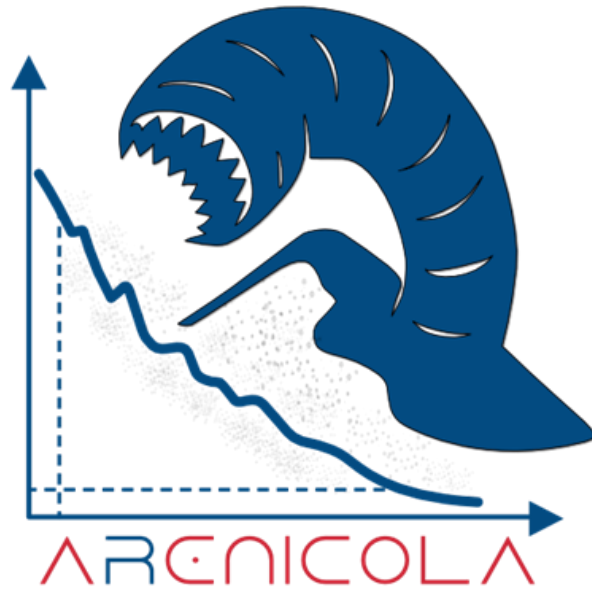




Challenges and Opportunities of Imaging Techniques in Luminescence Dating

27.05.2026 | MACH26 conference Jelenia Gora

Dirk Mittelstraß^{1,2,3,*}, Margret Fuchs³, Sebastian Kreutzer^{1,2}

¹LIAG Institute for Applied Geophysics, Hannover, Germany

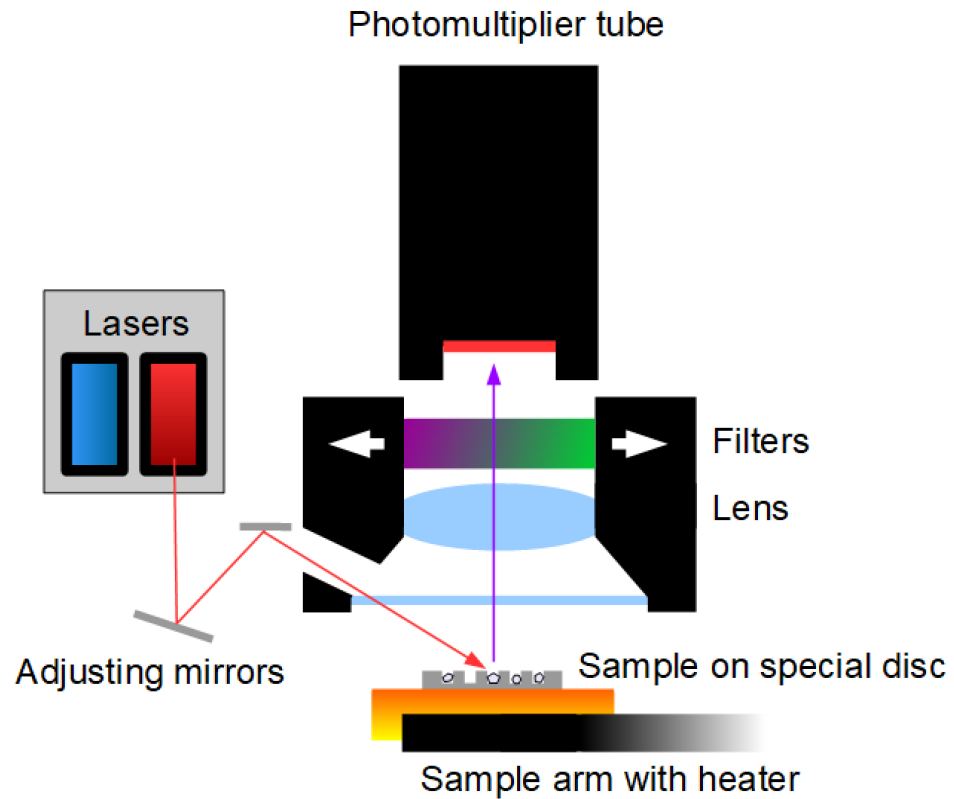
²Heidelberg University, Institute of Geography, Heidelberg, Germany

³HZDR Helmholtz Institute Freiberg for Resource Technology (HiF), Freiberg, Germany

