WATER-AMMONIA ICE METEORITES AND/OR AMMONIA(UM)-SILICATES FROM THE EARLY SOLAR SYSTEM: POSSIBLE SOURCES OF AMINO-RADICALS OF LIFE-MOLECULES ON EARTH AND MARS?

***Sz. Bérczi*[1], *B. Lukács*[2]**, [1]Eötvös University, Dept. Petrology and Geochemistry, H-1088 Budapest Múzeum krt 4/a. Hungary, berczisz ani@ludens.elte.hu; [2]Central Research Institute for Physics RMKI, H-1525 Budapest-114. P.O.Box 49. Hungary, lukacs@rmki.kfki.hu.

ABSTRACT

Water and nitrogen on Earth and Mars cannot have been condensed in their present form at the present solar distance, condensation temperatures being very low. They either could have been carried from the outer system by comets or icy planetesimals (which could be parent bodies of icy meteorites), or condensed as constituents of silicates (nitrogen via ammonia in ammonia(um)-silicates: one group with ammonium-ion, the other is crystal-ammonia in the silicate). After overview of these possible sources we calculated the possibility of survival of mainly water-ice meteorite falling to Antarctica and the chance of its identification on the basis of its ammonia content. Then, on the basis of thermodynamic data of ammonia(um)-silicates we placed the probable condensational region of them in the Lewis-Barshay model of the Solar System. Finally we discuss the role of these two kind of ammonia sources in the formation of the essentially water-ammonia symmetric amino acids on ancient Earth and Mars.

PROBLEMS

In the light of newer theories of planet formation there are some problems about the origin of water and nitrogen on inner planets. If one considers condensation from the solar nebula at higher than present temperatures, then water and nitrogen can not have been condensed at the distance of rocky planets. Water condensation may have happened at Jupiter and outwards, and N_2 cca. at Pluto [1]. There are two directions to explain their origin: transport from outside by comet-like icy planetesimals and/or condensations in higher melting point compounds.

WATER

For H_2O the first possibility means that cometary bodies transported outer solar system water ice inward. (Cf. the quite recent reports of lunar polar ice of possible cometary origin.)

The second possibility is the condensation of hydrated silicates. Lewis-Barshay model [1] suggests serpentine and tremolite. Their condensation temperatures are not too high but small amounts of them may have entered proto-Earth and more proto-Mars. If this is true, Mars contains more water than Earth, but mainly in bound state [1].

NITROGEN

Now let us apply these ways, *mutatis mutandis*, to N_2. Comets do not carry molecular N but do carry ammonia, cyanides &c [2].

As for local (at Earth and Mars solar distances) condensation of N compounds, simple ones are ruled out. Condensation temperatures on the Cameron adiabat are hardly calculated; but comparison with water indicates that they are rather low. Oxide boiling points vary but below that of water. C_2N_2 freezes at -34.4 C°, HCN at -15 C° and NH_3 at -33 C°.

As for silicates the case is more hopeful, but now there are two types of possible silicate compounds. One is the ammoni*um* silicates where NH_4-ion substitutes K as a pseudo-alcaline ion. Known members of this group are: *buddingtonite*, an ammonium feldspar [3], *tobelite*, an ammonium muscovite [4], [5], *ammonioleucite*, [6], *ammonium-illite*, [7], and *ammonium-phlogopite*, [8]. Such ammonium-silicates were thought to have been observed in the infrared spectrum of Ceres [9]. (This type - ammonium-ion substitution - does not occur for water because the OH_3^+ ion has no tendency to enter lattices, as lattice point ions.)

The other is the group of ammoniated silicates, where ammonia is analogon of water molecule in hydrated silicates.

AMMONIA IN ICE-METEORITES TO BE DISCOVERED IN ANTARCTICA

To see that the first mechanism worked one should see at least icy *meteorites*. Since one of the main mineral components of the cometary nucleus is water-ice, the existence of icy meteorites is real. But only Antarctic meteorologic conditions are suitable to preserve them for a longer time interval. Pure water ice cannot be identifyed there, but water-ammonia mixtures could; local ammoniogenesis is practically absent there. On the Antarctic interior ice with cca. 10 % ammonia content still can remain unmelted for myriads of years.

Nevertheless, there were observations of anomalous meteorite falls which might refer to ice in the falling meteorite. We know three types of such phenomena. (1) meteorites which were surprisingly cold right after their fall (i.e. the Dhurmsala (India) and Zsadány (Hungary) ones), and (2) impact events when the approaching body had blown up (i.e. Tunguz event). Moreover, (3) odor observations, yet mostly negliged from considerations, may also refer to some volatile components of the sublimating falling meteorite. Stinking odor may refer both to sulphuric compounds and ammonia compounds originally present in the falling body [10].

