Foreword

This is a volume on geological stewardship for the good of humankind. It is a theme particularly well suited to the twenty-first century, where no longer can any gloss be placed on existential threats related to human populations, human communities, human enterprises, nations, and refugee populations living within fragile environments and dealing with the nexus of coupled challenges related to energy resources, mineral resources, natural hazards, water quality and quantity, and climate change. Many of us can recall a time (for me, the 1960s, when I was in college) where education in geology was all about core courses for the major; where applications in the private sector were mainly oil/gas and the minerals industry; and where connecting our science to society was primarily in the hands of geological surveys. Many of us in academics can recall a time (for me, as an assistant professor in the 1970s) where individual contributions in outreach were mainly captured on a short list of assignments that someone outside of the university *asked* us to do. The minimal and passive attention to outreach was in stark contrast to our proactive designs of responsibilities, activities, and objectives in both teaching and research. In some subtle manner, things changed between the 1970s and now. Today much of the research we carry out as academics does indeed include tangible, proactively planned outreach and service to society. This relatively newly forged level of activity had not been forced upon us per se. Instead, the shift to be more proactive in framing our professional contributions to include substantive outreach may be a response to awareness that "clinical" investigation and application is an essential ingredient to grasping fundamental knowledge, especially when research involves the messy realities of hazards, risks, water contamination, exploiting hydrocarbons and ore deposits, failed structures in our built environments, and all of the insidious environmental changes in the Critical Zone, i.e., the dynamic interface of bedrock, soil, water, weather, climate, atmosphere, hydrosphere, lithosphere, ecology, and human populations.

But volume editors Jeff Greenberg and Greg Wessel would argue that an important part of expansion of research and teaching to engage in impactful outreach also comes from the heart and from a serious, intelligent, informed grasp of what we as human beings and human enterprises are doing to our home here on earth.

One important objective of this volume is to motivate more geoscientists to become more proactive in applying their research skills to earth environments, communities, and populations of greatest need. The papers within this volume collectively advocate the importance for everyday geoscientists to contribute in both small ways and large to improve and sustain our earth environments, while yet continuously providing to human populations the resources with which to live. Another message issuing from this volume underscores an understanding that effectiveness in outreach requires emotional intelligence, cultural awareness, and the capacity to team with experts from other fields and specialties as well as community leadership on the ground.

The contents and emphases in this volume are consonant with one of the three challenges singled out in the National Science Foundation's GeoVision Report (2009), namely reducing vulnerability and sustaining life. The GeoVision Report emphasizes, for example, that geohazards may now have reached their greatest historical level, given population growth, settlement patterns, and the expanding infrastructure of the built human environment. Resilience is a major theme, i.e., evaluating whether systems undergoing natural variations can resist extreme or irreversible change. Similarly, the National Research Council's listing of grand challenges in earth sciences (NRC, 2001) emphasized discovery of natural resources, characterization of

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natural hazards, rendering geoscience support to engineering, and ecosystem management with adaptation to environmental changes. I personally have noted that when grand challenges in earth sciences are identified by committee and panel experts drawn broadly from across disciplines, the challenges are always ones *explicitly linked* to outreach to society, i.e., translation of fundamental science to the good of society. Thus this volume, which urges geosciences onward for the public good, for global development, and toward a sustainable future, is indeed tightly aligned with future directions envisioned in grand challenges.

A flavor of the points of emphasis in this volume can be appreciated through phrases that, to my way of thinking, leap from the titles and abstracts. First we recognize that the volume goes beyond scientific objectives and discoveries to emphasize that sustainable successes as geoscientists in the outreach arena are brought about through thoughtful human approaches and innovative preparation: building good foundation skills for effective engagement; cultural understanding, diplomacy, community mobilization and participation; importance of looking and listening when functioning as an international community development practitioner; ethical, social, and cultural values in geosciences research, practice, and education; geophilanthropy as service rendered through volunteering time and expertise or by materially supporting geology-related projects; sustainable living through restorative impacts; equipping communities for sustainable resource management; spending time participating in local education; improved approaches to military aid; consideration of regional norms, customs, mores, and traditions; benefiting from ethnogeology; educating adaptable, interculturally competent geoscientists; expanding scientific capacity within communities; and even religious faith as motivation in developing a sustainable future.

