welcome to
Symposium X

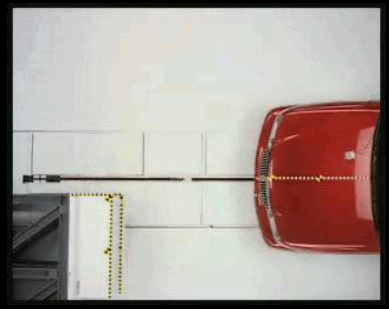
Sym'po|si|on, Sym'po|si|um <n.; -s, -si·en>

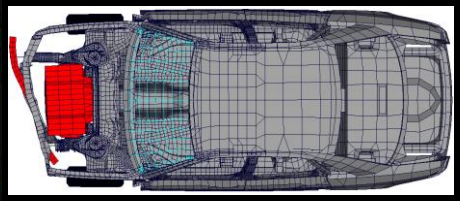
Drinking party of aristocratics in ancient Athens with strict rules. A *symposiarch* supervised the mixing of the wine with water, insuring a mix that would be conducive to conversation but (theoretically) not strong enough to lead to debauchery. As they drank, guests would give speeches, recite poetry, and sing about subjects proper to the symposium - love, eros, drink, and the like. Hired entertainment might also be present, at the discretion of the host. .....

The X-files of materials science - unsolved riddles from the dawn of research

Dierk Raabe
Max-Planck-Institut für Eisenforschung,
Düsseldorf, Germany
MRS 2006

metallurgy 2000 B.C.



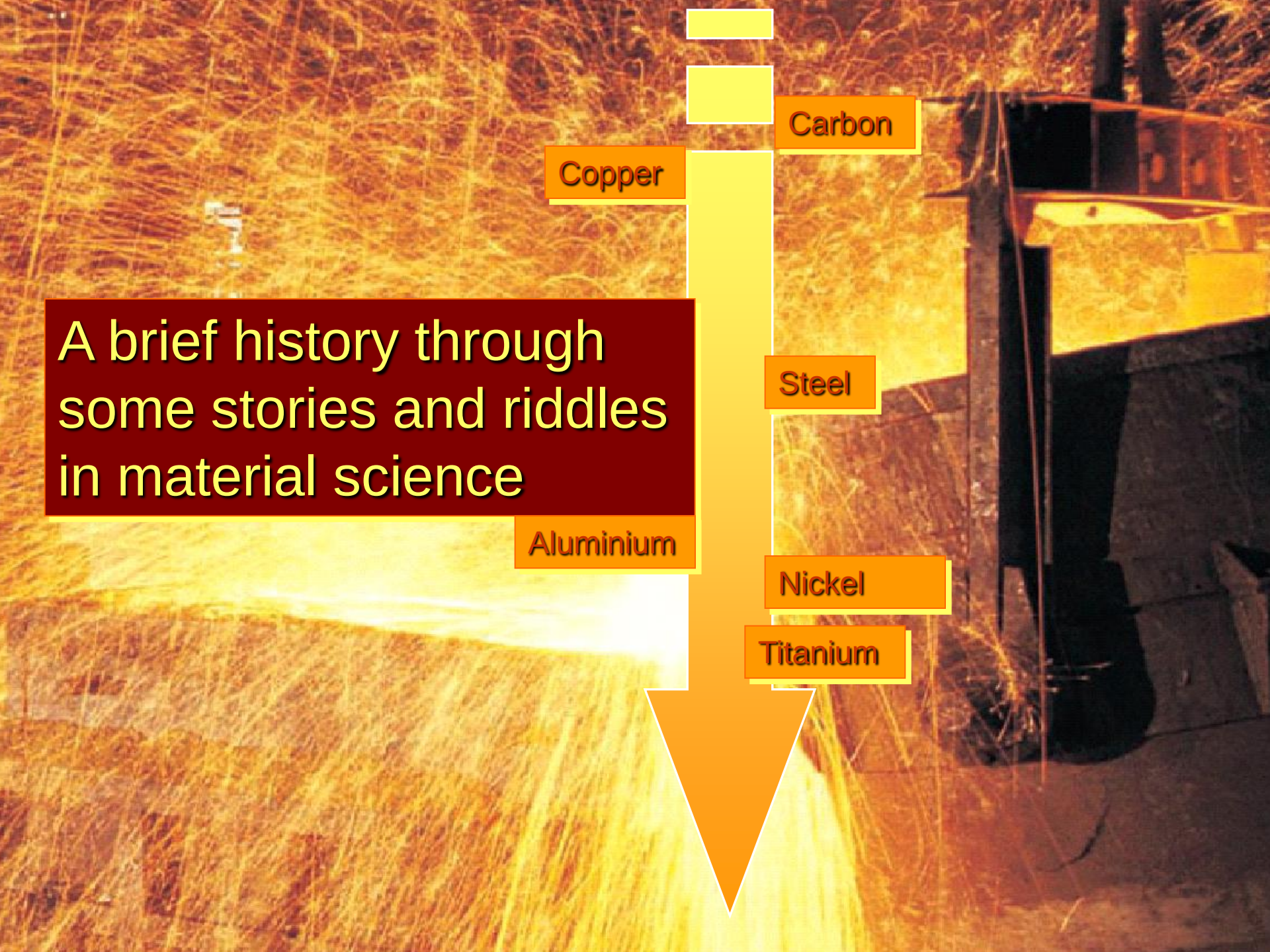


metallurgy 2000 A.C.

Travel through time

beer can 1820

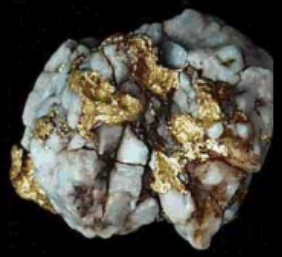
beer can 2000


Carbon
Copper
A brief history through some stories and riddles in material science
Steel
Aluminium
Nickel
Titanium

Some Mythology
and Etymology

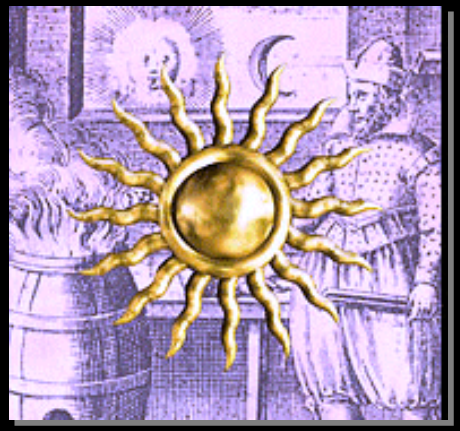
Aldebaranium, Austrium, Cassiopeium, Didymium, Erythronium, Florentinum, Glucinium, Helvetium, Illinium, Klaprothium, Krokoit, Masurium, Menachit, Plumbum-Candidum, Plumbum-Nigrum, Thoron, Unnilpentium

GOLD



egypt new empire
(18. –20. dynasty):
Amenophis I – III, Thutmosis I – IV, Hatschepsut, Echnaton, Ramses I – IX, Tut-ench-Amun

Echnaton replaces Amun by sun god Aton (gold as symbol)



Alchimist symbol for gold

Gold as a symbol for sun, power, and gods

Gold helmet (sumer); Amulet (Monte-Alban); Sun-carriage of Trundholm (Denmark)

Very spooky sky-map (star-gate) found in Nebra (Germany) (mystical version)

Gold, wealth and stupidity :
King Midas and God Dionysos (Bachus)

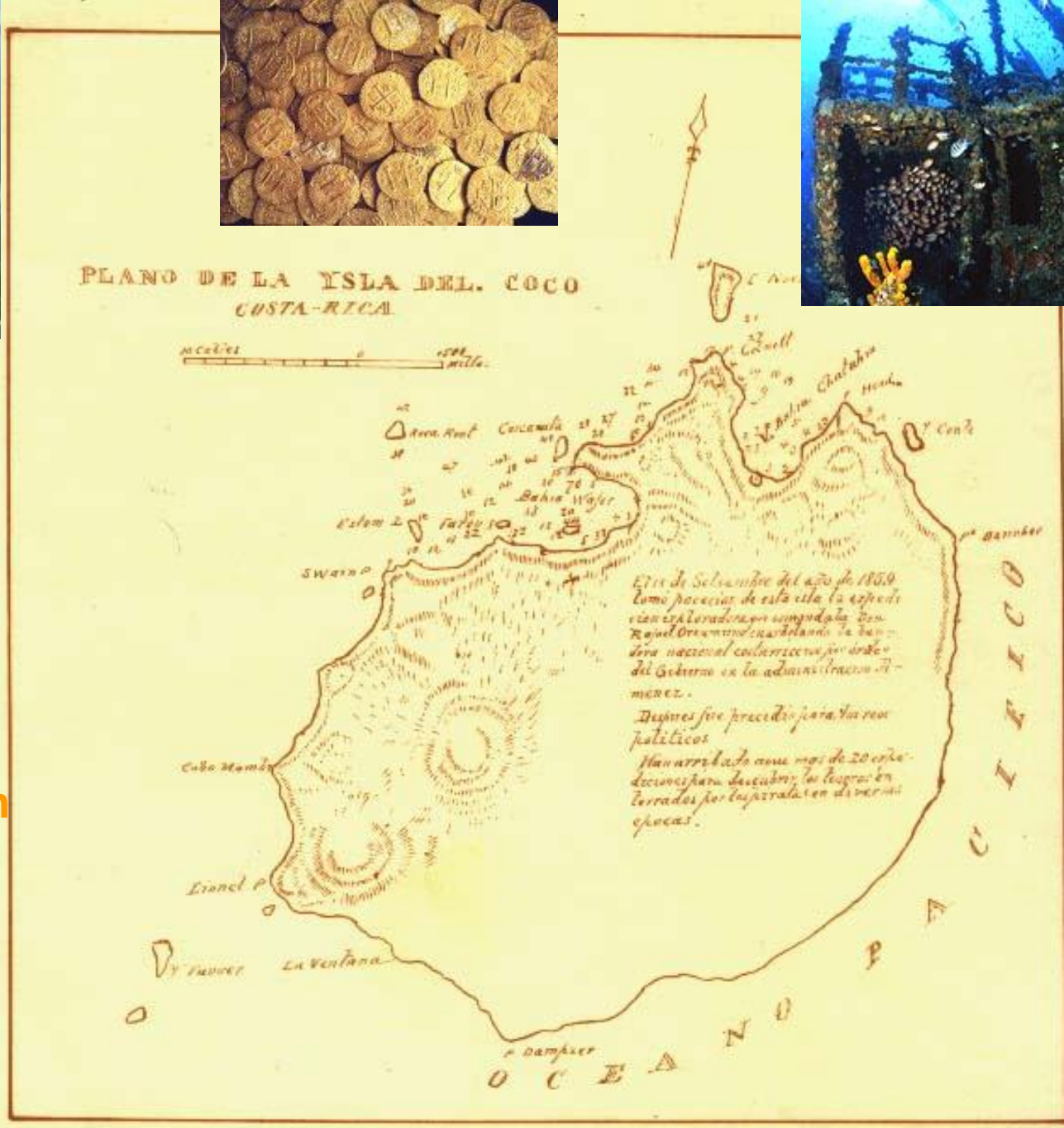
Midas of Phrygien, Satyr, wish, Gold-on-touch, nearly starve,
bath in river Paktolos (Phrygien / Lydien), carries gold since then

El Dorado

treasure hunting
(Central America)

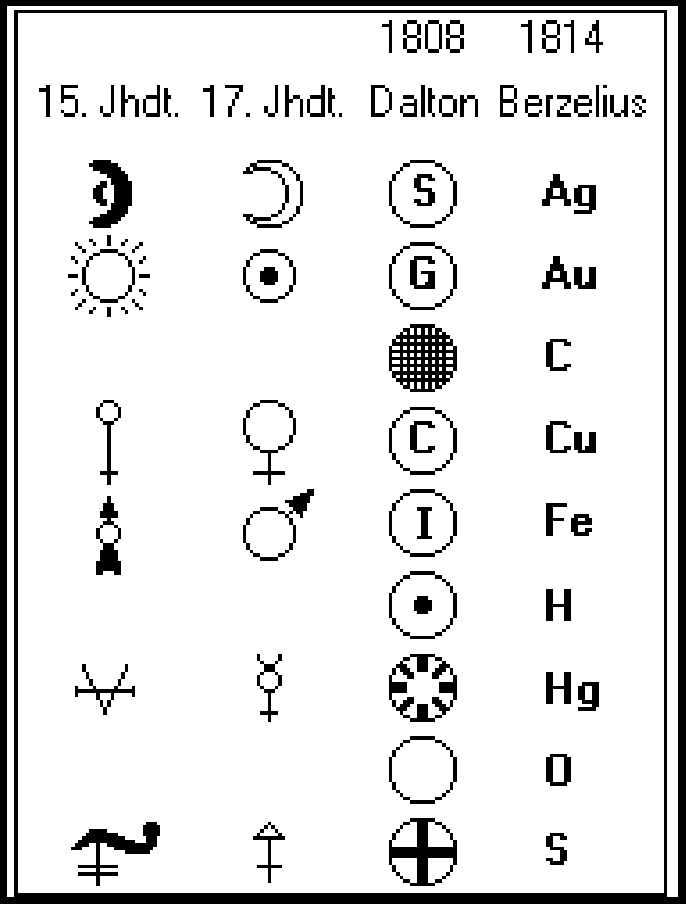
priests, gold dust

treasure island
coconut island (Costa Rica)
4,5 km X 6 km
Robert Luis Stevenson
Edward Davis, 1702
Benito Bonito, 1819



Map drawn by Jose Maria Figueroa 1883

Mythology after the early empires



Using metals: big change between man and environment

Good harvest and conditions were imparted from the gods not provided by technology

Using metals introduced strong change in man‘s world view and his view of the gods

Man became a more independent actor; was no longer a mere object of the gods: growth of self-confidence; master of his own luck

See: Euripides, Plinius, Ovid, Horaz, Vergil: Gods become angry because of mining and metallurgy. It was assumed that everything that was meant for man was available on the surface of the earth. The gods hid the minerals by purpose.

“Aurea prima sata est etas… “ the 4 world ages: Gold, Silver, Copper, Iron

Central figure: titan Prometheus

This discussion lasted until Rennaissance (Leonardo; Georg Agricola)

Prometheus

regenerative medicine in old Greece

Hephaistos (see also: Vulcan, Wieland, Ikaros and Dedalos myth)

son of Zeus and Hera, disabaled person, sea, saved, greek god of mining, metallurgy, engineers (Achilles weapons of Athenes and Achilles, Helios wagon, arrows of Eros), married to Aphrodite

Copper "cuprum" (name of cyprus in latin)

world largest copper industry

12

Greek and Phoenician Settlements in the Mediterranean Basin, about 550 B. C.

Donau
Schwarzes Meer
Troja
mykenische Vase
HETHITER
Zinn
MITANNI
Mykene
MYKENER
Kap Gelidonya
Kaş
Knossos
Kreta
Kommos
zyprische Töpferwaren
Ugarit
Stein-anker
Zypern
Elfenbein
MITTELMEER
Stein-anker
Byblos
Sidon
KANAANITER
Kupfer
Glas
Tyros
Marsa Matrûh
Pelusium
Askalon
Memphis
ÄGYPTER

Copper

what do these species have in common ?

guys from planet vulvan (Spock),

octopus,

snails,

spides,

..

Titanium

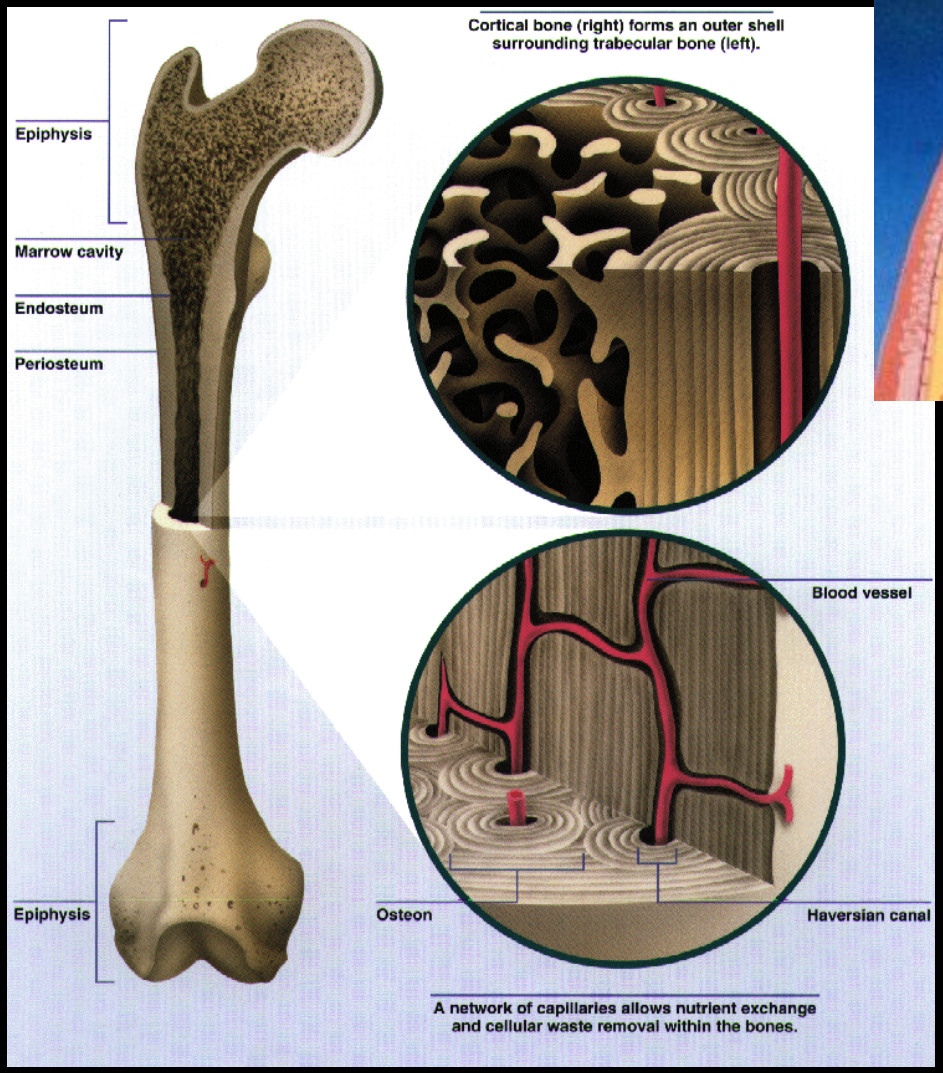
The titans (Hyperion, Iapetos, Okeanos, Koios, Krios, Rhea, Kronos .... Prometheus)

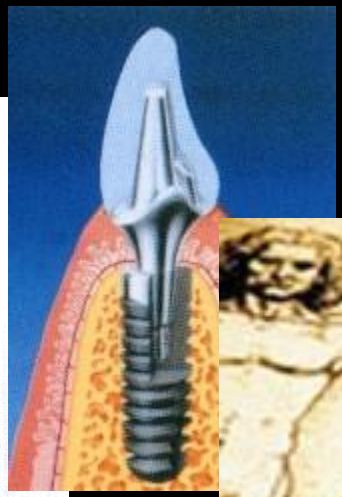
Children of Gaja and Uranos (greek: earth and sky)

1795, Klaproth

Oscar II - class

Titanium in the body
20 GPa as opposed to 110 GPa
– quo vadis Titan ?





