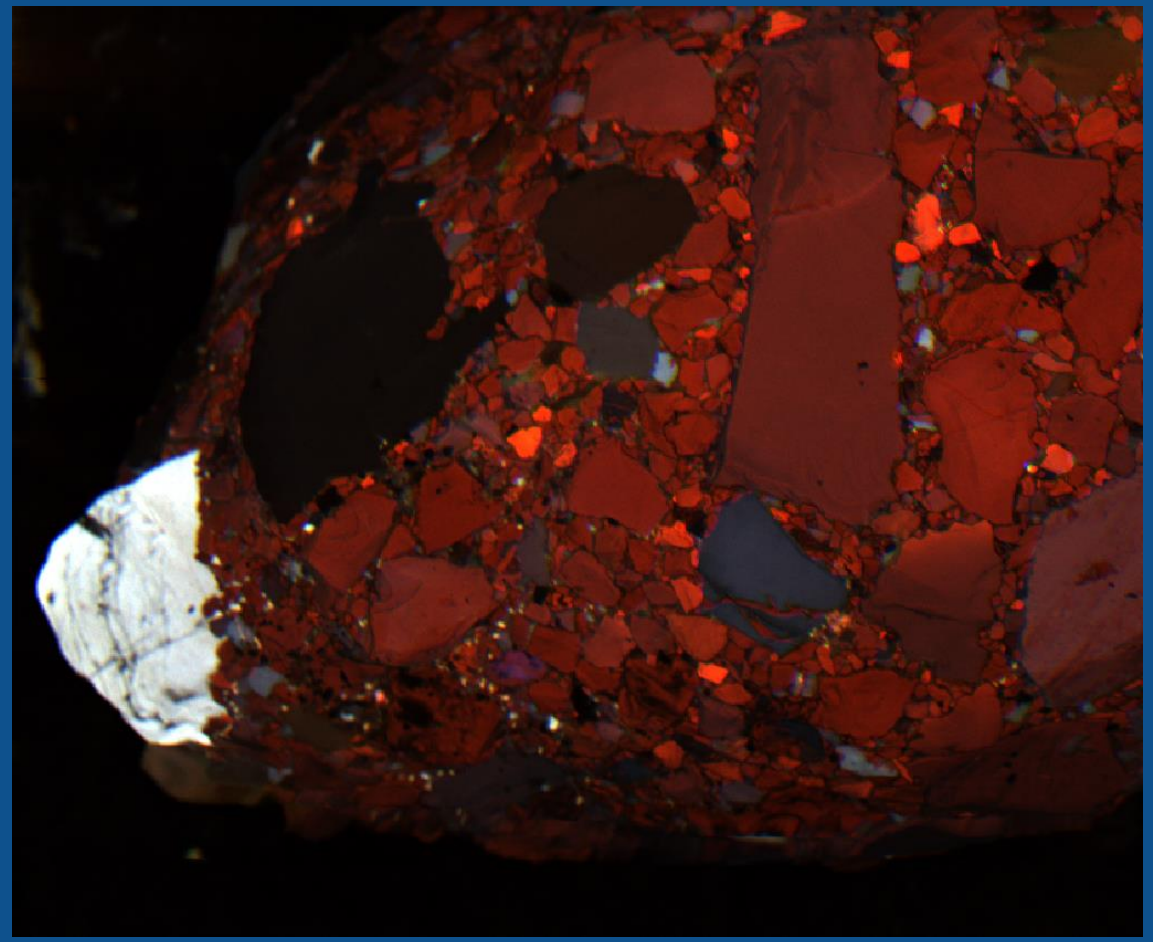
Correlative cathodoluminescence and EDS imaging of the benthic agglutinated foraminifer Liebusella goesi



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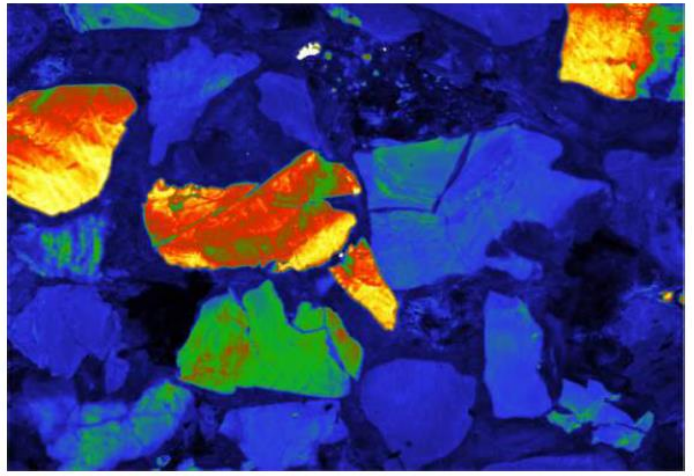
Imaging sedimentary rocks

- Sedimentary rocks are important both for studies of the earth's history as well as for being a source of fossil fuels
- They are formed by the accumulation of mineral and organic particles
- How to characterise sedimentary rocks?

