DISCOVERY OF AMINO ACIDS FROM DIDWANA-RAJOD METEORITE AND ITS IMPLICATIONS ON ORIGIN OF LIFE by Vinod C. Tewari et al.

Jour. Geol. Soc. India, v.60, 2002, pp.107-110.

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P.V. Sukumaran, Geological Survey of India, Alandi Road, Pune - 411 006, **Email:** pvs34@yahoo.co.uk, comments:

The greatest mystery in science is the origin of life and the greatest discovery in science will be the discovery of life beyond earth, if at all extraterrestrial life would ever be discovered. It is in this context that I read with interest the research communication by Vinod C. Tewari et al. on the discovery of amino acids in the Didwana-Rajod meteorite. However, there is little description of the meteorite, as to when did it fall, its repository, etc., as these aspects are very important while studying the amino acids in the meteorite.

Interestingly, all the three amino acids reported by the authors fall in the group of protein-building α amino acids present in all terrestrial life. Many amino acids other than those quoted by Oro et al. (1971) are now known from Murchison meteorite (for instance: Engel and Macko, 2001). And there are both protein-forming and non-protein-forming amino acids in Murchison meteorite, although the abundance of the former are very low or sometimes even below detection limits, But then, unless these amino acids are unequivocally shown to be the product of biogenic activity they have no relevance to the origin of life. There are two biosignatures that characterize amino acids in the terrestrial biosphere: one is that they exhibit chirality (asymmetry) and are optically active by virtue of being non-racemic (they contain unequal mixtures of die L- and D-enantiomers) and the second is that all of them are enriched in the light stable isotopes, particularly of C, N_2 and S (the enrichment is to the extent of 20 ‰ to 30 ‰ in the case of C and much more in the case of N_2) as a result of biosynthetic processes.

Recent studies on the stereochemistry and stable isotope geochemistry of amino acids from Murchison meteorite by Engel and Macko (2001) show that both of their enantiomers are enriched in the heavier isotopes of C and N_2 (^{13}C and ^{15}N) unlike terrestrial biogenic amino acids that are enriched in the light isotopes of these elements (^{12}C and ^{14}N). These findings, while confirming the extraterrestrial nature of the Murchison amino acids, rule out their biogenic origin based on isotope signatures, though dataset on stable isotope geochemistry of meteorite amino acids is scanty at present for any meaningful interpretation of isotope data. Therefore, the presence of three α amino acids reported by the authors cannot be taken as conclusive evidence for their biogenicity, more so in the absence of stereochemical and stable isotope data.

Another point that calls for attention is the serious problem of contamination faced while studying meteoritic organic compounds. The authors claim that their samples are free of contamination without giving any details. Many studies published earlier in the literature on meteorite organics have subsequently been rejected based on the fact that they are all terrestrial contaminants.

Attention of the authors is also drawn to two papers that appeared in March 2002 issue of Nature. One is by William. Schopf et al. who provided Laser-Raman spectroscopic evidence to confirm the biogenicity of the oldest fossils reported by Schopf (1993) from Apex Chert and the other by Martin Brasier et al. who contest the conclusion of the former authors on the same fossils using the same methods. These reports remind us how cautious and not precocious we should be while interpreting results related to very ancient fossils or carbon compounds in meteorites. Finally, the author's sweeping statement about the *discovery* of nannobacteria by McKay et al. (1996) needs to be taken with caution as this discovery is very controversial. We are thus yet to find evidence for extraterrestrial life although *absence of evidence is not evidence of absence* to quote the famous astrobiologist late Carl Sagan.

Nevertheless, studies along these lines are most fascinating and the authors deserve congratulation, as this study is perhaps the first of its kind in India.

V.C. Tewari, Wadia Institute of Himalayan Geology, Dehra Dun - 248 001 replies:

We are thankful to P.V. Sukumaran for congratulating us on our discovery of amino acids from Didwana-Rajod (DR) meteorite and taking keen interest in our short paper. The question of origin of life is quite fascinating and in recent years, the search for extraterrestrial life has changed in big way, and a new discipline, *astrobiology*, has emerged. The multidisciplinary field of astrobiology includes life's origin, evolution and distribution in the Universe and is one of the most exciting scientific developments today (Chela Flores and Raulin, 1998; Tewari, 1998, 2001, Tewari et al. 2002).

