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O brave new world: Geoscientists in an emerging green economy

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The phrase "O brave new world" hearkens back to Shakespeare's romantic comedy "The Tempest," written almost 400 years ago. In that play, the maiden, Miranda, has been raised on a remote island with only her aging father, Prospero, and the deformed slave, Caliban, for company. A shipwreck brings the King of Naples, his son, Ferdinand, and others in their party to the island. When confronted with these newcomers in the final act of the play, Miranda exclaims with genuine, albeit somewhat naïve, delight "O wonder! How many goodly creatures are there here! How beauteous mankind is! O brave new world, that has such people in't!" Some 300 years later, Aldous Huxley appropriated Miranda's line as the title of a novel; however, in contrast to the delightful new world envisioned by Shakespeare's character, Huxley's brave new world was a dystopian nightmare of society and technology run amok. Which of these senses of the phrase should apply to an emerging green economy?

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We all recall the nightmare of the market crash in the fall of 2008, followed by a financial crisis that we are still facing in the fall of 2009. On the heels of the crash, the United Nations Environment Programme (UNEP, 2008a) launched a "Green Economy Initiative" to communicate global plans for a green industrial revolution (UNEP, 2008a). In describing the motivations for this initiative, UNEP noted that "[a] crisis is a terrible thing to waste."

In the United States, President Barack Obama made greening of the economy a priority during his campaign. He has remained committed to that goal through support of green job training provisions in the American Recovery and Reinvestment Act and in his stated plans to invest US$150 billion over the next ten years for energy research and a transition to a clean energy economy (www.whitehouse.gov, 2009).

President Obama is not the only world leader who has been advocating this type of transition. Based on environmental concerns, UK Prime Minister Gordon Brown was a strong proponent of greening measures prior to the economic crisis, and he now also sees "building a greener Britain" as a route to economic recovery (BBC News, 8 Apr. 2009). Like Britain, Spain sees green technology as a solution to unemployment and a path toward future prosperity (Faiola, 2009). And even in countries like Australia that have fared better than others in the current economic climate there are calls for greening of jobs not only from environmental groups but also from Australian Council of Trade Unions President Sharan Burrow (Xinhua, 2009).

The emerging green economy pre-dates the current economic crisis. For example, a Canadian Broadcasting Company (CBC) News special report from March of 2008 (Kelly, 2008) noted that green technologies have become hot commodities for investors in light of anticipated cuts in carbon emissions. Germany has been slowly but steadily going green "by design" for the last two decades, with the government working in tandem with industry to create markets and businesses that profit from higher environmental standards (Theil, 2008). Numerous books (e.g., Milani, 2000; Danaher et al., 2007) as well as a document titled "Moving towards a green economy," issued by the Canadian government (Dept. of Finance Canada, 2005) in conjunction with release of its 2005 budget plan, provide additional evidence of the building interest in a green economy over the last decade. Groups exploring ways to build green jobs and businesses for sustainable development are also active in the emerging economic giants India (http://www.greeneconomyindia.com/) and China (http://www.efg2009.org/).

In March of 2009, the United Nations (UN) Green Economy Initiative formed a global task force with the goal of developing a variety of practical projects and policy proposals. As part of this overall initiative, the UN generated reports on a "Global Green New Deal" (UNEP, 2009) and on green jobs (UNEP, 2008b). As might be expected, there has not been universal enthusiasm for going green. In fact, some see these developments as a move toward a "brave new world" closer to Huxley's vision than to Shakespeare's, suggesting that green initiatives will kill jobs and the economy overall.

Examining the UN report on green jobs (UNEP, 2008b) may shed some light on some of the sources of apprehension. First of all, the report defines green jobs as "work that contributes to preserving or restoring the quality of the environment." To me, that sounds like a good fit for many geoscientists. Our research to elucidate the history and workings of our planet contributes directly and indirectly to improved understanding of the processes that shape the environment. Thus, I see geoscience as

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an essential foundation for preserving and restoring environmental quality.

