



2023 5 2 20

2023 5
2 20
10 30

Science

JAXA 6
2 Phase-2

Science 2023 2 24

(162173)

Soluble organic molecules in samples of the carbonaceous asteroid (162173)

Ryugu

Science

D O I 10.1126/science.abn9033

2023 2 24 4

2020 12 6

JAXA

Phase-1

6

2 Phase-2

Phase-2

本件内容の問い合わせ先

研究内容、論文に関すること
奈良岡 浩（九州大学）

naraoka@geo.kyushu-u.ac.jp
tachi@eps.s.u-tokyo.ac.jp

JAXA

isas-kouho@ml.jaxa.jp

JAMSTEC

koho@jimu.kyushu-u.ac.jp

press@jamstec.go.jp

nu_research@adm.nagoya-u.ac.jp

comms@mail2.adm.kyoto-u.ac.jp

koho@office.hiroshima-u.ac.jp

sci-pr@mail.sci.tohoku.ac.jp

jp-press@general.hokudai.ac.jp

media.s@gs.mail.u-tokyo.ac.jp

(162173)

Soluble organic molecules in samples of the carbonaceous asteroid (162173) Ryugu

1.

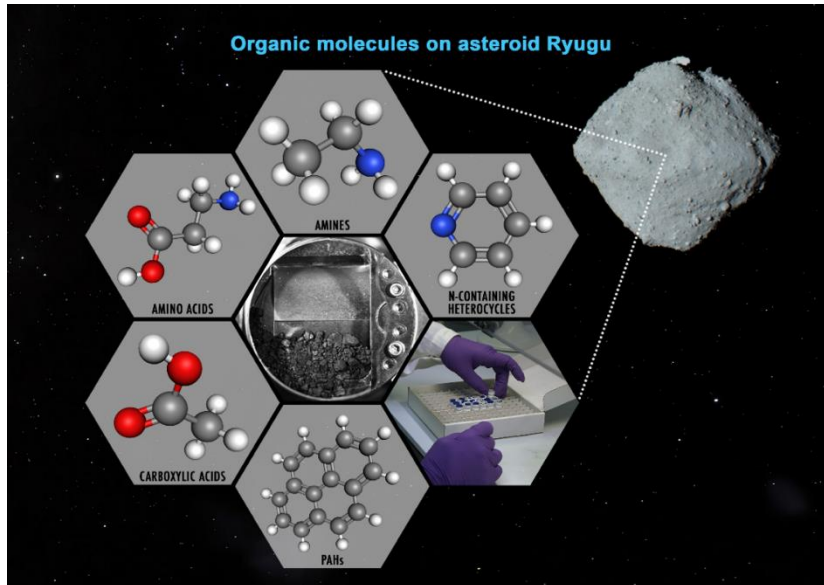
炭化水素としてはアルキルベンゼンや多環芳香族炭化水素であるナフタレン、フェナントレン、ピレン、フルオランテンなどが主に存在した。これらの存在パターンは地球上の熱水原油のパターンと似ており、リュウグウ母天体上で水の影響を受けていたことが示唆される。試料表面をメタノールでスプレーしてその場分析すると、異なる有機分子が異なる空間分布で存在しており、リュウグウ母天体上で、流体と鉱物との相互作用の中で、有機化合物が移動・分離した可能性が示唆された。

2.

C

1

1



©JAXA, University of Tokyo, Kochi University, Rikkyo University, Nagoya University, Chiba Institute of Technology, Meiji University, University of Aizu, AIST, NASA, Dan Gallagher.

