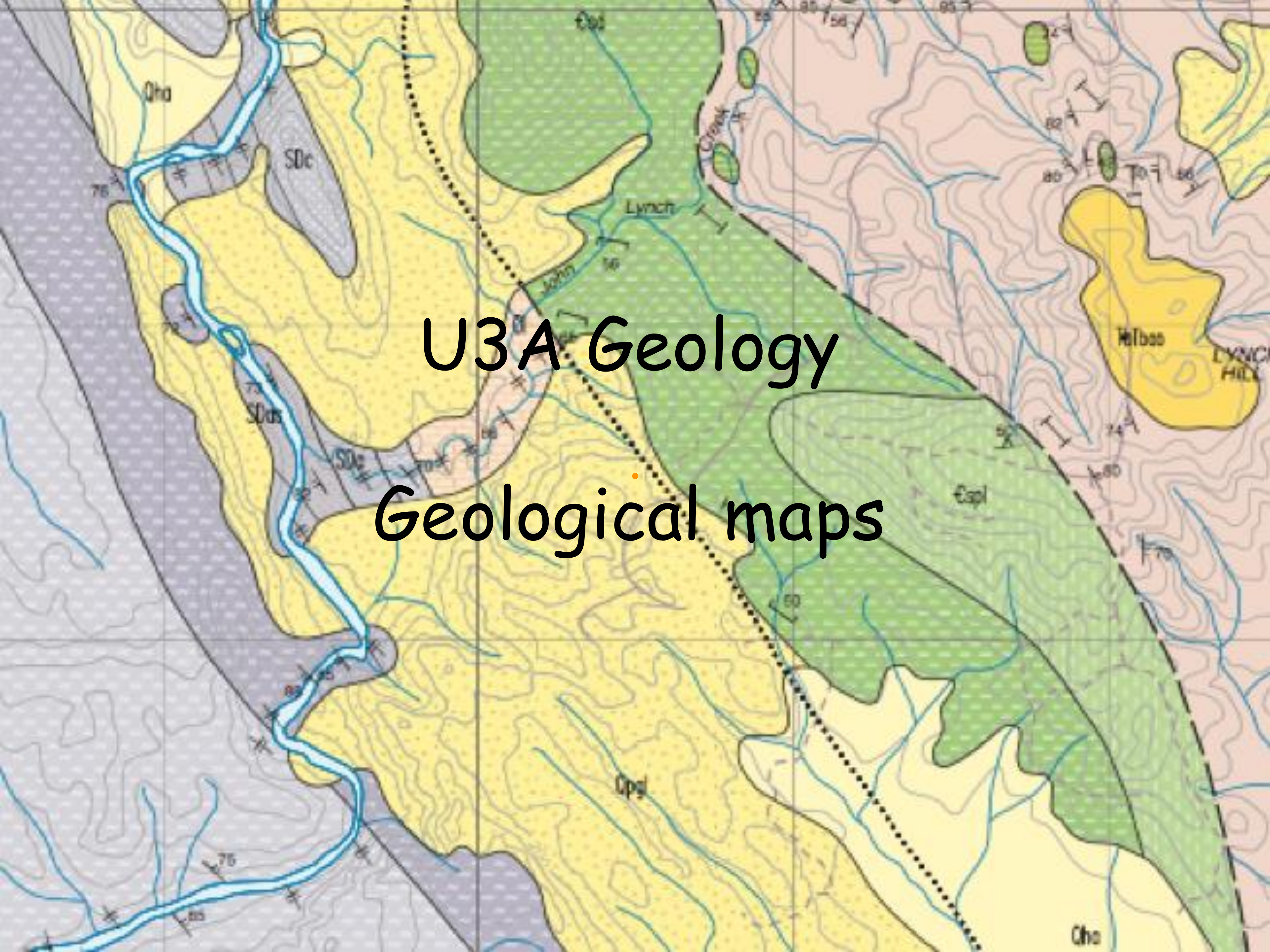
U3A Geology

Geological maps



Introduction

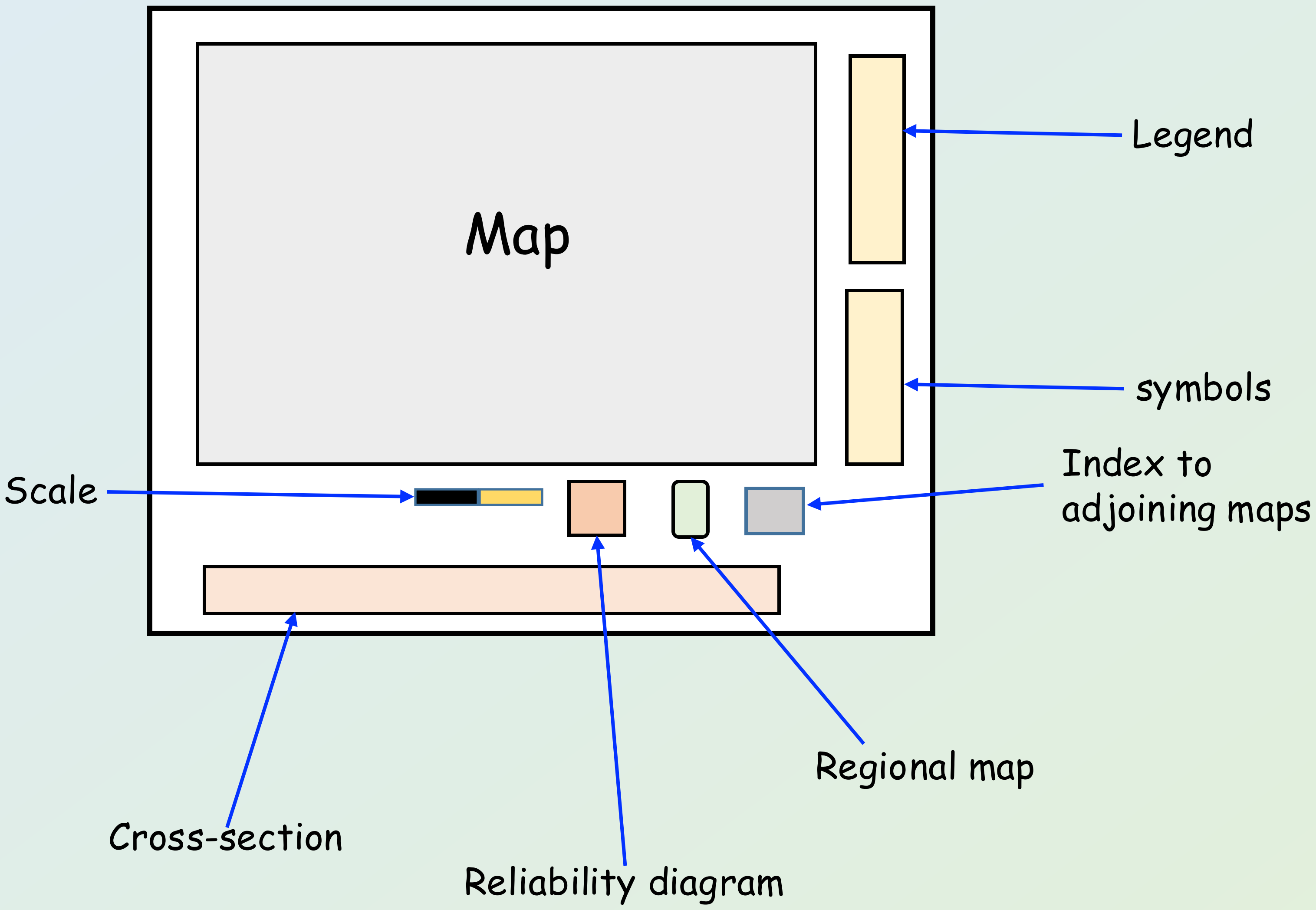
- Geological maps display distribution of rock types and selected structural elements for a defined geographical area
- distribution of rock types is shown using a colour or pattern coding
- important for interpreting the geological history of an area
- maps → prepared by State Geological Surveys, Geoscience Australia, mining and geotechnical companies
- maps published by State Government Surveys are typically on scales from 1:25,000 to 1:500,000
- resource and geotechnical companies normally produce smaller scale maps e.g. 1:500, 1:1,000

