

Aerial and surface effects of cosmic airbursts: recent events, geological archives and analogues

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Cosmic airburst: entry of high velocity extra-terrestrial bolide



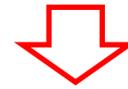
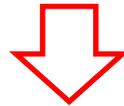
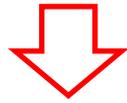
Atmospheric fireball

High altitude acoustic wave

Hot debris jet

Meteorite fall

Meteorite impact



Crater structure

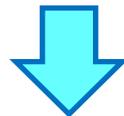


Surface deflagration

Surface fusion

Dispersion ellipse of meteorite fragments

Strewnfield of proximal ejecta



No exotic debris
Local effects

Melted surface

Meteorite debris

Impact ejecta debris

Zero Signal

Airburst surface Signal

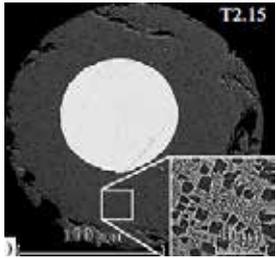
Meteorite Signal

Impact Ejecta Signal

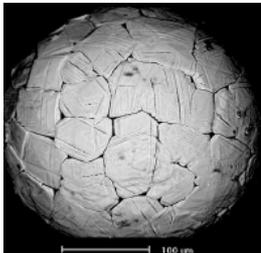


Multiple enigma, confusing situations

Zero Signal



1908 Tunguska



Geological deposits

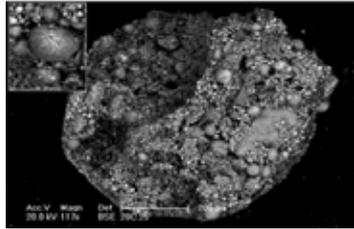
40×10^3 T.
annual cosmic rate

Confusion
anthropogenic emissions

Badyukov et al. 2011

Guiata & Martegani,
2008

Airburst Signal

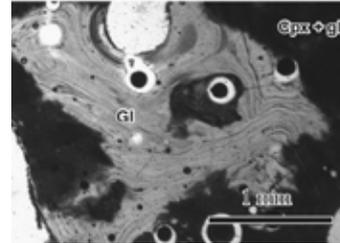


Cosmic spherules ??

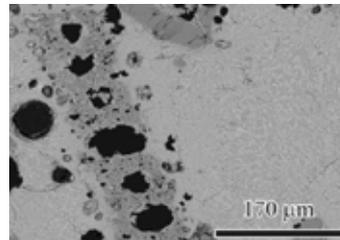
Ablation debris from
micrometeorites ??

480 Ka: Airburst layers
Transantactic Mountains

Rochette et al., 2008



Schlieren
Lechatelierite
>1700°C



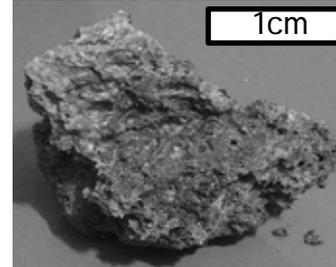
Local plant phytoliths

Dkhaleh impact
event Egypt,
145±19 ka

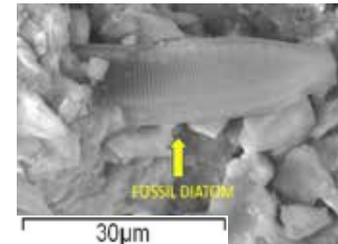
Airburst or
ejecta

Ozinski et al., 2008

Meteorite Signal



Sri Lanka, 2012
October 29
Carbonaceous
meteorite,



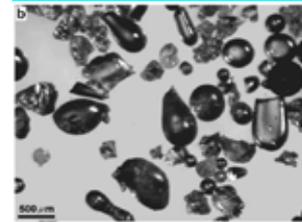
Diatoms

Cosmos origin?

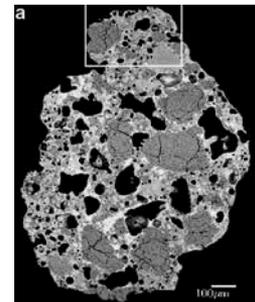
Antarctica species...

Wickramasingh
et al., 2013

Impact Ejecta Signal



Microtektites



Unmelted
clasts

Australasian
tektite
strewnfield

Glass & Koeberl,
2006

Studied materials

Experimental analogue

High velocity collision 4-8 km/s

Persephone light-gun power
Gramat CEA Defense Department

Reference situations Undisputed cosmic events

- 2011 August 3rd: Angles France meteor airburst, debris fall
- 1908 June 30 Tunguska (airburst)
- 1864 14 May Orgueil (meteorite fall)
- Henbury crater-field. NT-Australia
- Darwin glass strewnfield

Puzzling impact products Airburst or impact ejecta

- 0.8 Ma Australasian : tektites & microtektites in sedimentary archives
- Dakhleh glass, Egypt

Refuted cosmic events Exotic terrestrial debris

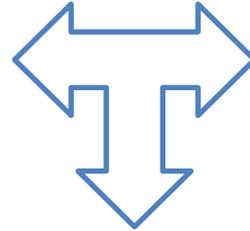
- Younger Dryas Debris Layer
- 4 kyr BP Debris Layer
- 2.4 kyr BP Debris Layer...

Different situations



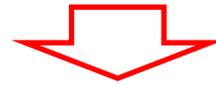
A similar signal

Identical precursors



Common physics

Similar forming processes
and initial conditions



Research hypothesis: effect of stratospheric dust
layers on the physics of airbursts



