The ARENICOLA project:

Radiofluorescence images digested by digital sandworms

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SCOPE

Notable methodological and instrumental advances and their successful application in dating studies have driven the acceptance of luminescence dating over the last decays. This has resulted in the acquisition of more accurate and precise ages.

Luminescence is commonly measured using non-imaging systems, such as photo-multiplier tubes. Imaging systems, such as highly efficient semi-conductor-based detectors are rarely used in dating studies, partly because of the challenges involved in efficient data processing.

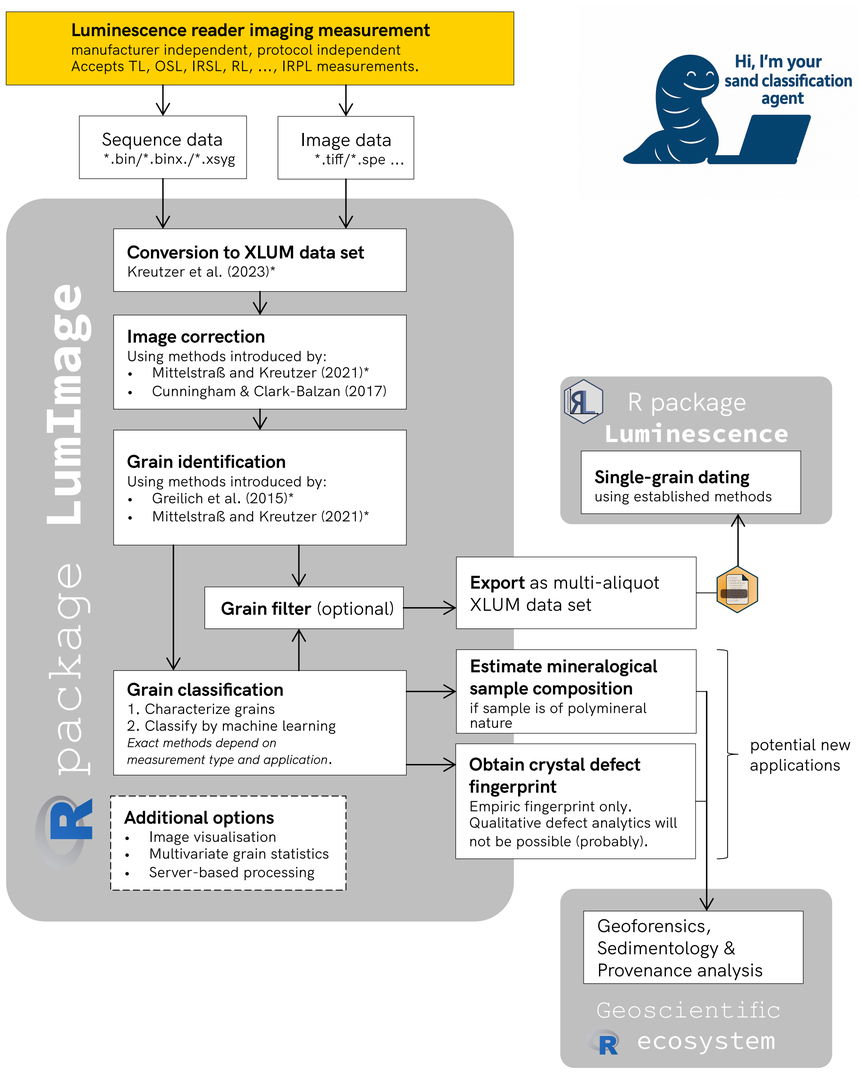
The DFG funded project ARENICOLA (08/2025 to 07/2027) is pursuing methodological breakthroughs in analysing spatially resolved multi-spectral radio-fluorescence signals on a single-grain level.

ARENICOLA will systematically investigate the luminescence properties of natural mineral grains using modern image analysis methods, such as machine learning to multispectral radio-fluorescence images on a set of pre-selected samples.

The specific objectives of ARENICOLA include the exploration of automated grain classification and component deconvolution of multi-spectral radio-fluorescence signals for in-depth investigation of sample data. Compared to optically and thermally stimulated luminescence, radio-fluorescence is recorded over extended periods of up to hours with sufficient signal intensities. These characteristics render radio-fluorescence suitable for grain identification.