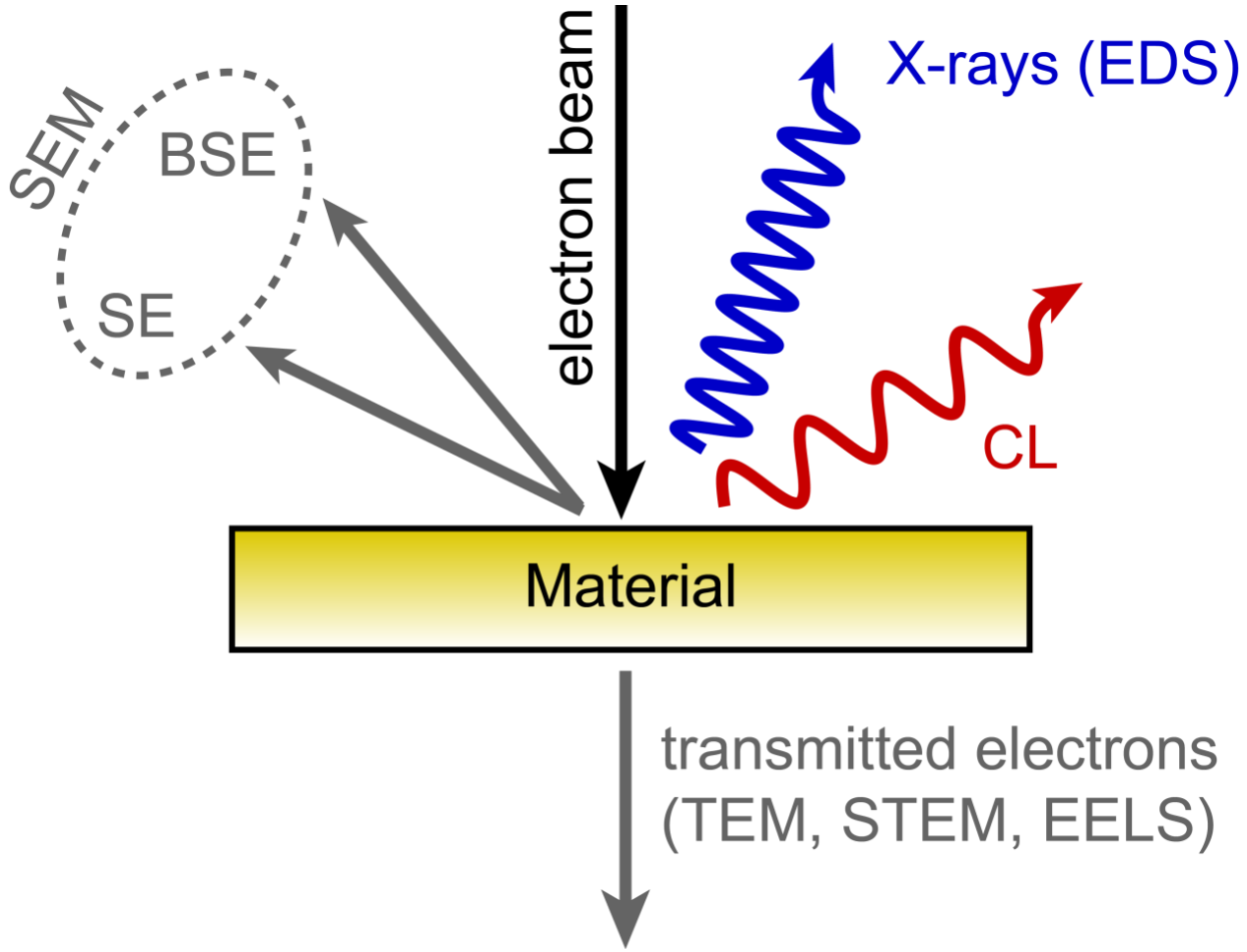
Using SEM-based cathodoluminescence (CL) imaging:

- ➢ High resolution
- ➢ Complementary to other SEM-based techniques like BSE imaging and EDS
- ➢ Provides contrast where standard SEM imaging may not



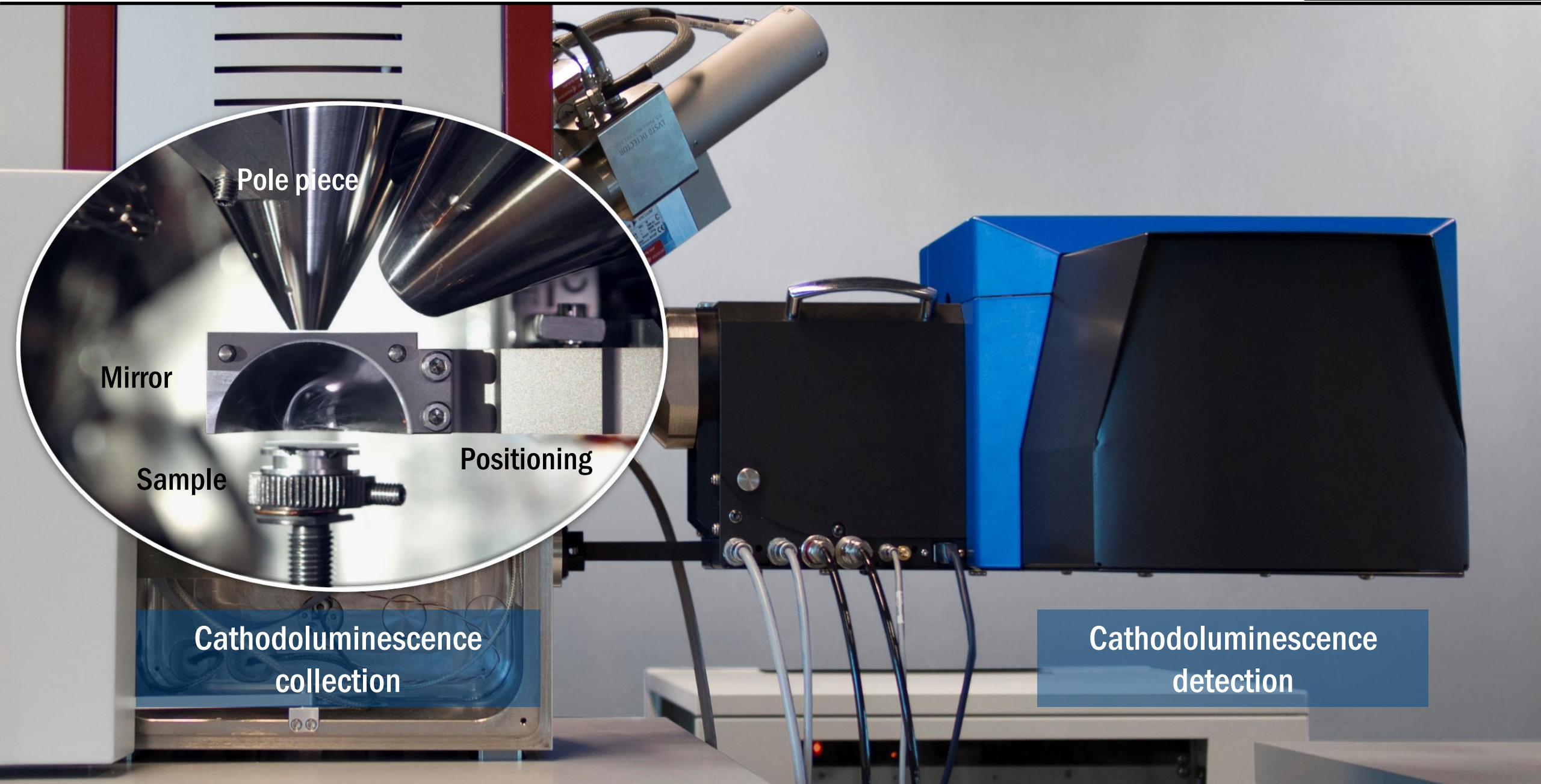
High resolution CL map of quartz sandstone

