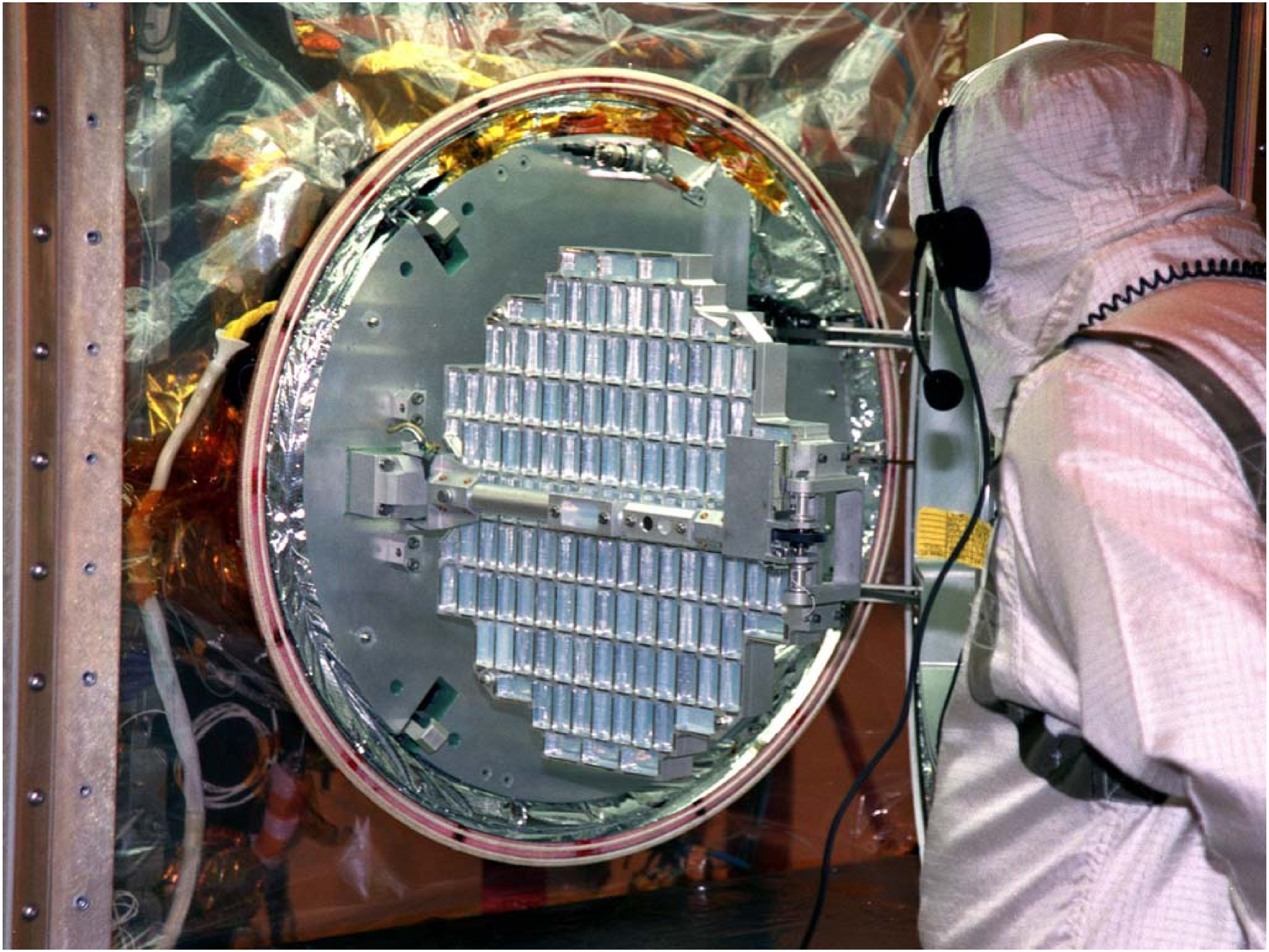
Aerogel

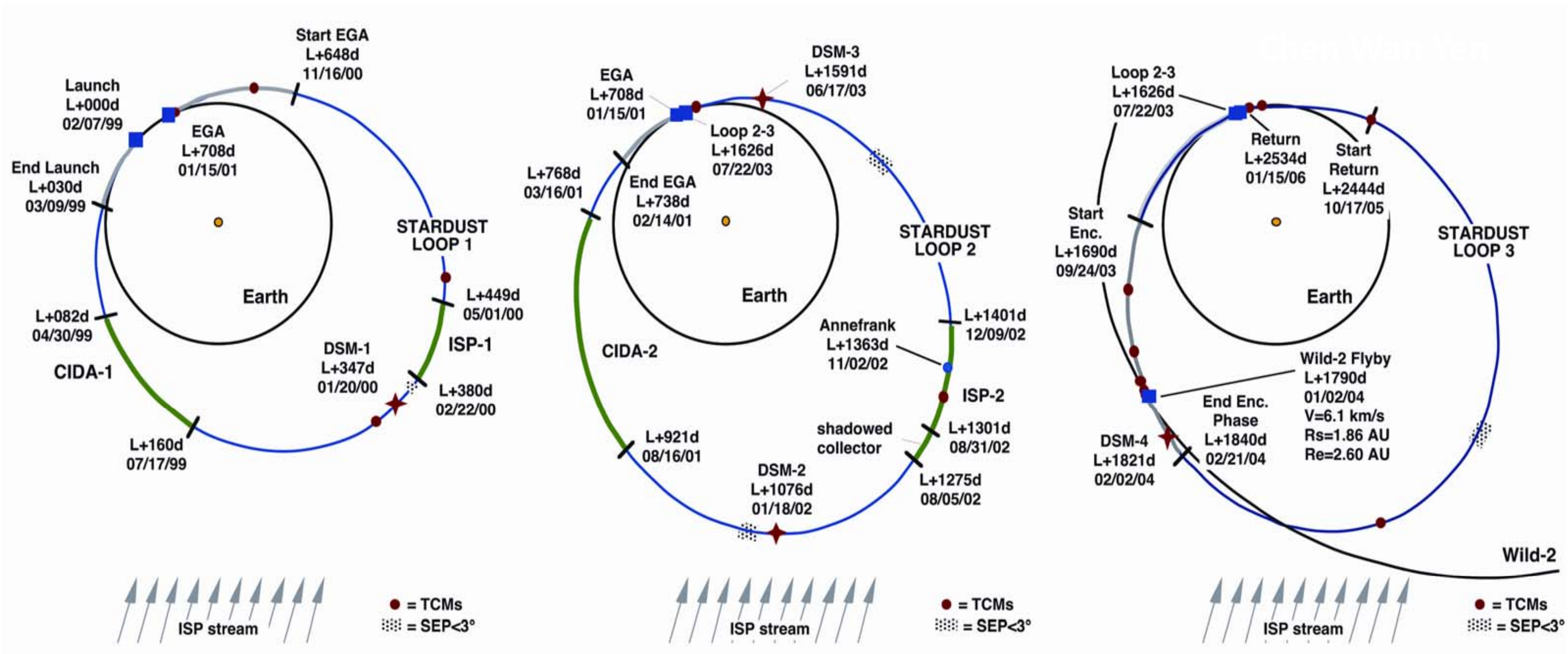
Least Dense Solid

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/cm^3, and are produced by the Jet Propulsion Laboratory in Pasadena, California, USA.

