Re: Dense fogs in Valles Marineris Mars.

Source: http://sci.tech−archive.net/Archive/sci.physics/2005−03/12781.html

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From: Mitchell Jones (*mjones_at_21cenlogic.com*)
Date: 03/25/05

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Date: 25 Mar 2005 02:20:18 EST
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In article <mjones−AD3070.00505617032005@spectator.sj.sys.us.xo.net>,
Mitchell Jones <mjones@21cenlogic.com> wrote:

> In article <1110884206.940776.184270@g14g2000cwa.googlegroups.com>,
> "Robert Clark" <rgregoryclark@yahoo.com> wrote:
>
> > Here's the link to that dense fog over Marineris:
> >
> > http://sciforums.com/attachment.php?attachmentid=3999
>
*> ***{Wow! Has that been retouched? If not, that's one of the most*
> spectacular Mars photos I've ever seen! Of especial interest is what
> appears to be a pool of liquid water showing at the far right of the
> photo. Using the scale shown, the location of the pool is 129 km down
> from the top edge, and 22 km in from the right edge. It looks like a
> nice blue pool of water! And I see other apparent pools elsewhere, all
> of them down in the low areas, some obscured by fog. The NASA folks, of
> course, will explain it all away. "It's just another one of them pesky
> false color photos," they will say. That's their standard comment
*> whenever lots of green or blue jumps out at the "lay" observer. −−MJ}****

***{After a considerable amount of digging and a few e−mails, I have managed to get a definitive answer concerning the bona fides of the photo linked above (i.e., at http://sciforums.com/attachment.php?attachmentid=3999). This comes from a source close to the European Space Agency who for the time being shall remain nameless: "This is a real picture, no specific image processing was used."

Daytime temperatures on Mars are frequently well above freezing, and I have seen reports of daytime summer temperatures upwards of 20 deg. C, though that is apparently unusual and those temperatures would probably not be reached at the bottom of a deep, dark canyon such as Valles Marineris. Under those circumstances, temperatures of 5 or 10 deg C might be attained, but the maxima attained under more favorable conditions would be very unlikely. Looking in an old edition of the *Handbook of Chemistry and Physics*, I see that the vapor pressure of pure distilled water at 5 deg C is 6.543 mmHg, and that the vapor pressure at 10 deg C is 9.209 mmHg. Since water can only exist in liquid form when its vapor pressure is less than atmospheric pressure, it follows that atmospheric pressure in Valles Marineris must lie within or above that range in order for pure, liquid water to exist there..

So, what is the atmospheric pressure at the bottom of Valles Marineris at the point where the photo was taken?

Well, typical "surface" pressures on Mars, according to *The Facts on File Dictionary of Astronomy* (pg. 268), are around 7 mb, which is (7/1013)(760) = 5.25 mmHg, and so on the face of it liquid water should not be able to exist there. However, at the location shown on the photo, the bottom of Valles Marineris is about 5 km beneath the arbitrarily chosen "surface" level. [See pg. 1, Adsorption water−driven processes on Mars, D. Möhlmann, DLR−PF, Berlin, available at the ESA website.] Since pressure increases as altitude decreases, the question is not whether liquid water can exist at the artifically designated "surface" level on Mars, but whether it can exist 5 km further down, under the higher pressures that prevail at the bottom of Valles Marineris.

To try to answer that question, let's use the so called "barometric pressure formula:"

P = P0e^(−Mg0z/RT)

In the above P0 is the pressure at the lower level, P is the pressure at the upper level, e is the base of natural logarithms, M is the mass of 1 mole of atmosphere, g0 is the appropriate gravitational acceleration, z is the vertical distance from the lower level to the upper level, R is the molar gas constant, and T is the average absolute temperature in the vertical column of atmosphere beginning at P0 and ending at the top of the stratosphere (i.e., the bottom of the ionosphere).

