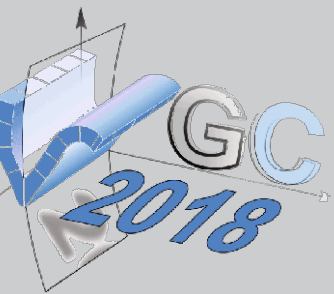


# Close-range sensing workflows in Structural Geology based on open-source/open access solutions

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## Data acquisition

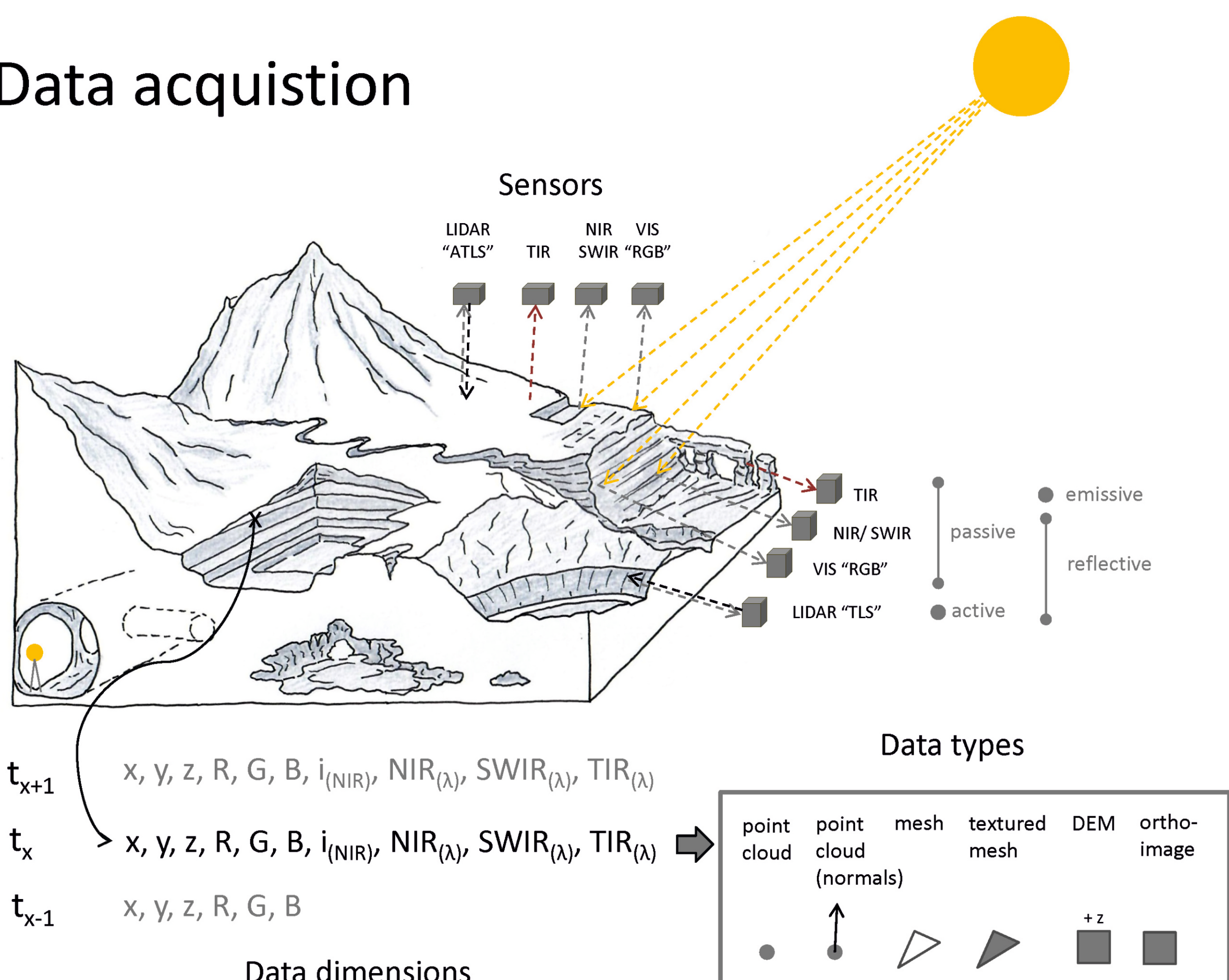


Figure 1: Schematic sketch illustrating typical geological outcrops (horizontal, vertical or mixed) and applicable aerial and terrestrial sensor types as well as resulting data dimensions and data types of digital outcrop models (DOMs)

