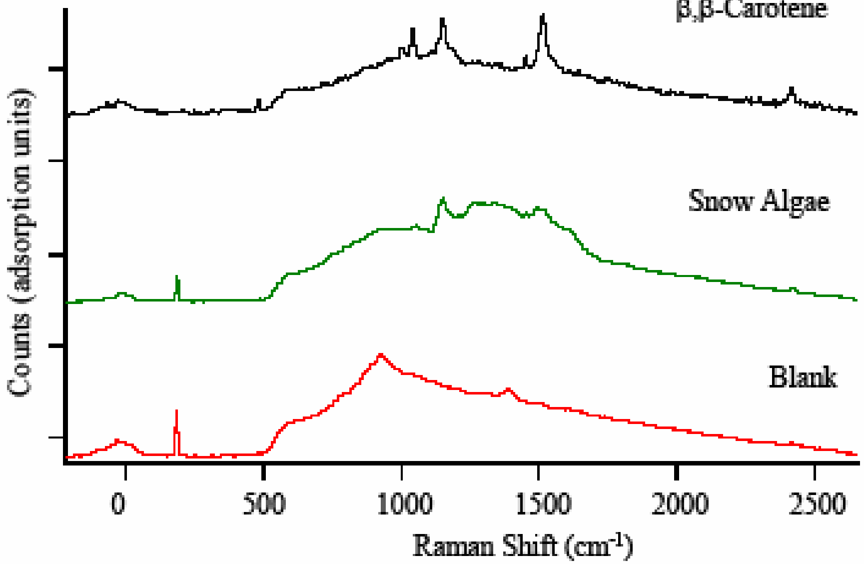
Surface Enhanced Raman Spectroscopy (SERS) for astrobiological exploration

Rab Wilson[2], Stephen A. Bowden[1]

1Department of Geology & Petroleum Geology, University of Aberdeen, Aberdeen AB24 3UE, UK
2Department of Electronics and Electrical Engineering, Oakfield Avenue, University of Glasgow, Glasgow, G12 8LT,UK

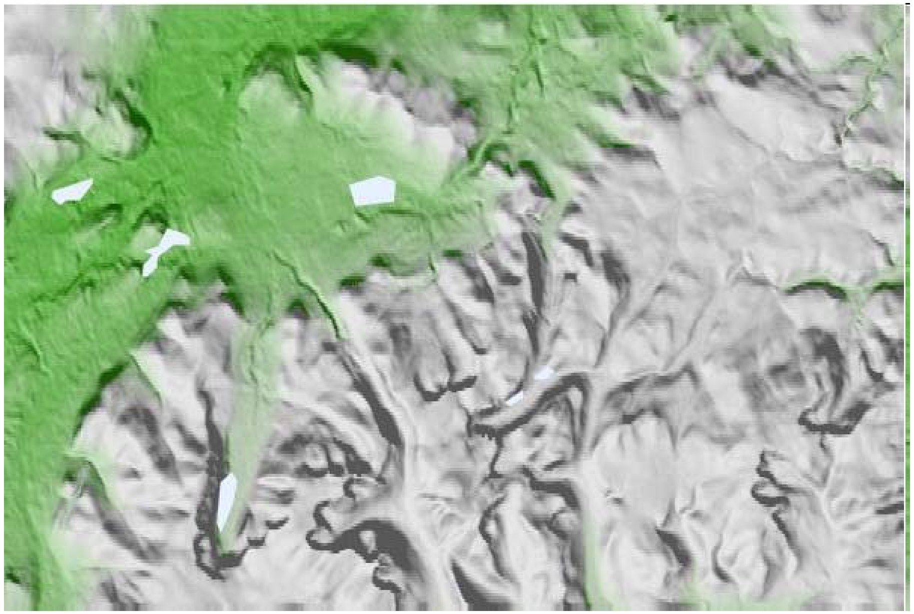
Snow Algae Cairngorm Plateau



•Snow Algal bloom –Cairngorm Plateau

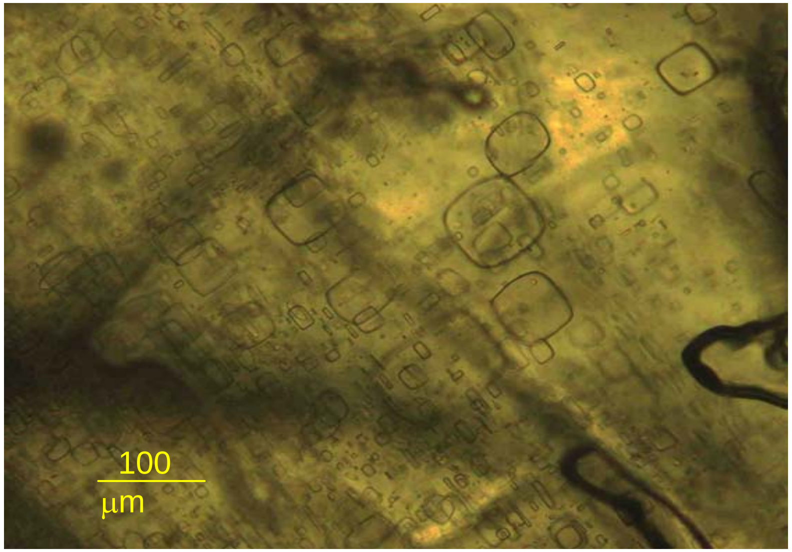
•Measurements performed on melted ice

•But this is best case scenario
– Lots of analyte
– knew what and where it was before we performed analysis

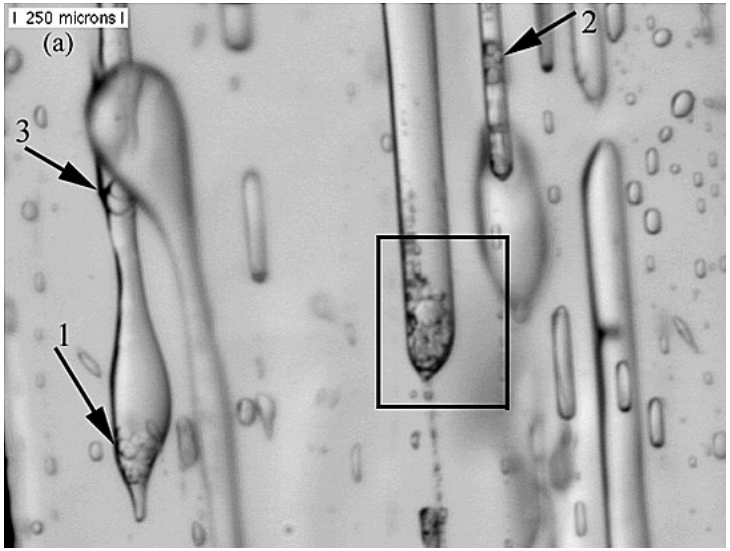


20 x 20 km of snow field

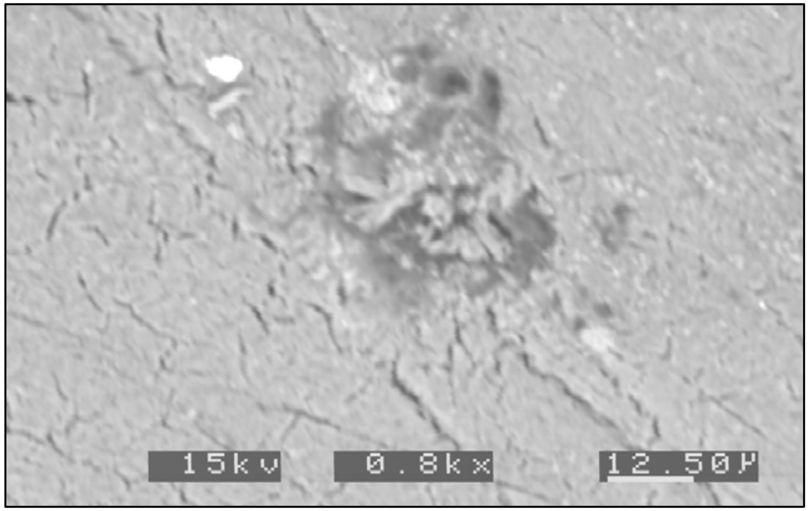
Analysing Organic compounds for Astrobiology/geology



Inclusions in Halite



Inclusions with sulphate salt in ice; Light et al 2003.