Why the top of the stratosphere? Because the barometric formula only calculates the effects of gravity on pressure. It is, in effect, a way of determining the weight of a vertical column of atmosphere of unit cross section at one level, based on knowledge of its weight at another level and its average temperature. Since simple pooling of air molecules under the influence of gravity ceases to be the dominant determinant of pressure at the top of the stratosphere, the column of air to which the barometric formula applies stops when the ionosphere is reached. That is not to say that the air above the stratosphere, beginning with the ionosphere, has no effect on pressures at lower levels. Rather it is to say that the effects in question have very little to do with the *weight* of the material, and a lot to do with such things as the solar wind, solar radiation, magnetic field lines, etc.−−things which the barometric formula does not take into account. During the day, in fact, the presence of upper atmosphere material has the effect of reducing the ground level pressure rather than increasing it, which is the exact opposite of what we would expect based on its weight. Thus to avoid calculating a ground level pressure that is too high, I will ignore the presence of that material.

We want to determine the pressure at the lower level, so we will solve the barometric formula for P0, which gives the following:

P0 = P/e ^(−Mg0z/RT) (1

The various values on the right side are as follows:

(1) P = 7 mb, or 700 Pa.

(2) The value of e is 2.718....

(3) The Martian atmosphere is .95 CO_2, .027 N_2, .016 A, and .0015 O_2, so the mass of a mole of atmosphere is M = [.95(44) + .027(28) + .016(40) + .0015(32)]/1000 = .04324 kg.

(4) Mars "surface" gravity is .37735849056603776 times that of Earth, so g0 = 3.698 m/sec^2.

(5) The altitude difference is z = 5000 meters.

(6) The molar gas constant is R = 8.314 J/kg.

(7) To come up with a value for T, the average absolute temperature below the ionosphere, requires a bit of work.

To begin, note that measurements by NASA's Mars Global Surveyor put the top of the Martian stratosphere at about 93,000 meters. [See http://agena.bu.edu/mars.htm.] That, therefore, will be the altitude of the top of the column of atmosphere with which we are concerned. And the altitude of the bottom of the column, for present purposes, will be 0 meters.

What we want is the average absolute temperature in that column of atmosphere. To get it, we cannot simply take the middle altitude and look up the temperature at that altitude, because the masses within the column are not distributed evenly. The temperature of a mole of gas is T = pv/R, and there are more moles per unit volume at the bottom of a column of atmosphere than at the top, because the atmosphere gets progressively thinner at higher altitudes. The average temperature, in short, comes at the altitude of average density. Thus we will calculate the average density, and then plug that value into the NASA Martian Atmosphere Calculator (see http://www.lerc.nasa.gov/WWW/K−12/airplane/atmosi.html) to determine the temperature at that altitude. That will be the value of T that we seek.

According to the hydrostatic pressure formula, p = hdg. We will re−write it as:

d = p/gh

d is the average density of the atmosphere in a column of unit cross section stretching from the "surface" to the ionosphere.

p is the pressure at the bottom of the column−−i.e., the surface pressure of 700 Pa.

h in this case is the distance from ground level to the ionosphere: 93,000 meters.

g is the gravitational acceleration on Mars, which is 3.698 m/sec^2.

The average density in the Martian atmosphere is therefore

d = p/gh = (700)/(3.698)(93000))

= .00203 kg/m^3, or .002, rounded.

Turning to the NASA calculator mentioned above and selecting "Mars" and "metric units", we find that the density of the Martian atmosphere is 0.002 at an altitude of 20,433 meters, and that the temperature at that altitude is −73 deg C. That, therefore, is the average temperature of the portion of the Martian atmosphere which lies below the ionosphere. The average absolute temperature in that region is therefore 273 − 73 = 200 K.

The estimated pressure at the bottom of Valles Marineris is therefore

P0 = 700/(2.718)^−(.04324)(3.698)(5000)/(8.314)(200), or

P0 = 1132.18 Pa, which is 11.3218 mb or 8.4942 mmHg.

Looking back at my vapor pressure tables for pure water, I find that they are less than 8.4942 mmHg for temperatures up to 8.8 deg C. That means pure water can exist in liquid form up to 8.8 deg C or 47.8 deg F, at the location shown in the photo.

But, of course, any water flowing into the bottom of Valles Marineris will without a doubt be mineral laden water from underground hydrothermal sources. The salinity will be high, and as dissolved minerals accumulate in water, its vapor pressure declines. Moreover, it is a simple, linear relationship known as Raolt's law−−to wit: the vapor pressure of a solvent containing dissolved minerals is directly proportional to the mole fraction of the solute in the solution, where "mole fraction" is simply the number of moles of the substance (water, in this case) divided by the total number of moles in the solution. Thus if V0 is the vapor pressure of pure water at a given temperature, f is the mole fraction of water in the solution, and V is the vapor pressure of the solution, then according to Raolt's law, V = fV0.