## Fracture network extraction

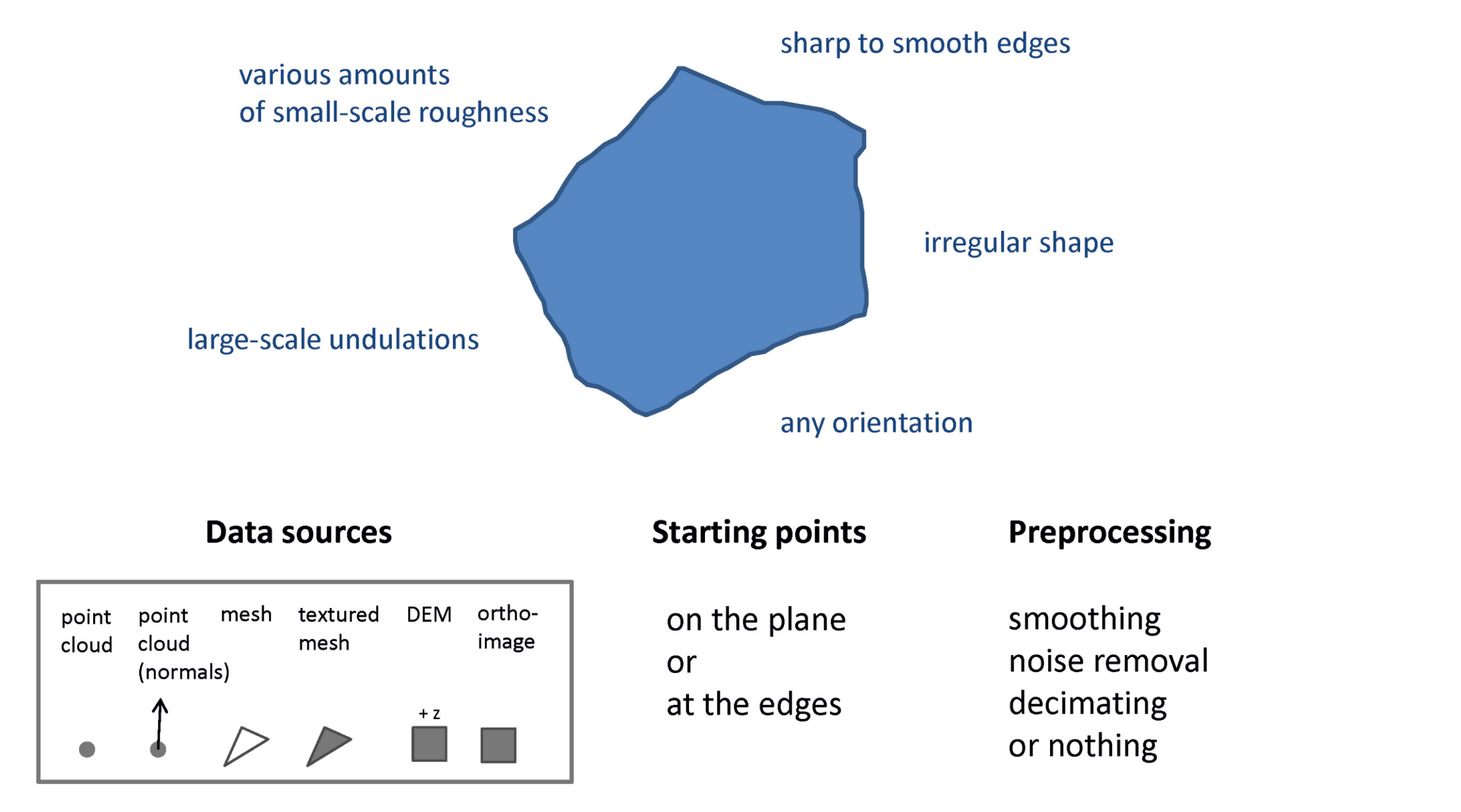


Figure 2: Schematic sketch illustrating initial conditions, challenges, data sources and analysing strategies of fracture network extraction.