Cathodoluminescence (CL) generation

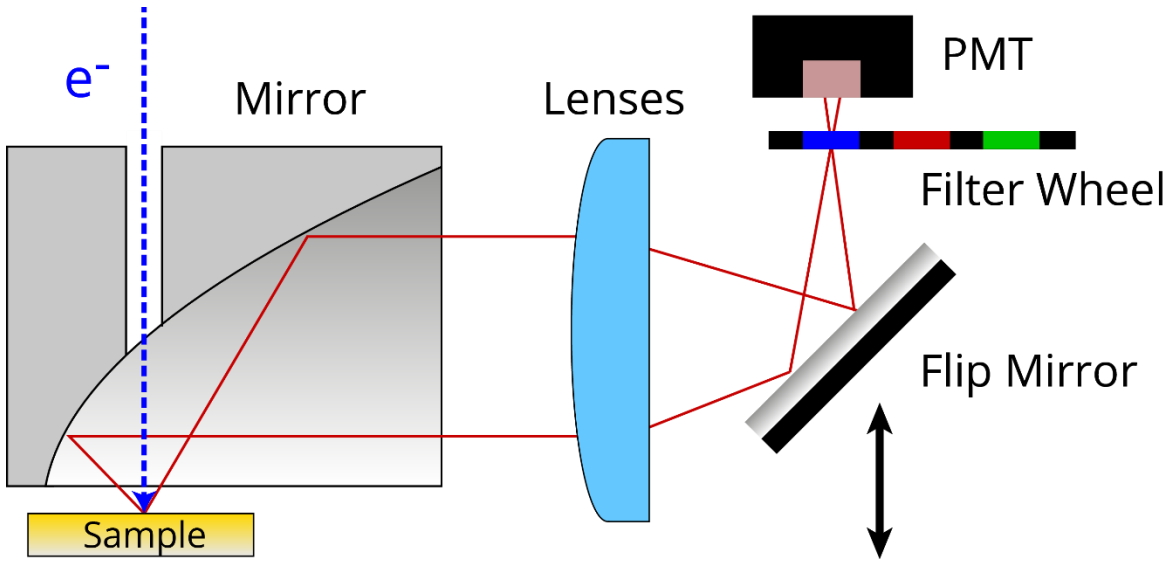


Cathodoluminescence is the process whereby light (UV-VIS-IR) is generated when an electron beam hits a specimen.

CL detector design

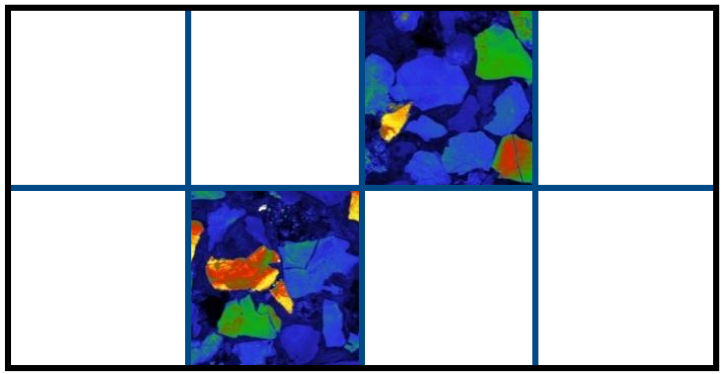


Mode 1: CL intensity mapping



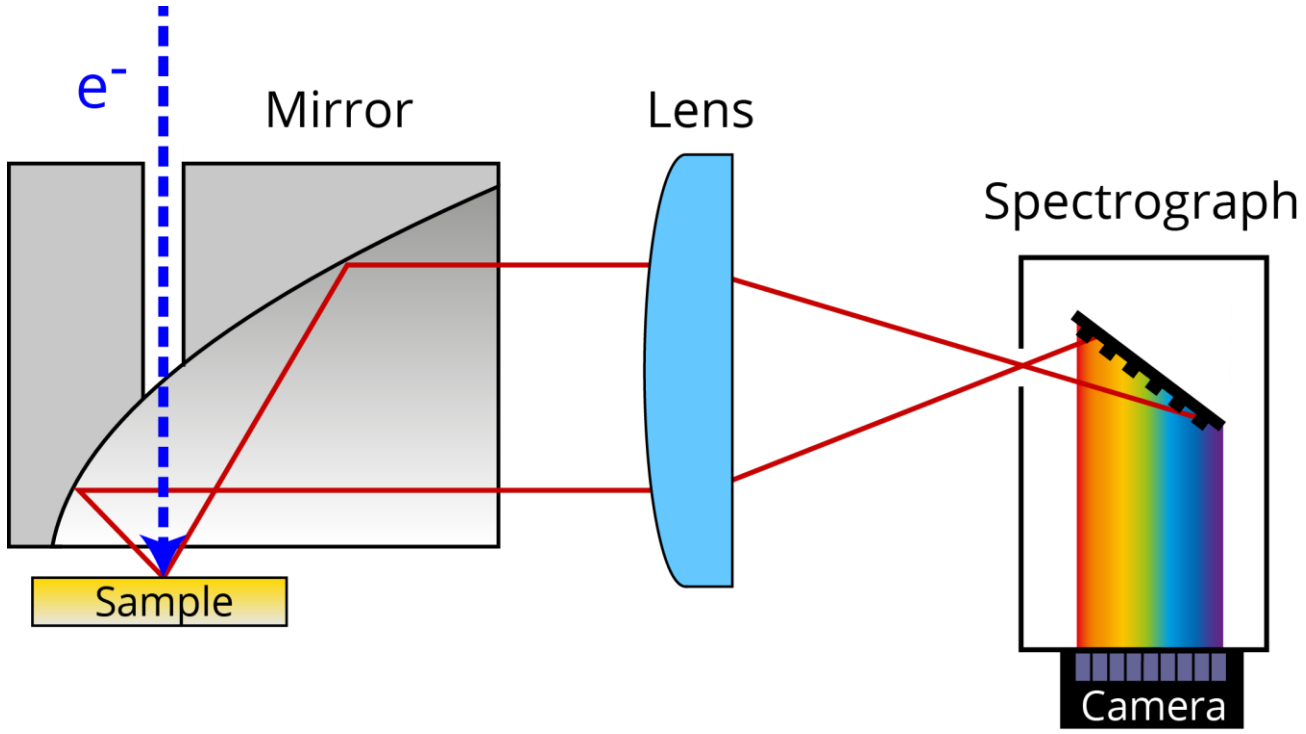
Fast (video rate) CL intensity mapping with a single pixel detector such as a PMT

