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AMINO ACIDS FROM THE YAMATO-791198 CARBONACEOUS CHONDRITE FROM ANTARCTICA

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The Yamato-791198 carbonaceous chondrite yielded indigenous amino acids. These consitst of various structural and optical isomers, indicating abiotic in origin. The amount of these amino acids is the largest of carbonaceous chondrites studied so far. Terrestrial organic contamination was nil to this chondrite.

Organic compounds of carbonaceous chondrites were formed in the early solar system. The extraterrestrial organic compounds provide usefull information on primordial organic chemistry in the early nebula process. The first unambiguous evidence to show the presence of such compounds was reported by the analysis of amino acids from Murchison carbonaceous chondrite.[1,2] Subsequently, several other carbonaceous chondrites available for analysis were examined for organic compounds. These studies were summarized recently.[3]

Successive discoveries of a large number of meteorites in Antarctica during past 15 years created a new opportunity to study organic compounds of carbonaceous chondrites. Studies of the first two carbonaceous chondrites(C2 type), Yamato-74662[4] and Allan Hills-77306[5,6] revealed meteoritic amino acids in the quantity as expected from previous studies of non-Antarctic chondrites. However, the most recent study of two more Antarctic carbonaceous chondrites(C2 type), Yamato-793321 and Belgica-7904 showed that amino acids were unexpectedly depleted in these carbonaceous chondrites as compared with the C2 chondrites.[7] Accordingly, we examined a new carbonaceous chondrite from Antarctica collected in 1979 by the Japanese Antarctic Research Expedition. The chondrite samples used for analyses were Yamato-791198.22(2.9 g) and -791198.73(1.2 g), both of which were a part of Yamato-791198 weighted 180 g and classified as a C2 type.[8]

These samples were taken out from teflon bags on a clean bench set inside of a clean room and powdered with great care. Portions of these powdered samples were analyzed by a CHN analyzer in the ordinary manner. The results were that Yamato-791198.22 contained 2.33(2.31)% carbon, and 0.12(0.13)% nitrogen, and 791198.73 did 2.26(2.26)% carbon and 0.12(0.13)% nitrogen. The values in parentheses were the results of duplicated analysis. The carbon and nitrogen contents reassured that the chondrite belongs to the C2 type.

For amino acids, one gram each of the powdered samples was extracted with 4 ml water by refluxing for 20 h. The extract was divided into two fractions, one unhydrolyzed, one hydrolyzed with 6 mol dm^{-3} HCl at 108 °C for 20 h. Portions of the two fractions were analyzed quantitatively by an amino acid analyzer by fluorescent detection and ninhydrin detection. Rest of the fractions were treated to yeild N-(trifluoroacetyl)amino acid isopropyl esters in the usual manner and were analyzed by a gas chromatograph equipped with a FTD detector and a Chirasil-Val glass capillary column in order to separate the D,L-enantiomers. A Solid Injector was used to remove a large solvent peak. A procedural blank was carried out in parallel to the sample analysis, using pre-ignited sand powder and 4 ml water. Water used was distilled, deionized and redistilled twice. The last two distilled water was collected in a glass bottle on the clean bench. All glass ware used was pre-heated at 450 °C for at least 4 h prior to use. The acid hydrolyzed fraction of the blank showed 0.2 nmol aspartic acid, 0.4 nmol serine, and 0.3 nmol glycine for 4 ml water used. Other amino acids were not detected at the 0.1 nmol level. These amounts were not significant and ignored on estimating the amounts of amino acids from the samples.

On the amino acid chromatogram by fluorescent detection, 17 peaks were identified as amino acids as shown in Fig. 1. Further, two more amino acids, sarcosine and proline, were determined by ninhydrin detection. Amounts of these 19 amino acids were listed in Table 1. The amounts were about 10 to 15% different between the two samples, Yamato-791198.22 and .73. This difference is rather minor, indicating homogeneous distribution of amino acids in the chondrite.