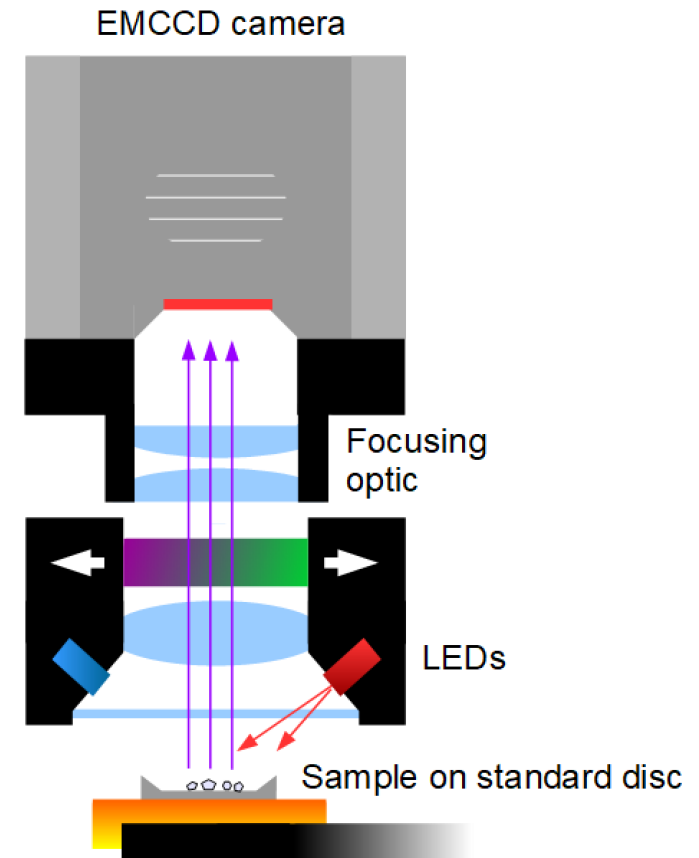
*dirk.mittelstrass@liag-institut.de

Single-grain OSL dating methods

Laser-based single-grain OSL system

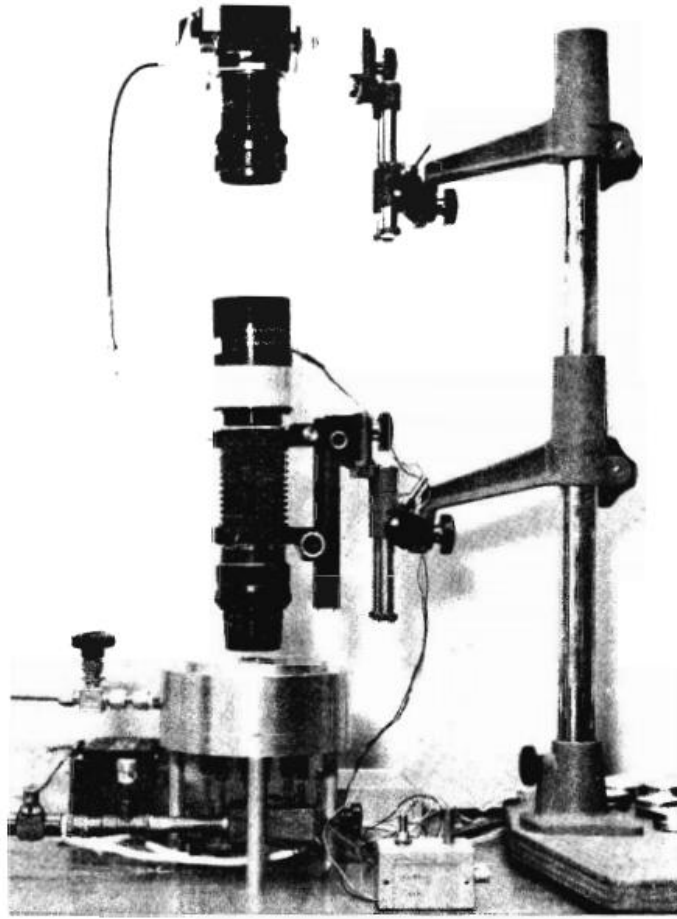


Imaging single-grain OSL system



Short history of luminescence imaging

Luminescence imaging device development in a dating context began in the **80ties** ...

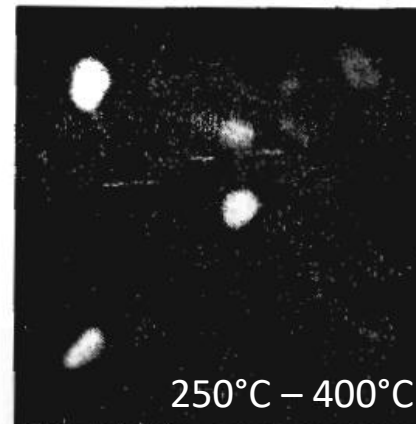


The use of an image intensifier to study the
TL intensity variability of individual grains

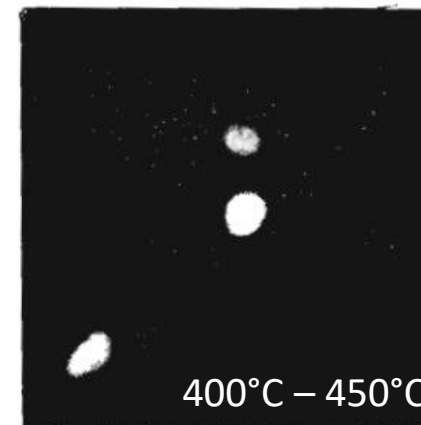
1985

D. J. Huntley and J. J. Kirkey

Physics Department
Simon Fraser University



250°C – 400°C



400°C – 450°C

TL images of quartz
grains, 120 ka Australia

Short history of luminescence imaging

... continued through the 90ties ...

1994

INVESTIGATIONS INTO THE THERMOLUMINESCENCE PROPERTIES OF SINGLE QUARTZ GRAINS USING AN IMAGING PHOTON DETECTOR

C. J. McFEE and M. S. TITE

Research Laboratory for Archaeology and the History of Art, University of Oxford, 6 Keble Road, Oxford OX1 3QJ, U.K.

1997

A LUMINESCENCE IMAGING SYSTEM BASED ON A CCD CAMERA

G. A. T. DULLER*†, L. BØTTER-JENSEN* and B. G. MARKEY*

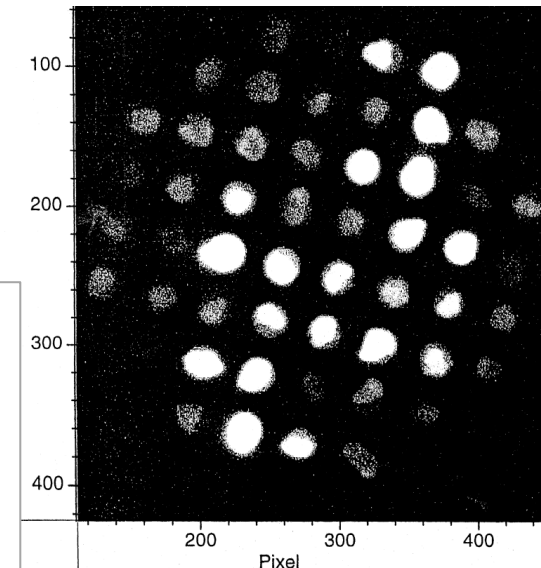
*Risø National Laboratory, Roskilde, DK-4000, Denmark and †Institute of Earth Studies, University of Wales, Aberystwyth, Wales, U.K.

