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that readers of the book, if they have not done so already, should also seek acquaintance with papers criticising the theory on this and other grounds. The theory of course does not stand condemned because no satisfactory mechanism has yet been found. But the scientific method of assessing theories in terms of degrees of probability, with avoidance of words like "belief" and "proof", needs heeding in this, no less than in all other fields of science.

K. E. BULLEN (Sydney, N.S.W.)

*Geothermal Energy — Review of Research and Development.* H. C. H. Armstead (Editor). UNESCO, Paris, 1973, 186 pp., U.S. \$14.00.

*Geothermal Energy* is a welcome addition to the skimpy library of general books on geothermal science and technology, particularly since the book covers the spectrum from exploration through field development to energy conversion and utilization. *Geothermal Energy* succeeds admirably in giving the reader an elementary insight into the various phases of geothermal work. The book is aimed at a broad audience of earth scientists, engineers, managers, economists, and planners and is edited with the laudable philosophy that "each specialist can gain a better perspective of his function . . . if he has at least some understanding of the problems and techniques of his collaborators." *Geothermal Energy* consists of 16 chapters written by different authors. Following introductory chapters on the basics of geothermal energy (H. C. H. Armstead) and on the tectonic setting of geothermal resources (Sir Edward Bullard), a section on exploration includes chapters on geology and hydrology (J. R. McNitt), geophysics (C. J. Banwell), geochemistry (G. E. Sigvaldason), and the structure and behavior of geothermal fields (G. Facca). A section on the development of geothermal fields is divided into chapters on drilling (K. Matsuo), well measurements (N. D. Dench), and collection and transmission of geothermal fluids (J. H. Smith). Utilization of geothermal energy is covered by chapters on electrical generation (B. Wood), district space heating (S. S. Einarsson), and industrial and agricultural applications (B. Lindal). The final section of the book deals with corrosion control (T. Marshall and W. R. Braithwaite), economics (H. C. H. Armstead), and the management of a geothermal field (R. S. Bolton). All 16 chapters are authored by scientists or engineers who are experienced in geothermal energy development and are recognized as experts in their particular specialty. The authors come from a variety of countries, with appropriate emphasis on the wealth of New Zealand experience on hot-water geothermal systems. Conspicuously missing, however, are contributors from either the industrial or the governmental sectors of the U.S.A.

Although *Geothermal Energy* succeeds in its broad objective of providing an introduction to geothermal science and technology, several individual chapters are seriously biased. The tectonic model advocated by J. R. McNitt in his chapter on geology and hydrology is by no means universally accepted

by structural geologists and in fact represents a somewhat unusual view of extensional tectonics and the relationship of tectonics to geothermal resources. The concepts of plate tectonics (as outlined in the chapter by Sir Edward Bullard) are nowhere mentioned by McNitt, although they seem to this reviewer to provide a powerful structural model in which to discuss the regional occurrence of geothermal resources. The chapter by G. Facca on the structure and behavior of geothermal fields is also biased in that it presents only the author's model for dry-steam geothermal fields and fails to acknowledge and reference alternative points of view (e.g., James, 1968; White et al., 1971).

Treatment of four subjects seems inadequate. Mathematical reservoir modelling and reservoir engineering are almost completely neglected, with important references such as James (1968), Whiting and Ramey (1969), and Donaldson (1970) nowhere mentioned. Borehole logging techniques are listed in several chapters, but (with the exception of temperature and pressure) the scanty discussion does not do justice to the available technology in the geothermal and oil service industries. Treatment of environmental effects of geothermal extraction is also inadequate, although perhaps accurately reflecting the little attention paid to environmental protection in many countries. And finally, the institutional and governmental factors so critical to geothermal development are scarcely mentioned.

The quality and completeness of bibliographic referencing is spotty, with some important references being omitted altogether. Particularly surprising is the failure of G. E. Sigvaldason to cite either of the primary references for the silica geothermometer (Mahon, 1966; Fournier and Rowe, 1966).

*Geothermal Energy* contains only a few errors of typography or fact. One of the more conspicuous occurs on p.28 in the discussion of the origin of geothermal waters. H/D is not constant at 6400 but varies from approximately 6300 to 9300, depending primarily on latitude and on distance from the ocean (see fig.1, p.51). This variation is, in fact, the key for the discrimination of meteoric and magmatic water (Craig et al., 1956; Craig, 1963). Also, The Geysers field in California is not at a considerable distance from volcanoes as stated on p.15; it is adjacent to the Quaternary Clear Lake volcanic field.