Guiness Book of World Records 2003

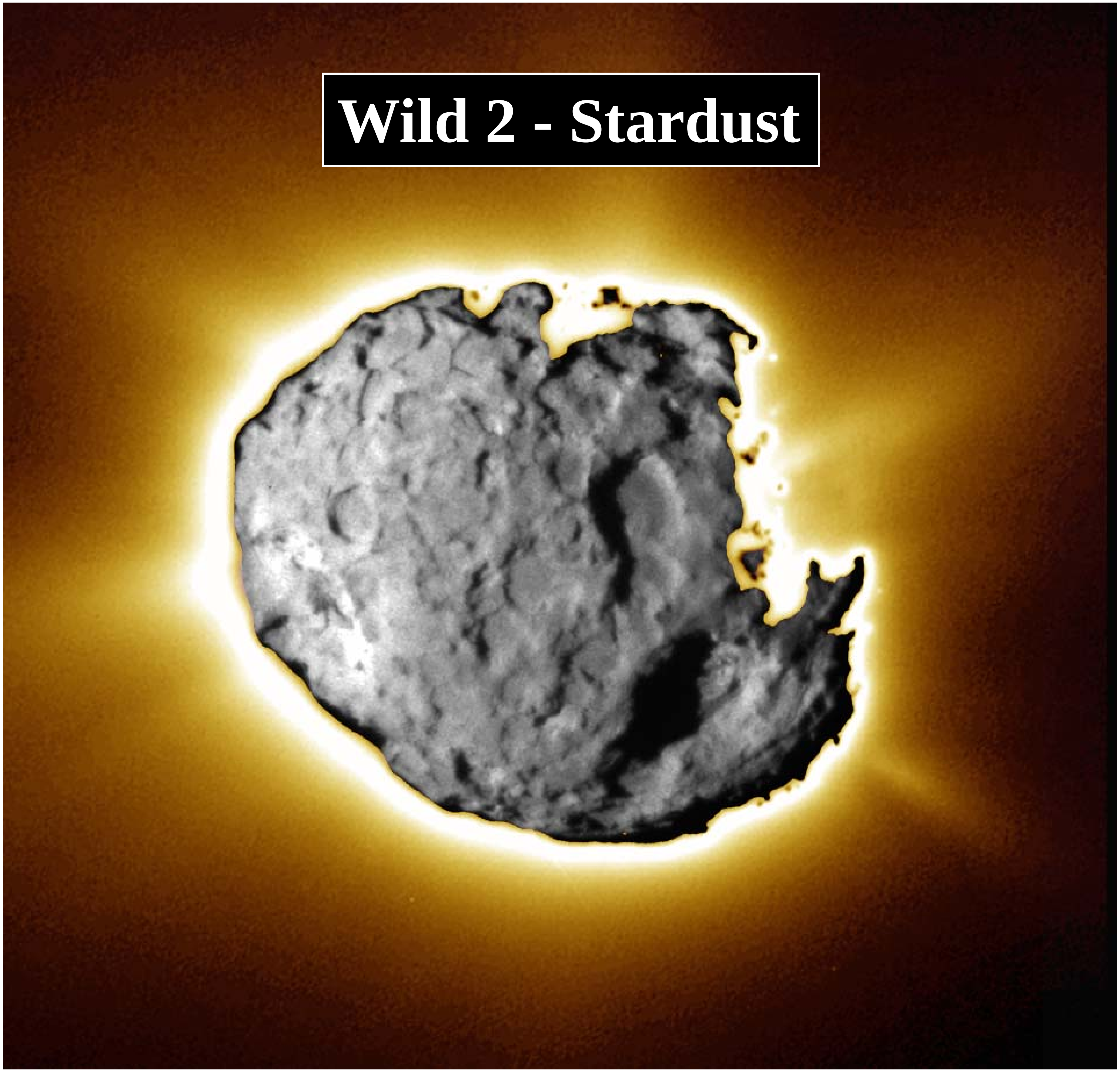


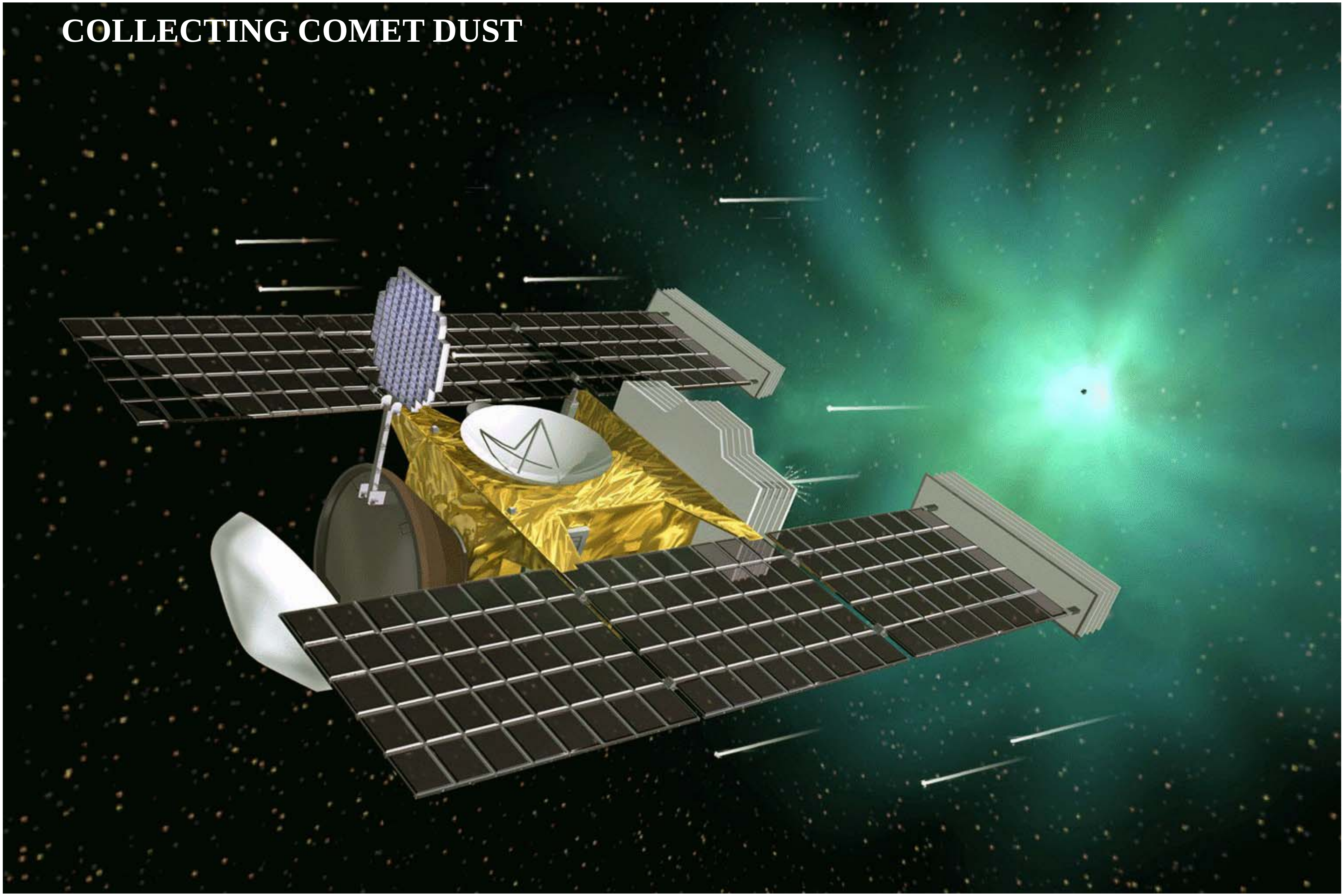
STARDUST'S ORBITS

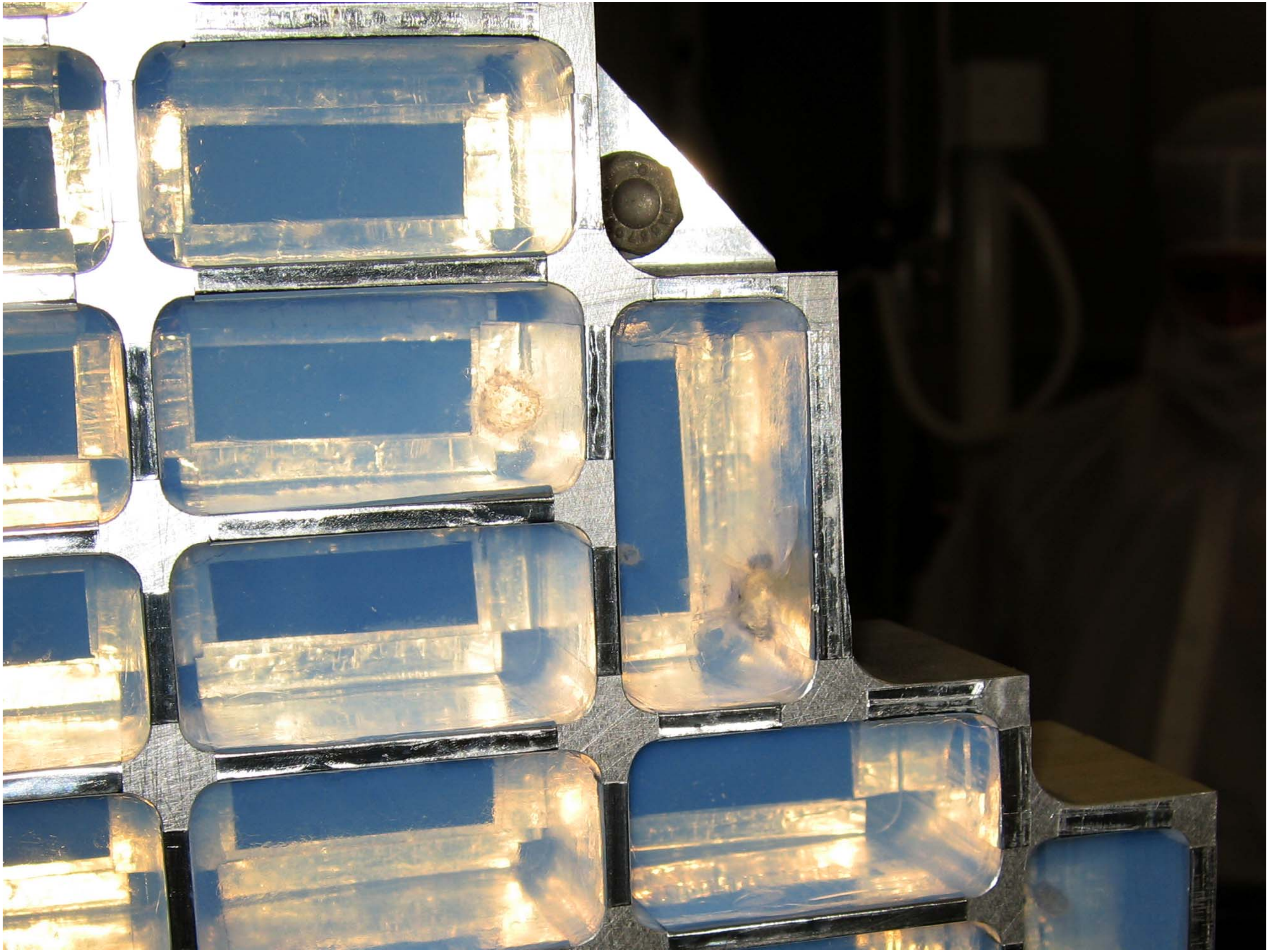


