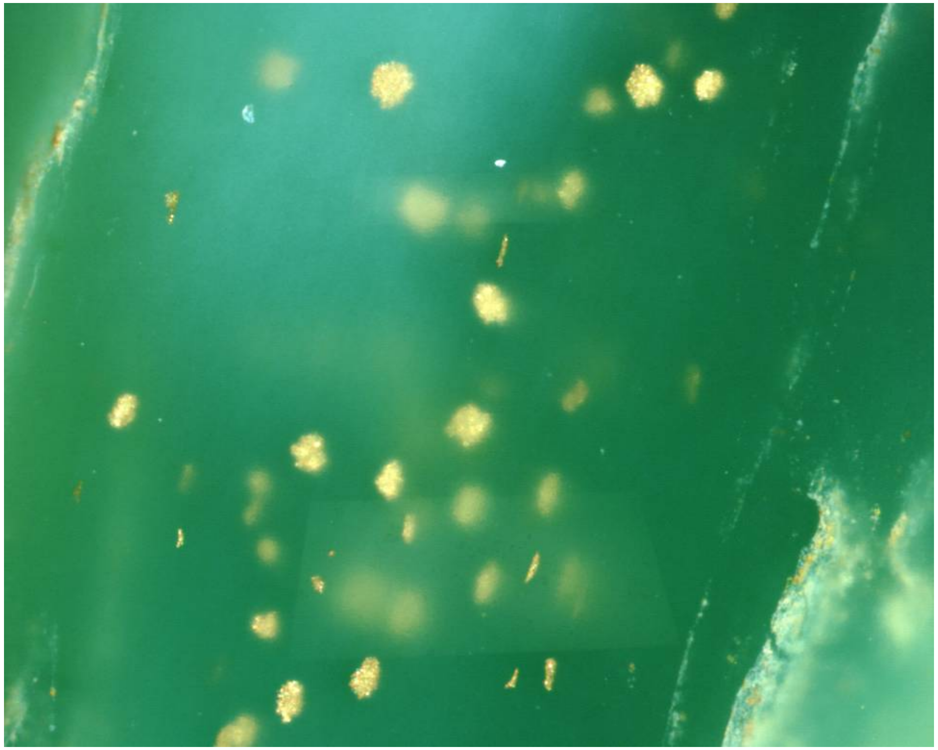


www.csiro.au

Invisible gold revealed in supergene and hypogene environments

Minerals Down Under

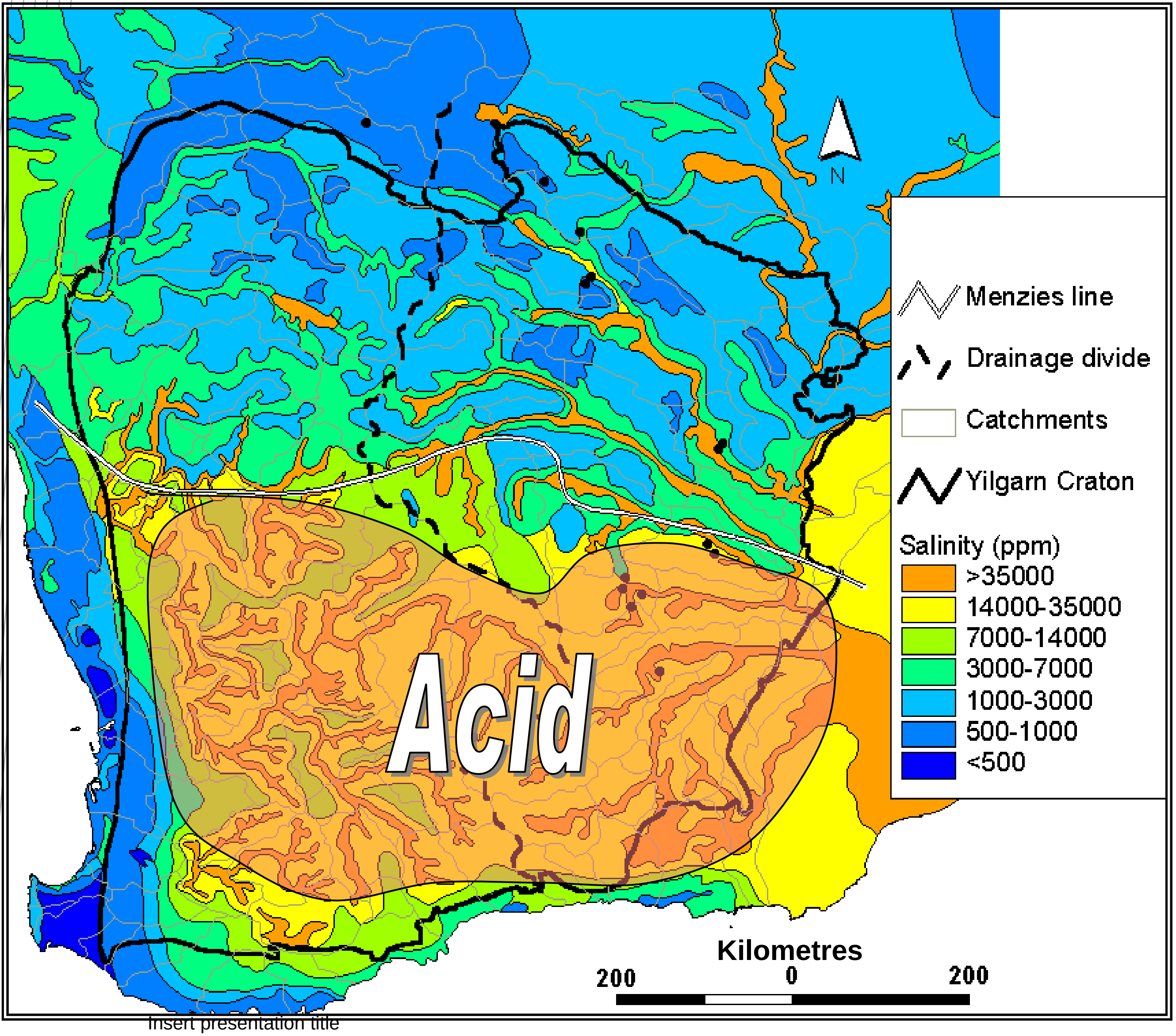
Rob Hough, Ryan Noble, David Gray

National Research FLAGSHIPS
Minerals Down Under

CSIRO

Hidden deposits

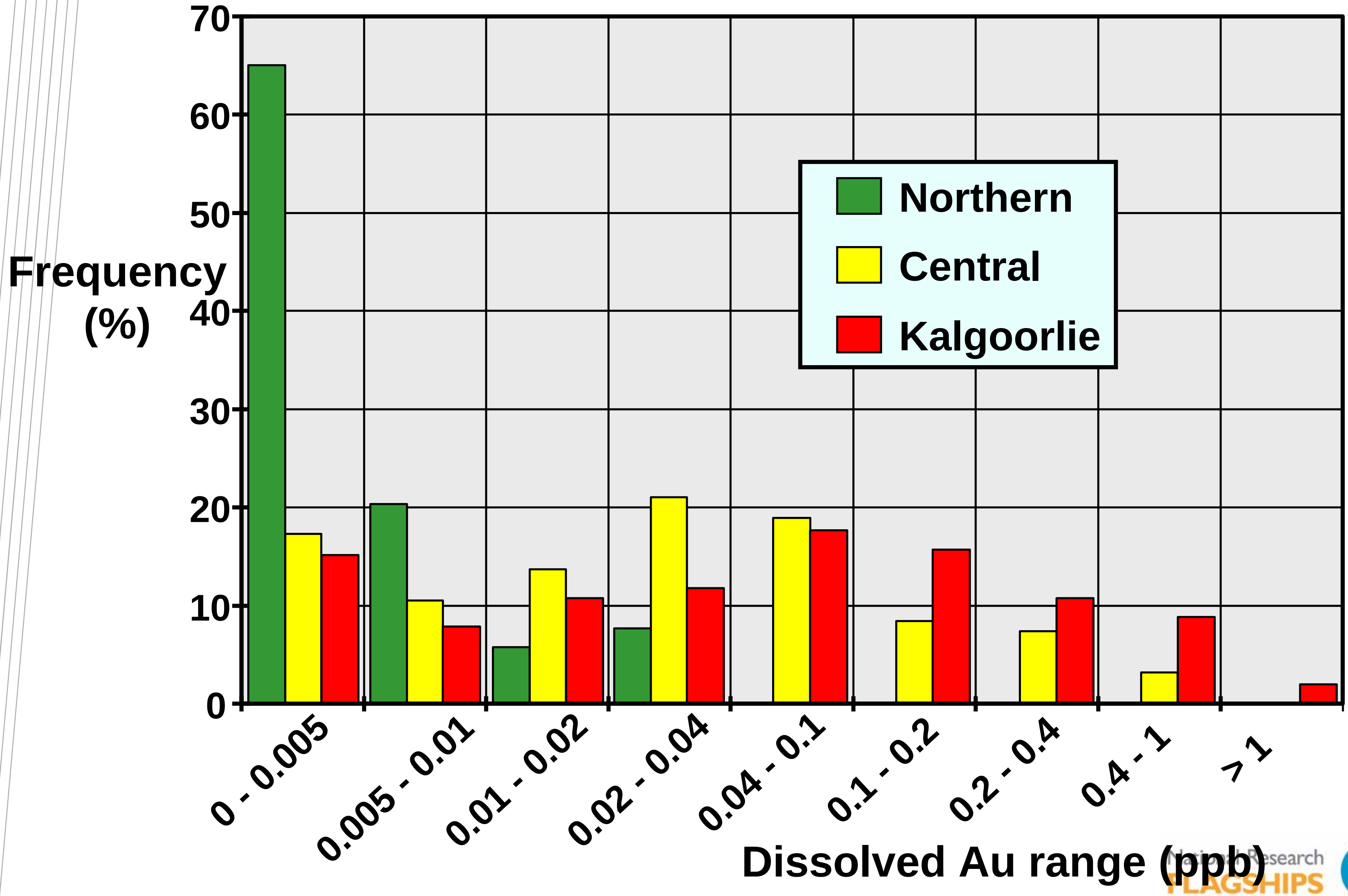
Yilgarn Craton – Salinity



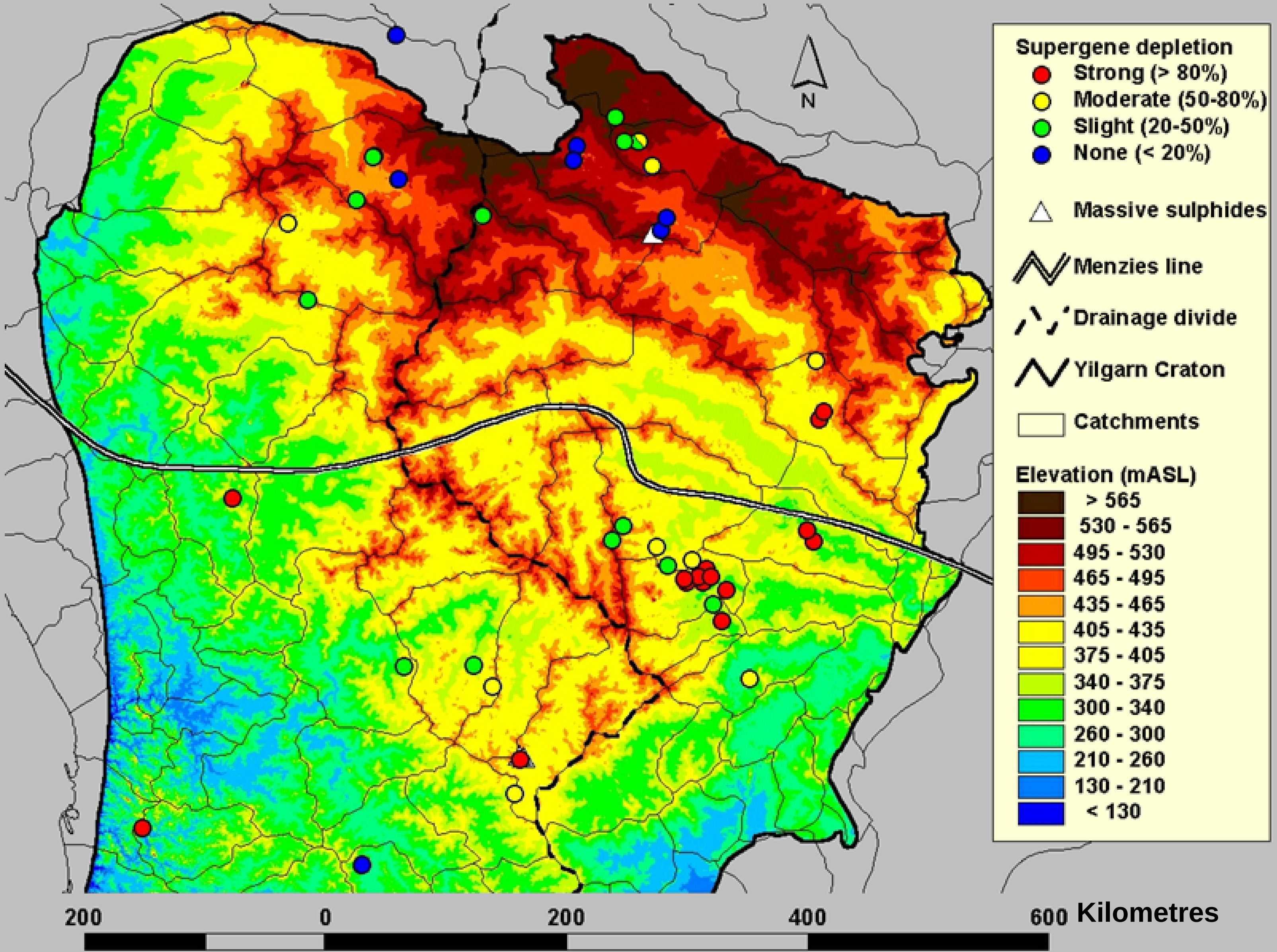
Modelled groundwater salinities in the Yilgarn Craton

(Commander, 1989)