Survival during fall can be guessed via the fall equations:

$$(4\pi/3)\rho R^3(dv/dt) = 6\pi\Gamma Rv - (4\pi/3)\rho R^3 g$$

$$c\Delta Td(4\pi\rho R^3/3)/dt = 6\pi\Gamma Rv^2$$

$$dz/dt = -v\cos\alpha$$

where R is radius, v is velocity, Γ is the viscosity, ρ is density, g is the surface acceleration, c is specific heat, ΔT is the temperature difference between local and evaporation ones, z is height and α is the impact angle. Now, comparing an icy body to a stone one observe that, although ΔT is smaller by 1 order of magnitude, c is larger by at least a half one. So icy meteorites evaporate faster, but not enormously so, therefore their survival during fall is not impossible, if they were large enough.

AMMONIA(UM) SILICATES INVOLVED IN THE LEWIS-BARSHAY SEQUENCE

The Lewis-Barshay model of Solar system condensation did not involved ammonia(um) containing silicates. Using data of [11], [3] and [12] as decay temperatures for buddingtonite, we could interpolate the approximate position of the condensational line of this mineral in the Lewis-Barshay model. This line falls between FeS and FeO lines, somewhat above to tremolite [13]. The crossing with the Cameron adiabat is cca. 600 K, higher than the condensation temperature of Earth (cca. 550 K) and of Mars (cca. 450 K).

Ammonium silicates could not have been too abundant in the solar nebula, because NH_4- formation is very suppressed at low pressure. Still, what small quantities were present, they could be condensed into Earth and Mars, more into Mars, than into Earth. Later the ammonia gassed out, and then finally, during a longer period, photodissociation could dissolve it, leaving N behind.

CHEMICAL MIRROR SYMMETRY FOR AMINO ACIDS TO WATER AND AMMONIA SOLVENTS: CONSTRAINTS TO THEIR PRESENCE TO LIFE IN PALEOATMOSPHERES OF EARTH AND MARS

Amino acids form modular building blocks for proteins, skeletal molecules to life. Amino acids are characterized by two types of radicals at their two ends: an acidic carboxyl and a basic amino ones. Neutralisation reaction between two such molecules, and between their two different types of end-radicals produces peptide-link and results in water solvent. But because of the strong similarities between the two main solvents: water and ammonia, another role of the dissociated solvent radicals of them (H^+, OH^-, and H^+, NH_2^-) can also be constructed. (In organic chemistry on the molecular chains H^+ is replaced by $COOH^+$ or $CO(NH)H^+$.) [14]. So the presence of ammonia could very much trigger the synthesis of biomolecules.

According to the above points, just after planet formation N may have been present even in the form of ammonia, which then was optimal for the first step of biogenesis. Observe that then the very young Mars was richer both in water and in ammonia than Earth, therefore chances for biogenesis were higher there. The environmental conditions preferred Earth only later, when the smaller Mars lost most of his atmosphere. Meteoritic measurements indeed veryfy that the primordial Martian environment was very different from the present one; e.g. ALH 84001 radically differs from shergottites [15,16].

REFERENCES

[1]Barshay, S.S., Lewis, J.S. (1975) *The Dusty Universe*, NealeWatson Academic, New York [2]Eugster, H.P., Munoz, J.L. (1966) *Science* ***151***, 683, [3]Erd, R.C., White, D.E., Fahey, J.J., Lee, D.E. (1964) *Am. Min.* ***49***, 831, [4]Vedder, W. (1965) *GCA* ***29***, 221, [5]Higashi S. (1982) *Mineral J.* ***11***, 138, [6]Hori H., Nagashima K., Yamada M., Miyawaki R., Marubashi T. (1986) *Am. Min.* ***71***. 1022, [7]Juster,T.C., Brown, P.E., Bailey, S.W. (1987) *Am. Min.* ***72***, 555, [8]Bos, A., Duit, W., Van der Eerden, A.M.J., Jansen, J.B. (1988) *GCA* ***52***, 1275, [9]King, T.V.V., Clark, R.N., Calvin, W.M., Sherman, D.M., Swayze, G.A.,Brown, R.H. (1991) *LPSC* ***XXII,*** 717, [10]Bérczi Sz, Lukács B. (1994) *XIXth Symp. Antarctic Met*. NIPR, Tokyo, 61-1, [11]Barker, D.S. (1964) *Am. Min.* ***49***, 851, [12]Levinson, A.A., Day, J.J. (1968) *EPSL* ***5***, 52, [13]Bérczi Sz., Lukács B. (1995) *XXth Symp. Antarctic Met*. NIPR, Tokyo, 39, [14]Bérczi Sz, Lukács B. (1996) *Acta Climatologica, Szeged*, ***XXX***, 5, [15]Mittlefehldt, D.W. (1994) *Meteoritics 29*, 214, [16]McKay, D.S. et al. (1996) *Science* ***273***, 924