the materials science of Terminator IV

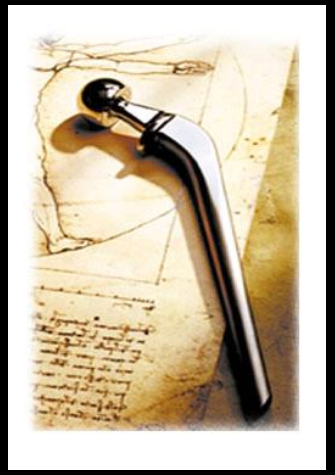
- very bio-compatible

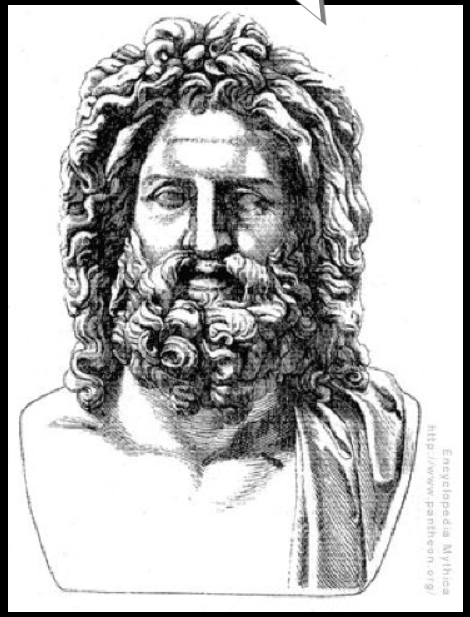
the world‘s first implant

Tantalos and the meal of the gods

was killed and grilled

was angry

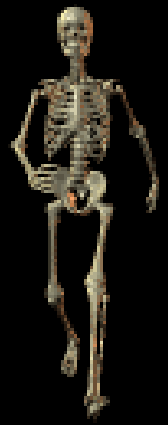




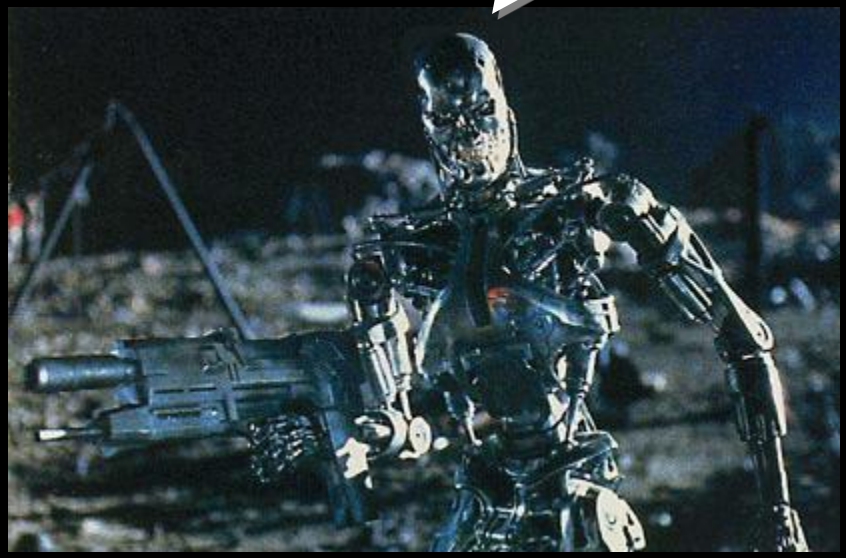
shoulder replaced by ivory

speaking of bone ….
endoskeleton vs. exoskeleton

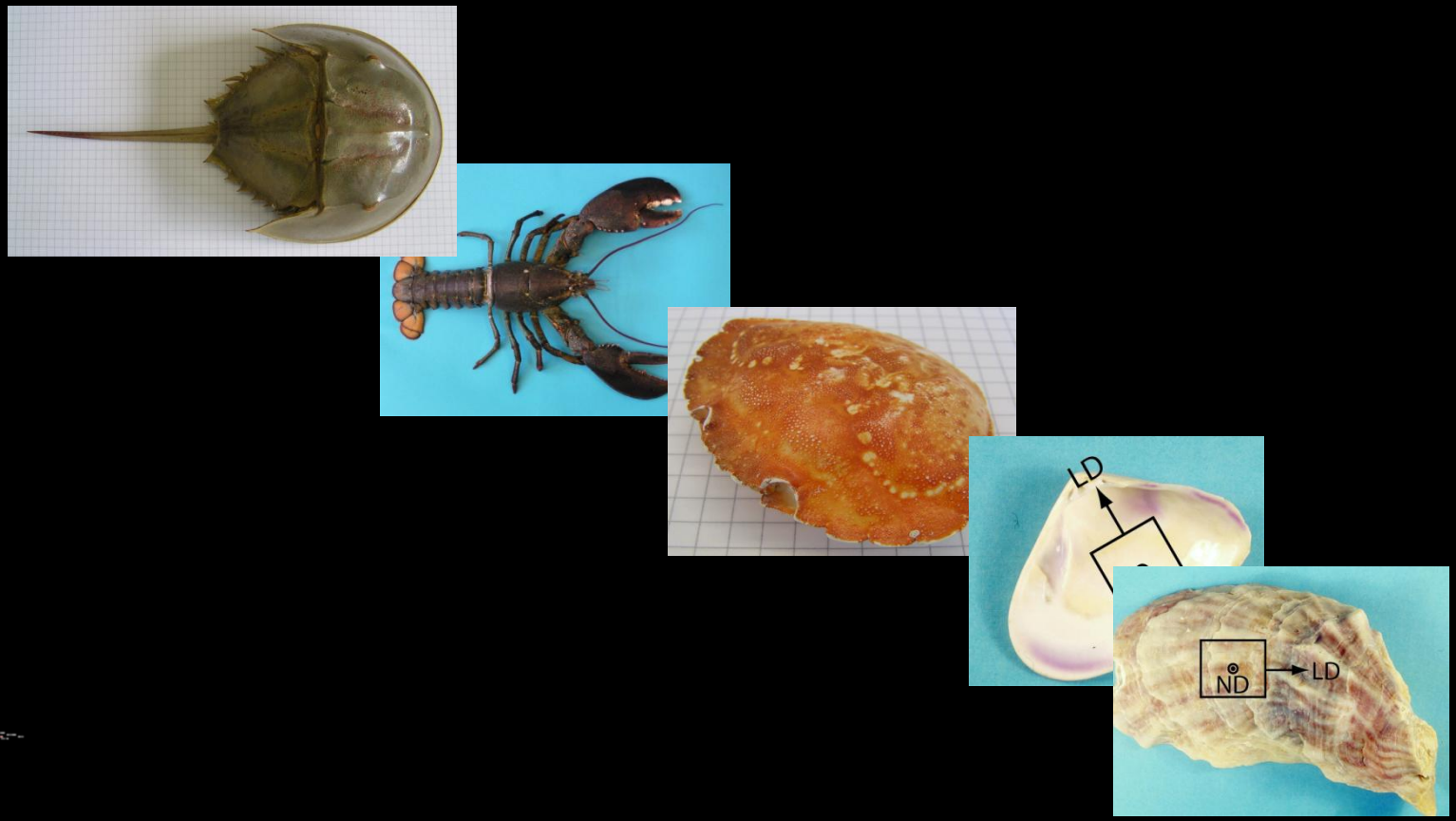
Hi, I am the traditional version



Hi, I am the new California version



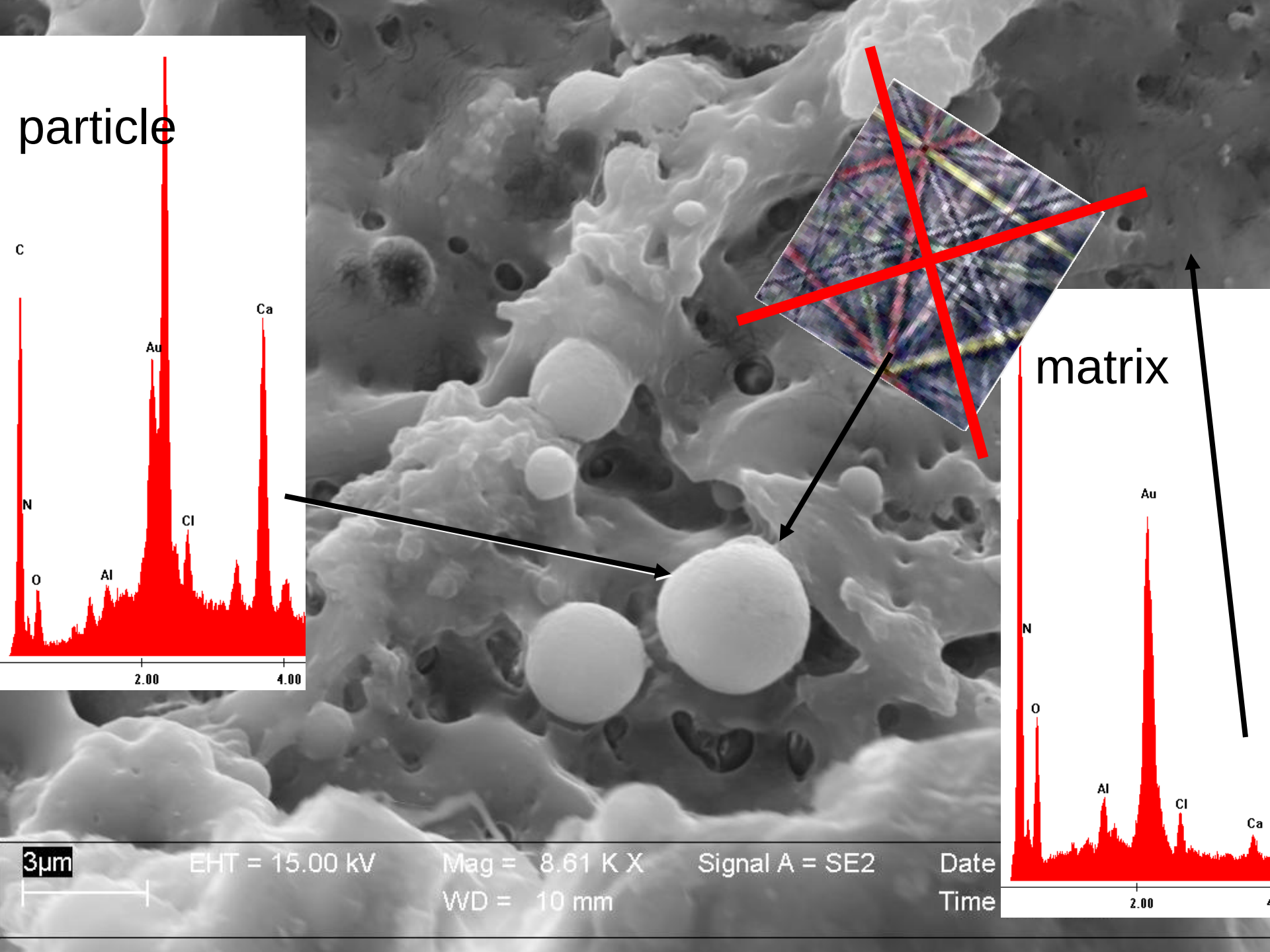
speaking of bone ….
endoskeleton vs. exoskeleton

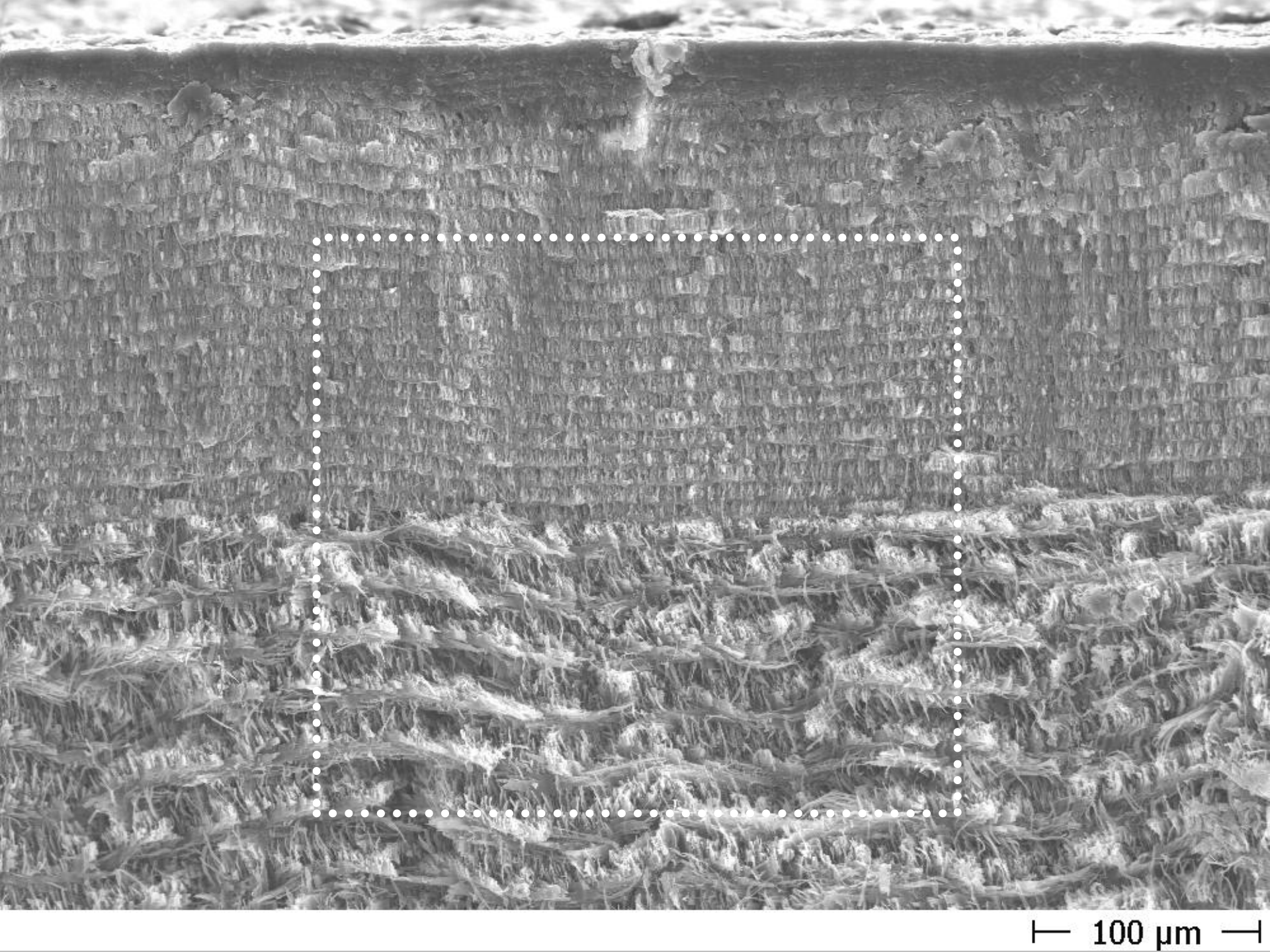


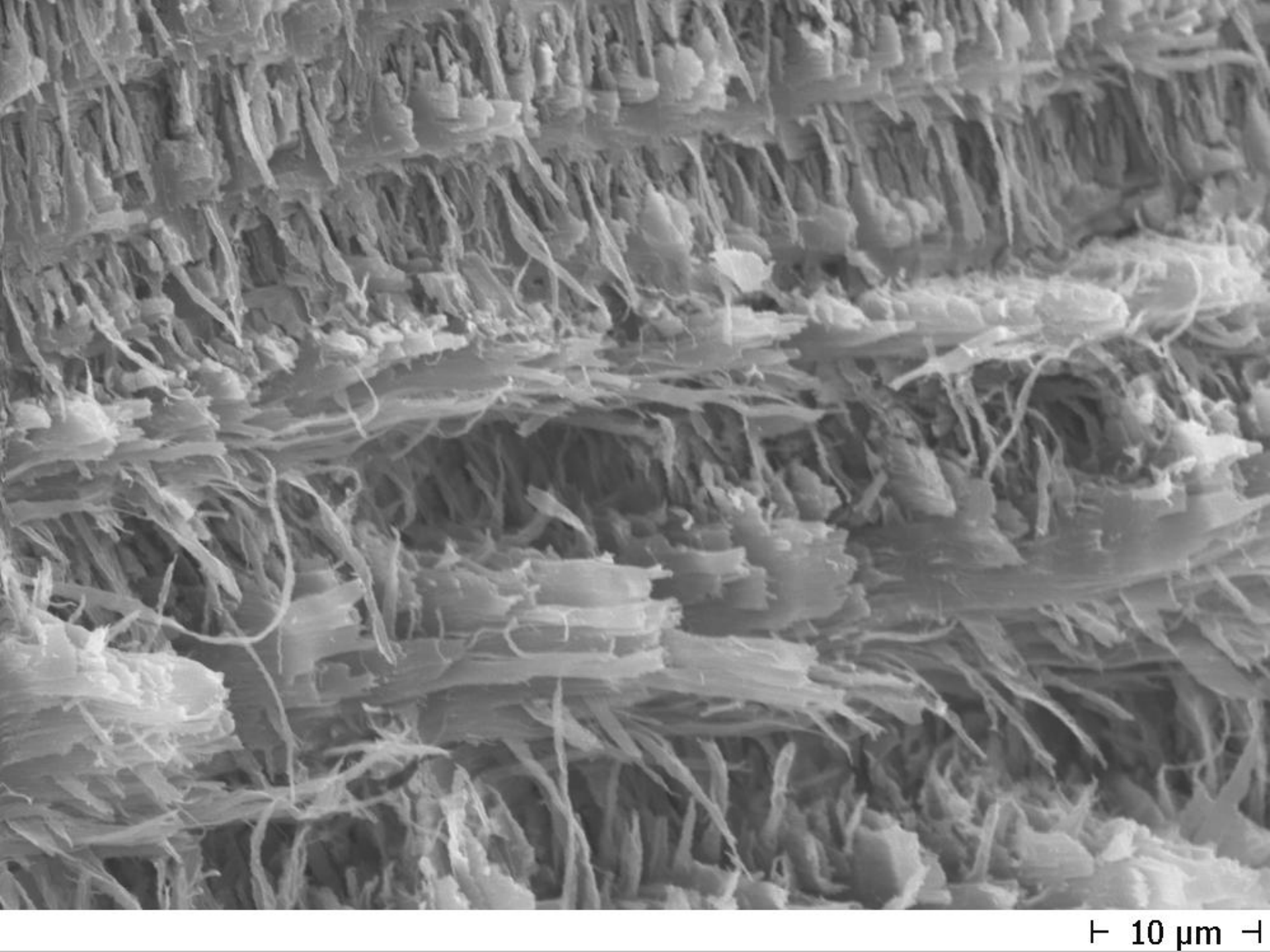
limited by weight and molding constraints …..