Dissolved Au Concentration – Yilgarn Craton

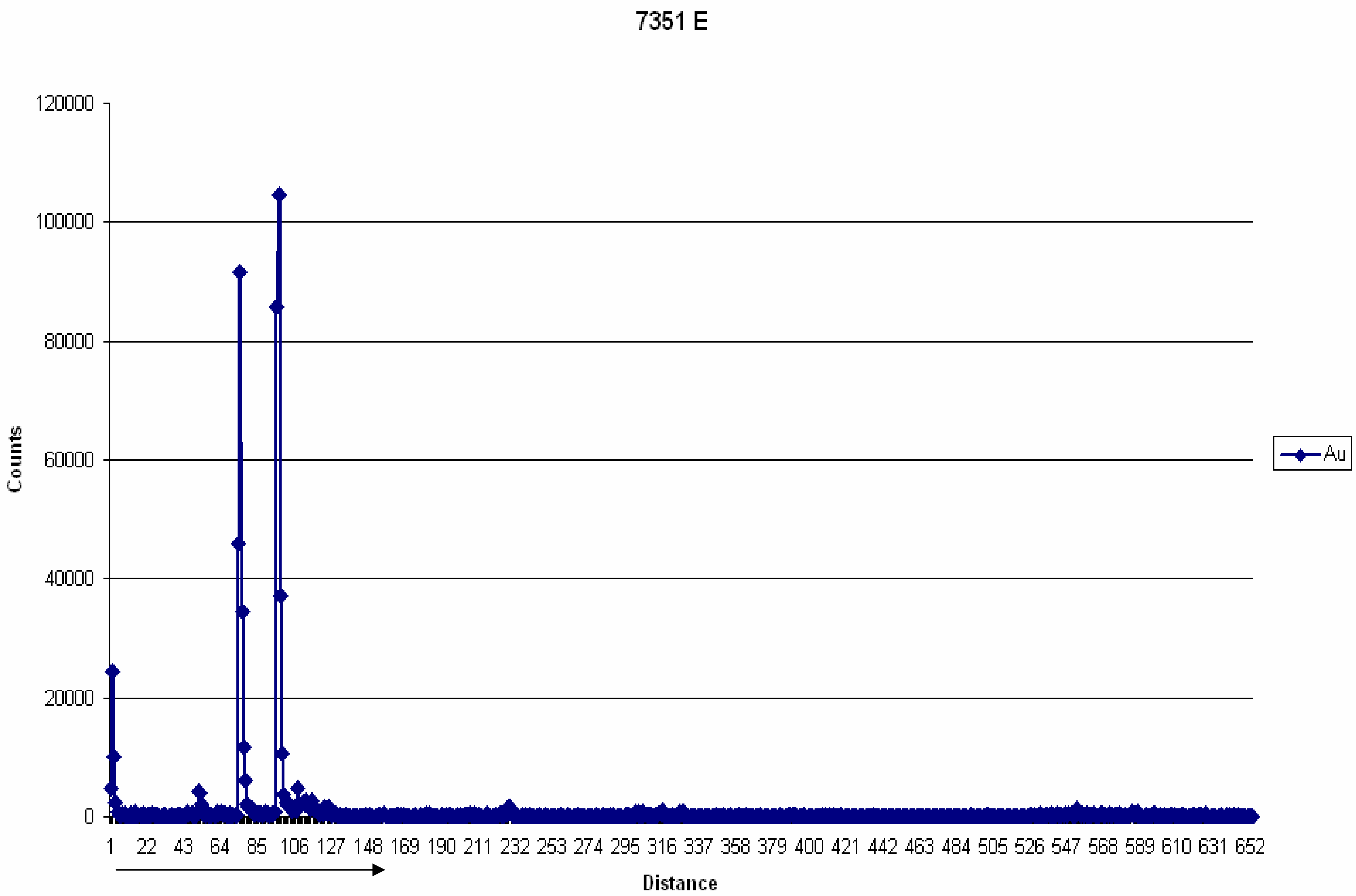


Supergene depletion of Au in the Yilgarn Craton



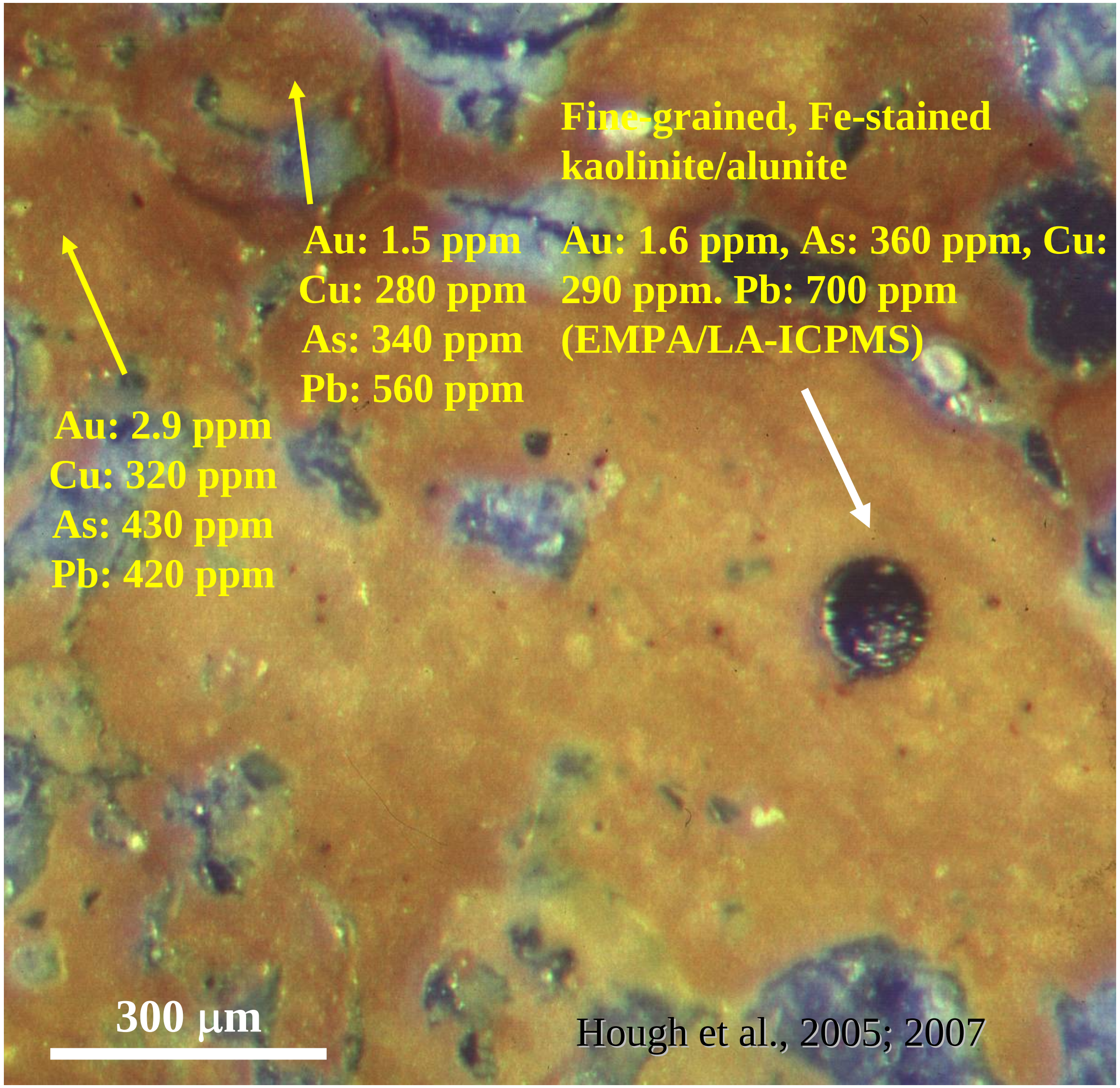
Complex regolith materials

Laser ablation transect of Au distribution



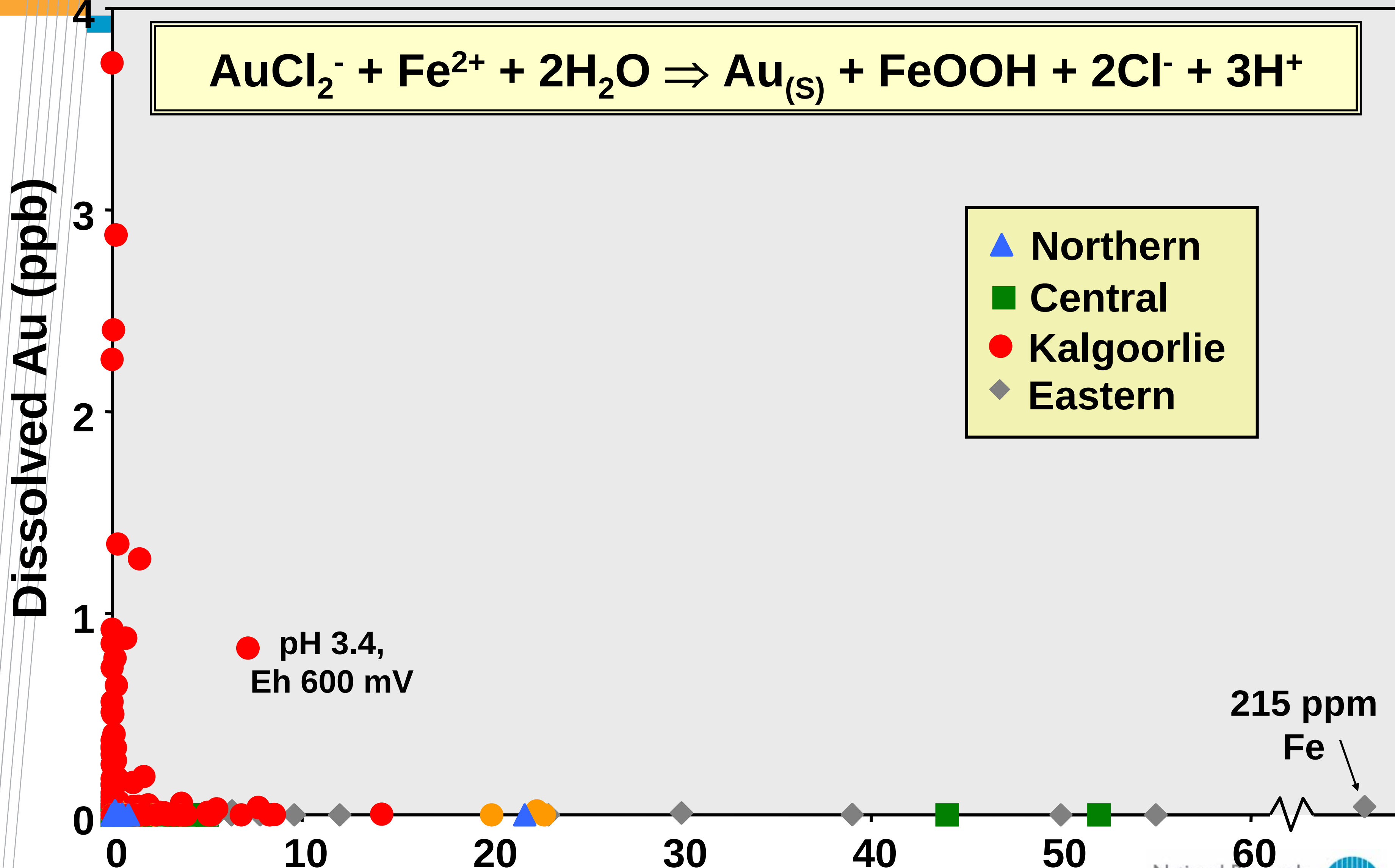
Alunite rich veins within slabby ferricrete (transported) Mount Gibson

Bulk analyses of: Au 0.1 ppm, As 36 ppm, Cu 85 ppm.



National Research FLAGSHIPS Minerals Down Under CSIRO

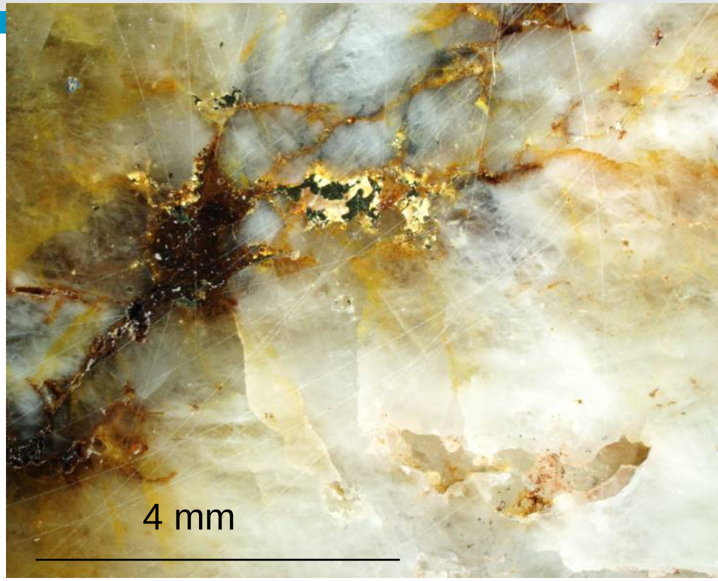
Dissolved Au vs. Fe (pH < 5.4)

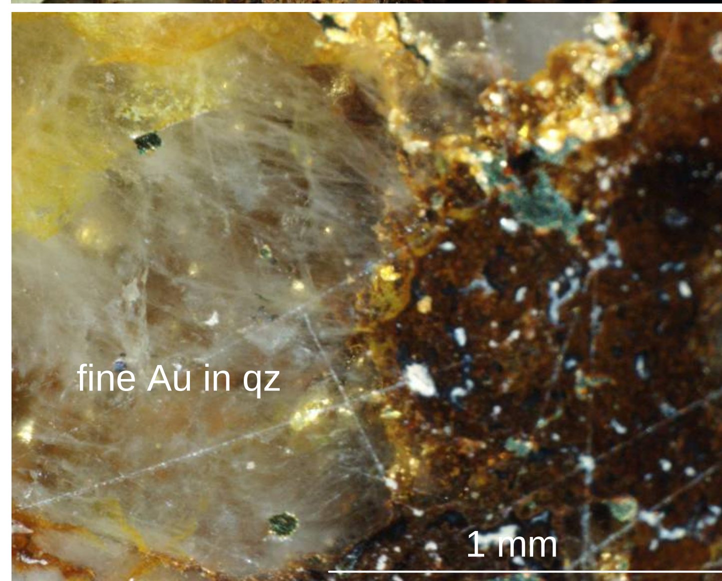


National Research FLAGSHIPS Minerals Down Under CSIRO

Golden Virgin Pit, Parker Range (WA)

Primary gold in quartz, iron oxide (after sulphide).
13-15 % Ag in the Au-Ag grains