Tiling and stitching



Fast imaging of relatively large areas

Mode 2: CL Spectroscopy



Collect a full spectrum from the sample at every excitation point

CL imaging of sedimentary rocks

CL detector mounted on a Scanning Electron Microscope (SEM)

- Typically the CL yield is high enough for rapid scanning and, in some cases, even video-rate scanning → CL Intensity Mapping
- This allows fast inspection of relatively large areas
- Spectroscopy can be used to quantitatively map the composition of the sample
- Mapping the quartz content, for example, enables the rigorous segmentation of granular and cemented material

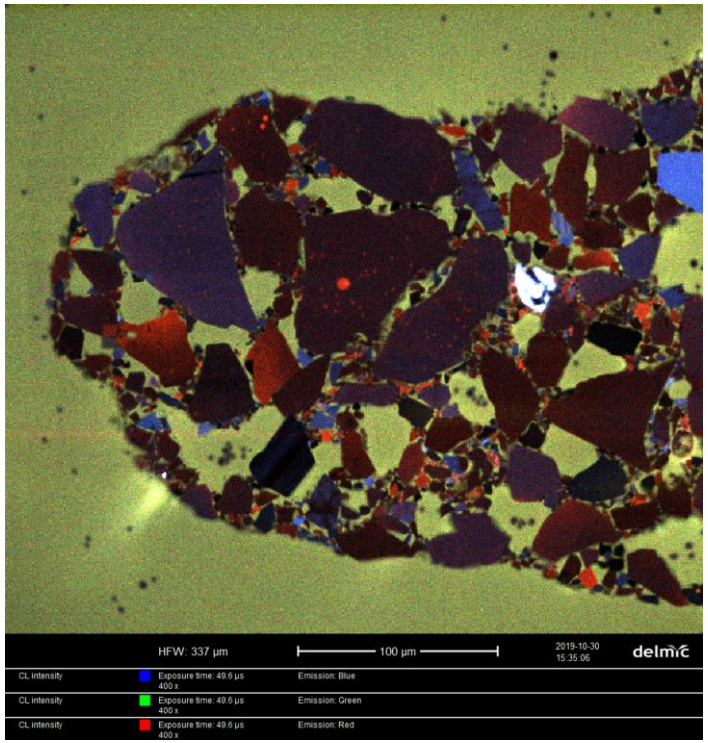
CL imaging of *Liebusella goesi*

- *Textulariid* benthic foraminifers live on and in seafloor sediments and form shells of agglutinated sediment particles
- They are very important biostratigraphic markers, and fossil agglutinated foraminifera are important archives for paleoceanographic reconstructions
- Furthermore, living *textulariids* show a strong diversity, populating a diverse range of marine habitats partly and can reach high living abundances, making them important for benthic ecosystems.

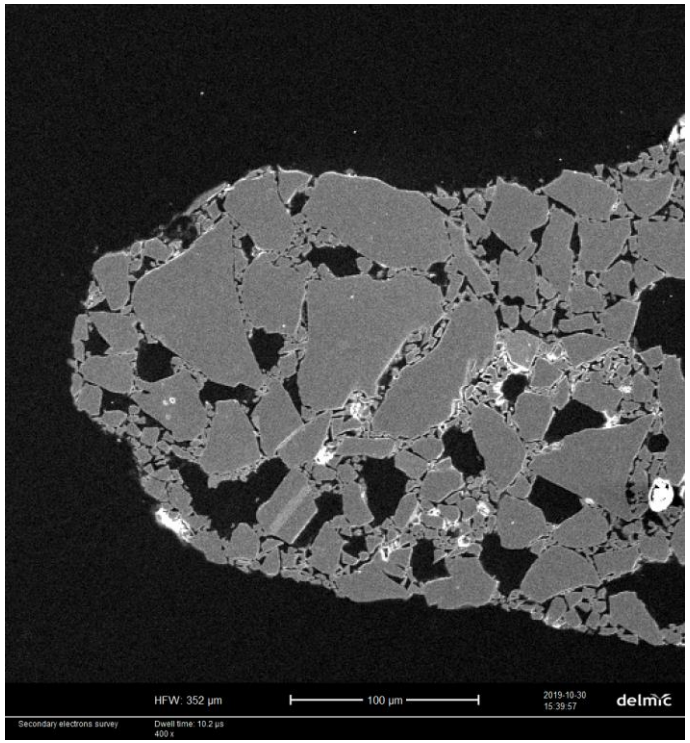
Goal of this study: Show how CL spectroscopy can be employed to study agglutinated foraminifera

Sample used: *Liebusella goesi* from the Swedish Gullmar Fjord

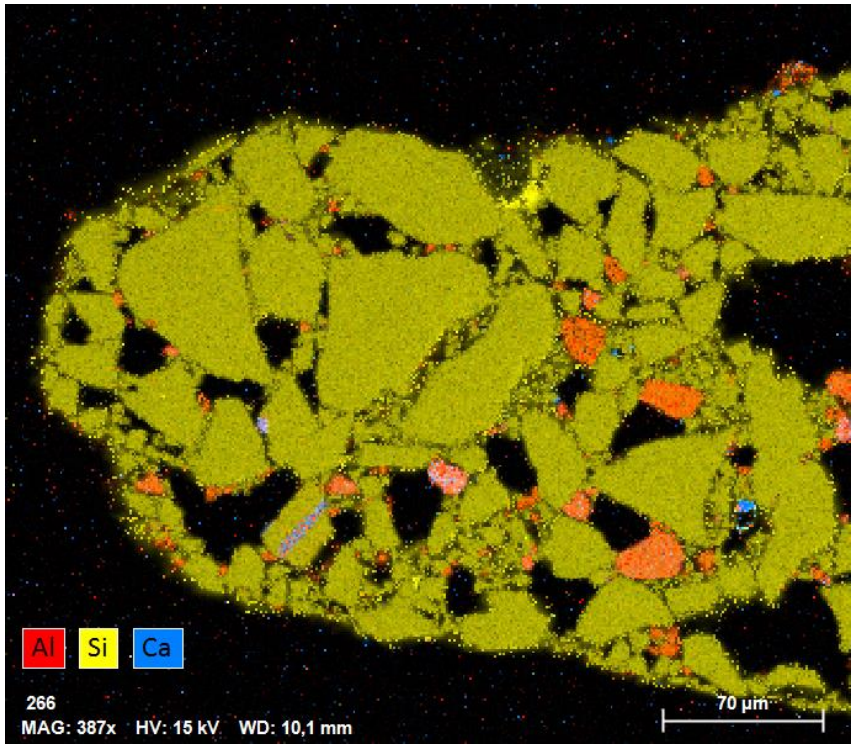
Correlative imaging: CL + SEM + EDS (Sample 1)