2000

A photon-counting imaging system (PCIS) for luminescence applications

Nigel A. Spooner*

Environmental Geochronology and Geochemistry, Research School of Earth Sciences, Australian National University, Canberra, A.C.T. 0200, Australia



Short history of luminescence imaging

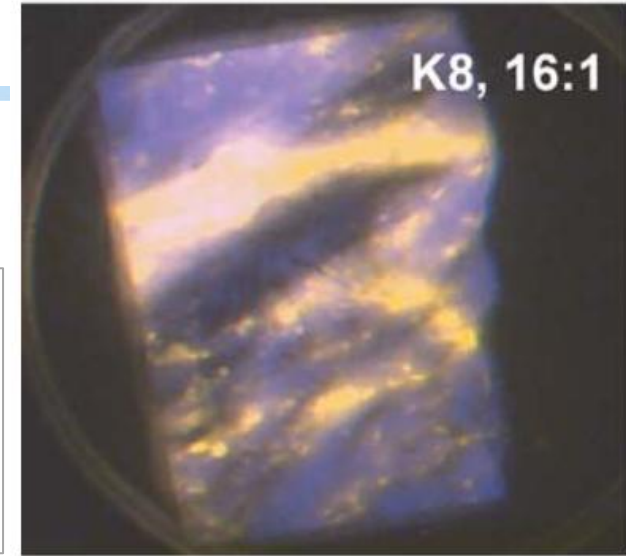
... and the years after 2000 ...

2004

CCD imaging of the infra-red stimulated luminescence of feldspars

Marc René Baril*

Department of Physics, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, Canada V5A 1S6



2006

Development of a spatially resolved dating technique using HR-OSL

S. Greilich*, G.A. Wagner

Forschungsstelle Archäometrie der Heidelberger Akademie der Wissenschaften am Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

2012

First steps toward spatially resolved OSL dating with electron multiplying charge-coupled devices (EMCCDs): System design and image analysis

Laine Clark-Balzan*, Jean-Luc Schwenninger

Research Laboratory for Archaeology and the History of Art, University of Oxford, Dyson Perrins Building, South Parks Road, Oxford OX1 3QY, UK

Short history of luminescence imaging

... until commercially available systems:

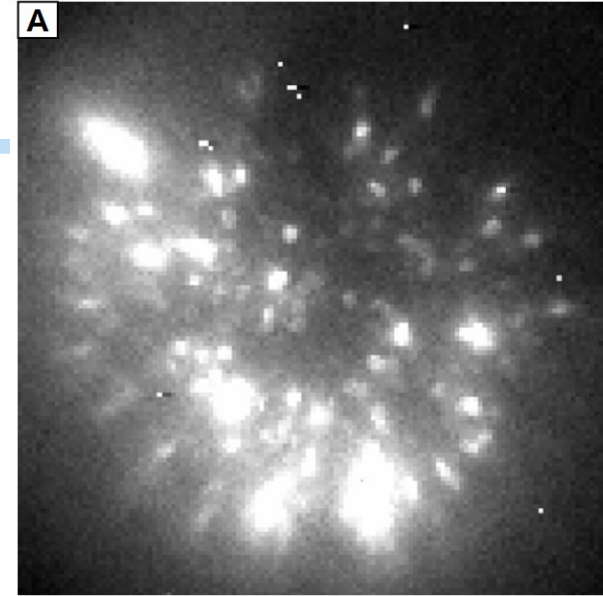
2013

LEXSYG – A NEW SYSTEM FOR LUMINESCENCE RESEARCH

DANIEL RICHTER^{1,2}, ANDREAS RICHTER¹ and KAY DORNICH¹

¹Freiberg Instruments GmbH, Delfterstr. 6, 09599 Freiberg, Germany

²Geographisches Institut, LS Geomorphologie, University of Bayreuth, Universitätsstr. 30, 95447 Bayreuth, Germany



2015

Single-grain dose-distribution measurements by optically stimulated luminescence using an integrated EMCCD-based system

S. Greulich ^{a,*}, N. Gribenski ^b, D. Mittelstraß ^c, K. Dornich ^c, S. Huot ^d, F. Preusser ^{b,1}

^a Division of Medical Physics in Radiation Oncology, German Cancer Research Center (DKFZ), Im Neuenheimer Feld 280, D-69120 Heidelberg, Germany

^b Department of Physical Geography, Stockholm University, 10691 Stockholm, Sweden

^c Freiberg Instruments, Delfter Straße 6, 09599 Freiberg, Germany

^d Département des sciences de la Terre et de l'atmosphère, Université du Québec à Montréal, CP 8888 Succ. Centre-Ville, Montréal, Québec H3C 3P8, Canada

2015

A luminescence imaging system for the routine measurement of single-grain OSL dose distributions

M. Kook ^{a,*}, T. Lapp ^a, A.S. Murray ^b, K.J. Thomsen ^a, M. Jain ^a

^a Center for Nuclear Technologies, Technical University of Denmark, DTU Risø Campus, Denmark

^b Nordic Laboratory for Luminescence Dating, Department of Geoscience, Aarhus University, Risø Campus, DK-4000 Roskilde, Denmark