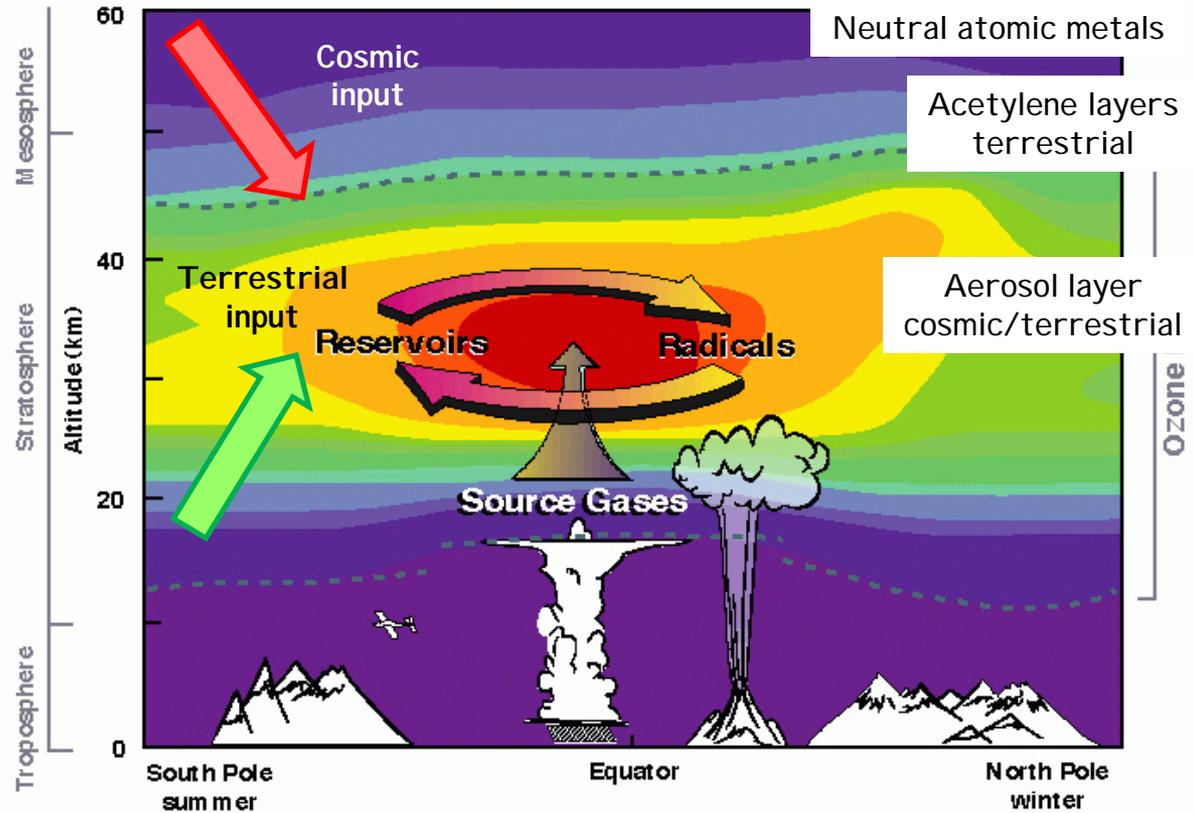
Concentration - Segregation - Pulverization

Effect of stratospheric dust layers on the physics of airbursts

- Hydrodynamic break
- Combustible concentration
- Aerosol aggregation



Airbursts: pulverization of terrestrial debris from stratospheric aerosols



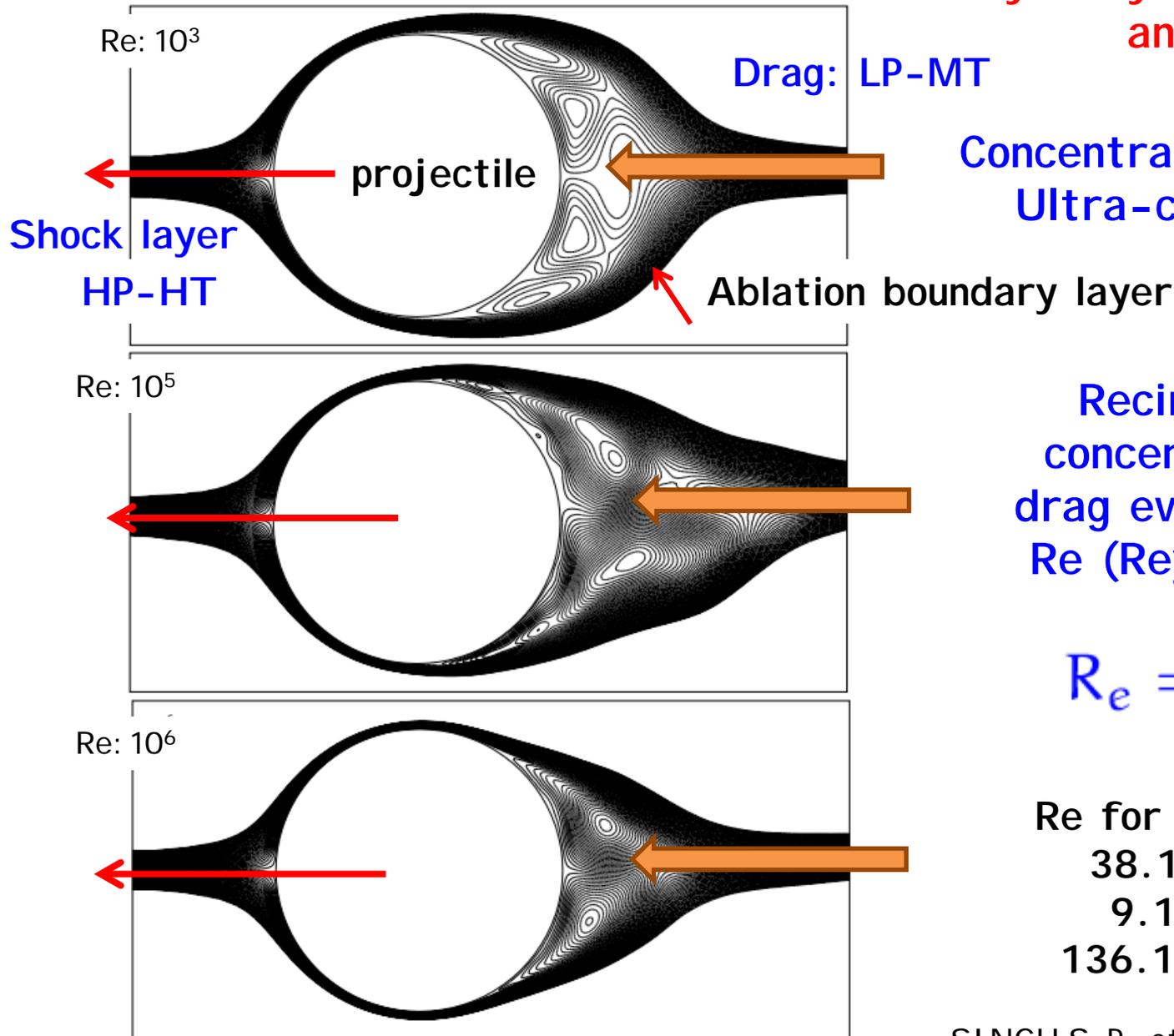
Hydrodynamical explanation and analogies

Concentration of aerosols
Ultra-centrifugation

Recirculation and concentration in the drag even at very high Re (Reynolds number)

$$Re = \frac{\rho V L}{\mu}$$

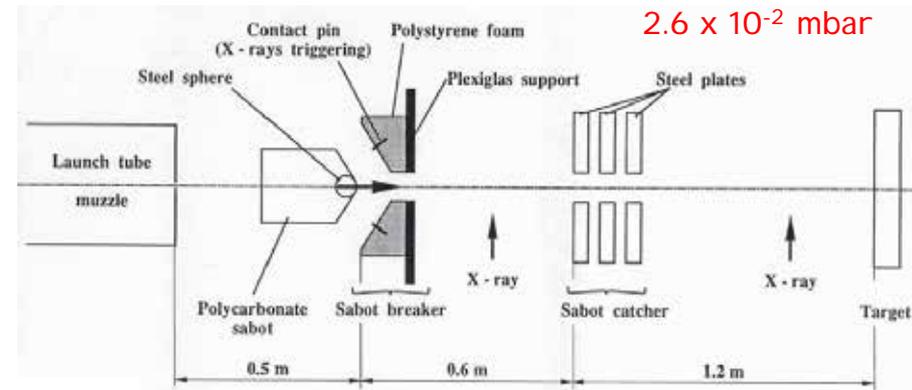
Re for Chelyabinsk :
38.10⁴ at 90 km
9.10⁶ at 50 km
136.10⁶ at 30 km



