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EXTREME MODEL ATMOSPHERE OF MARS

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EXTREME MODEL ATMOSPHERE OF MARS

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Abstract

Theoretical models of the atmosphere of Mars have been computed on the basis of our present factual knowledge with a minimum of assumptions. The mathematical method used has proven successful in the past in developing model atmospheres of Earth. Distinct from earlier approaches which have resulted in "best values" or "most likely conditions," the resultant model atmosphere gives extreme upper and lower limits for pressure, temperature, and density in the Martian atmosphere up to 150 km altitude. While this rigorous method has yielded reliable data needed for the engineering design of space probes, the spread of values is still extremely wide and indicative of our present scarcity of knowledge.

INTRODUCTION

When faced with the requirements of designing and building space probes to explore our neighboring planets, the scientific experimenter as well as the engineer must rely on quantitative data rather than best estimates. Mars has been the subject of astronomical observations for centuries, and there can be found in the scientific literature an abundance of material about its atmosphere. Yet an impartial, critical analysis soon reveals that our present reliable,

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quantitative knowledge of its characteristics is very scarce, indeed.

Consequently, I have recently attempted to compute theoretical models of the atmosphere of Mars on the basis of the very few available, factual data, together with a minimum of assumptions. Distinct from earlier approaches which have resulted in "mean values," these model atmospheres give extreme upper and lower limits for the distribution of pressure, temperature, and density in the Martian atmosphere up to 150 km altitude.

The mathematical method used is essentially one which proved successful in developing model atmospheres of Earth as recently as some twenty years ago, before the advent of sounding rockets and high-altitude balloon measurements. While I believe that this method has indeed yielded reliable data needed for the engineering design of space probes for the exploration of Mars, the spread of values is still very broad, and indicative of our present scarcity of knowledge.

METHOD OF COMPUTATION

The study took three steps towards a quantitative description of the principal physical parameters of the atmosphere of Mars. First, an attempt was made to derive extreme limits for the permissible ranges of atmospheric temperature, pressure, and density which could prevail near the Martian surface in middle and low latitudes. These limits were derived essentially from past observations of the mass of the Martian atmosphere per unit surface area, and from radiometric observations of the ground temperature, permitting inferences about the range of air temperature close to the ground.

Secondly, the permissible variations with altitude of these limits were computed for a Martian troposphere in convective as well as conductive equilibrium, with isothermal equilibrium above the tropopause. Taken into account were such uncertainties as our knowledge of mass and diameter of Mars (and hence gravitational acceleration) and variation of the intensity of solar radiation from aphelion to perihelion. This method allowed a reasonably confident calculation of probable lower limits up to about 80 km altitude. Reliable upper limits, however, could not be derived in such a rigorous way, primarily because of our practically complete lack of factual knowledge of the composition of the Martian atmosphere.

The third step, consequently, introduced a number of speculative assumptions with regard to the role played by minor constituents,

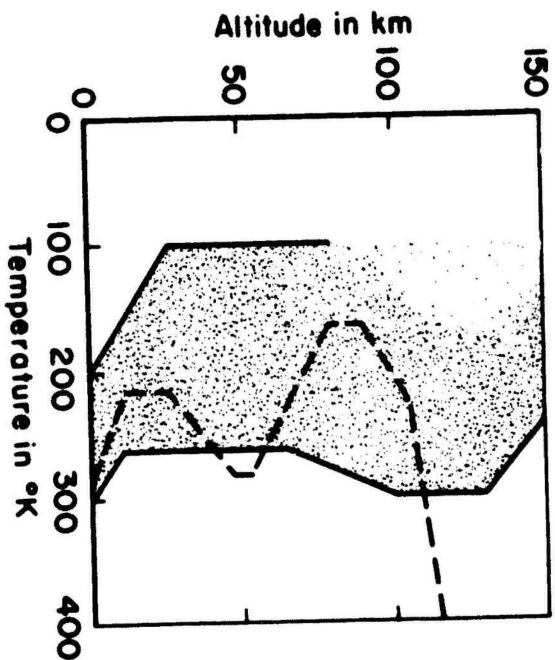
especially CO₂ and ozone. A resultant conjectural model was computed for the case of maximum heating caused by these constituents absorbing solar energy in the Martian atmosphere.