Why do we need geological maps?

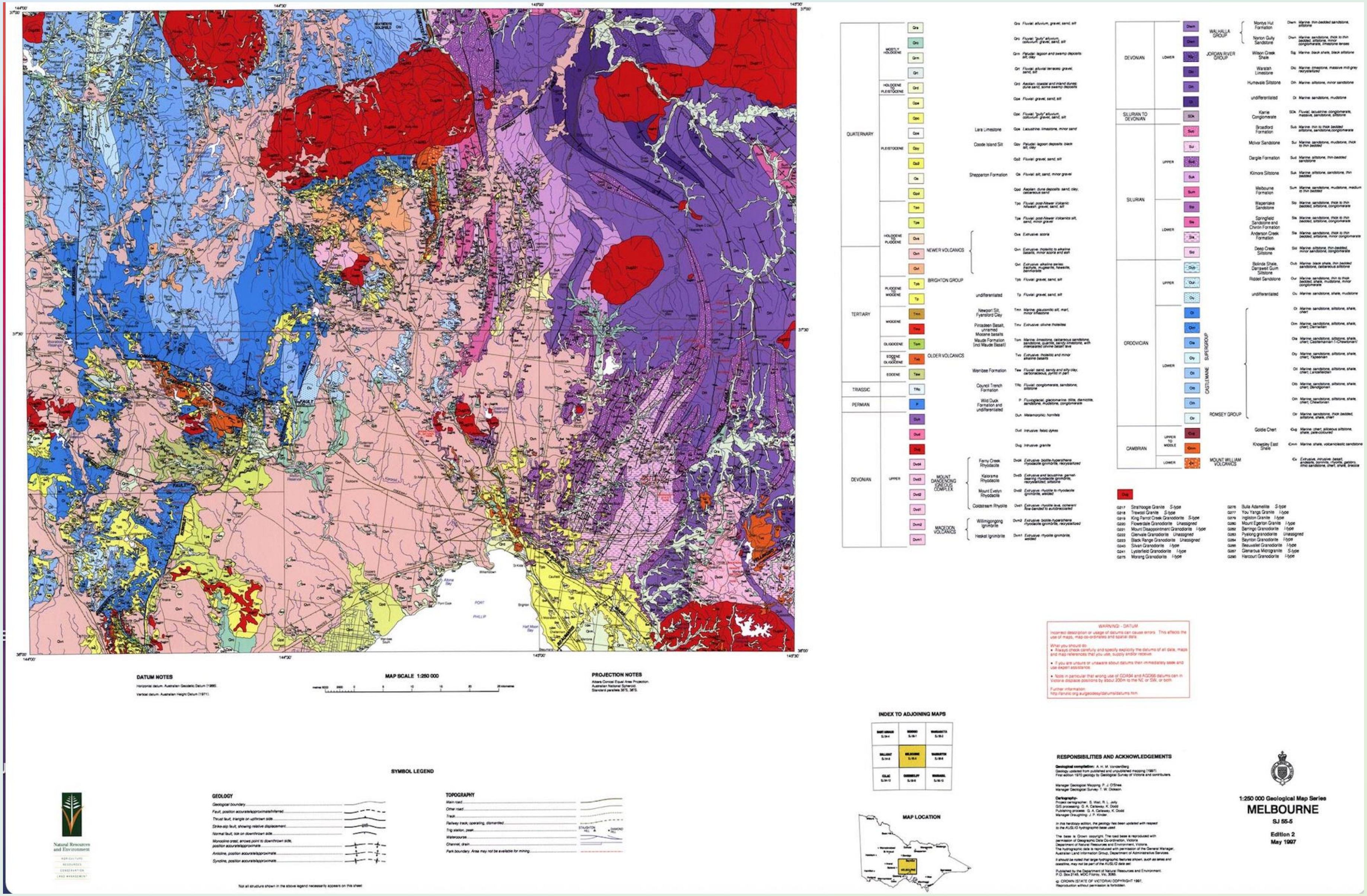
Geological information on maps is important for many reasons:

1. Targeting natural resources (minerals, oil, gas, water)
2. evaluating potential hazards (earthquakes, landslides, volcanic eruptions)
3. describing a fundamental part of the environment that controls the distribution of plants and animals
4. development of infrastructure (roads, dams, building estates)
5. landcare e.g. identifying areas of potential dryland salinity, erosion