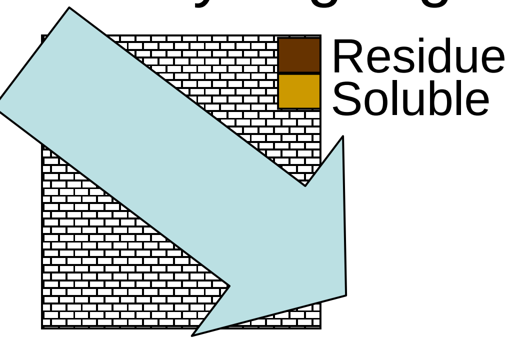


< ppm analysis – what it means
Solvent extraction/analyte concentration

-For physicists
- •Separation stages
- •Deconvolution not enough

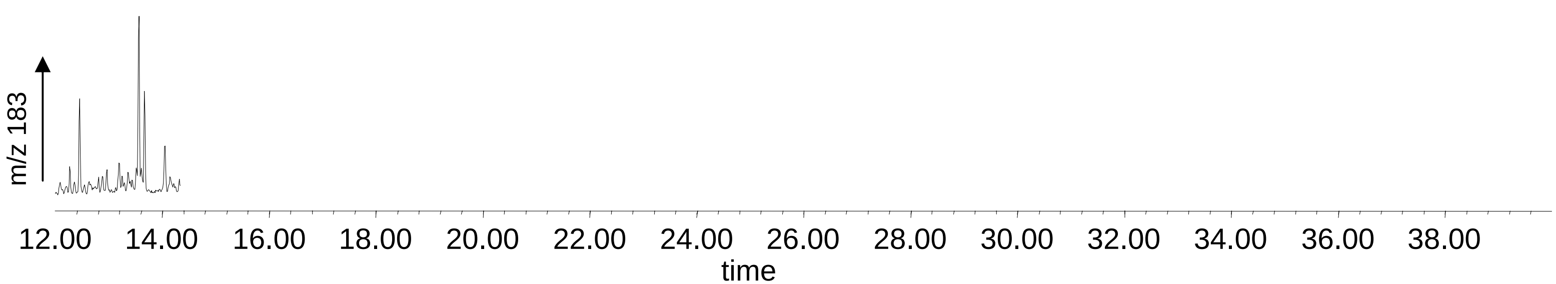
-Difficult and complex analysis
- -In engineer speak:
- •Many mechanisms
- •High power
- •High Mass

Analysing organic compounds in geological materials



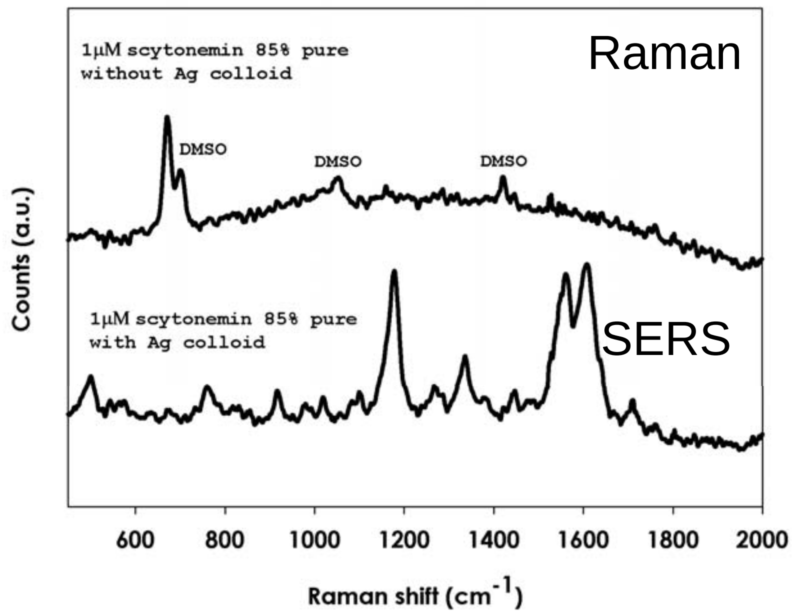
Soluble

1. Crush
2. Wash with solvent
3. Extract with solvent
4. **Concentrate**
5. **Transfer to analytical equipment**



Benefits of SERS over conventional Raman Spectroscopy

•SERS selectively enhances only specific molecules (factor 10^5 enhancement)
Can analyse organic compounds in solvents

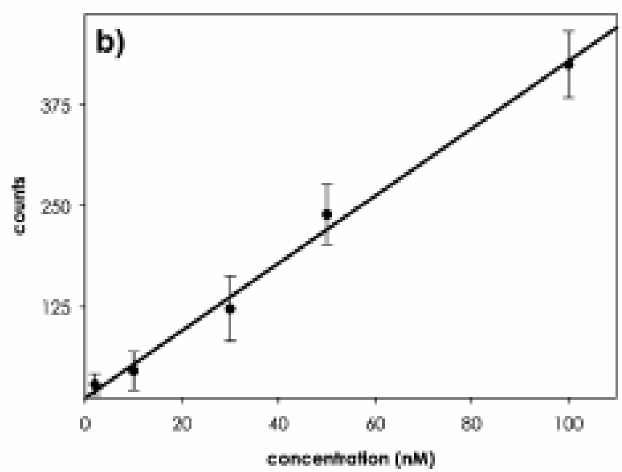


Fluorescence quenching?
•Natural extracts complex mixtures
-either fluoresce
-not possible to interpret spectra

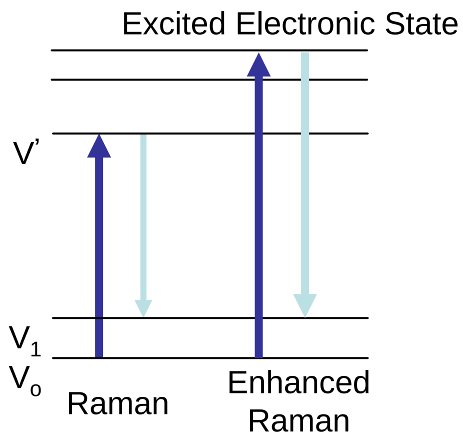
Limits of detection

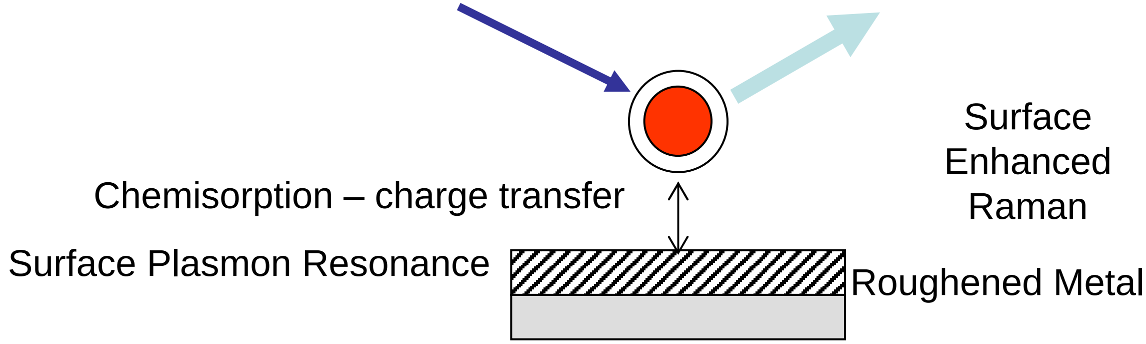
•For scytonemin
•Detection of 2nM > 3σ background noise