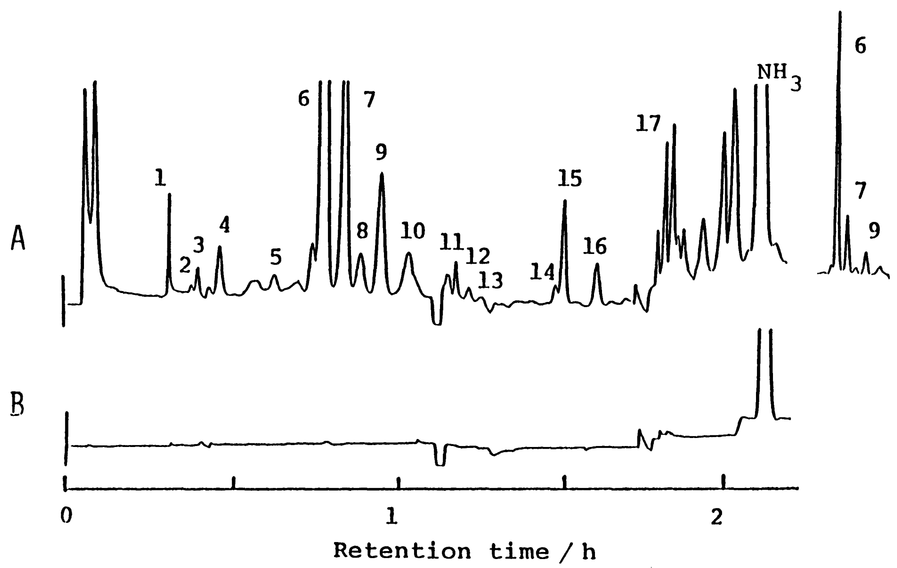

Fig. 1. Amino acid chromatograms of A) Yamato-791198.22(acid hydrolyzed fraction), and B) procedural blank. Peak No. 1. aspartic acid, 2. threonine, 3. serine, 4. glutamic acid, 5. α-aminoadipic acid, 6. glycine, 7. alanine, 8. α-amino-i-butyric acid, 9. α-amino-n-butyric acid, 10. valine, 11 norvaline, 12. isoleucine, 13. leucine, 14. β-amino-n-butyric acid, 15. β-alanine, 16. β-amino-i-butyric acid, 17. γ-aminobutyric acid.

Table 1. Amino acids from Yamato-791198(nmol/g)

Amino acids	Y-791198.22 Unhydrolyzed	Y-791198.22 Hydrolyzed	Y-791198.73 Unhydrolyzed	Y-791198.73 Hydrolyzed
Aspartic acid	0.05	4.9	0.05	4.8
Threonine	0.7	1.5	1.0	1.6
Serine	1.3	2.7	2.0	3.5
Glutamic acid	0.9	7.0	1.2	8.6
Sarcosine	5.3	8.0	5.3	7.9
α-Aminoadipic acid	2.3	12	2.9	12
Proline	4.6	13	3.8	11
Glycine	79	98	75	93
Alanine	39	50	35	46
α-Amino-i-butyric acid	340	360	280	310
α-Amino-n-butyric acid	36	47	31	42
Valine	11	14	9	13
Norvaline	10	14	10	14
Isoleucine	2.0	5.0	2.0	4.9
Leucine	1.5	2.3	1.5	2.3
β-Amino-n-butyric acid	n.d.[a]	n.d.[a]	n.d.[a]	n.d.[a]
β-Alanine	9.0	15	9.7	16
β-Amino-i-butyric acid	5.2	8.8	4.9	8.5
γ-Aminobutyric acid	2.4	8.6	2.6	8.0

a) n.d.; Quantity was not determined.

Upon HCl hydrolysis of the water extracts, the amounts of most amino acids increased only slightly. This suggests that a large portion of amino acids found were present in free form in the chondrite, or in some precursors that were easily hydrolyzed to amino acids during the water extraction. The most abundant amino acid was α-amino-i-butyric acid. A similar finding was reported with Murray, a non-Antarctic C2 chondrite.[9] Since α-carbon of α-amino-i-butyric acid has no C-H bond, this amino acid is relatively stable once formed and could be most abundant. On the other hand, dicarboxylic amino acids, such as aspartic acid, glutamic acid, and α-aminoadipic acid increased their amounts drastically by the HCl hydrolysis as reported for Yamato-74662.[4] Another notable observation for the amino acid found is the presence of various structural isomers, e.g. α- and β-alanine, and sarcosine(N-methylglycine) for C_3 amino acids, and α-, β-, and γ-aminobutyric acids in addition to normal- and iso-structures for C_4 amino acids. The presence of these various structural isomers clearly indicates that amino acids found from this chondrite were abiotic in origin.

