Origin and Evolution of Atmospheres and Oceans

Any effort to summarize available information and views on the origin and evolution of atmospheres and oceans makes it abundantly clear that the subject is a tough one, at once interdisciplinary in the highest degree and with little reliable data to start from. **The Origin and Evolution of Atmospheres and Oceans** (Wiley, New York, 1964. 326 pp. Illus. $12.50), edited by Peter J. Brancazio and A. G. W. Cameron, is a collection of 17 technical papers (by 18 authors), all but three of which were presented for the first time at a conference held at the Goddard Institute for Space Studies in April 1963. It has the usual advantages and disadvantages of such a collection—specialistic treatment of individual items balanced against a somewhat disconnected and uneven whole, with papers ranging from two-page notes to lengthy major articles. However, a good index and a preface in which the editors outline the main points considered and the conclusions reached compensate, to some extent, for the disconnectedness.

With the exception of Neptune, Pluto, the bare mention of Uranus, the asteroids, and planetary satellites other than Earth's Luna, all known solar satellites are here examined as to possible processes, rates, and dimensions of surficial accumulation of volatile elements. Much discussion also revolves around special problems posed by anomalies in the abundances and possible origins of xenon, argon, helium, and other rare gases and their isotopes in planetary bodies and in meteorites.

Earth, naturally, receives the most attention, the first seven papers and well over half the book being devoted mainly to it. Discussion gets off to a good start with the reprinting of W. W. Rubey's now-classic 1951 paper, "Geologic history of sea water" [*Bull. Geol. Soc. Amer.* **62**, 1111 (1951)], the longest and best documented paper in the book. This paper is no longer quite up to date in all details, but its principal conclusion, that the bulk of the terrestrial atmosphere and hydrosphere has arisen gradually from the earth's interior, is accepted as a point of departure for the rest of the book. Brancazio, for instance, follows with a brief review of convention in the earth's mantle in which he concludes that general acceptance of this idea, with the acceptance of consequent degassing, is hampered only by "lack of an adequate theoretical description." K. K. Turekian then considers quantitatively the degassing of argon and helium from the earth without reaching any firm conclusions, while G. J. Wasserburg, in a two-page note, finds that the present flux of argon and helium into the atmosphere is a mixture of radiogenic and atmospheric components, without any primordial gas.

Continuing the discussion of Earth's atmosphere (and that of Venus), H. D. Holland reviews the arguments advanced by Harrison Brown and others, based on terrestrial versus cosmic ratios of the noble gases, to conclude that "at $t = 0$ there was essentially no atmosphere present on the earth, and that the earth's atmosphere and hydrosphere have resulted from degassing of the earth's interior." Holland supposes nitrogen, ammonia, and methane to have been dominant volcanic gases during the first half-billion years but avoids the problem of where the nitrogen came from originally. He also discusses briefly the history of oxygen in Earth's atmosphere. In the next paper this topic is dealt with at greater length by L. V. Berkner and L. C. Marshall, who attempt a synthesis so broad that they understandably get into trouble with details—for example, their misinterpretation of Metazoa (multicelled animals, not "elementary algae, fungi, and bacteria," pp. 115 and 117). One may also quibble with their over-precise correlations of particular oxygen levels with particular evolutionary developments, but they are probably on the right track here. Berkner and Marshall's paper is a provocative one—it will certainly stimulate geologists, if only to point out that, in fact, some geologists *have* argued that the early atmosphere was "deficient in oxygen and otherwise radically different from that of the present day" [A. M. Macgregor, *S. African J. Sci.* **24**, 155 (1927)].

Discussion of Earth in particular is concluded with a paper by G. J. F. MacDonald, who, like Signer, Dollfus, and Field, uses the editorial we. MacDonald tells us, in a scholarly and quantitative paper which might better have been drastically condensed for this book in view of its availability elsewhere [*Reviews of Geophysics* **1**, 305 (1963)], that historical fluctuations in Earth's magnetic field could result in greater rate of escape from the earth's atmosphere than that now observed for helium, thus easing the problem of calculated accumulation in excess of that observed.

Six papers (including three of those discussed above) consider distribution and sources of the noble gases, particularly xenon, argon, and helium, in different parts of the solar system. Peter Signer discusses meteorites having excess rare gases and their grouping into three classes with respect to abundance of helium and neon, and to Ne^{20}/A^{36} ratios. He considers as still problematical our theories about the source, localization, and manner of introduction of these excess gases. The sources and anomalous abundances of the isotopes of xenon are the subject of papers by R. O. Pepin and A. G. W. Cameron. Pepin's long and highly technical paper reveals a wealth of raw data interpretable on several different and even contradictory models. He sees grave difficulties in accepting the view that excess Xe^{129} in the earth or meteorites is derived from a simple evolution of short-lived galactic I^{129}. If such is assumed, however, a formation interval for the earth can be calculated as about 320 million years (comparing with 270 million years based on plutonium-xenon calculations, and 250 million years obtained by Cameron from iodine-xenon calculations). Cameron considers anomalies in the abundances of isotopes of xenon, and of xenon with respect to krypton, compared to a chondritic standard. Although he recognizes no completely satisfactory theory, Cameron favors the ultimate derivation of the main part of the nonradiogenic and nonfissionogenic xenon from the solar wind. In addition, "we need a large fractionation of the krypton and xenon that have been outgassed from the earth, to the extent that xenon should be retained in the earth much more than krypton."

