

home and road games can be explained by a bias, assuming that every player *a priori* has a batting average 12 points better at home than on the road; further differences between individuals can be explained by chance. (c) Neither pure chance nor bias is capable of explaining the spread in batting averages with runners in scoring position versus bases empty; the evidence indicates that some players are truly better than others when batting with bases occupied.

In discussing the use of batting statistics to predict run production, the authors apply least squares linear regression to various models in order to arrive at correlations among various measures (batting and slugging average, on-base percentage, and more complex modern measures) and team run production. In the process, they also demonstrate pitfalls that can arise, such as a spurious correlation between sacrifice flies and runs scored. As they explain, teams that often have runners at third base with fewer than two out will have many sacrifice flies and will also have many runs.

These are only some of the topics treated in this book. There are a number of other intriguing analyses of team results and individual batting data. The book makes no claim of being an exhaustive treatise on statistical analysis of baseball—for example there is very little said about pitching statistics, nothing about fielding—but it is a most interesting and useful introduction to the subject. It should make enjoyable reading for physicists who are also baseball fans, and it ought to be required reading for baseball managers, executives, and commentators. Unfortunately, these are probably the least likely to buy and read this book.

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Isostasy and Flexure of the Lithosphere

▶ A. B. Watts
Cambridge U. Press, New York,
2001. \$110.00, \$44.95 paper
(458 pp.). ISBN 0-521-62272-7,
ISBN 0-521-00600-7 paper

The basic concepts of lithospheric isostasy and flexure predate the development of plate tectonics in the 1960s and 1970s. Nonetheless, those concepts continue to play a major role in modern Earth sciences.

In its simplest form, lithospheric isostasy is a restatement of Archimedes' principle: The upper parts of the Earth float on its interior. Such isostasy represents the balance of vertical forces

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that, to the first order, implies that there is equal mass within all columns of material. With the advent of plate tectonics, geophysicists came to understand the gross origin of the density variations that produce topographic relief: Earth's crust is chemically buoyant relative to the underlying mantle, and continental regions with thin crust float higher than oceanic regions of thin crust, as icebergs do in a field of ice floes. Regions in which Earth's shallow interior is hot float higher than the surrounding cool dense regions, and include midoceanic ridge axes, the Basin and Range Province in the west-

ern US, and oceanic swells, such as those around Hawaii.

The lithosphere is the cool, more-or-less elastic region of the shallow Earth, that is, the plates in plate tectonics. Geophysicists conveniently represent it as equivalent to an elastic plate floating on an underlying fluid. They model the deformation associated with loads, like river deltas, with the engineering theory of flexure, or bending, of an elastic plate.

Anthony B. Watts organizes his book *Isostasy and Flexure of the Lithosphere* in a historical fashion, both as a whole and within chapters and sec-

tions. This arrangement is helpful, because the concept of isostasy has had a long and checkered history, dating quantitatively to Isaac Newton. The terminology and formalism of the concept evolved before modern satellite measurement techniques, massive computers, and plate-tectonic concepts. Watts concentrates on vertical tectonics. I would have welcomed a treatment of the effects of isostasy on horizontal forces like "ridge push."

Watts organizes his presentation into developments before plate tectonics, in which he gives first names and initials of scientists, and developments since about 1975, in which his citations are those of an academic paper. He gives brief mention to the plate-tectonic revolution, when horizontal movements came to the forefront, and he provides only a short chapter on other planets. Students may find the historic treatment of modern concepts helpful. Sometimes, I wished that Watts had cut to the bottom line and started each topic with a critical summary.

Watts summarizes the early history of isostasy studies with detail not found in most geophysics books. The main points are well known: Newton represented Earth as a rotating hydrostatic fluid, which he predicted should be flattened at the poles. The French Académie believed the opposite; it conducted surveys in Ecuador and Lapland, work that confirmed Newton's hypothesis and established Earth's basic shape. The Académie's astronomically minded participants viewed masses of geological scale, like mountain ranges, as nuisances. By 1840, the British had conquered India. Like a fisherman with a large catch, they measured. The surveying methods by then were sufficiently precise that the mass of mountain ranges was evident. Physically, local irregularities in mass cause the equipotential surface of Earth to be slightly irregular and the measured latitude to change irregularly as one moves north. John Henry Pratt calculated that the expected effect from the Himalayas was far greater than was observed. George Biddell Airy showed that this discrepancy should have occurred if the mountains had a compensating thick floating root, like that of an iceberg. Pratt, in turn, proposed that lateral variations in density result from thermal expansion and high temperatures beneath mountain ranges.

The isostasy and its basic mechanisms were then in place in a manner not greatly different from that of modern plate tectonics. Practical surveyors and global geodesists accepted

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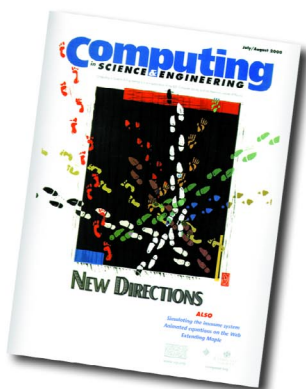
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isostasy as a way of correcting their measurements for the effects of topographic masses. Geophysicists confirmed the basic predictions of isostasy with accurate measurements of gravity and seismic structure. Many geologists rejected isostasy because it could not explain the complexity they saw in the geological record. This trichotomy—practical, geophysical, and geological—was in place when I entered graduate school in 1967.

Today, a dichotomy exists: First, geophysicists routinely use the approximation that the lithosphere is an elastic plate, floating on very viscous “solid” rock, in their modeling of gravity and vertical tectonics with sophisticated mathematics, which Watts ably summarizes. Second, resolving the lithosphere in a more realistic way has proved difficult because elastic plates give a good representation of the data even where the rocks are not really elastic, as is the case around fault zones.

Isostasy and Flexure of the Lithosphere provides an excellent guide for those applying flexural isostasy to practical problems. It is also a starting point for those wishing to learn more about the actual physics of Earth's lithosphere.

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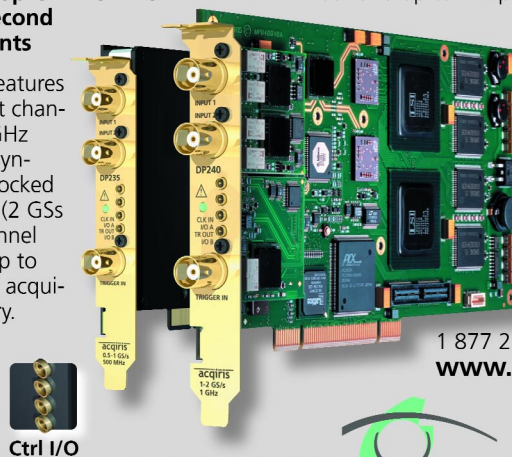
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