Reimagining the meaning and potentialities of 'geophysics'

David Jon Furbish

Department of Earth and Environmental Sciences, Vanderbilt University, Nashville, Tennessee, USA

This short essay was inspired by comments of Douglas Jerolmack (UPenn) on Twitter concerning the traditional narrow meaning of 'geophysics' versus the intellectual opportunities that a broader perspective might inspire.

***

To many in the geosciences, geophysics refers in its barest essence to disciplines that are centered on theory and methods underpinned by a subset of the classical equations of physics — the wave equation, Maxwell's equations, Fourier's law, the Cauchy momentum equation — as applied to continuum conditions at scales much grander than the constituent particle scale, and usually implying topics in 'solid-Earth' geoscience. For example, think seismology and acoustics, geodecy and geomagnetism, and geodynamics. The set of topics involved is at once large yet simultaneously quite restrictive: large as measured by the breadth of geo-topics addressed, and restrictive in the sense of representing a small fraction of what physics is. Noticeably absent in this view of the meaning of geophysics are connections with the fields of statistical mechanics and thermodynamics, soft matter physics including granular physics, condensed matter physics, quantum mechanics, biophysics, computational physics, and the rich mathematics and mathematical methods of these fields. Also underrepresented is the critical rationalism (think Karl Popper, David Deutsch) of pursuing theory and experiments hand-in-hand — appreciating that observations are theory-laden in designing experiments to systematically parse the ingredients of phenomena occurring in a messy world. This state of affairs, reflected in a narrow view of what geophysics means rather than what it could actually represent is, as Jerolmack suggests, a lost opportunity.

Among the general science areas, historically chemistry connected with physics first, notably in the late 19th and early 20th centuries with the incorporation of principles of statistical mechanics, thermodynamics and quantum mechanics into physical chemistry. The geosciences followed with geophysics — with great success! — but with its focus on solid-Earth problems, and whose narrow meaning was reinforced by academic and industry cultures that demarcated the practices of geology and geophysics. Next was biology, now spanning atomic to cellular to organismic to community scales. We often hear the cliché that, whereas the 20th century belonged to physics, the 21st century belongs to biology. The emergence of biophysics coupled with advances in computing, experimental methods and the engagement of applied mathematics is the fundamental reason for this. Of course, not all chemists do physical chemistry and not all biologists do biophysics. But for those at the interface, the lines separating chemistry and physics, and biology and physics, have blurred if not vanished. Meanwhile, such lines remain sharp with respect to many areas of the geosciences and physics.

To be sure, all of the areas of physics mentioned above are incorporated to varying degrees in the geosciences. (In this vein I am amazed, for example, by the history of advances in mineral physics and petrology, and recent efforts in paleontology.) And this certainly is true if 'geosciences' is meant to include the oceanic, atmospheric and planetary sciences. But for historical reasons outlined above these endeavors typically are not viewed as being geophysics. Yet

as Jerolmack notes, those outside the geosciences do not hold the same restricted view of the meaning of geophysics. Rather, theirs is an inclusive view, to simply mean the interface between physics and geosciences. Words and timing matter. One can hope that geoscientists reimagine the meaning and potentialities contained in the word geophysics. More importantly for now, the word geophysics may serve well as a hook to more broadly engage physicists in compelling geoscience problems — akin to what is occurring in 21st century biology.