Geology map components



Melbourne geological map



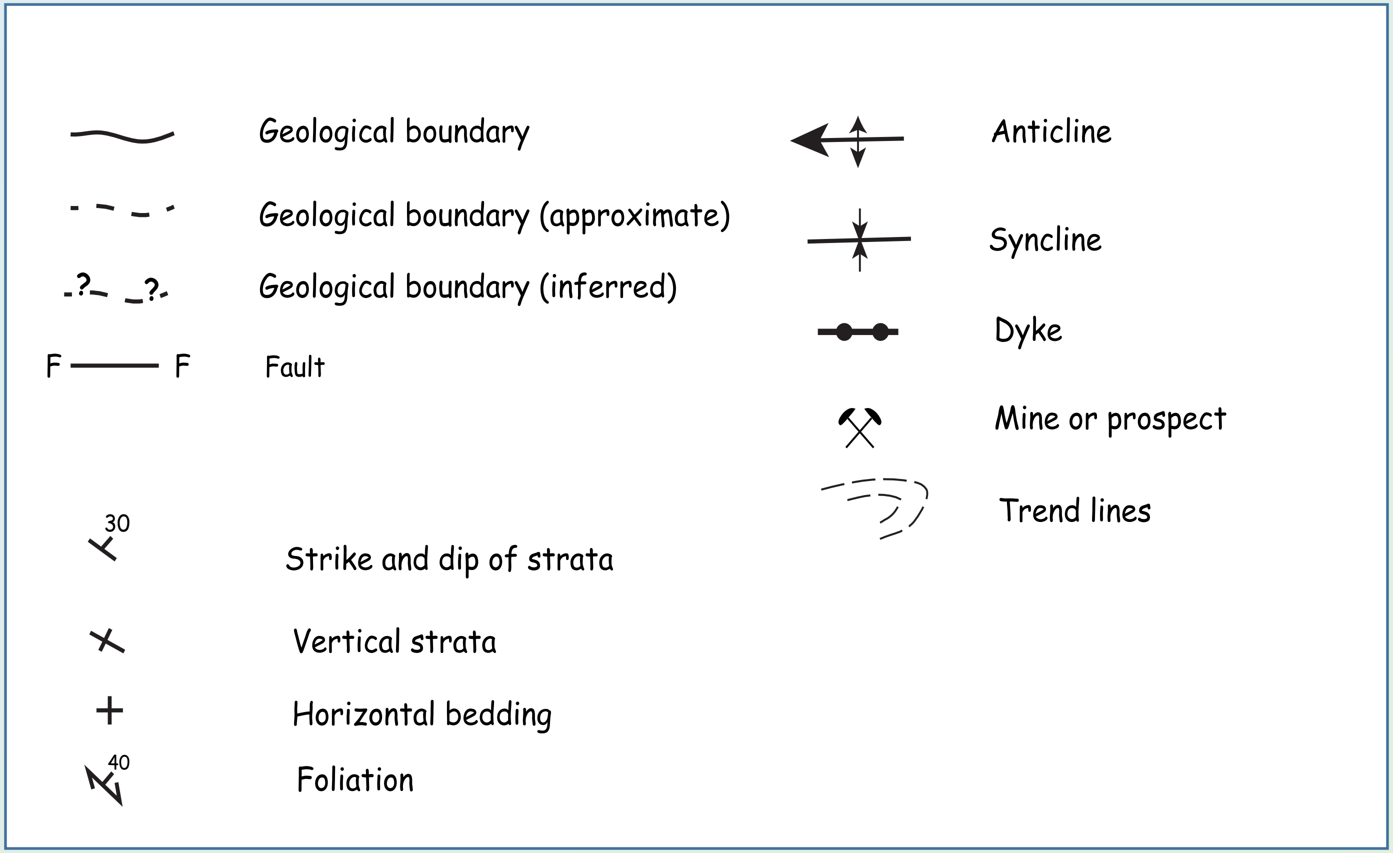
Legend

- Summarises the stratigraphy → each rock type shown on the map → represented by colour code and symbol enclosed in a box
- a description of the rock units is included
- ages of rock units and unconformities included

QUATERNARY	Qa	Alluvium
	- - - - - - - - -	unconformity
CRETACEOUS	Clm	Limestone
	Css	Sandstone
JURASSIC	Jsh	Shale
	- - - - - - - - -	unconformity
DEVONIAN	Dg	Granite
SILURIAN	Sms	Mica schist
	Sgn	Garnet gneiss

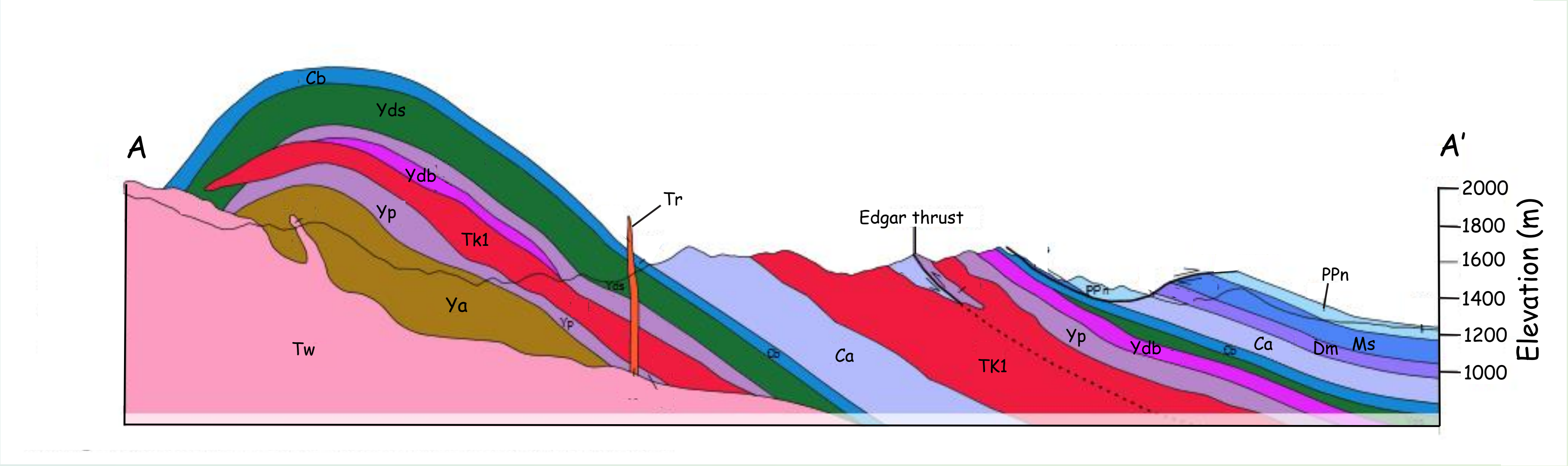
Symbols

- A table displays the geological symbols used in the map preparation
- when lines used to represent boundaries, faults etc. are dashed it means that they are approximate or inferred (with question mark)



