Amino Acid Degradation after Meteoritic Impact Simulation. M. Bertrand[1], F. Westall[1], S. van der Gaast[2], F. Vilas[3], F. Hörz[4], G. Barnes[4], A. Chabin[1], A. Brack[1]. [1]Centre de Biophysique Moléculaire-CNRS and Université d'Orléans, Rue Charles Sadron, 45071 Orléans cedex 2, France (bertrand@cnrs-orleans.fr). [2]Netherlands Institute of sea research, P.O.Box 59, NL-1790 AB Den Burg (Texel), The Netherlands. . [3] MMT Observatory, P.O. Box 210065, University of Arizona, Tucson, AZ 85721-0065, USA. [4] ARES, NASA Johnson Space Center, 2101 NASA Road 1, Houston TX 77058-3696, USA.

Introduction:
Amino acids are among the most important prebiotic molecules as it is from these precursors that the building blocks of life were formed [1]. Although organic molecules were among the components of the planetesimals making up the terrestrial planets, large amounts of primitive organic precursor molecules are believed to be exogenous in origin and to have been imported to the Earth via micrometeorites, carbonaceous meteorites and comets, especially during the early stages of the formation of the Solar System [1,2].

Our study concerns the hypothesis that prebiotic organic matter, present on Earth, was synthesized in the interstellar environment, and then imported to Earth by meteorites or micrometeorites. We are particularly concerned with the formation and fate of amino acids. We have already shown that amino acid synthesis is possible inside cometary grains under interstellar environment conditions [3]. We are now interested in the effects of space conditions and meteoritic impact on these amino acids [4-6]. Most of the extraterrestrial organic molecules known today have been identified in carbonaceous chondrite meteorites [7]. One of the components of these meteorites is a clay with a composition close to that of saponite, used in our experiments.

Two American teams have studied the effects of impact on various amino acids [8,9]. [8] investigated amino acids in saturated solution in water with pressure ranges between 5.1 and 21 GPa and temperature ranges between 412 and 870 K. [9] studied amino acids in solid form associated with and without minerals (Murchison and Allende meteorite extracts) and pressure ranges between 3 and 30 GPa. In these two experiments, the amino acids survived up to 15 GPa. At higher pressure, the quantity of preserved amino acids decreases quickly. Some secondary products such as dipeptides and diketopiperazins were identified in the [8] experiment.

Material and methods:
In order to study the effects of meteoritic impact on amino acids, samples were prepared by mixing 0.5 µmole of eleven amino acids and one dipeptide with 0,175 mg of saponite clay to simulate carbonaceous chondrite meteorites.

The samples were impacted at different pressures at the NASA Johnson Space Center Experimental Impact Laboratory: 153 Kbar, 210 KBar and 289 Kbar, simulating meteorite impacts with velocities of approximately 3 km/sec, 4.2 km/sec and 5.8 km/sec respectively

The organic compounds were extracted from the saponite clay with a water/organic solvent solution, functionalized to become volatile and analyzed by GC–MS (gas chromatography coupled with mass spectrometry)

Two methods of derivatization were used : the first was described by [10] in order to measure the percentage of remaining amino acids the second was developed in our laboratory [11] in order to determinate if racemization process has been occurred during the impact shock.

Results: Figure 1 shows all the results obtained for the 11 amino acids and the dipeptide.

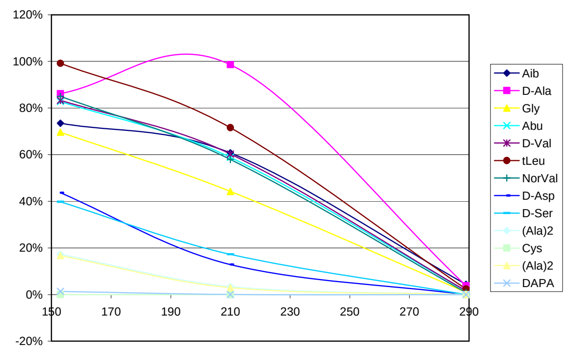

Figure 1. The survival of the amino acids and dipeptide used in the experiment at pressures ranging from 153-289 Kbar.

The results indicate good preservation of the amino acids and demonstrate that most of them were still present even with a 289 Kbar pressure impact. The surviving molecules fall into two groups: the first group consisted of amino acids with an alkyl chain (Aib, D-Ala, Gly, Abu, D-Val, tLeu and NVal), whereas the second group was made up of amino acids with a functional group in the lateral chain and of the dipeptide (Asp, Ser, Cys, DAPA and $(Ala)_2$). These last compounds were less resistant and were not found when the highest pressure was used.

It was noted that there was a enantiomeric-selective destruction of certain amino acids that led to their racemisation.

Discussion and conclusions:

Our experiment used different amino acids to those of the previous studies [8,9], thus expanding the database of the effects of impacts on amino acids. Moreover, the quantities of amino acids used are smaller and more comparable to those found in meteorites.

There was good preservation of the amino acids in our experiment, even up to pressures of 289 Kbar. Our results are in agreement with the amounts of amino acids found in meteorites, indicating that the experiment was a good simulator of meteorite impact conditions.

Our results throw up a possible explanation for the enantiomeric excesses that have been found in carbonaceous meteorites, for example Murchison. These excesses could be provoked by enantiomeric-selective destruction during impact shock.

References:

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