A second insight derives from points of emphasis on breadth of the research/outreach opportunities, domestically and abroad: improving disaster risk reduction, natural resource management, access to protected water resources, and infrastructure development; finding rare metals; exploiting unconventional deep-ocean resources; securing practical industrial minerals; using byproducts from SO_2 mitigation; mining above ground; discovering optimum locales for exploiting wind energy; effecting water access, sanitation, and security; discovering groundwater resources; dealing with degraded water quality and environmental contamination; addressing mineral hazards and public health, including radon exposure; planning urban development and land use; addressing drought and its consequences; designing structures with resilience in the face of earthquakes; reducing risks stemming from natural disasters, including earthquakes, landslides, flooding; and managing waste, in part through recycling.

Traction will come from our geosciences graduates. Geosciences graduates today enter a world where potential applications of their training are enormously broad. Graduates can cast their eyes on a variety of potential career pathways, e.g., into the metals, minerals, and energy industries; or into teaching in K-13, community colleges, colleges, and universities; or into public service within state or federal surveys; or into consulting firms or government agencies to address mitigation of natural hazards. But are we preparing our graduates for grasping that these career pathways cannot be viewed—as they once were—as being completely separate and isolated from one another? Are we allowing our graduates to see that these paths, taken together, have a linked responsibility to pay attention to the public good, global development, and a sustainable future through overall stewardship of our earth environments and our human communities? Have we in any way revealed to our graduates the enormous opportunities and challenges that lie at the interface of science and public policy? Will our graduates be prepared to help subdue the extreme polarization that American society currently is experiencing at the interface of energy and climate, or at the nexus of natural resources and the environment? Can we emphasize to our graduates what I attempted to emphasize in my GSA Presidential Address?: Find the place where your deepest passions intersect the world's compelling needs! And do it soon.

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REFERENCES CITED

NRC (National Research Council), 2001, Basic Research Opportunities in Earth Science: Washington, D.C., National Academy Press, 168 p. (available at http://www.nap.edu/catalog/9981/basic-research-opportunities-in-earth-science).

NSF (National Science Foundation), 2009, GeoVision Report: Unraveling Earth's Complexities through the Geosciences: Washington, D.C., National Science Foundation, Advisory Committee for Geosciences (George H. Davis, Chair), 39 p. (available at http://www.nsf.gov/geo/acgeo/geovision/nsf_ac-geo_vision_10_2009.pdf).

Introduction

The challenge of doing geoscience for the public good is not for the faint-hearted. It requires an ability to imagine what a better world might be like and a concern for the future of others as well as your own descendants. It requires that you value benefits that will be gained in the future, some of which may be aesthetic, environmental, or cultural, over those benefits (typically financial) that may be more immediate but are also short-lived. It also requires some level of savvy in dealing with those who do not share these priorities. Consider for a moment the amount of organization and planning that is necessary to mount a long-term campaign to address a problem that cannot be solved easily or solved within the lifetimes of those starting the campaign. It is much easier, for example, to open a new motel than it is to set up a temporary encampment for the homeless. You don't see people protesting the opening of new motels.

The challenge of doing geoscience for development that is truly sustainable is even more difficult. Except for a few short-lived attempts, we humans until now have failed to confine our actions and our growth to levels that would prevent long-term environmental degradation and minimize human suffering. Instead, we have chosen to become the most successful invasive species on the planet, fueled largely by burning the remains of creatures who came before us, to the immediate detriment of all other species and to the future detriment of our own kind. We began the fossil-fuel era innocently enough, but it is soon time for it to be succeeded, and that will take a high level of determination and state-of-the-art science and technology led by ethical motivations.

We also must reconsider our current economic systems. They have failed to overcome the inequitable distribution of food and other resources, giving birth to those two children of mankind so feared by Charles Dickens, as revealed by the Ghost of Christmas Present: Ignorance and Want (Dickens, 2006, p. 62, first published in 1843). We see their offspring today in the form of political and religious extremism, refugee crises, starvation, and millions of war dead.