Spatially resolved luminescence

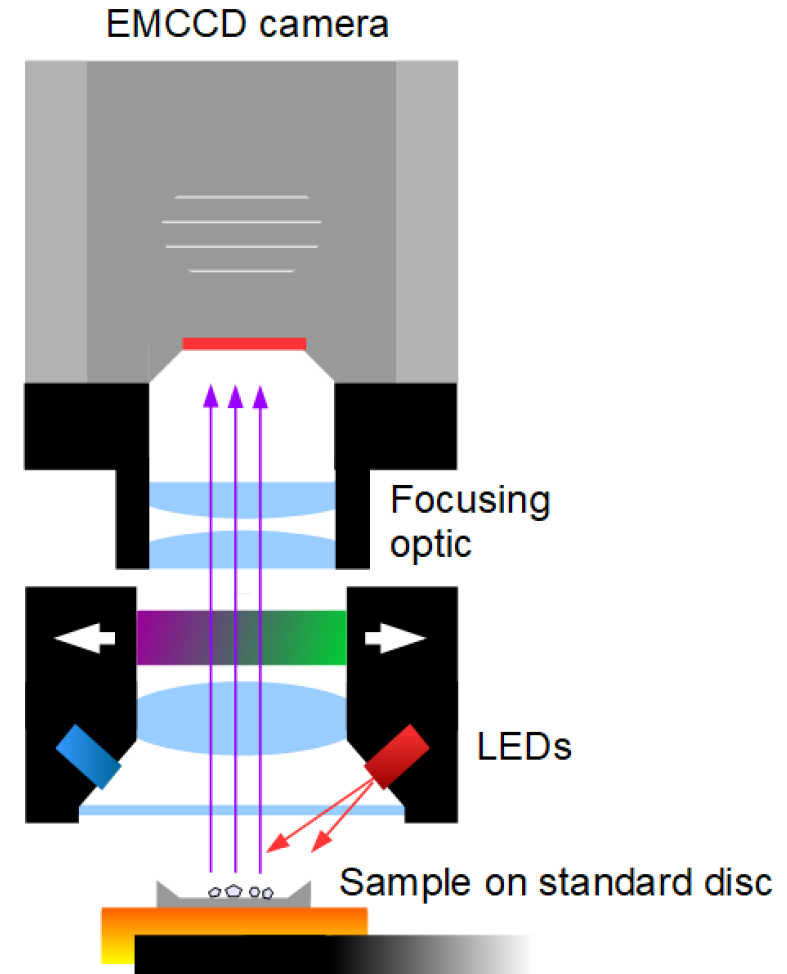
Advantages

- No special sample carrier required
- Samples other than coarse grains allowed
- Whole sample stimulated at once
- **Allows single-grain TL and IR-RF dating**

→ However, only very few application papers so far

Disadvantages

- High complexity of image processing
- **Signal cross talk**



Spatially resolved luminescence

Advantages

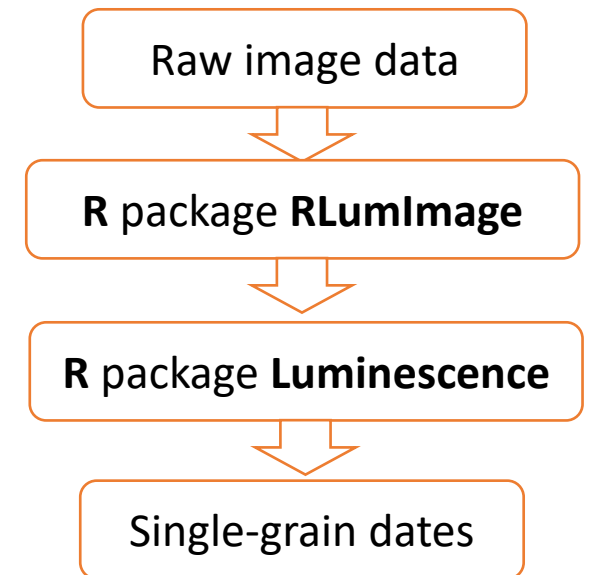
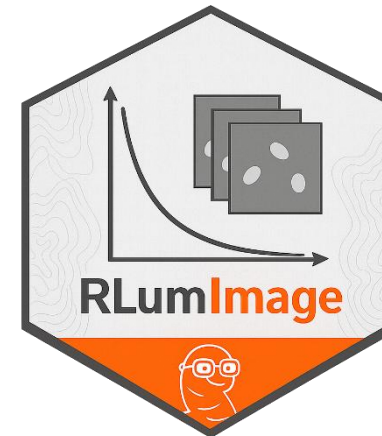
- No special sample carrier required
- Samples other than coarse grains allowed
- Whole sample stimulated at once
- **Allows single-grain TL and IR-RF dating**