CL Intensity map



SEM image

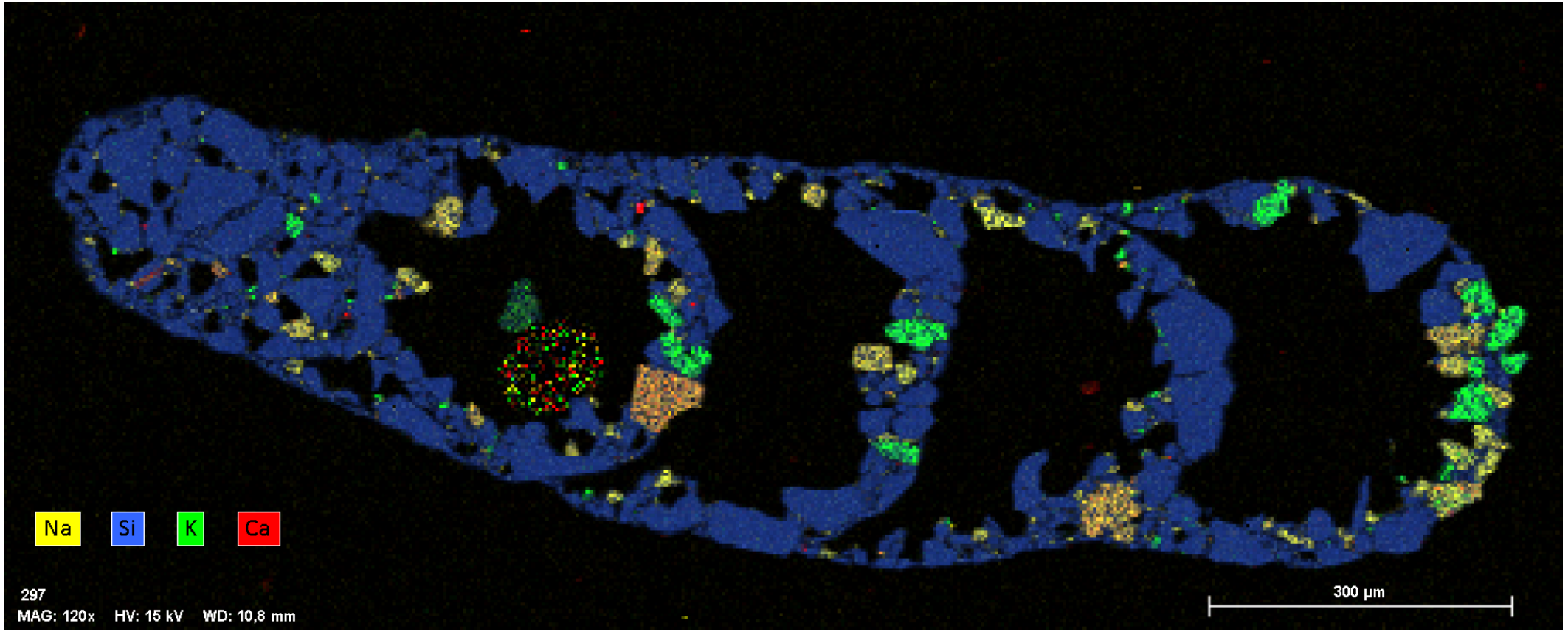


EDS map

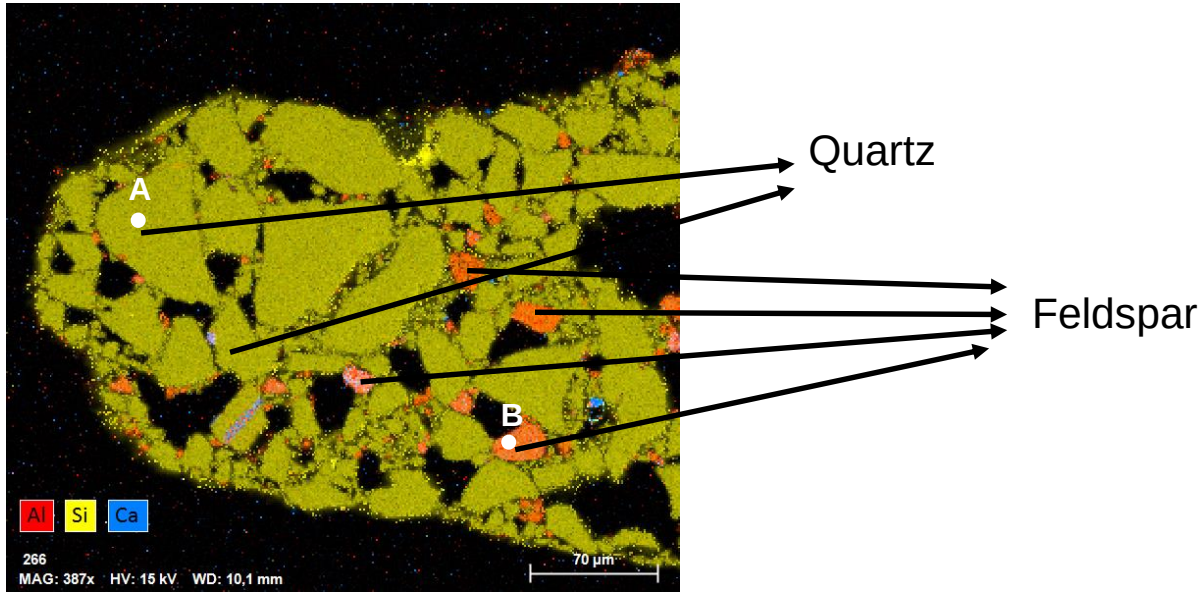
Electron energy = 10 keV

Electron energy = 15 keV

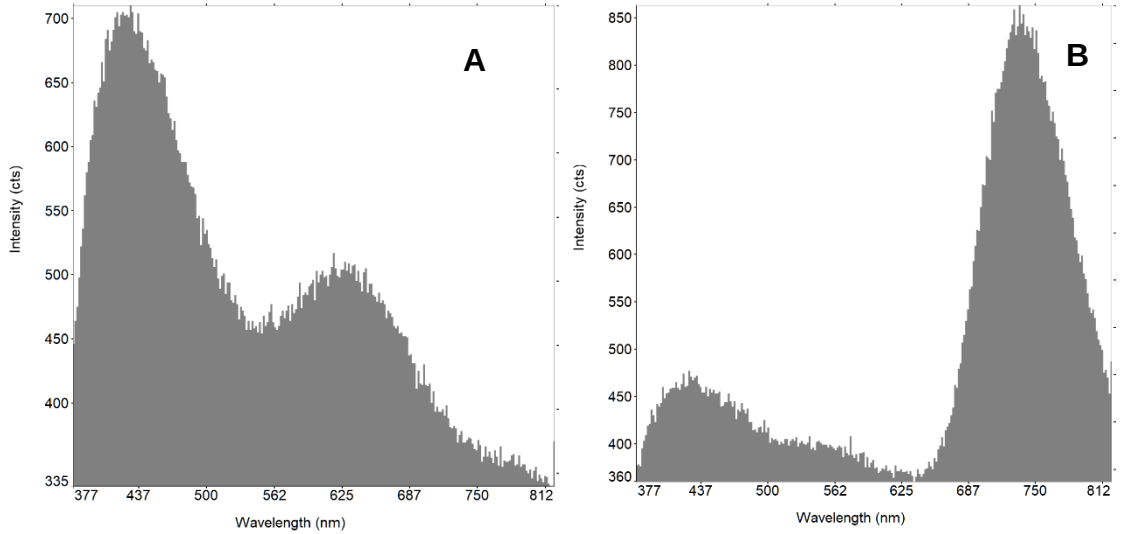
EDS imaging of whole organism (Sample 1)