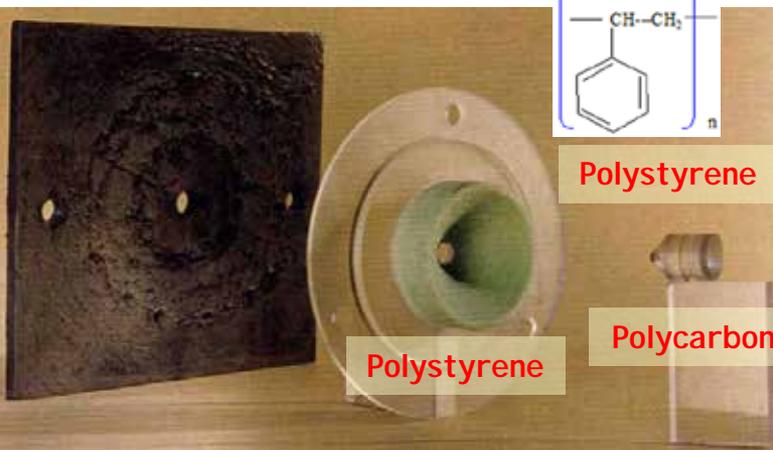
Experimental analogue: High velocity collision 4-8 km/s



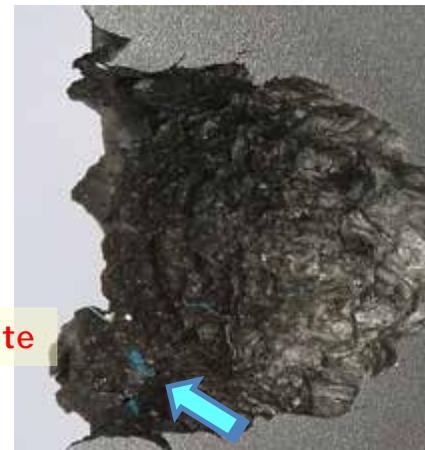
Persephone light-gun power- Gramat CEA- France



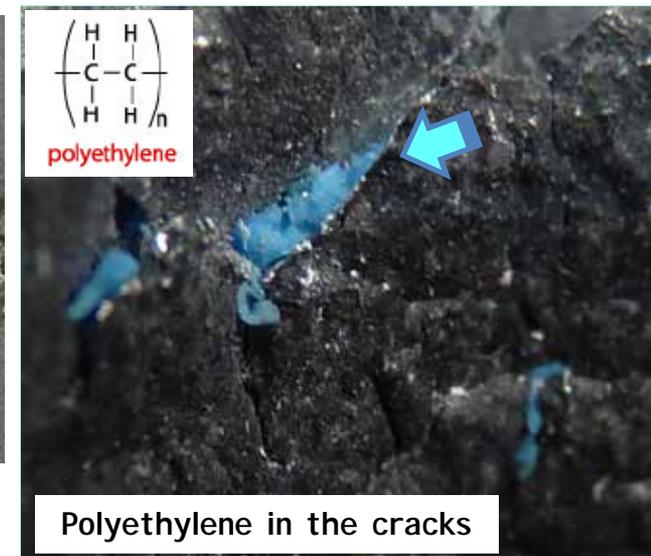
No velocity reduction



Sabot/Projectile separation



Aluminium target: delamination
Steel projectile: pulverization



Polyethylene in the cracks

Re=5.7, laminar regime
Re-circulation in the wake



Two generations of synthesized polymers
from the vaporized carbonaceous materials