Cross-section

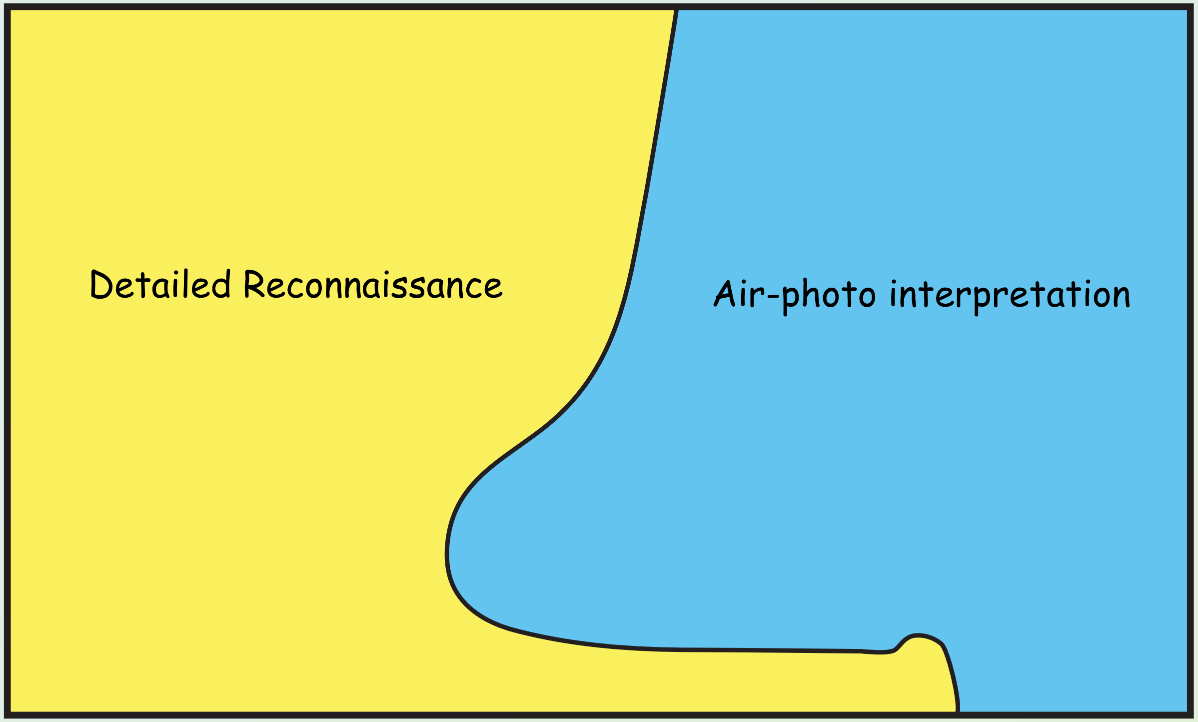
- Geological cross-section → vertical slice through a representative part of the map
- shows an interpretation of the structure and stratigraphic relationships of the map units (important for resource exploration)
- important aid in constructing a geological history of the area



Cross-section, Catalina Mountains, Arizona

Geological Reliability diagram

- Geologists may use different methods to map an area
- some methods more precise than others e.g. detailed ground survey more accurate than air-photo interpretation or series of traverses
- a Geological Reliability diagram provides a distinction between grades of reliability in map preparation



Geological Reliability diagram

Map preparation

- Geology maps are prepared mainly from ground survey after office techniques are used to plan the exercise
- examination of aerial photographs provides important information that assists in understanding of the nature of the terrain, access to area and aspects of the geology
- it is not normally feasible to analyse in situ every square metre of the mapping area
- interpretative geology may be used in map generation with the aid of aerial photographs

Planning and research stage

- Prior to venturing into the field to produce a geology map → various analyses and interpretations can be made to facilitate a more efficient mapping program → Planning and Research Stage
- Planning and Research mainly conducted in office → 2° data collection
- required 2° data:

  topographic map

  satellite images

  aerial photographs

  literature research

  geological maps of any part of the area

  geophysical maps

Geological mapping

Geological features such as distribution of rock types and geological structures are displayed on a map

- scale and detail of map depends on the reason for the map preparation
- maps can be prepared directly onto an aerial photograph
- alternatively a GPS can be used to locate rock boundaries and other geology that can then be plotted on a suitable base map

Usefulness of aerial photographs

- Photogeology → branch of geology involving geological interpretation through viewing aerial photographs
- aerial photographs provides capability to view large areas and examine and interpret geological features in large areas
- they play a significant role in map making and data analysis
- photointerpretation is done before, during and after fieldwork
- aerial photographs can be used to:

  (1) check out nature of terrain

  (2) check out and plan access to the area

Photogeology

- First used in WW1 for identifying enemy troop concentrations, defensive fortifications
- provides a means for initial interpretation of the geology of large areas (especially remote areas)
- plays a significant role in the process of map preparation
- single photographs → enable simple interpretation
- overlapping aerial photographs → stereographic vision → show topography → enable more detailed interpretation

Use of aerial photographs in premapping

- Provide an overview of good vs poor outcrop in an area → enable planning of traverse routes
- may show complex areas that require detailed mapping
- reveal large structures that may not be recognised on the ground (e.g. folds, faults, large scale sedimentary features)
- enable recognition of subtle changes in rock types
- use as a base map for geological mapping and field navigation

Information from aerial photographs

Information from single photograph

- Variations in tone, texture, pattern, shape, size and relief
- enables discernment of different rock units and simple geological structure