Venus is discussed in papers 5, 11, 12, and 14, with notable lack of agreement, particularly with respect to the presence and quantity of water in its atmosphere and on its surface. Carl Sagan stresses that "we do not now know the cause of the most obvious feature of Venus, its cloud layer." He considers a range of possibilities from hydrocarbon smog to transparent salts but leaves all issues in doubt, including the question of how the cytherean surface stays as hot as it does. Water vapor on Venus, opines Sagan, is probably less than 2×10^{-3} g/cm^2 (Spinrad and Richardson gave an upper limit of 3.5 $\times 10^{-3}$ g/cm^2). Holland agrees, finding no evidence of water. But A. Dollfus reports photometric absorption measurements that indicate about 1×10^{-2} g/cm^2, which would be comparable (from his measurements) to Earth if it were covered with clouds at an elevation of 13 kilometers. Thomas Gold, on theoretical grounds, argues that outgassing processes on Venus should be similar to those of Earth and that, because their masses are nearly the same and they both have cold traps in their outer atmospheres which restrict upward diffusion of water vapor, Earth and Venus should retain similar volumes of water above the lithosphere. In the case of Venus, with temperatures of 485° to 550°K in the colder parts, more of the water would be in the atmosphere and less in the hydrosphere.

Gold also offers some interesting speculations about the moon. On such a small planetary body, any gases that reached the surface would be "blown-away" by the solar wind, as well as being lost owing to insufficient gravitational attraction. However, at a surface temperature of 240°K (well below the freezing point of water) water produced by degassing would freeze at the surface, resulting in a thick layer of permafrost, underlain by liquid water at some depth. The consequences of such a situation are examined, but the evidence for lunar degassing is not discussed.

The Martian atmosphere is considered by R. M. Goody and A. Dollfus. Goody cites polarimetric measurements suggesting that the atmosphere of Mars is about one-fourth to one-fifth that of Earth and validating, within a factor of 2, Dollfus' estimate of 85 millibars for surface pressure. Atmospheric motion is revealed by the drift of clouds, possibly of water vapor, which Dollfus estimates as 1.5×10^{-2} g/cm^2. Goody points out, however, that difficulties exist even with the well-known polar caps of Mars—the mist that during winter months covers these caps having an albedo of only about 0.3. If this is an ice mist, as Dollfus believes, it is a very peculiar one, for we do not get an obscuring ice mist on earth with an albedo much below 0.8.

The possibility of an atmosphere on Mercury is reexamined by G. Field, who reasons that the escape velocities involved on a mass like that of Mercury (given as 0.054 Earth units) require that, *if* an atmosphere exists, it should consist of heavy gases such as argon. The recent spectrographic studies of A. N. Kozyrev suggesting a mercurial atmosphere of hydrogen presumably appeared too late for inclusion here.

Finally, the giant outer planets are found to resemble the sun more than they do the inner planets. P. J. E. Peebles advances reasons to consider that "both Jupiter and Saturn have hot interiors with very deep atmospheres" and no fixed surface below the cloud layer. The upper layers probably contain "a reasonable amount" of helium, and Jupiter is roughly 81 percent hydrogen (by mass). Nevertheless, these planets are considered to have relatively high-density cores. The high internal temperatures inferred are attributed to heat flux from radioactive decay. A very brief note by R. Wildt calls attention to the work of Spinrad and Trafton, utilizing old absorption spectra to show atmospheric motion and deduce a composition for the Jovian atmosphere of hydrogen, helium, a little neon, and somewhat less ammonia and methane.

In a nutshell, this book represents a strong endorsement of the outgassing process as a primary mechanism in the origin and evolution of atmospheres and oceans, coupled with a plea for more and better data from planets other than Earth, data gathered by the use of space probes and remote sensing devices.

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Ethnography

Culture and Community. Conrad M. Arensberg and Solon T. Kimball. Harcourt, Brace, and World, New York, 1965. xvii + 349 pp. $3.95.

Culture and Community describes and discusses human communities as syndromes whose systematic examination can "yield major insights into the connections among culture, society and personality that were long asserted to exist but were hitherto only partially specified." It is both a reference work and a manual for fieldworkers. As both it is outstandingly successful.

Although this book is largely a collection of articles published separately over a period of years, it is tied together so skillfully with new connective and interpretative material that it flows smoothly throughout. There are four main parts: a brief historical review, definitions, and a procedural outline for fieldworkers; a typology of American subcultures; a historical review of comparative ethnography of community life in America; and a final consideration of methodological theory and practice. The authors trace in great detail the development of concepts of communities as microcosms of the overall cultural frameworks within which they are set. Each different approach is described, examined carefully, and tested in the light of experience of the authors and other investigators. Out of this study there is developed a master method, modestly presented not as the ultimate best but as apparently the most fruitful that has been worked out so far. Thus, the authors have responded to the basic "oddity of the history of community study that one hunts almost in vain for a good account of the implicitly agreed-upon field techniques. They never seem to have been described thoroughly. . . ." Now they have been.

The authors go on to apply their method to various types of communities and aspects of community life in the United States. Here again their exposition covers a wide range in space and also depth in time, so that we feel the full force of the continuity and dynamics of cultural change. Old World origins and comparative material as well are also taken into full account. Nothing that can throw light on each type of community in question has been left aside.

Arensberg and Kimball have pre-