It should be clear to almost everyone that we can't continue down this same road. That is not to say that the problems we have (and are about to encounter) are obvious. Far from it. It is probably accurate to say that the majority of people alive today have an incomplete appreciation of the nature and significance of the environmental changes we are experiencing. The Syrian civil war, for example, was recently called the "first climate-change conflict" (Holland, 2015), but news coverage and public opinion have focused on religious, sectarian, and political differences leading to the conflict and have failed to recognize the impact of larger-scale environmental changes and the resulting social and economic impacts.

Ironically, in order to solve our environmental crises, we also need to address root causes that are social and political, including atomization and inequality. Atomization refers to "the disconnections that reduce incentives or ability to cooperate, generate information, and share information among people who significantly affect one another" (Lipow, 2012, p. 1). It is a weakening of our ability to act collectively rather than as self-interested individuals. Inequality (Dickens' "Want") occurs when few receive the benefits while many pay the costs. Followers of the current American political scene need look no further to see excellent examples of the effects of both.

The good news is that with advances in science and technology has come the realization that "*We have met the enemy, and he is us*" (Kelly, 1972). We now have options for dealing with this situation, and we can

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begin to transition entire societies, if not our entire species, to a different way of living. We can consciously direct our own evolution to craft a better world, at a time in history when it is desperately needed.

But there are many of us who are still without access to adequate natural resources or a safe and healthy environment. At the same time as we are designing our life in the twenty-first century and planning for the twenty-second, we have to address the needs of those still stuck in the nineteenth. Geoscientists have a role to play in both tasks; it may be the latter role that comes most naturally, but our participation in the former is just as important.

It is the need to address both tasks that led us to envision this volume. We two editors originally met at the 2013 GSA Annual Meeting where we each chaired similar sessions: T80, Geology for the Common Good: Sustainable Resources for the 21st Century (Wessel), and T82, Geoscience and International Development (Greenberg). In 2014, we joined and co-chaired the GSA session T143, Geoscience for the Public Good: Toward a Sustainable Future. We both confess a deep desire to see our broader profession become a leading agent of healing and responsible progress. The times demand a greatly increased focus in professional care about a livable planet.

Readers deserve both encouragement and an apology for the articles in this volume. Herein is a collection of diverse topics, all united in the theme of applied geoscience. The many authors serve to educate and inspire, but the wide variety of contributions may frustrate some readers because the collection is unorthodox compared to most GSA Special Papers.

Our motivation in providing such a volume is not academic but altruistic on a rather grand scale. As such, no single subject receives exhaustive analysis. Much more might have been included with many of these papers, but all provide excellent overviews of individual efforts that together represent the types of approaches we must take to address sustainability and global development. Dealing with sustainable development is, after all, somewhat like eating an elephant. It's best to attempt it one bite at a time.

We've grouped like papers together in topical sections. Our first section, Fundamentals and Foundations, looks at some big-picture issues that affect us all: The kinds of skills we need to engage effectively with people everywhere, how we are to act as ethical scientists, the reasons that we should undertake good works, and a discussion of how religion (of all types) provides ample motivation to address sustainability and global inequities. Given that so many world events today are influenced by religion as a dividing force, we think it is telling that we are addressing religion in this volume as a unifying force. Discussing religion in any sense is atypical for a scientific publication but totally appropriate here. The last paper in this section is equally bold in its proposal for how to address sustainability overall and through the mining industry, concluding that although we are not doing enough, there is light at the end of the tunnel and it is not necessarily a train headlamp.

Our second and third topical sections address the topics that are most frequently associated with geologists: mineral resources and water resources. In Metals, Minerals, and Energy Resources, the papers address unconventional sources of some commodities, the future demand for some resources, and the remarkable assertion that most of the metal resources available within human grasp are already bound up in our infrastructure. Only one of the papers addresses some aspect of energy: a fascinating account of research undertaken with an oil-related goal in mind that was found to apply just as well to renewable energy resources.

It is clear that the Metals, Minerals, and Energy Resources section could be expanded exponentially and still fail to address all mineral and energy resources. It is for that reason that we are considering a future project to examine many more mineral resources in greater depth, to provide a window into why these minerals are needed, and to predict where we might find them in the future while coincidentally improving our sustainability record.

