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THE ATMOSPHERES OF EARTH AND MARS IN

THE LIGHT OF RECENT PHYSIOLOGICAL CONCEPTS

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A comparative study of the physiological qualities of the terrestrial and Martian atmosphere is of interest for two reasons: first, it clarifies the real physiological properties of the oft-discussed Martian atmosphere, especially when viewed in the light of modern biological aspects of the terrestrial atmosphere; and second, it demonstrates what strange and - so-to-speak - extra-terrestrial conditions are encountered in present day high altitude flights.

A new concept has been recently developed from the biological and technical point of view with regard to the classification of the terrestrial atmosphere. According to this concept a transition zone between the atmosphere and free space must be recognized. This transition zone is characterized by the fact that the various functions which the atmosphere has for man and craft cease at various altitudes and those factors typical of space come into play, one by one, and finally dominate the field. A symposium, devoted entirely to the discussion of physics and medicine of this transition zone, was held recently.

This discussion will be confined to the functions of the atmosphere, resulting from its oxygen and barometric pressure. Figure 1 shows that the first marked signs of oxygen deficiency - or hypoxia - manifest themselves at a barometric pressure of 450 mm. Hg (12,000 feet), and that at 300 mm. Hg (21,000 feet) they reach a critical level. Hypoxia is again faced in breathing pure oxygen at a barometric pressure of 150 mm. Hg (36,000 feet). If the air pressure is decreased to 80-87 mm. Hg (50,000 feet), it then equals the level of the sum of carbon dioxide pressure (35 to 40 mm. Hg) plus water vapor pressure (47 mm. Hg), which exists within the alveoli of the lungs. Thus the 50,000 foot or 15 km level may be considered as the beginning of complete oxygen lack - or anoxia. Above this point the "time of useful consciousness" after explosive decompression, is reduced to about 15 sec and remains constant. So much for the oxygen component of the air pressure.

Apart from the effects caused by the decrease in oxygen partial pressure in the inspired air, the barometric pressure curve in Figure 1 shows two more distinct points, viz., (1) the occurrence of dysbaric symptoms such as aeroembolism at a pressure of one-third of an atmosphere, or 250 mm. Hg (24,000 feet); and (2) the boiling of body fluids at normal body temperature (37°C). As soon as the air pressure decreases to 47 mm. Hg, this latter effect of decreased barometric pressure must be reckoned with, since it is the water vapor pressure of body fluids at 37°C. Below this level, barometric pressure is unable to maintain water of 37°C in the liquid phase. This pressure corresponds to an altitude of 63,000 feet or 19 km.

This survey demonstrates that - at certain pressure levels - the functions of the atmosphere, viz., those of supplying air for breathing purposes and sufficient pressure to maintain body fluids in the liquid state, have reached their physiological zero-point.

Since there is no difference in the effects found at these corresponding altitudes and in those found in free space, they have been designated as space equivalent altitudes. While the previously mentioned factors of the atmosphere become zero, other factors - being attributes of free space and depending upon the vanishing atmospheric filter function - increase more and more until they finally attain the proportions of their occurrence in free space (heavy primaries of cosmic radiation, ultraviolet part of solar radiation, and meteorites).

These space equivalent conditions within our atmosphere indeed represent a characteristic transition zone between the atmosphere and free space. The atmosphere is no longer an effective one, nor is it yet free space. Rather, it represents a pseudo-atmosphere or a kind of prespace. Viewed from outside the earth, it represents a kind of preatmosphere. For this reason a special term "the aeropause" was recently suggested by K. Buettner for this particular zone of the atmosphere. In this way we replace the conventional topographical concept of a sharply defined border between atmosphere and space with the functional concept of a broad border zone. This zone in which the various functions of the atmosphere cease, begins at about 50,000 feet or 15 km, corresponding to a barometric pressure of 80 to 87 mm. Hg.

In view of this functional consideration of the terrestrial atmosphere, the problem of the physiological qualities of the atmosphere of the planet Mars presents itself in a new and very interesting light.