→ However, only very few application papers so far

Disadvantages

- High complexity of image processing
- **Signal cross talk**

Upcoming R package for luminescence image processing



- In early development
- Will go open-access later this year

Spatially resolved luminescence

Advantages

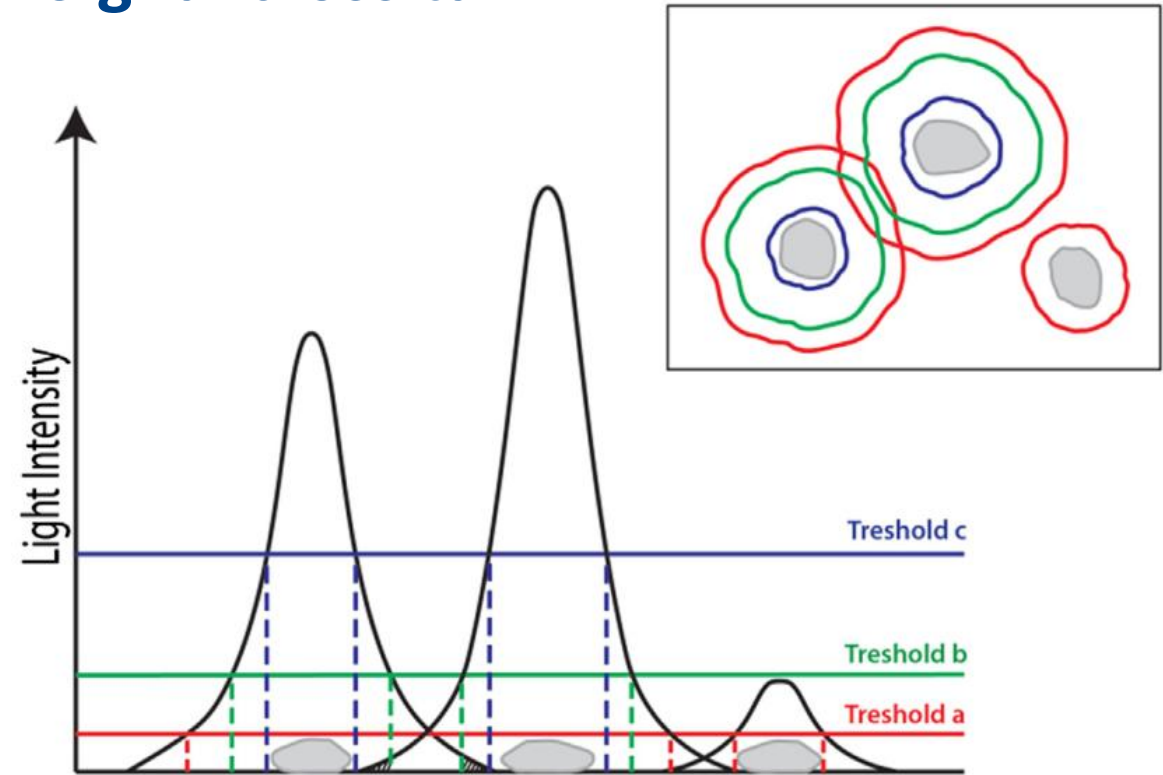
- No special sample carrier required
- Samples other than coarse grains allowed
- Whole sample stimulated at once
- **Allows single-grain TL and IR-RF dating**

→ However, only very few application papers so far

Disadvantages

- High complexity of image processing
- **Signal cross talk**

Signal cross talk



Gribenski, N., Preusser, F., Greilich, S., Huot, S., Mittelstraß, D., 2015. Investigation of cross talk in single grain luminescence measurements using an EMCCD camera. Radiation Measurements. <https://doi.org/10.1016/j.radmeas.2015.01.017>

Signal cross talk

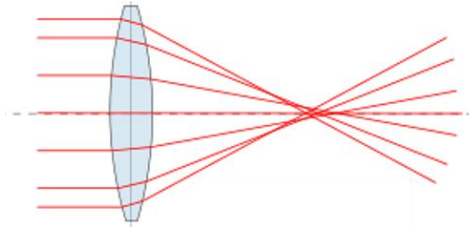
Image quality

Trade-off

Signal yield

Quartz OSL needs maximum signal yield at 365 nm

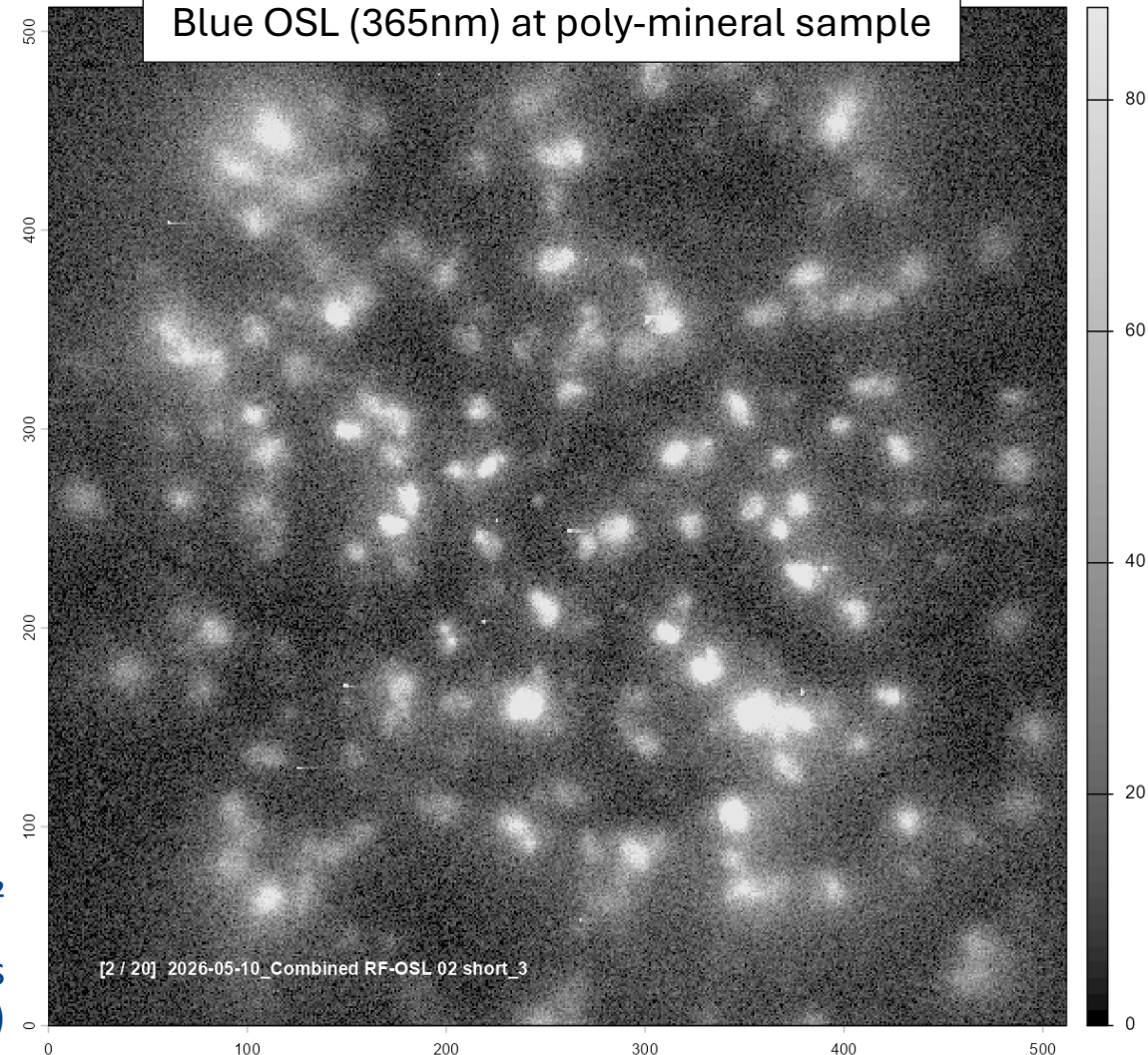
- Optical aberrations
- Aberration-corrected optics are not suitable