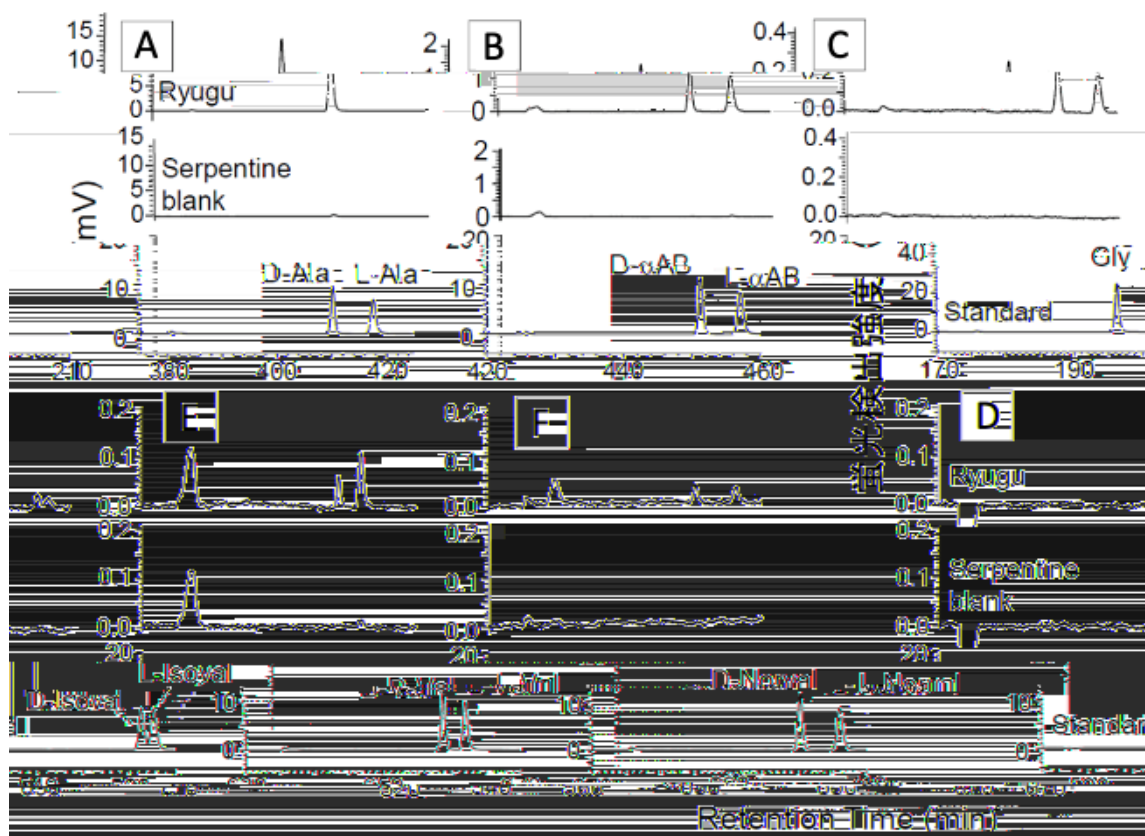
1

3.

C	N	H	S	O	
	3.8%	C 1.1%	H 0.16%	N 3.3%	S 12.9%
	CHNOS		21.3%		O

		2		1	¹³ C/ ¹² C	δ ¹³ C
-0.6	¹⁵ N/ ¹⁴ N	δ ¹⁵ N	+43	D/H	δD	+250
³⁴ S/ ³² S	δ ³⁴ S	-3		Cl (lvuna)	

/ LC-FD/HRMS D L- 3
 3D-HPLC/FD D L- 5
 15 4
 (β-, γ- α-
 2 1 /g
 ppb
 CI



©H. Naraoka et al. Science 379, eabn9033 (2023)

4

1013 hPa

-6.3

20 hPa

230

中には存在しているブチルアミンが検出されなかった。これらのアミン塩はリュウグウ表面で観測されている吸収帯 $\sim 3.1\mu\text{m}$ (NH)

2
Polycyclic Aromatic Hydrocarbon

4
PAH

PAH

$\text{C}_{16}\text{H}_{10}$

1 1
PAH Cl Ivuna

-CH₂-

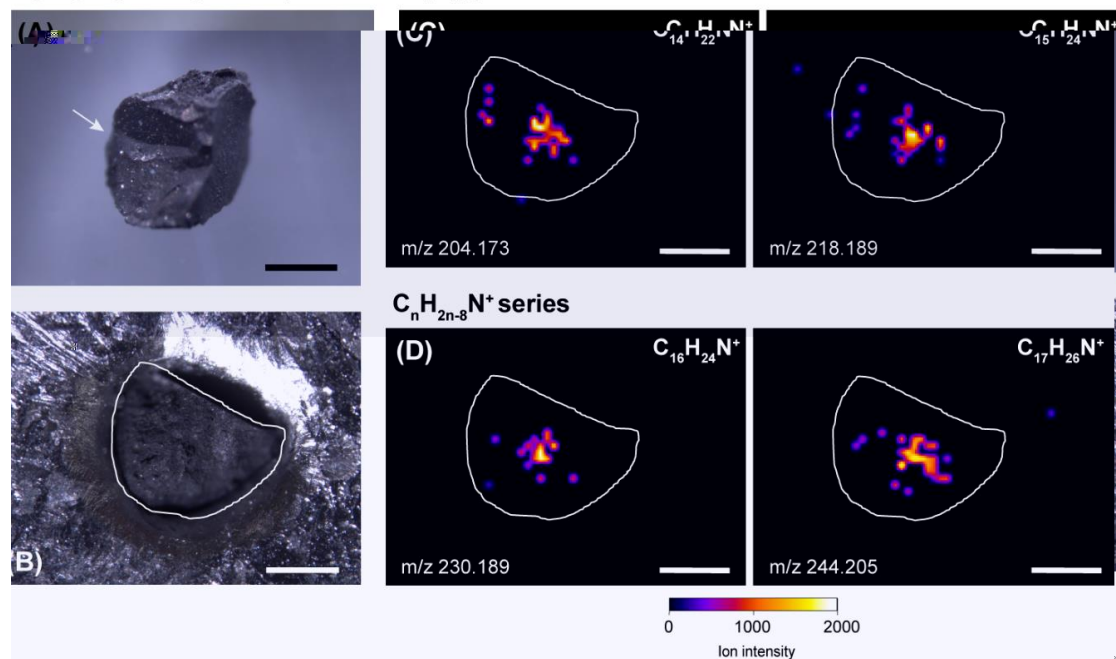
$\text{C}_n\text{H}_{2n-4}\text{N}^+$

8 16 11 11 22
17

1mm

5

Ryugu grain (A0080)



500

©H. Naraoka et al. Science 379, eabn9033 (2023)

4.