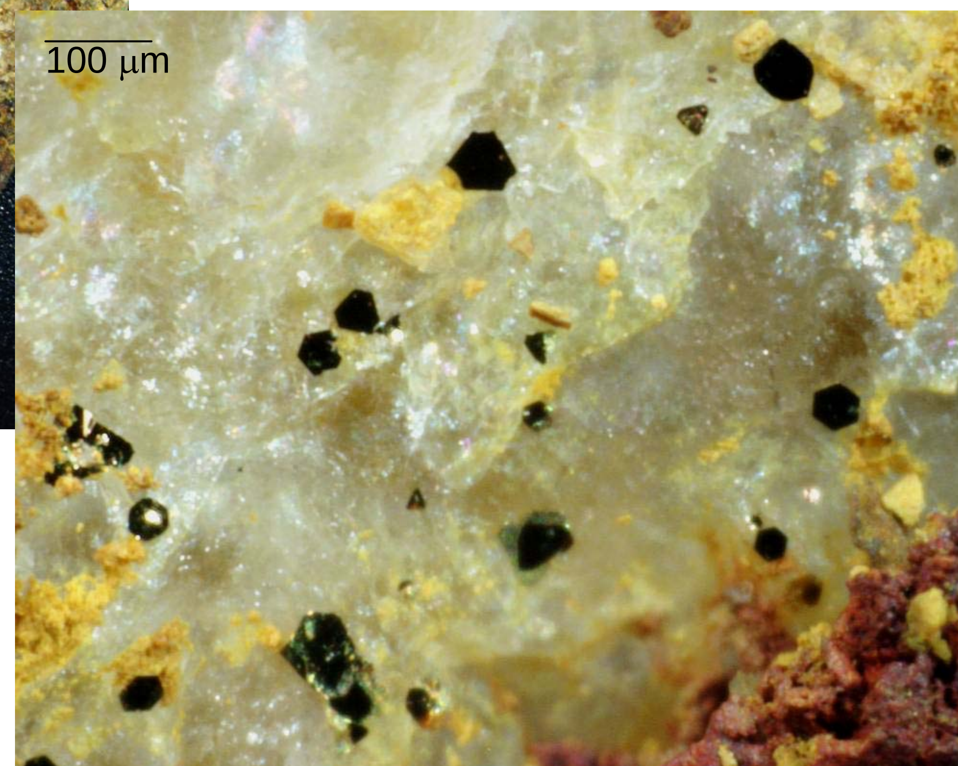




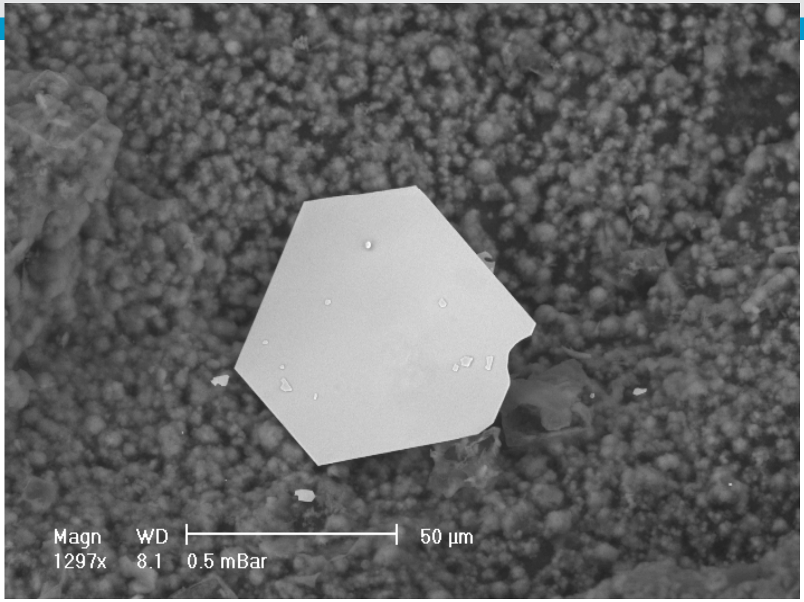
Quartz vein block from 30 m depth

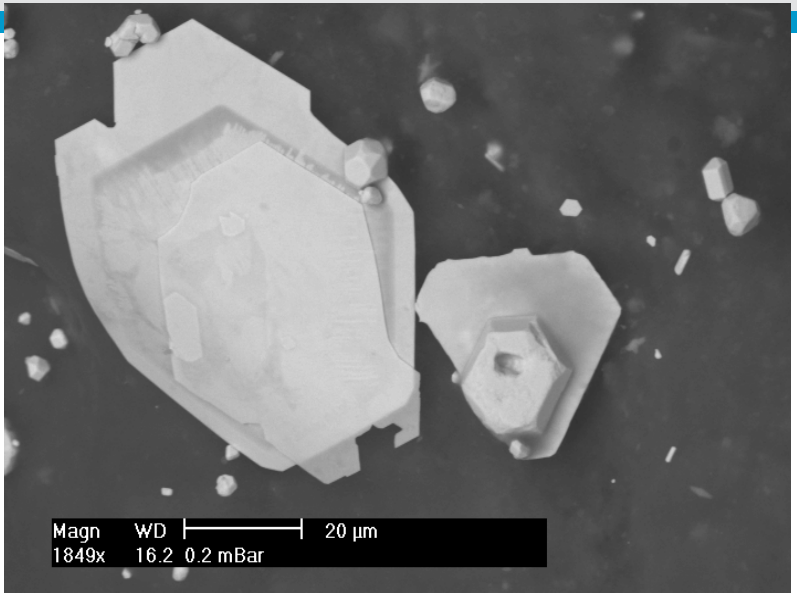
1cm

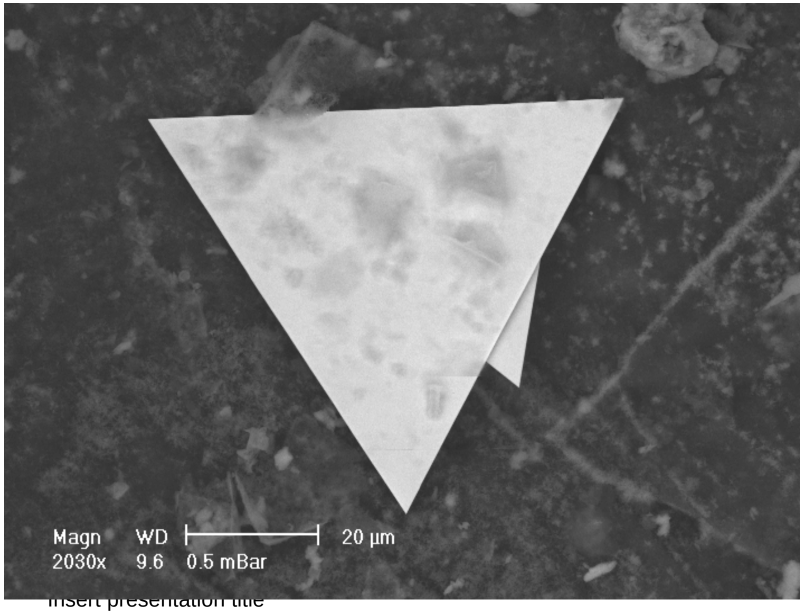
Iron oxide rich fracture surface

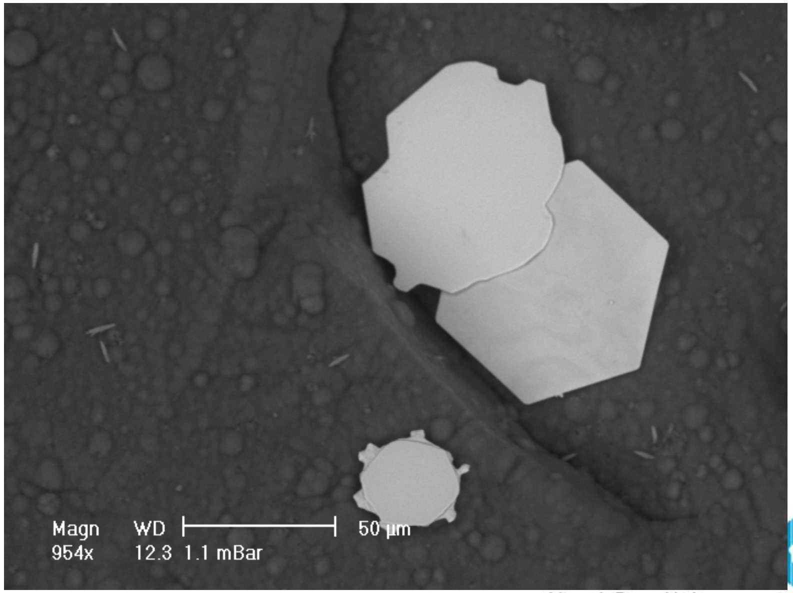


SEM: Back-scattered electron images

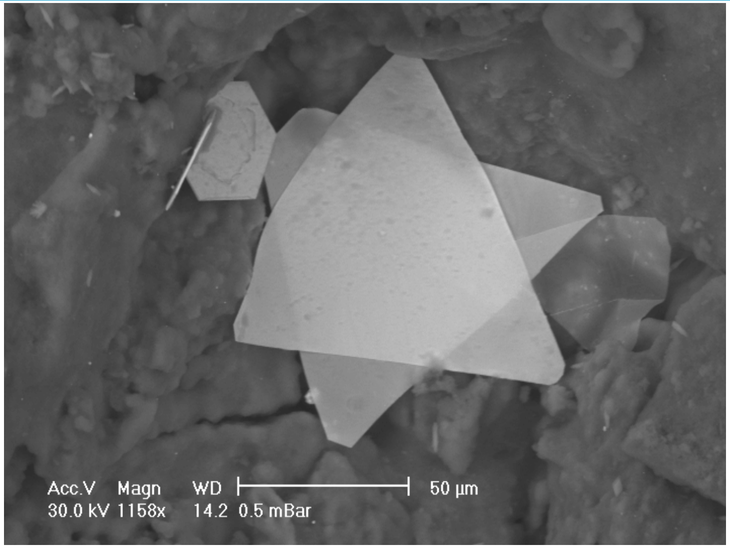


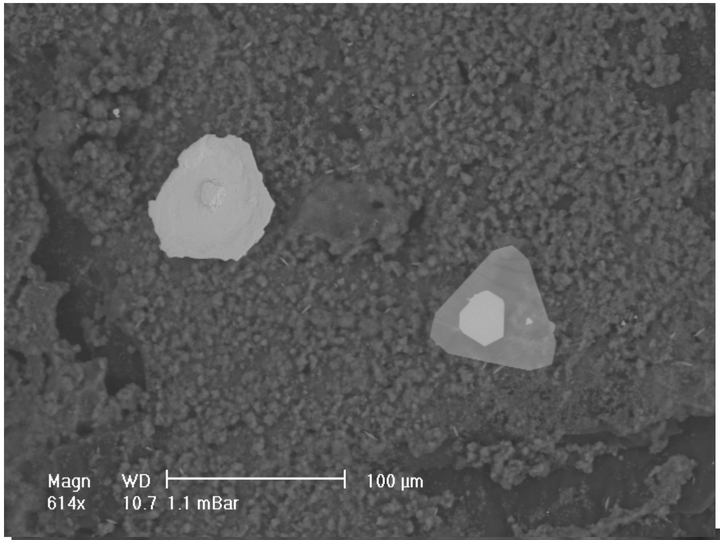


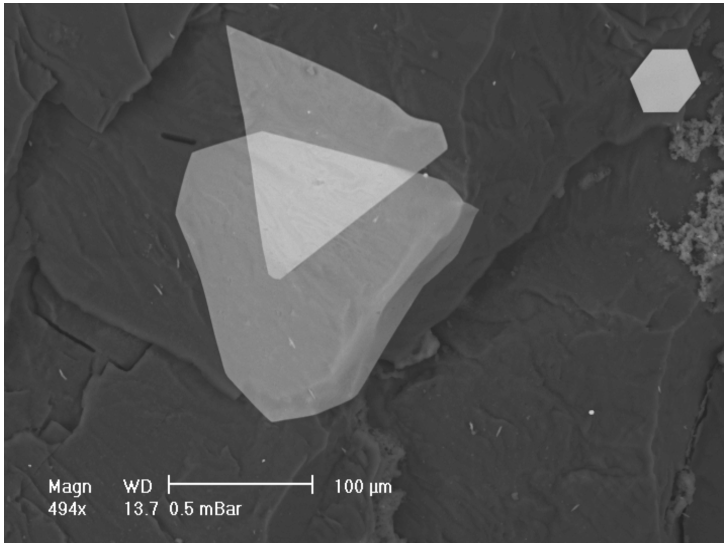


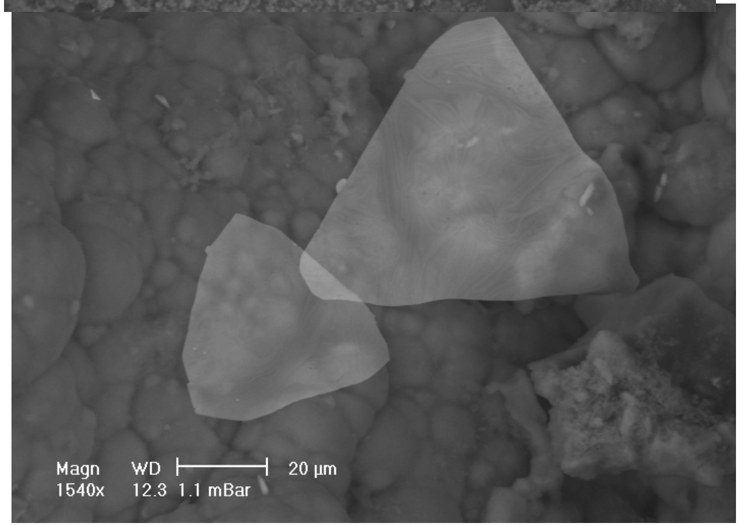


Thin films – overlap illustrates thickness effects on atomic number contrast

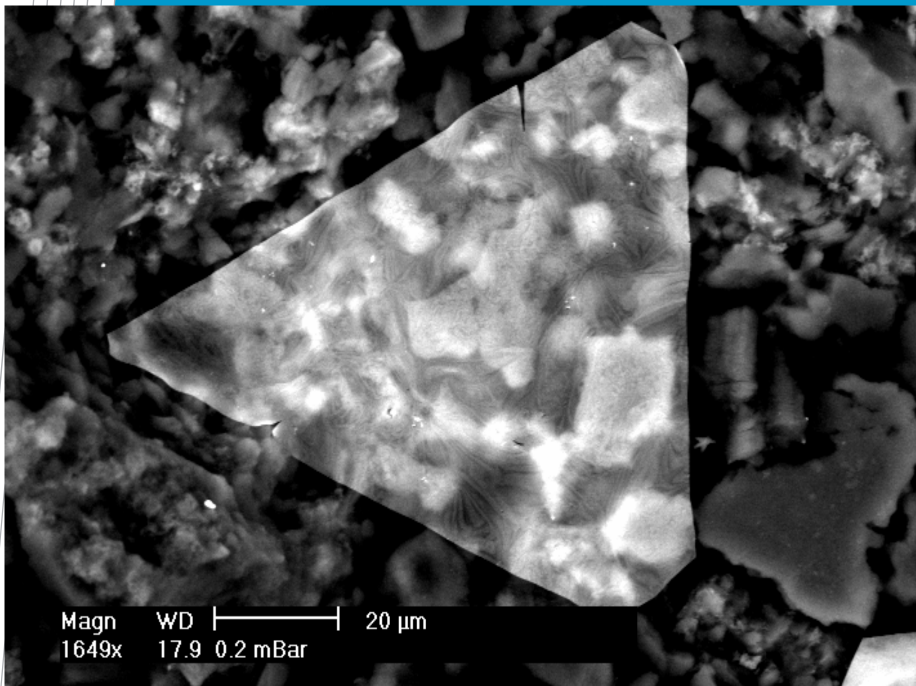