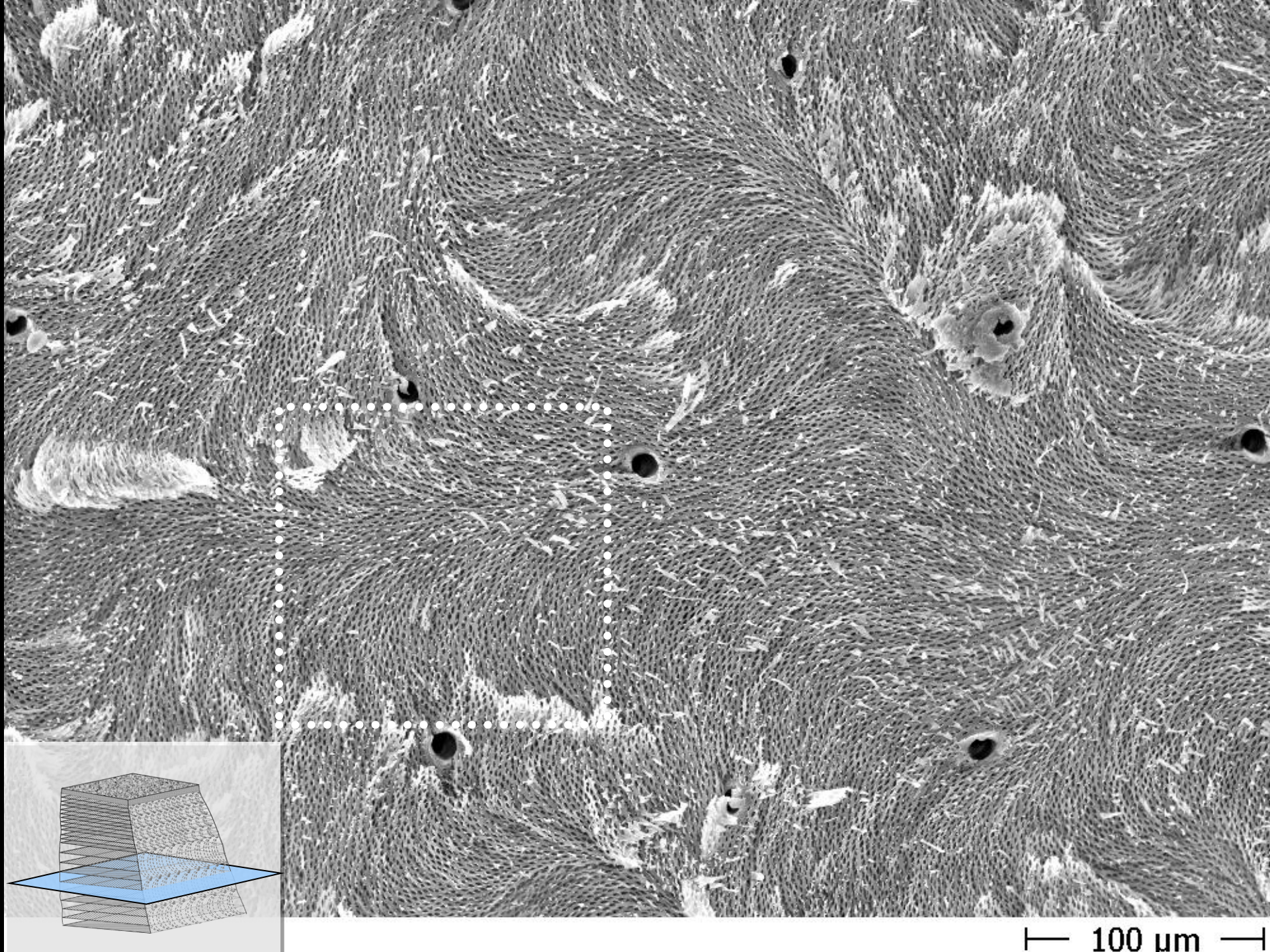
…OK: .. imagine molding for humans…. ;-)

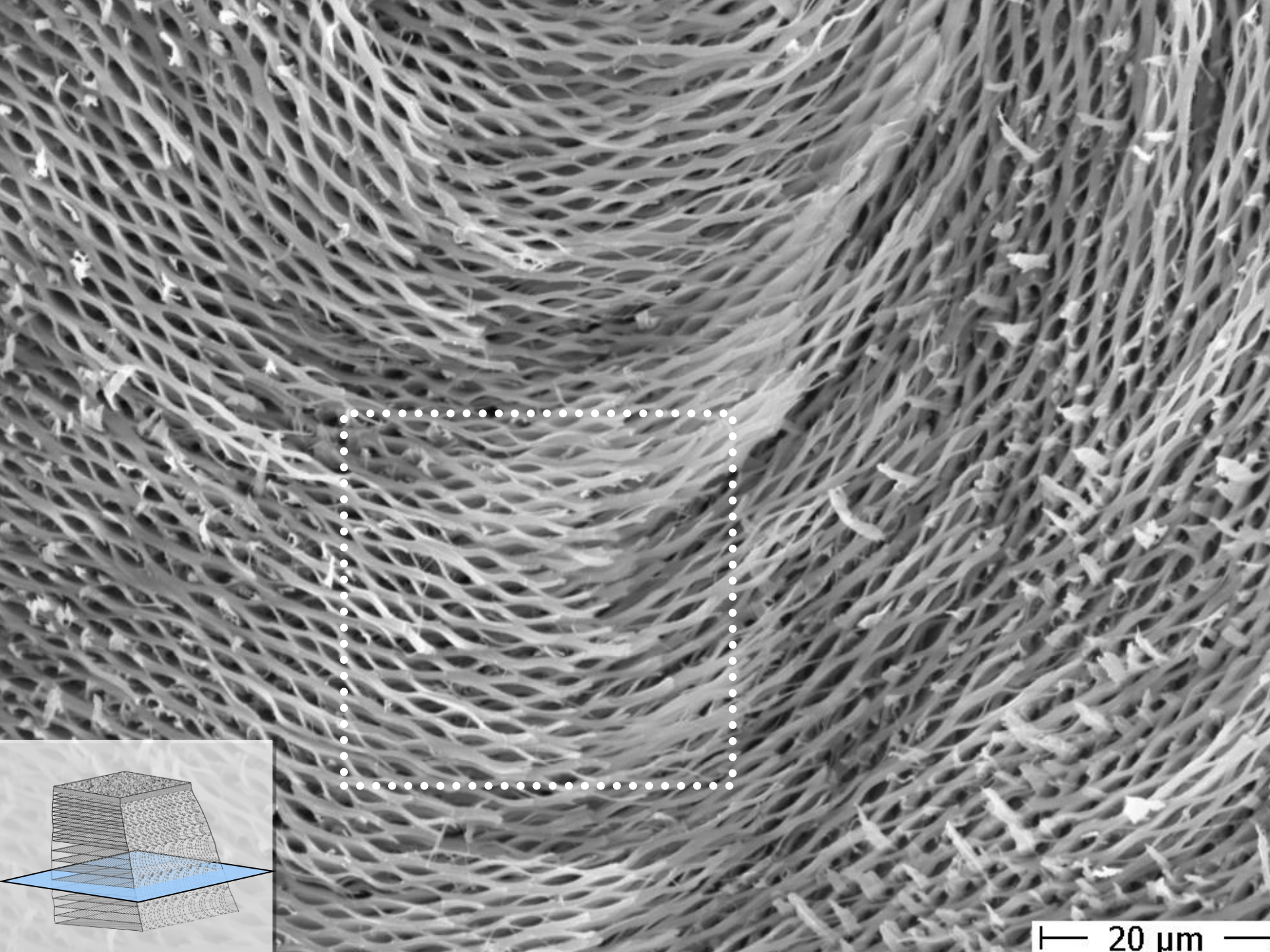
…. but do weight-limits really apply …. ??

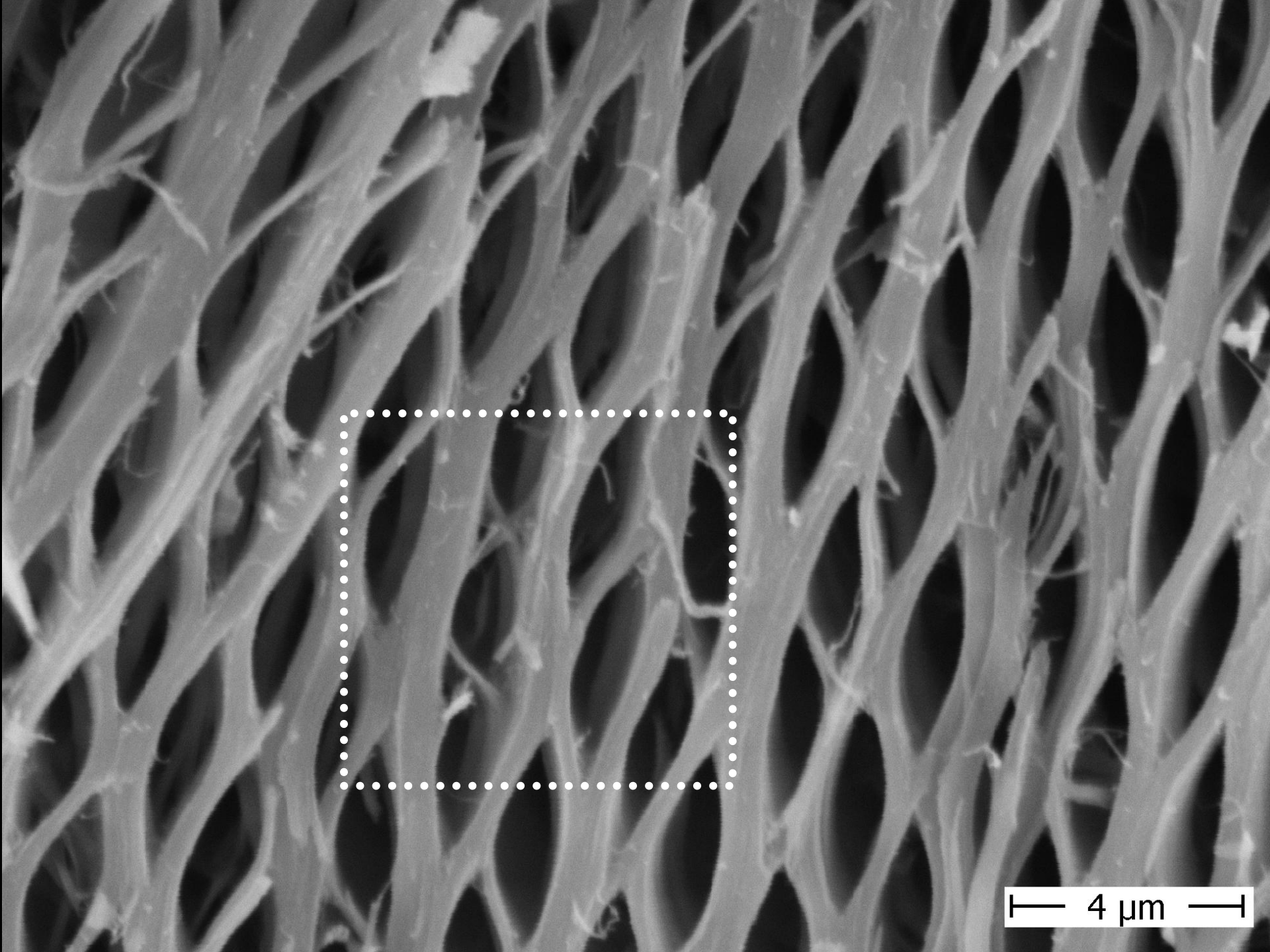

particle
C
Ca
Au
N
Cl
O
Al
2.00
4.00
matrix
Au
N
O
Al
Cl
Ca
2.00
3µm
EHT = 15.00 kV
Mag = 8.61 K X
WD = 10 mm
Signal A = SE2
Date
Time

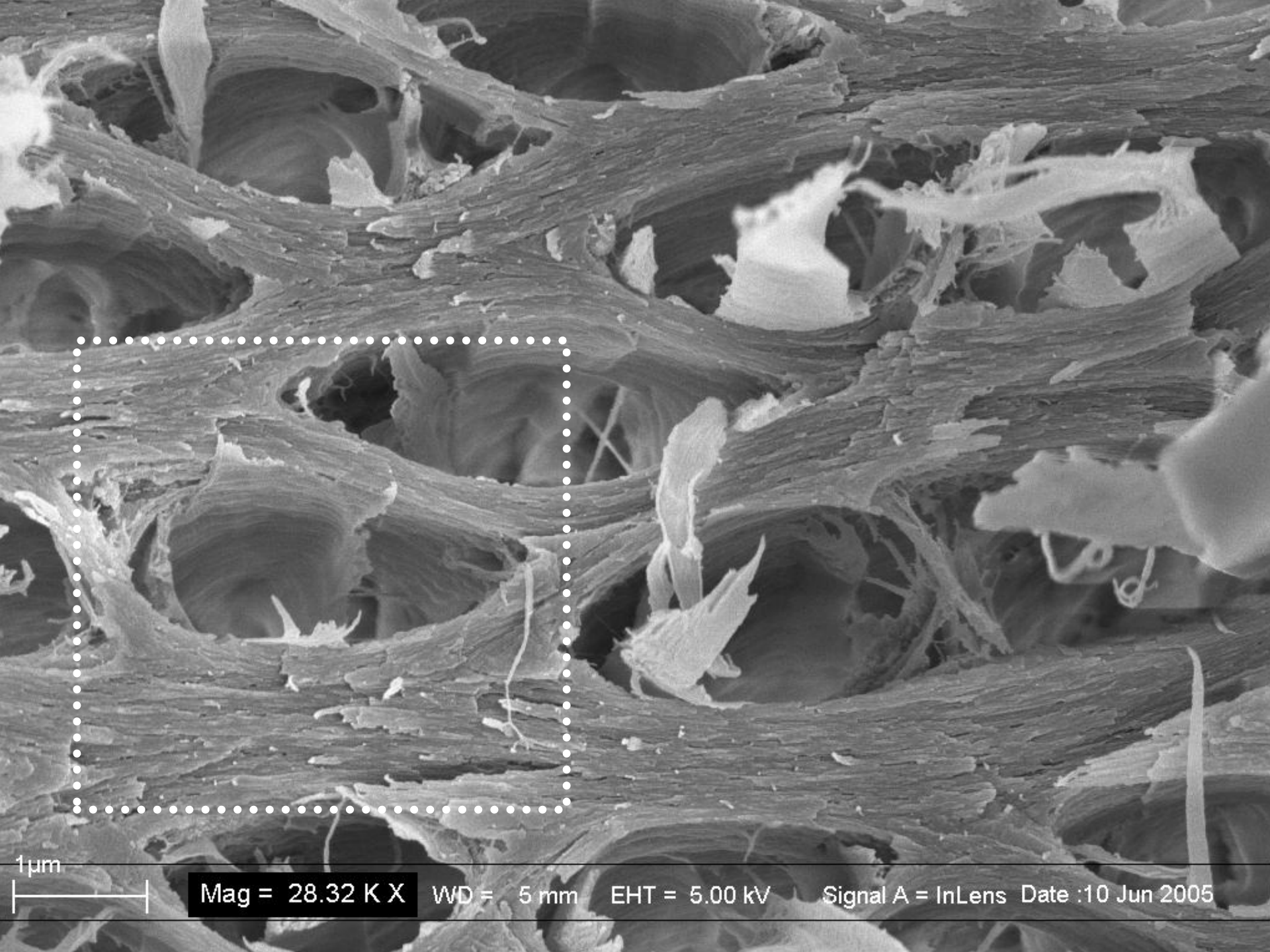

100 µm

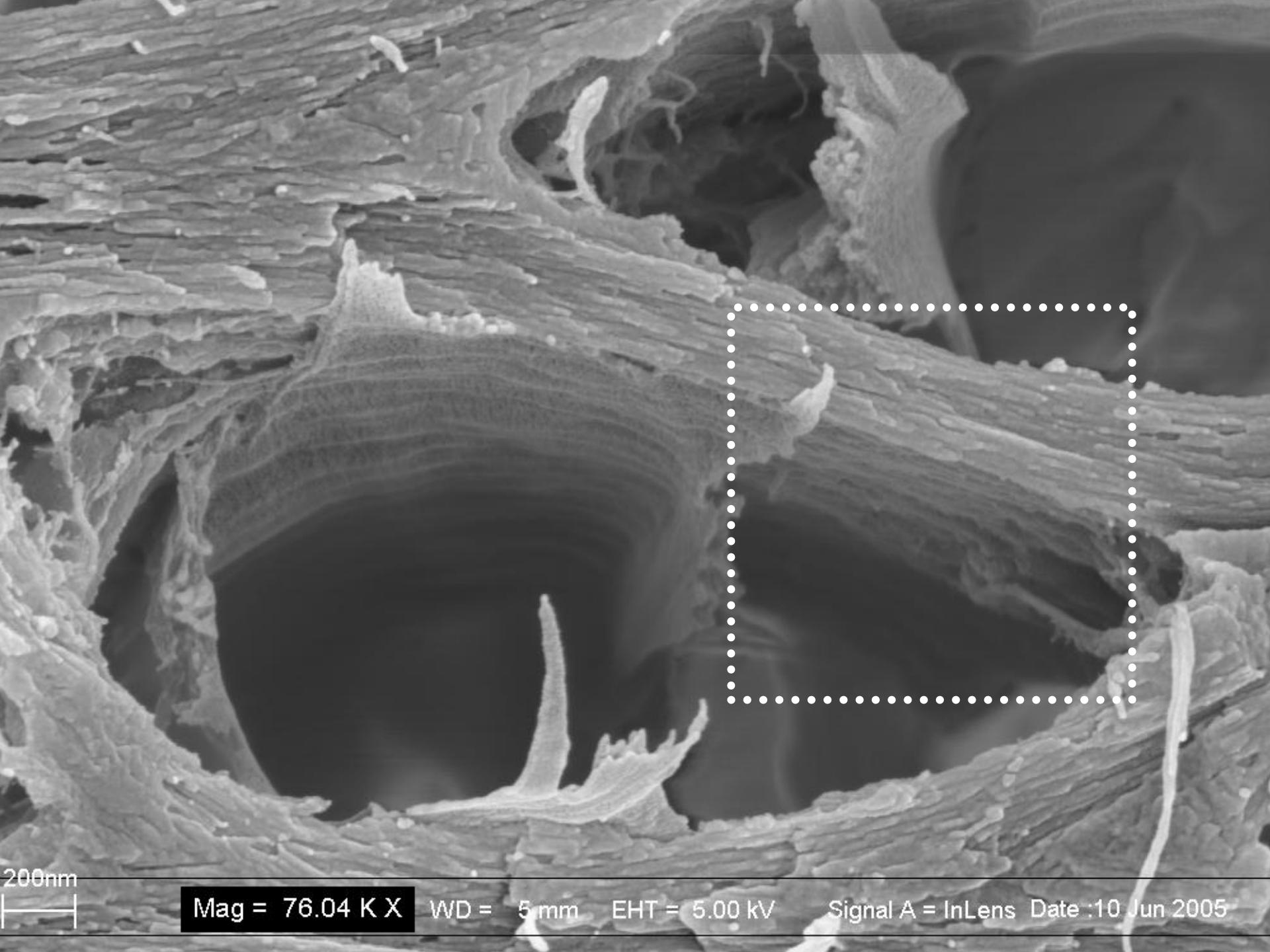

⊢ 10 µm ⊣


100 µm


20 µm

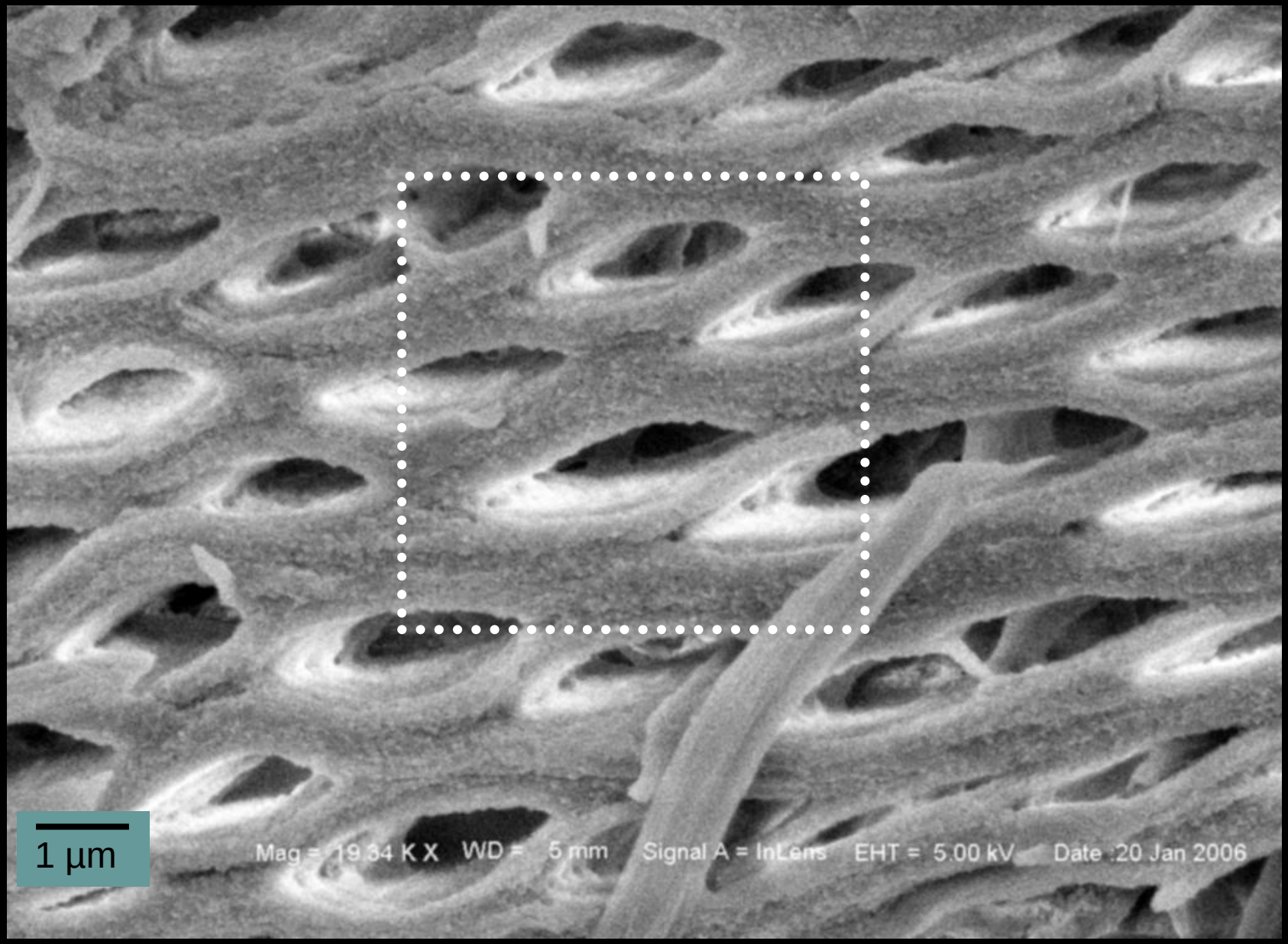

4 µm


1µm
Mag = 28.32 K X
WD = 5 mm
EHT = 5.00 kV
Signal A = InLens
Date :10 Jun 2005


200nm
Mag = 76.04 K X
WD = 5 mm
EHT = 5.00 kV
Signal A = InLens
Date :10 Jun 2005