•Detect lower concentrations of R6G

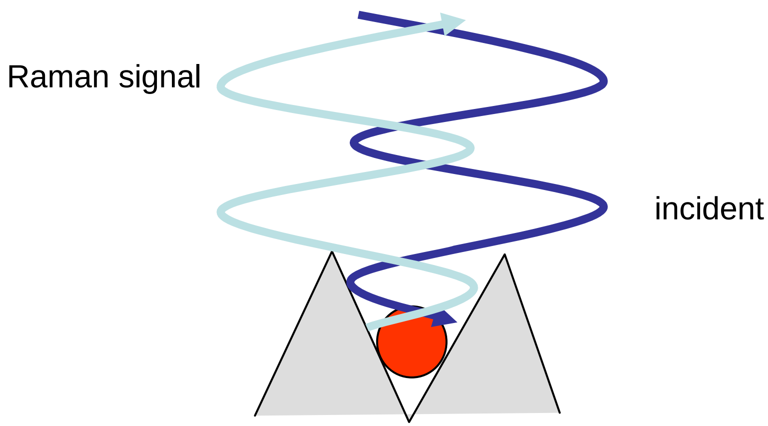


Surface Enhanced Raman Spectroscopy (SERS)

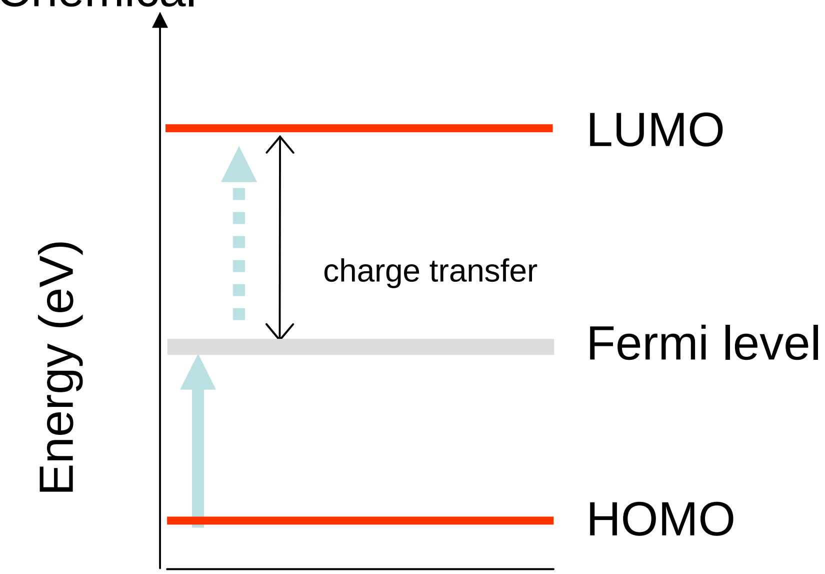




Electromagnetic



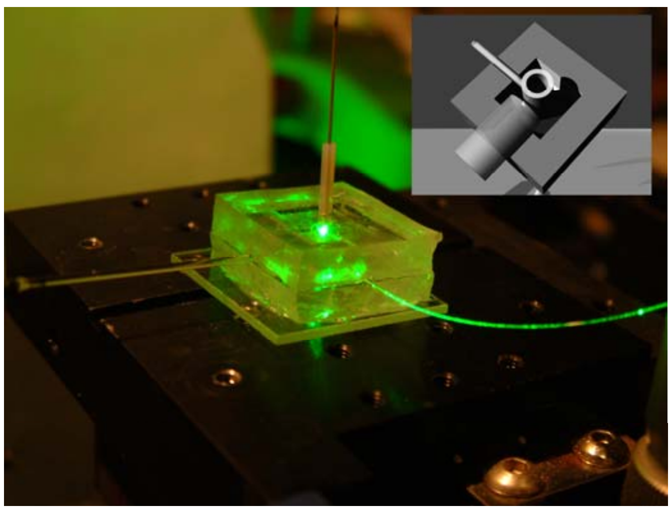
Chemical



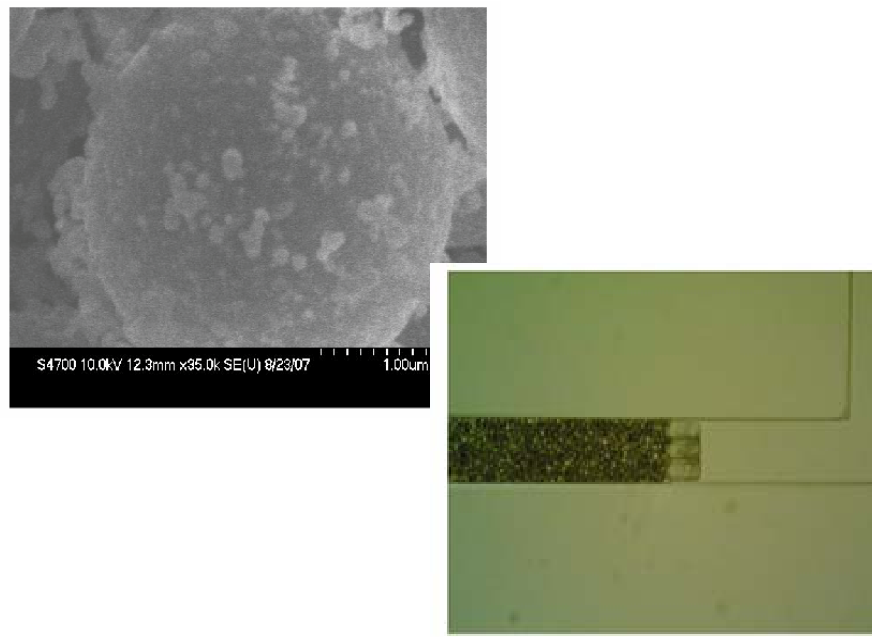
Equipment

- Light source - 514 nm, (typically about 10 mW laser)
- OTS Ocean Optics spectrometers
- Nitric acid, citric acid used to improve metal – analyte interaction