Papers in the third topical section, Water Resources, address water availability in both developed and developing nations, but from very different perspectives. In developed nations, it is not water availability that is the problem so much as it is management and protection of existing (usually adequate) resources. In developing countries, it is frequently lack of access to potable water that is the entire problem; without adequate supplies of safe drinking water, development in any form is stymied. For example, here in the United States it is easy to forget that human settlement and growth is dependent upon access to water. That is why population centers, both historic and prehistoric, are located where they are. In lands where the development potential is marginal at best, it is frequently so because access to water is limited, and climate change will only exacerbate this problem. It is for that reason that most of the papers in this section deal with water availability in areas that bear more than their share of civil strife and poverty; still, the need for clean water is universal.

The fourth section, Engineering, Public Safety, and Urban Development, includes papers that address aspects of another major emphasis of geologists and geological engineers, that of development construction and planning for urban development. Two of these papers (Higgins et al. and Overfield et al.) describe efforts to map and mitigate geologic impacts to public health from widely distributed rock and soil types, which could just as easily have been included in the Geologic Hazards and Risk Reduction section that follows. The potential overlap between these two sections is quite significant, but we have arbitrarily restricted geologic hazards to include only volcanic, seismic, and landslide hazards. A number of other geologic hazards are not represented in this volume (subsidence from groundwater withdrawal, karst-related hazards, mine collapse, expansive clays, etc.), which suggests that a wider consideration of geologic hazards is warranted in a future publication.

Waste Management is a topic that has not been associated with geology until relatively recently. However, the four papers presented in this section illustrate quite clearly just how important an understanding of surficial processes and shallow stratigraphy is to the sequestration, treatment, and disposal of human-generated wastes of all types. Just as geologists are critical to the location and exploitation of raw materials used in manufacturing, so are they critical to the proper disposal of the manufactured products when they reach the end-of-life stage.

The last three papers we place into the category of Multiagency and Regional Approaches because all three illustrate quite well the cross-border and inter-state nature of geologic investigations. Two papers, one by Schneider and one by Petterson and Tawake, demonstrate that sustainability and global development are best viewed on an international scale because of the interconnectedness inherent in our modern world. The paper by Berg et al. similarly shows that the geologic history of our planet had no respect for boundaries created by mankind. The Berg et al. paper also must break a record for the number of state and national agencies represented in one research effort. In this case, the 16 authors represent two nations, 9 American states, and a total of 11 state and federal agencies (including one agency in Canada). If nothing else, this paper proves that people can organize themselves into wide networks that effectively address specific needs. We'll need a lot more cooperation like that in the future.

We opened this Introduction with the statement that the challenge of doing geoscience for the public good is not for the faint-hearted. Geoscientists can count themselves as some of the most adventurous and self-reliant people on the planet, so faint-heartedness is not a question with us, but this kind of work is not accomplished by individuals acting alone. We shoulder the responsibility to do our individual parts, but critical to success overall is our ability to cooperate on a wider scale and across more boundaries than we have ever attempted before. We must use good science to collaborate and coexist. We also must be open to changing ourselves (the few) to accommodate the needs of the many. And we must find ways to help everyone imagine and create a better world for all of our children.

The authors in this volume have taken a bite of the metaphorical elephant. If you haven't already, we challenge you to do the same.

Gregory R. Wessel and Jeffrey K. Greenberg

REFERENCES CITED

Dickens, C., 2006, A Christmas Carol and Other Christmas Books: Oxford, UK, Oxford University Press, 438 p.

Holland, J., 2015, Syria may be the first climate-change conflict, but it won't be the last: Nation, v. 27, October, http://www.thenation.com/article/syria-may-be-the-first-climate-change-conflict-but-it-wont-be-the-last/ (accessed December 2015).

Kelly, W., 1972, Pogo: We Have Met the Enemy and He Is Us: New York, Simon and Schuster, 127 p.

Lipow, G.W., 2012, Solving the Climate Crisis through Social Change: Santa Barbara, California, Praeger/ABC-CLIO, LLC, 297 p.