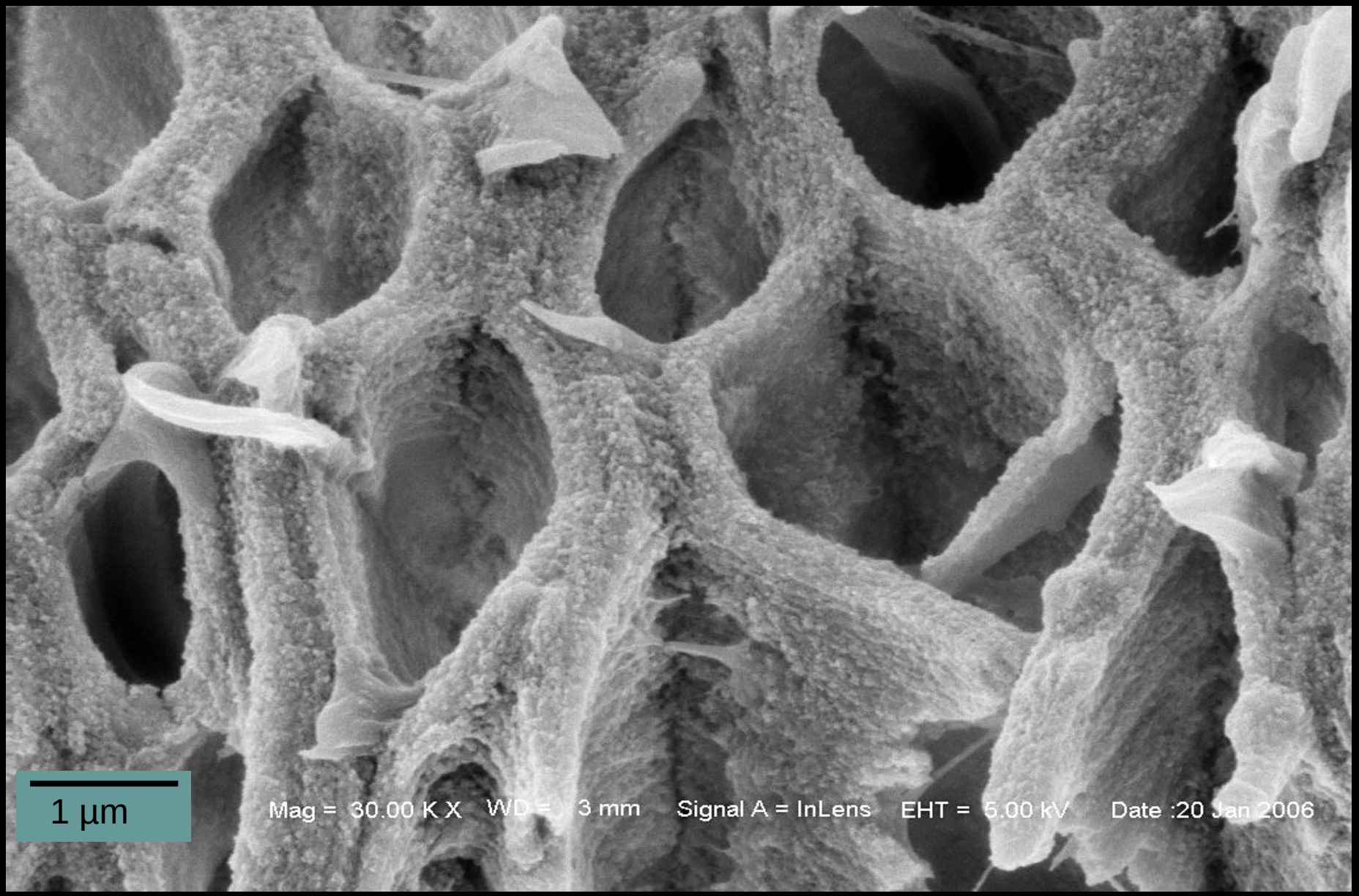
100nm
Mag = 133.31 K X
WD = 5 mm
EHT = 5.00 kV
Signal A = InLens
Date :9 Jun 2005

SEM chemical deproteinization



D. Raabe, lecture, MRS Fall, 28. Nov. 2006, texture lobster

SEM chemical deproteinization



D. Raabe, lecture, MRS Fall, 28. Nov. 2006, texture lobster

modern exoskeleton

modern exoskeleton

Thu Aug 21, 4:40 AM ET

Japanese companies are preparing to lauch a robot suit which helps the disabled or aged to walk. This file photo shows a university student demonstrating a prototype.(AFP/file/Yoshikazu Tsuno)

Berkeley Lower Extremity Exoskeleton, 2004

STOP
STEEL

anglo-saxon: iren
celtic: isarnon
old german: isarn, isen
latin, Fe: ferrum

some history

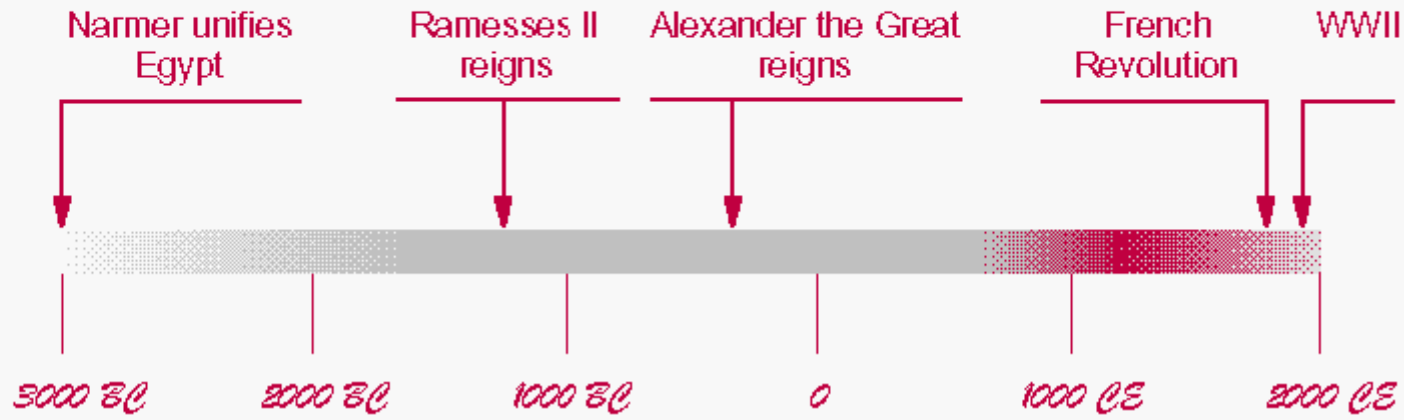
Cave-men : Hematite : “Leonardo‘s“ choice

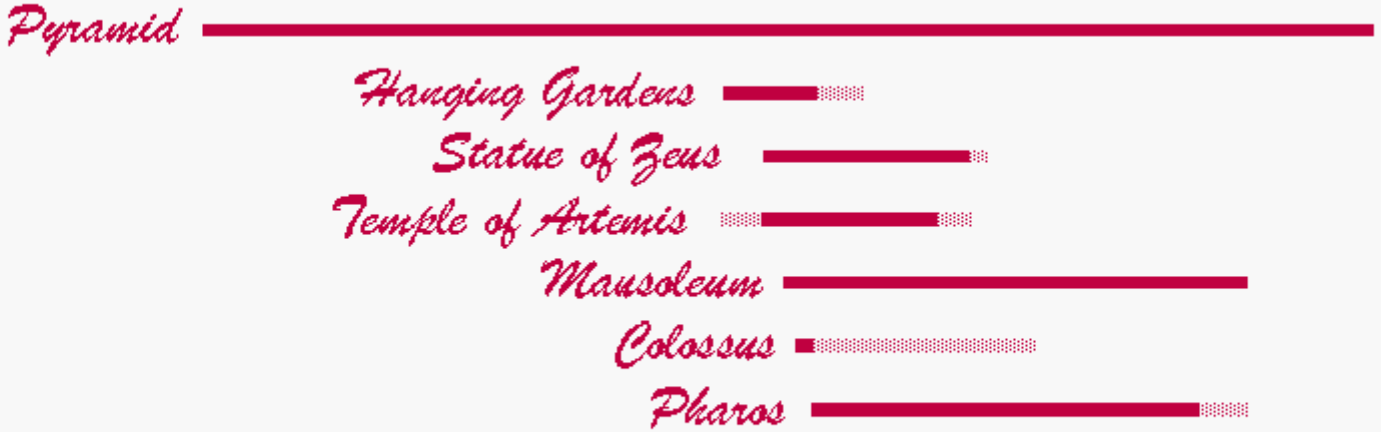
First ore reduction: since 3000 b.c. (Anatolia, Turkey, Syria)

From ca. 1000-1500 b.c. : Standard product for weapons

Mid-Europe: Hallstadt (Austria), Latène (Switzerland)

