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A fracking site in Williston, North Dakota. The state has suffered a housing shortage as a result of thousands of workers flocking to join the oil boom.

GEOSCIENCE

Fracking fundamentals

Scientists in the United States who are looking to ride the gas-exploration boom can find a variety of options for employment, from chemical research to environmental monitoring.

BY SID PERKINS

The practice of hydrofracturing (commonly called 'fracking') is booming in North America. The United States is the world's largest producer of shale gas, second only to Canada, and US shale-gas production increased by tenfold between 2006 and 2013. And despite concerns about the sustainability of fracking (see J. D. Hughes *Nature* **494,** 307–308; 2013) and its environmental impact, job opportunities in the industry — many of them science-related — are flourishing.

Fracking involves pumping large amounts of chemical-laden water and sand into subterranean shale formations to shatter rock and then prop open the resulting fissures, which frees up the oil and natural gas entombed there. The increase in hydrofracturing is driving a need for field geologists and petroleum engineers, as well as opening up job prospects for a wide variety of scientists, including chemists and environmental engineers. Many of the posts are related to the need to treat, recycle or dispose of the millions of litres of wastewater that a hydrofractured well can generate.

WELLSPRING OF OPPORTUNITY

The oil-and-gas industry consists of a wide range of companies, all the way from major producers (such as BP in London and Exxon-Mobil in Irving, Texas) and the subcontractors that provide services to them (such as Halliburton in Houston, Texas) down to consulting firms. Hence, the job opportunities are widespread and varied, with different companies often requiring different sets of technical skills and levels of experience. Most hire people holding bachelor's degrees and then train them in-house, says Michael Webber, deputy director of the Energy Institute at the University of Texas in Austin. But there are also plenty of slots for applicants with advanced degrees.

Preliminary figures from the American Geosciences Institute (AGI) in Alexandria, Virginia, show that about 75% of last year's US graduates in geology and geophysics went into the oil-and-gas industry. Furthermore, about 46% of those earning master's degrees and about 33% of those gaining PhDs in the United States also headed for the sector. This is "a very fundamental change", says Christopher Keane, the AGI's director of technology and communications; three years ago, the AGI reported that only some 10% of recently minted PhDs went into the private sector. This move towards industry may stem in part from a relatively limited academic market.

Salaries in the oil-and-gas industry, including the fracking sector, are attractive ▶

compared with most starting academic positions. According to the US Bureau of Labor Statistics, the median income of US geoscientists was just under US$91,000 in 2012. And the Bureau predicts that the number of geoscientist positions will leap by 16% (an increase of about 6,000 posts) by 2022, a full five percentage points higher than the average job growth in the United States during the same period.

North America is currently the hotbed for fracking-related jobs for scientists, but oil-and-gas-rich shales elsewhere will be tapped at increasing rates over the coming decades. For now, shale-gas production in Europe is almost zero but is expected to rise to nearly 85 billion cubic metres by 2040. Likewise, China is expected to produce 141.5 billion cubic metres of shale gas by 2040, making up 50% of the country's natural-gas production.

Fracking in Greene County, Pennsylvania.

DANIEL J. SOEDER

PLUGGING THE GAPS

Poll data underscore the requirement for particular technical skills related to fracking. A survey of oil-and-gas industry professionals by the Society of Petroleum Engineers, based in Richardson, Texas (*J. Petrol. Technol.* **65,** 82–85; 2013), identified a need for people with skills in the recycling, disposal and treatment of wastewater.

Keane notes that prospective employers cite two potential skills gaps in particular among new recruits: a lack of quantitative skills (such as expertise in fluid dynamics) and a lack of field experience (only 40% of recent graduates had attended at least one 6-week-long field camp, the equivalent of an internship). Filling these gaps would boost a job candidate's desirability. Although gaining quantitative skills is fairly standard in a geoscience or petroleum-engineering degree, getting pre-graduation field experience is a bit harder, says J. Foster Sawyer, an exploration geologist at South Dakota School of Mines & Technology in Rapid City. Most of the schools offering petroleum-engineering degrees reserve their field camps for students at their schools, so those seeking to maximize their chances to secure this credential should consider attending these programmes.