*Geothermal Energy* is unique in providing the trained earth scientist or engineer a broad introduction to most aspects of geothermal energy and as such is essential reading for anyone new to the field. In addition, even the experienced geothermal investigator will find the chapters outside his personal specialty to be useful in broadening and deepening his knowledge. *Geothermal Energy* is indeed a valuable publication, with information content well worth the price.

#### REFERENCES

- Craig, H., 1963. The isotopic geochemistry of water and carbon in geothermal areas. In: E. Tongiorgi (Editor), Nuclear Geology on Geothermal Areas. Cons. Naz. Ric., Lab. Geol. Nucleare, Pisa, pp. 17-53
- Craig, H., Boato, G. and White, D. E., 1956. The isotopic geochemistry of thermal waters. Nucl. Processes Geol. Settings, Natl. Res. Council Sci. Ser. Rep., 19: 29-44.

Donaldson, I. G., 1970. Temperature and pressure  
Fournier, R. O. and Rowe, J. K., 1966. The silica content of water  
James, R., 1968. Wairakei geothermal field, New Zealand. J. Sci. Tech., 11: 706-714  
Mahon Jr., W. A., 1966. Geothermal resources of New Zealand. N.Z. J. Sci. Tech., 9: 1-10  
White, D. E., Muffler, L. J., and Fournier, R. O., 1966. Geothermal systems compared with hydrothermal systems. J. Geophys. Res., 71: 5311-5318  
Whiting, R. L. and Ramey, D. W., 1969. Geothermal energy: A review of the geology and geophysics of geothermal steam fields.

*Focus on Environmental Geology: Readings from Oregon*  
University Press, 1971

This is a useful, geology case-histories and readings material for courses in environmental policy in the environment.

The book is in the hands of those who like a neat, both natural and the consequences of those processes such as erosion and Hostile Environment activity, tectonic movement, erosion, sedimentation, and treatment that is un-

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- Donaldson, I. G., 1970. The estimation of subsurface flows and permeabilities from temperature and pressure data. *Geothermics, Spec. Issue 2*, 2(1): 677-683.
- Fournier, R. O. and Rowe, J. J., 1966. Estimation of underground temperatures from silica content of water from hot springs and wet-steam wells. *Am. J. Sci.*, 264: 685-697.
- James, R., 1968. Wairakei and Larderello, Geothermal Power Systems Compared. *N. Z. J. Sci. Tech.*, 11: 706-719
- Mahon Jr., W. A., 1966. Silica in hot water discharged from drillholes at Wairakei, New Zealand. *N.Z. J. Sci. Tech.*, 9: 135-144.
- White, D. E., Muffler, L. J. P., and Truesdell, A. H., 1971. Vapor-dominated hydrothermal systems compared with hot-water geothermal systems. *Econ. Geol.*, 66: 75-97.
- Whiting, R. L. and Ramey Jr., H. J., 1969. Application of material and energy balances to geothermal steam production. *J. Pet. Eng. Tech.*, July 1969, pp. 893-900.

L. J. P. MUFFLER (Menlo Park, Calif.)

*Focus on Environmental Geology — A Collection of Case Histories and Readings from Original Sources.* Ronald W. Tank (Editor). Oxford University Press, 1973, 474 pp., £2.25.

This is a useful, generally well-selected, adequately illustrated collection of case-histories and readings in paperback that will be good, solid collateral material for courses in environmental geology and engineering geology. It will also be instructive to land-use planners and others concerned with public policy in the environmental and natural resource areas.

The book is in three major sections that may cause some problems for those who like a neat organization. The first section deals with earth processes, both natural and those modified or activated by human activities, the consequences of those processes for the works of man, and predicting natural processes such as earthquakes. Under the general title of "Geologic Hazards and Hostile Environments" are included the topics volcanism, earthquake activity, tectonic movements and sea level changes, mass movement and erosion, sedimentation, and floods. The section suffers from the unequal treatment that is unavoidable in packaging selections from several authors.

The second and third sections are entitled "Supplementary Readings" — Part I dealing with Mineral Resources and Environment and Part II with Urban Geology. I wondered why the papers classed as "Supplementary Readings" in "Mineral Resources and the Environment" or in "Urban Geology" were not given the same status as papers in the first section, but the failure to perceive an organization does not detract from the usefulness of the book. "Supplementary Readings Part III" is simply some extra bibliographic citations. There is also a Geologic Time Scale and a short glossary.

The collection lacks papers on radioactive wastes and power plant siting — both important contemporary environmental issues of concern to geologists.

P. T. FLAWN (Austin, Texas)