papers are informative and well presented. Those that struck me as particularly valuable include ones by J. B. Hutchings on spectra and photometry, by A. Slettebak on rotational observation of Be stars, and by D. G. Hummer on line formation in expanding atmospheres. As W. P. Bidelman points out in his concluding remarks, emission lines in early-type stars are produced by a number of different mechanisms, and, despite the stars' Be classification, no one model is likely to be successful in explaining their properties. The symposium clearly sets out the uncertainties in our understanding of the Be phenomena. As in the case of the Ap stars, the observational data overwhelm our ability to deal with them theoretically. This results not from a lack of effort on the theoretical side but rather from the great mathematical difficulties of constructing models that are sufficiently realistic to explain the observations.

Struve's 1942 comment about Ap stars may apply to Be stars as well: We are convinced that at least "the phenomena are not supernatural."

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A Minority View in Geophysics

The Expanding Earth. S. WARREN CAREY. Elsevier, New York, 1976. x, 488 pp., illus. $34.50. Developments in Geotectonics 10.

The idea of a significant expansion of the earth is anathema to most earth scientists, but not to S. Warren Carey, who has advocated it for a long time. The last presentation of his ideas to a major audience occurred at a continental drift symposium nearly 20 years ago, at which time the ideas of continental drift, seafloor spreading, and plate tectonics were not accepted as they are today. Many of the arguments he presented for the theory of the expanding earth are the same as those that are now acceptable for the theories of plate tectonics and continental drift. Since many aspects of plate tectonics are minor premises of the expanding earth syllogism, Carey thinks we have not looked hard enough at the entire story he has to tell.

The idea of earth expansion is not original with Carey. It was first proposed by Lindemann 50 years ago, and about 40 years ago P. A. M. Dirac concluded that the gravitational constant G varied inversely with the age of the universe. More recently, Egyed, Owen, Dicke, and others have espoused earth expansion under one guise or another.

Better than most continental drifters, Carey deals with the geometry of continents, how they may have drifted or been deformed, and the tectonic evidence of the phenomenon. He considers deep earth structure and possible relations among solar, planetary, and terrestrial phenomena. He does this with great vigor and in considerable detail, referencing many little-known Soviet works, as well as the most recent publications in the Western literature. He starts with the assumption that we have not yet discovered all the cause-and-effect relationships and an alternative look at the data is worthwhile.

He does not, however, philosophize deeply on what makes a cause-and-effect relationship acceptable, that is, on how we establish a theory in the observational earth sciences, where laboratory experiments and repeatability tests are impossible.

The book is not as tightly organized as some with so unitary a subject. It includes expostulations on related subjects and critiques of other papers to illustrate alternative interpretations. There are four main sections, whose titles only vaguely reflect their contents: Introductory Review, Some Principles, Regional, and Retrospect. The format appears to be author-produced, with typed pages and nearly all figures being Carey's own drawings and sketches.

Possibly the most easily accepted part of Carey's work is his hypothesis about how continents have moved and been shaped in the last 200 million years. He recognizes only a few types of continental deformations or interactions. These he gives special Greek names (such as rhombochasm and oroclinotath), which are difficult to pronounce or remember. Plate tectonicists have had little quarrel about the occurrence of these continental movements, because they are geometrical in nature and largely consistent with plate tectonic theory.

Possibly the least easily accepted part of Carey's work is his explanation of deep-sea trenches. He finds it easy to believe that the mid-ocean ridges are the foci of seafloor spreading (by earth expansion, rather than by conveyer-belt motion), but believes there is no subduction down trenches, only upward motion behind them. The difference between the passive Atlantic continental margins with no trench or associated volcanic earthquake belt and the active Pacific margins with prominent trench and volcanic earthquake belt is, he thinks, primarily a matter of oceanic sedimentation rate. Many would agree that the structure of many passive margins is consistent with their being filled trenches, but we know that there are few filled trenches adjacent to the ring of fire around the Pacific. He points out that plate tectonicists are open to criticism when they have the seafloor moving under Japan in the western Pacific while the spreading center has been swallowed under the North American continent. He points out that if all adjacent continents (and their mid-ocean ridges) are moving away from Africa we have a problem of a missing subduction zone around Antarctica. These and other points he makes cause the plate tectonicist to feel uncomfortable.

One of the main observational facts that supports the idea of seafloor spreading in preference to the expanding earth theory is the sequence of linear magnetic anomalies marking the precise increase of age of the seafloor away from the mid-ocean ridges. Carey recognizes the existence of these and says they are not inconsistent with an expanding earth, but he does not prove the case.

How much did the earth expand? The answer to that depends upon which author you talk to, which part of the earth you are considering, and what age you are referring to. Some say that the radius in the late Paleozoic was only 0.7 what it is today, others that it increased with time or pulsated. Carey is a great proponent of localized uplift, calling areas of uplift "geotumours."

What caused the earth to expand? The author says simply "I do not know." Is the earth undergoing a phase change at constant mass? Is the secular decrease in the gravitational constant a fundamental law of nature? Perhaps these questions need be considered only after there is agreement on observational evidence.

Many scientists do not know of Carey's work because his publications are few. Of those who do, few accept all his ideas, although they universally find him a refreshing thinker and a true scholar. His fertile mind has covered so much megageophysics that it will come as no surprise if, in the future, many of his ideas are found to strike very close to the mark. Carey, who is retiring this year from the University of Tasmania, has made a substantial contribution to earth science during his career and will be especially long remembered for this stimulating and controversial book.

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