Chronology

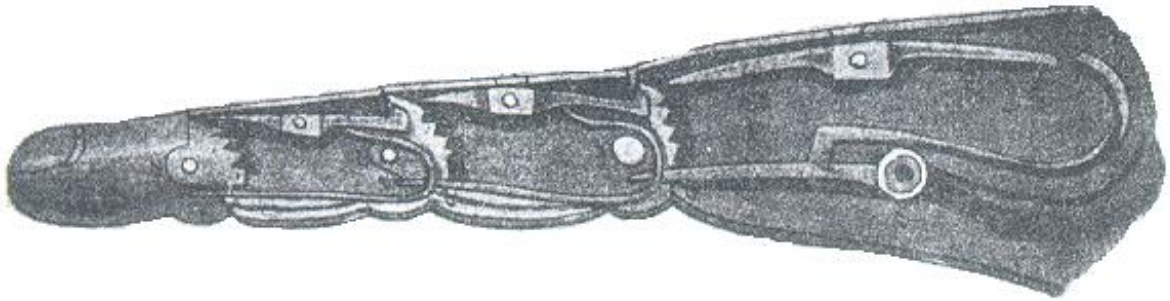


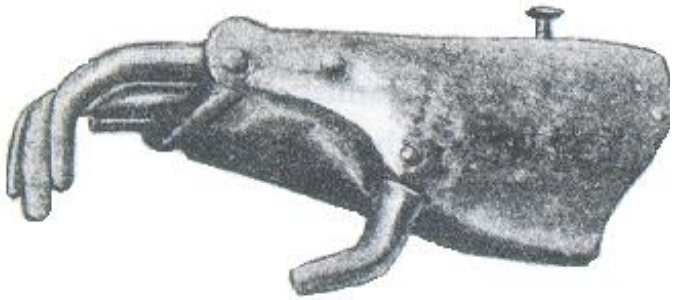


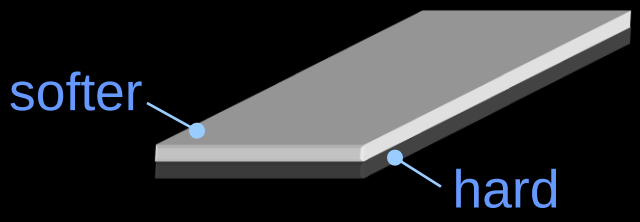
USA, since independence

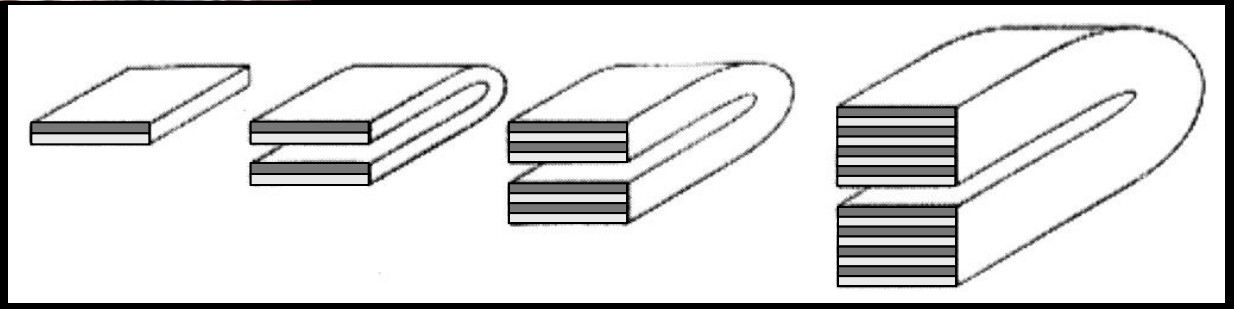
12.03.1889

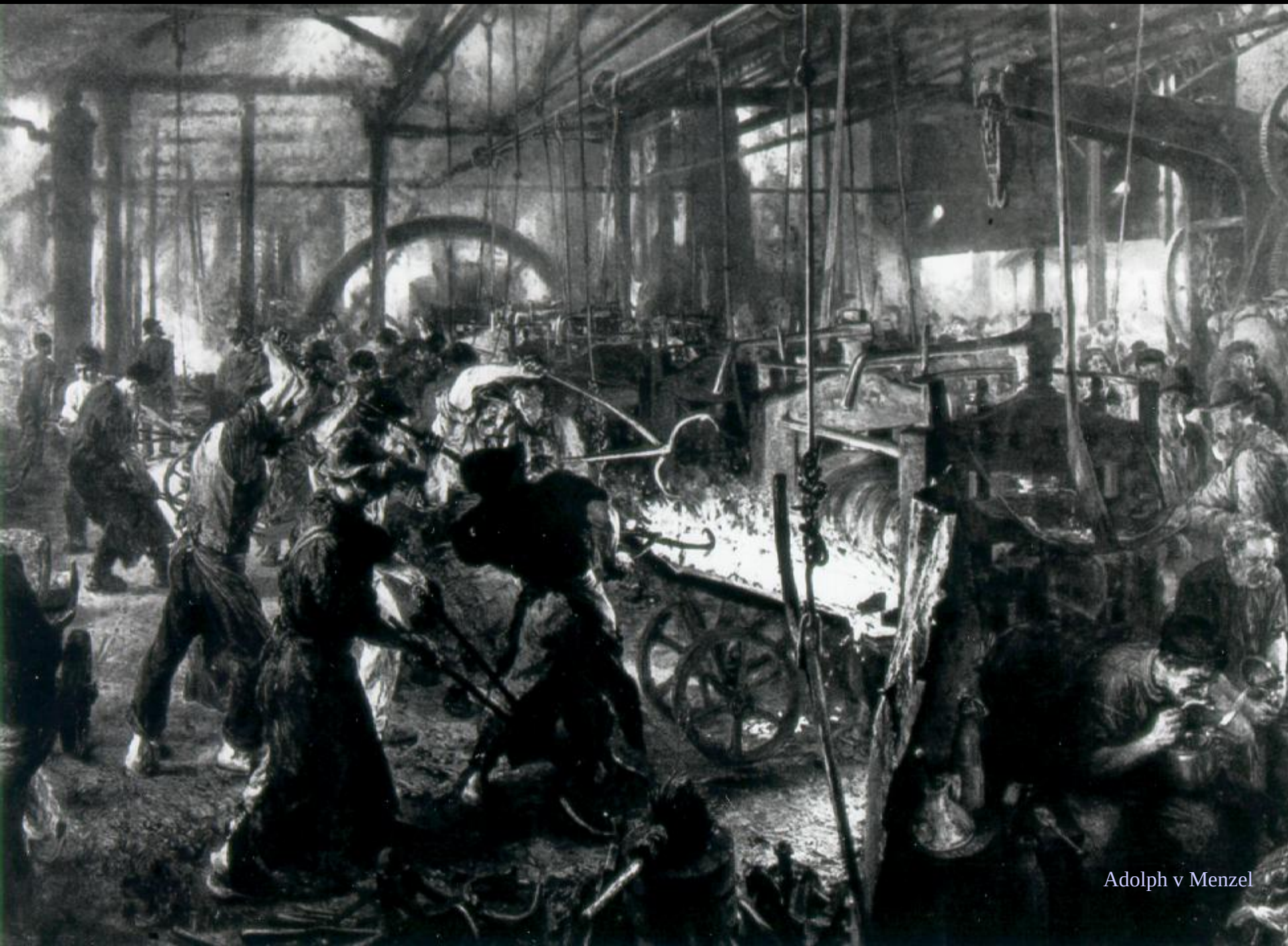
Eiffel tower

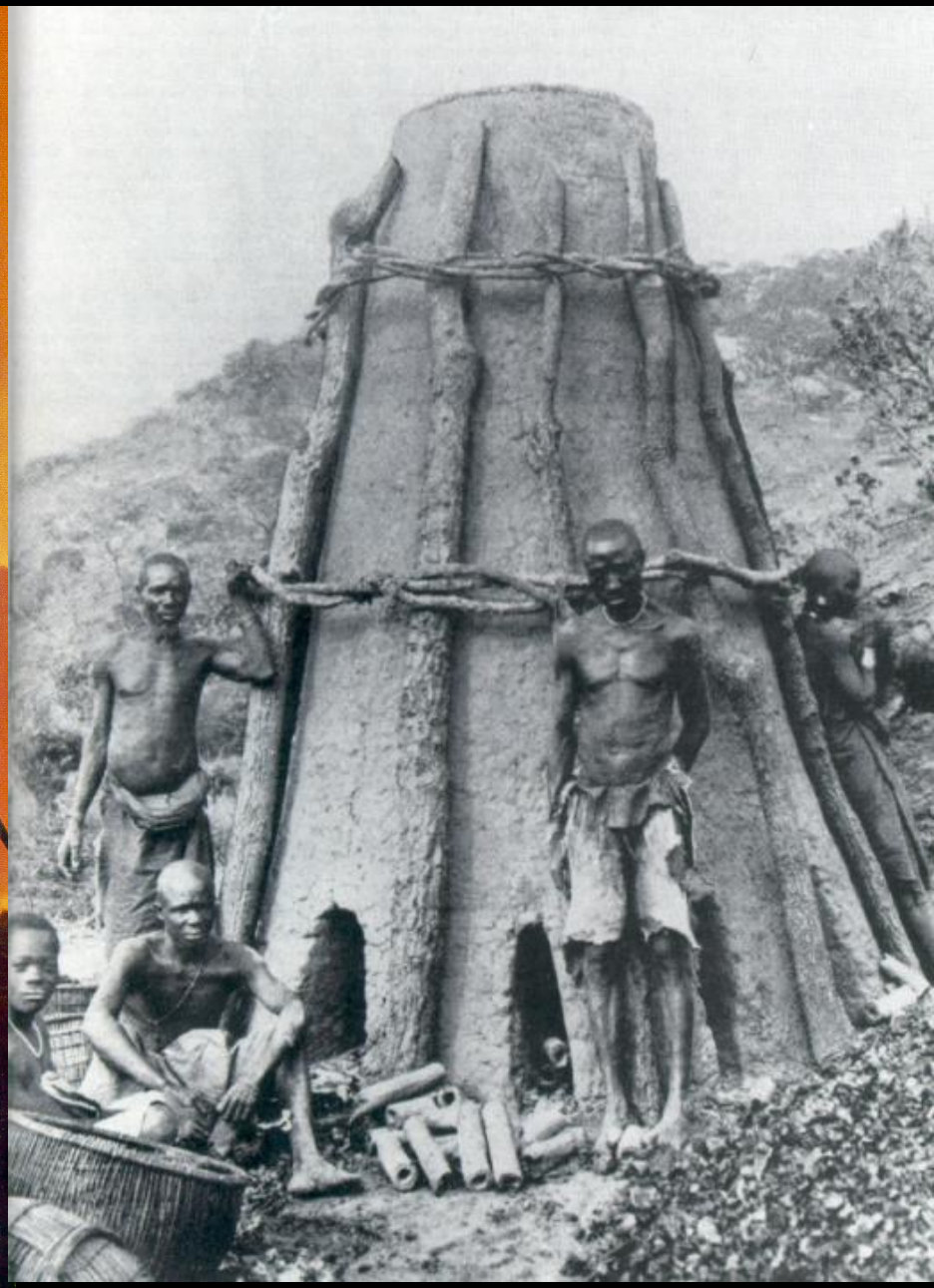


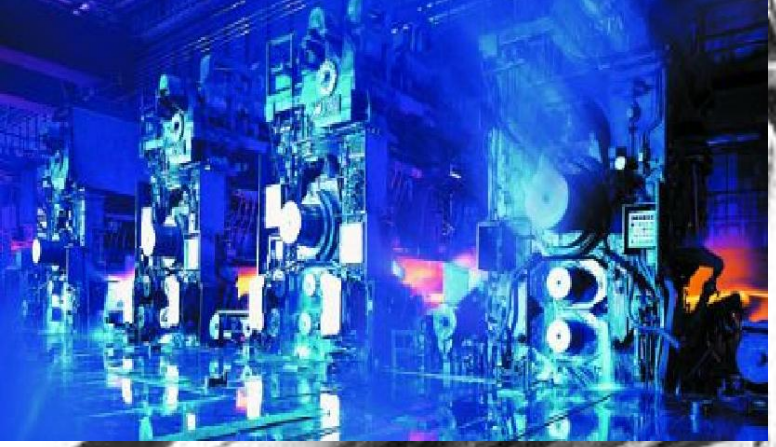


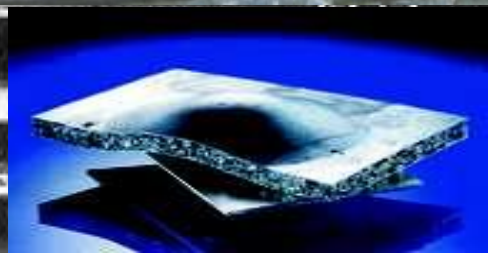

softer
hard



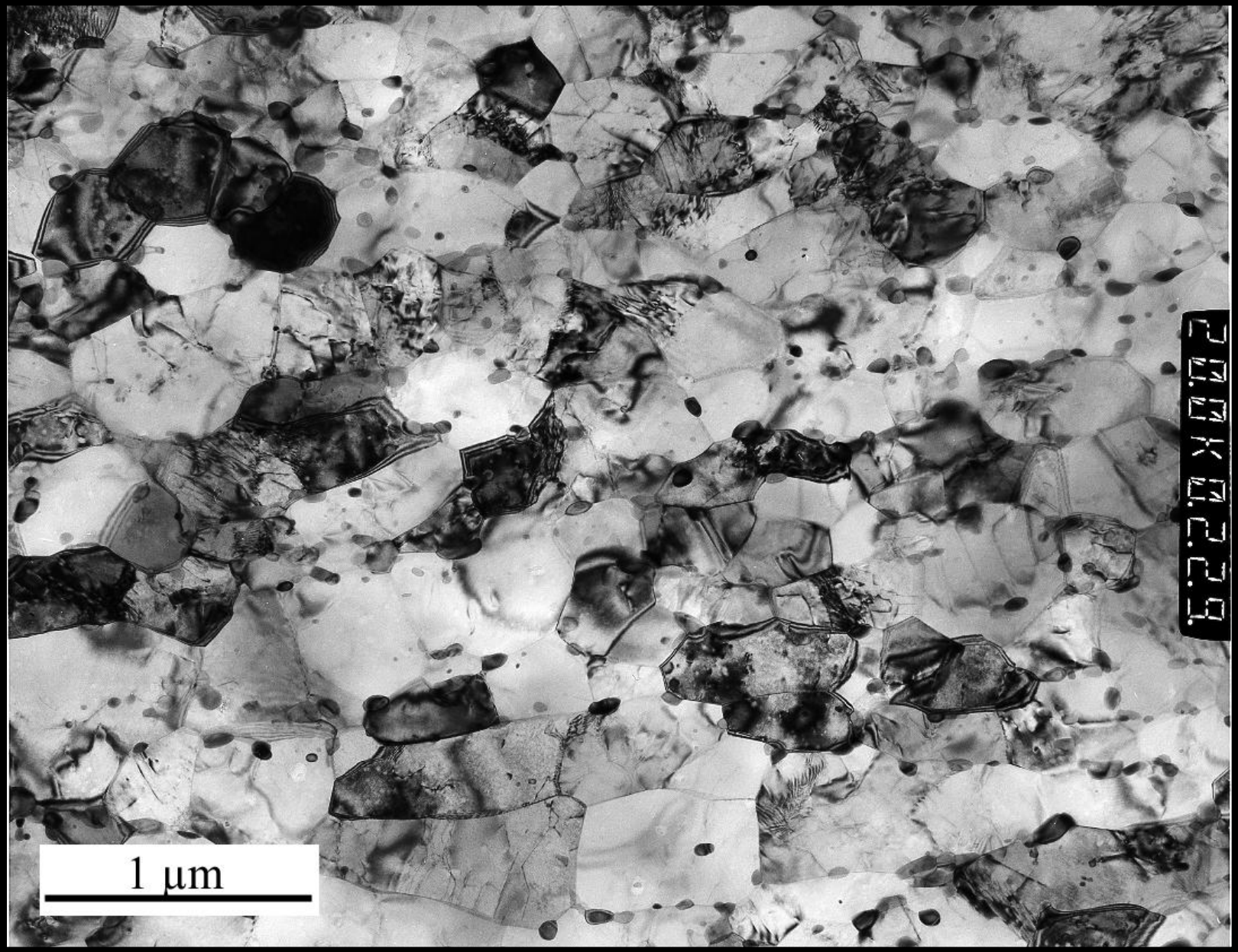

Adolph v Menzel



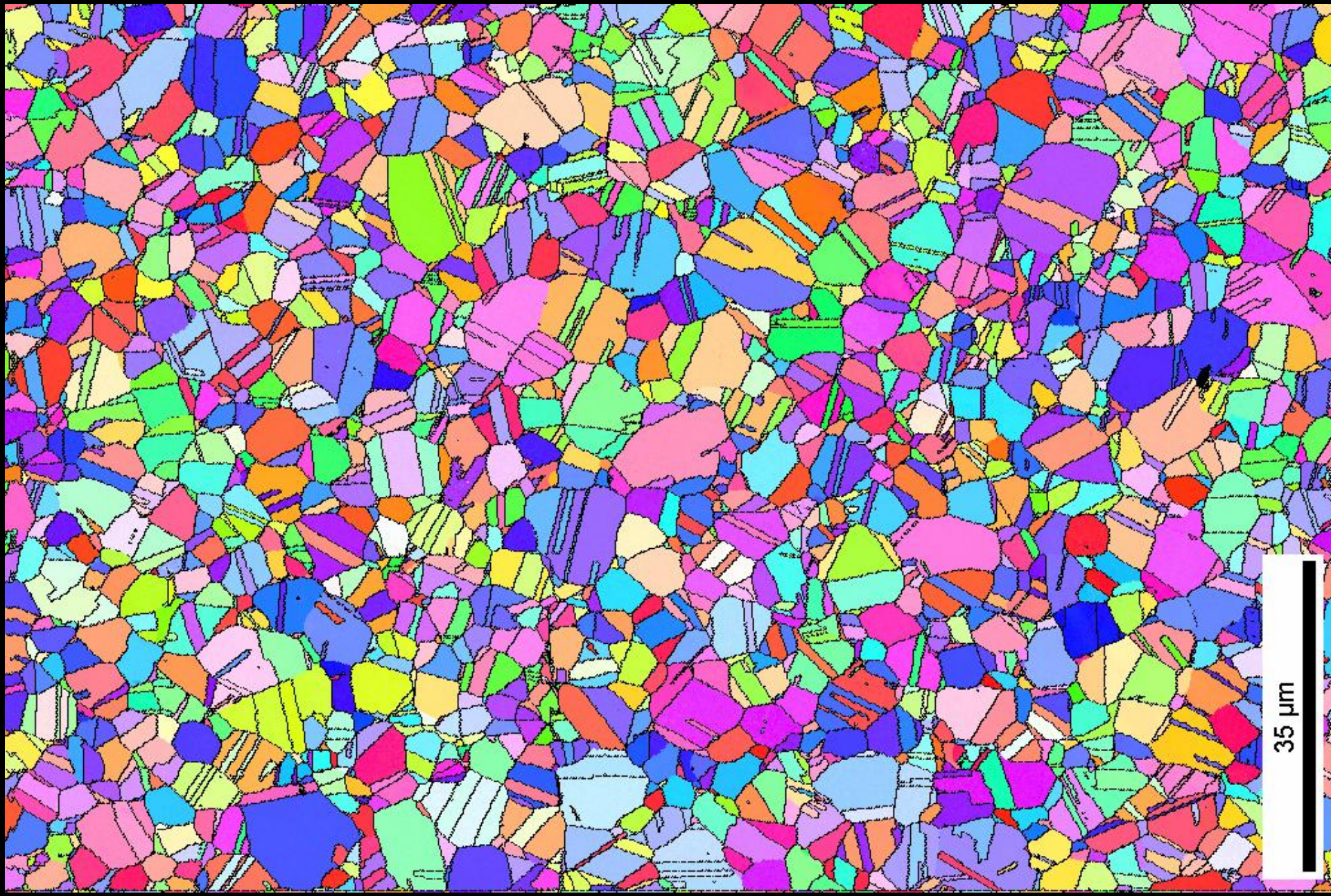




UFG Steels

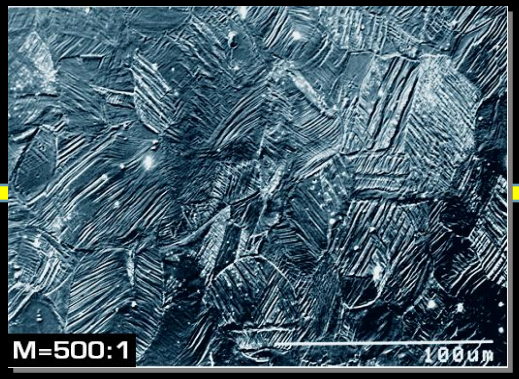


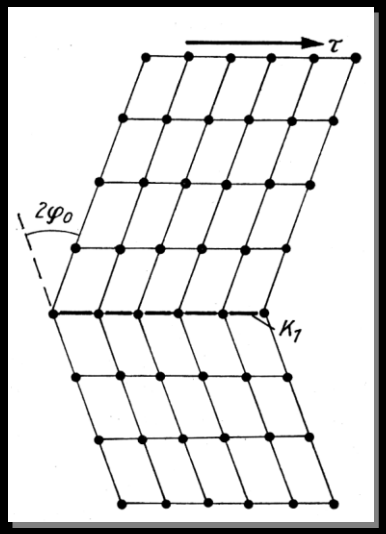
TRIP, TWIP and Triplex Steels



TWIP

deformation twinning



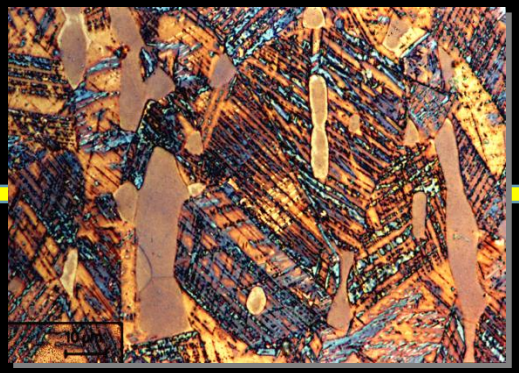


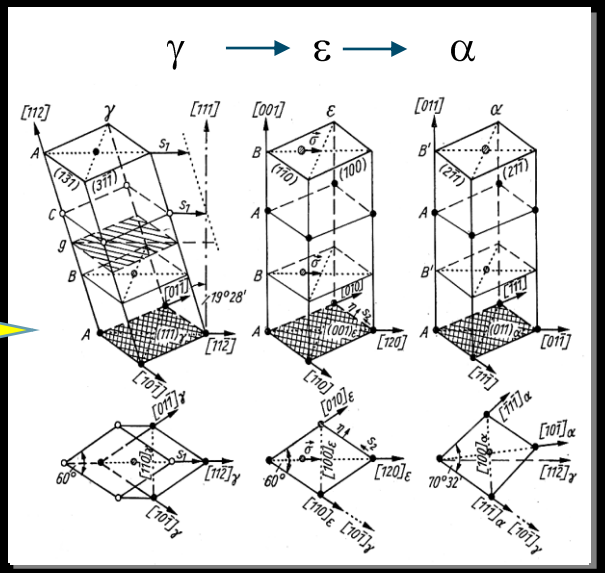
Austenitic FeMn [Al, Si]Steels

Austenitic / Ferritic FeMn [Al, Si] Steels

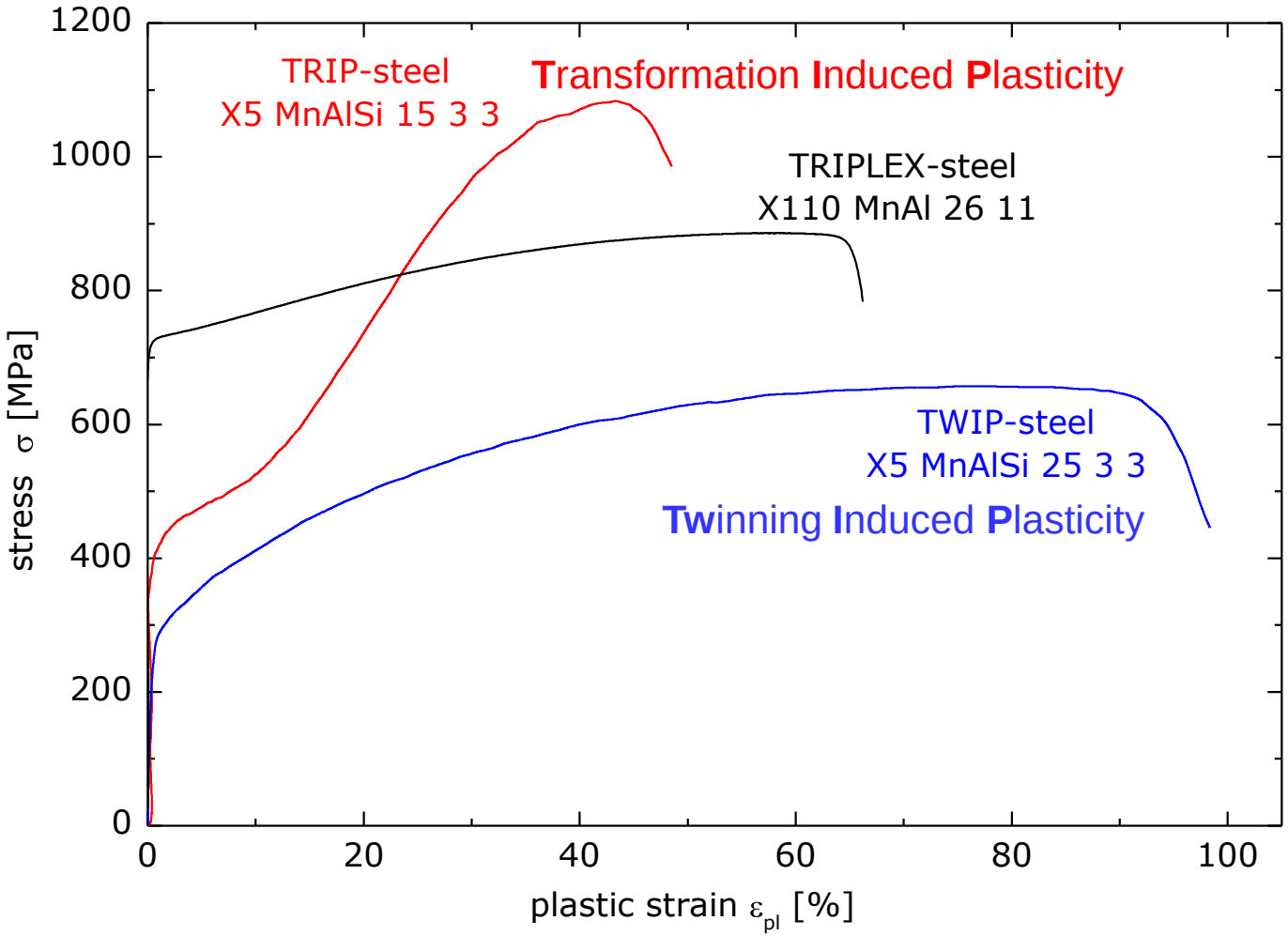
TRIP

$\gamma \rightarrow \varepsilon \rightarrow \alpha$ Martensite transformation





characteristic stress-strain-curves of TRIP-, TWIP- and TRIPLEX-steels (strain rate $10^{-4}s^{-1}$)