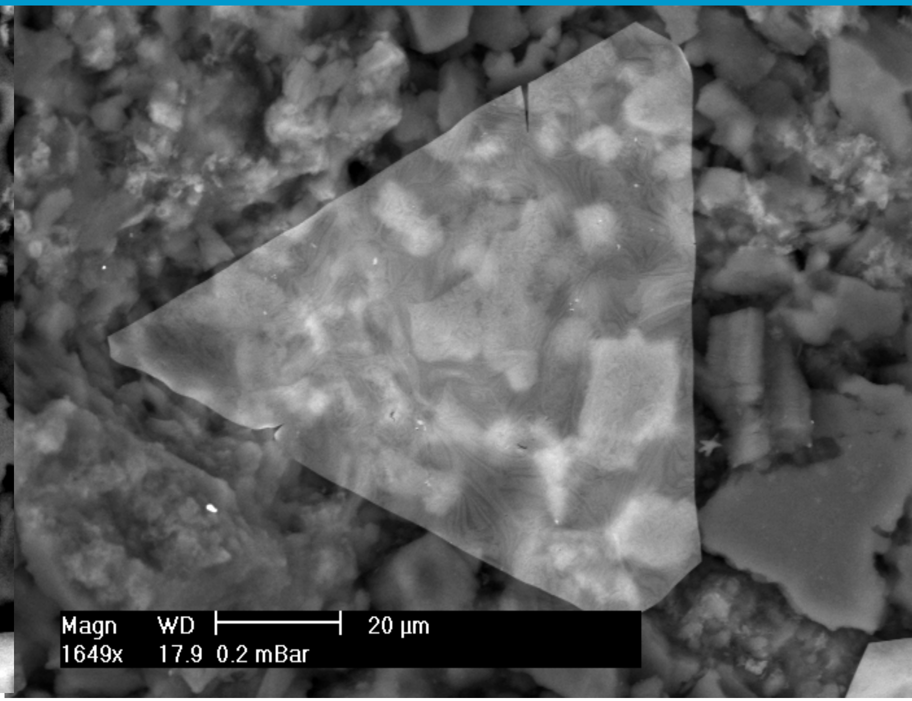


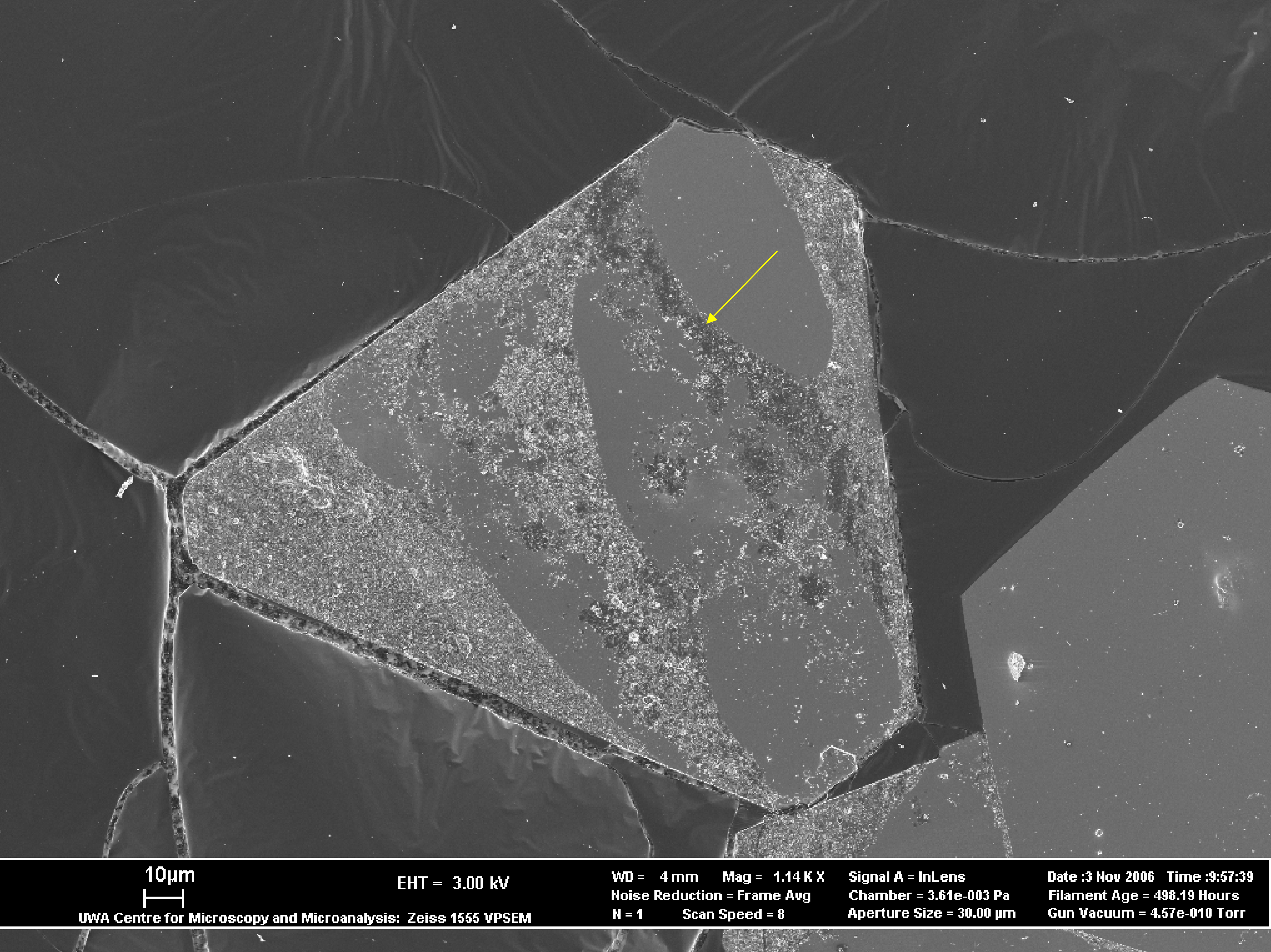


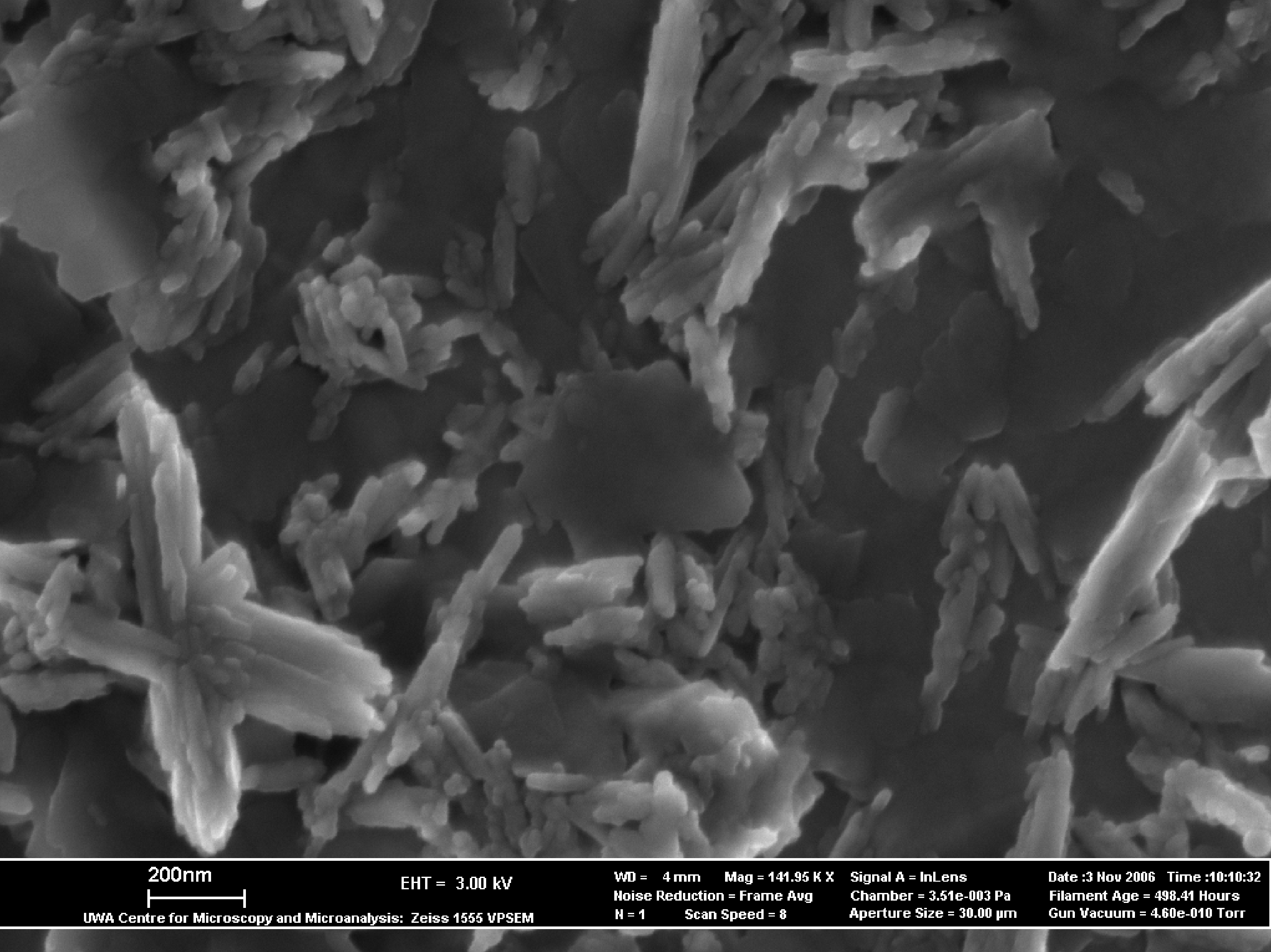


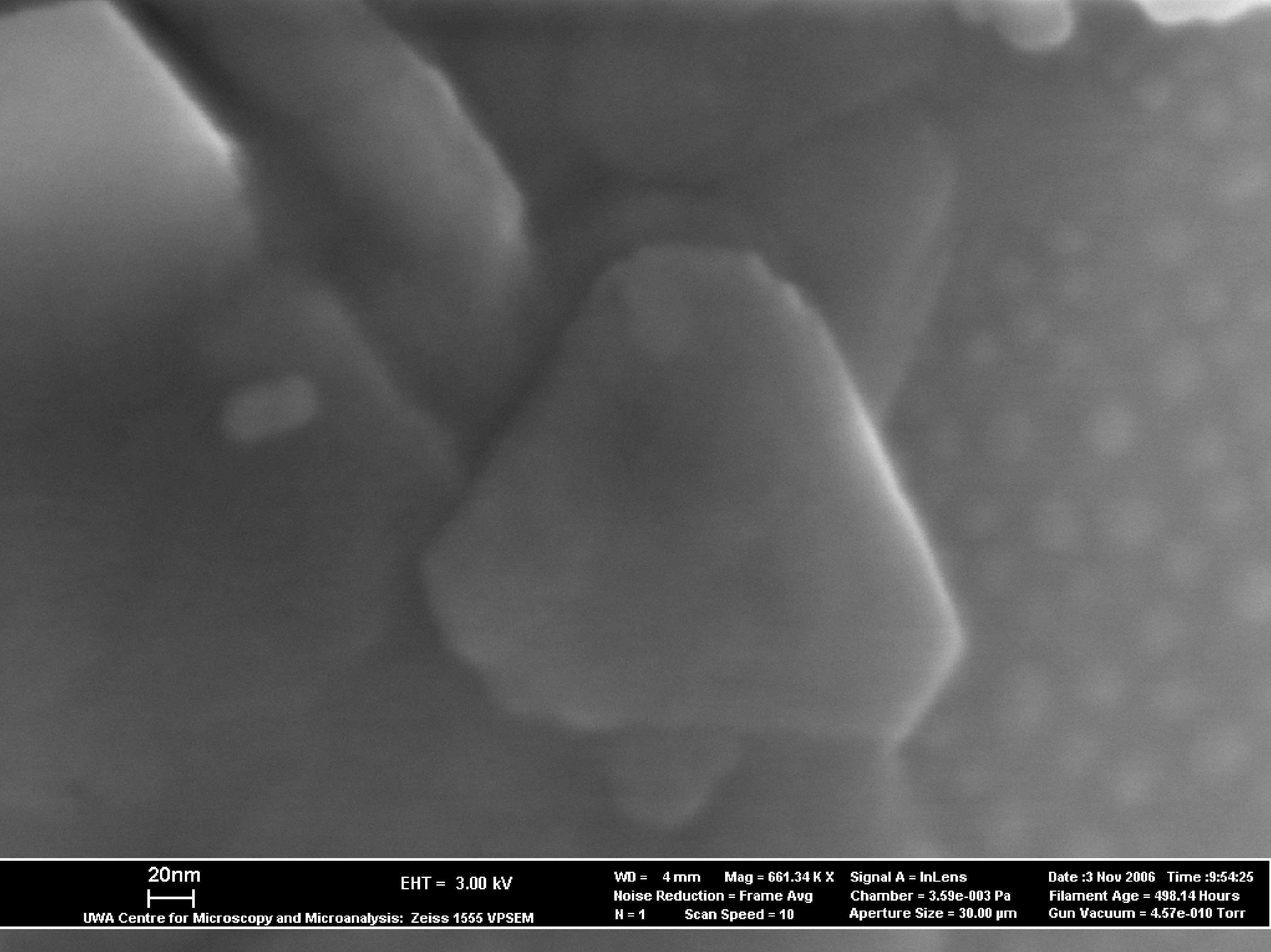
Electron transparent gold



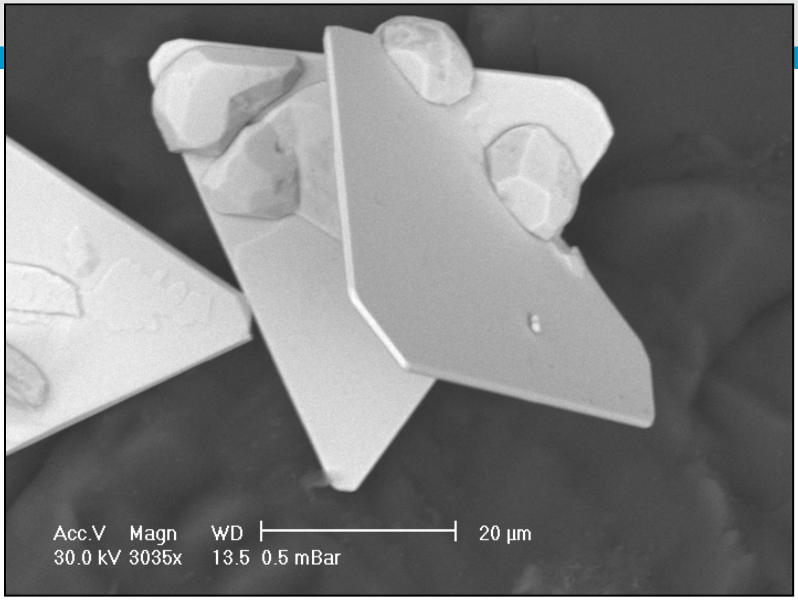


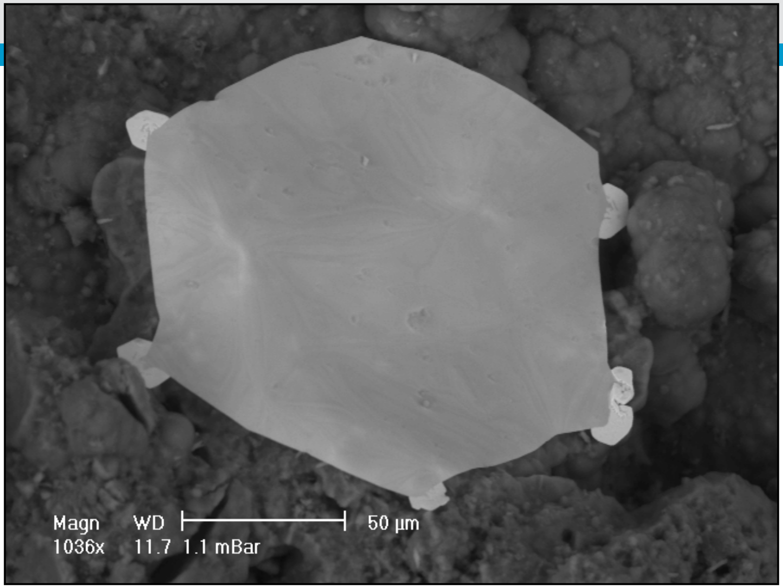

10µm
EHT = 3.00 kV
WD = 4 mm
Mag = 1.14 K X
Signal A = InLens
Date :3 Nov 2006
Time :9:57:39
Noise Reduction = Frame Avg
Chamber = 3.61e-003 Pa
Filament Age = 498.19 Hours
UWA Centre for Microscopy and Microanalysis: Zeiss 1555 VPSEM
N = 1
Scan Speed = 8
Aperture Size = 30.00 µm
Gun Vacuum = 4.57e-010 Torr