Characterisation of *Liebusella goesi* (Sample 1)



EDS map



CL spectroscopy

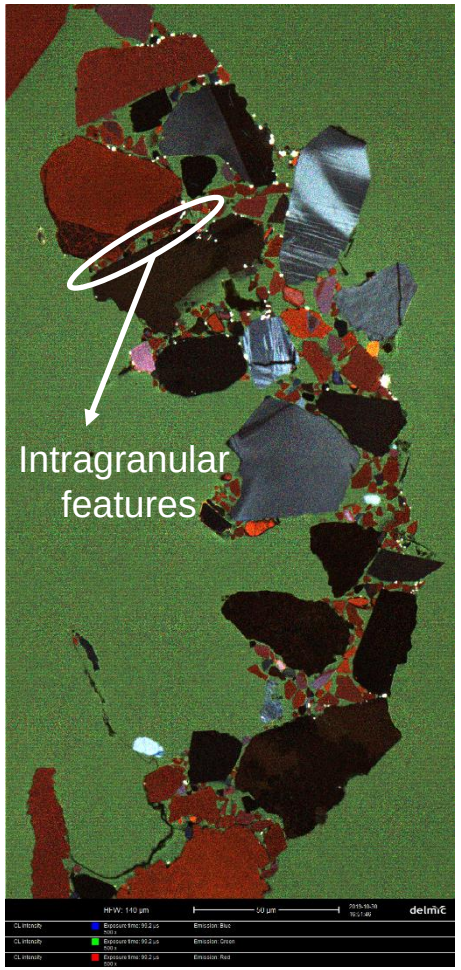
2 materials indicated:

- Quartz
- Al-feldspar

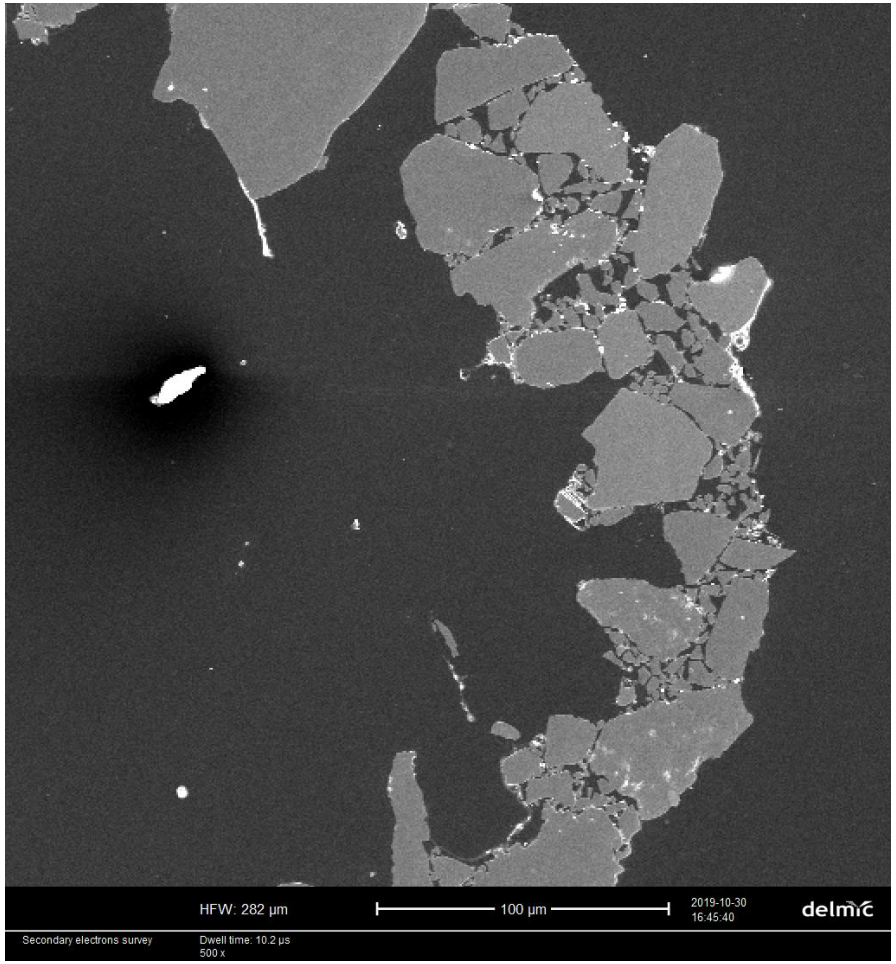
2 types of spectra observed, confirming the materials:

- Quartz
- Feldspar

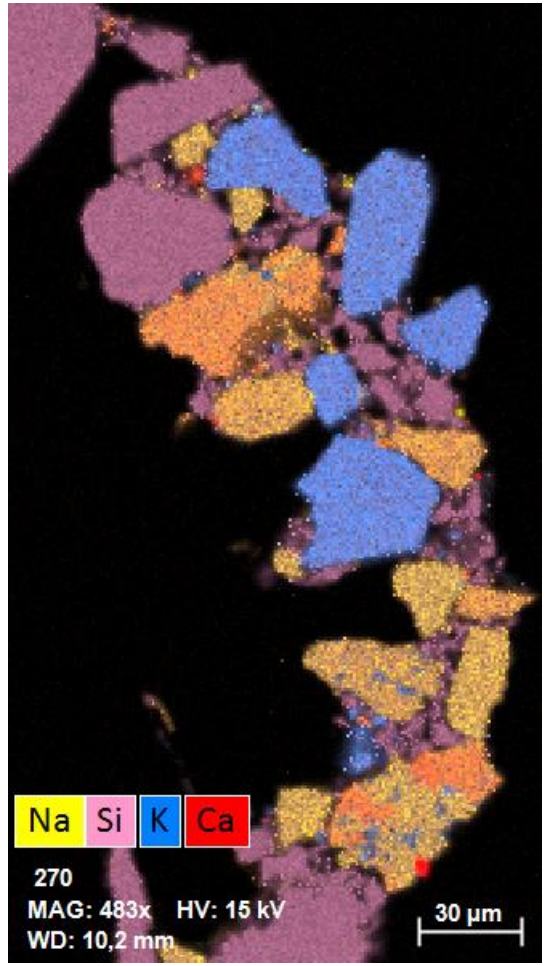
Correlative imaging: CL + SEM + EDS (Sample 2)



CL Intensity map



SEM image

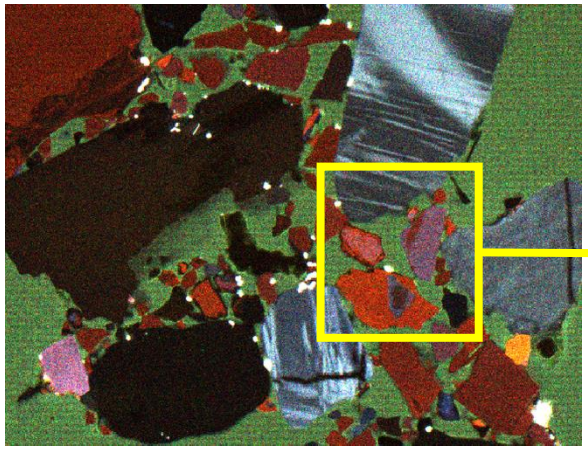


EDS map

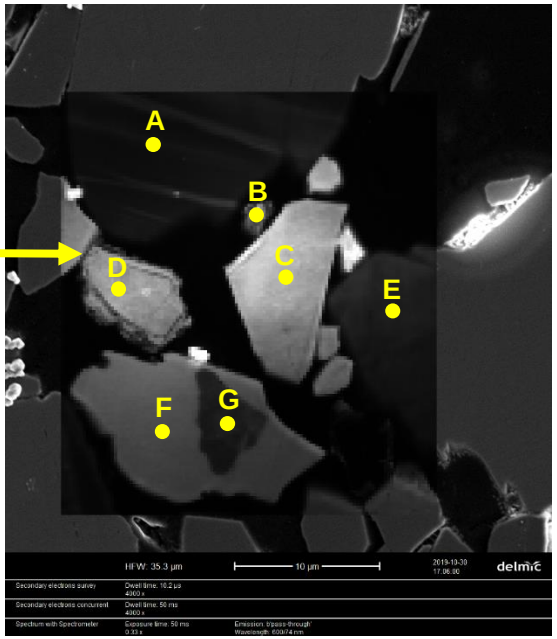
Electron energy = 5 keV

Electron energy = 15 keV

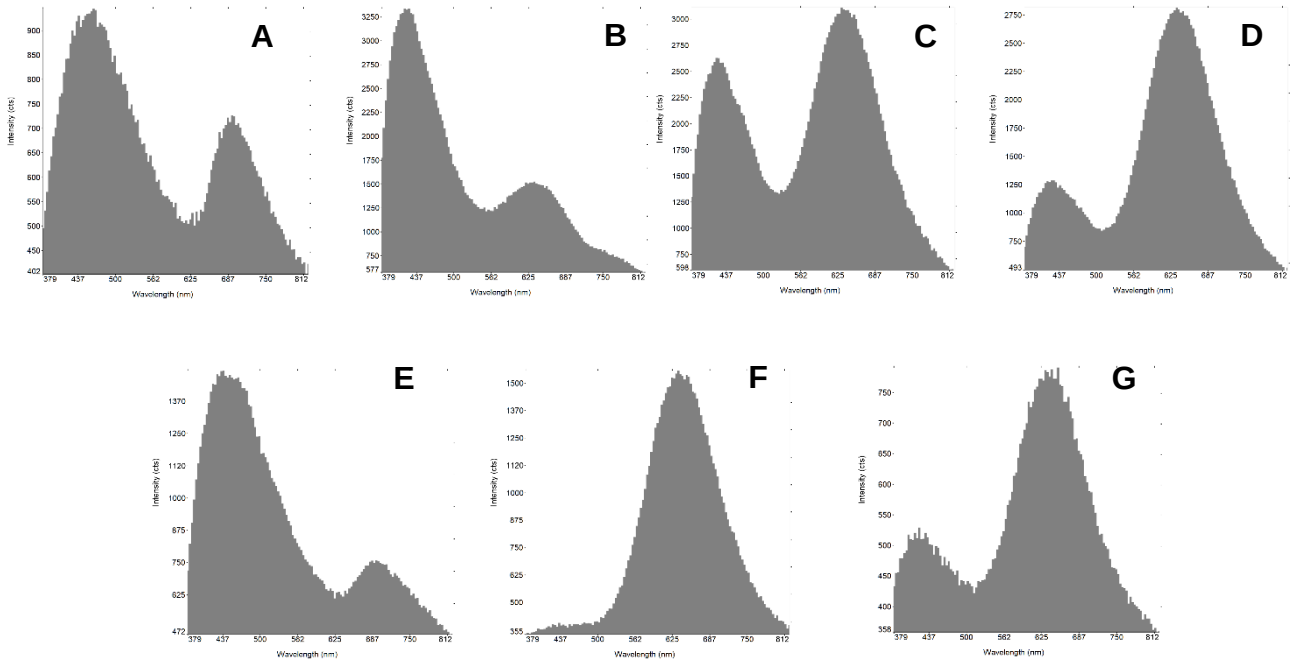
Characterisation of *Liebusella goesi* (Sample 2)