On the gas chromatogram(Fig. 2), 15 amino acids were determined of which 14 were also detected by the amino acid analyzer. The rest is δ-aminovaleric acid. As seen in Fig. 2, D-enantiomers of seven amino acids were detected as well as their L-enantiomers. The presence of these D,L-enantiomers is another good evidence for abiotic origin of the amino acids found from the chondrite. The enantiomeric abundance of most amino acids were not clear because of the presence of many small unresolved peaks around the baseline. However, alanine and, to a certain extent, α-amino-n-butyric acid showed the abundance approximately equal. This nearly equal abundance for alanine is a good indication that the chondrite samples were not contaminated by terrestrial organic matter, especially proteinous matter.

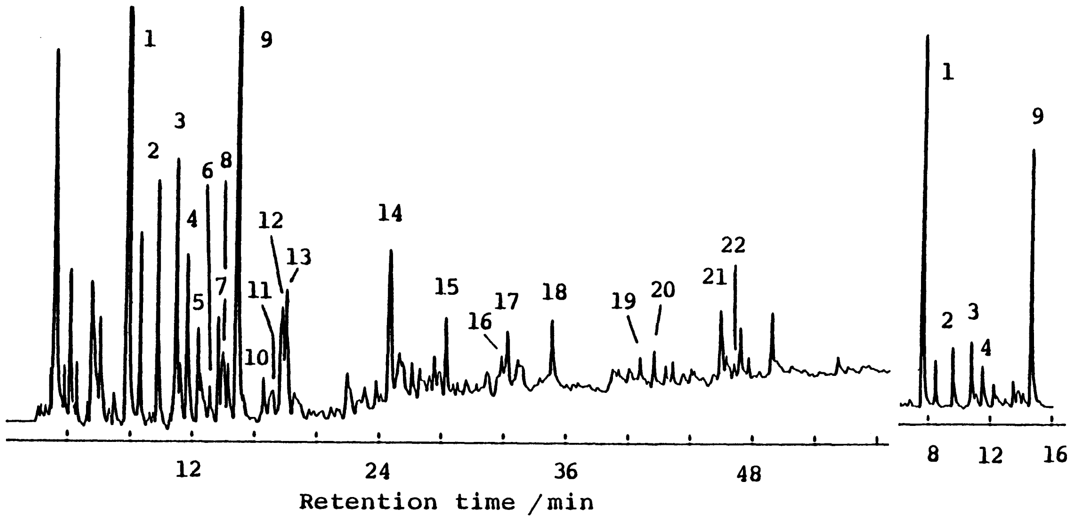

Fig. 2. Gas chromatogram of the hydrolyzed fraction of Yamato-791198.22. Peak No. 1. α-amino-i-butyric acid, 2. D-alanine, 3. L-alanine, 4. sarcosine, 5. D-α-amino-n-butyric acid, 6. D-valine, 7. L-α-amino-n-butyric acid, 8. L-valine, 9. glycine, 10. D-norvaline, 11. D,L-β-amino-i-butyric acid, 12. β-alanine, 13. L-norvaline, 14. D,L-proline, 15. γ-aminobutyric acid, 16. D-aspartic acid, 17. L-aspartic acid, 18. δ-aminovaleric acid, 19. D-glutamic acid, 20. L-glutamic acid, 21. D-α-aminoadipic acid, 22. L-α-aminoadipic acid.

Yamato-791198 yielded about 670 nmol amino acids per gram sample, Murchison did about 400 nmol/g,[5] and Yamato-74662 did about 110 nmol/g.[4] Therefore, Yamato-791198 is likely the most amino acid-rich carbonaceous chondrite ever estimated of both Antarctic and non-Antarctic chondrites. The specially clean environment of Antarctica preserved this amino acid-rich carbonaceous chondrite. It guarantees the possible existence of other pristine organic compounds in this chondrite. Therefore, Yamato-791198 is likely one of the most valuable carbonaceous chondrites ever found for the study of extraterrestrial organic compounds.

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