The UN report anticipates four effects on employment during a transition to a green economy: (1) additional jobs will be created; (2) some employment will be substituted; (3) certain jobs will be eliminated without direct replacement; and (4) existing jobs will be transformed and redefined. Creation of new jobs is certainly a good thing, but jobs that might be eliminated without direct replacement is a cause for concern.

The discussion within the green jobs document that is most likely a source for apprehension among geoscientists is the following paragraph: "As the move towards a low-carbon and more sustainable economy gathers momentum, growing numbers of green jobs will be created. Although winners are likely to far outnumber losers, some workers may be hurt in the economic restructuring toward sustainability. Companies and regions that become leaders in green innovation, design and technology development are more likely to retain and create new green jobs. But workers and communities dependent on mining, fossil fuels and smokestack industries—or on companies that are slow to rise to the environmental challenge—will confront a substantial challenge to diversify their economies" (p. 4).

As an aside, it is heartening to note that a number of large geoscience employers are already rising to the environmental challenge, as evidenced by strong rankings of several energy and geotechnical firms in a 2009 *Newsweek* assessment of green practices in major U.S. companies.

But more to the point, where do geoscientists fit into a green jobs future? The American Geological Institute's (AGI) recent report on the "Status of the Geoscience Workforce" (AGI, 2009) gives us a picture of current employment trends. It is probably no surprise that the AGI data show the vast majority of recent Ph.D.'s finding positions in academic institutions (67%) or government research (14%). That employment mix is likely to remain stable in the transition to a green economy. In fact, the job picture for geoscientists in research and teaching positions should strengthen if the current trends toward increase federal investments in science and education are sustained.

At the M.S. level, the AGI data indicate that jobs in the environmental sector already account for ~20% of recent grads, and those opportunities are likely to be enhanced in a green economy. For example, an article published in *Science* (Coontz, 2008) highlights the strong career opportunities in hydrogeology. A more recent *New York Times* article (Zimmerman, 2009), which cited an employment forecast from the Bureau of Labor Statistics, ran with the headline "Hiring in Hydrology Resists the Slump."

Publications produced as part of the Year of Planet Earth (IYPE; http://yearofplanetearth.org/content/downloads.html), of which GSA is a sponsor, highlight other environmental geoscience opportunities related to natural hazards, sustainable resource development and management, and human health. The 2009 GSA Annual Meeting program showcased many of the exciting scientific developments in environmental geoscience, as well advances in applying those developments to societal needs. As it celebrated its 50th anniversary, GSA's Hydrogeology Division sponsored more than 40 technical sessions. The Tuesday "Lunchtime Keynote" lecture by Lucy Jones described a unique experiment in geohazard communication that took place in California in 2008 as well as just a week before the meeting. The Pardee Symposium "Hazards and Health" brought together geoscientists, health professionals, and emergency managers.

The AGI workforce data also indicate that 21% of recent M.S. grads have found employment in the petroleum industry. This is one of the employment sectors that the UN report suggested might be a loser in the transition to the green economy. But I think that is not necessarily the case. Projections of world fuel use through 2030 are available from the most recent assessment by the U.S. Energy Information Administration (Fig. 2 *in* EIA, 2009). While these projections are based on a reference scenario in which there are no substantial changes to current laws and policies, they do nevertheless forecast a significant increase in the use of renewables. However, fossil fuel use also continues to increase—particularly coal and natural gas. (The liquid petroleum picture is complicated by the fact that the EIA projections lump biofuels with oil.) How much will this picture change over the next 20 years in a transition to a green economy?