Brüx, Frommeyer, Max-Planck-Institut für Eisenforschung, Düsseldorf

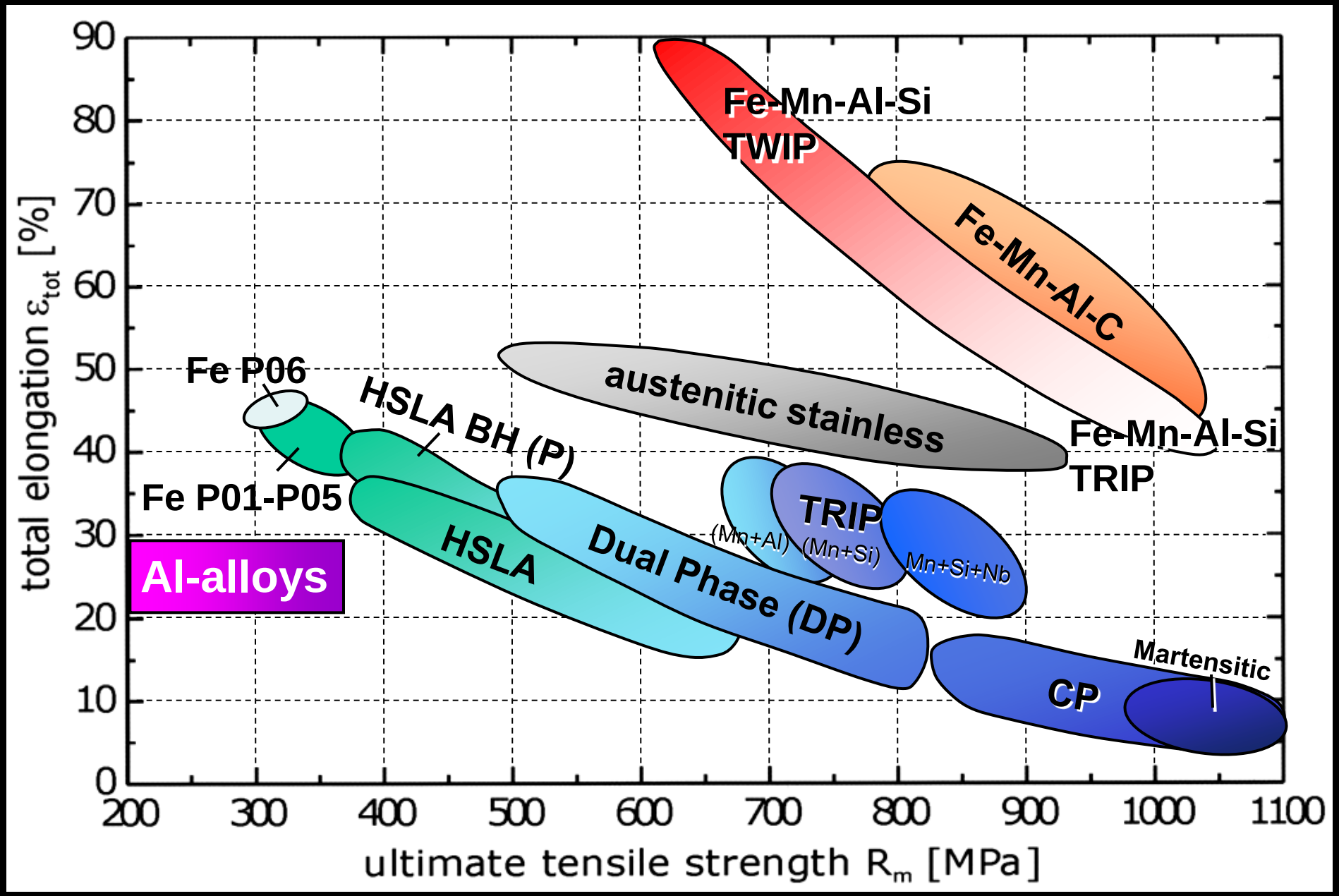
TWIP steel (X5 Mn Al Si 25 3 3)

Undeformed sample

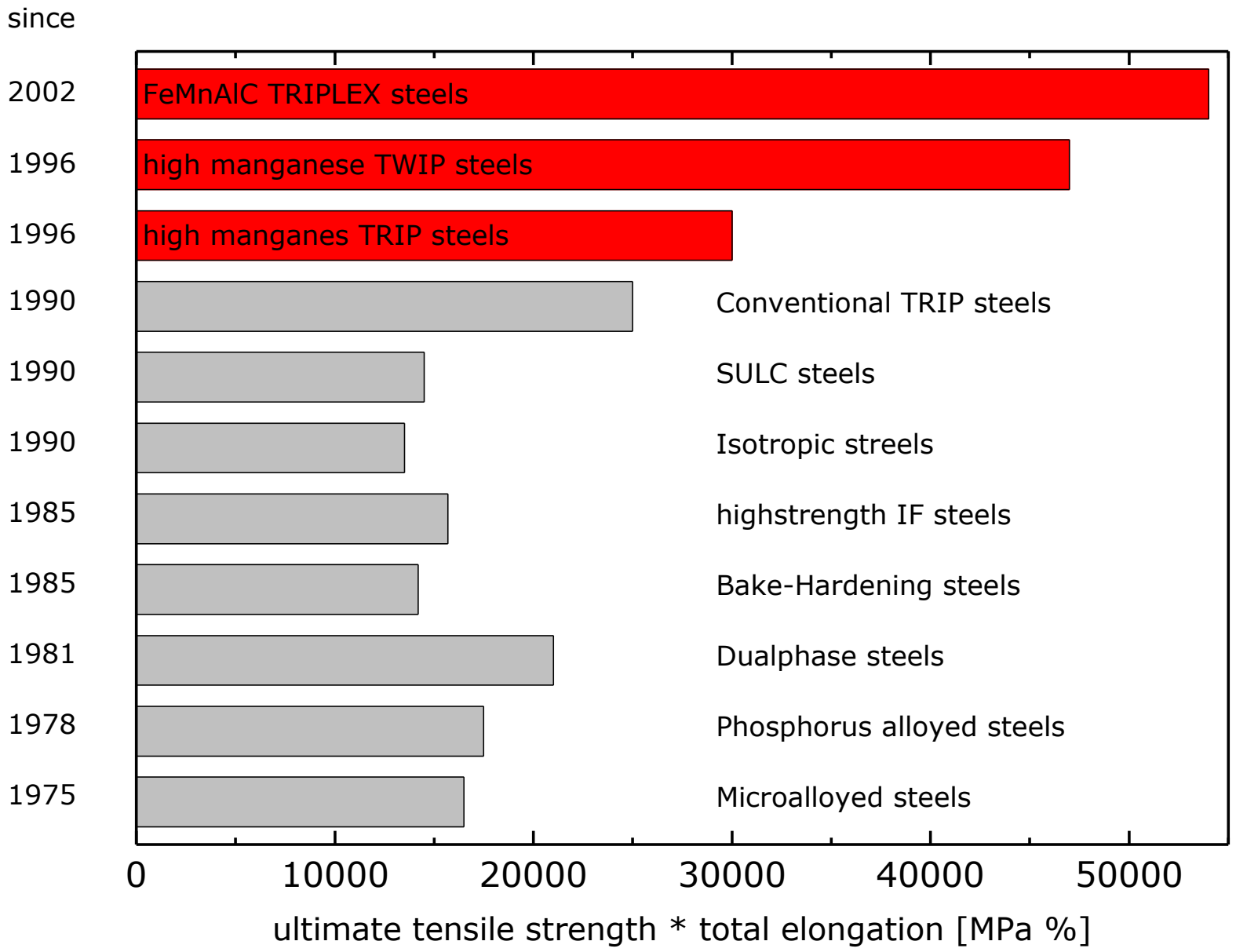
Sample after twisting by 1080° (T = 20 °C)

Brüx, Frommeyer, Max-Planck-Institut für Eisenforschung, Düsseldorf

Ductility/Strength combinations of steels for automotive applications



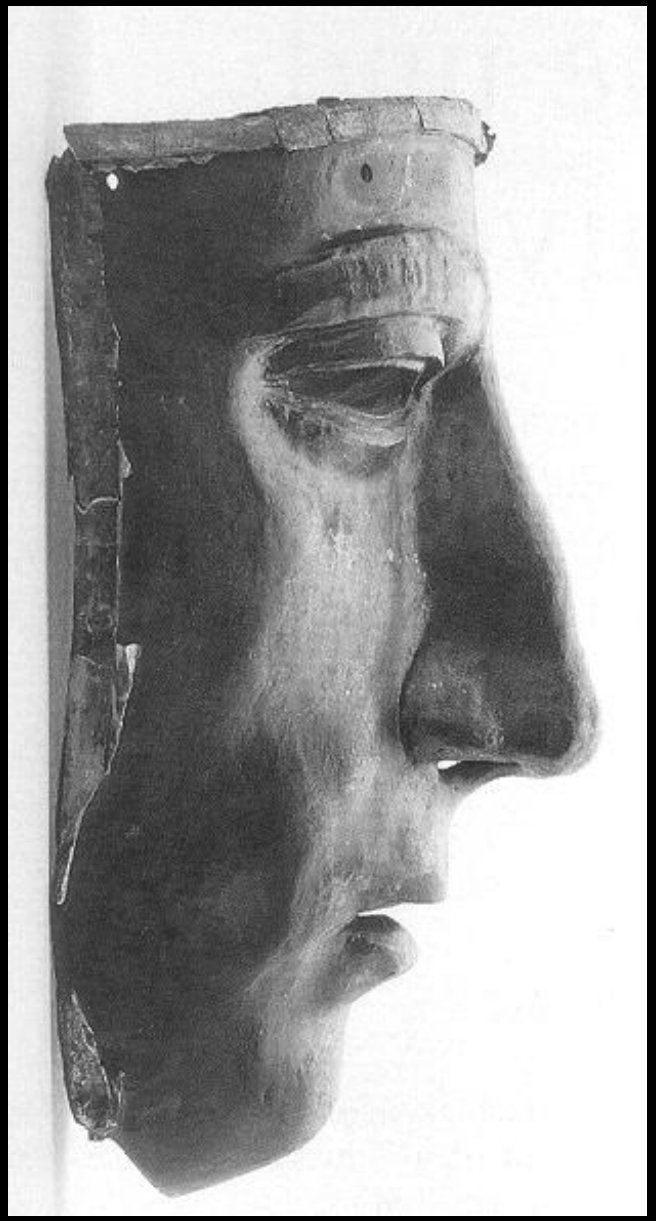
High Strength Steels



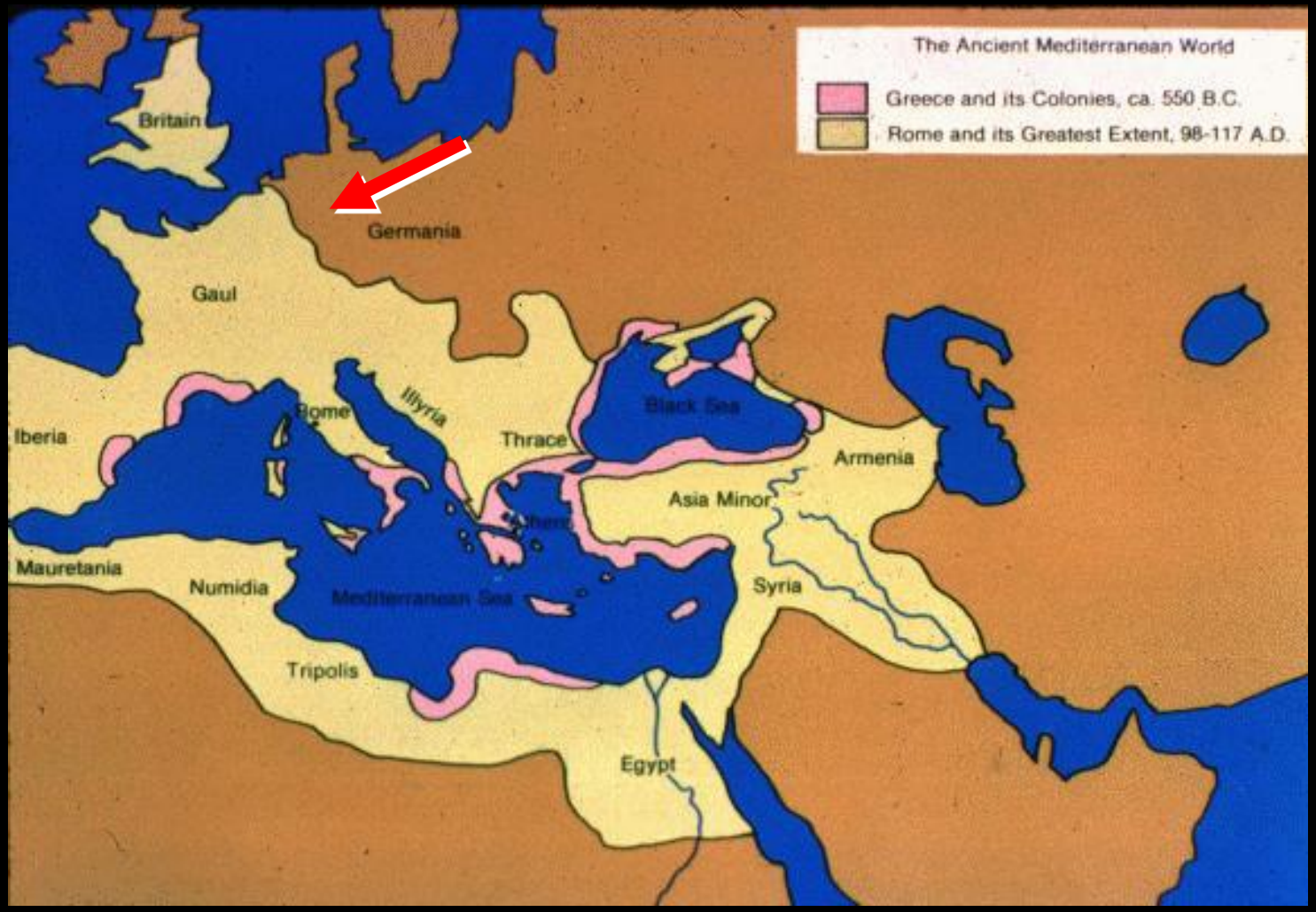
weight of truck : 96 t

modern steels carry 800 t

conventional steels carry 140 t

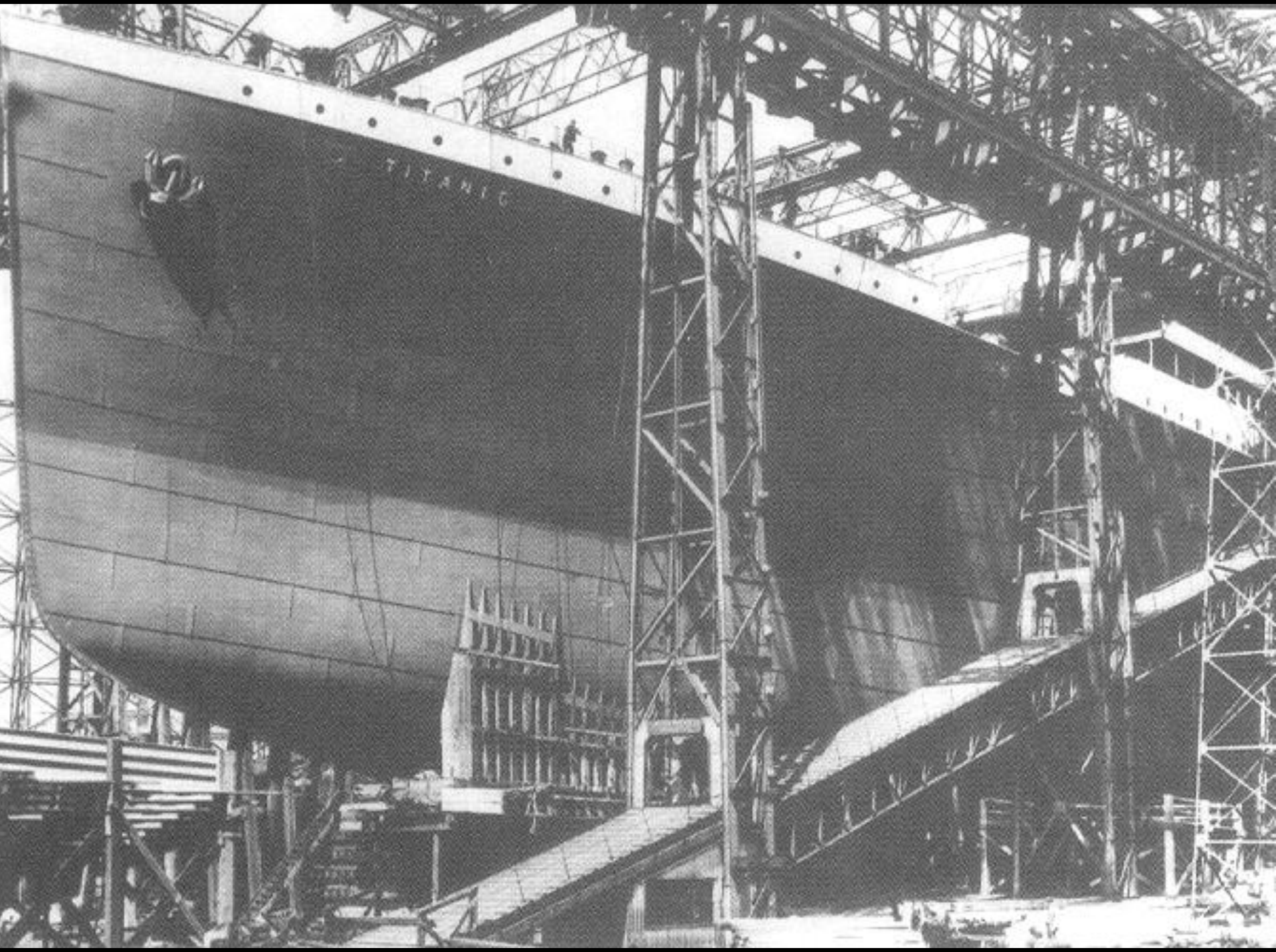


9 a.c.: Wiehen mountains, Tetoburg Forrest

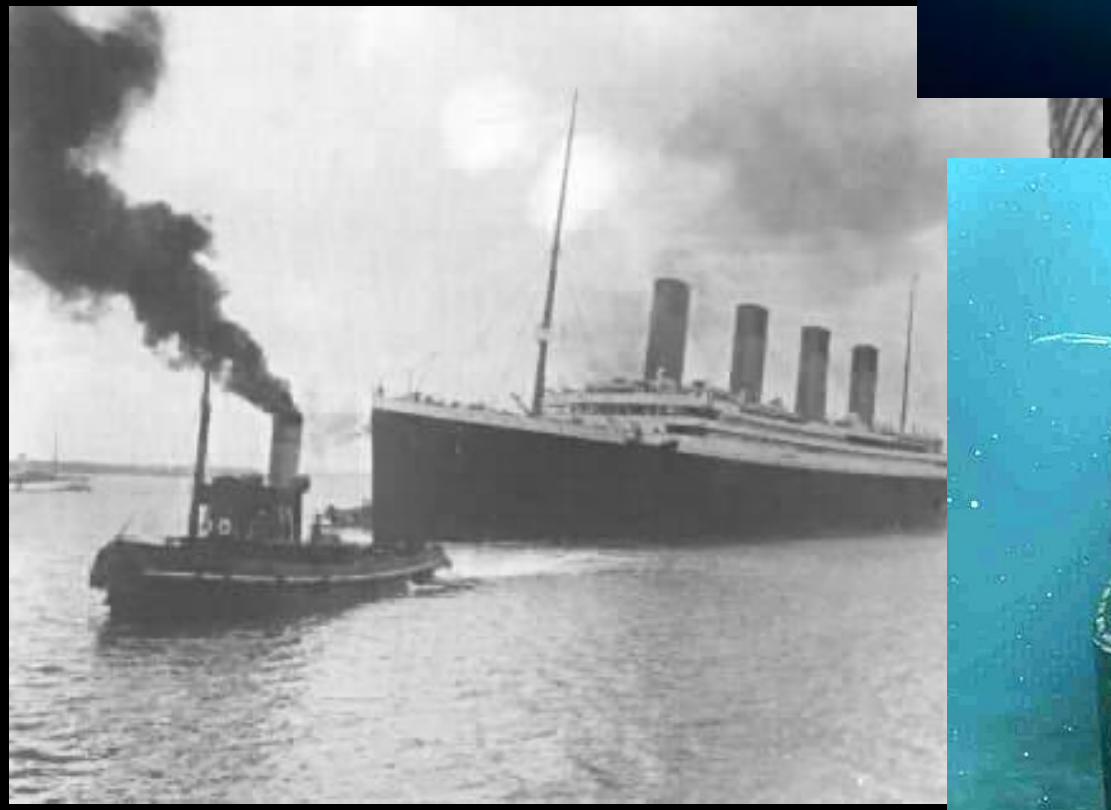

The Ancient Mediterranean World
Greece and its Colonies, ca. 550 B.C.
Rome and its Greatest Extent, 98-117 A.D.
Britain
Germania
Gaul
Iberia
Rome
Illyria
Thrace
Black Sea
Armenia
Asia Minor
Mauretania
Numidia
Mediterranean Sea
Syria
Tripolis
Egypt

Kutub column: 900 B.C., 17 t, 16 m

Strauss
Maurer


TITANIC

- water too cold
- brittle-to-ductile transition
- small cracks around each rivet
- crack progagation along perforated sheets



Napoleon:

George III

continental barrier against England
- Chance for companies like Krupp
(.....zum Zweck der Verfertigung des englischen Gußstahls und aller daraus resultierenden Fabrikate…..)