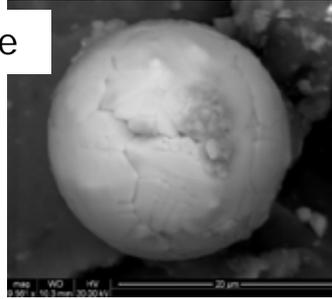
Front crater: HP shock-HT

Concentration, segregation, pulverization

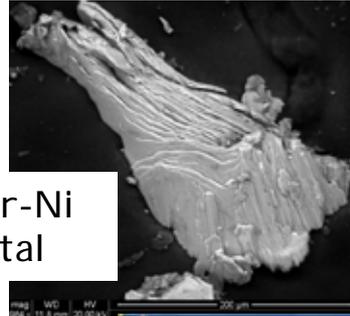
Wake: vaporization

Pulverised carbon/metal/debris

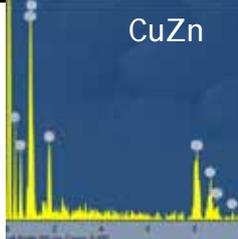
Magnetite



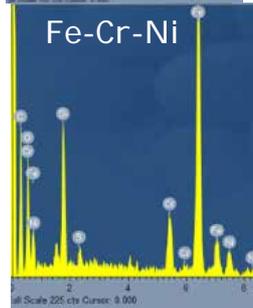
Fe-Cr-Ni metal



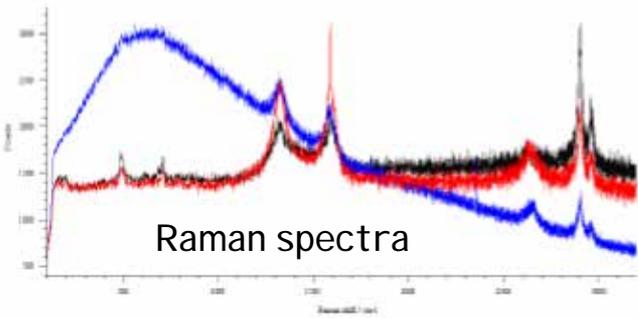
CuZn



Fe-Cr-Ni



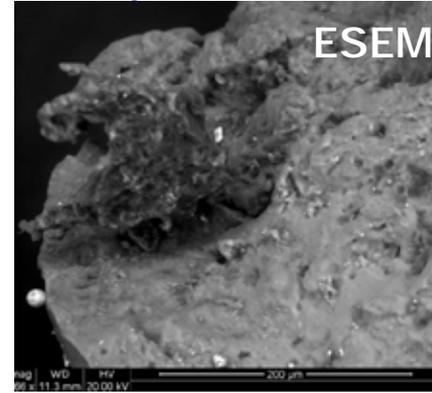
Graphite, shocked-graphite, graphene



Raman spectra

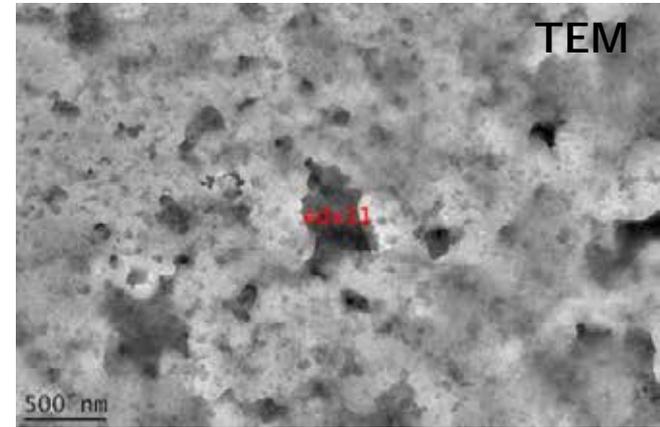


Polymers

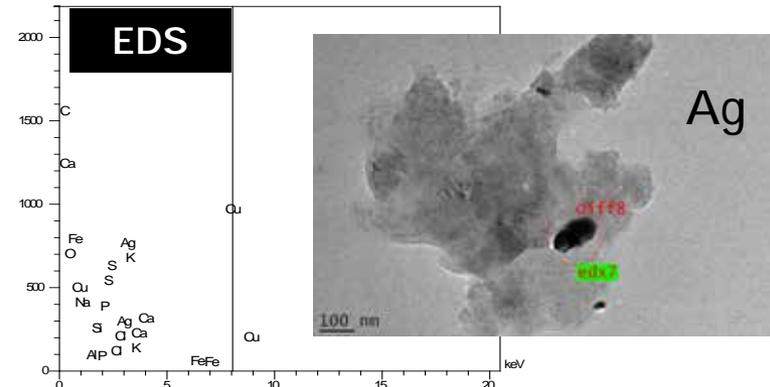


ESEM

Carbon matrix: nanoparticles



TEM



EDS

Ag

All past and recent cosmic events



Unique surface soil signal



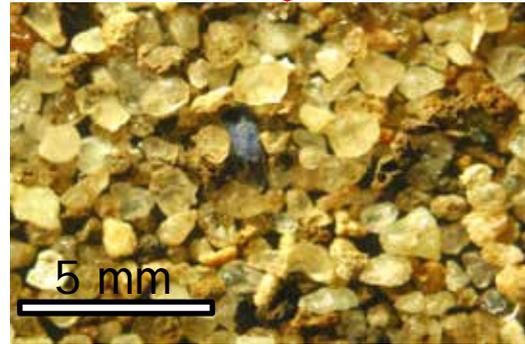
Meteor airburst
Angles (France)
2011 August 3rd



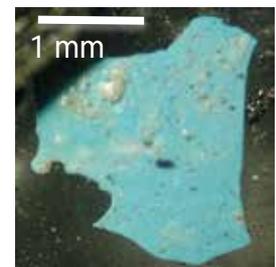
Henbury Crater Field (NT-
Australia) ca 4.8 kyr BP



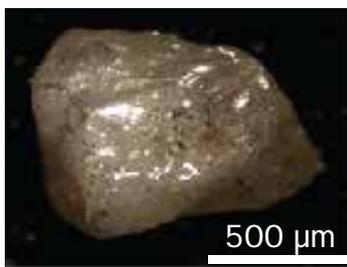
1908 Tunguska
debris layer



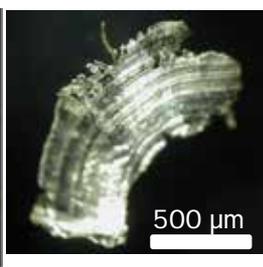
Similar exotic
terrestrial debris



Composite polymers



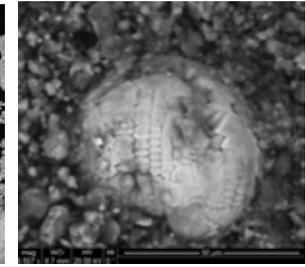
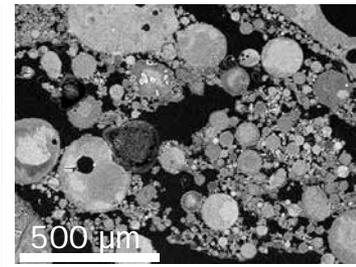
Metal/Carbon
splashed grains



Metal flakes



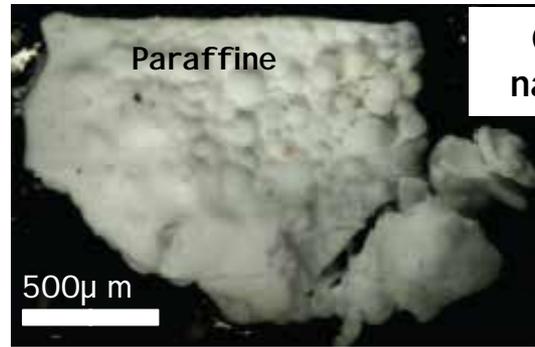
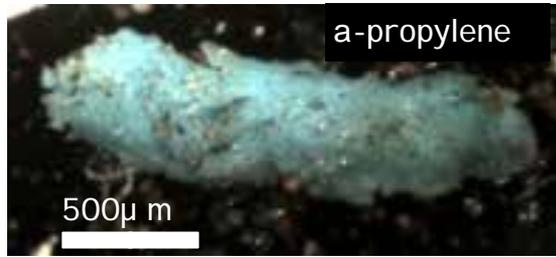
Terrestrial Hybrid Aggregates



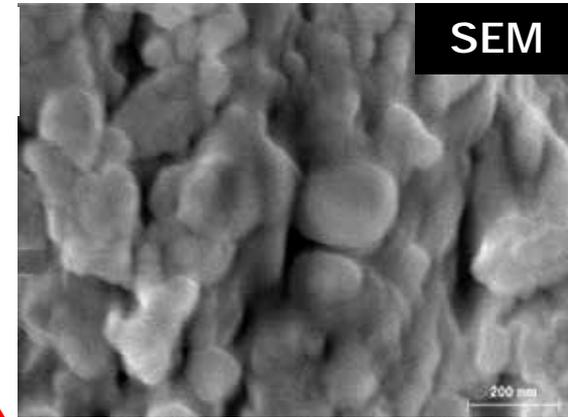
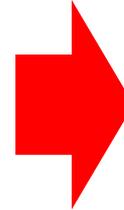
Concentration - Segregation - Pulverization

Polymer Nanocomposites

Low Temperature Polymer "cold glue"

