distinguished from lava, which flows.)

The book gives a background from classical literature of some of the myths surrounding Hekla, then proceeds to the placing of Hekla in the two active volcanic belts running southwesterly-northeasterly in South Iceland. The next discussion is of the eruption history of Hekla. The changes in types of lava and tephra during an eruption as well as in successive eruptions are described. The list of the 13 known eruptions starting with that in 1104 leads naturally to a detailed discussion of the 1947 eruption, which is then followed by a description of the 15th and last eruption of 1970.

Throughout the detailed accounts of the 1947 and 1970 eruptions the distribution of tephra in time and space is carefully analyzed, as is the flow of lava in both eruptions. A reader can very well become awe-stricken at the disasters which have flowed from the volcano through its tephra fallout. In the 1970 eruption alone tephra containing fluorine contaminated an area of 450 farms, owning 95,000 sheep, and over 6,000 lambs and 1,500 ewes were killed by fluorosis. Fortunately, the fluorine-contaminated tephra is ejected only during the Plinian phase, usually in the first two or three days of the eruption. The wind and weather determine the extent of damage.

Many geophysical problems arising from studies of the tephra and lava are mentioned. For example, the amazing difference in composition of the xenoliths ejected perhaps will give an insight into what is happening in the lower crustal layers which are the source of magma for this volcano. Fifteen figures, two plates, and 54 illustrations are carefully keyed to the text. The book is highly recommended to anyone interested in volcanoes.

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Pre-Tychonic Data Reanalyzed

Ancient Astronomical Observations and the Accelerations of the Earth and Moon. ROBERT R. NEWTON. Johns Hopkins Press, Baltimore, 1970. xx, 310 pp., illus. $10.

The secular accelerations of the earth's rotation and of the moon in its orbit are strongly interrelated with the definition of time, with the long-term behavior of the earth's interior, and with the question of variability of the gravitational constant, predicted by the Brans-Dicke scalar-tensor theory. Thus a study of these accelerations that declares that most of the classical work in this area is wrong is likely to attract attention. Newton sets about to destroy the credibility of the methodology of earlier investigators, to establish his own methodology as being without the flaws of his predecessors', and to reanalyze the available astronomical data from pre-Tychonic times. Having established a solution at roughly double the conventional value (due to Spencer Jones) of the lunar acceleration in modern times, Newton concludes with some geophysical speculations, attempting to explain how the accelerations could have changed as drastically since ancient times as his results indicate.

The degree of success attained by Newton will lie in the eye of the beholder. The great difficulty of his subject results from the nature of the observations: poorly documented accounts, frequently by inexperienced observers, of celestial events visible to the naked eye, such as eclipses and occultations. In some cases, the definitions of measurement terms are in doubt. Nearly always, the date and location of the observations are unknown. Perhaps Newton's greatest contribution is his critique of the usual procedure (the "identification game") for assigning dates and localities to such events, a procedure which he claims artificially minimizes the departure of the final result from the initial assumption, and which can lead to the classical result even if a table of random numbers is used. The situation is perhaps overstated, but it seems clear that there is much room to suspect the classical results of serious bias.

Newton is much less convincing in his own treatment of the observations, and many readers will reject the work outright because of its unsatisfactory aspects. This would be a mistake. He has replaced the "identification game" with a statistical guessing match fully as subjective. He criticizes other authors for failing to go to primary sources, and then does not bother to consult easily available references. Sometimes his statistical principles seem at variance with the proper ones as understood by this reviewer. Estimates of achievable observational resolution of eclipse magnitudes are based on laboratory tests with paper cutouts rather than on real eclipse experience. Conventional terminology and usage are widely flouted. But, it is not obvious that these flaws negate the numerical results. Even if they do, the ground has been broken for a thorough reexamination of this subject.

Newton's unconvincing geophysics need not undermine the view that such a reexamination is in order, for his calculations are based on acceptance of the "modern" value of the lunar acceleration. Van Flandern, however, has indicated a very large correction to the conventional value for the present epoch also, obtaining a value roughly compatible with the values obtained by Newton for 200 B.C. and A.D. 1000. These two studies in fact provide important support for one another's numerical results. Astronomers and geophysicists will be well advised to examine this work carefully.

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The Chandler Wobble

Earthquake Displacement Fields and the Rotation of the Earth. A NATO Advanced Study Institute, London, Ontario, June 1969. L. MANSINHA, D. E. SMYLIE, and A. E. BECK, Eds. Reidel, Dordrecht, and Springer-Verlag, New York, 1970. xii, 310 pp., illus. $19.80. Astrophysics and Space Science Library, vol. 20.

In 1891 S. C. Chandler, a businessman in Cambridge, Massachusetts, reported that his analysis of latitude observations showed two periodic components in the motion of the pole—an annual term, and a component with period 14 months. It was not long before the periods of Chandler's wobble were explained. The 14-month term turned out to be the Eulerian free wobble with period lengthened from the theoretical 10 months to 14 months because of elasticity of the earth. The annual component was nicely explained by the seasonal changes in the inertia of the atmosphere and the distribution of snow, groundwater, and ocean mass.