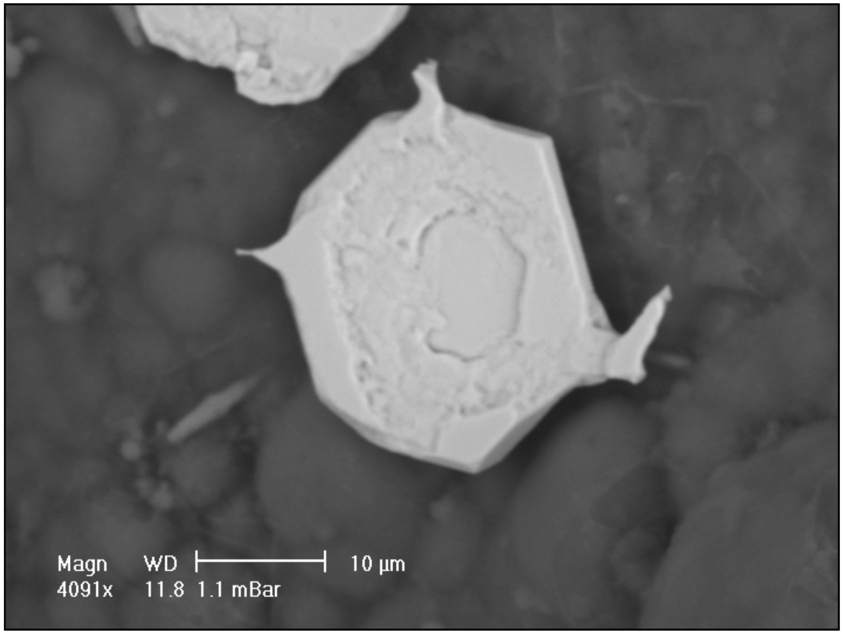

200nm
EHT = 3.00 kV
WD = 4 mm
Mag = 141.95 K X
Signal A = InLens
Date :3 Nov 2006
Time :10:10:32
Noise Reduction = Frame Avg
Chamber = 3.51e-003 Pa
Filament Age = 498.41 Hours
N = 1
Scan Speed = 8
Aperture Size = 30.00 µm
Gun Vacuum = 4.60e-010 Torr
UWA Centre for Microscopy and Microanalysis: Zeiss 1555 VPSEM


20nm
EHT = 3.00 kV
WD = 4 mm
Mag = 661.34 K X
Signal A = InLens
Date :3 Nov 2006
Time :9:54:25
Noise Reduction = Frame Avg
Chamber = 3.59e-003 Pa
Filament Age = 498.14 Hours
UWA Centre for Microscopy and Microanalysis: Zeiss 1555 VPSEM
N = 1
Scan Speed = 10
Aperture Size = 30.00 µm
Gun Vacuum = 4.57e-010 Torr

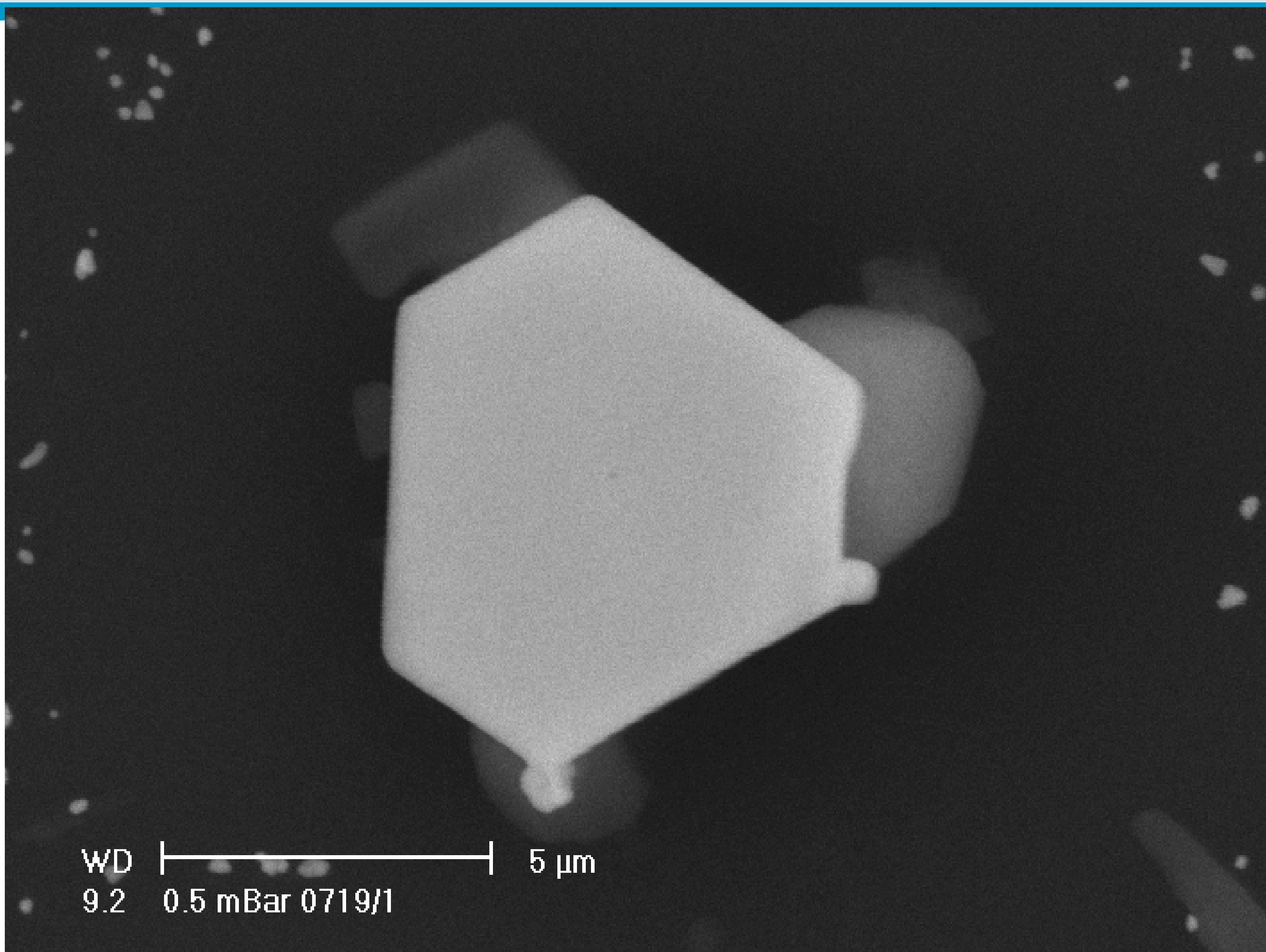
Octahedra precipitated later (drying phenomenon)





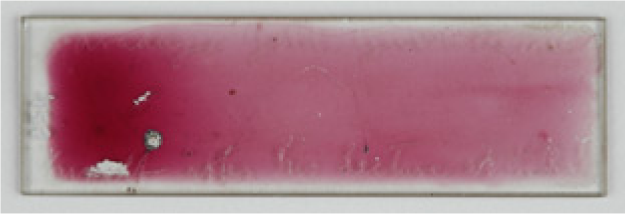


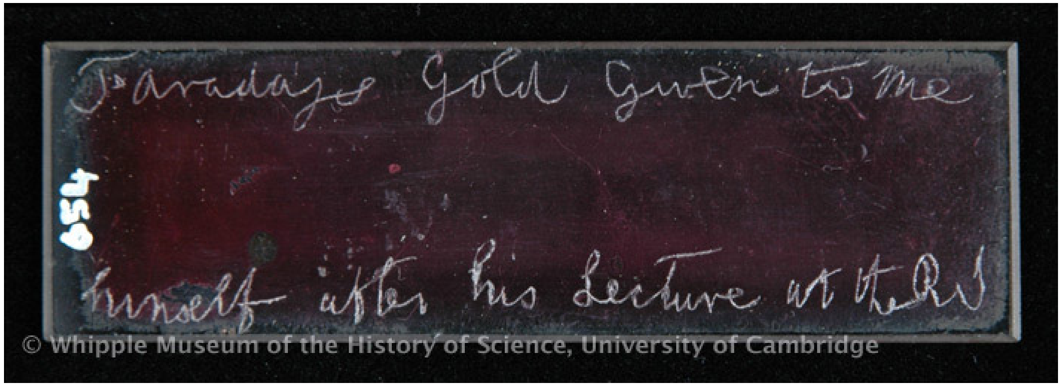
National Research FLAGSHIPS Minerals Down Under CSIRO


WD
5 µm
9.2 0.5 mBar 0719/1

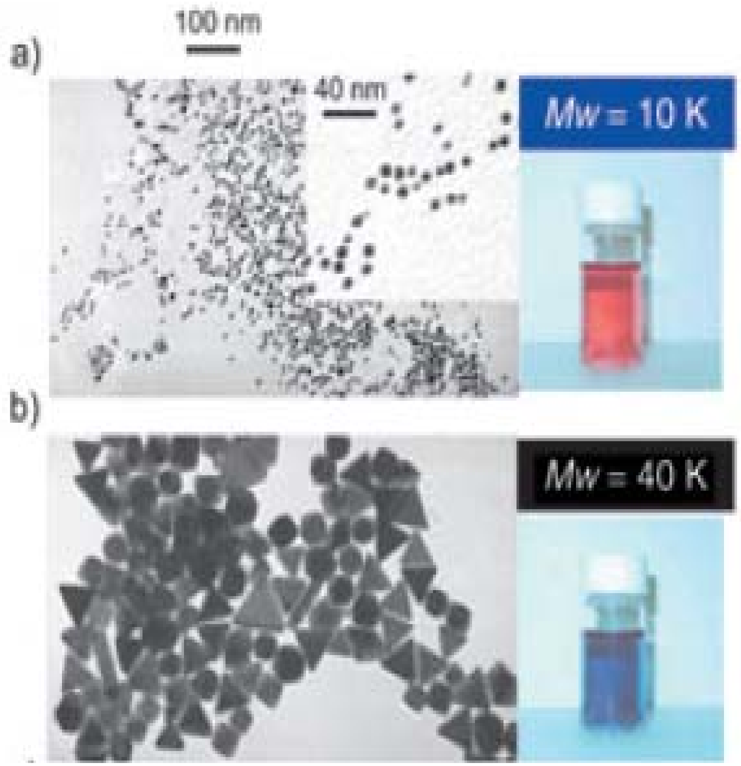
Faraday 1850 – changed gold sols blue from red

‘known phenomena seemed to indicate that a mere variation in the size of [gold] particles gave rise to a variety of resultant colours’



