11. Runs with PbTe (3), sealed with Pyrex in Nb and Ta capsules (chromel-alumel and platinel-II thermocouples, respectively), were made in the range 6 to 38 kb. A rather flat maximum was suggested near 981° ± 3°C and 25 to 33 kb.
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Mars Ice Caps

Abstract. *Minimum atmospheric temperatures required to prevent CO_2 condensation in the Mars polar caps are higher than those obtained in a computer experiment to simulate the general circulation of the Mars atmosphere. This observation supports the view that the polar caps are predominantly solid CO_2. However, thin clouds of H_2O ice could substantially reduce the surface condensation rate.*

Leighton and Murray (*1*) have argued that, in light of the new data on the surface pressure of Mars (*2*), the polar caps are most probably composed of solid CO_2 rather than of water ice, as previously supposed (*3*). They explicitly neglected the exchange of heat between the atmosphere and the ground, as well as the role of horizontal heat transfer by the atmosphere. These factors are considered here for two plausible models of atmospheric conditions over the Mars ice caps. The results tend to support the conclusions of Leighton and Murray, but downward emission by possible clouds of water ice introduces some uncertainties.

During the period of polar winter darkness, both solar radiation and heat conduction in the ground can be ignored, and the heat balance condition at the ground surface is

$$\epsilon\sigma T_a^4 + H = \sigma T_G^4$$

where T_a is the atmospheric temperature (for simplicity the atmosphere is assumed to be isothermal), T_G is the ground surface temperature, ϵ is the atmospheric emissivity, σ is Stefan's constant, and H is the turbulent transfer of heat from the atmosphere to the ground. When the sense of H is to transfer heat downward, then the temperature gradient near the ground surface is stable, and we can use the bulk transfer law for H (*4*),

$$H = \rho C_P C_D |\mathbf{v}| (T_a - T_G)$$

where ρ and C_P are the surface air density and constant pressure specific heat, respectively, $|\mathbf{v}|$ is the surface wind speed, and C_D is the surface drag coefficient. Under terrestrial conditions over new snow or ice surfaces $C_D \approx .001$ (*4*).

The condition that no solid CO_2 be deposited on the ground is therefore that

$$\epsilon\sigma T_a^4 + \rho C_P C_D |\mathbf{v}| (T_a - T_G) \geqq \sigma T_c^4$$

where T_c is the CO_2 condensation temperature (146.3°K for a 5 mb, 100 percent CO_2 atmosphere), for if this condition is not satisfied at any time, the ground will cool either to T_c or to some higher temperature at which the condition is satisfied. The right-hand side of this expression has been evaluated under two assumptions for ϵ for various values of $|\mathbf{v}|$, assuming that the atmosphere is composed almost entirely of CO_2 having a surface pressure of 5 mb.

In the first model ϵ is due only to carbon dioxide and water vapor, with the total amount of water vapor in an atmospheric column equal to 10^{-3} g/cm^2 consistent with observations (*5*). Under these conditions ϵ is a weak function of temperature, varying between 0.13 and 0.19 over the range 150° to 250°K.

In the second model ϵ is due to a cloud of ice crystals whose total column mass is 10^{-3} g/cm^2. This is about the densest cloud one might expect consistent with observations (*5*). Under the conditions of water vapor pressure and temperature on Mars one would expect ice particle sizes between those in terrestrial mother-of-pearl clouds and noctilucent clouds, that is, particles having a radius of 1 μ or less (*6*). Since, at the temperatures of interest, the blackbody function peaks near 20 μ, the size parameter $\alpha \equiv 2\pi r/\lambda$ (r is the particle radius, λ the wavelength) is small enough that the absorption cross section can be approximated by

$$\sigma_a \approx -4\pi r^2 \alpha \cdot Im\left(\frac{m^2-1}{m^2+2}\right)$$

where m is the complex index of refraction (*7*). Under these conditions, the optical depth of the ice cloud depends only on the total ice content and is independent of the particle size; furthermore, scattering is quite negligible. If we use Kislovskii's data for m (*8*) and the above relation, $\epsilon = 0.73$ for the 10^{-3} g/cm^3 cloud, and it is sensibly independent of temperature. Since the cloud is nearly black in the spectral region of CO_2 emission, inclusion of CO_2 emission at temperature T_a leads to practically the same emissivity.

The atmospheric temperatures required to prevent CO_2 deposition as a function of surface wind speed are shown in the figure for these two models. In the case of the clear sky, the combination of atmospheric temperatures and wind speeds required seems far too high to prevent CO_2 deposition, especially in view of the fact that higher air temperatures over the polar region reduce the horizontal temperature gradient and consequently reduce the horizontal heat flux into the polar region. In the case of the ice cloud, it is not certain that the required temperatures are too high. However, a numerical experiment to simulate the the circulation of the Mars atmosphere has recently been carried out, the primitive equations of atmospheric motion

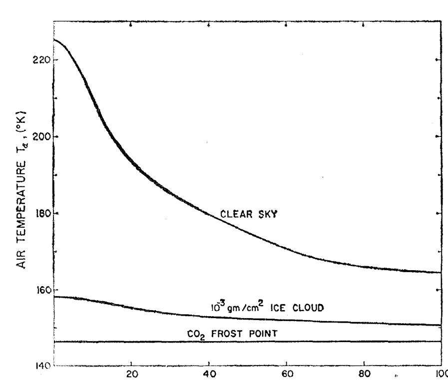

Fig. 1. Minimum temperatures of an isothermal CO_2 atmosphere required to prevent CO_2 frost formation for a 5 mb surface pressure. The figure can be interpreted for values of the drag coefficient other than .001 by identifying the abscissa scale with ($10^3 C_D |\mathbf{v}|$) rather than with $|\mathbf{v}|$.

on a finite difference grid being used (*9*). The results gave atmospheric temperatures over the winter polar cap region averaging near 140°K and surface wind speeds in that region on the order of 10 meters per second or less; in fact, a polar CO_2 ice cap of about the size of the observed cap did form in the experiment.