Silver Colloid in flow cell



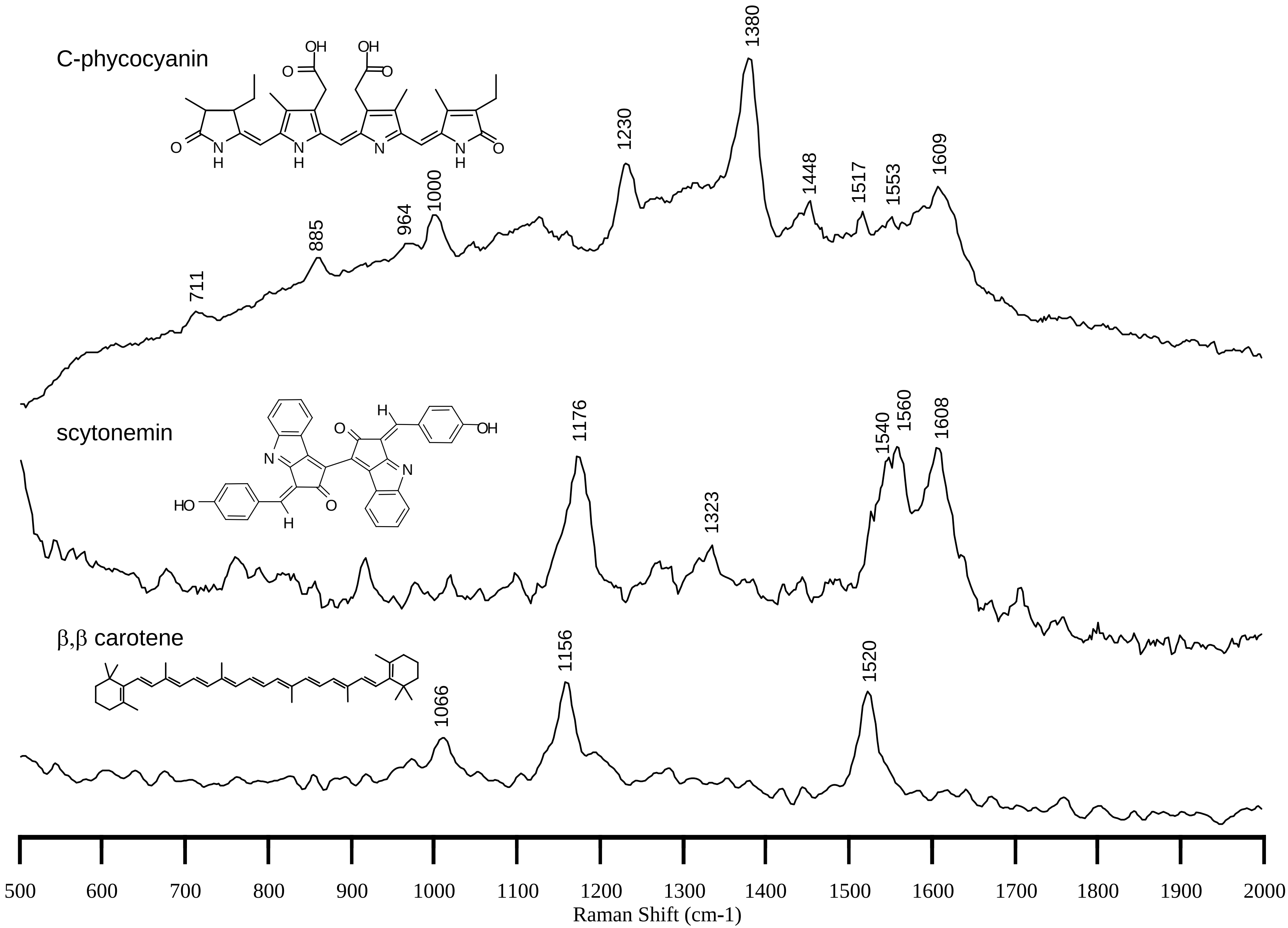
Silver Beads and bead trap



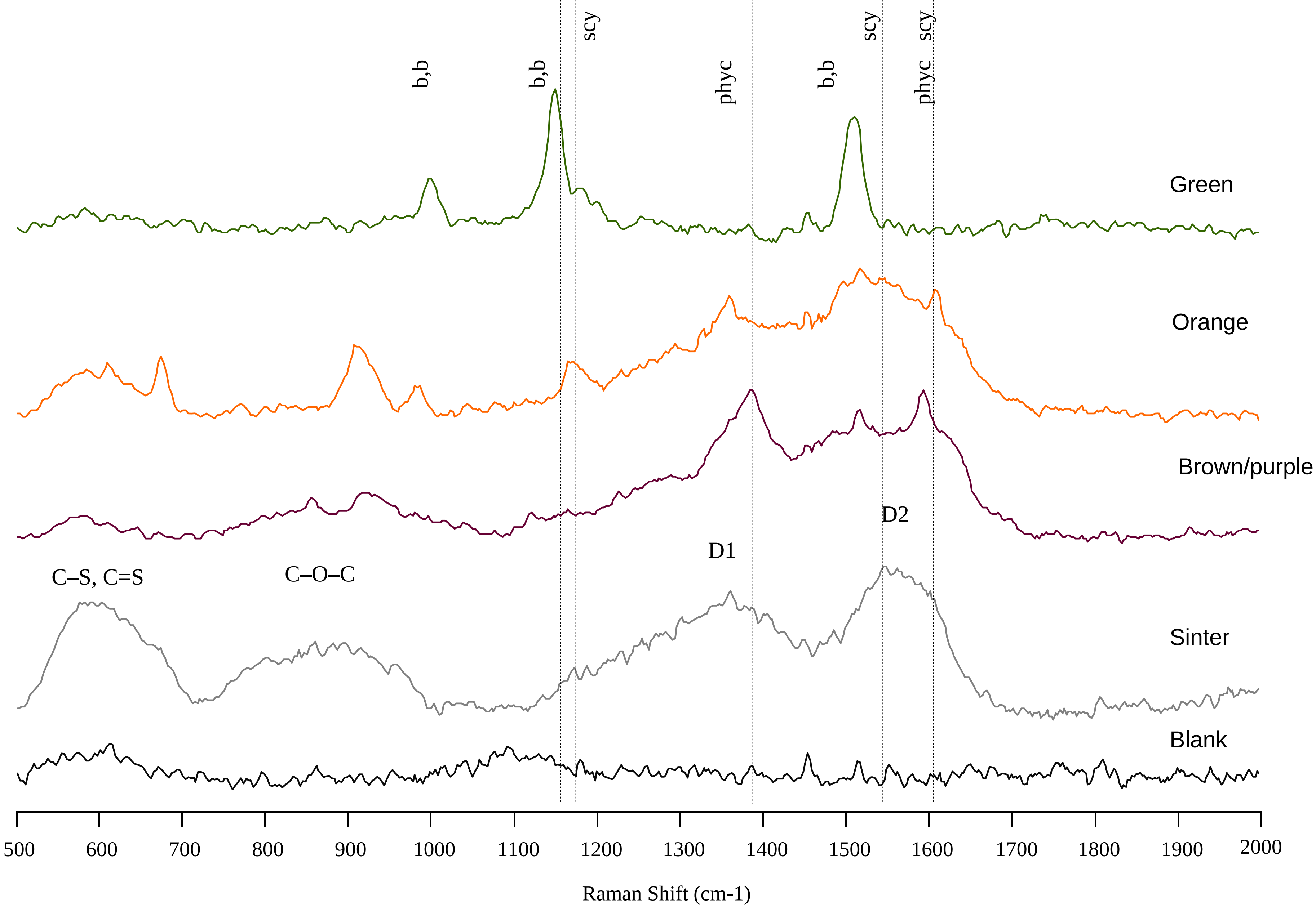
Biomolecules from hydrothermal system I

Purple Orange Green

1. **Samples ground and crushed**
2. **Extracted with Acetone**
3. **Acetone analysed by SERS**

