GEOPHYSICS

Did You Feel It?

Gregory C. Beroza

The grip that earthquakes have on our imagination is expressed by the penetration of seismological vocabulary into wider use. Extreme events—if they're sufficiently disruptive—are described as "like an earthquake." "Seismic" is used as an emphatic synonym of "significant." The point of origin of an unfortunate event is referred to as "the epicenter." The worst conceivable disasters are described as "the Big One." At their worst, earthquakes are the most extreme, sudden-onset disasters humankind has had to deal with. Nothing else has caused such devastation on such a large scale so quickly. Earthquakes are yet more unnerving because they refute the notion of terra firma, occur without warning, and progress from barely perceptible to violent in seconds. Fortunately, large earthquakes occur infrequently. But that makes them unfamiliar to those who have the misfortune to be caught in them, difficult to prepare for, and challenging to study.

The Earthquake Observers traces the emergence of seismology from the aftermath of the 1755 Lisbon earthquake through the development of the local magnitude scale in 1935. Historian Deborah Coen (Barnard College) draws on a surprising number of luminaries who have commented on earthquakes or used them as metaphors for other events. These include the usual suspects (e.g., Alexander von Humboldt, Charles Darwin, John Muir, and Mark Twain) already well known to seismologists but also others (e.g., Immanuel Kant, Charles Dickens, Friedrich Nietzsche, Ernst Mach, and Karl Popper) whose intersections with earthquakes are less familiar. In documenting the history of early seismic observations in Scotland, Switzerland, Austria, and California, the author demonstrates how the approach, and even the goals, of earthquake science are intertwined with and influenced by their historical and political context. The book is well written, the documentation meticulous, and the depth of research impressive. At many points in the narrative, I marveled at the extent of the relevant material Coen has unearthed.

The Earthquake Observers
Disaster Science from Lisbon to Richter

by Deborah R. Coen
University of Chicago Press, Chicago, 2013. 356 pp. $35, £24.50. ISBN 9780226111810.

The book's central theme is that seismology began as a broadly participatory enterprise, with the public providing essential information on the location and character of earthquakes, but in its shift to a quantitative field driven by instrumentation and analysis, something important was lost. Although Coen focuses on seismology, she also touches on other highly relevant efforts, such as understanding weather, where citizen-scientists have played important roles. The chronology of attempts to recruit amateur earthquake observers that Coen assembles to make her case is fascinating, and on that basis alone the book is worth reading. Seismologists will recognize the origins of tensions in the field that exist to this day, such as the distinction between regional and teleseismic earthquake monitoring, in the early development of the field.

Coen chronicles many attempts of observers to document the direction of approach of seismic waves and the direction of shaking during an earthquake as clues to the quake's point of origin and physical mechanism. The futility of these efforts, given the variety of seismic waves with differing polarizations, is obvious to seismologists (in retrospect), and I found reading about these earnest attempts interesting but a bit painful. In recounting them, the author (perhaps unwittingly) makes the case for an instrumental approach.

It's natural that scientists seek to quantify earthquakes to the extent possible, and instrumentation is essential to that effort. In the early 19th century, the technology to record ground-shaking with fidelity did not exist. Until the dawn of the 20th century, accounts of eyewitnesses and the effects of earthquakes on structures were all that was available. As instrumentation improved to the point where quantitative analysis of seismograms was possible, it was inevitable that the emphasis of earthquake science would shift, and we're better informed as a result. Advances in instrumentation underlie most of what we have learned about earthquakes—from locations precise enough to define the three-dimensional geometry of faults to quantification of the intensity of shaking used for earthquake-resistant design. Recent discoveries, such as the diversity of slow earthquakes, continue to drive the field in unanticipated directions and are only possible through improved instrumental observing systems.

That's not to say that there isn't an important role for public contributions of the sort that Coen extols. There are, after all, billions of people and only thousands of earthquake-monitoring sensors. Internet technology lets researchers recruit help from interested citizens on a massive scale. For example, the U.S. Geological Survey's Did You Feel It? website (*1*), which gathers reports of shaking, received over 77,000 responses for the 2010 El Mayor–Cucapah earthquake. Data from the system have demonstrated that the crust in the eastern United States transmits seismic waves more efficiently than in the West and even revealed the signature of postcritical reflections off the Mohorovicic discontinuity in people's perceptions of the strength of shaking (*2*). The Internet has also enabled a new hybrid citizen-expert model in which telemetry from volunteers and inexpensive sensors embedded in, or connected to, personal com-

Dramatized depiction. "Earthquake wave at Lisbon," the frontispiece from (*4*).

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puters are used to form earthquake monitoring networks (*3*). The author briefly mentions Did You Feel It? but does not highlight the return of citizen science that it represents, as I expected she might—perhaps because her account ends with the introduction of Richter's local magnitude scale in the 1930s.