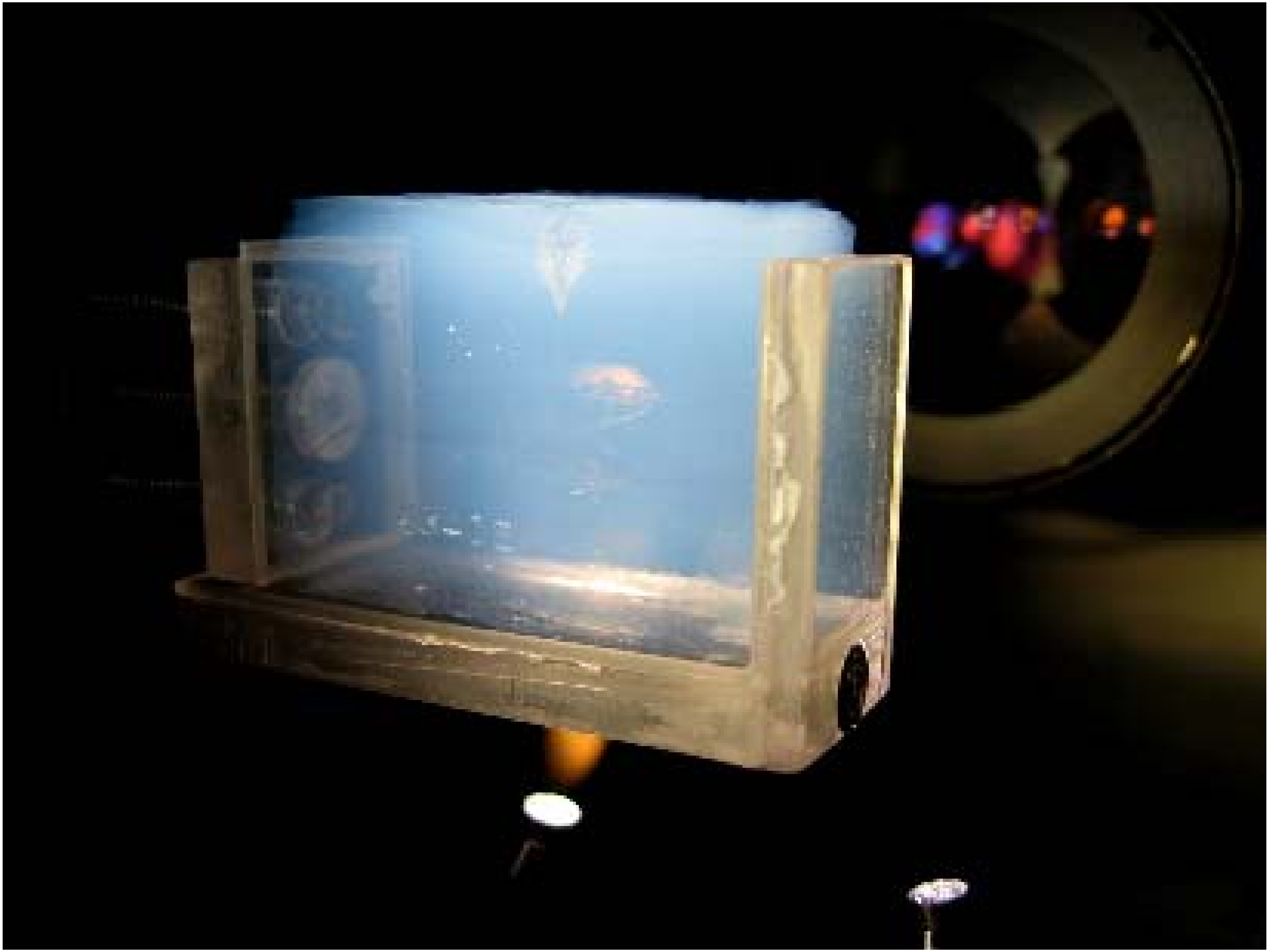
Delta II Launch

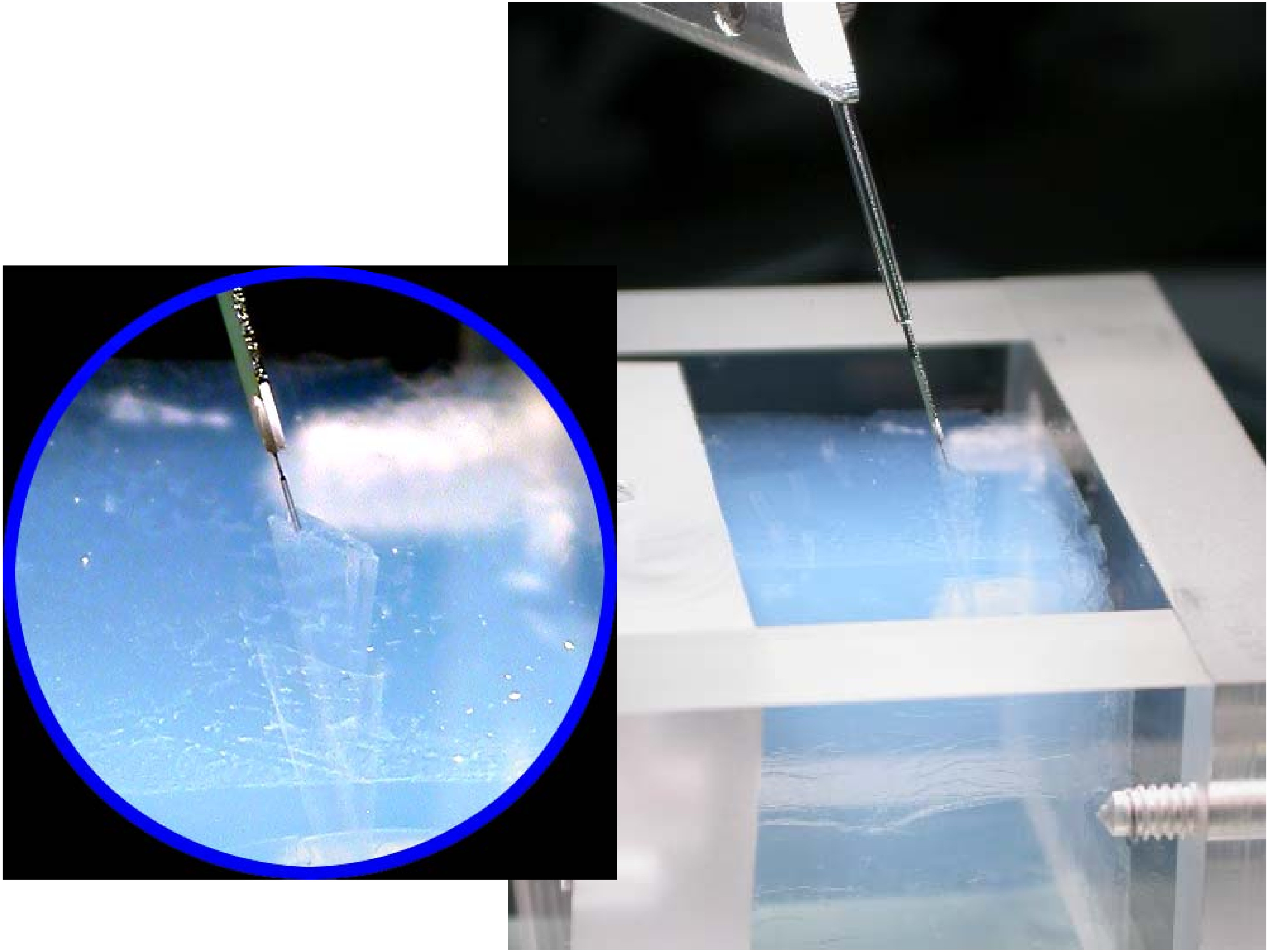
6.12 km/s

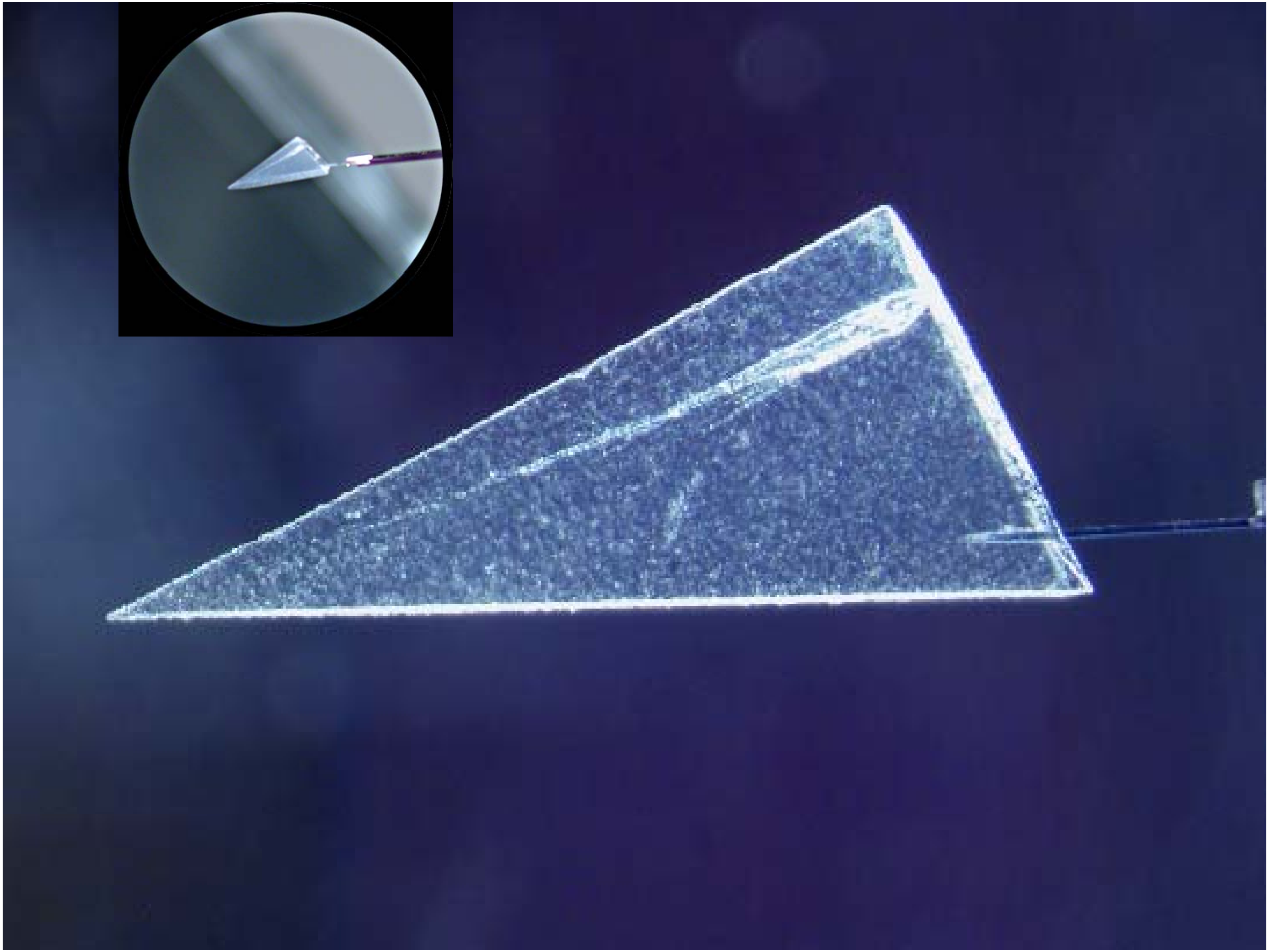

Wild 2 - Stardust

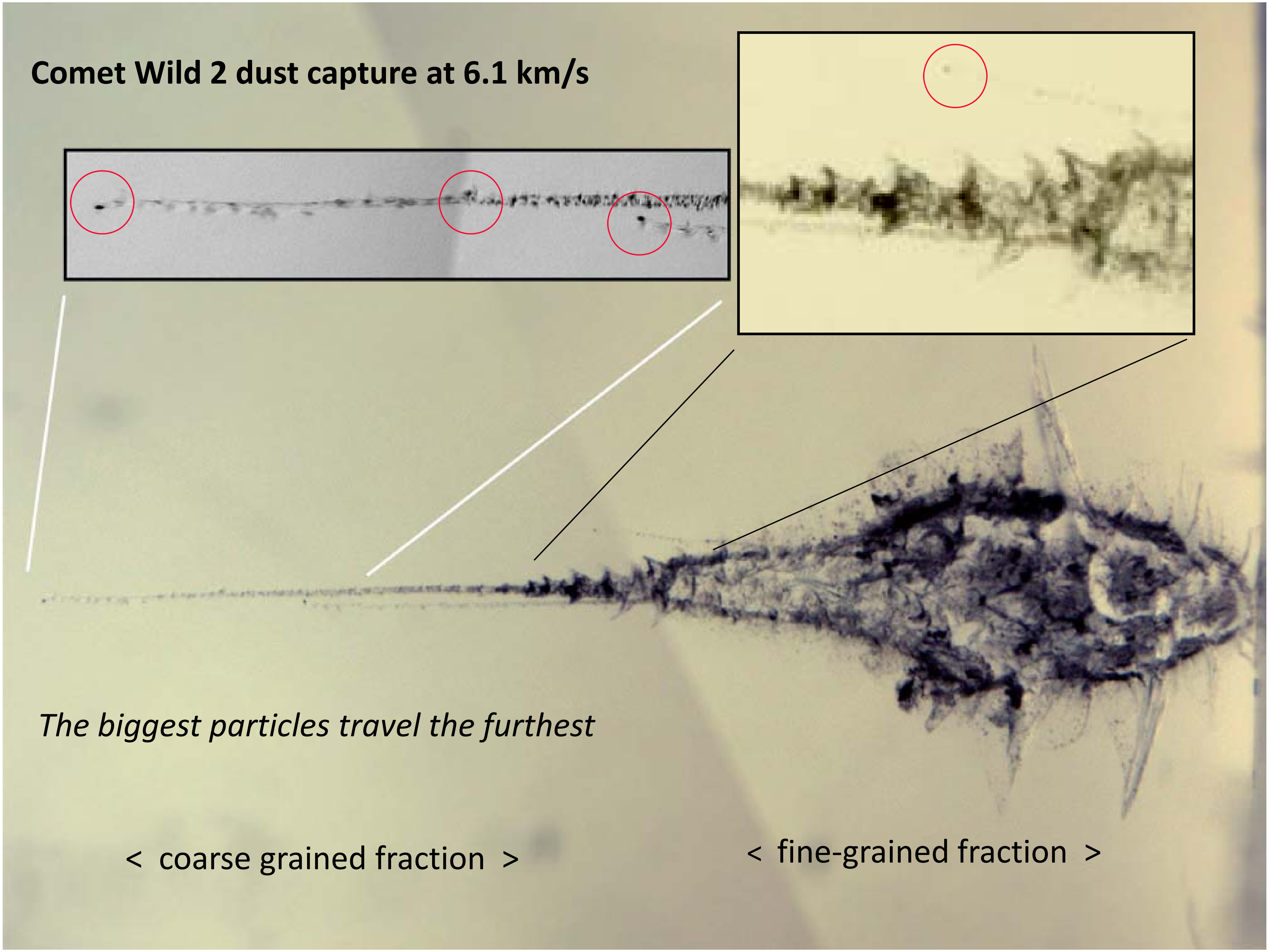

COLLECTING COMET DUST










Comet Wild 2 dust capture at 6.1 km/s
The biggest particles travel the furthest
< coarse grained fraction >
< fine-grained fraction >