The following are some of the physical data of this atmosphere, contained in recent important reviews and books in astronomical literature. The air blanket on Mars is optically traceable up to an altitude of 100 km. In his recently published book "The Planet Mars", de Vaucouleurs discusses the reliability of the various values found in the literature for the barometric pressure on Mars. The estimations made during the last 15 years point to the value of 90 mb or 70 mm Hg as the most probable one. Oxygen is not present in the Martian atmosphere. However, carbon dioxide has recently been detected. The same holds true for water vapor. The main constituents are probably nitrogen and argon. The temperature on Mars can reach 30°C on the side exposed to sunlight, however, it drops during the night to -60°C or -70°C.

This data may be sufficient for our consideration. Compared with our own atmosphere, the Martian atmosphere at surface level with a pressure of nearly 70 mm. Hg, corresponds to an altitude of 17 km or 56,000 feet. It is justifiable to use this level as a base line for the pressure altitude diagram of the Martian atmosphere, drawn in the pressure altitude of the terrestrial atmosphere, as shown in Figure 1. The Martian air pressure curve is taken from the book of de Vaucouleurs. Conditioned by the lower gravity on Mars (38 percent of that of terrestrial gravity) the pressure decreases more slowly with increasing altitude than that of the terrestrial pressure curve. Therefore, above a certain level (about 30 km) the air pressure on Mars is higher than that at the same altitudes above the earth's surface.

Turning to the physiological properties of the Martian atmosphere we recall that there is no oxygen on Mars. This means anoxia. Even if the atmosphere of Mars consisted of pure oxygen, it would still mean anoxia for a human or a warm-blooded animal, because the pressure lies below 80 to 87 mm of mercury - the sum of carbon dioxide pressure and water vapor pressure in the lungs. On Mars, a pressure suit containing pure oxygen must have a pressure of at least 3 times the air pressure on the Martian surface, in order to provide sufficient oxygen for respiration. From a physiological standpoint, it is devious to use the term "atmosphere" when referring to the airblanket on Mars since the true meaning of the Greek word "atmos" is "breath". The airblanket on Mars actually represents a pseudoatmosphere.

On the surface of Mars, the boiling point of water is at 43°C, however, this temperature is never reached. The highest temperature measured above the green areas in the tropics on Mars is about 30°C. As already stated, the vapor pressure of water at 37°C and that of the body fluids, lies at a pressure of 47 mm. Hg, which corresponds to an altitude of 63,000 feet on earth. The analogous level in the atmosphere on Mars lies at an altitude of not quite 4 km or about 13,000 feet.

In conclusion, it can be presumed that the space equivalent conditions concerning anoxia, and the boiling point of body fluids, are found at 50,000 feet and beyond in the terrestrial atmosphere. On Mars they begin at the surface. Thus the Martian atmosphere is nothing more than that zone in the terrestrial atmosphere which has just recently been termed as the "aeropause". With regard to the previously mentioned functions, it possesses nearly the same physiological, or more precisely, ecological valences. This comparison makes it very clear that the Martian atmosphere, as physical environment, is completely unphysiological for high living beings as we know them. We may make the cautious statement that lower organisms, which can survive the severe climatic conditions existing above the 56,000 foot level of the terrestrial atmosphere, may also be able to withstand Martian atmospheric conditions. There is, however, one important difference. The temperature in the terrestrial stratosphere is constantly at about 55°C. This would indicate that active life of those micro-organisms that were found in this zone during the 1935 ascent of the balloon EXPLORER II is not possible. On Mars, during the night, the temperature may drop even as much as 20 Centigrades lower. During the day, however, it may rise to 20 or 30°C in summer. This would permit active life during the day. The higher carbon dioxide concentration on Mars may make the ecological conditions favorable for photo-autotrophs, e.g., green plants. In this entire picture, however, the filter function of the Martian atmosphere against solar and cosmic radiation and other extra-Martian factors, must not be overlooked.

Apart from our conclusions, with regard to Mars, the comparative study attempted here demonstrates most convincingly the extreme conditions with which the present day high altitude flier is confronted. It has been shown that the air pressure line of Mars at its surface must be placed into the region of 17 km or 56,000 feet of terrestrial altitude. This altitude is - so-to-speak - the Mars level within our own atmosphere, as referred to in Figure 2. To fly above this level would mean flying under Martian or Mars-equivalent conditions. This in turn may serve to emphasize the importance of all types of protective measures and equipment for flights into the aeropause.

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Physiologically speaking, on such flights the pilot actually enters the "Martian Zone" of our own atmosphere.

