I can address many of these questions.

A large part of my current research is on gas shales. These are fine-grained sedimentary rocks that have trapped natural gas, which has become an important energy source in unconventional reservoirs. I conduct permeability measurements on core plugs of gas shales in the GeoFluids Lab at the Bureau and integrate them with microscale imaging and pore-size analysis to help me understand mass transport in tight systems. This project is a wonderful opportunity to work and communicate with researchers and students from inside and outside our research group.

I received my Ph.D. from The University of Texas at Austin in 2011 and am currently a Postdoctoral Fellow at the Bureau. My research on soft muds is supported by the Integrated Ocean Drilling Program (IODP), and the project on hard rocks is a Shell-University of Texas Unconventional Research (SUTUR) project in collaboration with the Department of Petroleum and Geosystems Engineering titled “Mass Transport in Gas Shales,” which is funded by Shell.
Leaning against the railing on the bow of the JOIDES Resolution was a solid reminder of why I love my job. We had just passed through the Mona Passage, the sun was setting, flying fish were racing in and out of our bow waves, and we were only days away from testing the latest Integrated Ocean Drilling Program (IODP) technology designed, in part, by our lab.

I manage the Geofluids Lab at the Bureau, one of two labs in the GeoFluids consortium, a joint UT-MIT research group. We are dedicated to understanding how fluids move through the crust, from shallow marine sediments on down to tight, low-permeability shales. Much of the work we do in the lab requires equipment that cannot be bought off the shelf; instead, I build components from scratch. Through planning, testing, failing, and overcoming, the laboratory staff and I are able to create systems and experimental apparatuses that allow us to answer questions that previously were unattainable. But we don’t just build experimental set-ups; we also make our own rock! Using a technique refined by our consortium, we make our own mudstones through a process called resedimentation. Through this process we take dried clays and silts, combine them with water and salt, remove air bubbles, pour them into large tubes, and incrementally add weight over a period of weeks to months. In the end we have a mudstone not too different from those found in the Gulf of Mexico. With these samples we can run a suite of experiments to help us to better understand how sediment changes and evolve as it is buried in the Earth’s crust.

Running lab experiments is only part of what I do. A large portion of my time has been spent modifying and refining our remotely deployable pressure and temperature probe—the T2P. The T2P is designed partly to help us link our discoveries in the lab with the real world. We use the T2P by lowering it through the drill string of the JOIDES Resolution. When it reaches the bottom, the drill string is pumped full of seawater, driving the probe into the formation below. While in the formation, the tool’s data acquisition system is recording pressure and temperature, which helps the onboard scientists understand the conditions under which the sediment was deposited and how it has evolved. By repeatedly deploying the tool as the borehole is deepened, we can construct a pressure profile providing a glimpse into the past. In using field data in conjunction with laboratory-derived models, we are able to make predictions about what pressures will be like in the deep ocean. With this knowledge we can identify high-risk regions of overpressure that may be susceptible to failing (via underwater debris flows) or may cause risk to industry activities. I take pride in knowing that what I do today will not only advance our science, but will help people make informed decisions. It doesn’t hurt that I have a blast in the process.
Finalizing proposals, editing web pages, keeping on budget, tracking publications, organizing databases, communicating with sponsors, scheduling meetings, all while making sure Peter Flemings has plenty of caffeine, is a typical day in my job. As the Project Manager for Peter Flemings’ research group I am responsible for a myriad of tasks.

The UT GeoFluids Consortium, an industrial associates program at the Bureau, is my primary project. UT GeoFluids studies the state and evolution of pressure, stress, deformation, and fluid migration through experiments, models, and field study. This industry-funded consortium is dedicated to producing innovative concepts that couple geology and fluid flow. Results are used to predict pressure, stress, trap integrity, and borehole stability. The UT GeoFluids team combines geoscientists at U.T. with geotechnical engineers at MIT. My job is to support this research by taking care of the logistics that are involved in day-to-day operations, marketing consortium accomplishments, and running the annual consortium meeting. I support 20 staff and students between UT and MIT.

In addition to UT GeoFluids, I am the Project Manager for Peter Flemings’ SUTUR project, Mechanisms of Gas Flow in Shale, and his Department of Energy project, Controls on Methane Expulsion during Melting of Natural Gas Hydrate Systems. I keep these projects on task and budget so that they can meet their research goals.

I bring many years of project-management experience to the Bureau. I began my career in the arts as a stage manager in theatre and then moved into production management of television and film. Although my background isn’t rooted in science, I enjoy working at U.T. in the environment of learning and supporting research at the Bureau.