CONCLUSIONS

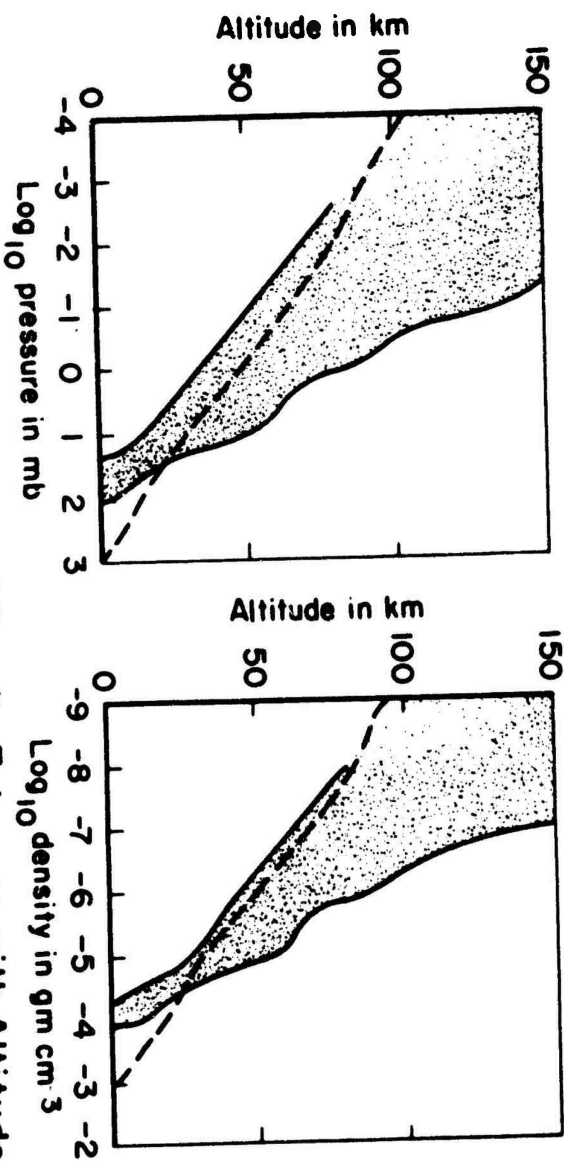
The detailed calculations and the numerical results of the limiting envelopes for three specific model atmospheres are being published elsewhere.⁽¹⁾ Figure 1 is an attempt to combine these results in one realistic model atmosphere which gives probable extreme limits for the basic atmospheric conditions which we must expect to prevail on Mars up to altitudes of 150 km. It constitutes a parametric envelope of the extreme values at each altitude; actual conditions over middle and low latitudes should fall between these limits independently of time of day or of season. For purposes of ready comparison, representative mean conditions in the Earth's atmosphere are also shown in the figure. Since above the altitude of about 130 km, properties will depend so sensitively on the atmospheric composition,⁽²⁾ it was felt that computations of reliable limits would be too speculative at this time.

Obviously, the range of values is undesirably broad. Yet it probably reflects more realistically our actual knowledge about the atmosphere of Mars, than do model atmospheres based on "best values" or "most likely conditions." In the near future we can expect that any single datum obtained by means of space probes or high-altitude balloons will make it possible to narrow these wide limits of possible conditions. Using any of our present factual knowledge, I must hesitate to do so.

MARS MODEL ATMOSPHERE



Variations of Temperature Extremes with Altitude



Variations of Pressure and Density Extremes with Altitude
(Earth ARDC 1959 Model Atmosphere shown as dashed line)

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