The Didwana-Rajod meteorite fell on 12 August 1991 at 10.00 p.m. (IST) at a site near Didwana in Nagaur district, Rajasthan, The meteorite was initially studied by Paliwal et al. (1997). It was fully crusted and free of fractures. It contained typical thumb marks of a meteorite. The fusion crust was moderately thick. The polished surface shows poorly developed banded structures, dark brown chondrules and a few white specks. Chemical analysis using ICP AES and AAS gives concentration of Fe (31.77%), Mg (14.08%), Al (1.05%), Ca (1,12%), K (0.086%) and Na (1.05%). The Didwana-Rajod meteorite is classified as H5 chondrite using the Mössbauer spectroscopy and mineralogy (Paliwal et al. 2001). A piece of the same meteorite was studied for the detection of amino acids and possible biogenic signatures. The sample containing amino acids and investigated for petrography, scanning electron microscopy and Laser Raman spectroscopy (Tewari et al. 2001, 2002) has the repository no WIF/DID/2001 and lodged in the Museum of the Wadia Institute of Himalayan Geology, Dehra Dun, Uttaranchal.

Amino acids are the most biologically relevant carbon molecules in meteorites (Oro et al. 1971). We agree with Sukumaran that protein forming and non-protein forming amino acids have been reported from Murchison meteorite (Engel and Macko, 2001). Amino acids exists in mirror image pairs (Chiral compounds) and terrestrial living organisms are left handed. The discovery of left handedness in meteorites of the early solar system provides a strong bases for believing that meteorites and comets were the main source of the origin of life on Earth and probably on Mars.

Proteins are generally enriched in $\delta^{13}C$, however, individual amino acids can exhibit a wide range of isotopic values and thus their relative distributions can influence whole $\delta^{13}C$ values (Hare et al. 1991). However, there is not sufficient isotope data at present from meteorites to generalise the results and compare with Murchison meteorite (Engel and Macko, 2001). Our main aim of the present short communication is to report the presence of amino acids (Phenylalanine, Tyrosine and Tryptophan) in the DR meteorite. The stereochemical and carbon isotopic analysis of the DR meteorite for biogenicity is being carried out and the results will be published in a detailed paper. The preliminary investigations have shown that O isotope values are $\delta^{18}O = +3.8$ ‰ and $\delta^{17}O = +2.5$ ‰ and $^{15}N \approx 3.4$ ‰ (Paliwal et al. 2001). Sulphur is also found in the reduced form in the amino acids cysteine and methionine.

The sulphur isotope data neither support nor refute the biogenic activity in the meteorites.

Regarding the contamination Bada et al. (1998) have demonstrated that the amino acids in meteorites are due to Antarctic ice contamination. The DR meteorite is fresh and not subjected to such contamination after fall and before recovery, limiting the chances for terrestrial contamination. The terrestrial microbial contamination on the fusion crust of DR meteorite like ALH 84001 and Nakhla meteorite is also ruled out. There is no evidence of terrestrial carbon (Carbon-14) in DR meteorite. Therefore, the three reported amino acids are extraterrestrial.

Laser Raman spectroscopic study of the 3500 million years old microbes from Apex Cherts of western Australia confirms the biogenic material present in the microbiota (Schopf et al. 2002; Brasier et al. 2002). The controversy is regarding the bacterial morphology and the rocks in which the microbes were found (Schopf, 1993) come from a hydrothermal vein (Brasier et al. 2002). Schopf has agreed that the source of the biogenic material is hydrothermal.

The Laser Raman spectorscopic study of the Neoproterozoic - early Cambrian microbiota from the Deoban-Gangolihat, Blaini-Krol-Tal, and Buxa (Menga) microbial (stromatolitic) carbonates of the Lesser Himalaya confirm the presence of a variety of amino acids (Tewari et al. 2001; Tewari, 2001b). Amino stratigraphy along with biochemostratigraphy may be established in the Proterozoic sequences to understand the terrestrial evolutionary events of life on Earth. We do not fully agree with Sukumaran that the evidence for extraterrestrial life does not exist. The nanobacteria from the Martian meteorite ALH-84001 (McKay et al. 1996; Gibson et al. 2001 and the references there in) has been extensively studied and the divergent opinion both in support and in opposition about the evidence for possible biogenic activity on Mars exist.