Sea water, for example, contains 35 gm of dissolved salts for every kg of water, with the salts being mostly NaCl. Let's simplify slightly and assume the 35 gms are entirely NaCl. In that case, since the molecular weight of NaCl is 58, the solution contains 35/58 = .6 mol, and, since there are 1000 gms of H2O, which is 55.6 moles, it follows that the mole fraction of H2O in sea water is 55.6/(55.6 + .6) = .989, and so for sea water V = (.989)V0 as per the Raolt's law formula.

That, of course, means there is very little reduction in vapor pressure when sea water is substituted for pure water. In fact, that only takes us up to 8.9 deg C, where the vapor pressure drops to V = (.989)(8.551) = 8.457 mmHg, which is just slightly less than the atmospheric pressure of 8.49 mmHg. Thus if the water pouring into Valles Marineris were like sea water on Earth, then it would remain liquid at temperatures up to 8.9 deg C, or 48 deg F.

However, sea water on Earth is not saturated with NaCl. In fact, 358 gms of NaCl can be dissolved in 1 kg of water at 10 deg C (and more at higher temperatures). That would be 358/58 = 6.17 moles. The 1000 gm of H2O is 51 moles. Hence the mole fraction of water would be f = 55.6/(55.6 + 6.17) = .9. Result: V = (.9)V0. And that, based on another look at the vapor pressure tables, is enough to permit liquid water to exist up to 10.2 deg C, or about 50 deg F.

Other solutes, or multiple solutes, can take us even higher. Most effective are salts with a low molecular weight and a high solubility, so that the mole fraction of the solute jumps up, thereby reducing the mole fraction of the solvent (water). Looking in my handbook again, I see that the solubility (by interpolation) of LiCl at 12 deg C is 733 gm in 1000 gm of H2O. Molecular weight of LiCl is 42, so that's 17.45 moles. The 1000 gm of H2O is 55.6 moles. Therefore the mole fraction of water is 55.6/(55.6 + 17.45) = .761. Hence at 12 deg C we find that V = (.761)(10.52) = 8.01 mmHg. And that works: with P = 8.49 mmHg and V = 8.0 mmHg, the water will remain liquid at 12 deg C, or 53.6 deg F.

Getting from 10 to 12 deg C by means of lithium chloride sounds like a stretch, of course, but it could happen. It seems likely that the water flowing into Valles Marineris is icemelt caused by heat emanating from the magma chambers of the nearby Tharsis volcanos, and if the ultimate source of the water is Mars' long since frozen ancient seas, it might very well contain lots of dissolved salts, including LiCl. On Earth, for example, it is estimated that there are 230 billion tons of lithium chloride in sea water, but only 14 million tons on land. [See http://202.221.217.59/print/news/nn04−2004/nn20040418a9.htm.] Moreover, there is a process that would automatically raise all solutes to saturation, given sufficient time. (See explanation further down.)

Anyway, regardless of how far above 10 deg C water can remain liquid in Valles Marineris, it is a sure thing that pools of liquid water are a real possibility there. Given the photo referenced earlier, showing the fog and the apparent pools of blue water, it is my guess that Valles Marineris was carved by underground icemelt flowing into the bottom of the canyon, with the source of heat being the magma chamber under the nearby Tharsis volcanos. I would suggest that geothermal heating from magma near Valles Marineris melts buried ice from an ancient Martian sea, and that liquid water then flows out into the bottom of the canyon. Based on the above calcs, such water could remain liquid at least to 10 deg C and, arguably, to 12 deg C. Since solar heating would seldom push the summer temperature above 10 deg C, and since water flows entering the canyon from vents at the bottom would cool quickly by evaporation to temperatures at which they would remain liquid, it follows that if steady inflows of geothermally heated water are available at the bottom of the canyon, pools of liquid water will exist there.