RESEARCH ARTICLE

Comet 81P/Wild 2 Under a Microscope

Don Brownlee,[1] Peter Tsou,[2] J˘r™meAl˘on,[3,4] Conel M. OÕD Alexander,[5] Tohru Araki,[6]
Sasa Bajt,[7] Giusepp e A. Baratta,[8] Ron Bastien,[9] Phil Bland,[10,11] Pierre Bleuet,[12] Janet Borg,[13]
John P. Bradley,[14] Adrian Brearley,[15] F. Brenker,[16] Sean Brennan,[17] John C. Bridges,[18]
Nigel D. Brown ing,[19,20] John R. Brucato,[21] E. Bullock,[22] Mark J. Burchell,[23] Henner Busemann,[5]
Anna Butterwort h,[24] Marc Chaussido n,[25] Allan Cheuvron t,[26] Miaofang Chi,[14] Mark J. Cintala,[27]
B. C. Clark,[26] Simon J. Clemett,[28] George Cod y,[29] Luigi Colange li,[21] George Coo per,[30]
Patric k Cordier,[31] C. Daghlian,[32] Zurong Dai,[14] Louis DÕHendecourt,[13] Zahia Djouadi,[13]
Gerardo Doming uez,[33] Tom Duxbury,[2] Jason P. Dwo rkin,[34] Dent on S. Ebel,[35]
Thanasis E. Economou,[36] Sirine Fakra,[37] Sam A. J. Fairey,[38] Stewart Fallo n,[14]
Gian luca Ferrini,[39] T. Ferroir,[40] Holger Fleckenstein,[41] Christine Floss,[42] George Flynn,[43]
Ian A. Franchi,[44] Marc Fries,[29] Z. Gainsforth,[24] J.-P. Galli en,[45] Matt Geng e,[46] Mary K. Gill es,[47]
Philip e Gillet,[40] Jamie Gilmour,[48] Daniel P. Glavin,[34] Matth ieu Gounelle,[49,10] Monica M. Grady,[18]
Gil es A. Graham,[14] P. G. Grant,[14] Simon F. Green,[18] Faustine Grossemy,[13]
Lawrenc e Grossman,[36,50] Jeffrey N. Gros sman,[51] Yunbin Guan,[52] Kenji Hagiy a,[10]
Ralph Harvey,[53] Philipp Heck,[54] Gregory F. Herzog,[55] Peter Hoppe,[54] Friedrich H□rz,[56]
Joachim Huth,[54] Ian D. Hutcheon,[4] Konst antin Ignatyev,[57] Hope Ishii,[14] Motoo Ito,[58]
Damien Jacob,[59] Chris Jacob sen,[60] Stein Jacob sen,[61] Steven Jones,[2] David Josw iak,[1]
Amy Jurewicz,[62] Anton T. Kearsley,[10] Lindsay P. Keller,[56] H. Khodja,[47] A.L. David Kilcoyne,[37,47]
Jochen Kis sel,[63] Alexander Krot,[64] Falko Langen horst,[65] Antonio Lanzirotti,[66] Loan Le,[67]
Laurie A. Leshin,[68] J. Leitner,[69] L. Lemelle,[40] Hugues Leroux,[70] Ming-Chang Liu,[71] K. Luening,[17]
Ian Lyon,[48] Glen MacPherson,[22] Matthew A. Marcus,[37] Kuljeet Marhas,[72] Bernard Marty,[73]
Graciela Matrajt,[1] Kevin McKeegan,[71] Anders Meibom,[48] Vito Mennella,[74] Keiko Messenger,[9]
Scott Messenger,[58] Takash i Miko uchi,[75] Smail Mostefaoui,[76] Tomok i Nakamura,[77] T. Nakano,[78]
M. Newvill e,[66] Larry R. Nittler,[5] Ichiro Ohn ishi,[79] Kazumasa Ohs umi,[80] Kyok o Okudai ra,[81]
Dimitri A. Papanastassiou,[82] Russ Palma,[83,84] Maria E. Palumbo,[8] Robert O. Pepin,[84]
David Perkins,[26] Murielle Perronnet,[56] P. Pianetta,[57] William Rao,[85] Frans J. M. Rietmeijer,[15]
Fran¨ois Robert,[49] D. Rost,[22] Alessandra Rotun di,[86] Robert Ryan,[2] Scott A. Sandford,[87]
Craig S. Schwandt,[13] Thomas H. See,[88] Dennis Schlutter,[83] J. Sheffield-Parker,[89]
Alexandre Simionov ici,[54] Steven Simon,[50] I. Sitnitsky,[90] Christopher J. Snead,[24]
Maegan K. Spencer,[96] Frank J. Stadermann,[42] Andrew Steele,[29] Thomas Stephan,[69]
Rhonda Stroud,[89] Jean Susini,[14] S. R. Sutton,[50,66] Y. Suzuki,[91] Mitra Taheri,[87] Susan Taylor,[92]
Nick Teslich,[14] Kazu Tomeoka,[77] Naotaka Tomioka,[77] Alice Toppani,[3,14]
Josep M. Trigo-Rodr'guez,[93,94] David Troadec,[68] Akira Tsuchiyama,[95] Anth ony J. Tuzzoli no,[34]
Tolek Tyliszczak,[35,45] K. Uesu gi,[96] Michael Velbel,[97] Joe Vellen ga,[26] E. Vicenzi,[22] L. Vincze,[98]
Jack Warren,[9] Iris Weber,[69] Mike Weisberg,[99] Andrew J. Westphal,[24] Sue Wirick,[41]
Diane Wooden,[87] Brigit te Wopenka,[72,100] Penelope Wozniakiewicz,[10] Ian Wright,[18]
Hikaru Yabuta,[29] Hajime Yano,[81] Edward D. Young,[71] Richard N. Zare,[96] Thomas Zega,[81]
Karen Ziegler,[71] Laurent Zimmerman,[25] Ernst Zinner,[42] Michael Zolensky[56]

The Stardust spacecraft collected thousands of particle s from comet 81P /Wild 2 and returned them to Earth for laboratory stu dy. The preliminary examination of these samples shows that the non vo latile port ion of the comet is an unequ ilibrated assor tment of materials that have both presolar and solar system origi n. The comet contains an abundan ce of sili cate 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 regio ns of the solar nebula. Their presence in a comet proves that the formation of the solar system include d mixin g on the grandes t scales.

Stardust was the first mission to return soli d 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 distan t planet. The samples, isolated from the planetary region of the solar system for billions of years, provi de new insight into the formation of the solar system. The samples provide unprecedented opportun ities both to corroborate astronomical

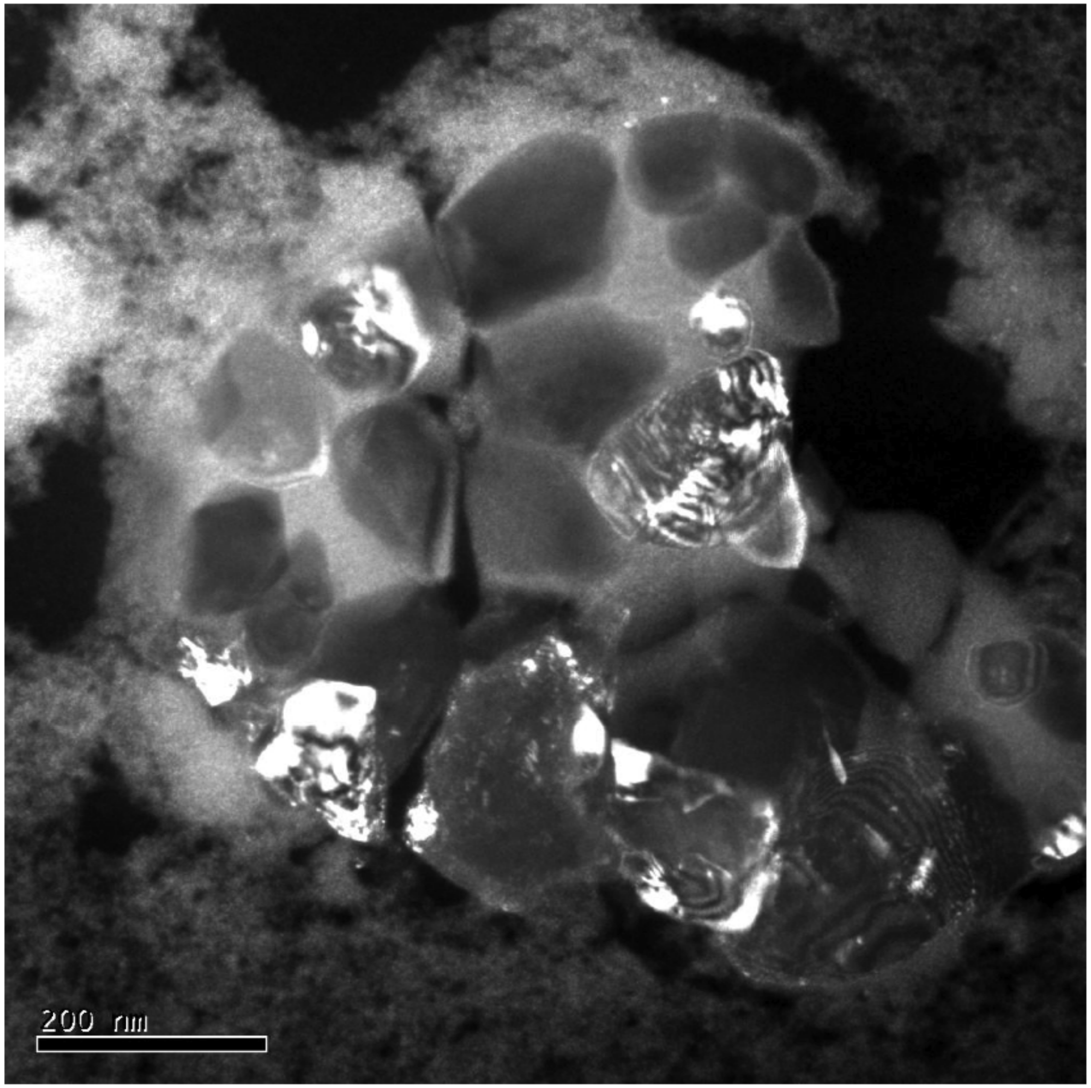
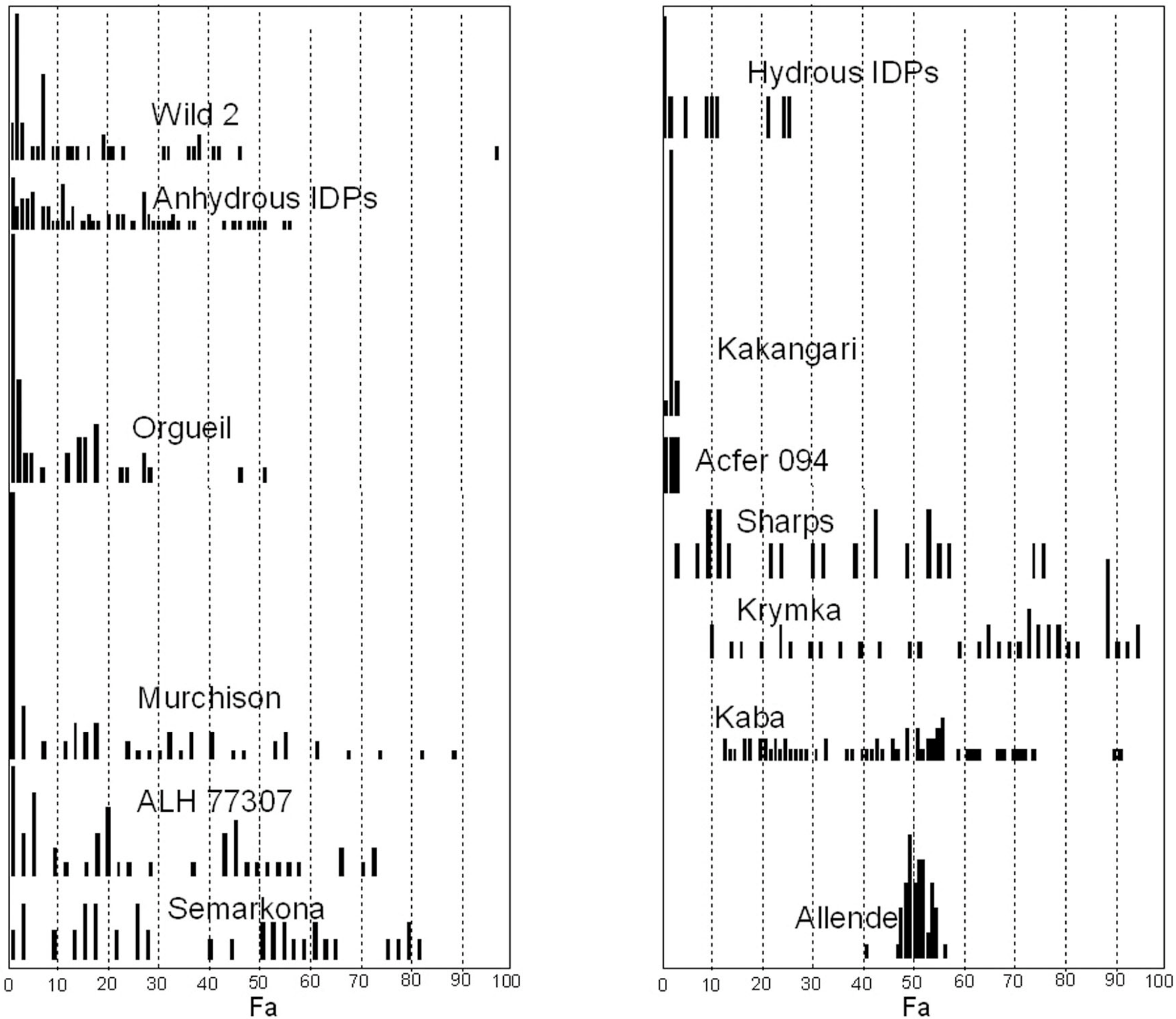
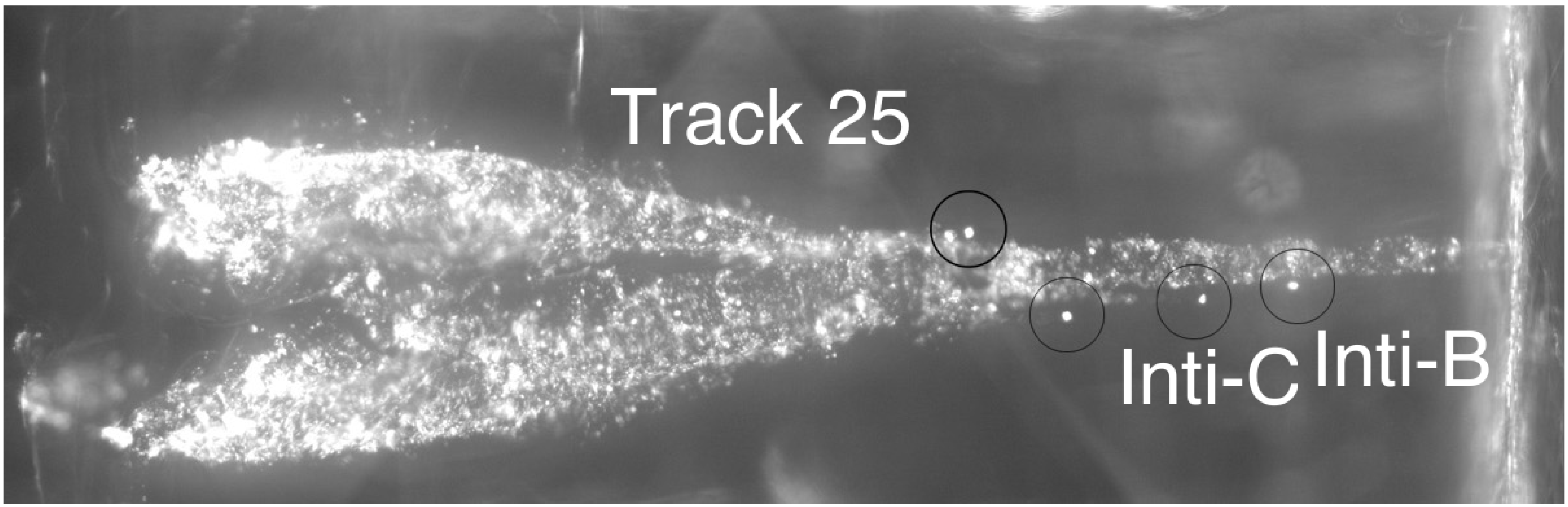