As one indication, we can consider the analyses that were undertaken by the Intergovernmental Panel on Climate Change (IPCC) working group on mitigation (IPCC, 2007). The IPCC developed two realistic upper- and lower-bound scenarios for which they estimated how greenhouse gas emissions in the electricity sector would change as a result of switching sources of energy, implementing carbon capture and storage, and increasing efficiency. While the more optimistic scenario projects greenhouse gas emissions stabilizing at nearly 2004 levels by 2030 (Fig. 4.29b *in* IPCC, 2007), renewables and nuclear still constitute only a relatively modest percentage of the total energy mix. Projections of potential changes in the transportation sector (Fig. 4.30 *in* IPCC, 2007) also show fossil fuels continuing to dominate in 2030. The bottom line is that even with aggressive moves to convert to green energy over the next two decades, fossil fuels are likely to continue to play a significant role in the global energy mix. As Scott Tinker emphasized in a number of talks and briefings during his term as American Association of Petroleum Geologists (AAPG) president last year (e.g., Tinker, 2008), fossil fuels will be an important bridge to any alternative energy future.

Coupled with a likely need for continued oil and gas exploration and production are the rather skewed current age demographics of geoscience employees in that industry. The AGI workforce report (AGI, 2009) includes a figure showing a large peak of petroleum industry employees who may be approaching retirement in the coming decade. Thus, while new employment in oil and gas may not grow as much as environmental employment in a green economy, I do not expect it to be a big loser either.

In fact, geoscientists with training relevant to the petroleum industry might see growth in employment if geologic carbon storage becomes a major greenhouse gas mitigation strategy in the green economy. Skills and technologies for petroleum exploration and development, ranging from basin-scale seismic imaging to analysis of pore scale features, are important to the evaluation of sequestration targets. Successful large-scale sequestration also requires improved understanding of a variety of geochemical and geomechanical processes. Carbon

sequestration (both in subsurface formations and through other processes at or near Earth's surface) was a prominent theme at the 2009 GSA Annual Meeting, with more than 70 technical program abstracts and two lunchtime keynote talks, one on Sunday by the Geology and Society Division's Distinguished Lecturer, Patricia Woertz, CEO of Archer Daniels Midland, and one on Monday by the Halbouty Lecturer, Sally Benson, professor of Energy Resources Engineering at Stanford.

The other potential geoscience employment sector loser noted by the UN report is mining. Similar to the petroleum industry, data from the AGI workforce report indicate that mining has rather unfavorable age demographics. While recycling and improved processing may reduce some demand for new raw materials, a shift to clean energy technologies could actually increase the demand for rarer minerals, prompting new opportunities for geoscientists involved in mineral exploration as well as in development of strategies for more environmentally benign resource extraction and reclamation.

Expanding opportunities for geoscientists are expected in a green economy for development of low carbon energy sources, such as geothermal. If expanded use of nuclear power is part of the clean energy mix, geoscientists will also find expanding opportunities related to safe siting of reactors and safe management of radioactive waste.

As noted in a feature article in a recent issue of *Earth* magazine (Wayman, 2009), water and energy are inextricably linked. Geoscientists are likely to play important roles in the assessment of water-energy issues related to biofuels and to energy technologies that require water for cooling.

Overall, I believe that geoscientists will be among the winners in the job market of an emerging green economy. However, we must address a number of challenges to make this a smooth transition. We must continue to educate the public and decision makers about the importance of geoscience to society. GSA's Geology and Society Division, its position statements developed through the Geology and Public Policy Committee, and the facilitation of interactions between GSA members and government decision makers through our Washington office all contribute to meeting that challenge. We must be creative in identifying new applications of our science to emerging energy technologies and strategies to maintain a habitable planet. And those of us in academia must carefully consider how best to train the next generation of geoscientists to adapt to a changing job market. I believe this will require depth in "traditional" areas of geoscience related to Earth and planetary systems processes, from the deep interior to the shallow crust at Earth's surface, and the history and complex evolution of the physical Earth, its climate, and the life it supports. At the same time, the next generation of geoscientists will need increasing breadth and interdisciplinary training to interact effectively with colleagues from other fields, including material science, various engineering specialties, and biological sciences such as microbiology, ecology, and evolutionary biology, as well as with social scientists.

If we are able to meet these challenges, then I am confident that a future Miranda, finding herself suddenly facing a group of twenty-first-century geoscientists, will exclaim without irony, "O wonder! How many goodly creatures are there here! O brave new world, that has such [geoscientists] in't!"

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