The mechanism of excitation and damping of the 14-month wobble has been debated to this day. Among the hypotheses advanced are nonseasonal changes in the inertia tensor of the atmosphere and in the ocean load, electromagnetic core-mantle coupling, and changes in the solid earth inertia tensor accompanying earthquakes. Some famous men attempted to find what excites the Chandler wobble, including Larmor, Jeffreys, MacDonald, Munk, Columbo, Shapiro, and Runcorn. Despite this array of talent no generally acceptable theory emerged and the debate continued. In 1968 two young scientists at the University of Western Ontario, Mansinha and Smylie, reopened the question of excitation of the wobble by large earthquakes with the publication of a startling paper in which changes in the pole path were correlated with major earthquakes. They presented a theoretical explanation using the latest seismological data on the extent of the seismic source. Although questions were raised about the statistical validity of the correlation and the adequacy of the theory, the paper was sufficiently well founded to trigger a resurgence of interest in the problem.

The new theoretical and experimental results which emerged led to a NATO Advanced Study Institute at the University of Western Ontario in June 1969. This book, which represents the results of the conference, will become a standard reference work on the geophysical causes and consequences of polar motions. In a single volume one can find a review of the entire subject and specialized reviews as well as new results on the elastic theory of dislocation, the observation of deformation fields in the earth, the precise measurement and analysis of polar motion and rotation, and statistical correlation studies of the excitation of the Chandler wobble by different mechanisms. All told there are 28 articles, each followed by a transcript of the discussion.

Although the NATO Institute was stimulated by the revival of the earthquake mechanism for the Chandler wobble, the conferees chose not to validate this or any other hypothesis. The problem is still an open one which will undoubtedly receive much attention in the next few years. To paraphrase an earlier worker, the subject touches on every branch of geophysics. By the time it is covered, information will have been gained on air and ocean masses, atmospheric, oceanic, and bodily tides, elasticity and anelasticity of the earth's mantle, the earthquake mechanism, and the motion in the fluid core.

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Rational and International

The Metric System. A Critical Study of Its Principles and Practice. MAURICE DANLOUX-DUMESNILS. Translated from the French edition (1965) by Anne Garrett and J. S. Rowlinson. Athlone Press, London, 1969 (U.S. distributor, Oxford University Press, New York). x, 162 pp., illus. Paper, $2.50.

Prepare Now for a Metric Future. FRANK DONOVAN. Weybright and Talley, New York, 1970. 212 pp., illus. $5.95.

Britain and other Commonwealth countries have already undertaken conversion to the metric system, and the United States Congress has recently commissioned a study of the desirability and practicality of our country's doing so. English-speaking readers should therefore benefit from these two books expounding the history, principles, and practical usage of the system.

Danloux-Dumesnils's study commences with the chronological history and scientific development of the metric system. In 1790 Talleyrand urged that a plan for the unification of weights and measures be a joint Franco-British collaboration and declared it "an enterprise whose outcome must one day belong to the whole world." The British diplomatically refused. In the following ten years, the French pioneers in founding the system included Borda, Condorcet, Delambre, Fabbroni, Lagrange, Laplace, Lavoisier, Lefèvre-Gineau, Méchain, and Monge. A French law of 1795 initiated the metric system, one of 1837 made it fully effective, and a decree in 1961 repealed earlier legislation by adopting the modernized metric Système International, SI. The metric system was made legal but optional in use by the United States in 1866 and by Britain in 1897.

The principles underlying the system were (i) to use decimal numbers, not fractions, to count the units, (ii) to generate for each basic unit sub- and supersizes which differed in powers of 10, and (iii) to select the basic unit size for each property so that combination units also tended to be unity. The density of water expressed either in grams per cubic *centi*meter or in *kilo*grams per cubic *deci*meter was unity (1 cubic decimeter = 1 liter). Gauss in 1825 developed a coherent system of electrostatic units, and ten years later Weber continued it for electromagnetic units. In 1861 the British (William Thomson, Clerk Maxwell, and Latimer Clark) adopted electrical standards from which emerged the *cgs* (centimeter, gram, second) system. In 1913 the French proposed the *mks* (meter, kilogram, second) system. Finally in 1960 the General Conference of Weights and Measures modernized it to *SI* (meter, kilogram, second, ampere, Kelvin, candela), based on the 1901 proposal of the Italian Giovanni Giorgi to "rationalize" the units of electricity and magnetism. The International Bureau of Weights and Measures has preserved the metric standards since 1878 in their headquarters at Sèvres, France.

Danloux-Dumesnils undertakes critical analysis of measures in terms of unit concepts, dimensionality, precision, rationality, coherency, symbolism, comparability, calibrations, arbitrary and legal definitions, standards, norms, biological units, and subjective observations. He shows that because a measure is the combination of a counting number and a unit, for practicality the size of the unit should be so chosen as to keep the numbers small. He dislikes the 12 unit prefixes, from *tera*, 10^{12}, to *pico*, 10^{-12}, and suggests that we instead count in numbers. I might illustrate this—a resistance of 13.3 kiloohms might better be expressed as 13.3×10^3 ohms. My own restriction here would be that the exponents be multiples of 3. Many scientists, however, keep the number between 1 and 9 and vary the exponent: 1.33×10^4 ohms.

I cannot resist digression here by interjecting some noneuphonious combinations of prefixes and SI units (some derived), impractical as they may be: astraampere, attometer, femtofarad, gigagram, hectohertz, nanonewton, nembujoule, picopoise, teratesla. And in honesty I must remind the 135 kilomembers of the AAAS that each is urged to use the SI units in his published work (resolution passed 30 December 1970; see *Science* **171**, 711 [1971]). Oh well, many commendable endeavors have their humorous extremes. To continue reviewing:

Danloux-Dumesnils goes on to give technical descriptions of units for length, area, and volume (I hope "ca-