Interestingly, there is a photo of a portion of Reull Vallis, one of the canyons feeding into Valles Marineris from the north, which appears to show a lake of liquid water more than 100 km in length, and averaging 15 or 20 km in width. See http://www.esa.int/export/SPECIALS/Mars_Express/SEMAZ625WVD_1.html to view this photo.

If you see nothing but bare rocks, then I suggest that you note the following facts:

(1) If there is no wind or other source of disturbance, the surface of water is as flat as a sheet of glass.

(2) If there are no suspended particulates, water is perfectly transparent.

(3) The intrinsic color of water is blue, a fact that is revealed progressively, as the water becomes deeper and deeper. [See http://webexhibits.org/causesofcolor/5B.html.]

(4) The sky is not blue on Mars, so there is no opportunity for reflection to make shallow water appear to be blue, as often happens on Earth. Thus if water on Mars shows blue, it will be deep water only.

With those facts in mind, I suggest that you download the hi−res tiff version of the above referenced photo and study it carefully. If you do, you will note that a distinct water line is visible most of the way around the lake, and that as the water gets deeper and deeper, its blue coloration is progressively revealed.

I say that's a lake−−a huge one, as a matter of fact.

Here is how such a lake would come into being:

(1) An upwelling of hot water from a deep geothermal source would spread out on the bottom of the canyon.

(2) Atmospheric pressure at the bottom of the canyon would be roughly 8.49 mmHg and, if the air temperature were above roughly 10 to 12 deg C, vaporization by boiling would promote rapid cooling of the water and

would increase its salinity.

(3) Over the eons, the salinity of the remaining water would be progressively increased, each time the atmospheric temperature rose high enough to cause a repetition of (2), above.

(4) Eventually, the salinity of the water, due to the buildup of multiple solutes, would be so high that boiling would seldom occur.

Conclusion: the photo of the fog shows an episode where the air temperature rose high enough to promote boiling; and the photo of the lake in Reull Vallis shows the normal case, where the air temperature is *not* high enough to promote boiling.

Interestingly, a continuation of such boiling episodes for millions or billions of years would result in total saturation of the water, and continued "salting out" of minerals onto the bottom. The result would be a buildup of immense mineral deposits in the locations where the repeated boiling episodes were occurring. The area beneath and around the lake at Reull Vallis, for that reason, may very well contain some of the richest surface mineral deposits in the Solar System.

There probably aren't any fish in the lake, however. :−)

−−Mitchell Jones}***

> > *Bob Clark*
> >
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> > *Robert Clark wrote:*
> > > *Presentations from the First Mars Express conference held in February*
> > > *are available here:*
> > >
> > > *First Mars Express Conference Presentations.*
> > > *http://sci.esa.int/science−e/www/object/index.cfm?fobjectid=36537*
> > >
> > > *These reports are longer than the 2−page abstracts seen from the*
> > *Lunar*
> > > *and Planetary Science Conference, some over 30 pages long.*
> > >
> > > *A great image of dense fog in Valles Marineris is shown in this*
> > > *report:*
> > >
> > > *Reflectance of fog in Valles Marineris.*
> > > *A. Inada*
> > > *http://sci.esa.int/science−e/www/object/doc.cfm?fobjectid=36724*
> > >
> > > *And this report has a beautiful full−color image of this very dense*
> > > *fog:*
> > >
> > > *Adsorption water driven processes on Mars.*

> > > *D. Möhlmann*
> > > *http://sci.esa.int/science−e/www/object/doc.cfm?fobjectid=36779*
> > >
> > > *This article speculates on how adsorbed layers of water might be used*
> > > *by microbes on Mars.*
> > >
> > > *Valles Marineris is both low altitude and low latitude so should be*
> > > *within the pressure and temperature range to permit liquid water for*
> > > *this fog close to the surface.*
> > >
> > >
> > > *cf.,*
> > >
> > > *From: Robert Clark (rgregoryclark@yahoo.com)*
> > > *Subject: Supercooled liquid water can occur in clouds below 0 degrees*
> > > *C.*
> > > *Newsgroups: sci.astro, alt.sci.planetary, sci.geo.meteorology,*
> > > *sci.geo.geology, sci.geo.mineralogy*
> > > *Date: 2004−07−30 06:53:02 PST*
> > > *http://groups.google.co.uk/groups?th=5bba314873613fde&*
> > >
> > >
> > > *Bob Clark*