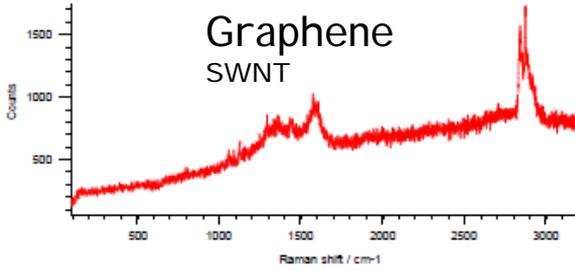


Coalesced nanospheres

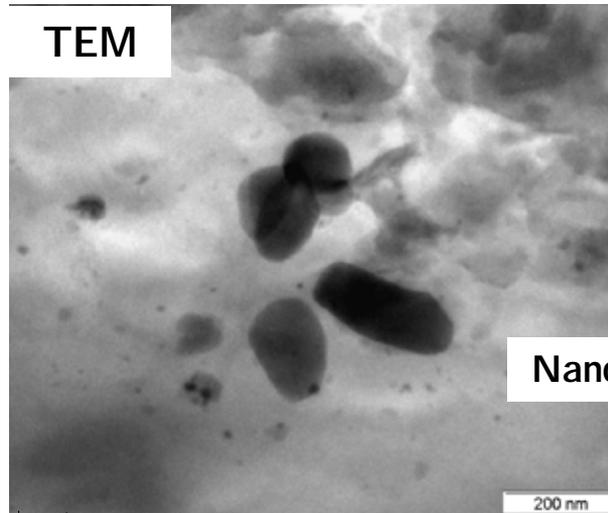


Raman spectra

Graphene SWNT



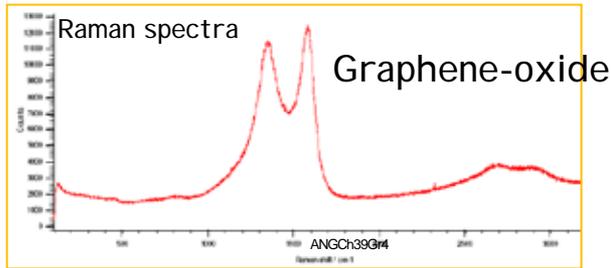
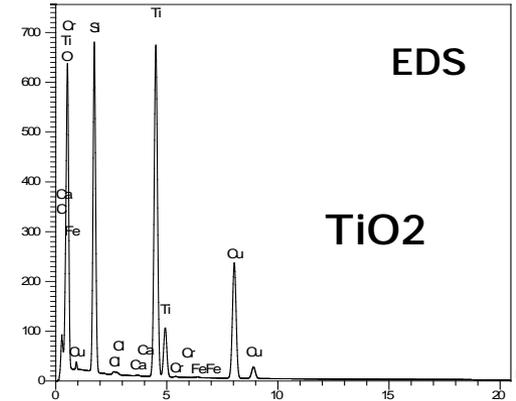
TEM



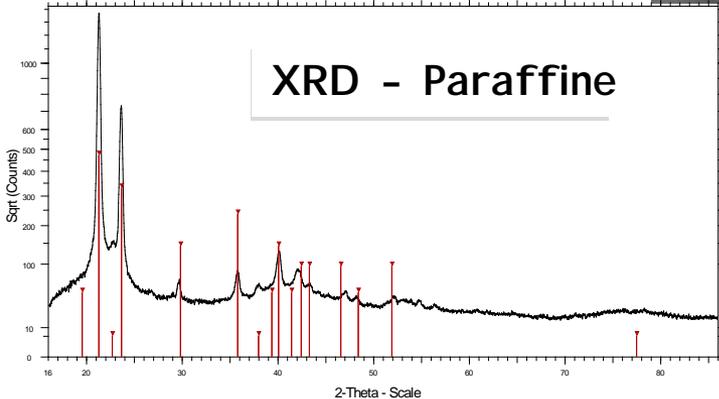
SEM

EDS

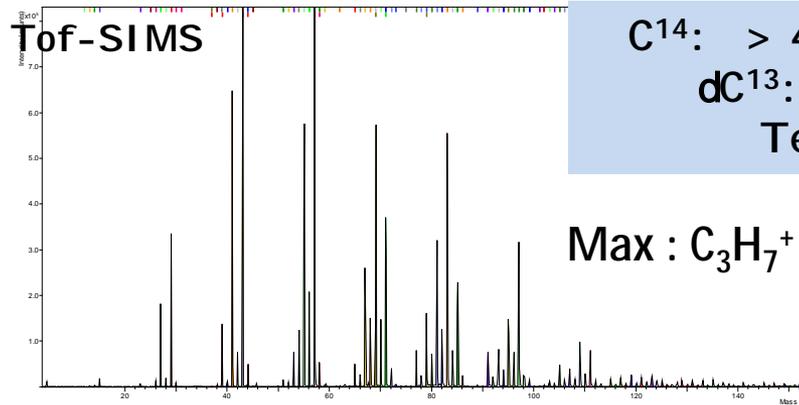
TiO₂



XRD - Paraffine



ToF-SIMS

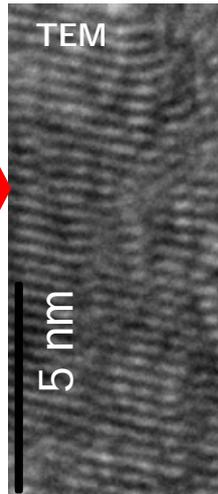
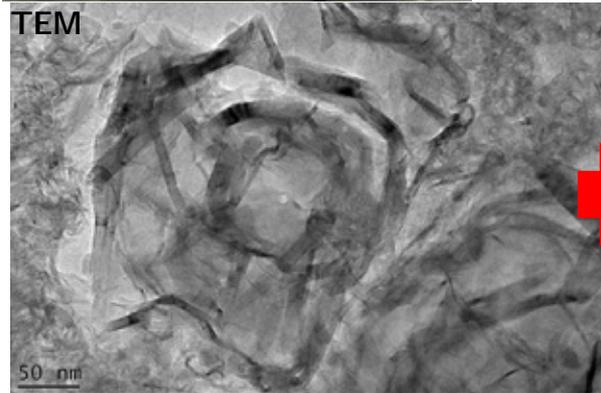
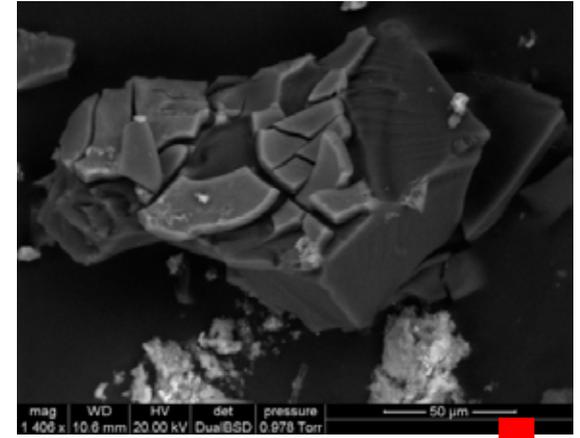
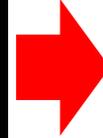
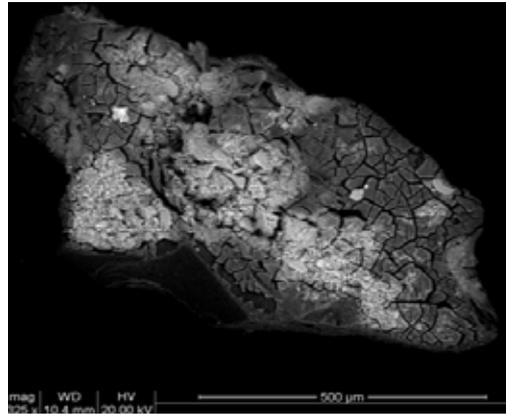
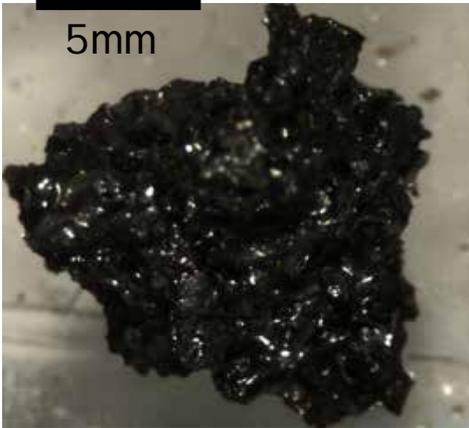