5 s exposure at 50 mW/cm²

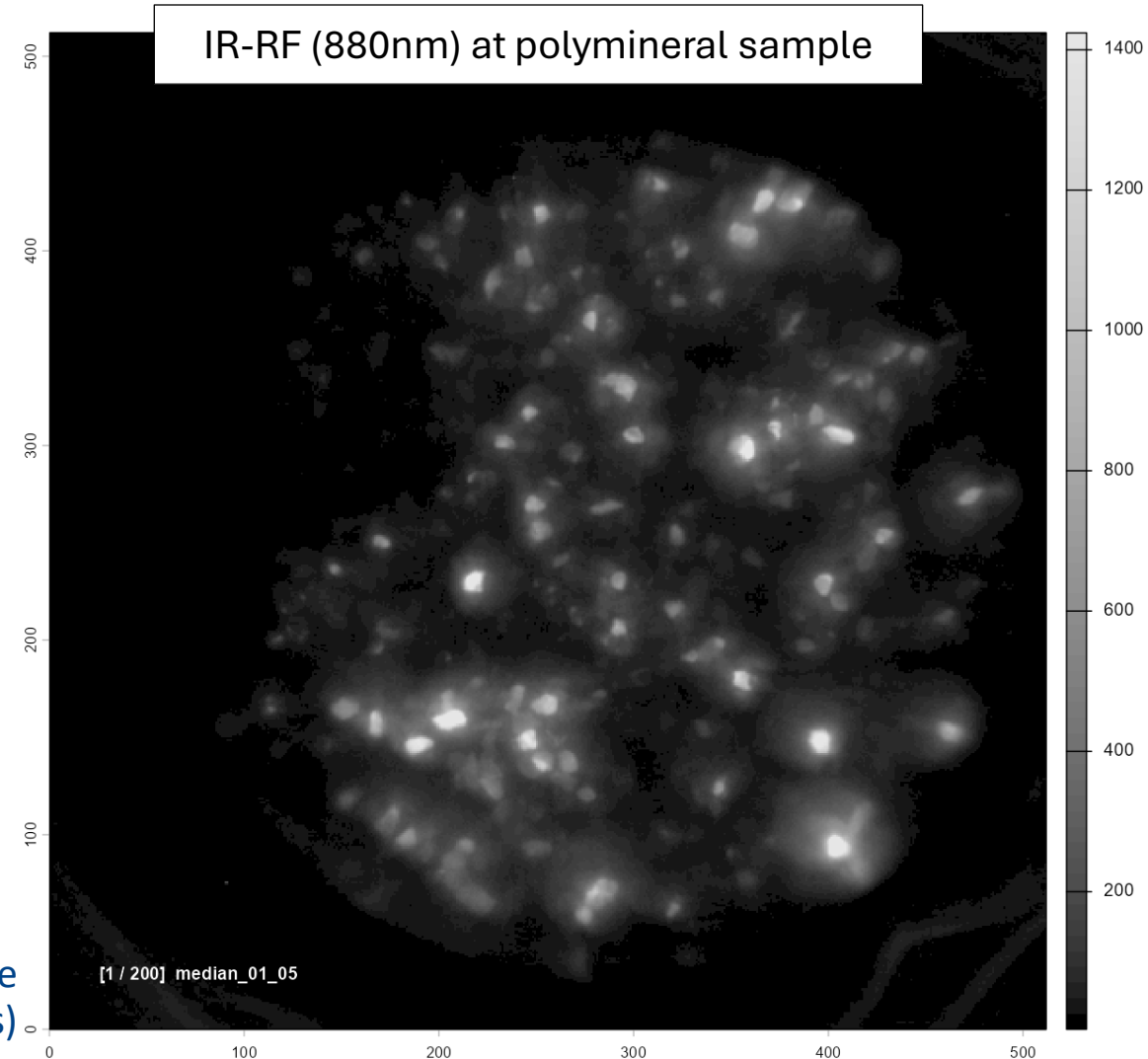
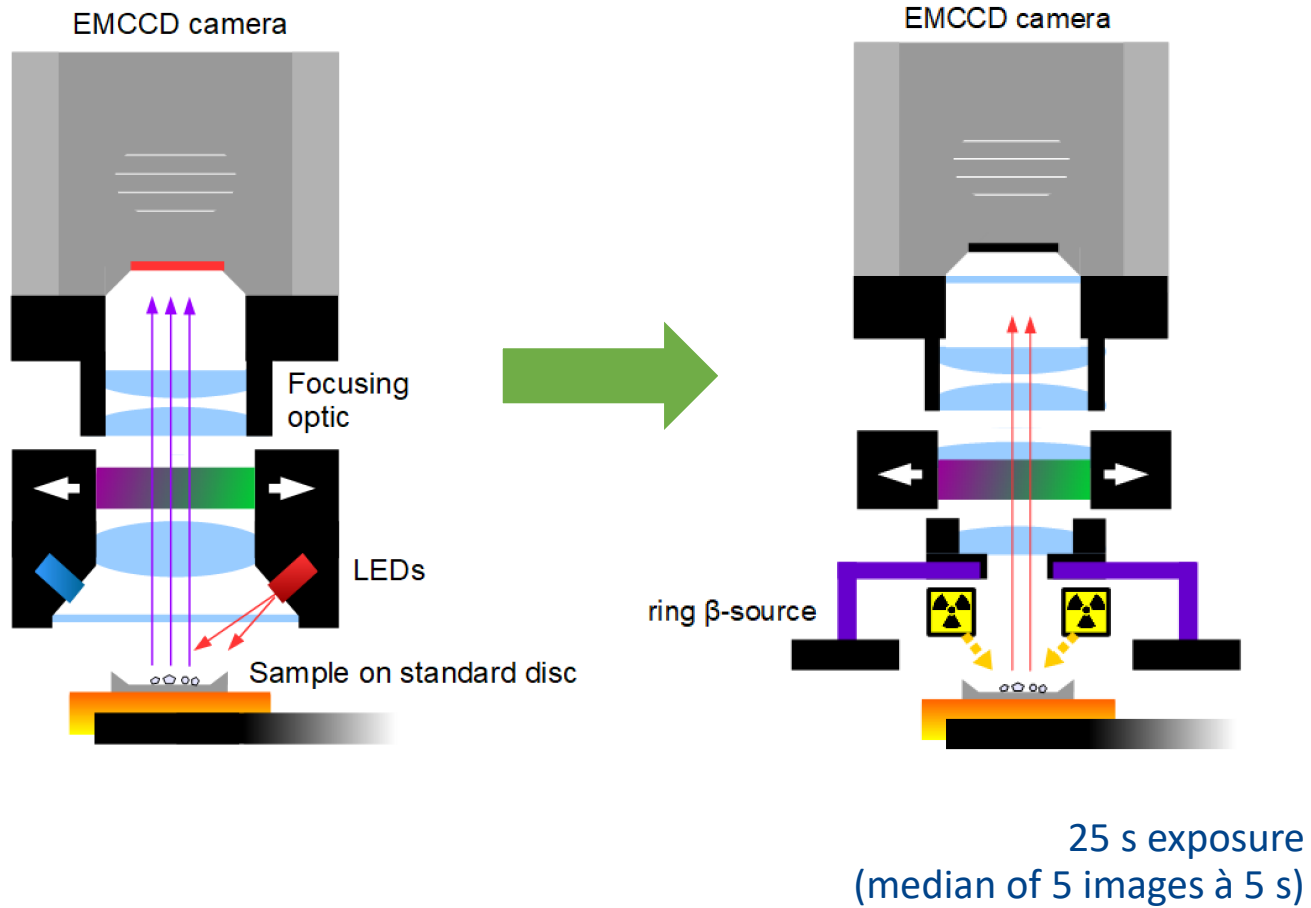
Optimized optics
(not commercially available)