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LEGENDS

Figure 1 - The altitude-barometric pressure diagram of the Martian atmosphere projected into the altitude-barometric pressure diagram of the Earth atmosphere. The pressure curve of the Martian atmosphere is taken from S. H. Hess and G. de Vaucouleur.

Figure 2 - The atmosphere of Mars projected into the atmosphere of Earth on the basis of barometric pressure. Shading indicates the density of the air which goes - to some extent - parallel with the pressure.

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Figure 2 - The atmosphere of Mars projected into the atmosphere of Earth on the basis of barometric pressure. Shading indicates the density of the air.

STRUGHOLD

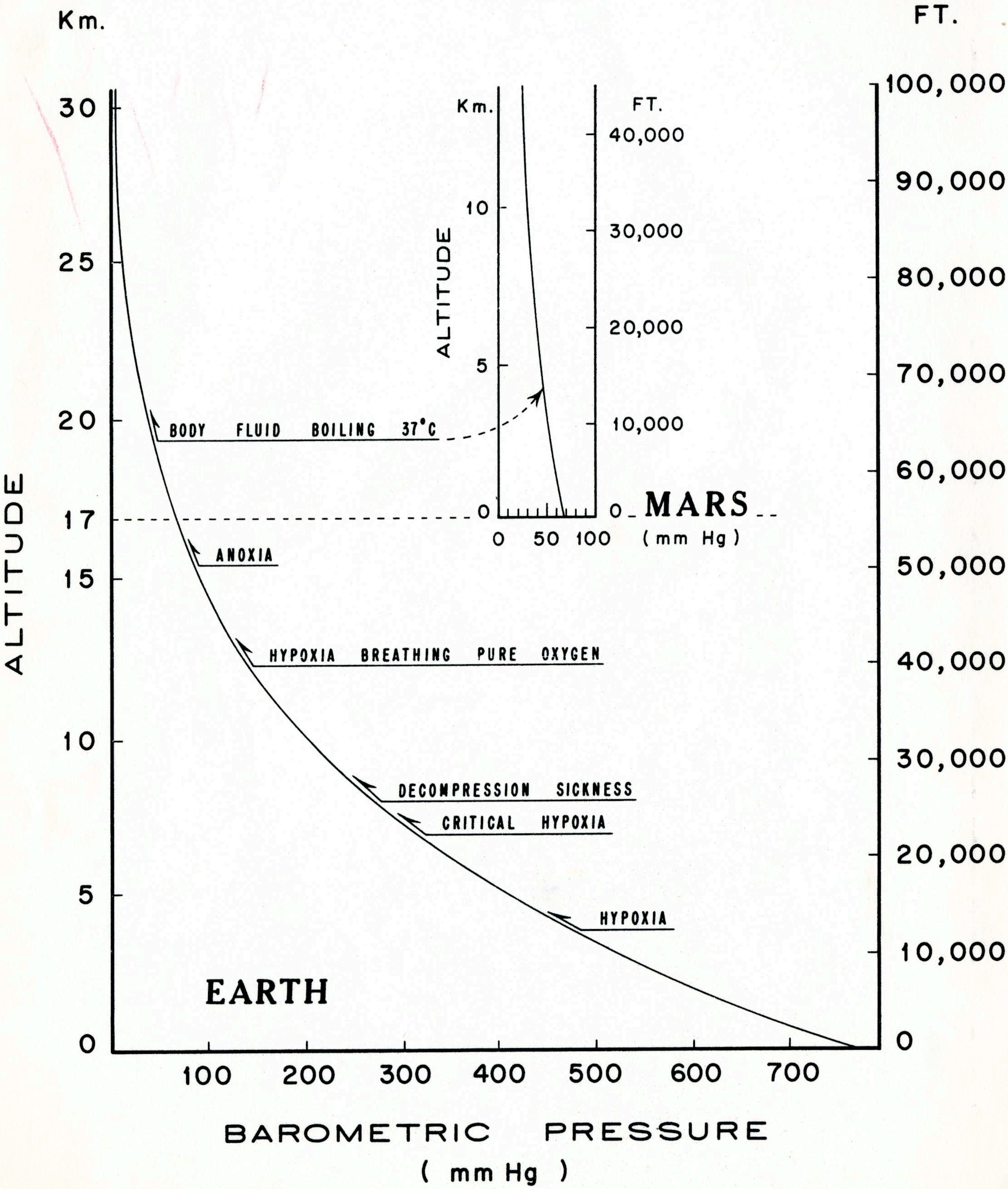
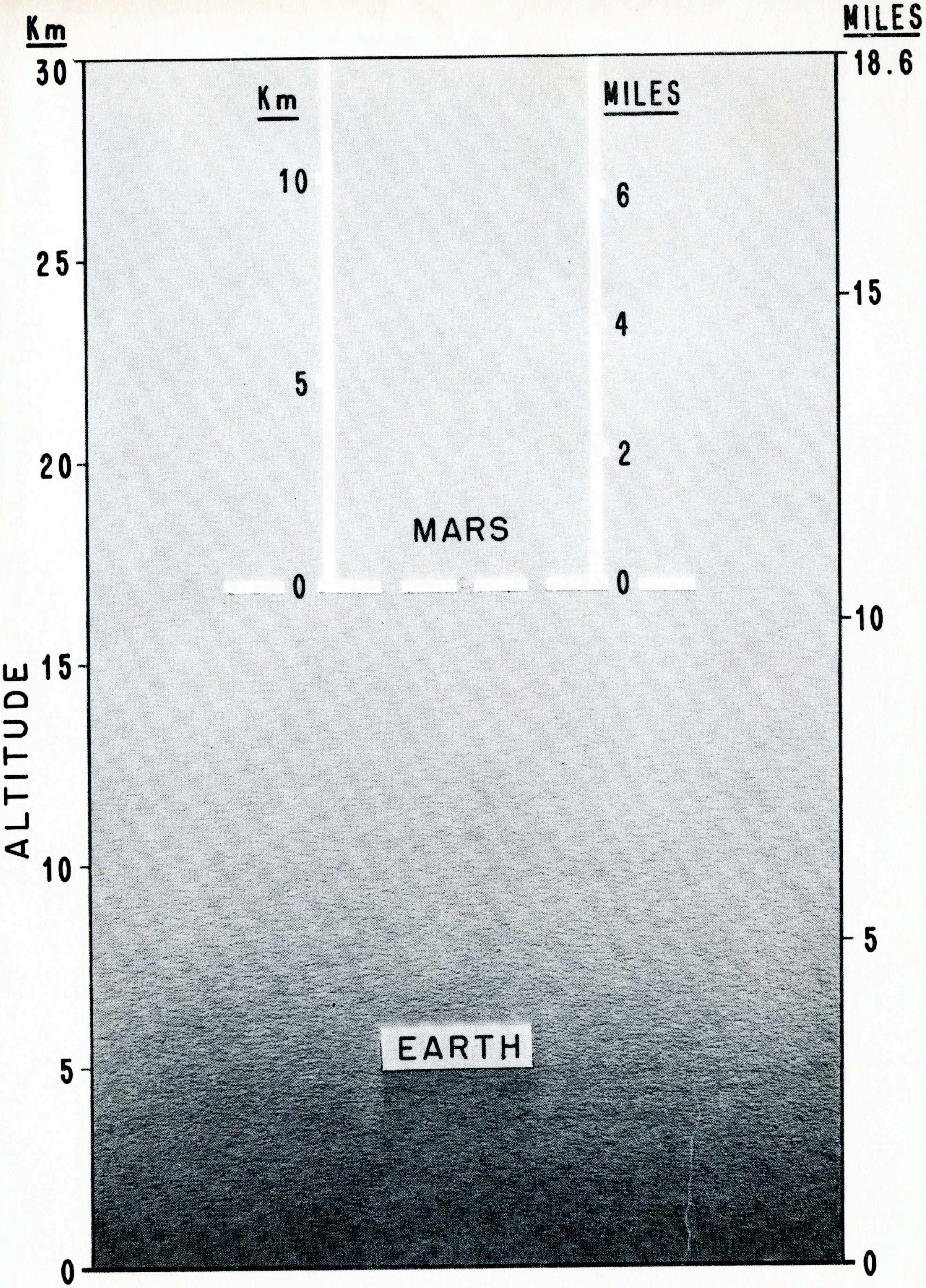


FIG. I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20
15
10
5
0
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MILES
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15
10
5
0
Km
10
5
0
MILES
6
4
2
0
MARS
EARTH

STRUGHOLD