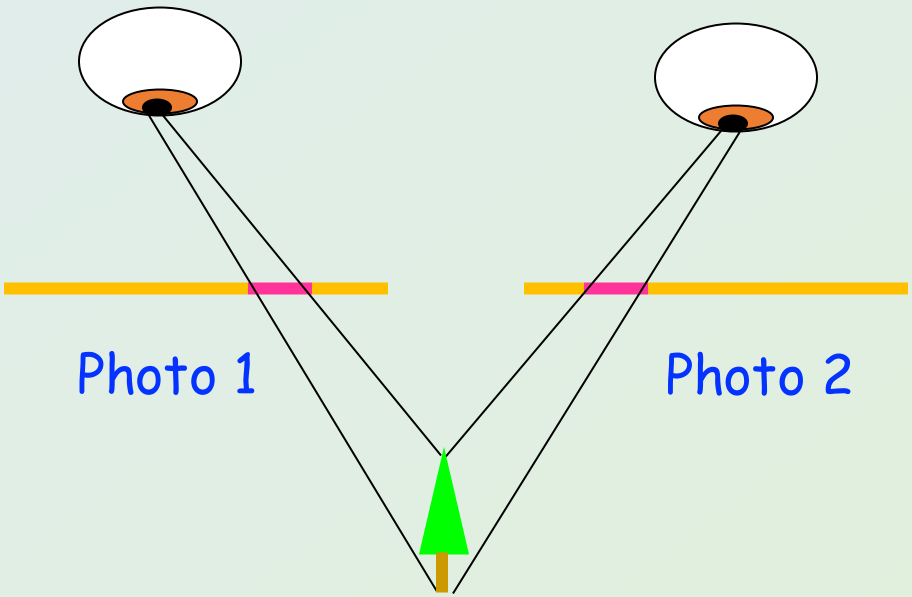
Information from stereo paired photographs

- Enables interpretation of topography
- aids in interpretation of geological structures (estimates of dip and plunge angles)

Aerial photograph -Lake Amadeus Area, NT

Stereoscopic viewing of aerial photographs

- If we have photographs of an object taken from two different positions and view each simultaneously, we form a stereographic image of the object
- in stereophoto vision, the left eye looks at left photo, right eye looks at right photo (unlike normal, unaided where lines of sight converge)



Use of stereo pairs

Pocket stereoscope

- Good for field use
- must overlap photos
- magnifies (2x or 4x)
- reduced field of view

Mirror stereoscope

- Best for office use
- separates the photos
- generally no enlarger
- larger field of view

Limitations using aerial photographs

- Enables discrimination of different rock units but cannot definitively identify rock types
- thick vegetation can obscure outcrop
- cannot distinguish small scale geological features
- although useful in interpreting the geology of an area → should be used in conjunction with ground fieldwork

Mapping techniques

- Initial steps → determine the stratigraphy and define mapping units from geology traverse
- stratigraphy determined from facing directions e.g. sedimentary structures (cross-bedding, load casts etc.)
- when selecting mapping units, must consider:
  (1) scale of the map → mapping unit must be thick enough to be evident on the map
  (2) mapping units must have some continuity through the area

Information gained from ground mapping

(i) Details of rock types present (textures, mineralogy, structures)

(ii) distribution of rock units in the area

(iii) sequence of the different rock types and the nature of the boundaries between them

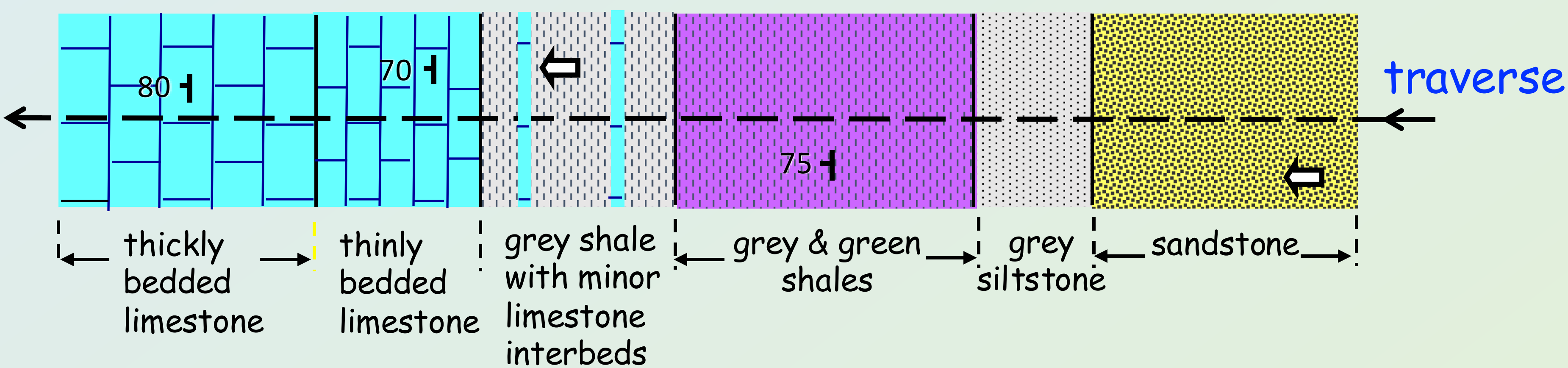
(iv) overall structure i.e. how folding and faulting has affected the sequence of rocks

(v) metamorphic effect on rocks

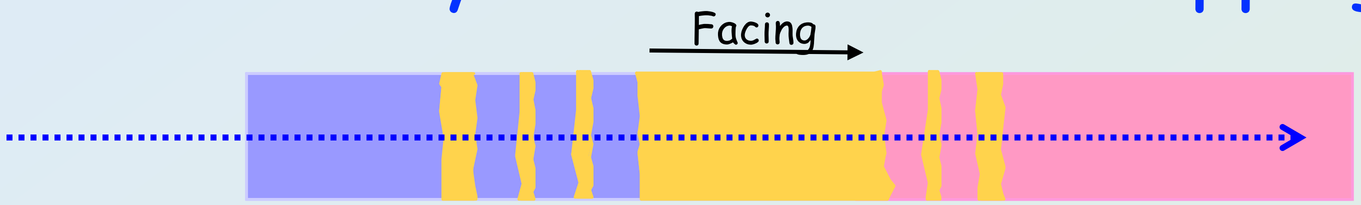
All of the above are important in establishing the geological history and economic potential of an area