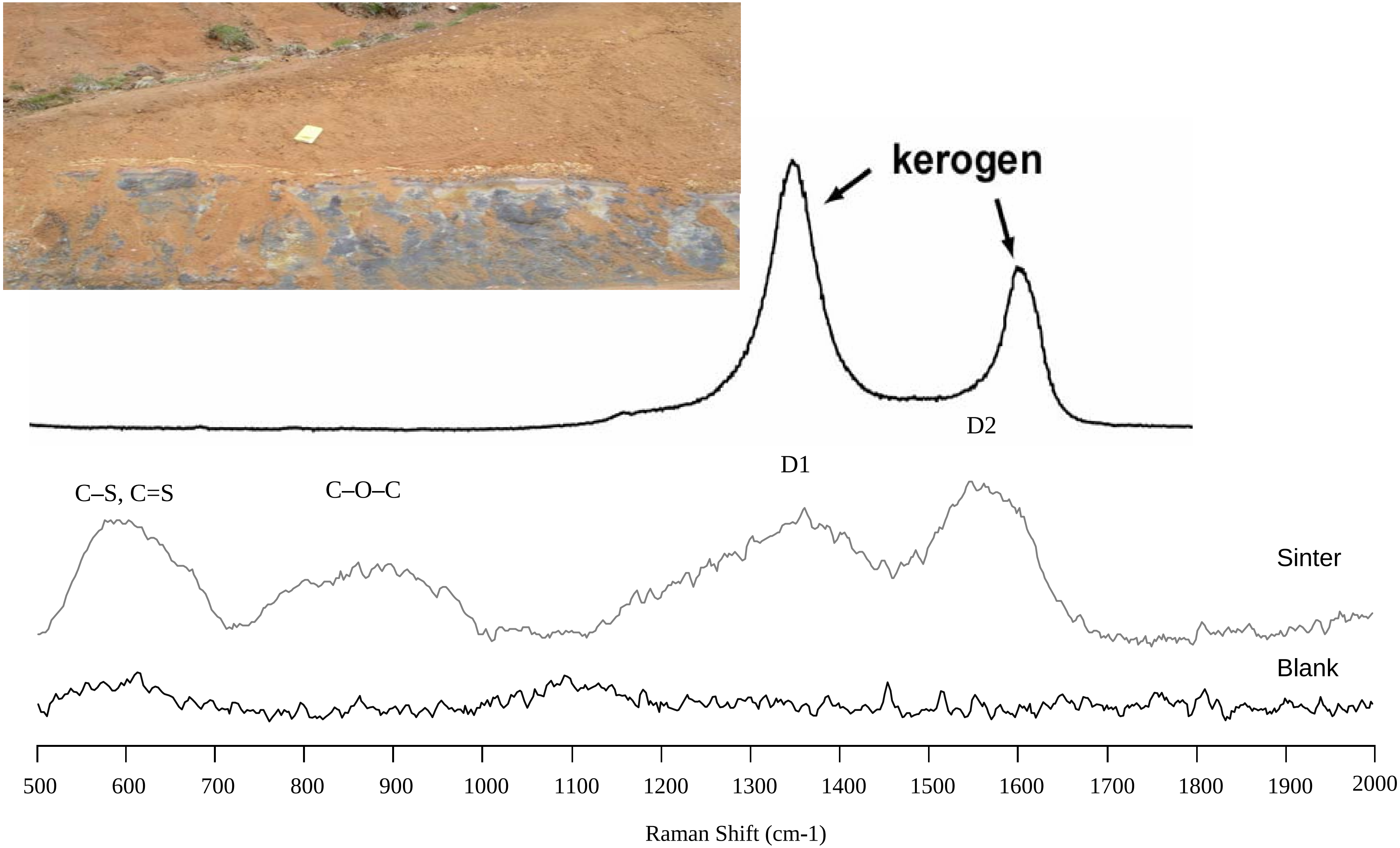

C-phycocyanin
OH
OH
O
O
O
N
H
N
H
N
N
H
O
711
885
964
1000
1230
1380
1448
1517
1553
1609
scytonemin
H
O
OH
N
N
HO
O
H
1176
1323
1540
1560
1608
β,β carotene
1066
1156
1520
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Raman Shift (cm-1)