C¹⁴: > 43 500 year BP
dC¹³: -30.3 o/oo
Terrestrial

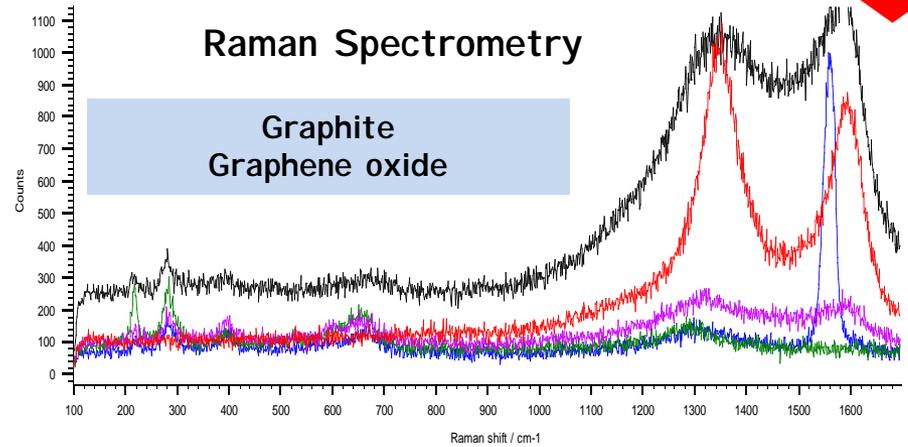
Many carbon radicals
Amino-acids

Frontal debris

High Temperature Glassy Carbon: refractory

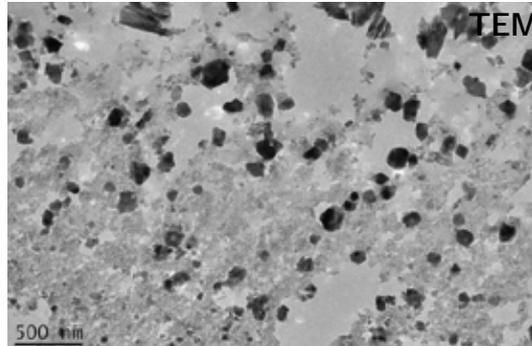
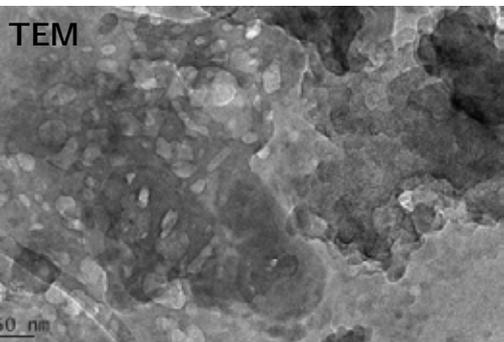


Raman Spectrometry

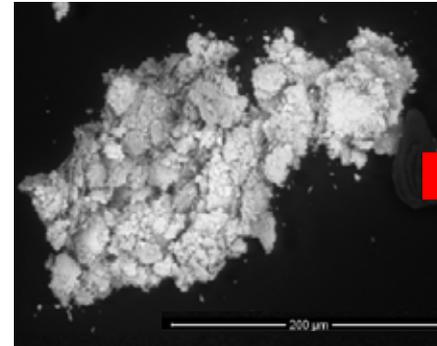


Graphitized plant cells

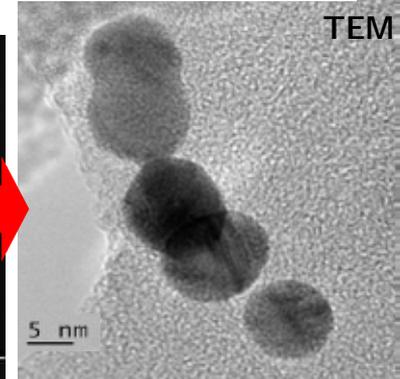
Nano-porous silica in graphitic carbon & nano-metals



Micro-agglutinate magnetite-graphite-Ag



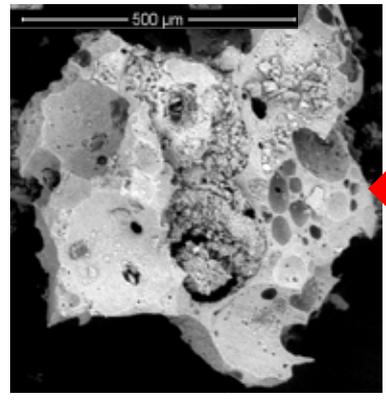
Nano-spheres Ag



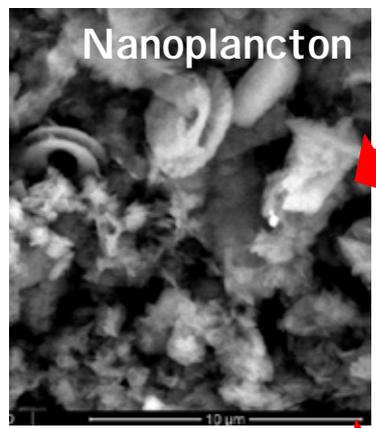
Zhamanshin (Kazakhstan)
14 km impact crater 0.9 Ma



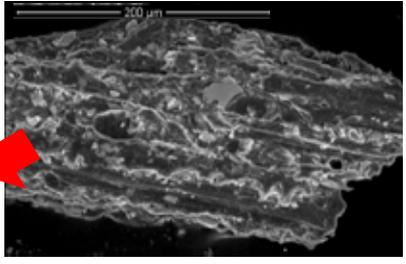
"Impact-breccia"



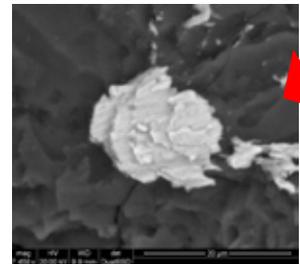
Terrestrial inclusions



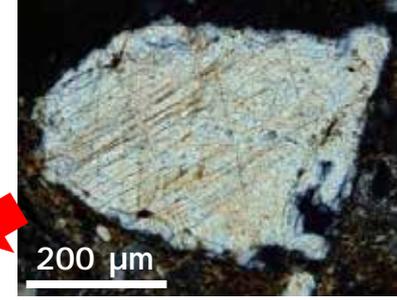
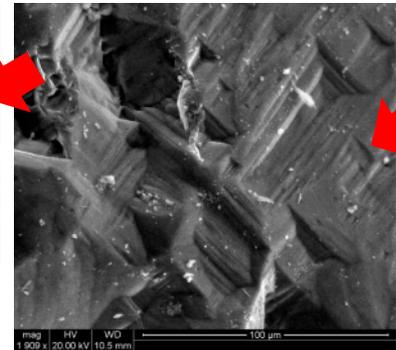
Nanoplankton