Geological traverse

- Prior to commencing mapping of an area, it is normal practice to map along one or more traverses selected more or less perpendicular to the strike of bedding and construct a stratigraphic sequence
- it may be necessary to conduct more than one traverse → to cover all of the rock formations in the area

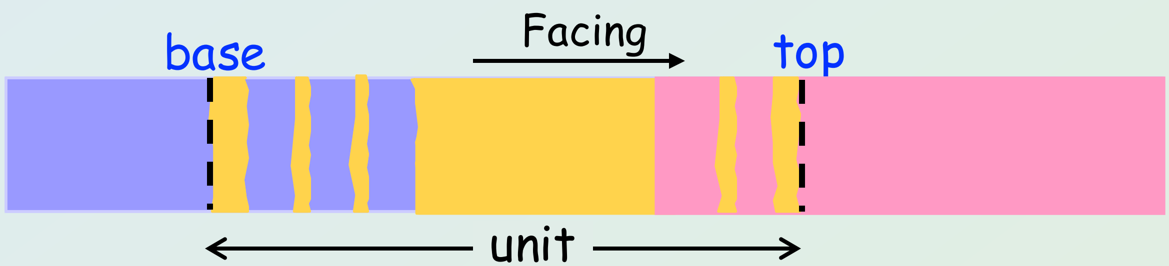


Boundary definition for mapping units



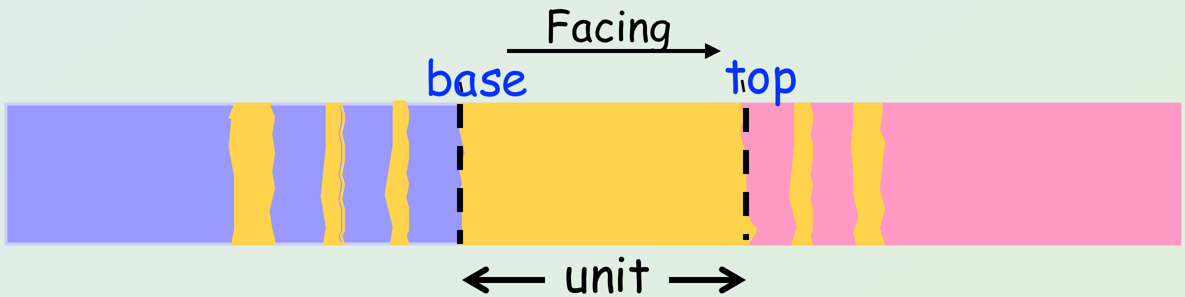
Option 1

Base defined by the first the incoming of dolomite.
Top defined by the last appearance of dolomite



Option 2

Base defined by the outgoing of sandstone.
Top defined by the first appearance of shale



Choosing mapping units

- Units should be traceable around the area → must crop out moderately well → be continuous → not lens out
- should show up on the scale of the map
- units may comprise one rock type or a number of related rock types
- it may be necessary to revise the units as mapping proceeds
- units chosen will depend on:

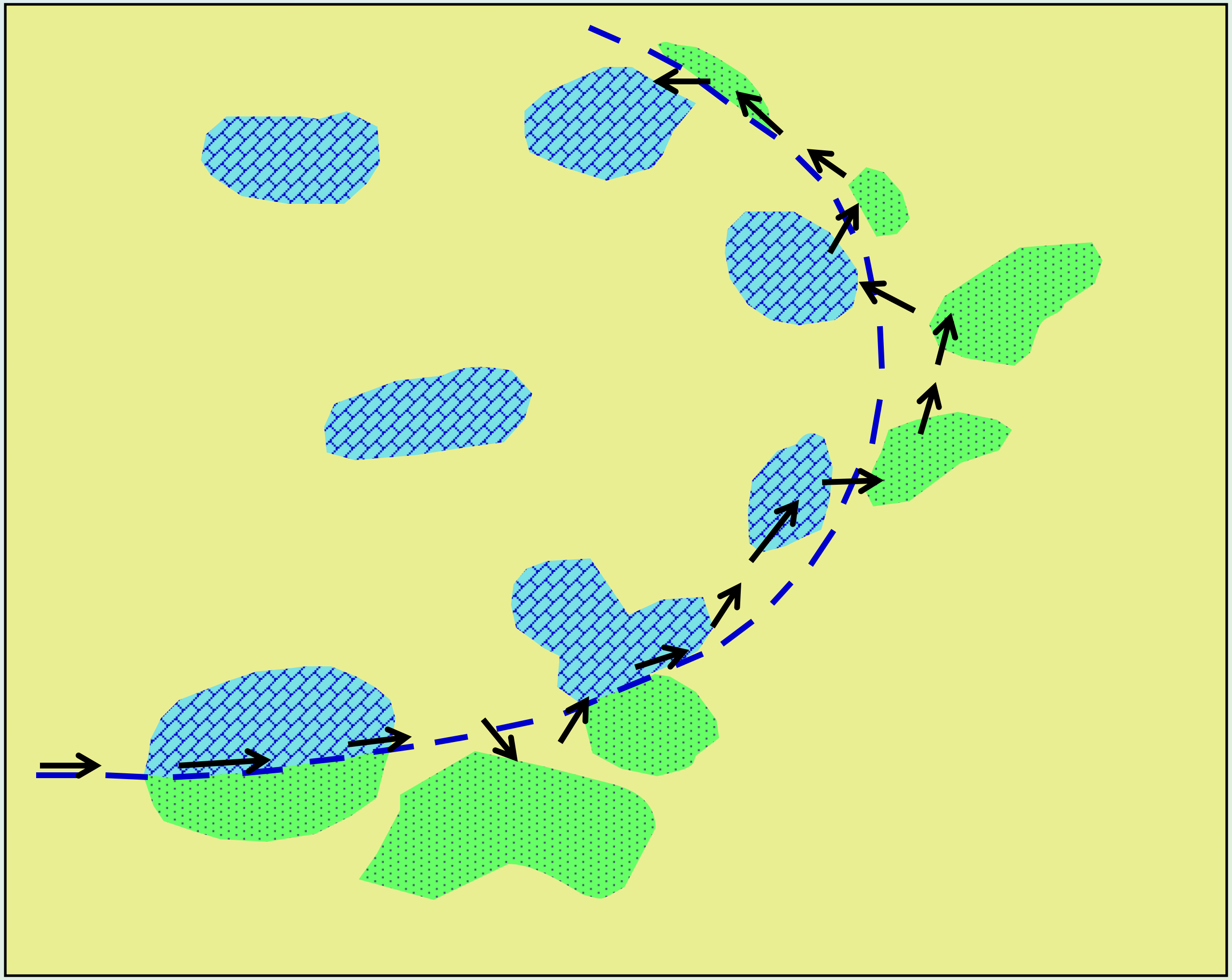
  scale of mapping

  nature of outcrop

  reasons for map production

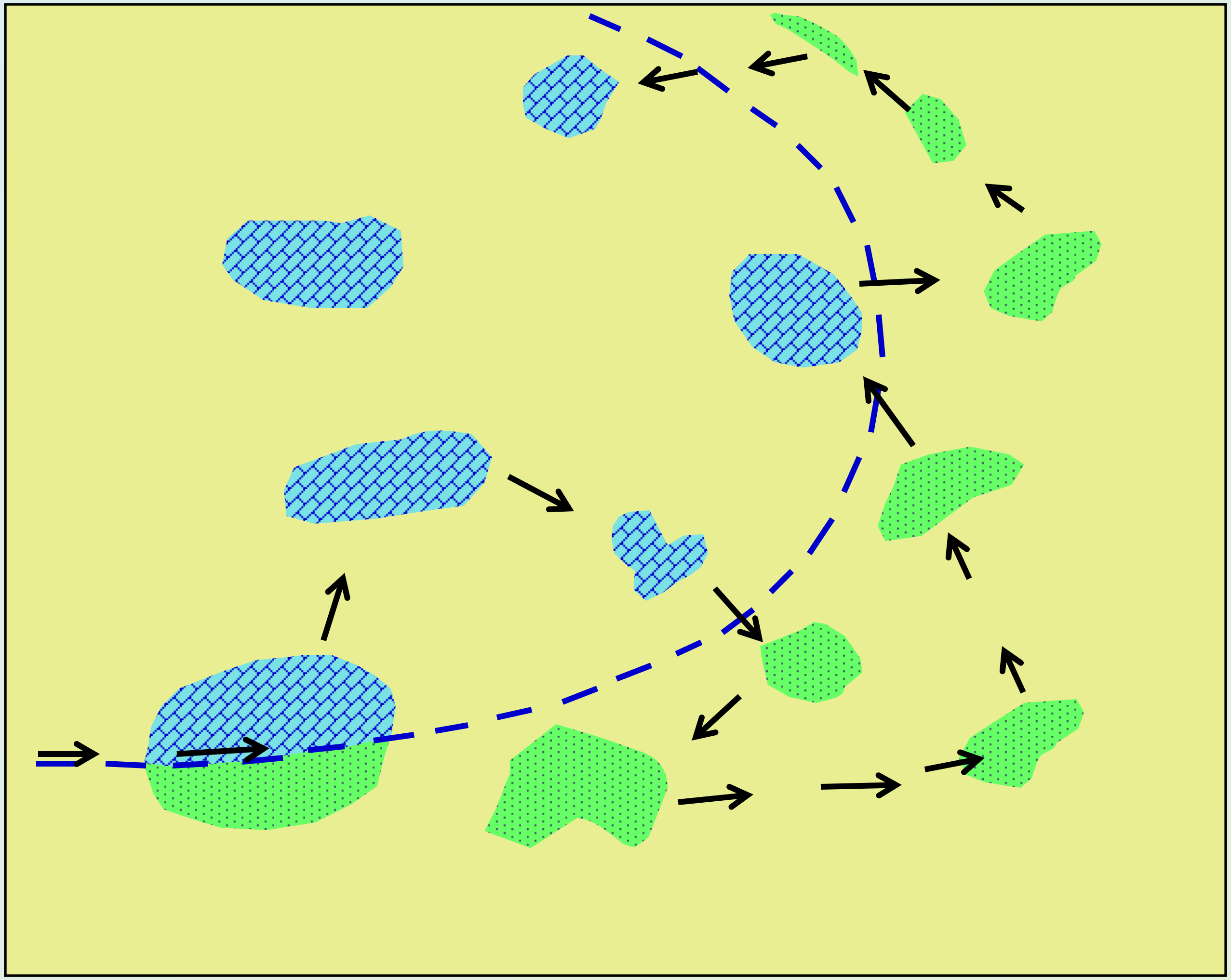
Boundary mapping

- Involves following boundaries defined by traverse section
- plotted directly on to base map (aerial photo, topo map)