	SfM (VIS)	SfM (TIR)	SfM + external images (NIR/SWIR/TIR)	TLS	TLS + images (VIS)	TLS + external images (VIS)	TLS + external images (NIR/SWIR/TIR)	Image Processing	Point Cloud SfM	Mesh	Programming 3D Geology
<b>PREPARATION</b>											
Cleaning	○	○	○	○	○	○	○				
Marking (Scale)	○	○	○	○	○	○	○				
Marking (Direction)	○	○	○	○	○	○	○				
Marking (Level)	○	○	○	○	○	○	○				
Marking (Location)	○	○	○	○	○	○	○				
<b>ACQUISITION</b>	●	●	●	●	●	●	●				
Imaging Scanning	●	●	●	●	●	●	●				
<b>PREPROCESSING</b>											
Raw data filtering	○	○	○	○	○	○	○				
Image enhancement	○	○	○	○	○	○	○				
Image selection	○	○	○	○	○	○	○				
Image Alignment	○	○	○	○	○	○	○				
Sparse PC creation	○	○	○	○	○	○	○				
Dense PC creation	○	○	○	○	○	○	○				
<b>REDUCTION</b>	○	○	○	○	○	○	○				
PC trimming	○	○	○	○	○	○	○				
PC subsampling	○	○	○	○	○	○	○				
<b>CORRECTION</b>											
Radiometric distance correction				○	○	○	○				
Radiometric angle correction				○	○	○	○				
Rectification				○	○	○	○				
PC Scaling				○	○	○	○				
PC Orientation (North, Level)				○	○	○	○				
PC Georeferencing				○	○	○	○				
<b>MERGING</b>											
PC & Images (simultaneous)				○	○	○	○				
PC & Images (successive)				○	○	○	○				
PC & PC (simultaneous)				○	○	○	○				
PC & PC (successive)				○	○	○	○				
PC & Mesh				○	○	○	○				
<b>CONVERSION</b>											
PC to Mesh				○	○	○	○				
Mesh to textured Mesh				○	○	○	○				
<b>ANALYSIS</b>											
Manual point-picking	○	○	○	○	○	○	○				
Semi-automatic point-picking	○	○	○	○	○	○	○				
Geometric classification	○	○	○	○	○	○	○				
Geometric feature detection	○	○	○	○	○	○	○				
Spectral classification				○	○	○	○				
Spectral feature detection				○	○	○	○				
Geometric & spectral classification	○	○	○	○	○	○	○				
Geometric & spectral feature detection	○	○	○	○	○	○	○				
<b>OUTPUT</b>											
Line network				○	○	○	○				
Plane network				○	○	○	○				
Directional data				○	○	○	○				
Fracture network				○	○	○	○				
Realistic DOM				○	○	○	○				
Lithological data				○	○	○	○				
Structural data				○	○	○	○				
(Multi-) Spectral DOM				○	○	○	○				
Lithological data				○	○	○	○				
Heterogeneity				○	○	○	○				
Mineralization				○	○	○	○				
Alteration				○	○	○	○				
Series of DOMs				○	○	○	○				
Temporal-spatial changes				○	○	○	○				

## Background

In Structural Geology, many projects start with intensive field-based data acquisition campaigns, which might be performed in quite different types of natural or artificial outcrops. For some years, this field work has been substantially influenced and transformed by various close-range sensing techniques that allow the field geologist to create a digital outcrop model (DOM) and to take along plenty of geometrical and spectral information about the outcropping rocks.

In general, DOMs can be utilized for outcrop visualisation, documentation, manual outcrop analysis ("point-picking"), extraction of spectral data and/or semi-automatic extraction of geometric data. Within a structural investigation DOMs might be deployed for fold analysis, fault analysis, extraction of fracture networks, fracture roughness estimation, detection of neotectonic activities or digitisation of geological features for 3D-models of various scales resulting in a large number of analysing techniques.

