foraminifera as watermass indicators both on the continental shelves and in the deep ocean.

After discussing the distribution of the various benthonic species found in normal marine waters, the text touches upon the distribution of species in several marginal marine environments, such as marshes, lagoons and other nearshore habitats of abnormally high or low salinities.

The principles of foraminiferal ecology are treated in simple terms by showing how the most commonly measured factors of the environment can be correlated with the distribution of species. Altogether 13 environmental parameters are described with temperature, salinity, depth and substrate as major factors that are discussed at length. Most of the evidence presented has been gathered in the field with only a few laboratory experiments that test the observed species - environment relationships. This shortcoming has been recognized for decades, but new advances in experimental ecology of foraminifera have not been forthcoming at a rate comparable with other aspects of foraminiferal research.

A relatively new and expanding field is the cytological study of foraminiferal protoplasm and the investigation of test microstructures. The authors' treatment of these fields is rather short, but sufficient as an introduction. It is well supported by references for anyone interested in the topic beyond the scope of the book. Microstructures of foraminiferal tests are discussed in conjunction with the general description of the foraminifera. In additon to a classical account of the various shapes of foraminiferal tests, the authors describe recent advances in the research of foraminiferal wall structures based on scanning electron microscopy.

A large section of the text is dedicated to the methods of sample collection and their preparation for study. The description of samplers is detailed and includes some of the less well known and highly specific instruments in addition to the commonly used corers, bottom grabs and nets. The discussion of laboratory methods include such common problems as staining of protoplasm, separation of tests from sediments, and the highly specialized field of cytological techniques.

Foraminiferal tests exhibit a great variety of morphologic features that must be sorted according to genera and species. The book describes a number of methods that permit the recognition of some of the more obscure but diagnostic features of the tests such as, the arrangement of chambers next to the proloculus made more visible by oils and stains. The principles of classification of foraminifera are discussed, including the history of foraminiferal research.

The chapter on faunal studies and their application is the longest and illustrates a new trend in research on Recent foraminifera. The new emphasis is twofold: 1) an improved utilization of the information that foraminifera can supply through analysis by multivariate statistics and graphics, and 2) the use of foraminiferal data in describing relatively recent changes in oceanography. The classical studies of faunas are thus being supplemented with environmental studies that involve a number of disciplines.

The concluding remarks of the book deal briefly with the existing gaps in foraminiferal research. The authors emphasize the need for more studies in physiology of foraminifera, in particular the functional role of structures, such as the function of sieve plates, pores and various subcellular bodies of the protoplasm. Life cycles of most species are poorly understood and more work is needed with foraminiferal cultures focusing on the duplication of the natural environment as much as possible.

It is evident that in future foraminiferal research will increasingly depend on expertise in many fields and the most recent advances in instrumentation. To mention only a few, the various electron microscopes capable of resolving extremely minute structures, electron probes and microanalysers that can detect trace elements and determine isotope ratios within the layers of a test may provide answers in such problematic fields as taxonomy, natural histories or paleoecology of foraminifera. These possibilities are not evaluated sufficiently in the concluding chapter, but on the other hand, I recognize the fact that it is virtually impossible to include everything in a book dealing with such a multi-disciplinary topic as Recent foraminifera.

Working with Recent foraminifera I find the book useful both as an aid to research and as a basic text. It is easy to read and the illustrations are sufficient in number and of good quality. More discussion on advanced ecological and statistical principles would be helpful, however, reference to these can be found in the extensive bibliography, which in itself is a great asset to the volume. Using the argument of James Hutton that the present is a key to the past, the book is also highly recommended to fossil foraminiferologists.

MS received January 26, 1977

The Bowels of the Earth

By John Elder
Oxford University Press
222 p., 1976
Price $17.65

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I wish I could recommend this book, but I cannot.

Heaven knows we need fresh approaches in the teaching of our subject and in methods of really stimulating the interest of those people outside it, particularly the younger and uncommitted ones. The author has attempted to do this by presenting the earth in an unusual, and what should have been refreshing, way but somehow or another the book just does not come off, and it is difficult to point to any one particular reason why it does not come off.

However to judge from the preface, I think one reason may be that the author started off with a specific approach, and very limited audience, in mind but then changed course half way through.

An extensive quotation from the preface might be in order.

"Who is this book written for other than myself?

The man in the street. You should see one aspect of modern geology very clearly; our understanding of dynamical processes inside the earth - a sort of meteorological - physiological insight. The glossary-index will be especially helpful, not only for this book but for others which cover

related topics.
I hope you won't be put off by rather a lot of mathematical formulae.
The Student. Perhaps you are studying science at school or are a university undergraduate . . . The problems (p. 185), many of which are very difficult, are for you to tackle.
I hope you will find them stimulating.
The teacher. This is not a course text book, but I expect you will find useful teaching material in it . . . leave most of the description (of our subject) in books (and make) our students spend their time doing experiments, simulations, and problems. I don't pretend that this book is the answer to these difficulties, but I hope that its approach will suggest usable teaching devices to you.
The expert. I have very little here for you".

