Aerogel

Least Dense Solid
The solid substance with the lowest density is aerogel, in which tiny spheres of bonded silicon and oxygen atoms are joined into long strands separated by pockets of air. The latest and lightest versions of this substance weigh just 3mg/cm³, and are produced by the Jet Propulsion Laboratory in Pasadena, California, USA.

Guiness Book of World Records 2003
STARDUST’S ORBITS

Delta II Launch

6.12 km/s
COLLECTING COMET DUST
Comet Wild 2 dust capture at 6.1 km/s

The biggest particles travel the furthest

< coarse grained fraction >  < fine-grained fraction >
Comet 81P/Wild 2 Under a Microscope

Don Brownlee, 1 Peter Tsou, 27* and 81 M. O’D. Alexander, 1 Tohra Araki, 81
Sana Bajt, 9 Giuseppe A. Baratta, 10 Ron Blanton, 11 Pierre Blenez, 12 Janet Borg, 13
John P. Bradley, 14 Adrian Brearley, 15 F. Brenker, 16 Sean Brennan, 17 John C. Bridges, 18
Nigel D. Brown, 19 John R. Brucato, 20 E. Bullock, 21 Mark J. Burchell, 22 Henner Busemann, 23
Anna Butterworth, 24 Marc Chauvière, 25 Alan Chevrot, 26 Xiao-fang Chi, 27 Mark J. Cintala, 28
B. C. Clark, 29 Simon J. Clement, 30 George Cody, 31 Luigi Colangeli, 32 George Cooper, 33
Patrick C. Cordier, 34 C. Daghi, 35 Zurong Dai, 36 Louis D'Hendecourt, 37 Zahia Djioudi, 38
Gerardo Dominguez, 39 Tom Duxbury, 40 Jason P. Dworkin, 41 Denton S. Ebel, 42
Thanasis E. Economou, 43 Shinya Fakra, 44 Sam A. J. Fairey, 45 Stewart Fallon, 46
Gianluca Ferrini, 47 T. Ferro, 48 Helger Fleckenstein, 49 Christine Floss, 50 George Flynn, 51
Ian A. Franch, 52 Marc Fries, 53 Z. Gainforth, 54 J.-P. Gallien, 55 Mathieu Goullée, 56 Nica M. Grady, 57
Giles A. Graham, 58 P. G. Grant, 59 Simon F. Green, 60 Faustine Grossemann, 61
Lawrence Grossman, 62 Jeffrey N. Grossman, 63 Yasubin Guan, 64 Kenji Hagiyama, 65
Ralph Harvey, 66 Philipp Heck, 67 Gregory F. Herzog, 68 Peter Hoppe, 69 Friedrich H. I, 70
Joachim Huth, 71 Ian D. Hutcheon, 72 Konstantin Ignatyev, 73 Hope Ishii, 74 Motoko Ito, 75
Damien Jacob, 76 Chris Jacobsen, 77 Stein Jacobsen, 78 George Colangeli, 79 John C. Bridges, 80
Amy Jurewicz, 81 Anton T. Kearsley, 82 Lindsay S. Keller, 83 H. Khodja, 84 A.L. D. Kilcoyne, 85
Jochen Kiselev, 86 Alexander Krot, 87 Falko Langenhorst, 88 Antonio Lanzilotti, 89 Ivan Leshin, 90
Laurie A. Leshin, 91 J. Leitner, 92 L. Lemelle, 93 Hugues Leroo, 94 Ming-Chang Liu, 95
Ian Lydon, 96 Glen MacPherson, 97 Matthew A. Marcus, 98 Kuljeet Mathas, 99 Bernard Marty, 100
Graciela Marratj, 101 Kevin Meekegan, 102 Anders Melhorn, 103 Vito Mennella, 104 Keiko Messenger, 105
Scott Messinger, 106 Takashi Miki, 107 Smail Mostefou, 108 Tomoki Nakamura, 109 T. Nakano, 110
M. Newville, 111 Larry R. Nittler, 112 Ichiyo Ohnishi, 113 Kazumasa Ohsumi, 114 Kyoko Okada, 115
Dimitri A. Papamastorou, 116 Russ Palma, 117 Maria E. Palumbo, 118 Robert O. Pepin, 119
David Perkins, 120 Murielle Perronnet, 121 P. Pianetta, 122 William Rao, 123 Frank J. M. Rietmeijer, 124
Francois Robert, 125 D. Rost, 126 Alessandra Rotunno, 127 Robert Ryan, 128 Scott A. Sandford, 129
Craig S. Schwab, 130 Thomas H. See, 131 Dennis Schlutter, 132 J. Sheffield-Parker, 133
Alexandre Simonović, 134 Steven Simon, 135 I. Smitsky, 136 Christopher J. Stence, 137
Maegan K. Spencer, 138 Frank J. Staudermann, 139 Andrew Steele, 140 Thomas Stephani, 141
Ronda Stroud, 142 Jean Sturhahn, 143 S. R. Sutton, 144 Yasuaki Suzuki, 145 Mitra Taherzadeh, 146
Suan Taylor, 147 Nick Teschke, 148 Kazu Tomeoka, 149 Neatoka Tomioka, 150 Alice Toppani, 151
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Jack Warren, 161 Iris Weber, 162 Mike Weisberg, 163 Andrew J. Westphal, 164 Sue Wrixon, 165
Diane Woodhead, 166 Britte Wurpel, 167 Penelope Wozniakiewicz, 168 Ian Wright, 169
Hikaru Yabuta, 170 Hajime Yano, 171 Edward D. Young, 172 Richard N. Zaré, 173 Thomas Zega, 174
Karen Ziegler, 175 Laurent Zimmermann, 176 Emst Zinner, 177 Michael Zoelensky, 178

The Stardust spacecraft collected thousands of particles from comet 81P/Wild 2 and returned them to Earth for laboratory study. The preliminary examination of these samples shows that the non-volatile portion of the comet is an unequilibrated assemblage of materials that have both presolar and solar system origin. The comet contains an abundance of silicate grains that are much larger than predictions of interstellar grain models, and many of these are high-temperature minerals that appear to have formed in the inner region of the solar nebula. Their presence in a comet proves that the formation of the solar system include mixing on the grandest scales.

Stardust was the first mission to return solid samples from a specific astronomical body other than the Moon. The mission, part of the NASA Discovery program, retrieved samples from a comet that is believed to have formed at the outer fringe of the solar nebula, just beyond the most distant planet. The samples, isolated from the planetary region of the solar system for billions of years, provide new insight into the formation of the solar system. The samples provide unprecedented opportunities both to corroborate astronomical
Figure 1. Bright field TEM image showing an olivine and pyroxene sample. Individual olivine and pyroxene grains crystallites are surrounded by amorphous matrix (which may or may have been produced during capture).
A Cometary Refractory Inclusion

- **Spinel**
- **Fassaite**
- **Diopside**
- **Melilitite**
- **Anorthite**
Pyroxene in Inti has the Same Composition as in Refractory Inclusions
SUMMARY

The mineralogical, mineral-chemical and isotopic compositions of the samples from Comet Wild 2 are very similar to those of the anhydrous fraction of carbonaceous chondrites.

Hydrated phyllosilicates are notably absent from the comet samples.

Comet Wild 2 contains refractory inclusions and ice, thus juxtaposing both the highest- and lowest-temperature solar nebular condensates.