Blue OSL (365nm) at poly-mineral sample



Spatially resolved radiofluorescence

Our solution: Switch to IR-RF of K-feldspars



Spatially resolved radiofluorescence

2005

unpublished

Spatially resolved infrared-radiofluorescence (IR-RF) dating on single feldspar grains
Krbetschek, M.R., Degering, D.

Presented at the 11th International Conference on Luminescence and Electron Spin Resonance Dating, Cologne, Germany, p. 103.

2021

Spatially resolved infrared radiofluorescence: single-grain K-feldspar dating using CCD imaging

Dirk Mittelstraß^{1,★} and Sebastian Kreutzer^{2,3,★}

¹independent researcher: Berthelsdorfer Str. 13, 09599 Freiberg, Germany

²Geography & Earth Sciences, Aberystwyth University, Aberystwyth, Wales, United Kingdom

³IRAMAT-CRP2A, UMR 5060, CNRS-Université Bordeaux Montaigne, Pessac, France

2026

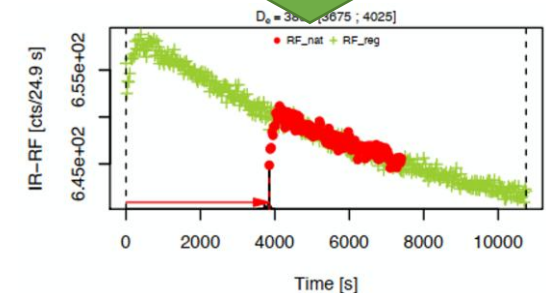
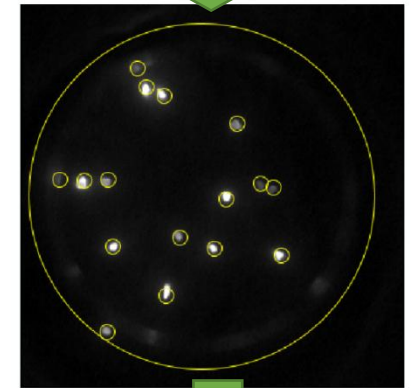
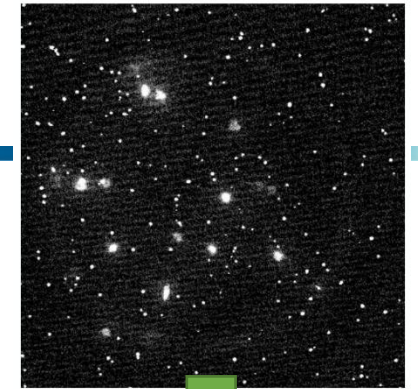
Spatially resolved infrared-radiofluorescence (SR IR-RF) measurements for single-grain feldspar dating

Raju Kumar^{a,b,*}, Marine Frouin^c, Mariana Sontag-González^b, Taylor Grandfield^c, Jean-Luc Schwenninger^b

^a Department of Geology and Geophysics, Indian Institute of Technology (IIT) Kharagpur, Kharagpur, West Bengal, 721302, India

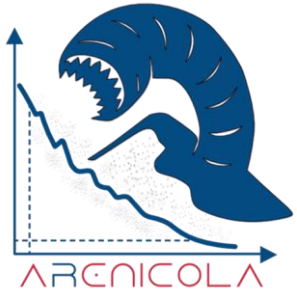
^b Luminescence Dating Laboratory, RLAHA, School of Archaeology, University of Oxford, OX13TG, UK