We therefore have to examine the book in the light of these general objectives.

First, we come across terms such as the "the Global Jampot", "the Egg Model Earth", "the Earth as a Jumping Bean", "the Jelly Model Earth", "Rock Mushrooms" etc., all useful everyday word pictures calculated to stimulate the interest of the man in the street. Unfortunately, there are also numerous terms used throughout the text which it would be unreasonable to expect the man in the street to be familiar with, and which are either undefined or just ill defined in the glossary-index (GI). For example we run across an equipotential surface (gravitational) on page 19 which is not defined in the GI although it is associated with the geoid; even some students have difficulty visualizing this concept at first. On page 23 we come across the word "Rheology". In the GI it simply refers us to "Bladder Model" but there is no definition under "Bladder Model". Similarly, anelasticity isn't defined although its meaning could probably be deduced by the student. More importantly, elastic and anelastic behaviour is explained in terms of "dashpots" and "springs" with no expanation of what a "dashpot is or why it is used to represent one aspect of deformation. This sort of problem for the man in the street occurs throughout the text and as the final example I would cite the term "enthalpy", which is not defined in the GI. How many first year students would know what it means (although once again they may be able to deduce the meaning from the context) let alone the man in the street? No, there is not much to excite and hold the interest of the man in the street.

How about the student? Well, this is probably the best place to outline the author's plan. The idea is to approach the earth from far off and examine it in the light of its appearance and behaviour on different geometrical scales. Thus, to an observer far out in space the earth is a small stationary spherical stone, but as he comes nearer he observes that the stone is not spherical and is in fact rotating and by the time he has landed on the surface and run some simple experiments he discovers that the earth is neither perfectly rigid nor homogeneous. The next step is then to examine systems on the global scale, continental and mantle scale and so on to progressively smaller geometrical scales. The basic idea is good, although in this reviewer's opinion too little attention is paid to the time scale.

At the beginning of chapter 4 the effect of time-scale on deformation is tackled in a very round-about way but the statement is made that "the total strain is made up of two parts: an elastcc part proportional to load and a time dependent, fully recoverable part that varies with rate and duration of loading". The existence of a nonrecoverable (plastic?) component of strain, time dependent or otherwise, gets only an incidental mention. More attention to the time dependency of strain at this point might make some of the later chapters more comprehensible.

There are some places in the text where the approximation used for obtaining rough working figures are just too crude (even at this level), confused and confusing to be of much value. To illustrate this, I quote a fair amount of material from a section headed "Review of Energy Stocks" on pages 37 and 38.

> "A good approximation to the gravitational energy of planetary body with only a mantle and core is
>
> $$W = W_o [1 + (\tfrac{4}{5}\,\xi - 1)\rho^4]$$
>
> where $W_o = \tfrac{4}{3}\pi^2 G a^4 \rho\rho_m$
>
> $\rho = r/a$, the relative core radius;
> $\xi = \rho_c/\rho_m$ the ratio of densities of core and mantle material. Per unit mass the energy represented by W_o is $\pi G a^2 \rho_m = 3 \times 10^4$ kJ kg^{-1}. Of this a proportion $\tfrac{4}{5}(\xi - 1) \simeq 0.2$ will be released as the core diminishes from ρ=1 to ρ=0. Thus about 6700 kJ kg^{-1} will be released, an amount equivalent to about twice the initial thermal energy".

My first comment is that if we are going to pull equations out of the blue, why not use the accurate expression, which is quite easily derived. Second, even if I use some of the basic data for the earth quoted by Elder in his table 5.1, I cannot reproduce the figures he gives even reasonably approximately; here I must admit to making the assumption that in the author's calculation he is in fact taking the earth as the planetary body in question - he doesn't say so. Maybe there is a printing error in one of the equations for, using the later statement about the energy per unit mass, substitution in the expression for W_o leads to a value for the total mass equal to the mass of the whole earth using its mean density ρ; this is clearly incorrect since examination of the expression for W shows that it must be greater than W_o when $\rho_c > 1.25\,\rho_m$, which it clearly is for the earth.

In any case if I use the data of table 5.1 in the equations (which are not numbered in the text) the value of W_o/unit mass is 3.8×10^4 kJ kg^{-1} (and W expressed per unit mass becomes 4.1×10^4) and not the 3×10^4 given by Elder, whereas if ρ_c is meant instead of ρ the value is 7.6×10^4 (which is far too high a value for the earth); and what exactly does the author mean when he talks about energy being released as the core diminishes from ρ=1 to ρ=0. At ρ=1, r=a and we have a uniform earth, but when ρ=0, r=0. Since if r=0 we have no core, and presumably the mass remains constant, we are back to the case of a uniform earth. How then can there be a loss of energy as ρ goes from 1 to 0 (unless there is a change in radius and mean density). Note also that his statement $(\tfrac{4}{5}\,\xi - 1) \simeq 0.2$ implies that $\rho_c = 1.5\,\rho_m$ which again is at variance with the data in table 5.1.