Polymerised plant

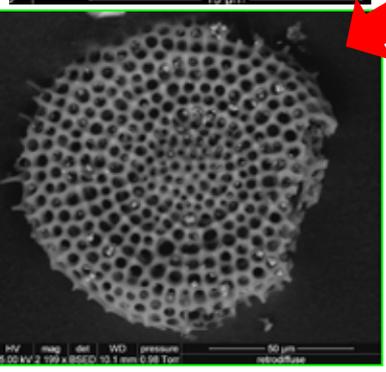


Segregated metals

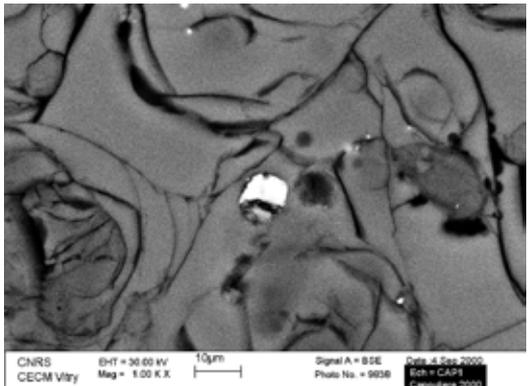


Shocked quartz injected with graphite, graphene & polymer

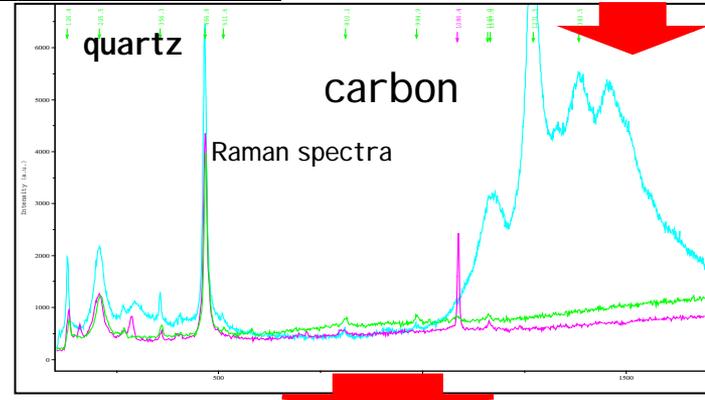
Marine microorganisms



Saccospyris antarctica



Diaplectic quartz

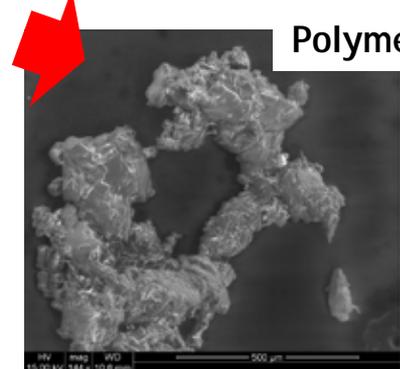


Concentration of terrestrial aerosols

Barranc de la Boella (Esp.) 0.8 Ma -
Human occupation
Mammuthus Meridionalis
Defense fragment with black traces