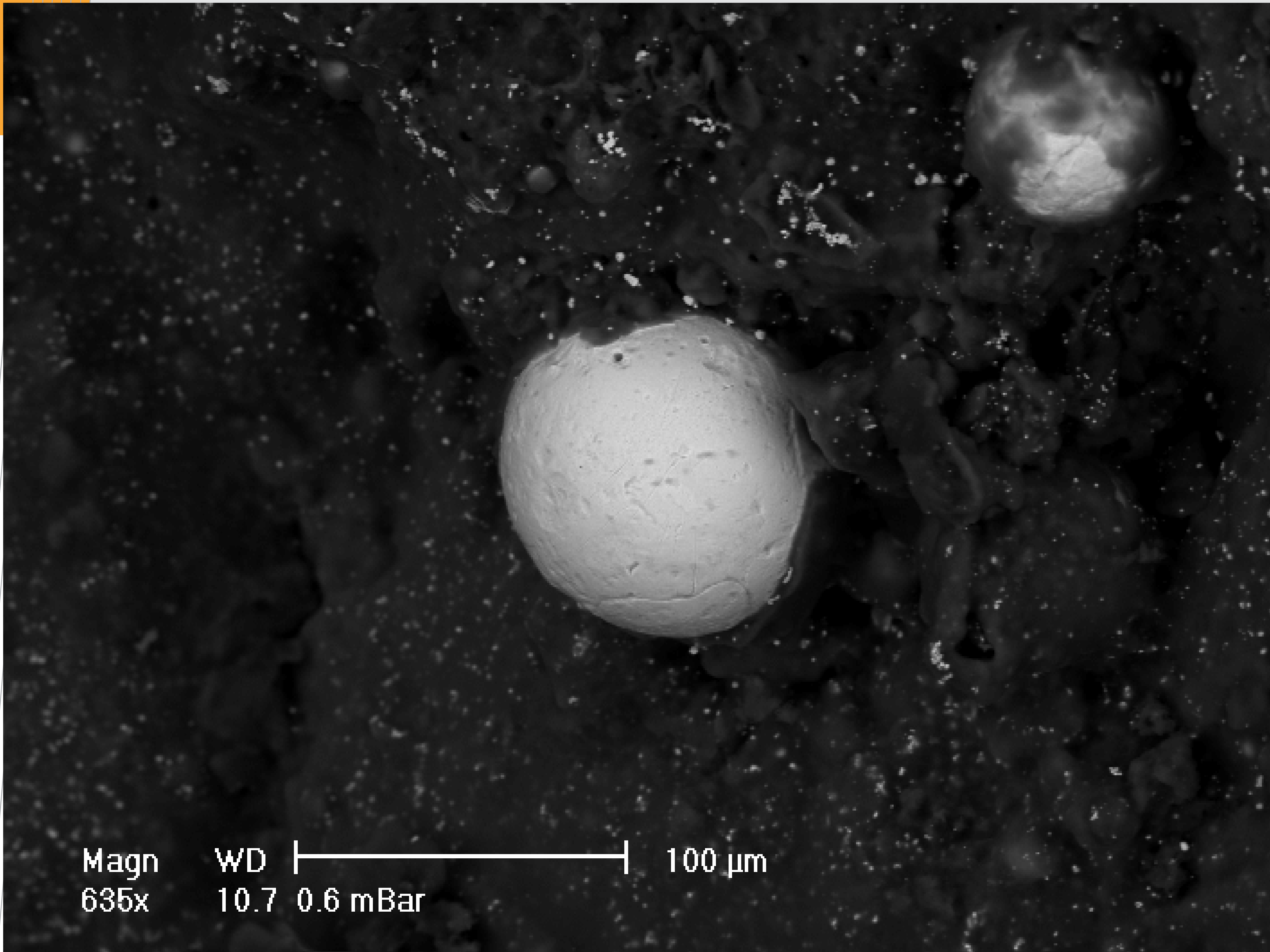


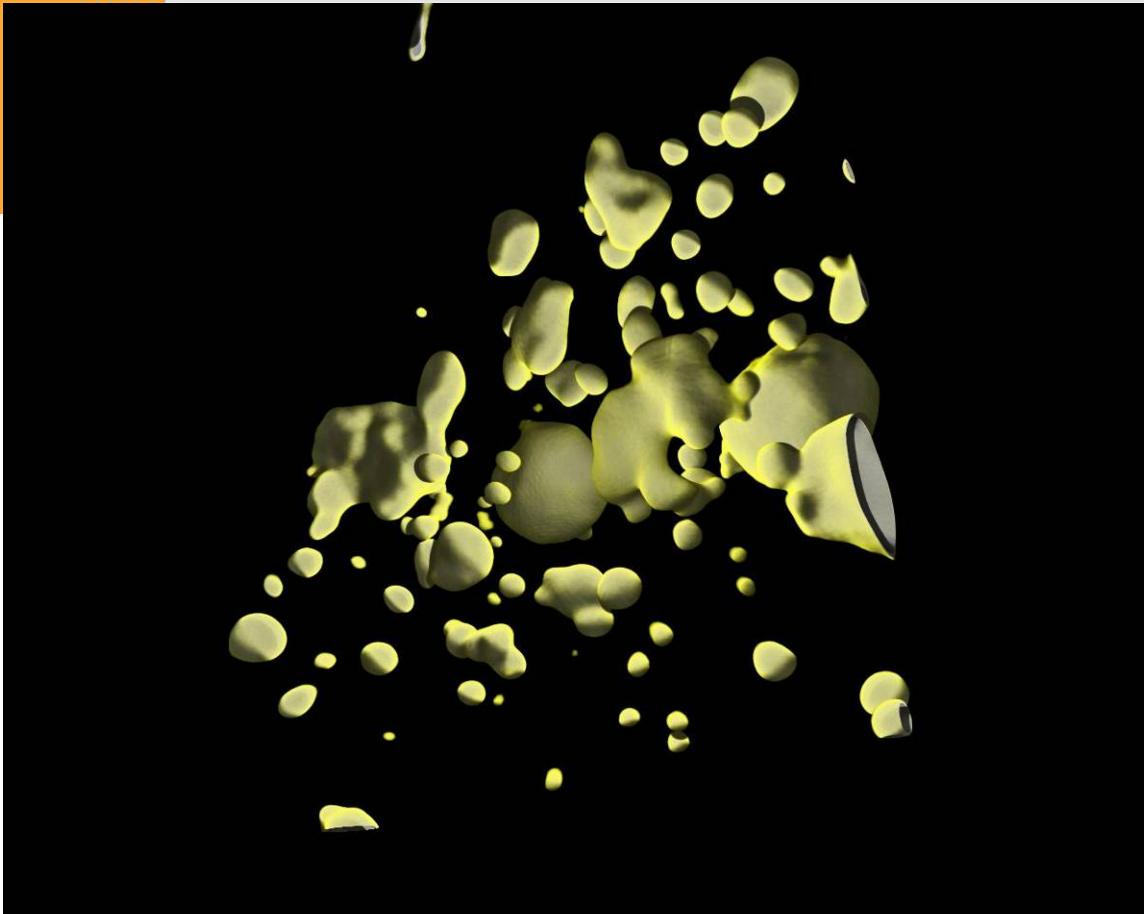
Nanoparticulate gold

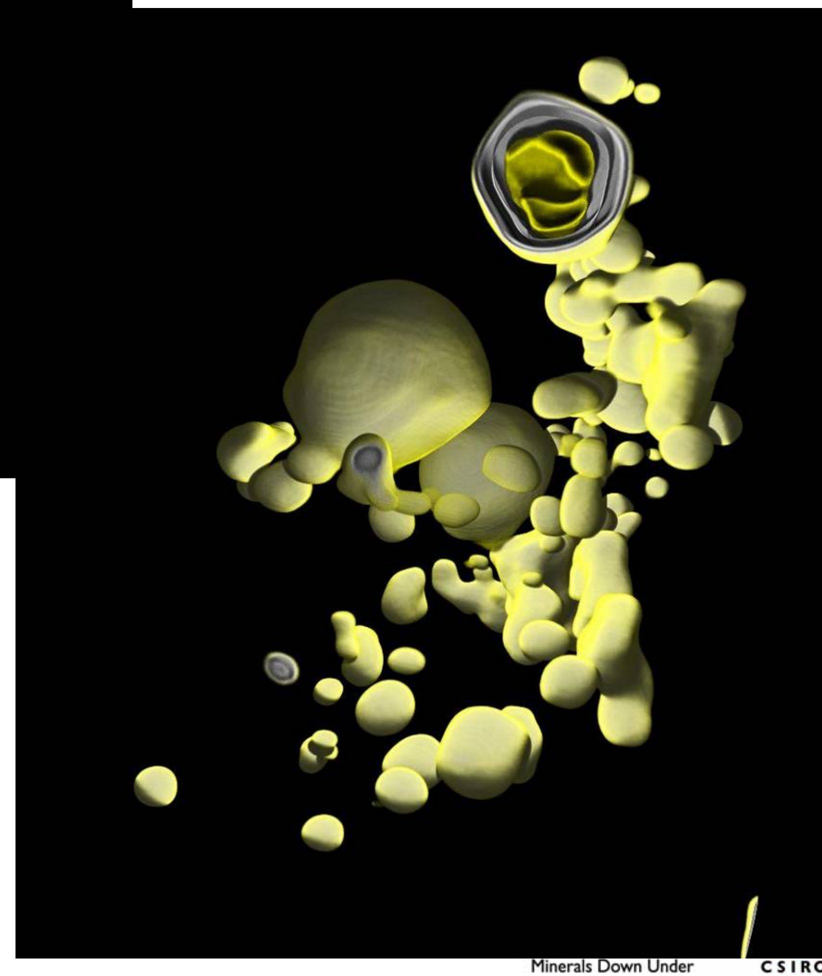


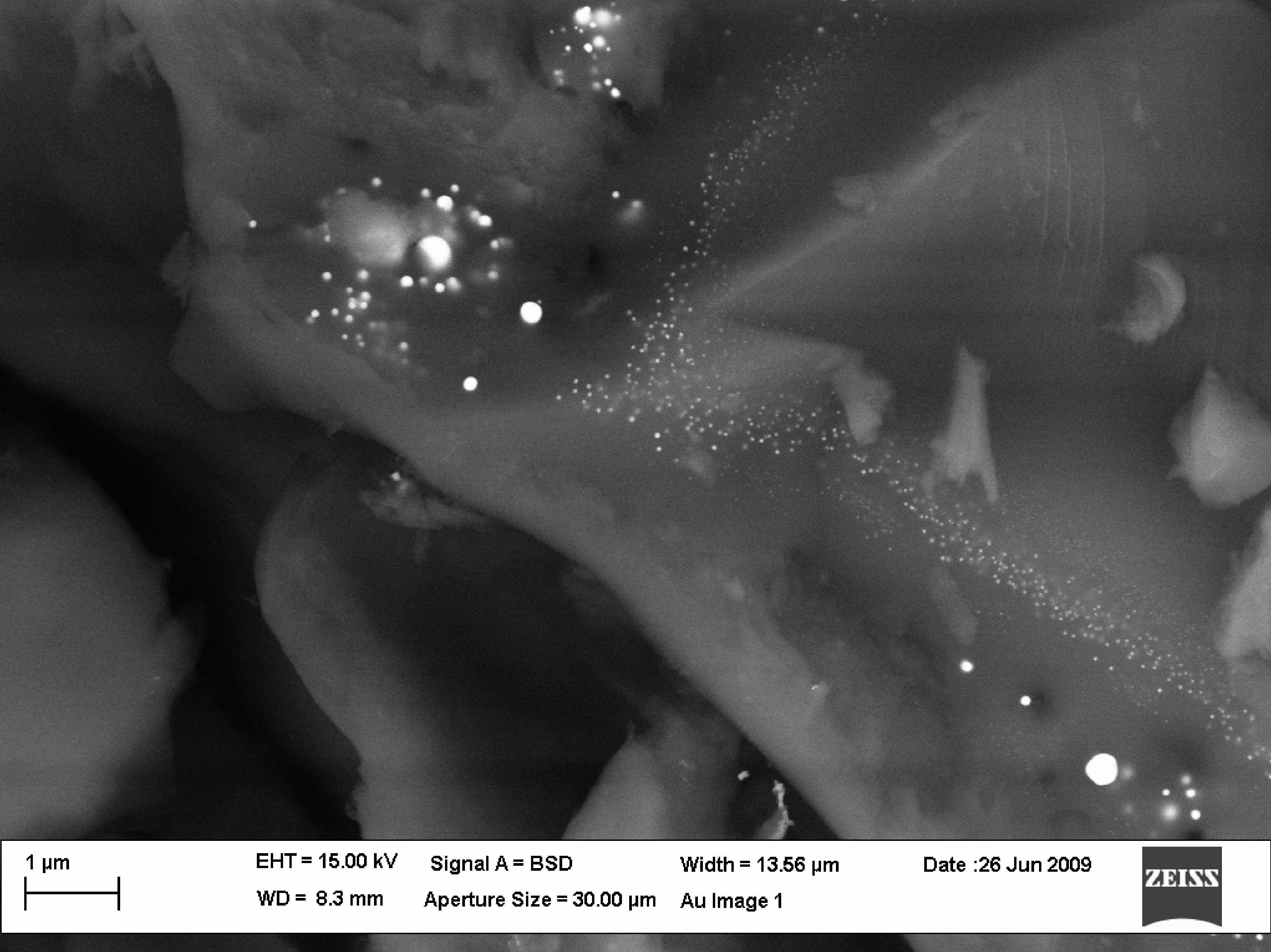
Tsuji et al., 2005

- Colloidal suspension
- Affects UV-Vis and colour of suspensions
- Controlled growth of size and shape of particle
- Stable form of transport: colloid can remain stable up to 400°C (relevant to hydrothermal transport)

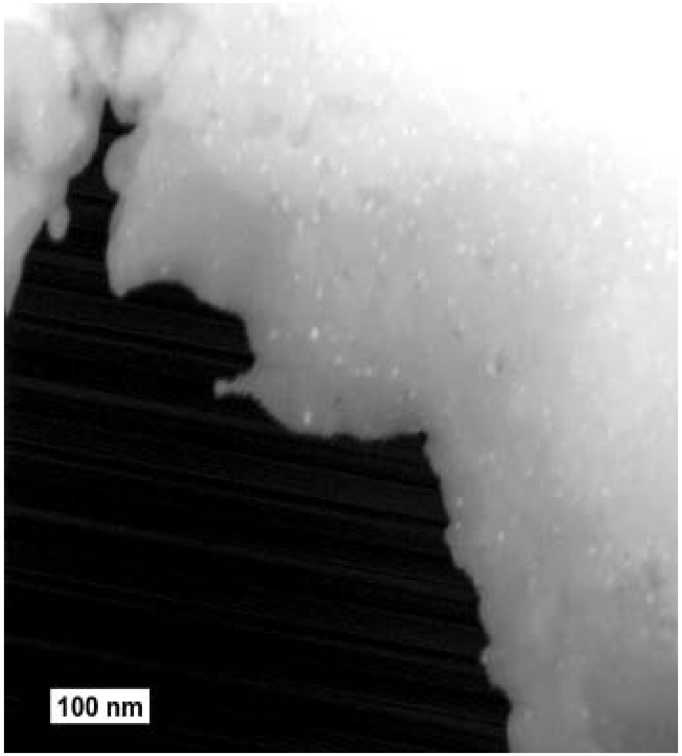

Magn
635x
WD
10.7 0.6 mBar
100 µm

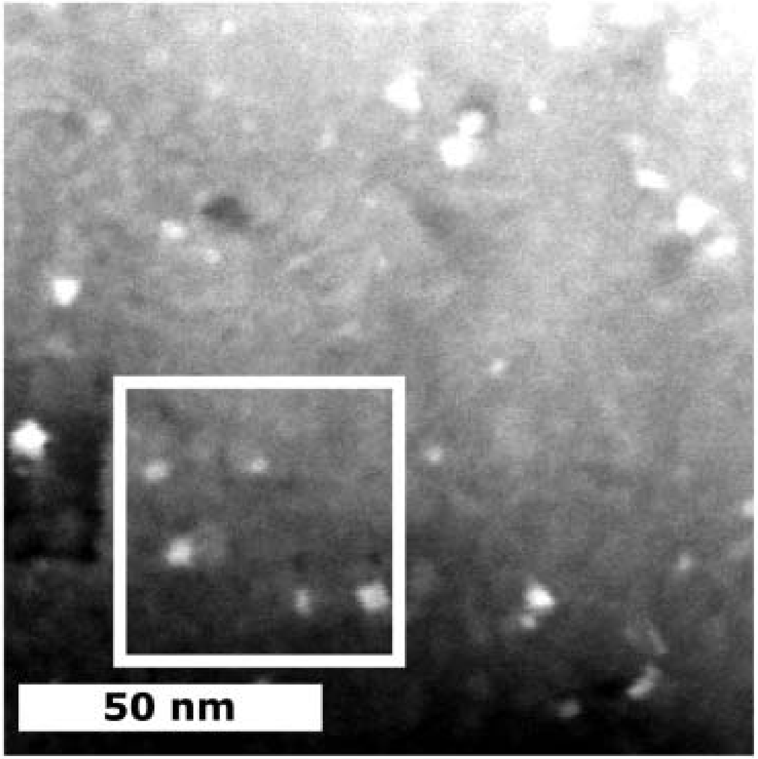



Minerals Down Under
CSIRO


1 µm
EHT = 15.00 kV
WD = 8.3 mm
Signal A = BSD
Aperture Size = 30.00 µm
Width = 13.56 µm
Au Image 1
Date :26 Jun 2009
ZEISS