"People with a keen knowledge of rock mechanics and petrophysics are in very short supply right now."
Scott Tinker

People with a keen knowledge of rock mechanics (how rocks respond to force) and petrophysics (how rocks and fluids interact) "are in very short supply right now", says Scott Tinker, a subsurface geologist and associate dean at the University of Texas at Austin. Before returning to academia 15 years ago, he spent 17 years in the oil-and-gas industry gaining such skills — interpreting rock, seismic and borehole sensor data to search for and develop oil- and gas-rich deposits, and then using those data to build three-dimensional models of oil and gas reservoirs. Such experience is mostly gained through on-the-job training, although some institutions offer classes in such areas. Interested scientists should carefully investigate programmes to ensure that they are offering marketable skills.

PROBLEMS CREATE OPPORTUNITIES

The problems associated with fracking wastewater can be attacked on several fronts, opening up niches for a range of scientists. The search is on for alternatives to the current cocktail of chemicals that is added to water used for fracking: these chemicals (which are often noxious by themselves) have ample opportunity to react with each other in the hot, high-pressure environment deep within the well, spawning potentially even more unpleasant by-products. And the potential for pollution will increase: although about 34% of today's US natural gas production comes from fracking, that fraction will rise to 50% in 2040, according to the US Energy Information Administration.

Chemists could play a major part in reducing wastewater problems, says David Alleman of ALL Consulting in Tulsa, Oklahoma. For one thing, he notes, researchers — whether in the oil-and-gas industry or in academia — are trying to mitigate environmental impacts by designing greener chemicals that either degrade more quickly or are less toxic. Moreover, chemists are looking to design blends in which the ingredients do not react detrimentally with each other within wells. "There's a lot of room for 'downhole' chemists to figure that out," says Webber.

There is also a demand for civil engineers tasked with projects such as designing better surface ponds for storing wastewater. That is because much of the risk from fracking comes from leakage into aquifers, and this occurs mostly from the surface rather than from wells below ground. Environmental engineers and wastewater-treatment specialists could also use their expertise to alleviate problems after a well has been fracked — either by treating the water or by developing no- or low-water technologies.

Petroleum engineer Mukul Sharma heads a research group at the University of Texas at Austin that is trying, among other things, to develop alternative fracking fluids. In Sharma's team, which includes about 27 graduate and five undergraduate students, most are pursuing degrees in chemical, mechanical or civil engineering. But the team also boasts students pursuing degrees in applied maths, geology or geophysics. "This is a very interdisciplinary problem, so it requires people who have a wide variety of backgrounds," he says.

Sharma and his colleagues, both within the industry and in academia, face a tough challenge. Possible alternatives to chemical-laden water include foams based on nitrogen or carbon dioxide. Such fluids would reduce the volume of waste generated during the fracking process because the gas could be removed from the foam after use. But a downside might be the need to inject chemicals to break up the thick foam (potentially creating chemical waste of a different sort). Issues such as these provide ample research opportunities.

RETIRING TYPE

The 16% rise in the number of geoscientist jobs in the United States by 2022 doesn't take into account the sizeable number of positions that will open owing to retirements or attrition. According to the most recently published AGI data, about 12% of the geoscientists working in 2011 are expected to retire by 2018.

GREGORY DANIEL

The retirements will mean a big loss of technical knowledge in the federal and state regulatory and safety agencies, says Keane, so expert environmental engineers will be needed to monitor air quality and chemical use. For people joining the field, he notes that "it's going to be a tough transition", but early-career scientists will be well positioned to quickly advance into managerial positions, and experienced scientists also have cause for optimism. "People who have been in the field five to ten years will have incredible opportunities."

Whether mid-career scientists or freshly minted graduates, geoscientists interested in the oil-and-gas industry have plenty of options — and in some cases better prospects than in academia for well-paying posts with advancement potential. "Right now, the job market is strong, and the future for young geoscientists is very bright," says Sawyer. ■

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