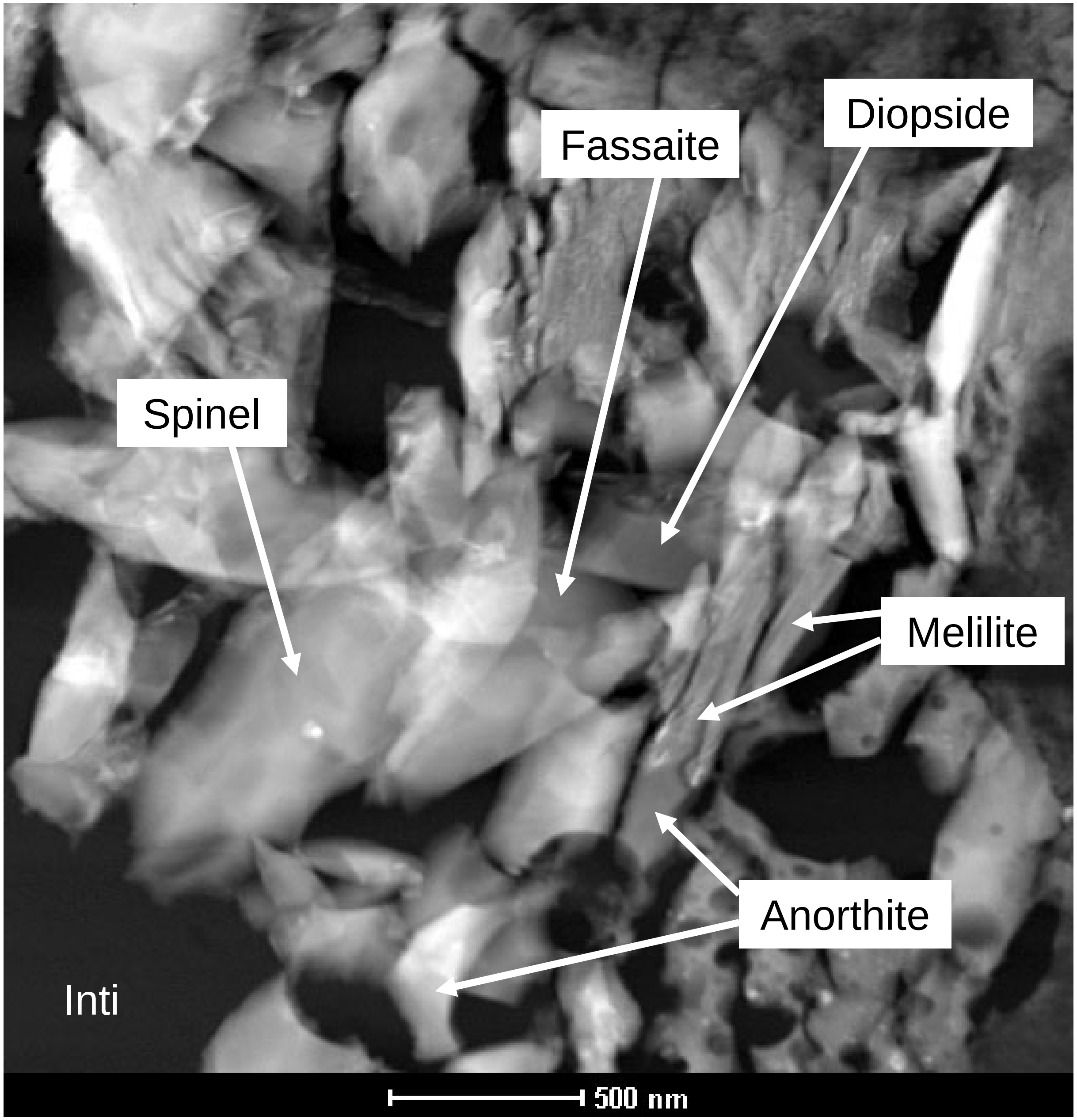
Figure 1. Bright field TEM image showing an olivine and pyroxene sample. Individual olivine and pyroxene grains crystallites are srrounded by amorphous matrix (which may or may have been produced during capture).