However if we again use Elder's figures, 0.2 times 3×10^4 (from $\pi G a^2 \rho_m$) is 6×10^4 and not 6.7×10^4; I know that the difference between the two numbers in neither here not there as far as order of magnitude estimates are concerned but the type of person for whom the book is allegedly written will; a) puzzle over why two significant figures are quoted in one case and not the other, b) observe the two figure numbers rounded to one significant figure, would be 7 x 10^4 and not 6 x 10^4, c) conclude that the numbers therefore refer to different things, but ask what are they? d) wonder why neither number can be reproduced more closely using the data in table 5.1.

This is not the only section which gives trouble but I have spent considerable time going over it since it is illustrative of what I believe to be the basic weakness of the book. Numbers, equations and assumptions, some justified and some not, too often spring out of nowhere; symbols appear which may or may not have been defined earlier (there are still one or two I haven't been able to find again although they may be buried somewhere), and lack of references in the text often makes it very difficult to determine whether the author is making a quantum jump in logic on his own or relying on the work of others. Numbered equations and a table of symbols would certainly make life easier, and the lack of a good bibliography is inexcusable. The "Reading list" contains seven items amongst which are the *Encyclopedia Brittanica* and the *Journal of Geophysical Research* (all of it); some specific references appear in the GI but many of them are difficult to match to the text. In fact this is a book which would require considerable time (certainly more than I can devote) for a very sophisticated student or teacher to unravel in order to make their own assessment of the validity or otherwise of some of the author's end results.

It seems to me that Elder has taken what may well have been a very successful lecturing technique and attempted to transfer that technique lock, stock and barrel into the printed form. Unfortunately, what may be legitimate scribblings and approximations in the classroom, where students can ask questions when the waters become muddy, require tidying up before they get into print.

It would require very little effort to tidy up the numbers and make them self consistent while at the same time preserving what I believe is Elder's main intent - to encourage students to make order of magnitude calculations for limiting cases so as to establish limits on what is reasonable and what is unreasonable.

After all, surely in addition to encouraging students to "think conceptually" we should also be encouraging them to set out their ideas clearly (as well as concisely) and above all to make sure that numerical supportive evidence is self consistent and reproducible.

In summary, then, the basic idea behind the book is good but in my opinion it is too poorly executed to be worth buying.

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Geology and the New Global Tectonics

By J. Robert Janes
Macmillan of Canada,
468 p., 1976.
$12.50

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Charles Lyell first published his *Principles of Geology* in 1831. It brought geology into the forefront of science and completely changed the understanding of the earth and its inhabitants. Janes' book may well bring about a change in the study of geology in secondary schools in Canada. A decade ago, the attitude prevailed that geology should be the prerogative of the universities but landings on the moon excited the teenagers. The relationship of geology and environment further advanced the science as a worthy endeavour for secondary schools. The geographer capitalized! The Canadian Geoscience Council produced a report of consensus from secondary school teachers that a textbook was not really needed. The teaching of geology in high schools in Canada is increasing slowly. Several texts produced in the United States are available. But these never cover the Canadian occurrences of earthquakes, the origin of potash deposits in Saskatchewan, the character of the Athabaska tar sands, mineral deposits of the Canadian Shield, and astroblemes which Canada has more than any other country.

The book has 13 chapters which are arranged to capture, first with the spectacular, the imagination of the young reader. Chapter 1 is devoted to plate tectonics with a text including many "hard" facts which may require modification later. "The North Atlantic is widening at a speed of about three cm/year and the South Atlantic is moving somewhat faster". Numerous simple but comprehensive diagrams show plate distribution, topography of the ocean bottom, and a cross section of the crust with mid-ocean ridge and subduction zone. Chapter 2 on earthquakes leads with a report on the 1964 Alaska event almost in newspaper style, a resumé table of the severest quakes with death tolls since the year 858 to the four major quakes of 1976, and a resumé of earthquakes in Canada. The theoretical explanation of shock waves, seismographs and a resumé of the Richter scale should be adequate for secondary school students. The chapter continues with the earth's magnetic field, a comparison of continental and oceanic crust, isostasy, tsunamis, and earthquake prediction and prevention. (These topics may not seem related but the arrangement is quite acceptable). Chapter 3 covers volcanoes - types, character of lava with chemical analysis, volcanic gases and diatremes. A review of some of the traditionals - Vesuvius, Pelée, Kilauea - is followed by a review of volcanism in British Columbia - Edziza, Garibaldi) and also short discussion of volcanic sequences in the Precambrian. Closing the chapter with paleomagnetism in the ocean's floor does seem out of place.

Now with the student firmly in his grasp, Janes continues with the realities of igneous intrusions such as the Monteregian Hills and Muskox, then sedimentary rocks with types and classifications, distinctive features and origins. The discussion of salt domes overlooks occurrences on the Atlantic Shelf and the Arctic but the character of deep sea oozes, with manganese nodules and their recovery, and relationship to plate tectonics is commendable. The chapter on metamorphic rocks covers agents, rock types with discussion of the role of heat, pressure, water and the significance of metamorphic grade. The chapter ends with granitization.

The remaining chapters cover geologic structures, weathering and ground water, erosion, glaciation, time and