^c Department of Geosciences, University of Stony Brook, NY, 11794-21, USA



Single-grain equivalent dose

Spatially resolved radiofluorescence

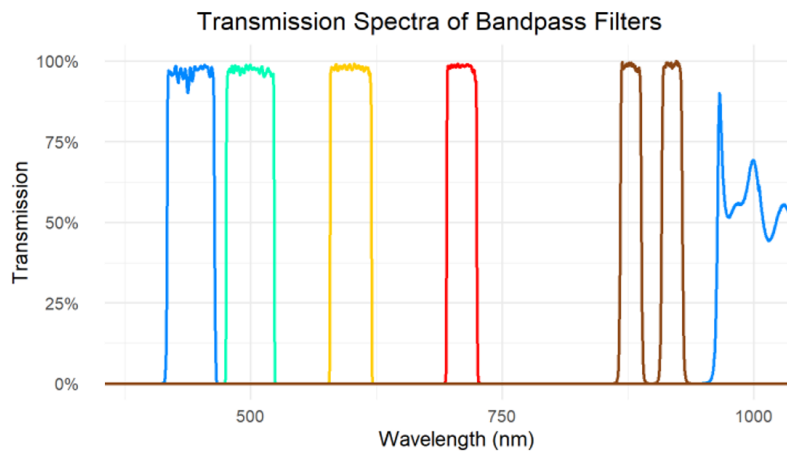


Measure RF at multiple emission bands and classify grains based on spectral fingerprint

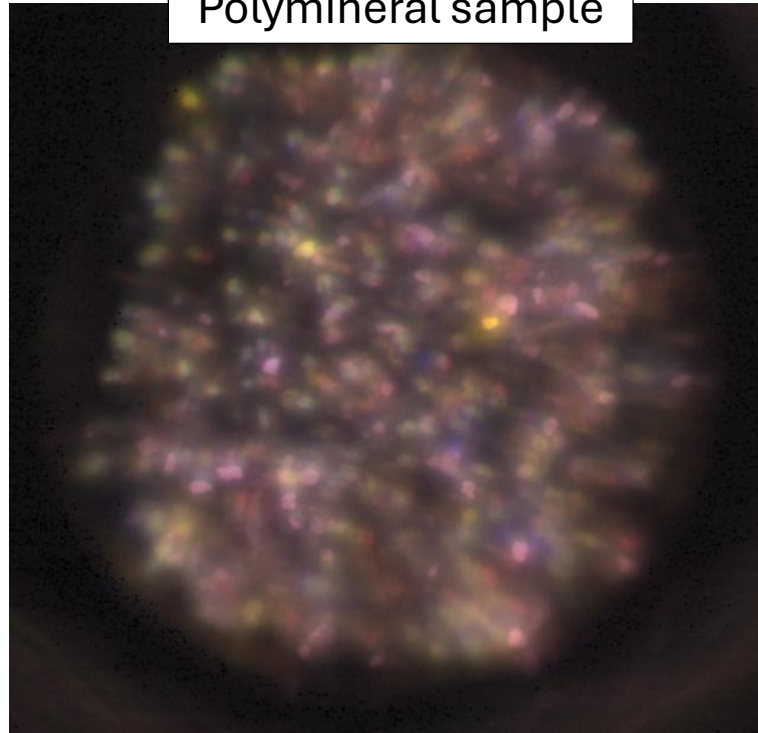
→ Select only K-feldspars for dating in polymineral sample

→ New tool for analysing sample provenance and defect inventory

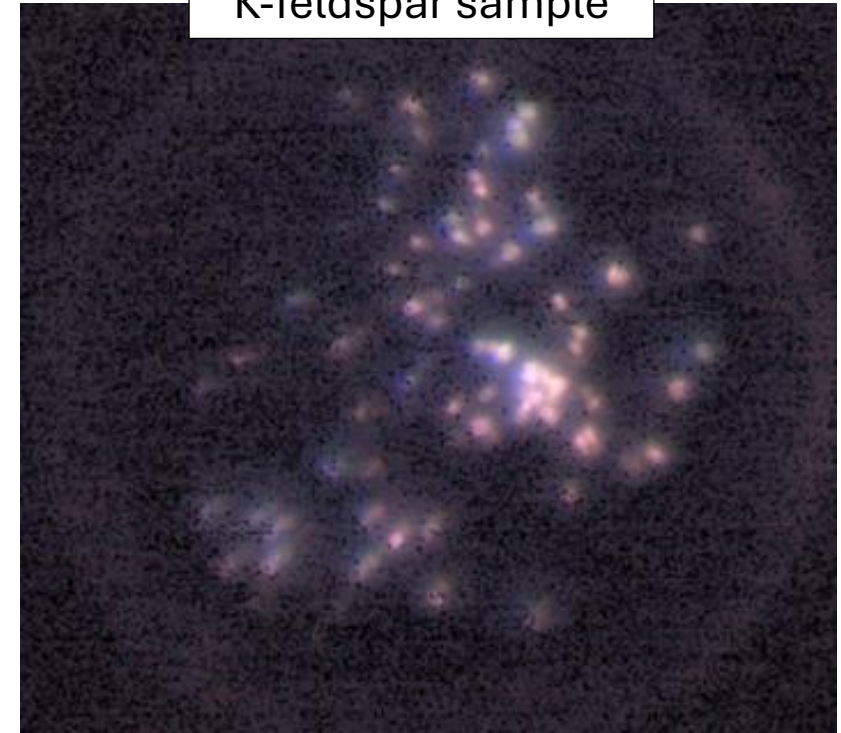
6- band multispectral RF
10 min measurement time



Polymineral sample



K-feldspar sample



Thank you for your attention

#553815036 ARENICOLA