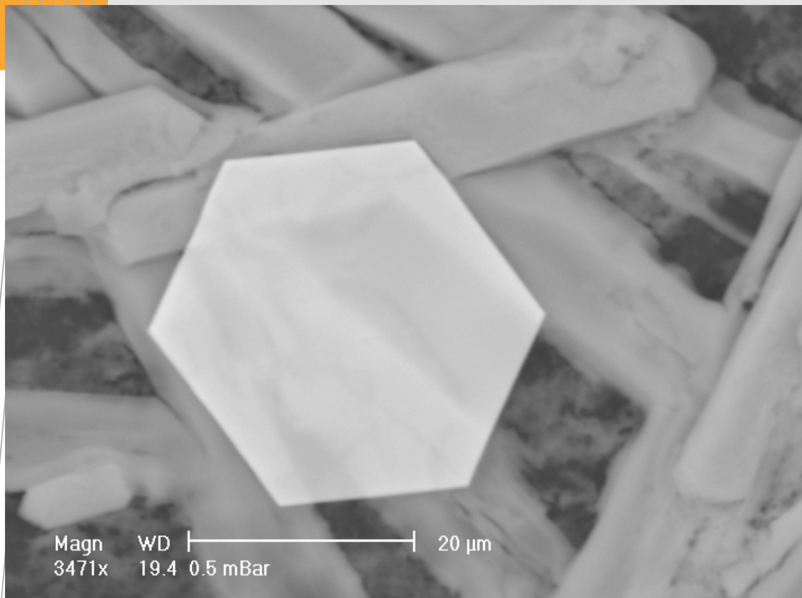
Gold nanoparticles in refractory ores

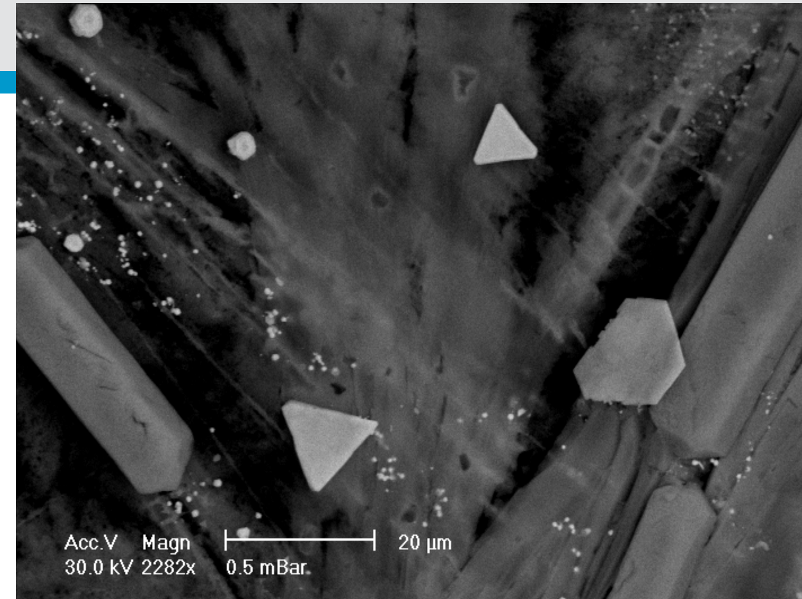


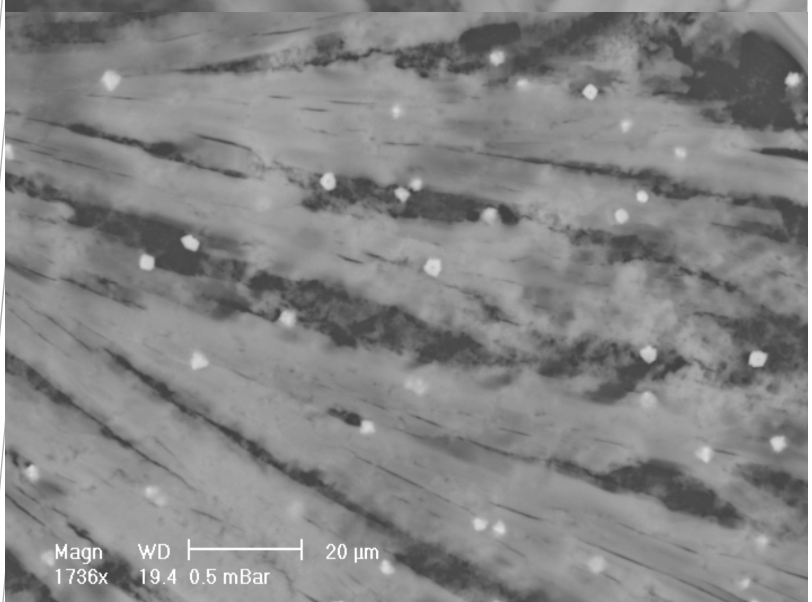


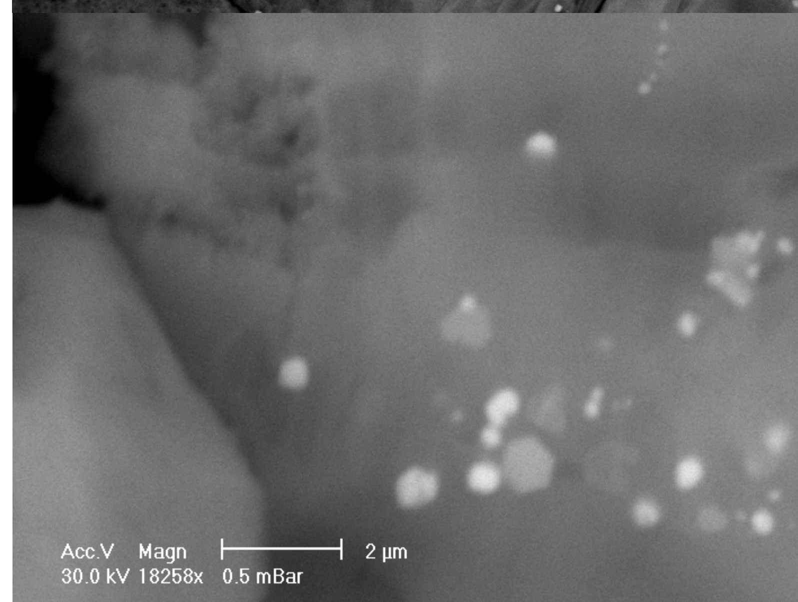
Palenik et al., 2004

Gold chloride evaporation: Extractable gold

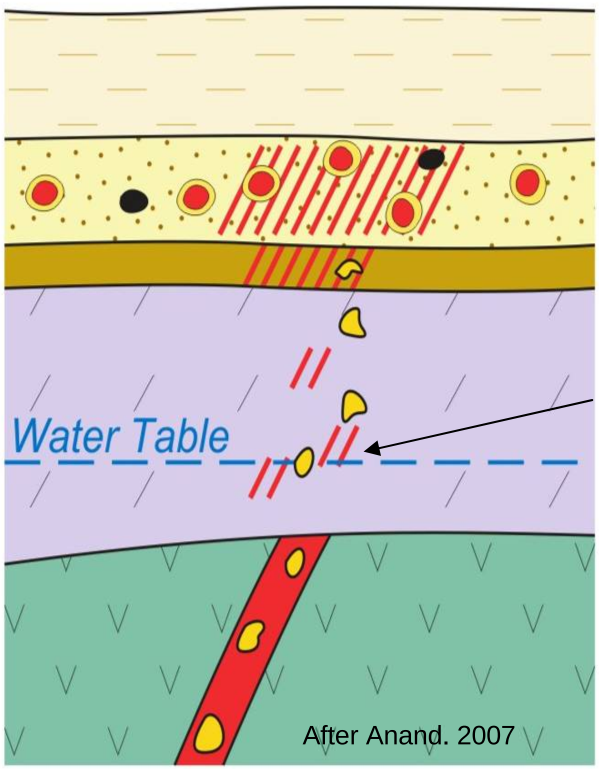


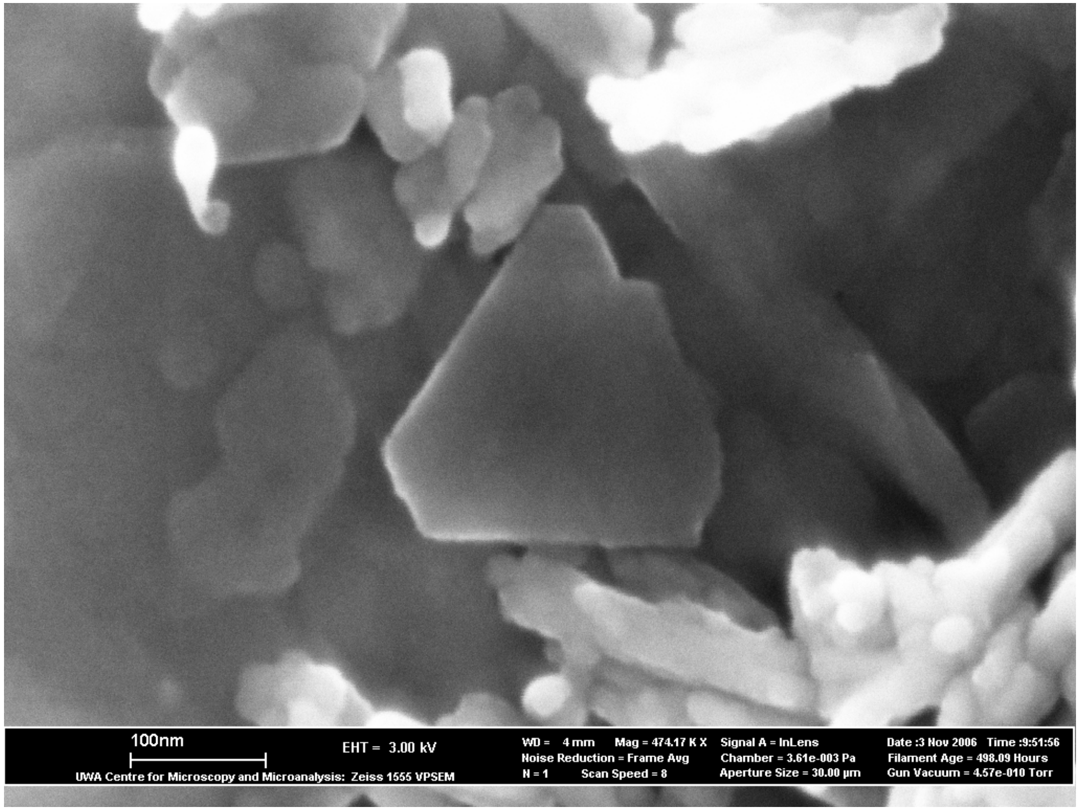




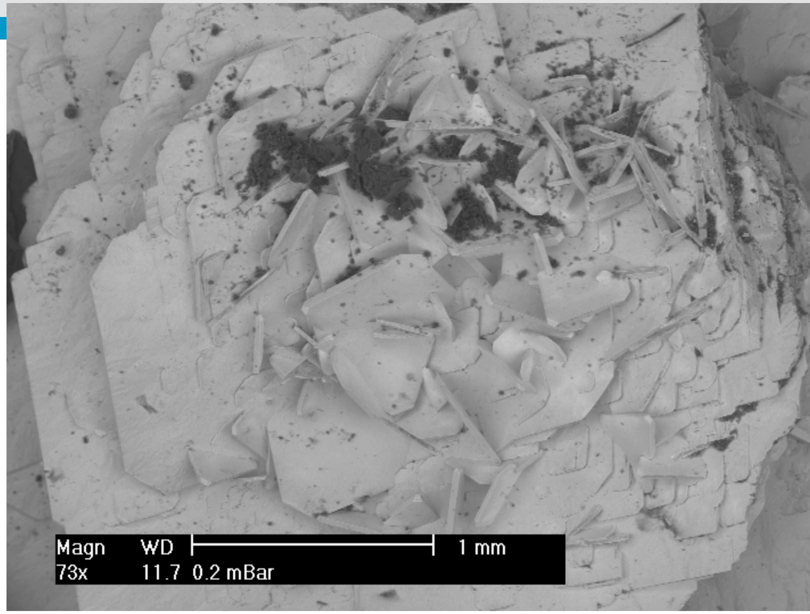


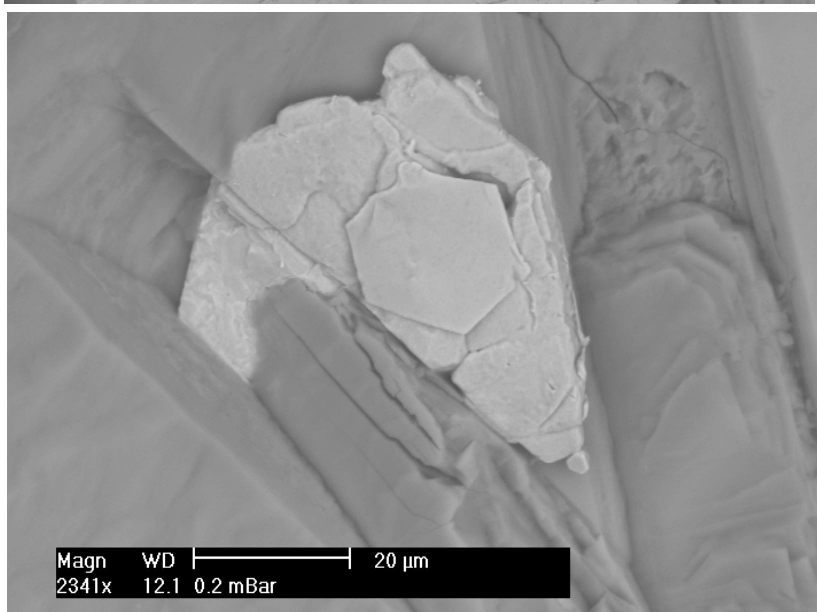
Hough et al. 2008 Geology

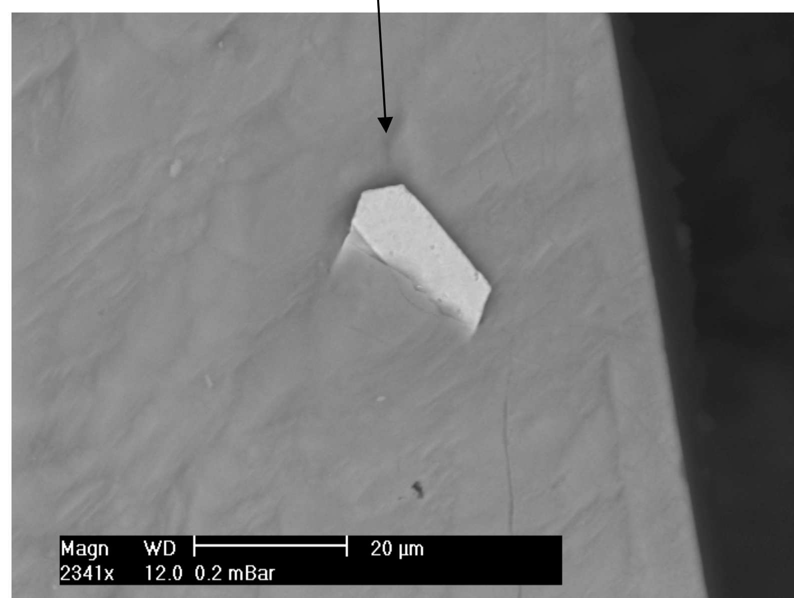




Barytes – evaporite ‘rose’





