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

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