Napoleon and the Can

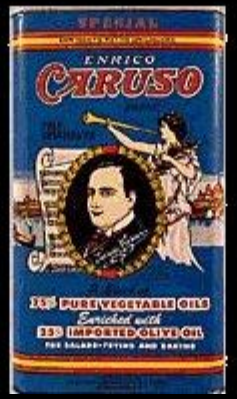
food supply to troops

La revolution:
Nicolas Appert of Paris

jokes about british bajonetts

received can food on St. Helena

1858: Ezra J.Warner ?



Nickel

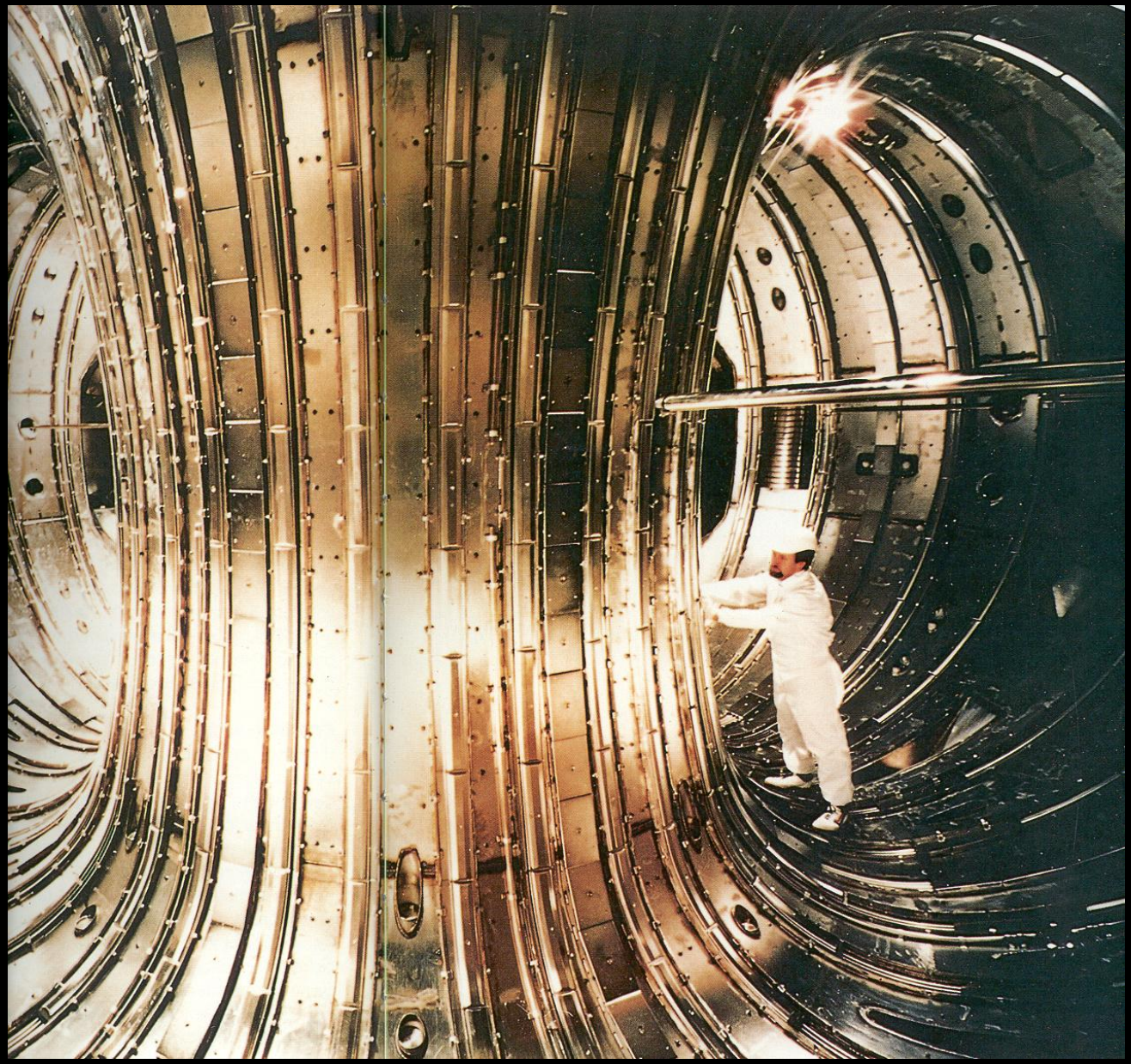
1751, Cronstedt

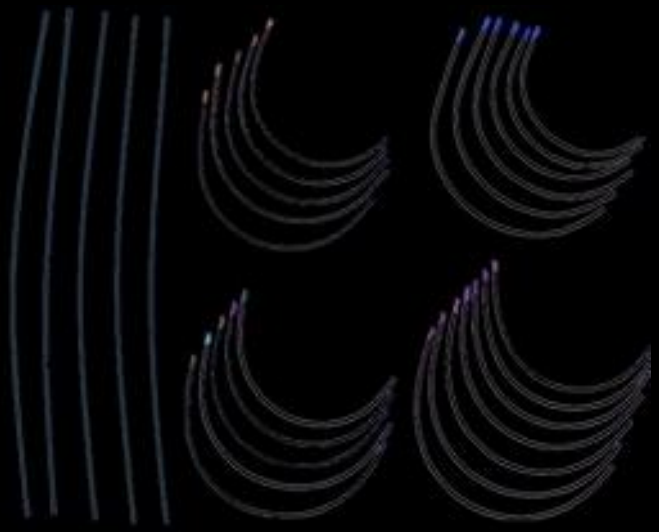
Ni in Cu ores *(red Nickel stone, Nickelarsenide)*

Cu devil *(St. Nicholaus-Cu)*

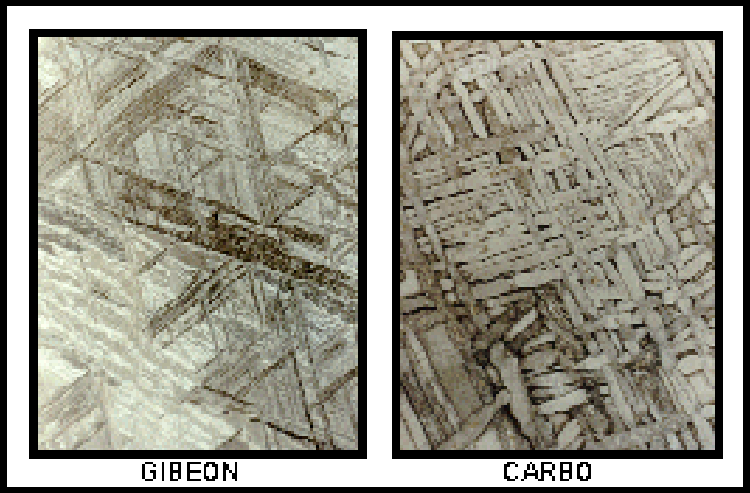
Mountain Nickel:

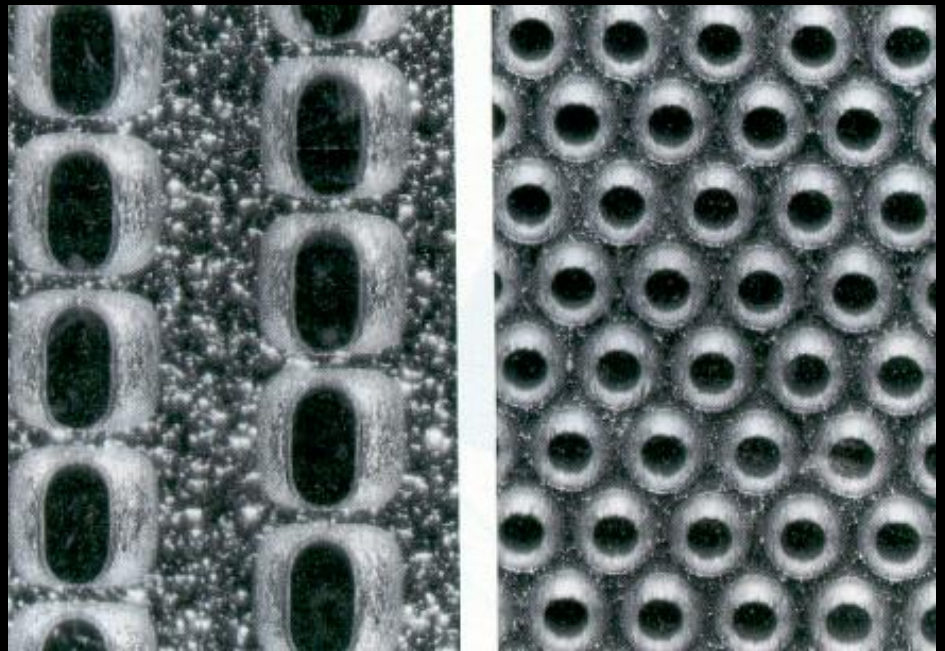
“dwarf, hobbit“

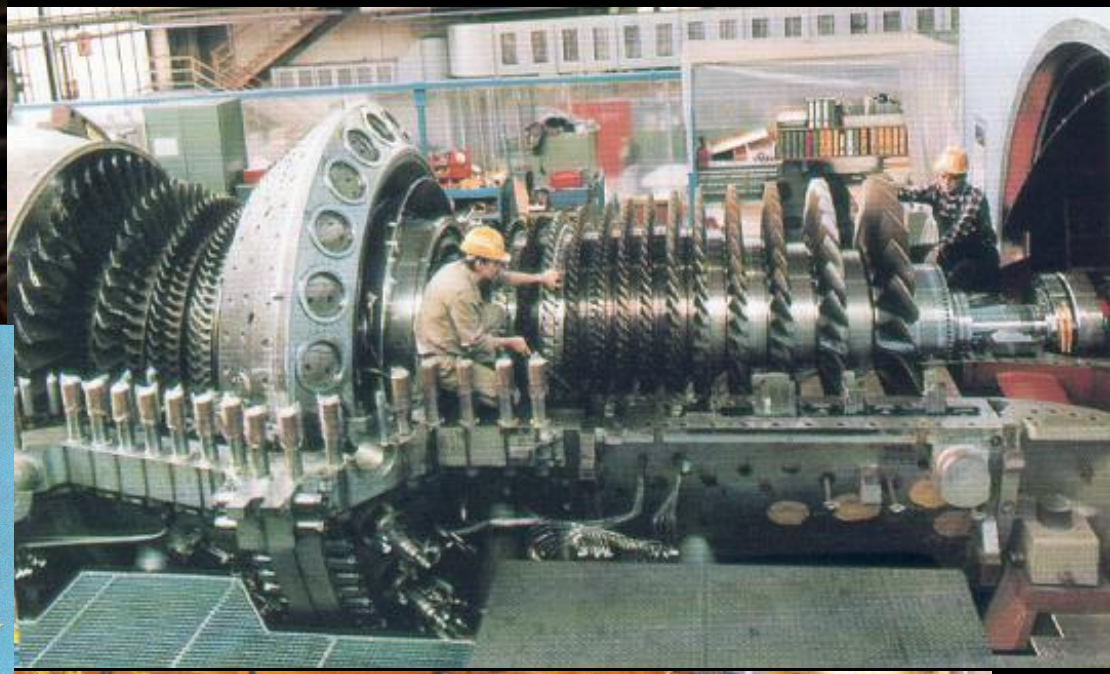


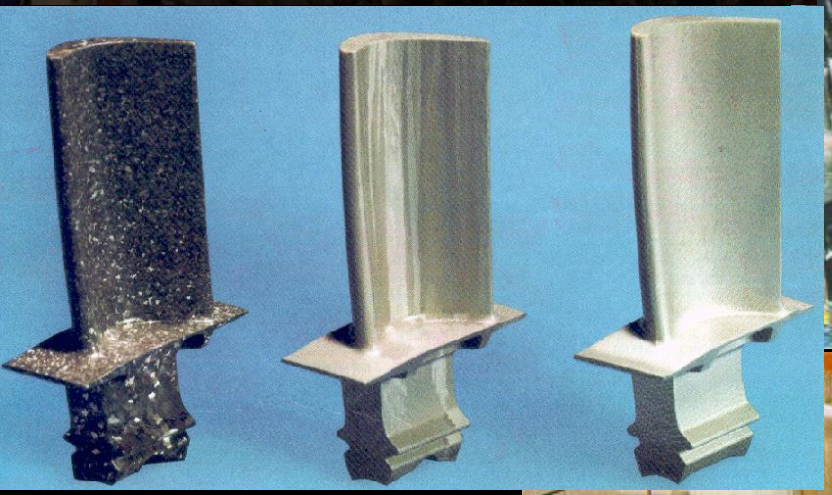


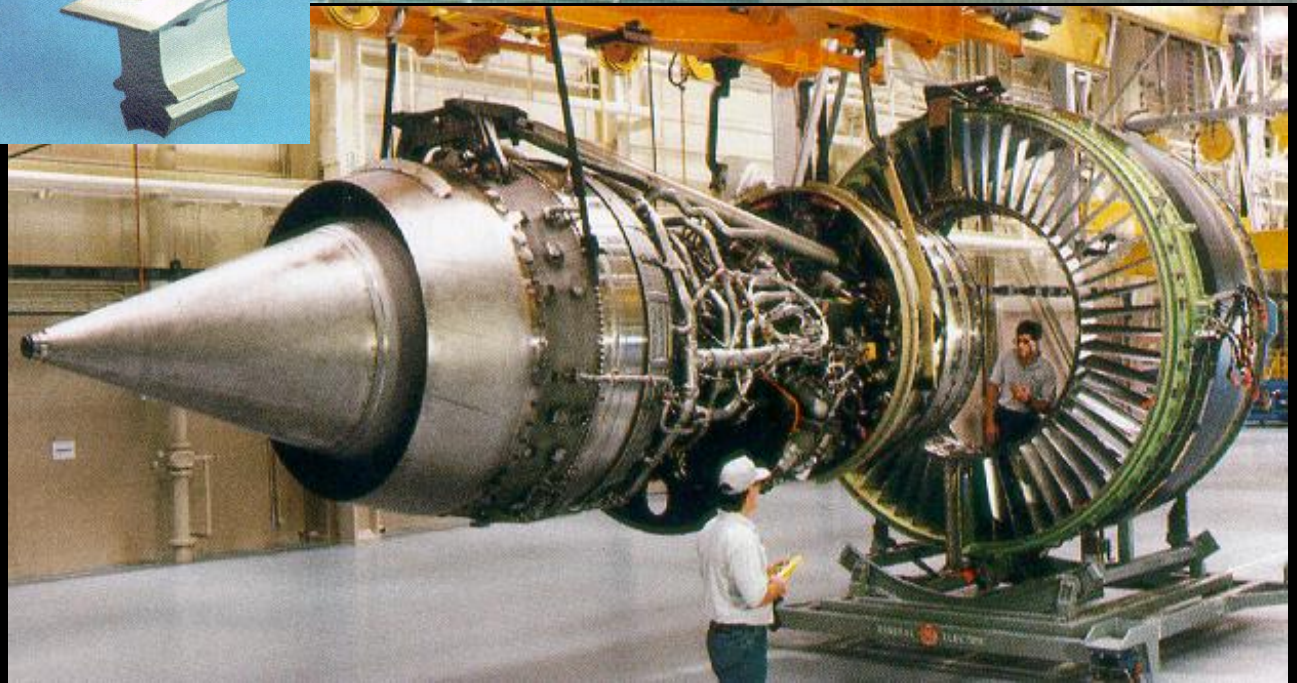
35% Ni, no thermal expansion, memory-effect
Invar, Guillaume, 1920 Nobel price