Science

Soluble organic molecules in samples of the carbonaceous asteroid (162173) Ryugu

Naraoka, H.¹, Takano, Y.², Dworkin, J.P.³, Oba, Y.⁴, Hamase, K.⁵, Furusho, A., Ogawa, N.O.², Hashiguchi, M.⁶, Fukushima, K.⁷, Aoki, D.⁷, Schmitt-Kopplin, P.^{8,9,10}, Aponte, J.C.³, Parker, E.T.³, Glavin, D.P.³, McLain, H.L.^{3,11,12}, Elsila, J.E.³, Graham, H.V.³, Eiler, J.M.¹³, Orthous-Daunay, F.-R.¹⁴, Wolters, C.¹⁴, Isa, J.^{15,16}, Vuitton, V.¹⁴, Thissen, R.¹⁷, Sakai, S.², Yoshimura, T.², Koga, T.², Ohkouchi, N.², Chikaraishi, Y.⁴, Sugahara, H.¹⁸, Mita, H.¹⁹, Furukawa, Y.²⁰, Hertkorn, N.⁸, Ruf, A.^{21,22,23}, Yurimoto, H.²⁴, Nakamura, T.²⁰, Noguchi, T.²⁵, Okazaki, R.¹, Yabuta, H.²⁶, Sakamoto, K., Tachibana, S.^{18,27}, Connolly, Jr., H.C.²⁸, Lauretta, D.S.²⁹, Abe, M.^{18,30}, Yada, T.¹⁸, Nishimura, M.¹⁸, Yogata, K.¹⁸, Nakato, A.¹⁸, Yoshitake, M.¹⁸, Suzuki, A.³¹, Miyazaki, A.¹⁸, Furuya, S.²⁷, in, Sc.98 662.14 Tm0 g0 G -0.0298tak0008e0000

¹⁶Planetary Exploration Research Center, Chiba Institute of Technology, Narashino 275-0016, Japan.

¹⁷Université Paris-Saclay, CNRS, Institut de Chimie Physique, Orsay 91405, France.

¹⁸Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (JAXA), Sagamihara 252-5210, Japan.

¹⁹Department of Life, Environment and Material Science, Fukuoka Institute of Technology, Fukuoka 811-0295, Japan.

²⁰Department of Earth Science, Tohoku University, Sendai 980-8578, Japan.

²¹Université Aix-Marseille, CNRS, Laboratoire de Physique des Interactions Ioniques et Moléculaires, Marseille 13397, France.

²²Department of Chemistry and Pharmacy, Ludwig-Maximilians-University, Munich 81377, Germany.

²³Excellence Cluster ORIGINS, Garching 85748, Germany.

²⁴Department of Earth and Planetary Sciences, Hokkaido University, Sapporo 060-0810, Japan.

²⁵Division of Earth and Planetary Sciences, Kyoto University, Kyoto 606-8502, Japan.

²⁶Department of Earth and Planetary Systems Science, Hiroshima University, Higashi-Hiroshima 739-8526, Japan.

²⁷Department of Earth and Planetary Science, University of Tokyo, Tokyo 113-0033, Japan.

²⁸Department of Geology, School of Earth and Environment, Rowan University, Glassboro, NJ 08028, USA.

²⁹Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA.

³⁰School of Physical Sciences, The Graduate University for Advanced Studies, Hayama 240-0193, Japan.

³¹Marine Works Japan Ltd., Yokosuka 237-0063, Japan.

³²Aizu Research Cluster for Space Science, University of Aizu, Aizu-Wakamatsu 965-8580, Japan.

³³Research of Interior Structure and Evolution of Solar System Bodies, National Astronomical Observatory of Japan, Mitaka 181-8588, Japan.

³⁴Department of Planetology, Kobe University, Kobe 657-8501, Japan.

³⁵Department of Physics and Astronomy, Seoul National University, Seoul 08826, Republic of Korea.

³⁶Research and Development Directorate, JAXA, Sagamihara 252-5210, Japan.

³⁷Faculty of Science, Niigata University, Niigata 950-2181, Japan.

³⁸Department of Physics, Rikkyo University, Tokyo 171-8501, Japan.

³⁹Center of Data Science, Ehime University, Matsuyama 790-8577, Japan.

⁴⁰Instituto de Astrofísica de Canarias, University of La Laguna, Tenerife E-38205, Spain.

⁴¹Faculty of Engineering, Kindai University, Higashi-Hiroshima 739-2116, Japan.

⁴²JAXA Space Exploration Center, JAXA, Sagamihara 252-5210, Japan.

⁴³Department of Chemistry, University of Tokyo, Tokyo 113-0033, Japan.

⁴⁴Department of Mechanical Engineering, Kanagawa Institute of Technology, Atsugi 243-0292, Japan.

*Deceased.

DOI 10.1126/science.abn9033

2023 2 24 4

5

1

C (N) H O S

2

ESI

3

APPI

ESI

ESI

4

FT-ICR/MS

5-6

5