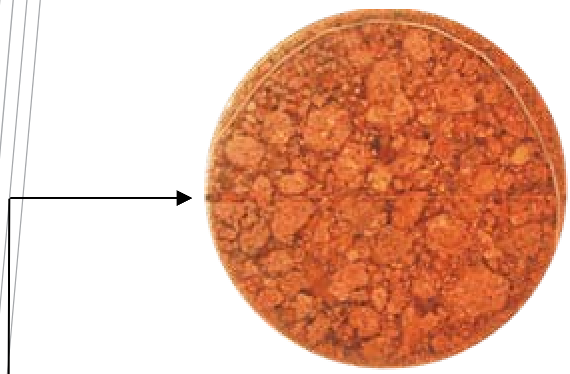


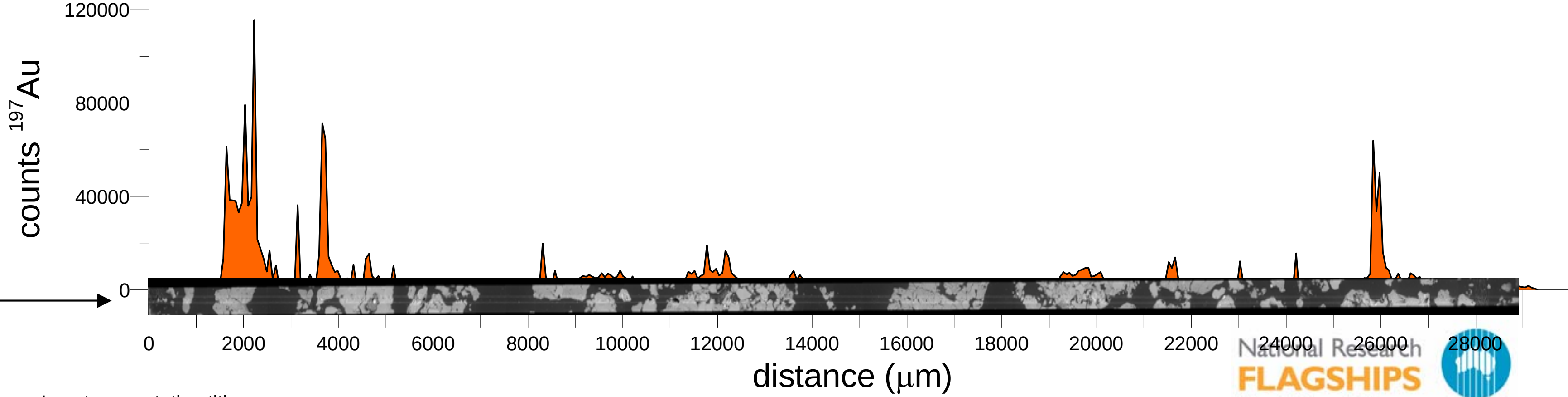
Using LA ICP MS to study nature of gold in calcrete

Lintern, 2008

- 20 samples studied to date
- Au is "nuggetty"
- Au-rich zones not related to other geochemistry e.g. Ca
- Au peaks appear not related to micro fabric features
- Results consistent with evapotranspiration model for Au accumulation in calcrete

LA ICPMS traverse across polished section of Au-rich calcrete (arrowed)



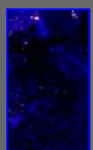


Maia-96 at the Australian Synchrotron – XFM line

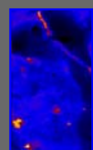
Recent data from XFM beamline, AS **December 2008 trials**

Run (#304): Bounty deposit, WA
Regolith, calcrete

Mel Lintern, CSIRO 2009



Au



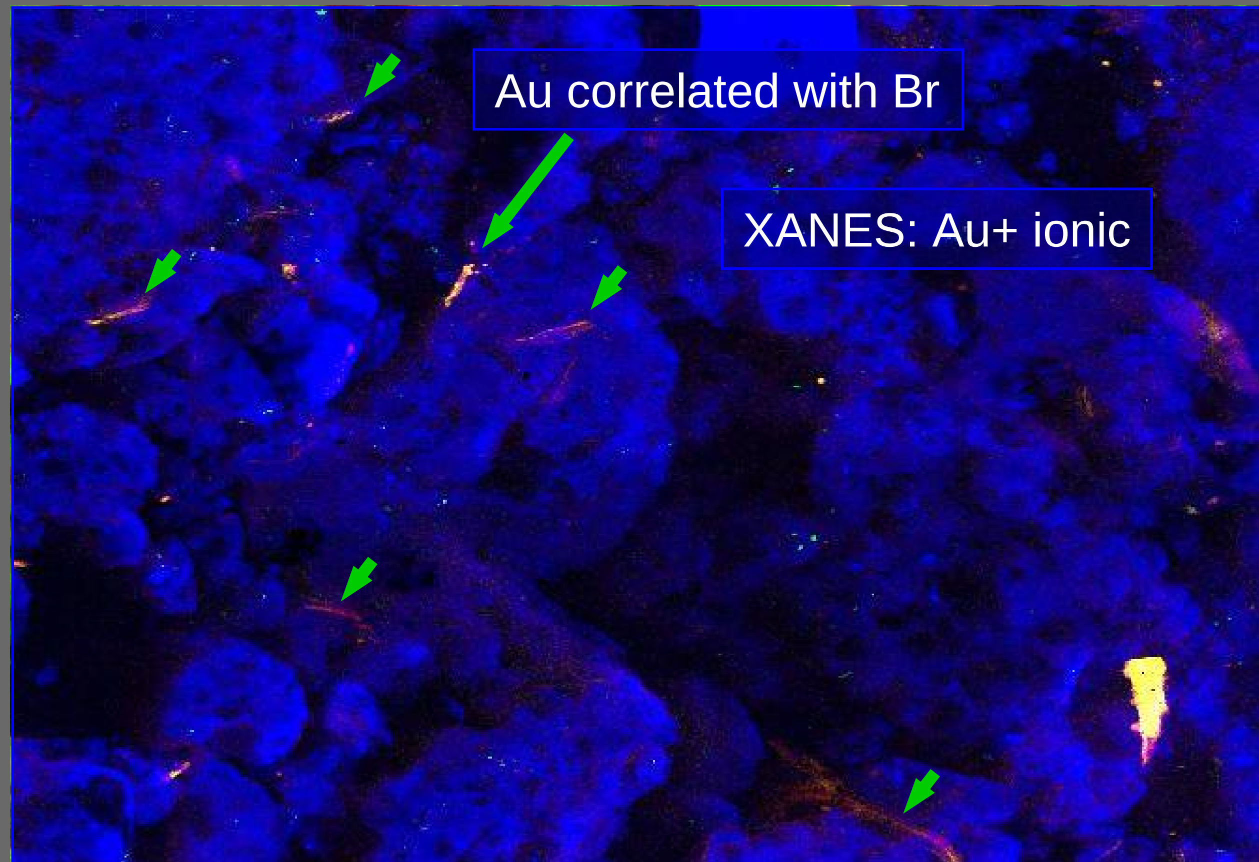
Br

APS: 117 x 203 pixels
(0.7 x 1.1 mm^2)
1 s dwell, 6 x 6 µm^2 pixels

Translucent to high-energy X-rays: Rb K, Sr K, beam

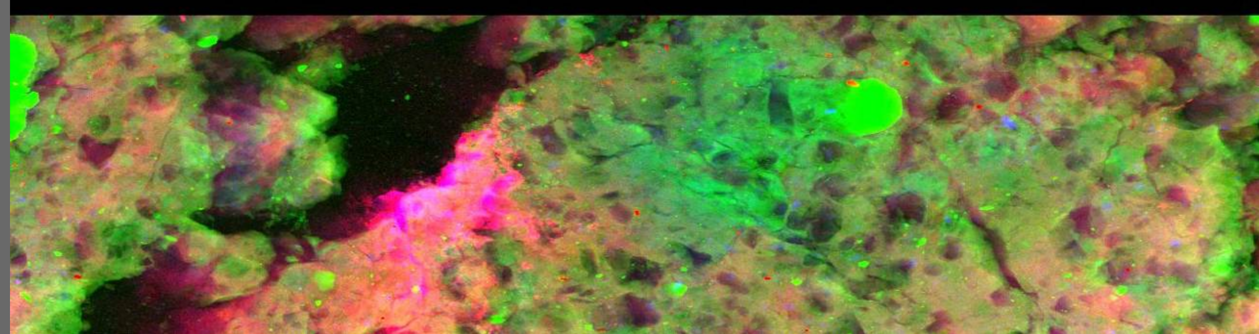
Dr Mel Lintern
CSIRO Exploration and Mining

Br-Au-Fe RGB composite



XFM beamline, 20.1 keV
Beam size $\phi \sim 1$ µm^2

Sr-Fe-Rb RGB composite



GeoPIXE 4.6 Dynamic Analysis

Colloidal nanoparticulate gold and sulphates: Evaporation

- **Stable colloidal transport of gold, some differences in precipitate from different ligands but still {111} crystals.**
- **Seeing 'Invisible' gold.**
- **Gold transport in areas where saline groundwaters interact with gold deposits worldwide.**
- **Sulphates an important mineral host for gold in the regolith including in weathered sediments**

National Research FLAGSHIPS Minerals Down Under CSIRO

National Research FLAGSHIPS Minerals Down Under CSIRO

ELSEVIER

Available online at www.sciencedirect.com
SCIENCE @ DIRECT®

Journal of Colloid and Interface Science 287 (2005) 159–166

JOURNAL OF
Colloid and
Interface Science

www.elsevier.com/locate/jcis

Size-controlled synthesis of colloidal platinum nanoparticles and their activity for the electrocatalytic oxidation of carbon monoxide

Zhicheng Tang, Dongsheng Geng, Gongxuan Lu *

State Key Laboratory for Oxo Synthesis and Selective Oxidation, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou, 730000, China

Received 16 October 2004; accepted 25 January 2005

Available online 17 March 2005

Synthesis of Tetrahexahedral Platinum Nanocrystals with High-Index Facets and High Electro-Oxidation Activity

Na Tian,[1] Zhi-You Zhou,[1] Shi-Gang Sun,[1]* Yong Ding,[2] Zhong Lin Wang[2]*

The shapes of noble metal nanocrystals (NCs) are usually defined by polyhedra that are enclosed by {111} and {100} facets, such as cubes, tetrahedra, and octahedra. Platinum NCs of unusual tetrahexahedral (THH) shape were prepared at high yield by an electrochemical treatment of Pt nanospheres supported on glassy carbon by a square-wave potential. The single-crystal THH NC is enclosed by 24 high-index facets such as {730}, {210}, and/or {520} surfaces that have a large density of atomic steps and dangling bonds. These high-energy surfaces are stable thermally (to 800°C) and chemically and exhibit much enhanced (up to 400%) catalytic activity for equivalent Pt surface areas for electro-oxidation of small organic fuels such as formic acid and ethanol.

Generally, catalytic performance of nanocrystals (NCs) can be finely tuned either by their composition, which mediates electronic structure (*1*, *2*), or by their shape, which determines surface atomic arrangement and coordination (*3*, *4*). Fundamental studies of single-crystal surfaces of bulk Pt have shown that high-index planes generally exhibit much higher catalytic activity than that of the most common stable planes, such as {111}, {100}, and even {110}, because the high-index planes have a high density of atomic steps, ledges, and kinks, which usually serve as active sites for breaking chemical bonds (*5*–*7*). For example, a bulk Pt(210) surface possesses extremely high catalytic reactivity for electroreduction of CO_2 (*8*) and electro-oxidation of formic acid (*9*). The bulk Pt(410) surface exhibits unusual activity for catalytic decomposition of NO, a major pollutant of automobile exhaust (*10*). Thus, the shape-controlled synthesis of metal NCs bounded by high-index facets is a potential route for enhancing their catalytic activities.

It is, however, rather challenging to synthesize shape-controlled NCs that are enclosed by high-index facets because of their high surface energy. Crystal growth rates in the direction perpendicular to a high-index plane are usually much faster than those along the normal direction of a low-index plane, so high-index planes are rapidly eliminated during particle formation (*11*). During the past decade, a variety of face-centered cubic (fcc) structured metal NCs with well-defined shapes have been synthesized, but nearly all of them are bounded by the low-index planes, such as tetrahedron, octahedron, decahedron, and icosahedron, enclosed by {111} facets (*12*–*14*), cube by {100} (*12*, *15*), cuboctahedron by {111} and {100} (*16*), and rhombic dodecahedron by {111} (*17*). Here we describe an electrochemical method for the synthesis of tetrahexahedral (THH) Pt NCs at high purity. The THH shape is bounded by 24 facets of high-index planes ~{730} and vicinal planes such as {210}

[1]State Key Laboratory of Physical Chemistry of Solid Surfaces, Department of Chemistry, College of Chemistry and Chemical Engineering, Xiamen University, Xiamen 361005, China. [2]School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, GA 30332–0245, USA.

*To whom correspondence should be addressed. E-mail: sgsun@xmu.edu.cn (S.G.S.); zhong.wang@mse.gatech.edu (Z.L.W.)

732 4 MAY 2007 VOL 316 SCIENCE www.sciencemag.org

INSTITUTE OF PHYSICS PUBLISHING NANOTECHNOLOGY

Nanotechnology **17** (2006) 1797–1800 doi:10.1088/0957-4484/17/6/042

Synthesis of single crystalline triangular and hexagonal Ni nanosheets with enhanced magnetic properties

Yonghua Leng[1], Yaohua Zhang[1], Tong Liu[1], Masaaki Suzuki[2] and Xingguo Li[1,3]

ARTICLES

Biological synthesis of triangular gold nanoprisms

S. SHIV SHANKAR[1], AKHILESH RAI[1], BALAPRASAD ANKAMWAR[2], AMIT SINGH[1], ABSAR AHMAD[3] AND MURALI SASTRY[1]

[1]Materials Chemistry, National Chemical Laboratory, Pune – 411 008, India
[2]Chemistry Department, Abasaheb Garware College, Pune – 411 004, India
[3]Biochemical Sciences Division, National Chemical Laboratory, Pune – 411 008, India
*e-mail: sastry@ems.ncl.res.in

Silver-based crystalline nanoparticles, microbially fabricated

Tanja Klaus*, Ralph Joerger, Eva Olsson, and Claes-Göran Granqvist

Department of Materials Science, The Ångström Laboratory, Uppsala University, P. O. Box 534, SE-751 21 Uppsala, Sweden.

Edited by Frank H. Stillinger, Bell Laboratories, Lucent Technologies, Murray Hill, NJ, and approved September 21, 1999 (received for review May 20, 1999)

Triangular Nanoplates of Silver: Synthesis, Characterization, and Use as Sacrificial Templates For Generating Triangular Nanorings of Gold**

By *Yugang Sun* and *Younan Xia**

Controlling the shape of metallic nanostructures has been a subject of intensive research in recent years because it provides another effective strategy (in addition to the control