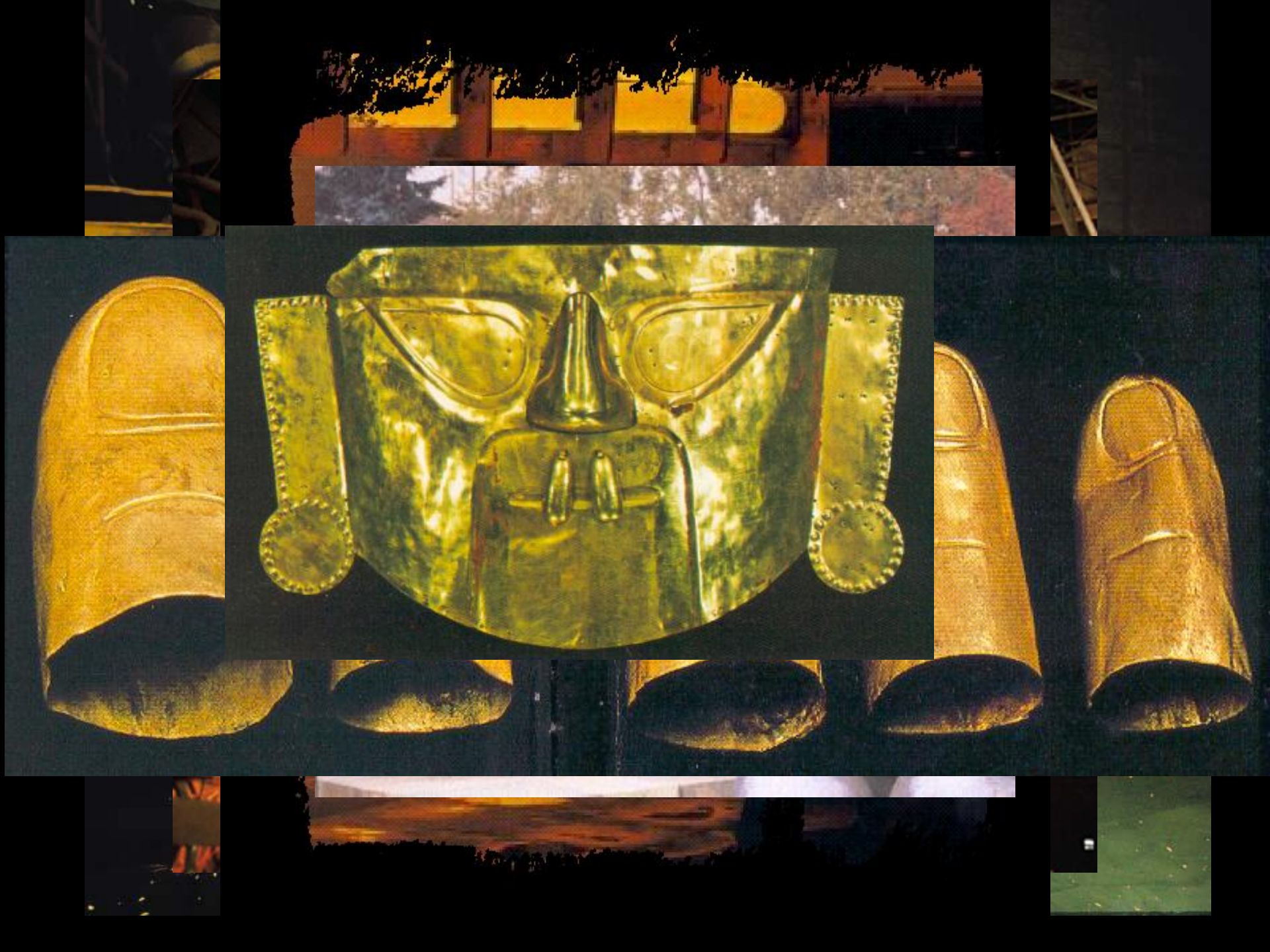




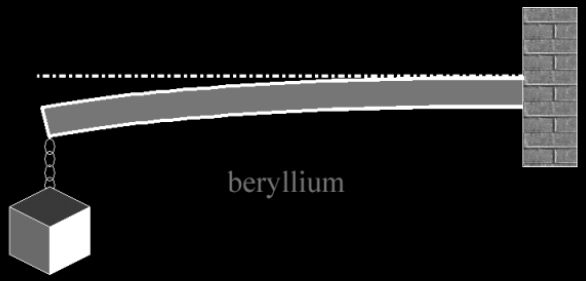


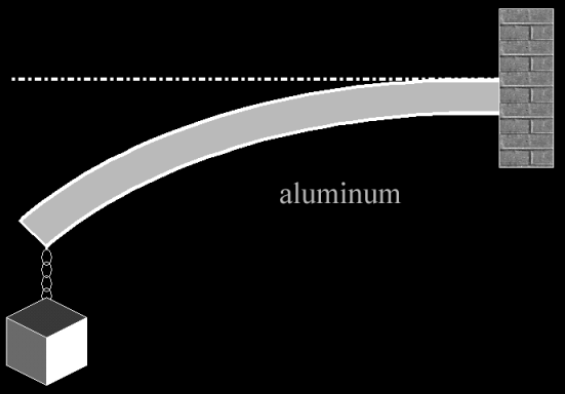
Thanks

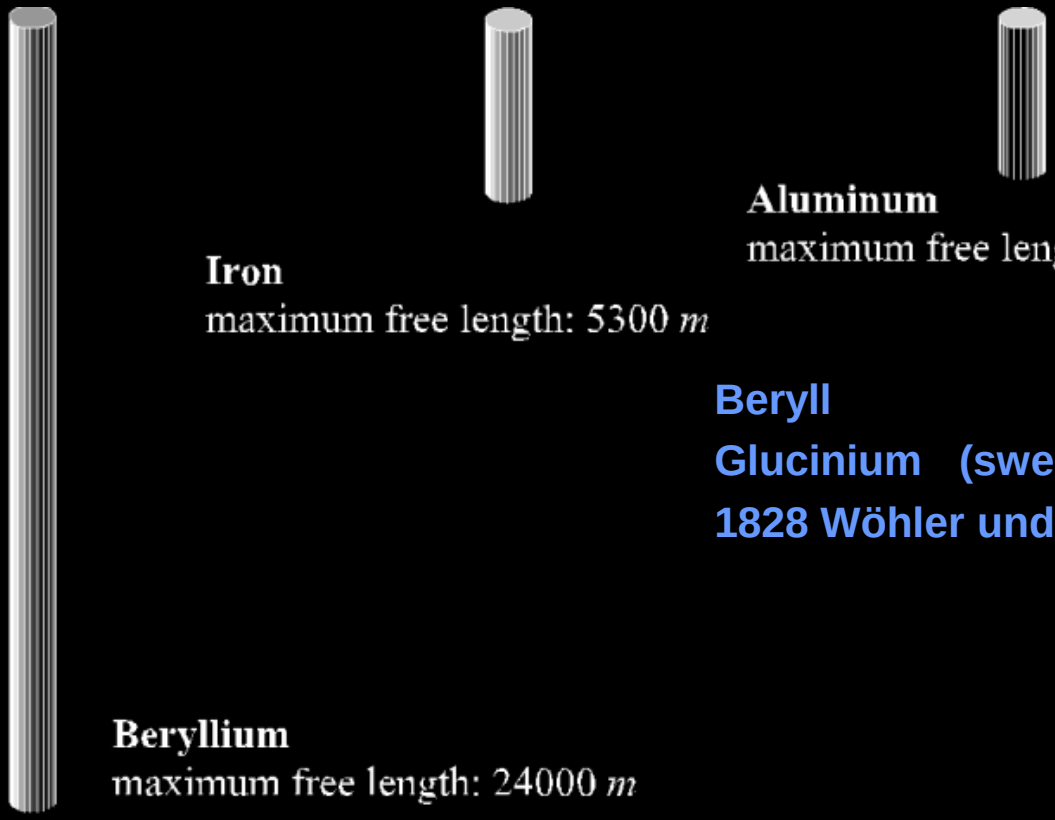
watching me?
trust no one
deceive envelgle obfuscate
the lives of every man woman and child
is there more?
more than you'll ever know.
they closed our ey
you and mulder are the only one
feeling a little
in the dark
they're here, aren't they
mr.mulder, they've been here for a long long



Beryllium







Iron
maximum free length: 5300 *m*

Aluminum
maximum free length: 4800 *m*

Beryllium
maximum free length: 24000 *m*

Beryll
Glucinium (sweet oxide)
1828 Wöhler und Bussy

Silver

Land of Silver

- kkupfer : in situ compüosites – bcc / amorphpus - bcc copper ??
- gold : song ??
- kogllenstoff: hummer etc
- schöns bild von steinzeitwandmalerei
- eisen –
- Ta / Nb : schulter des pelops - erstes i planatat

Mid-Europe

Frühe Eisenzeit in unseren Breiten : Hallstattkultur (Salzkammergut in Oberösterreich , 2500 Gräber)

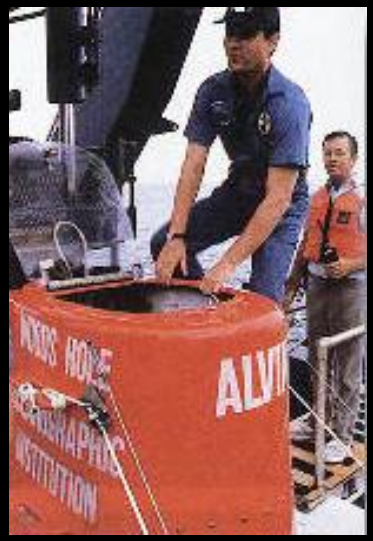
Hallstattkultur C (800-630 v. Chr.)
Hallstattkultur D (630-475 v. Chr.)

Späte Latène-Kultur (La Tène, Opferplatz, Neuenburger See, Schweiz)

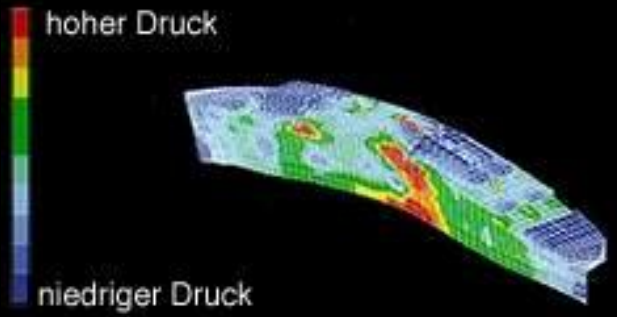
frühe Latènekultur A (475-400 v.Chr.)
frühe Latènekultur B (400-275 v.Chr.)
mittlere Latènekultur C (275-150 v.~Chr.)
späte Latènekultur D (150 v.Chr.-Zeitenwende)

Die Titanic

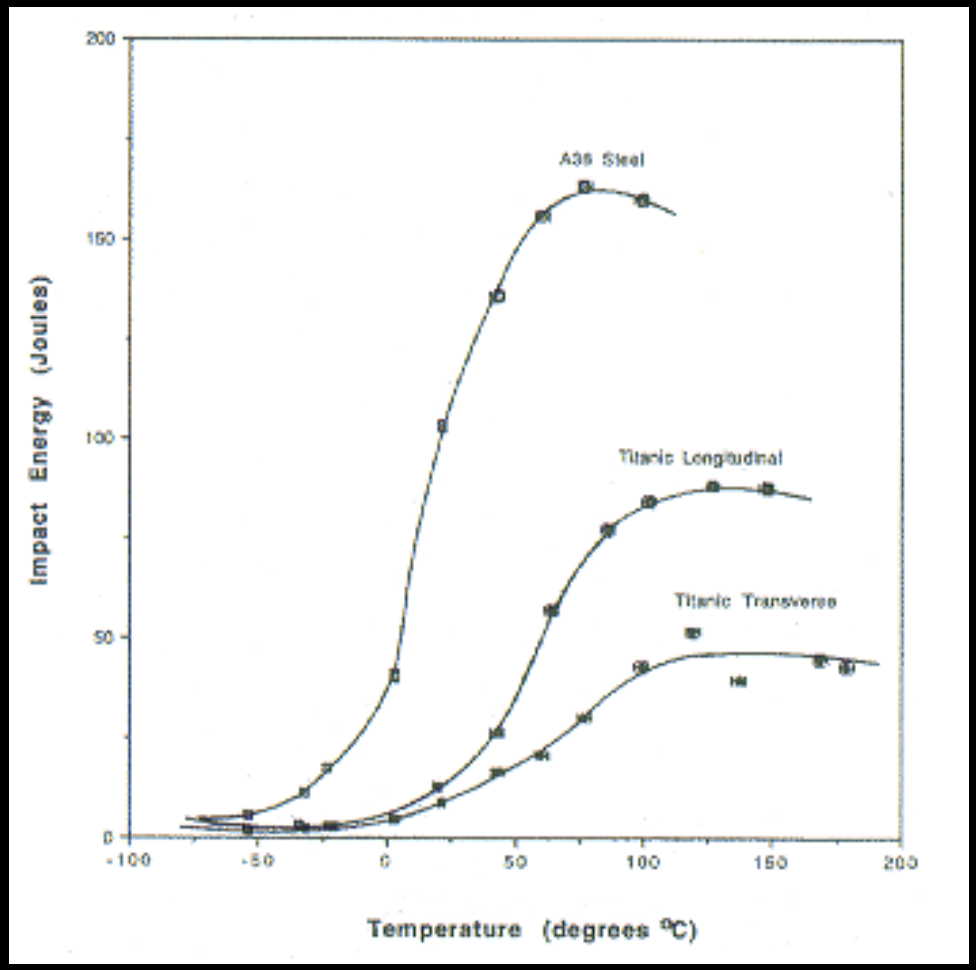
vorher (14. April 1912)
269 Meter Länge
46329 Bruttoregistertonnen
18 wasserdichte Schotts
Werft Harland & Wolff

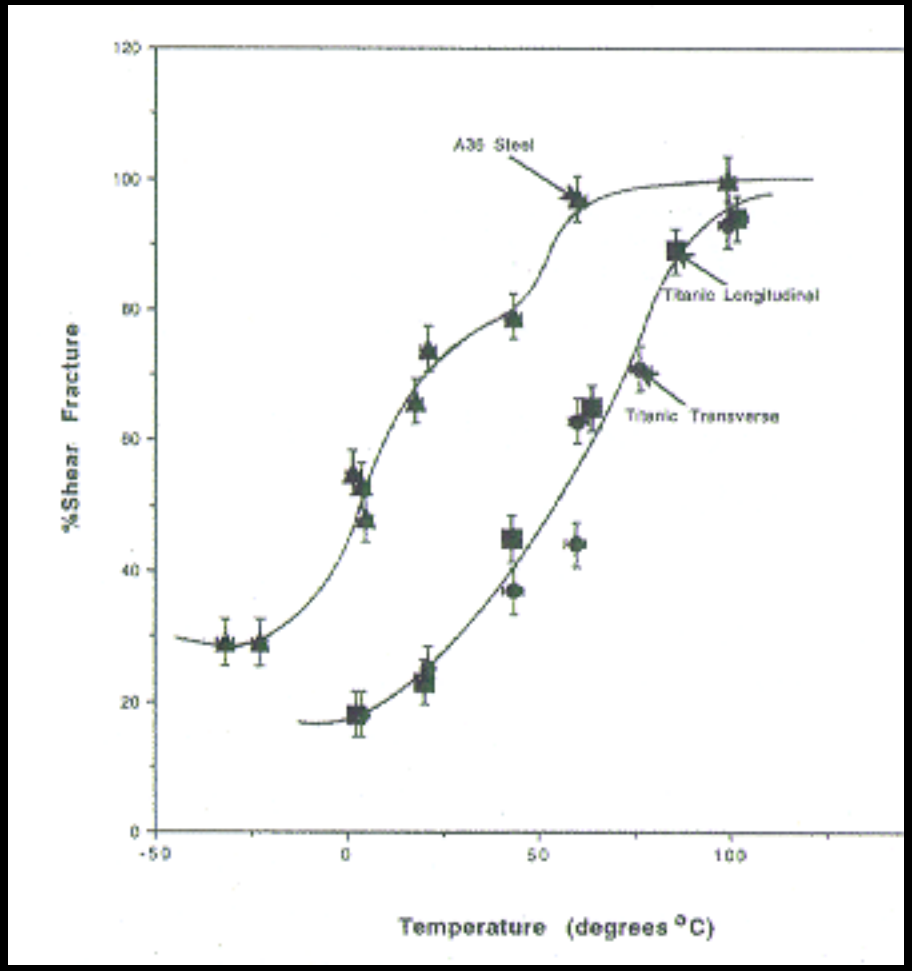


nachher (1. September 1985)
3658 Meter Tiefe, Alvin
Robert D. Ballard
33.664 Tonnen Wasser im Schiff
Vorschiff ins Wasser gesunken
Heck ragt hoch,
Hebel erzeugt 25.000 t / m²



.....Nordroute, schnell und kalt.....

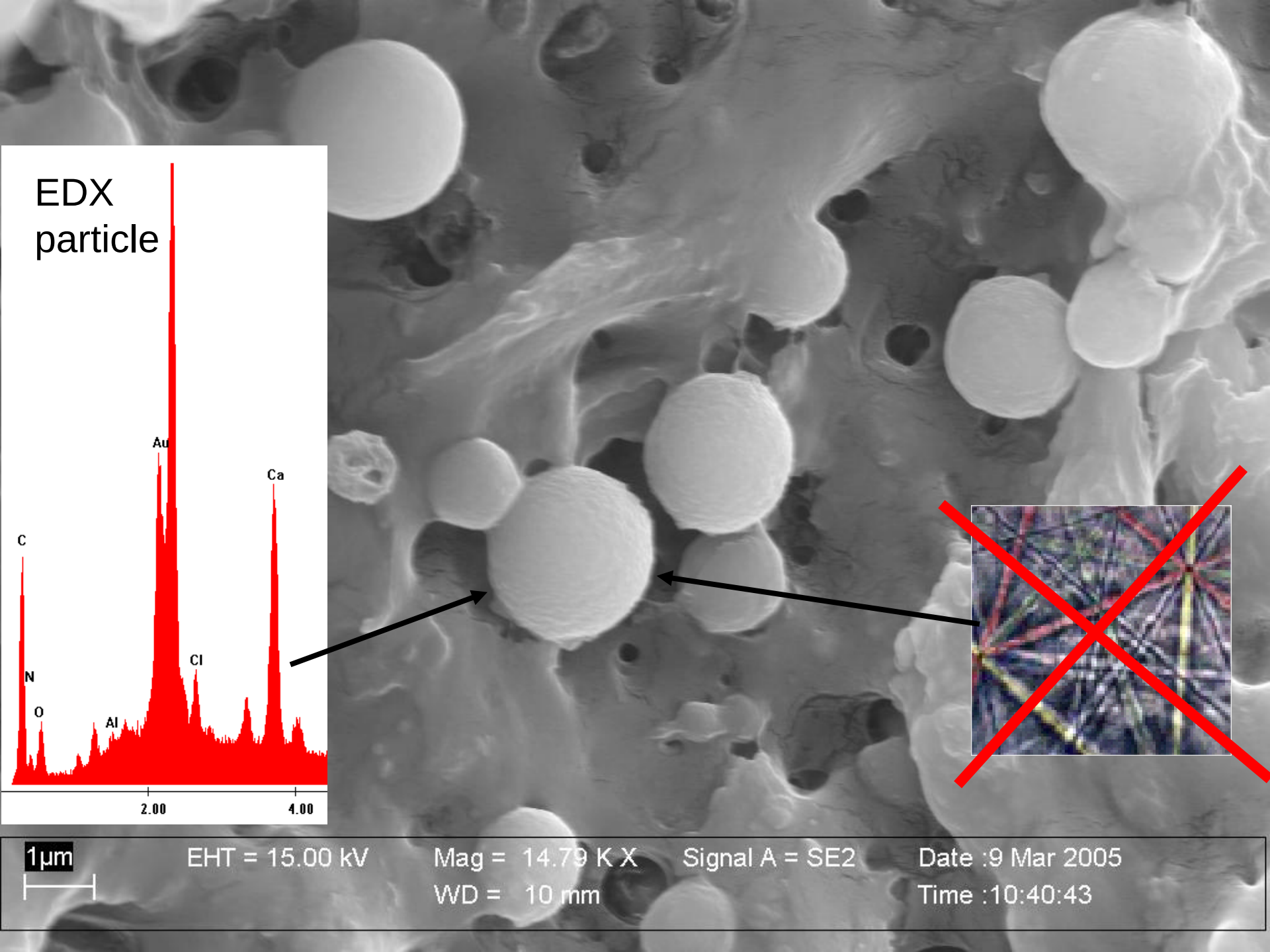




1808, Iglau (Austrian Empire), meteorite shower, investigate by Karl von Schreibers (Vienna Mineral Collection, Alois von Widmmannstätten (Porcelain manufacturer); more than 100 metorites (some weighed 12 pounds); Widmmannstätten discovered the characteristic microstructure:

- **stone (Aerolithe)**
- **iron (Siderithe)**
- **iron and stone (Siderolithe)**
- **glas (Tektite)**

Siderithe: ca. 6% of all, polycrystals, Fe and Ni (natural stainless steel)
since 4000 b.c. (Amundsen)


EDX
particle
C
N
O
Al
Cl
Au
Ca
2.00
4.00
1µm
EHT = 15.00 kV
Mag = 14.79 K X
WD = 10 mm
Signal A = SE2
Date :9 Mar 2005
Time :10:40:43