The cold polar atmospheric temperatures in the experiment can be explained qualitatively. The atmosphere of Mars is a very efficient radiator, so that any perturbations in temperature from local radiative equilibrium are rapidly damped. Hence, for a given intensity of circulation relatively little heat will be transported (compared with Earth, for example). The result is that horizontal heat transfer into the polar cap region is rather inefficient. The numerical model did not incorporate the possibility of ice cloud formation. However, if ice clouds did form over the polar cap region, more energy would be lost due to upward emission by the clouds at a temperature warmer than the ground, so that more horizontal heat transport would be required to maintain a given air temperature than would be required without clouds; at the same time, there is no obvious way in which ice cloud formation could bring about the required increase in circulation intensity.

On this basis I conclude that CO_2 condensation in the Mars polar caps is quite likely. However, the deposition rate may be strongly dependent on the formation of extremely tenuous water ice clouds in the winter polar regions.

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Electrophoretic Variation of Galactose-1-Phosphate Uridyltransferase

Abstract. *A specific method for starch-gel electrophoresis of galactose-1-phosphate uridyltransferase has been developed. Electrophoresis of red-cell hemolyzate from normal subjects and subjects homozygous for the Duarte variant has shown that the Duarte variant has a slightly faster electrophoretic mobility than the normal enzyme under the various conditions used. Molecular-weight estimation on Sephadex G-200 indicates that this observed difference in electrophoretic mobility of the Duarte variant is not due to difference in molecular size. Both enzymes have a molecular weight of approximately 85,000.*

Galactosemia is a recessively inherited error of metabolism characterized by virtual absence of the activity of the enzyme, galactose-1-phosphate uridyltransferase (UDP glucose: α-D-galactose-1-phosphate uridyltransferase, E.C. 2.7.7.12). The red blood cells of heterozygotes for galactosemia have approximately one-half the normal amount of this transferase (*1*). Recently, however, we have presented genetic evidence that some individuals with approximately one-half normal red-cell transferase activity are actually not heterozygous for galactosemia. Instead, such individuals were homozygous for another gene, the Duarte variant. This gene is much more prevalent than the gene for galactosemia, reaching a frequency of approximately 0.055 in the general population (*2*). Identification of individuals homozygous for the Duarte variant was based entirely upon the pattern of transmission of quantitative deficiency of the red-cell transferase activity within a family. Biochemical investigation revealed no abnormality in the active site of the enzyme; the *p*H optimum, thermal stability, and affinity of the enzyme for both of its substrates appeared to be normal (*3*). We have now developed a sensitive technique for the accurate localization of transferase activity on starch gels and show that the transferase of the Duarte variant has a different electrophoretic mobility in appropriate systems than that of transferase from the red cells of normal individuals or individuals heterozygous for galactosemia.

Electrophoresis of hemolyzates prepared from saline-washed red cells that have been frozen and thawed and of partially purified enzyme (*3*) was carried out with the vertical starch-gel method (*4*). Gels containing 13, 16, and 20 percent starch in 0.005 to 0.010*M* potassium phosphate buffer, *p*H 7.0, were used. The gels were chilled for 2 to 3 hours before application of the samples. The buffer compartments contained 0.1 to 0.5*M* potassium phosphate buffer, *p*H 7.0. Electrophoresis was carried out for 16 hours at 4°C at a gradient of 4 volt/cm. The transferase was localized on the gel by the use of a reaction mixture comprised of the following: 1.42 m*M* uridine diphosphoglucose (UDPG); 5.65 m*M* galactose-1-phosphate (Gal-1-P); 12.4 m*M* cysteine; 1.2 m*M* triphosphopyridine nucleotide (TPN); 8 m*M* $MgCl_2$; 91.0 m*M* tris-acetate buffer, *p*H 8.0; 1 unit of glucose-6-phosphate dehydrogenase (G-6-PD) per milliliter; 0.8 unit of phosphoglucomutase (PGM) per milliliter; and 0.005 unit of 6-phosphogluconic dehydrogenase (6-PGD) per milliliter.

The position of transferase was ascertained by examining the gel under long-wave ultraviolet light. In the presence of the transferase, UDPG and Gal-1-P react to form glucose-1-phosphate, which is converted to glucose-6-phosphate by PGM. In the presence of G-6-PD and 6-PGD, glucose-6-phosphate is oxidized and triphosphopyridine nucleotide (TPN) is reduced. The reduced TPN can readily be observed on the gel because of its fluorescence in ultraviolet light. The specificity of the reaction was confirmed as follows: (i) "galactosemic" hemolyzates resulted in the appearance of no fluorescent bands, and (ii) no fluorescence occurred when either UDPG or Gal-1-P was omitted from the reaction mixture.

The enzyme in the red cells of homozygotes for the Duarte variant invariably had more rapid electrophoretic mobility than the transferase from normal erythrocytes (Fig. 1). This was true in all 26 experiments with enzyme from the two available homozygotes. The separation of the two types of enzyme was approximately the same at *p*H values of 8.0, 7.5, 7.0, and 6.5. Incorporation of 1.0*M* urea into the gel did not influence enzyme activity or the relative mobility of the two enzymes. The separation of the two