OPINION

Converging Research Fields Need Converging Communities

The seismological community consists of researchers in academia, government, and industry working on a wide range of research topics that include: earthquake dynamics, induced seismicity, deep earth structure, the exploration and production of reservoirs, and hazard analysis. In practice, the results of this research are presented at various conferences and in journals that fall under the auspices of professional societies, such as the Seismological Society of America (SSA), the American Geophysical Union (AGU), and the Society of Exploration Geophysicists (SEG).

There are a number of converging trends in the seismological community despite the broad range of topics studied. In exploration geophysics, micro-seismicity enjoys increasing importance in a number of applications. Induced seismicity is a side-effect of hydrofracturing carried out to produce tight gas reservoirs and is used to diagnose fluid migration. Characterization and monitoring of induced seismicity is used for the exploration and production of hydrocarbons and is important in geothermal energy production and carbon sequestration. The academic seismological community relies increasingly on the use of large arrays such as the US-Array. The methodology used for analyzing data with such large continental arrays will come closer to methods used in the field of exploration seismology, which relied for decades on array techniques. In industrial seismology, there has been a resurgence in waveform inversion based on adjoint methods, as proposed in the 1980s by Albert Tarantola. The topic of education and outreach is important throughout the geoscience community. A growing public concern has led to the shutdown of projects for geothermal energy and carbon sequestration. Public outreach may help develop an understanding and appreciation of the risks, or lack thereof, of seismicity induced by man-made activities. Related to this is the importance of outreach and education for earthquake preparedness.

The importance of these topics cuts across the different groups of the seismological community in industry, government, and academia. Often, however, these groups neither communicate well nor take advantage of the additional value that can be gained from collaboration. Much could be gained from an increased interaction of researchers in different areas of the seismological community. For example, expertise within academic groups or the U.S. Geological Survey on locating microseismic events is often not used in industry. On the other hand, industrial experience on array techniques could be helpful in optimally using the data collected with large arrays.

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In addition to sharing research expertise, the different groups could collaborate in other ways. Both the academic and industrial geophysics communities would be served well by a dedicated outreach effort to promote geophysics as a high-tech field whose findings and achievements are exciting and have great societal relevance. Collaboration can further aid in workforce development, as graduate students need jobs and the industry needs well-educated geoscientists. Yet few companies have a presence at the annual meetings of the SSA and AGU and few academic researchers attend the SEG meeting. In fact, I have sometimes noted a certain disdain among academic seismologists for industrial applications of seismology. The increasing commonalities and shared interests in pure and applied seismology call for increased broad interaction among researchers working in different areas of the seismological community. Converging research fields need converging research communities.

How then, can the different parts of the seismological community create greater synergy? Geophysics undergraduate and graduate programs tend to focus on either the applied or the fundamental aspects of geophysics. Highlighting both aspects would help to create a more synergistic mindset among students. Mutual visits among researchers working on different aspects of seismology would foster collaboration, especially when such visits are used for seminars or training. Joint research projects are, of course, a highly effective way to bring researchers together. Focused research workshops on topics of common interest can be useful. For example, a joint research workshop on micro-seismicity that is co-organized and sponsored by the

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SEG and the Incorporated Research Institutions for Seismology (IRIS) might bring researchers together who otherwise would not interact. Review articles, written by researchers active in different parts of the seismological community, could serve a similar purpose. Special issues of journals such as *Seismological Research Letters* or *The Leading Edge* could also help to promote more interaction among seismologists.

It is essential that the leadership of professional societies acknowledges that converging research fields need converging research communities. Such convergence can be realized without sacrificing the purpose and needs of the different research communities; it simply establishes collaboration whenever it provides additional value.

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