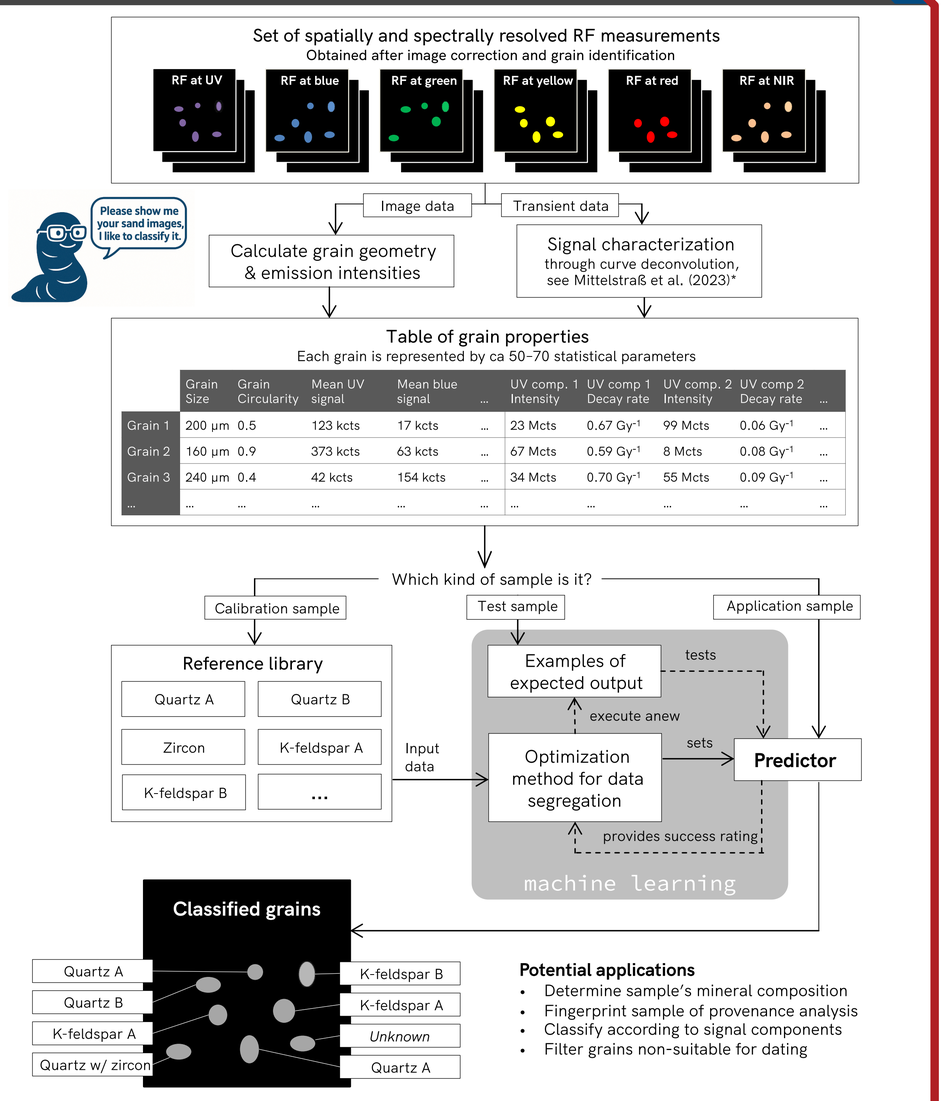
To that end, ARENICOLA will generate single-grain radio-fluorescence image training data-sets and ready-to-use open-source software to simplify and improve existing luminescence dating protocols. It will further support new and more efficient geochronological applications for palaeoenvironmental studies.

SOFTWARE



Software concept outlining the development of open-source R packages, for analyzing project data.

CLASSIFICATION



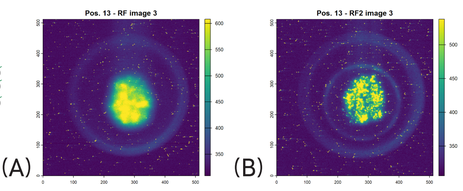
Example of the analysis workflows as to be implemented in ARENICOLA.

TEST RUNS & CHALLENGES

Linearized IR-RF signal curve attributes | **Prediction results**

Example grain no.	Actual grain origin	Lifetime 1	Lifetime 2	Lifetime 3	Intensity 1	Intensity 2	Intensity 3	Alikeness to BDX	Alikeness to defect cooling	Alikeness to TH0	Predicted grain origin
1	**TH0**	4.3	5.8	8.9	6.9	8.6	12.0	0.04	-0.03	**1.01**	**TH0** ✓
2	**BDX**	0.0	6.1	17.4	-3.0	10.0	21.3	**1.02**	0.25	-0.15	**BDX** ✓
3	**defect cooling**	6.3	7.1	21.2	9.9	-10.7	24.4	-0.33	**0.96**	0.20	**defect cooling** ✓

PLS regression models obtained from training data:
- BDX data against others
- defect cooling against others
- TH0 data against others



Left: Semi-automated grain classification from a trial run on old IR-RF data. The challenge here was to identify two different sample specimen and discard meaningless data from a defect cooling system (Mittelstraß & Kreutzer, 2021). **Top-right:** RF measurement results of a sediment mix: (A) RF image measured at 880 nm, here only K-feldspar grains were detected. (B) RF image measured at 410 nm of the same aliquot. Only quartz grains were detected. The image blur is caused by an still unfocussed optic in this wavelength range. **Technical challenges** to overcome: (1) Implement RF measurement using a rotating filter wheel (software); (2) Optimize optic for different focal planes for different wavelengths; (3) Develop correction optic for sharp images in all wavelengths.

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