Biomolecules in hydrothermal system II

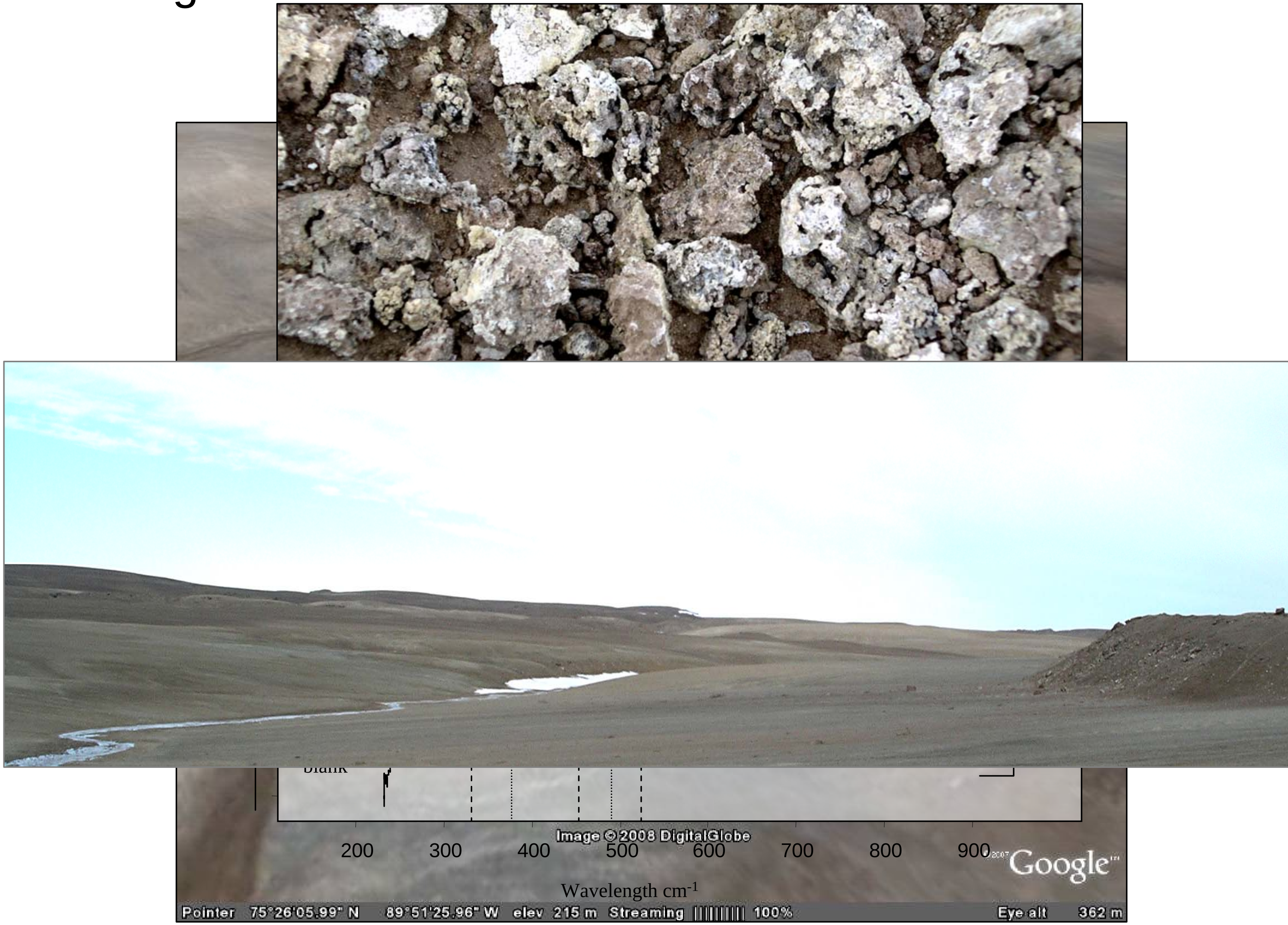


Bio/Geomolecules in hydrothermal system II

Measurement from grey goo most significant over time

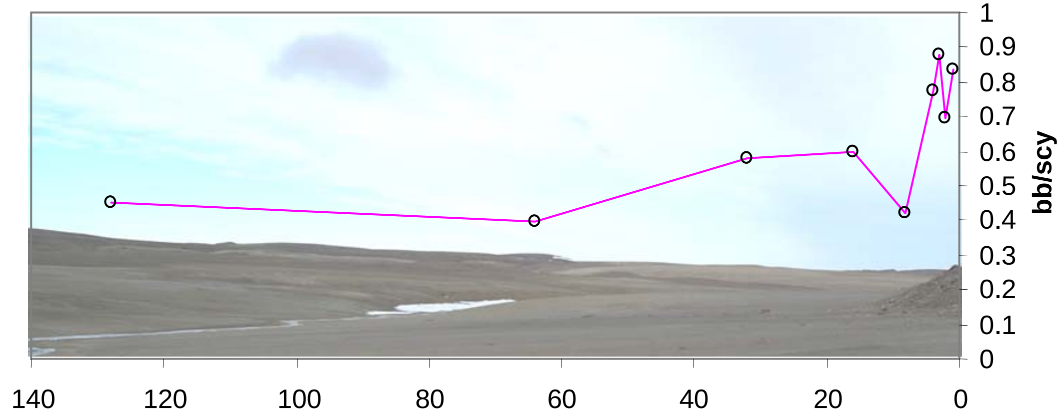


Monitoring Arctic micro oases

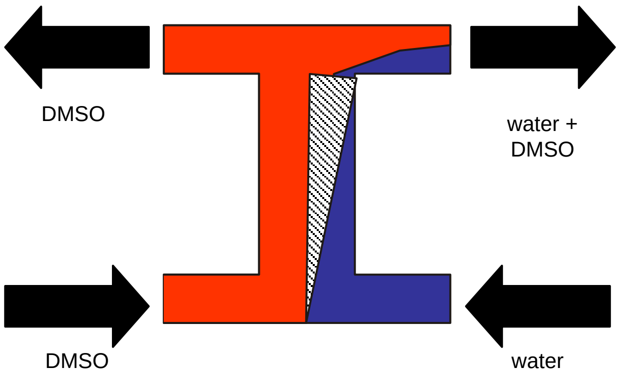


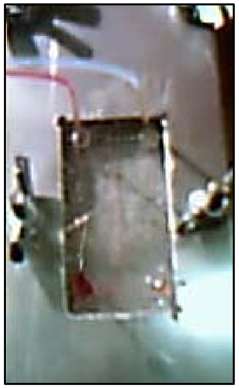
Monitoring Arctic micro oases

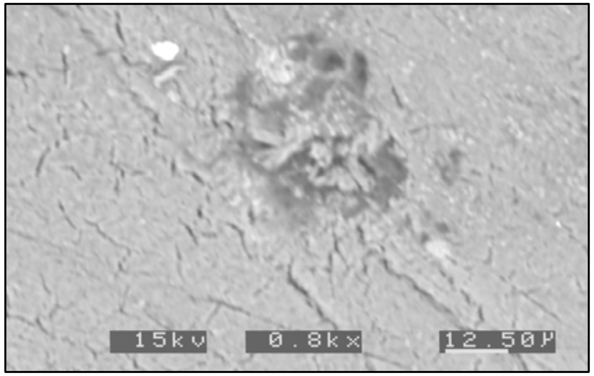
Loss of carotene relative to scytonemin, consistent with trends seen in UV-VIS data