CL Intensity map

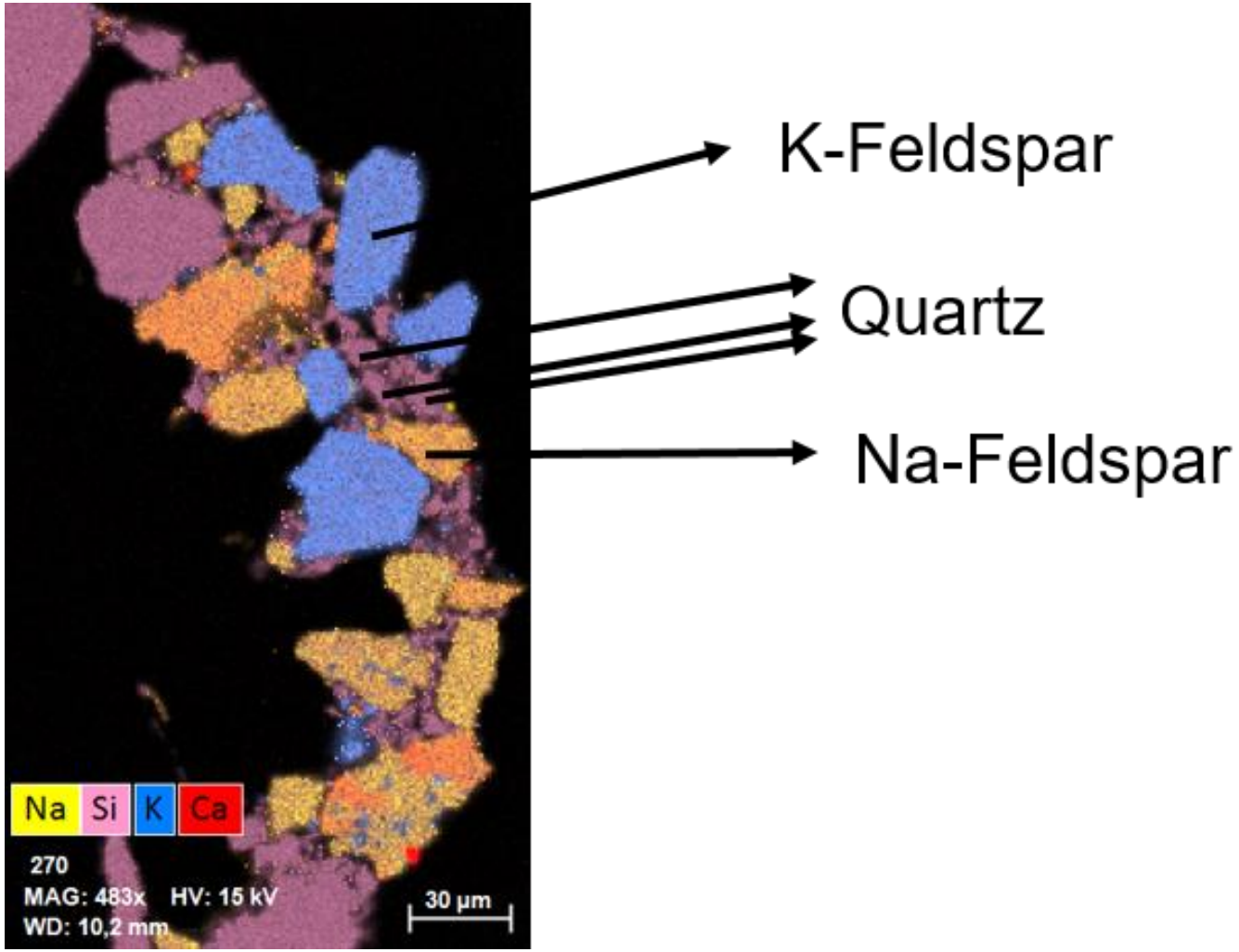


CL Spectroscopy Map



CL spectra at different locations of the spectroscopy map

Characterisation of *Liebusella goesi* (Sample 2)



Conclusions

- Fast panchromatic CL imaging using a photomultiplier tube was performed over a large area of the foraminifera, which revealed textures and contrasts of interest in the shell (test)
- Together with the high resolution SEM image acquired simultaneously, this dataset can be valuable in establishing the geological history as well as in identifying the chemical composition of the cement used for the agglutination of sediment particles
- EDS measurements were performed, revealing the spatial distribution of elements such as potassium, calcium, sodium, silicon and oxygen, in the sediment particles of the shell
- This was useful in indicating the presence of minerals such as quartz and feldspar, and hyperspectral CL imaging was performed to rigorously identify them, and to visualize intragranular features, not visible in the EDS data
- Based on the CL spectral data, we were further able to identify different grades/types of quartz and feldspars. These results show that these foraminifera prefer different sediment materials with varying grain sizes, depending on the size of the newly formed chamber, to achieve the highest mechanical stability

More CL

If you have any questions about cathodoluminescence in general, or about this work in particular, please feel free to contact me at hari@delmic.com or visit our website www.delmic.com

More CL imaging at the EGU:
Please visit this presentation if you are interested!

EGU2020-4515, Session GMPV1.2
“Table-top Cathodoluminescence Microscopy for Geology”
Toon Coenen, Wednesday, 06 May 2020, 08:30-10:15