Ultimately, Coen is on the mark in saying that the science of earthquakes needs a strong human element. The Kantian ideal of earthquake studies—expressed in *The Earthquake Observers*, by a quote from Kuno Fischer, as "focused squarely on the lawful necessity of nature"—is a useful approach but incomplete without considering the effects of earthquakes on people. The public, after all, is at risk from earthquakes, and there is no substitute for public participation in comprehending and mitigating that risk.

References

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SCIENCE FESTIVALS

Serpentine Figures in Edinburgh

Deborah Dixon and Elizabeth Straughan

Jason Hackenwerth's *Pisces* (2013).

CREDIT: JOSHUA SMYTHE/EDINBURGH INTERNATIONAL SCIENCE FESTIVAL

Edinburgh International Science Festival
Various venues, Edinburgh, Scotland. Through 7 April 2013. www.sciencefestival.co.uk/

This year marks the 25th anniversary of the Edinburgh International Science Festival, an event that showcases the past, present, and possible future of scientific discovery and, in particular, the many contributions of Enlightenment Scotland. Drawing on archives and expertise from a wealth of sites across the city (from the University of Edinburgh to the National Botanic Garden) and using a series of atmospheric spaces (from St. Giles Cathedral to St. Andrews Square), the festival emphasizes not so much the role of science in culture as science as culture.

The festival accomplishes this understanding of science as culture in diverse ways. It is an engine for the public communication of science, accomplished through learning activities, talks, debates, and exhibitions. Key participants in these endeavors are the blue–t-shirted science communicators, who explain how science underpins all manner of everyday activities and objects, from cooking to plastic bags. The festival also displays a sustained emphasis on what it is like to practice science, most evident in the hands-on activities on offer at the City Art Centre, from unwrapping mummies to building robots. In addition, it includes a series of events that explicitly seek to break down the notion of a distinction between the sciences and the arts—by referencing a shared sense of curiosity and wonder, certainly, but also by illustrating how ideas and concepts from both traditions have been and are being translated, reworked, and reconfigured.

Two such translational events, in which scientific ideas and concepts become manifest in an artistic medium, have been introduced into the Grand Gallery of the National Museum of Scotland—a three-story, glass-and-cast-metal concourse with wraparound balconies that formerly was the foyer to the Edinburgh Museum of Science and Art (1866–1904). Artist Jason Hackenwerth's *Pisces* (2013) is a site-specific latex and air sculpture that was assembled from balloons in the Grand Gallery and then hoisted up and hung from the ceiling. The piece draws on Hackenwerth's prior work, wherein the balloon scaffolding and tumescent forms reference marine and insectoid organisms that loom large above an audience yet retain an airy, playful quality. In addition, *Pisces* very much responds to the content and form of the Gallery space, as its tightly wound curves replicate what mathematician Jacob Bernoulli called the *Spira mirabilis* (marvellous spiral), displayed in the shell collection on the museum's third floor. The undulating surfaces of *Pisces* also reflect the rounded, Romanesque Revival arches of the Gallery's roof and supports.

Curves, and their reiteration, are also central to *Chaos and Contingency* (2013), a performance by the Janis Claxton Dance Company, with a cast of nine dancers from Scotland and China, and music composed by Philip Pinsky. Although the dance is performed on the ground floor, it has been designed with the Grand Gallery's architecture of vision in mind, as each balcony affords a differing view of the clustering and dispersal of bodies. At the outset of the piece, the dancers slowly spread out with a synchronization that sees them gently lift their arms, twist their bodies, and raise their heads skyward. Such mirroring does not last, however, as individually and in groups the dancers introduce small variations in both pose and pace; these in turn are mirrored and varied as the dance proceeds. There is an animal physicality to how the bodies swirl, roll, swerve, and almost collide. It is this fleshiness that suggests a tension between a disciplining of the body (and of the collective) and a continual evolution of form.

Both *Pisces* and *Chaos and Contingency* can be considered examples of what art historians call the *figura serpentinata* (serpentine figure). In them, swirling convex and concave shapes blur the boundaries between organisms, unifying those into a new body that challenges prior taxonomies but that also finds a balancing point wherein each element occupies a new resting place. This serpentine figure finds resonance in various scientific concepts and models, from the double helix of DNA to the spiraling arms of galaxies. Yet, as the architectural theorist, landscape designer, and artist Charles Jencks reminded the audience at his 23 March lecture, "Landforms," art and science are not themselves in an equal dialogue. Where science holds the upper hand in regard to content—that is, in its exquisite and highly specialized descriptions of how the universe works—art retains the power of the spectacle. Although metaphors such as the serpentine figure provide something of a common ground between art and science, there is no resolution. Nor is there a point around which the two can be counterbalanced. Perhaps it is this irresolution and falling apart—this very asymmetry—that animates such interdisciplinary efforts?

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