Meanest measurements possible - Towards a SERS μTAS





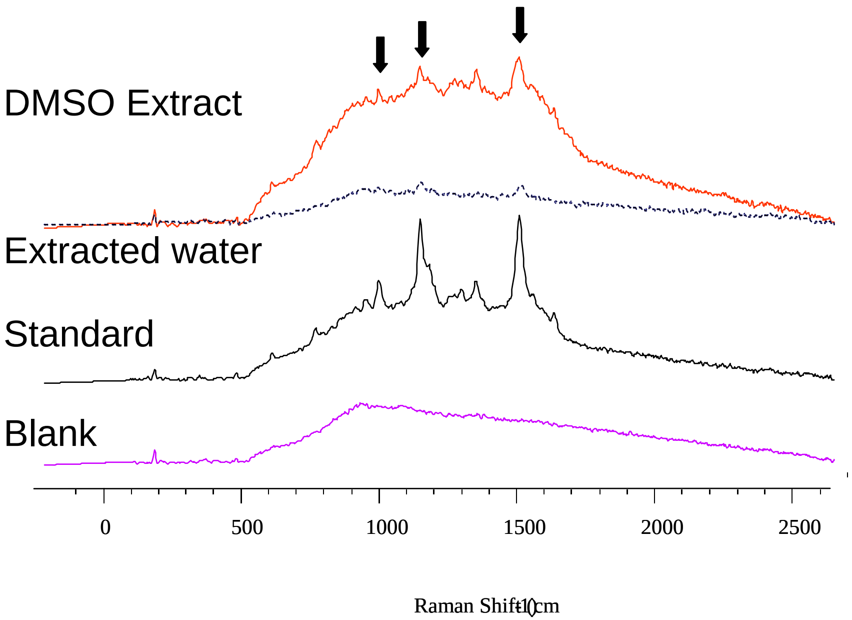


H-cell

- Extract β,β carotene from epsomite crystals

- By circulating less extracting solvent can concentrate sample

- Next stage to integrate components +LC-SERS

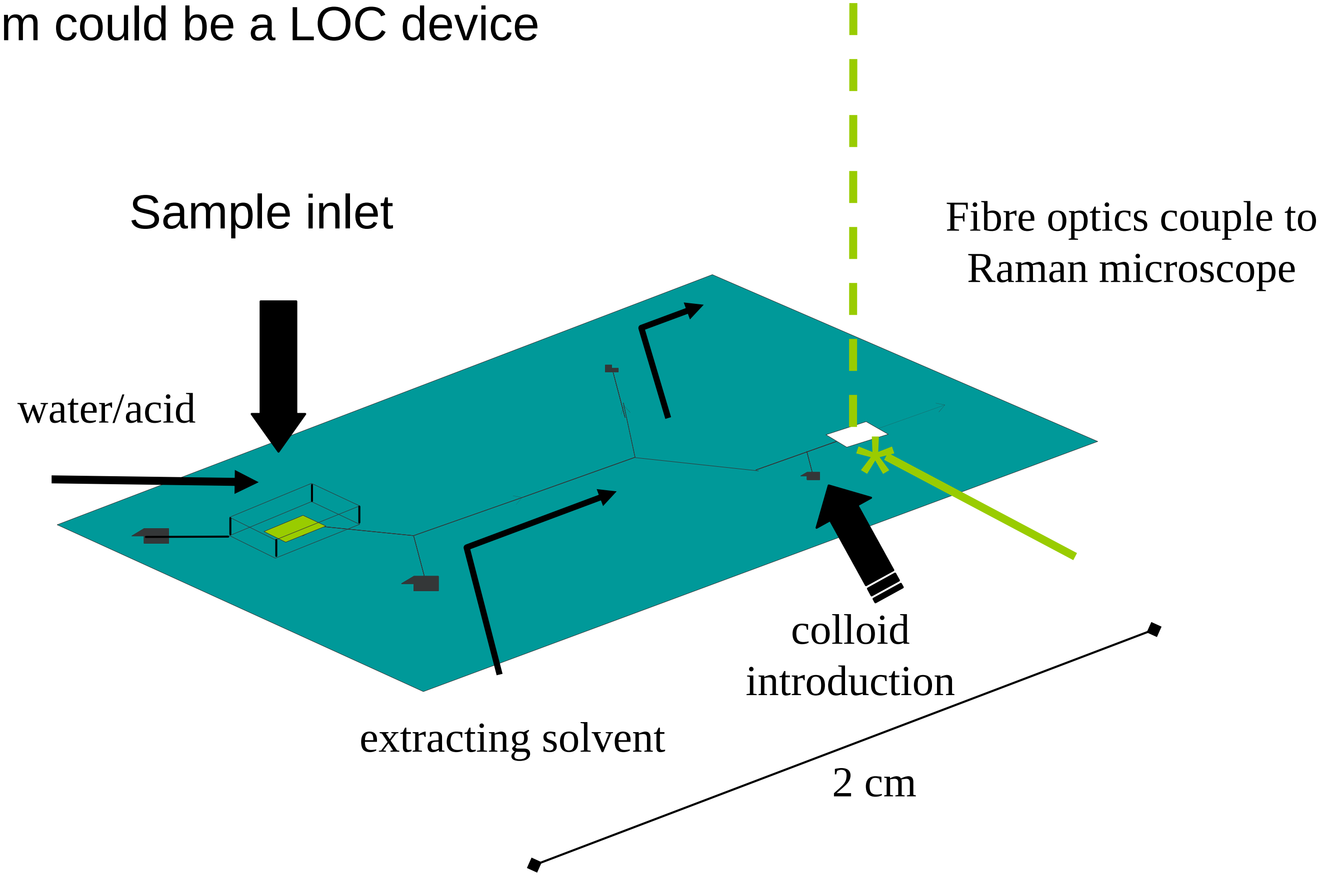


Conclusions

SERS can provide organic geochemical information – e.g. detect specific molecular structures in sediments at 10's ppm. This is something Raman Spectroscopy can't do