Latter might be carried out on point clouds or meshes (with or without spectral information) and may differ in pre-processing and processing steps as well as in software solution. Therefore, the analysing structural geologist faces various tools, data formats, file types, operations and outcomes. Our investigation focus on the compilation of useful, transparent, sustainable and comparable workflows or "pipelines", which can be executed by open-source/open-access solutions.

## Thematic workflows

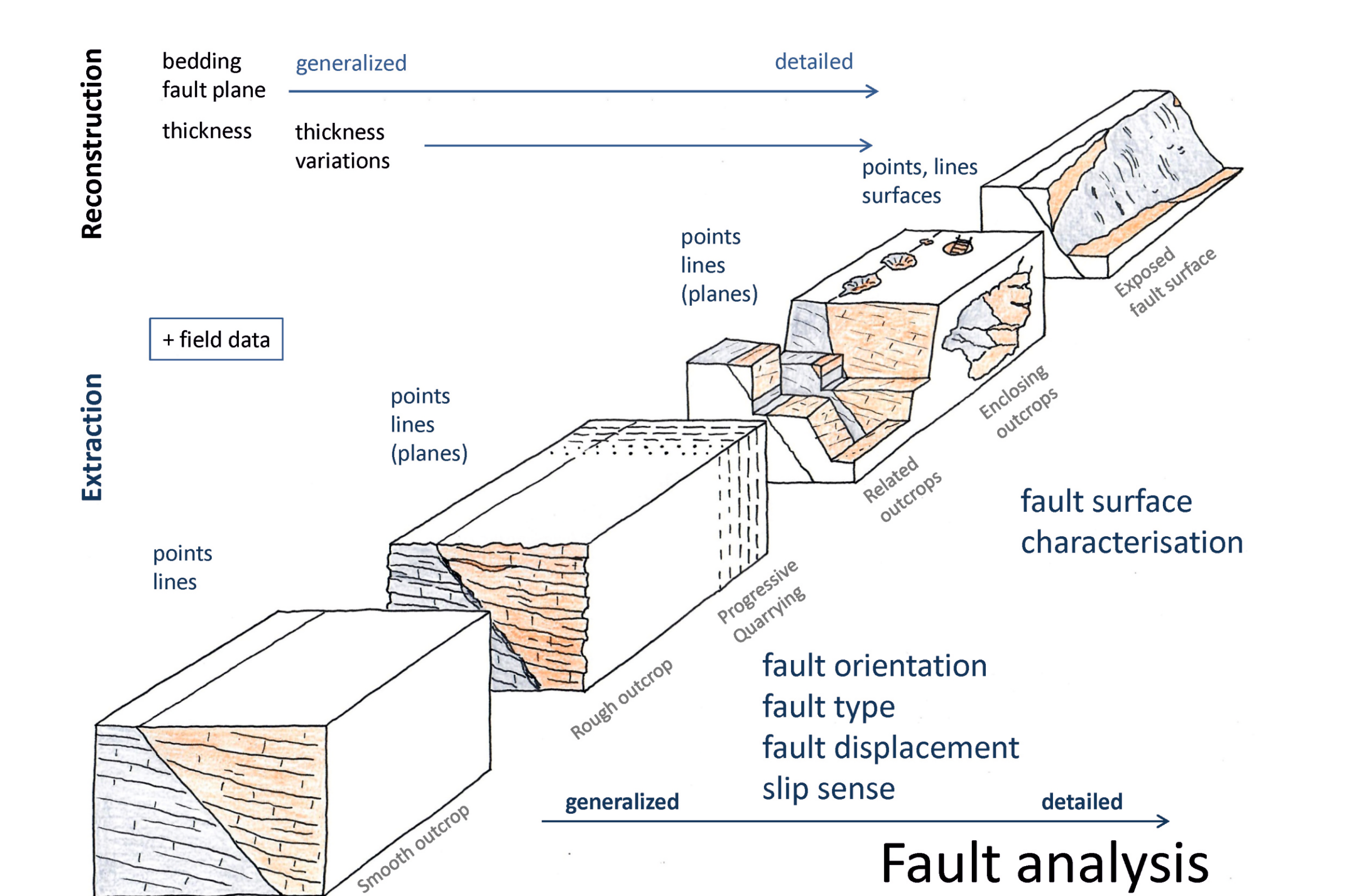


Figure 3: Schematic sketch illustrating common geological outcrop types exposing extensional faults and extractable 2D and 3D objects.

