EVOLUTION OF MARS ATMOSPHERE IN POST-NOACHIAN EPOCHS. Héctor Javier Durand-Manterola and Héctor Pérez-de-Tejada. Depto. de Física Espacial, Instituto de Geofísica, UNAM. C.P. 04510, México D.F. México. e-mail: hdurand@fis-esp.igeofcu.unam.mx

We develope a model to examine the evolution of the Mars atmosphere by including processes related to the lost of mass to space, the oxidation of the planetary surface and degassing. In our model we made the following assumptions: a) The amount of mass M in Martian atmosphere at time t is the sum of the degassed mass (M_d) from planetary body and the lost mass (M_l), i.e. all the mass removed from the atmosphere in the same period. b) the degassing rate can be expressed as a descendent exponential. c) The mass lost is the sum of the mass of the ions dragged by the solar wind (M_i), the neutral particles lost by dissociative recombination (M_{dr}), and the mass of oxigen lost in oxidation of the surface rocks (M_o). d) Ionic mass loss rate is proportional to the solar ultraviolet irradiance and to the kinetic energy density of the solar wind. e) The dissociative recombination rate is proportional to the magnitude of the flux of incident solar radiation. f) The oxidation rate is constant in time and equal to 5 kg/s. g) The atmospheric composition was the same in all time. Solving all these coditions we obtained the total mass of atmosphere, the mean troposferic temperature, and the mean superficial presure:

$$M(t) = (A/B)[\exp[B(t - t_0)] - 1] - \left[\frac{\alpha\ \rho\ C\,D^2}{2(m+2r+1)}\left(t^{m+2r+1} - t_0^{m+2r+1}\right)\right] - \frac{\beta\ C}{m+1}\left(t^{m+1} - t_0^{m+1}\right) - 5(t - t_0)$$

$$T(t) = T_{ea}\left(1+\frac{3\tau_a M(t)}{4M_a}\right)^{1/4}\left(1+0.4\left(1-\frac{t}{t_a}\right)\right)^{-1/4}$$

$$P(t) = \frac{M(t)T(t)P_a}{M_a T_a}$$

In which $t_0 = 10^9$ yr $= 3.156\mathrm{x}10^{16}$ s, $\rho = 7.15\mathrm{x}10^{-21}$ kg m^{-3}, C = $1.898\mathrm{x}10^{21}$ s$^{1.24}$, t is time in seconds, m = - 1.24, D = $5.27\mathrm{x}10^{12}$ m s$^{-0.585}$, r = - 0.415, T_{ea} = 217 K, τ_a = 0.1272, M_a = $2.65\mathrm{x}10^{16}$ kg, t_a = 4.6 Gyr = $1.45\mathrm{x}10^{17}$ s, T_a = 222 K, α should be between $-4.37\mathrm{x}10^{8}$ s m and $-1.75\mathrm{x}10^{9}$ s m, and β fluctuate between -0.058 kg/s and -1.153 kg/s. In the first equation we have the parameters A and B that is still necessary to determine, if we take $t = t_a$, in which t_a is current time, we can find A in function of B. But B is a parameter that controls the velocity of degassing of the planet and this is poorly known. Then we used B as free parameter of the model.

Figure shows mass, temperature, and pressure for intermediate values of α and β. The model depicts time variations of the atmospheric mass, pressure, and temperature as a function of a free parameter. The variation of this parameter showed two possible scenarios. In the first, with low values of the parameter, Mars always remained frozen with temperature below the water ice melting point. In the other case, with greater values of the parameter, the planet had three periods, or "eras": one frozen period at the beginning of degassing with temperatures below ice melting point, a second period with temperatures above this melting point and pressures enough to maintain liquid water in planet surface. In the third period planetary temperature return to frozen values, this period continuous at present. While the first scenario is inadequate to life evolution the second one is more clement and is consistent with this evolution. This second case is also consistent with the presence of outflow channels and glaciation in Martian surface. In this case we can explain the formation of outflow channels as follows: In first frozen era water present in volcanic emissions froze immediately and deposit together with ashes or piroclastic material. When the warm era arrive, ice in these rocks liquefied and the rock failed forming the chaotic terrain that many of the Martian channels have in their headwaters. The flowing water from this event could cut the channels. Some authors (Squyres, 1989) proposed that melting of water was produced by intrusions of molten rock under subsurface ice reservoirs. But if this was the case outflow channels will be distributed in all the planet surface but these features are in equatorial and template regions showing that the responsible of its formation was a climatic phenomena.

In the warm era it is also possible that the aqueous sedimentation in the Valles Marineris was formed in lakes without the ice cover proposed by Squyres (1989). In Earth $[H_2O]/[CO_2]$ (ratio of total degassed water to total degassed CO_2) ≈ 10 (Pollack, 1981). Assuming that in Mars this ratio have the same value we obtained an estimation of the amount of water degassed: a global ocean between 50 to 96 m depth.

When arrive the second frozen period the planet still had water in surface then it is possible that Mars had a glaciation as assert Kargel and Strom (1992). Our results agree with the time range given by Kargel and Strom (1992) to glaciation in the planet (0.25 Ga - 2.3 Ga before present).

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