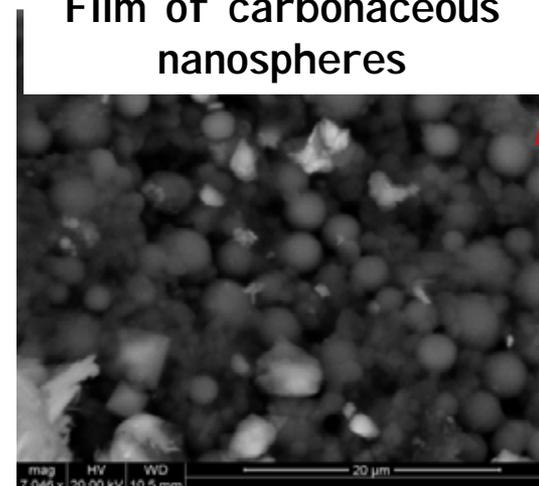


Polymer pulverisation at the surface



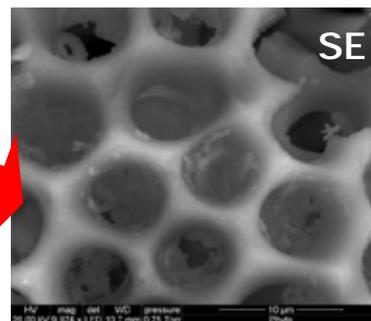
Polymers

Film of carbonaceous
nanospheres

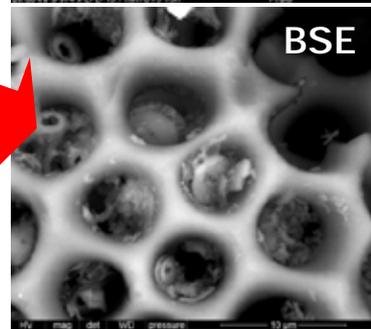


Fe-Cr-Ni

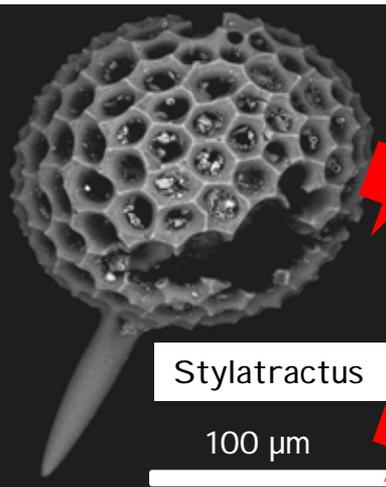
Metals



SE



BSE



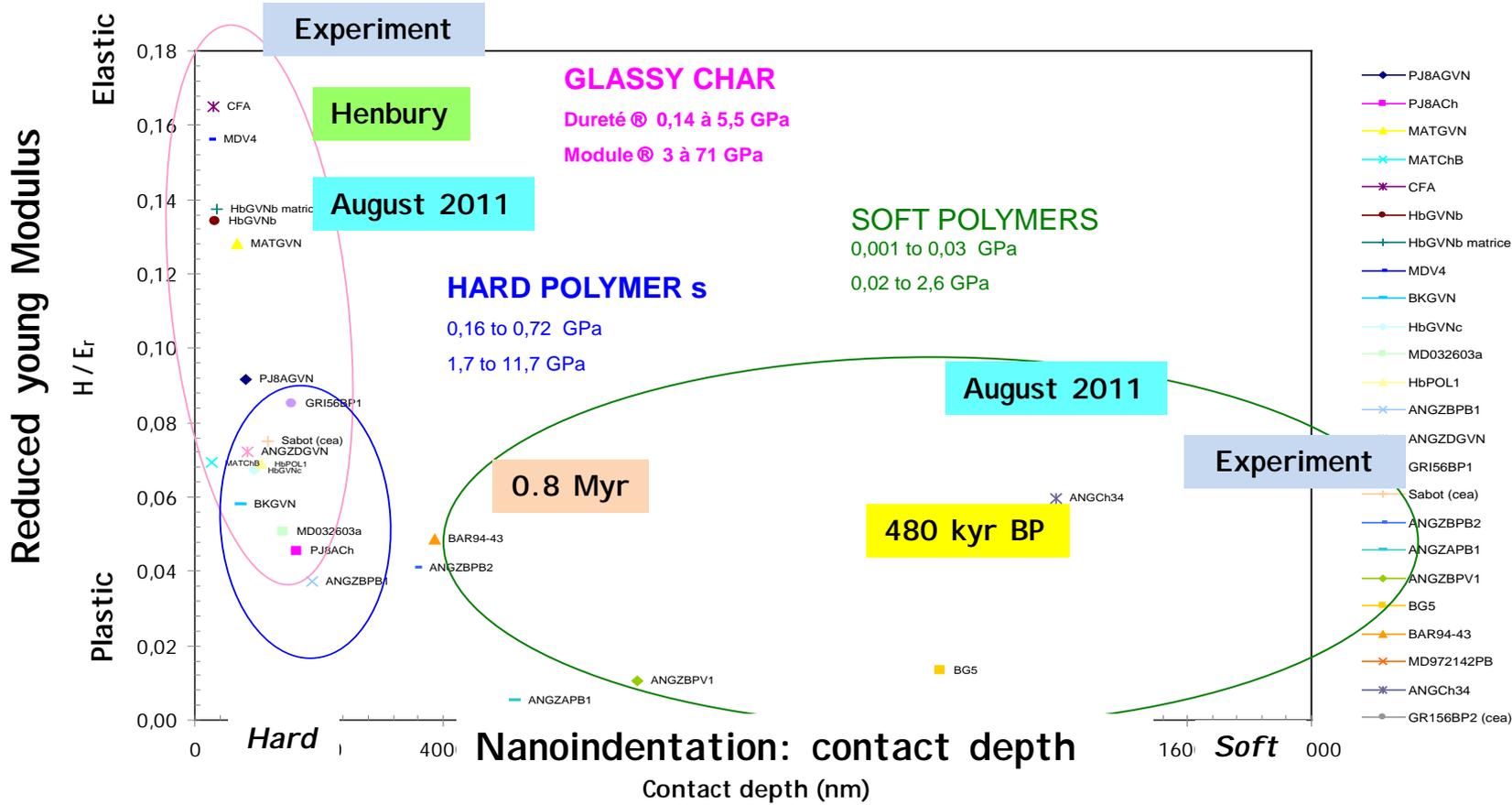
Stylatractus

100 µm

Marine aerosols
(Antarctica)

Mechanical properties of the Nano-Composites (under 10 mN charge)

Highly resistant, non biodegradable: effect of nanoparticles???



Young modulus of usual materials in GPa

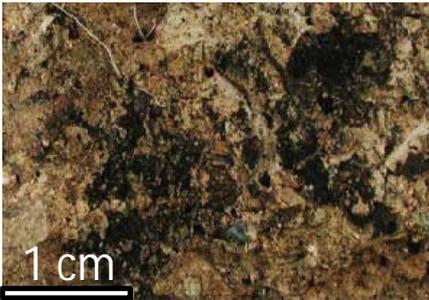
Diamond	Alumine	Steel	Mullite	Glass	Granite	Graphite	Concrete	Wodd	Polystyrene	Polyethylene	Rubber
1100	380	210	145	70	60	30	20 à 50	9 à 20	3,2 à 3,5	0,14 à 0,38	0,77 à 4,2

Aerial effects of cosmic airbursts

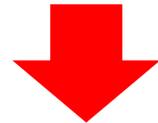


- Production of Polymer Nanocomposites (PNC) from terrestrial aerosols precursors
- Synthesis of new carbonaceous species
- Velocity reduction

Sudden atmospheric loading by carbonaceous aerosols



CCN effects:
Heavy rains
Violent hailstorms



Surface effects

Surface pulverisation of PNC :
hydrophobic, UV resistant, plastic/elastic

Change of radiation budget, surface
rheology, soil & water chemistry



Critical role of nano-sized particles TiO_2 , Al, As, Pb ...
on environment and human health

Cosmic airbursts

Pulverization at the Earth's surface of resistant natural composite plastics

Regional discontinuity



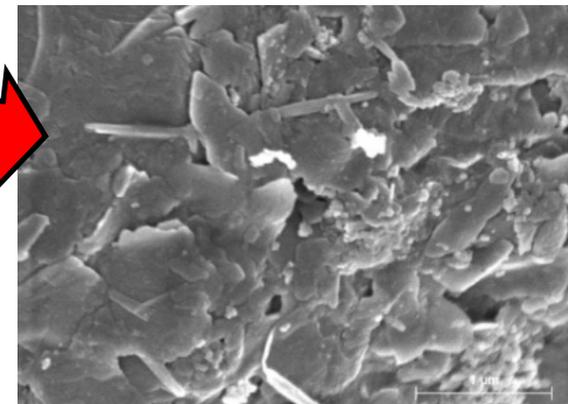
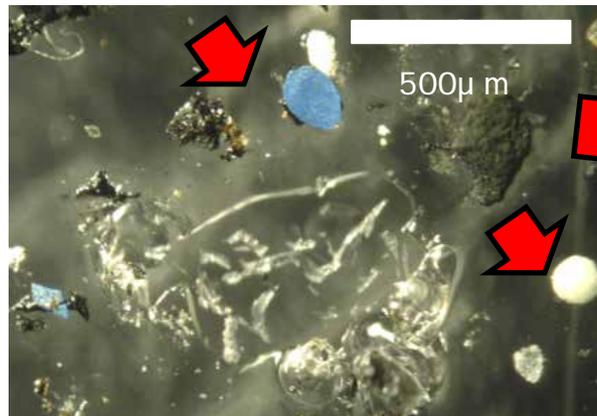
Remarkable surface



65 Myr K/T boundary layer
Trempe basin, Spain
coll. Davinia Díez-Canseco

Polymer nanocomposites and polymer-coated marine microfossils

Binocular



ESEM

long lasting records of cosmic airbursts and impact events

Take-home deep thoughts ...

- Cosmic impacts are part of Earth and Human history
- Cosmic impacts have been a driving force of life and human evolution
- Cosmic impacts are deep in human psyche and most probably in our genes.
- Cosmic impacts are essential for the re-cycling of life and of natural resources

Why not re-discovering how to continue the great adventure with cosmic impacts? ...

Thank you!