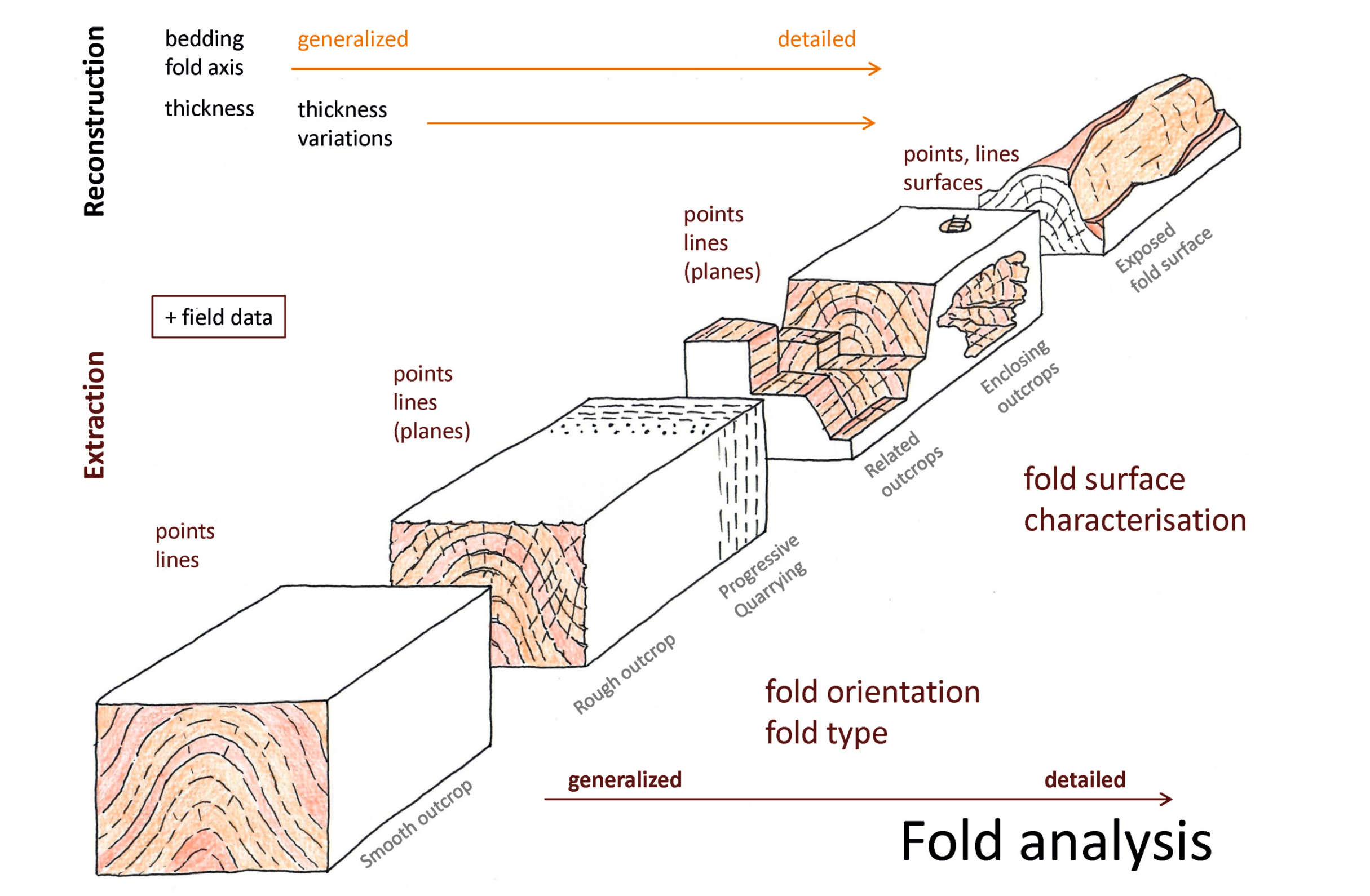


Figure 4: Schematic sketch illustrating common geological outcrops exposing fold structures and extractable 2D and 3D objects.