This requires further sample processing – but this can all be automated

Such a system could be a LOC device



B-Presentation
Survival of Organic Compounds in ice-HVI

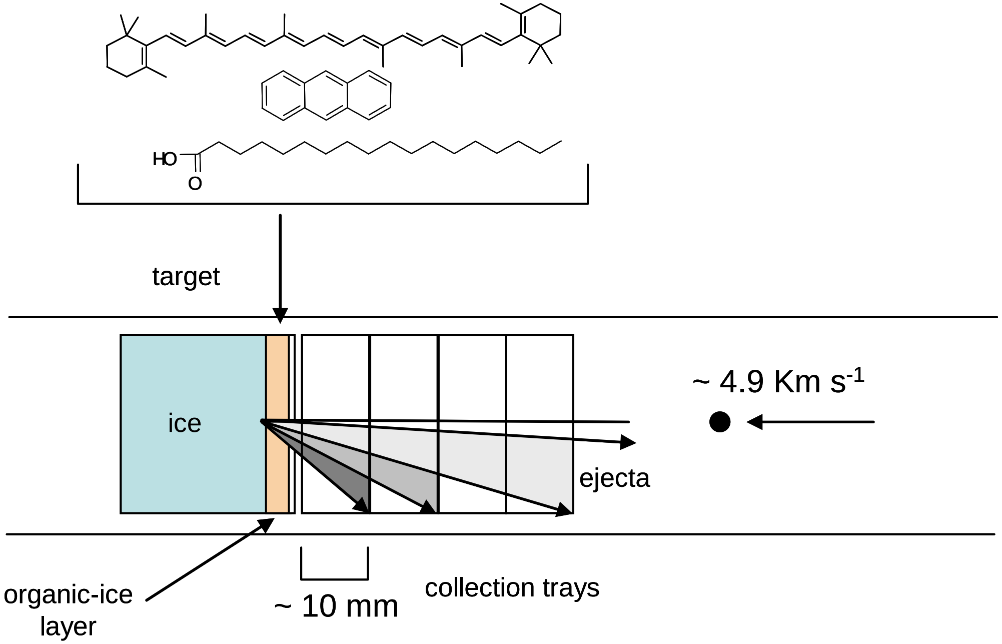
Stephen Bowden & John Parnell

University of Aberdeen

Mark J Burchell

Canterbury – University of Kent

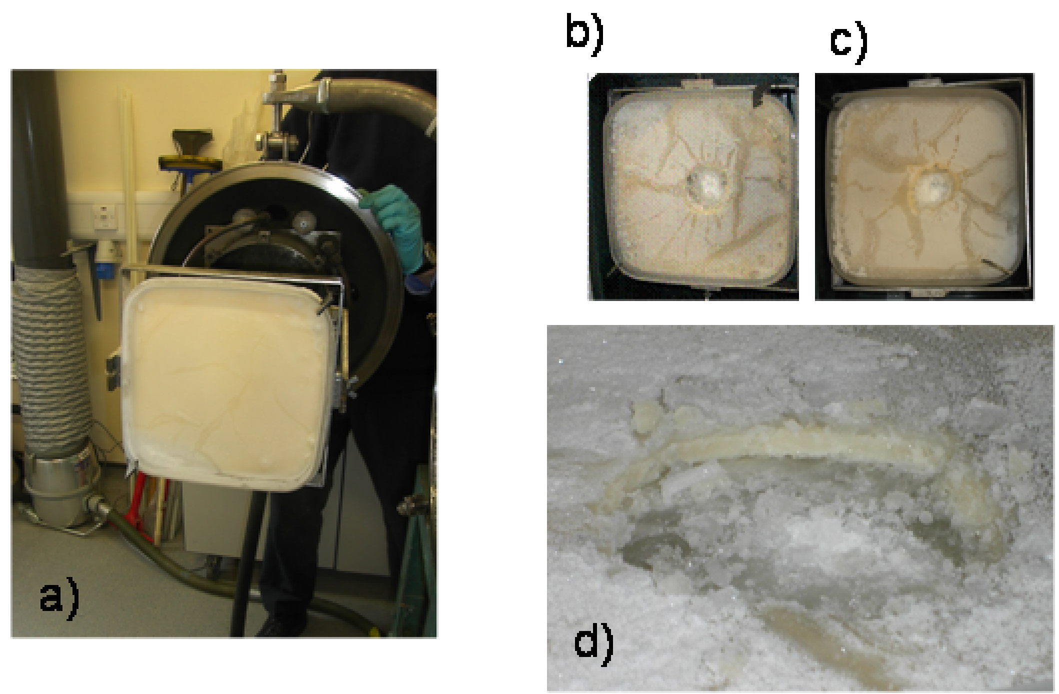
Method



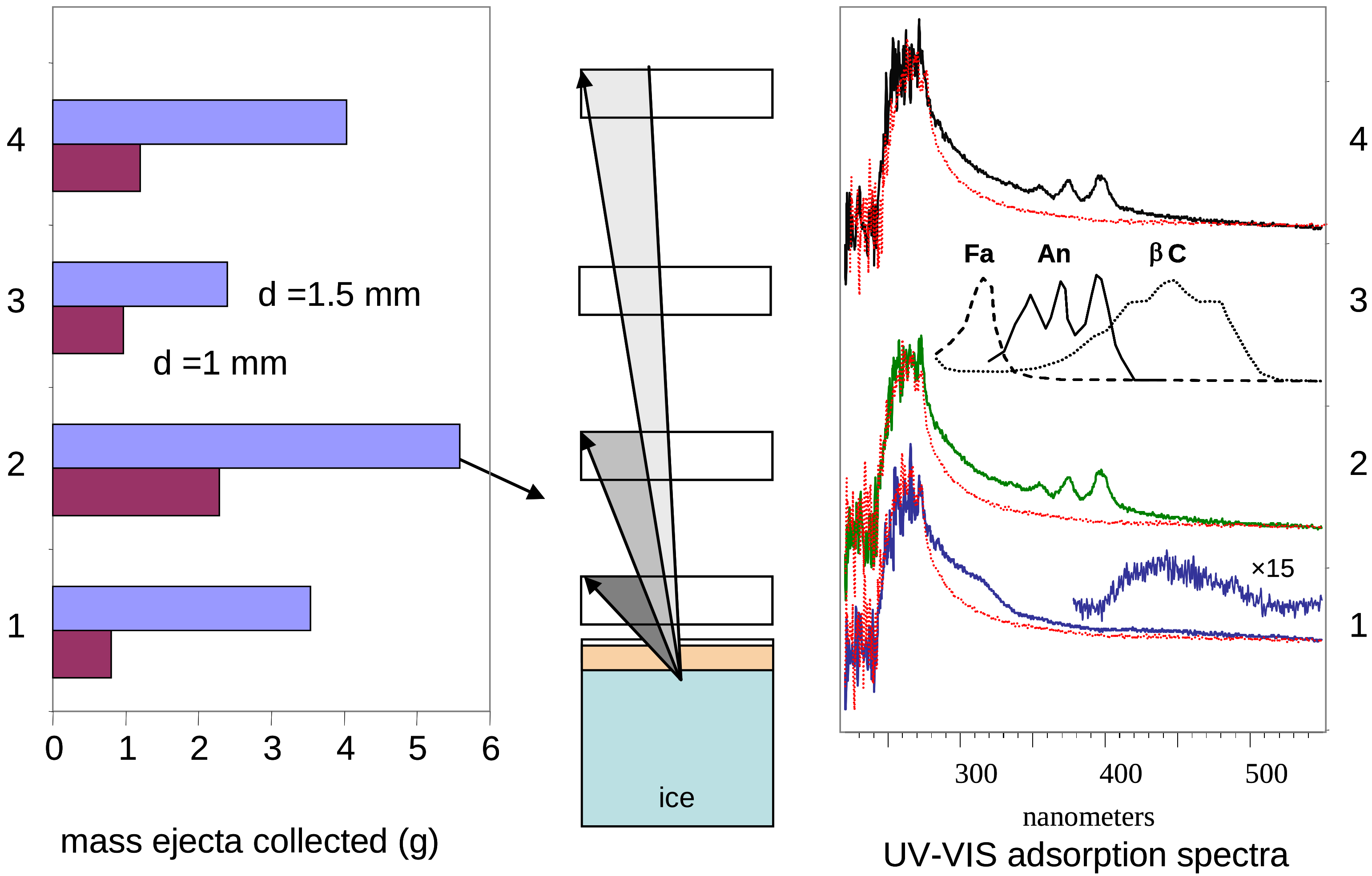
HVI-ice impact studies performed Canterbury, University of Kent

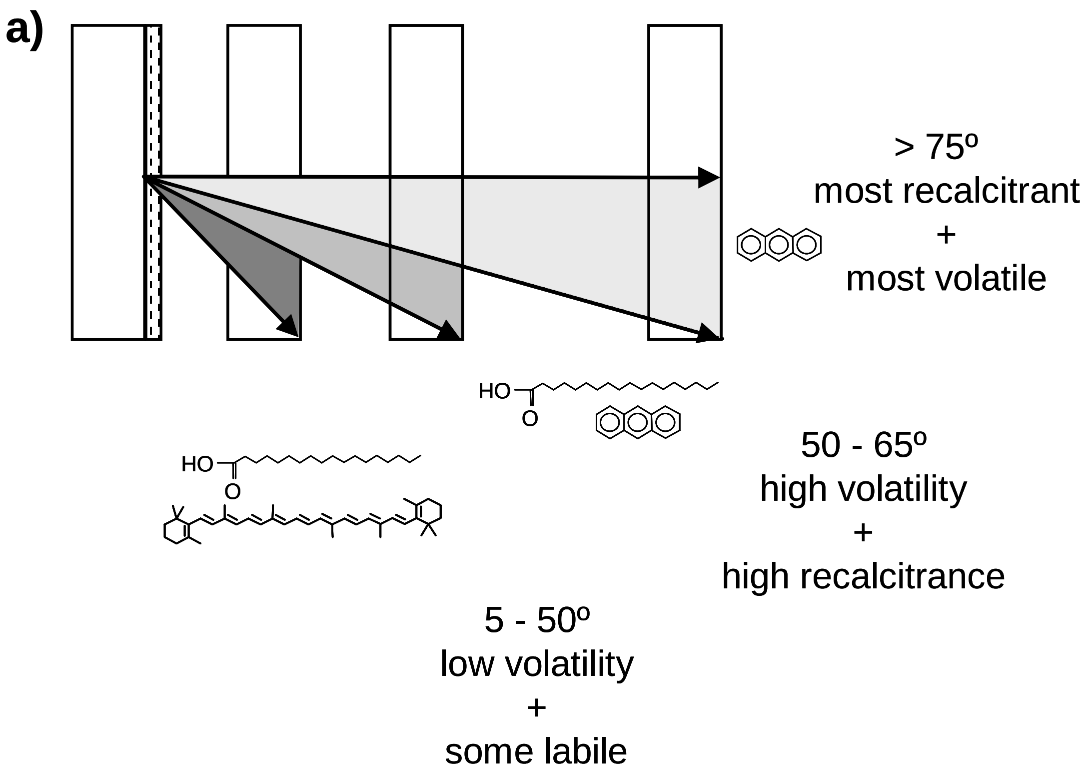
- Ice doped with organic compound
- 1.5 mm d projectile at ~5 kms^{-1}

- Ejecta collected and analysed



UV-VIS spectroscopy and GC-MS (data not shown) used to analyse products





- Most altered fraction is very altered
- Suspect that radicalisation of water helps drive reactions

Acknowledgements

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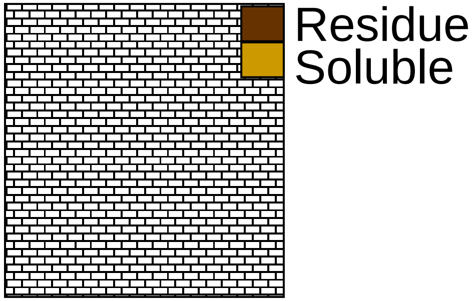
Icelandic Institute of Natural History; Krisjan Jonasson; Paula Lindgren;
Eric Strukel

Analysing organic compounds in geological materials



Residue

1. Crush/break
2. Dissolve matrix
3. Collect residue
4. **Screen through residue**
5. Involves microscope
6. Human discretion