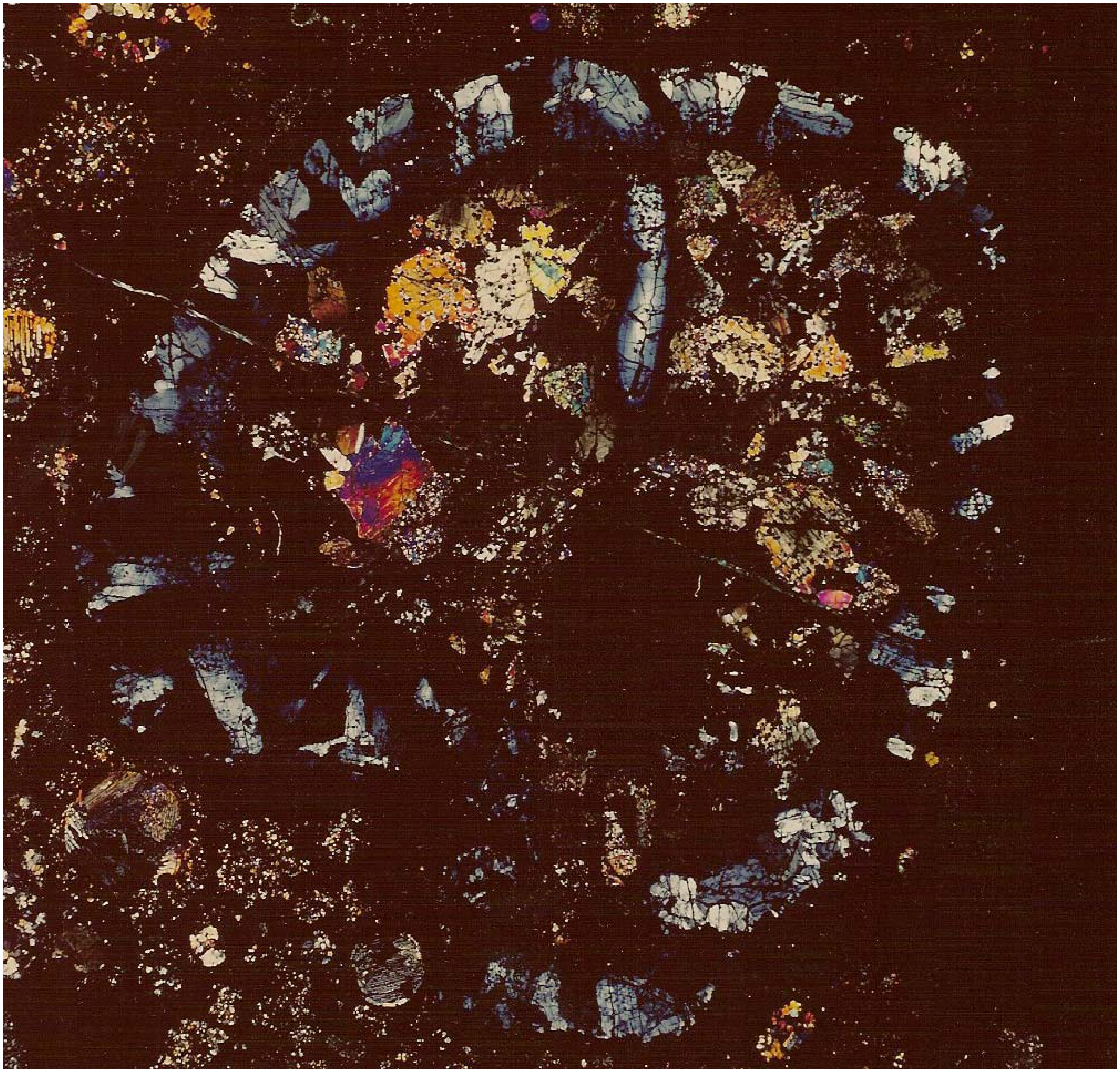


Wild 2
Anhydrous IDPs
Orgueil
Murchison
ALH 77307
Semarkona
Hydrous IDPs
Kakangari
Acfer 094
Sharps
Krymka
Kaba
Allende
0 10 20 30 40 50 60 70 80 90 100
Fa
0 10 20 30 40 50 60 70 80 90 100
Fa