Thomas-Keptra et al. (2001) have reported Martian magneto fossils from the meteorite ALH-84001 and suggested that these truncated hexa-octahedral magnetite crystals were produced by biogenic process. The additional record of possible biogenic features in two Martian meteorites Nakhla (1.3 Ga old) and Shergotty (300 - 165 Ma old) are compelling if not conclusive evidence for biogenic activity on Mars. The Shergotty meteorite was an observed fall in India (named after Shergotty village in Bihar) in 1865. This meteorite was transferred to the British Museum of Natural History, London after its recovery. The conclusive evidence of life on Mars will emerge from the return of Martian rocks in 2008. Till then we have to wait to know whether extraterrestrial life has ever existed on Mars in geological past or it still exists there. The late Carl Sagan phrased it well: *Extraordinary claims require extraordinary evidence.*

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Abhayanand Singh Maurya, Department of Earth and Planetary Sciences, Nehru Scicence Centre, University of Allahabad, Allahabad - 211 002, comments:

I have read the short communication in your recent issue by Tewari et al. I am very happy to know that this kind of studies are also undertaken in India.

Overall, I don't agree with Tewari et al. regarding the transportation of life from outer planets to earth by meteorites for the following reasons:

1. Evolution of life from the transported protolife/ molecules from outer space to earth does not appear to be possible because fall of meteorites is not a regular or even process. The question also arises on their volume and location of the falls in oceans/continents.
2. In my opinion life originated simultaneously on all planets because during 4.6 to 3.6 Ga all the planets passed through similar conditions. According to experiments of Urey and Miller (1953) on the origin of life, almost all amino acids could be obtained in their experiments to conclude that life originated from inorganic substances in very hot and drastic conditions by different chemical reactions.

V.C. Tewari, Wadia Institute of Himalayan Geology, Dehra Dun - 248 001 replies:

We thank Abhayanand Singh Maurya for taking interest in our short note on discovery of amino acids from Didwana-Rajod meteorite. We do not agree with Maurya's comment that life cannot be transported to Earth from outer space. Numerous theories exist for the origin of life presently under serious consideration within the scientific community. Extraterrestrial or panspermia theories suggest that life existed in outer space and was transported by meteorites, asteroids, or comets to Earth. Meteorites are samples of solar debris and of the material ejected from Mars (asteroid belt between Mars and Jupiter). Martian meteorites are being closely studied for evidence of extinct life. Meteorites fall regularly on Earth (continents/Oceans) and most of the observed falls are from the deserts world over where it is easy to collect them. There are reasons to believe that building blocks of life (amino acids or organic compounds) required to start life on Earth may have come from outer space. Meteorites can be particularly useful in this regard especially carbonaceous chondrites which are rich in carbon. Extraterrestrial compounds have been discovered in meteorites like Murchison, Murray and Didwana-Rajod meteorite (Tewari et al. 2002; Cooper et al., 2001). The Murchison meteorite is generally used as the standard reference for organic compounds in extraterrestrial material. Amino acids and other organic compounds are thought to have been delivered to the Earth by asteroids and comets and must have played a significant role in the origin of life on Earth.

The Urey and Miller experiments (Miller, 1953) have demonstrated that organic material may have been produced naturally in the primordial (soup) environment of Earth. However, new evidences have drawn the components of Miller's atmosphere into question. One criticism of Urey-Miller type experiments is that they produce equal numbers of left and right handed amino acids. Regarding Maurya's comment on simultaneous origin of life on other planets, it is likely that the Earth was not suitable for life much before 3.8 Gyr ago. There is direct evidence that microbial life consists of prokaryotes and stromatolites (microbialites) formed by the lithification of laminated microbial mats that existed on Earth 3.5 Gyr ago (Tewari, 1998).

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CORRIGENDUM

In the editorial entitled 'Glimpses of Lost Indian Civilization' published in the October issue of the journal v.60, October 2002, pp.367-369, two mistakes have crept in, which need to be corrected. The place where NIOT scientists worked is Gulf of Cambay and not Dwaraka. The subheading appearing on p.367 should read as 'New Archaeological Site in the Gulf of Cambay'. Again on p.369, the subtitle should read as 'Under Water Structure in Gulf of Cambay' and not Dwaraka.