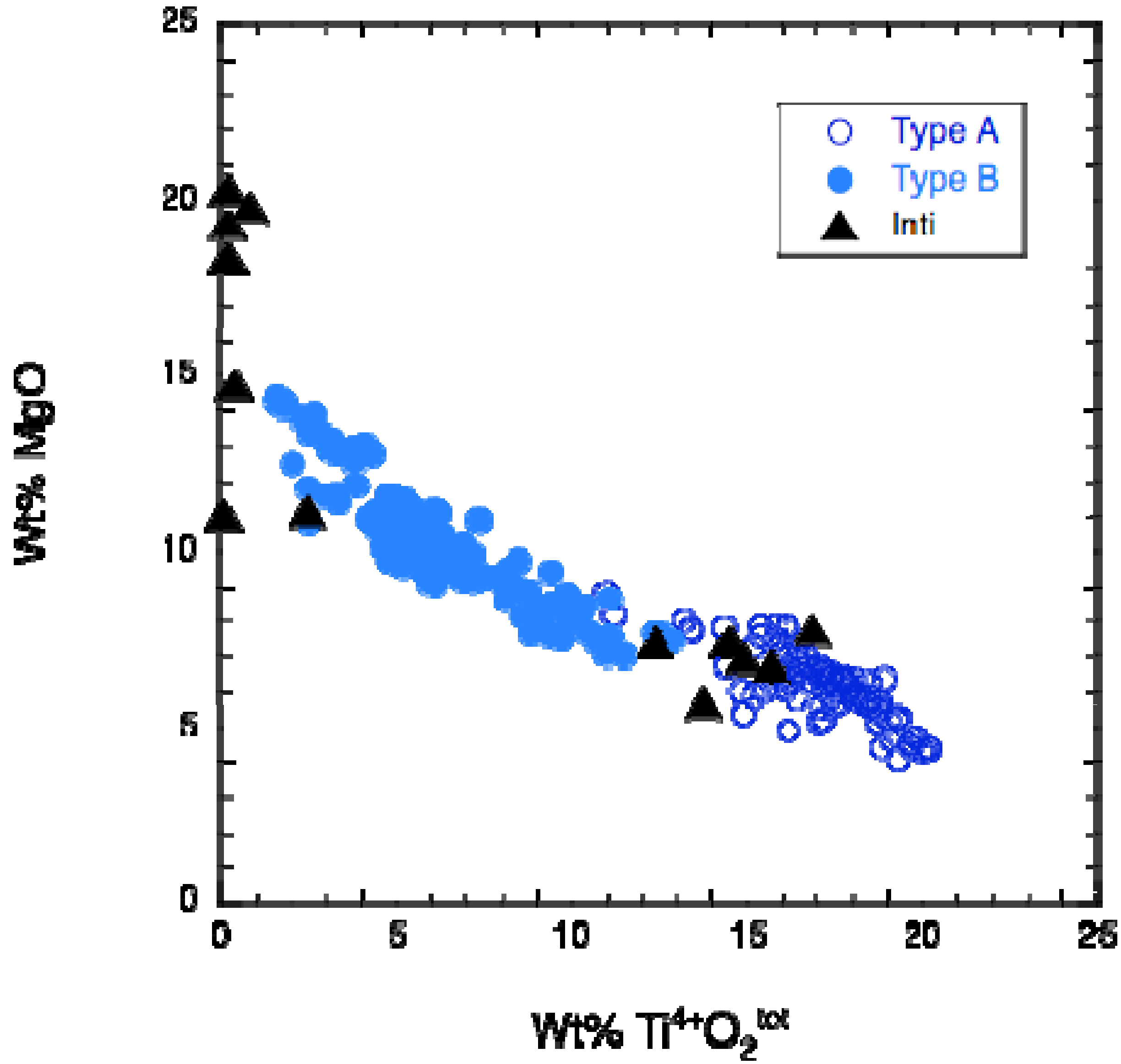

Track 25
Inti-C
Inti-B

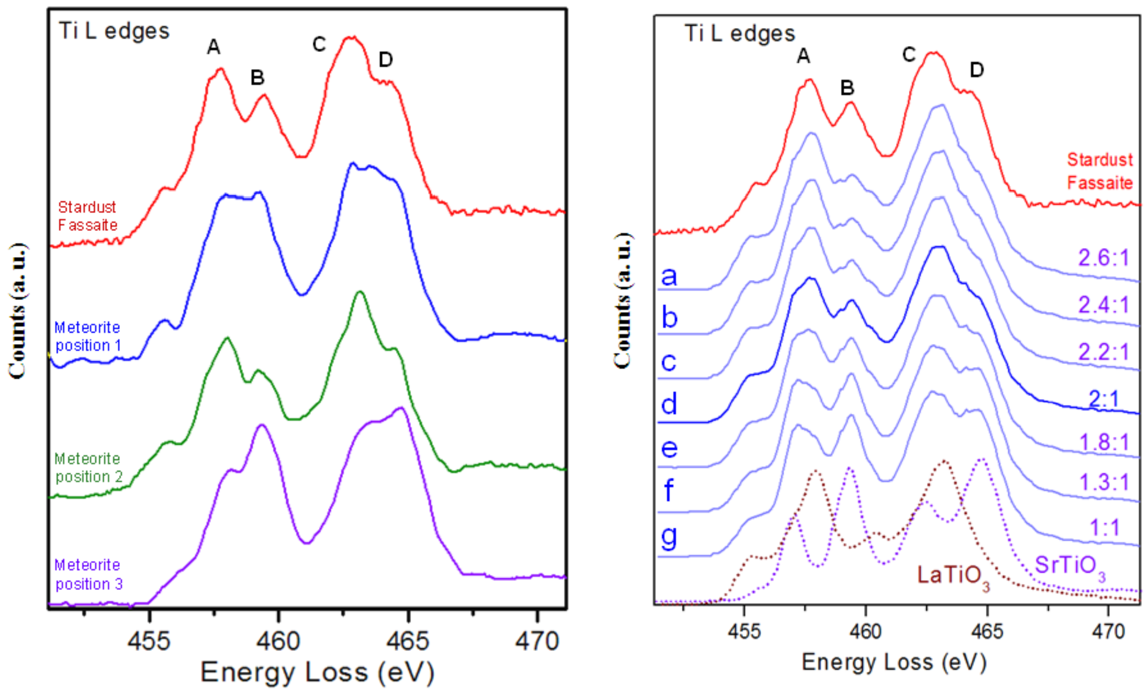
A Cometary Refractory Inclusion



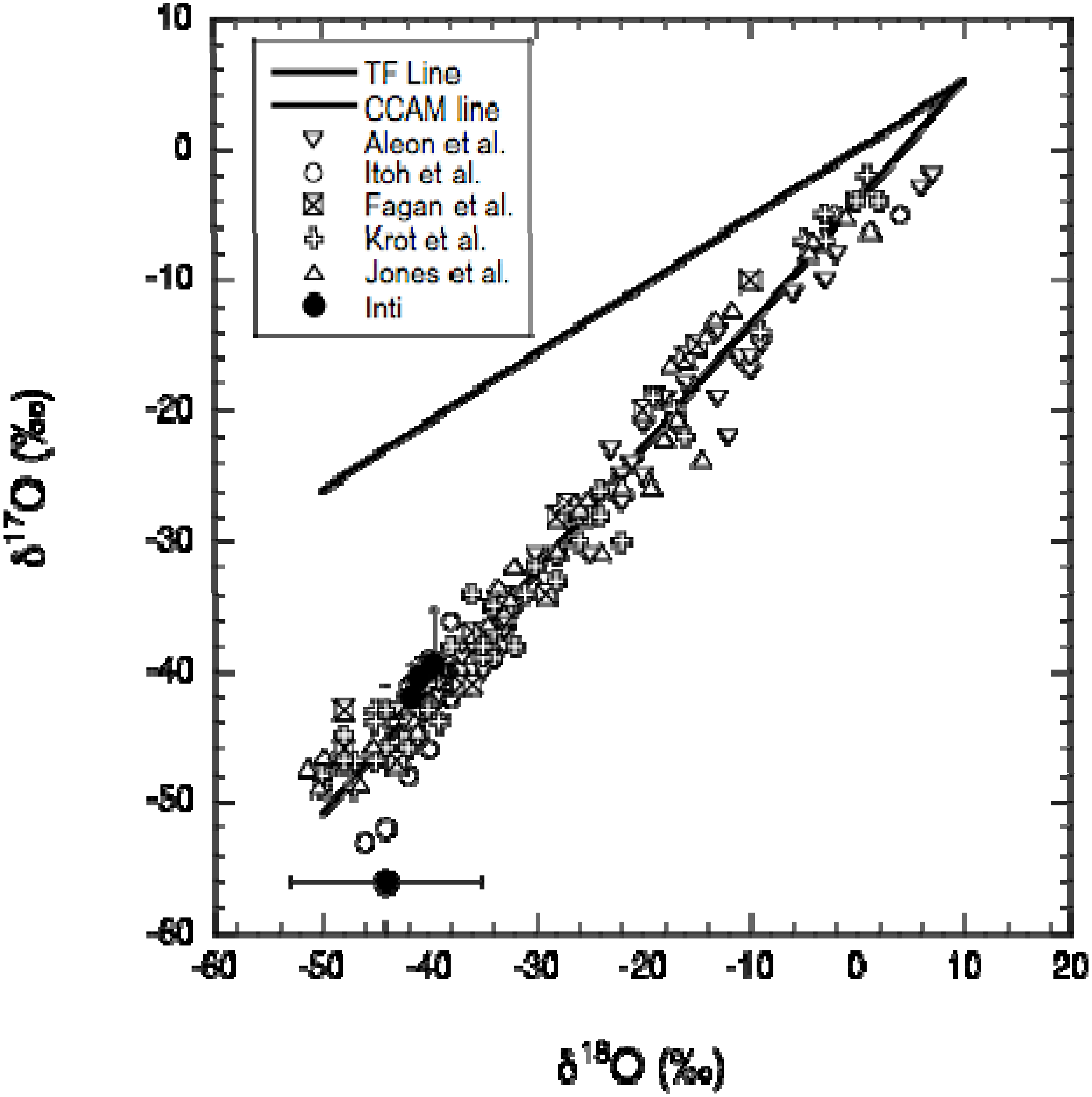


Pyroxene in Inti has the Same Composition as in Refractory Inclusions

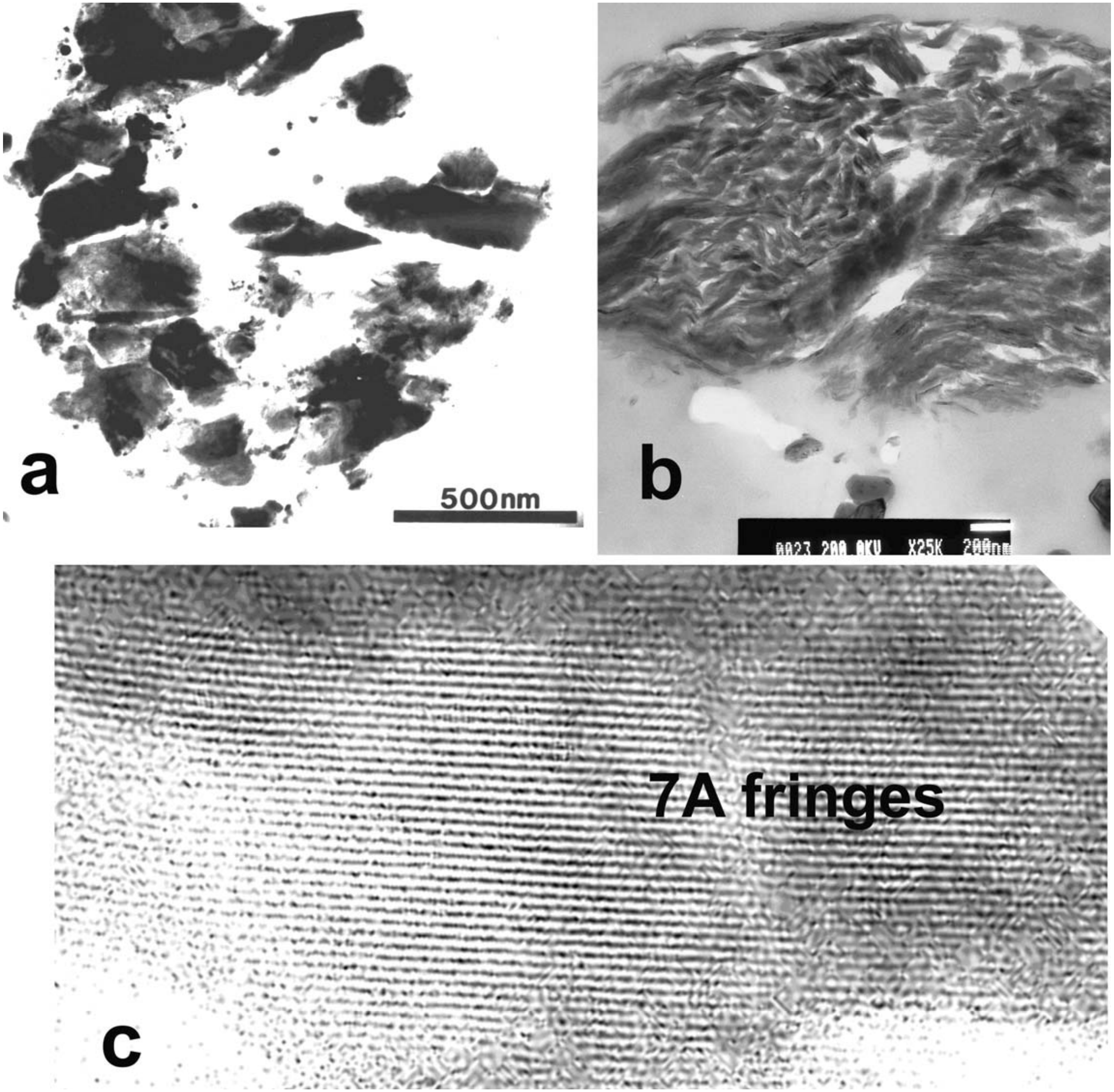




Ti L edges
A
B
C
D
Stardust Fassaite
Meteorite position 1
Meteorite position 2
Meteorite position 3
Counts (a. u.)
455
460
465
470
Energy Loss (eV)
Ti L edges
A
B
C
D
Stardust Fassaite
a
b
c
d
e
f
g
2.6:1
2.4:1
2.2:1
2:1
1.8:1
1.3:1
1:1
$LaTiO_3$
$SrTiO_3$
Counts (a. u.)
455
460
465
470
Energy Loss (eV)



TF Line
CCAM line
Aleon et al.
Itoh et al.
Fagan et al.
Krot et al.
Jones et al.
Inti
δ17O (‰)
δ18O (‰)
10
0
-10
-20
-30
-40
-50
-60
-60
-50
-40
-30
-20
-10
0
10
20


a
500nm
b
0023 200.0KV X25K 200nm
7A fringes
c

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.