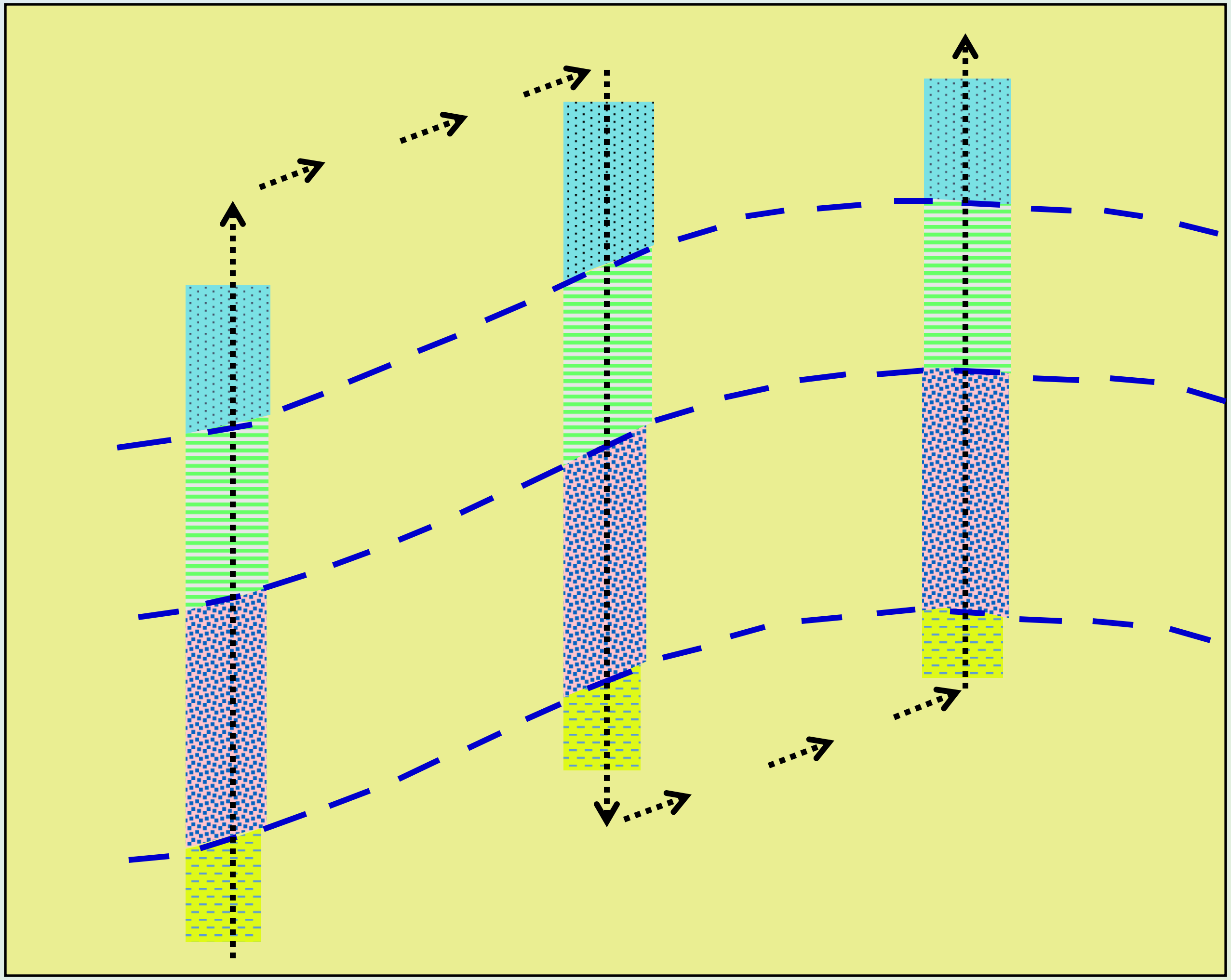
Outcrop mapping

- Commonly employed where outcrop is sparse
- method involves later boundary interpretation



Traverse mapping

Commonly used in densely vegetated areas



Map compilation

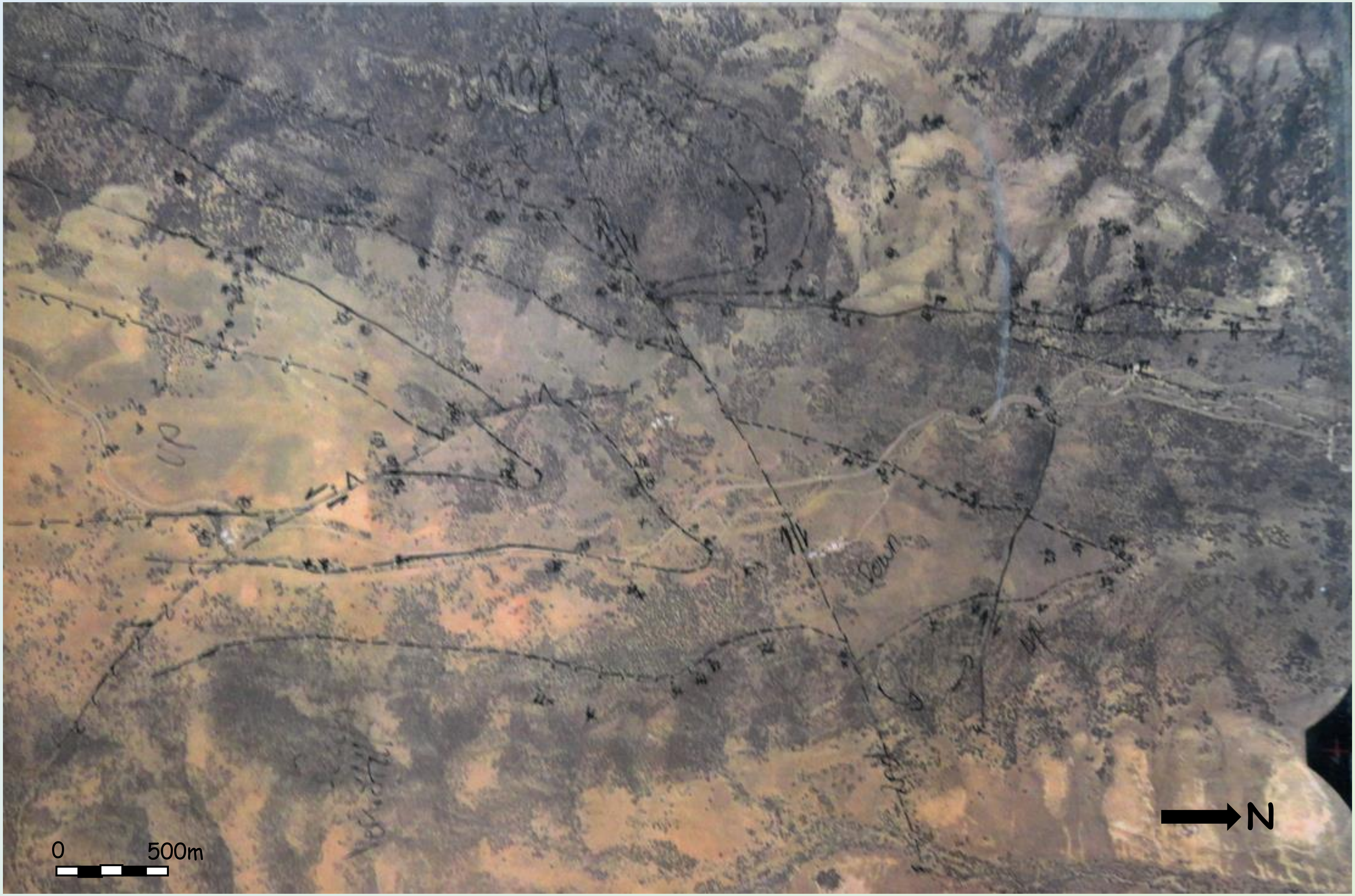
Geology maps are prepared from ground survey after office techniques are used to plan the exercise

(a) field mapping done directly on to laminated photocopy of aerial photograph or on to a topographic map

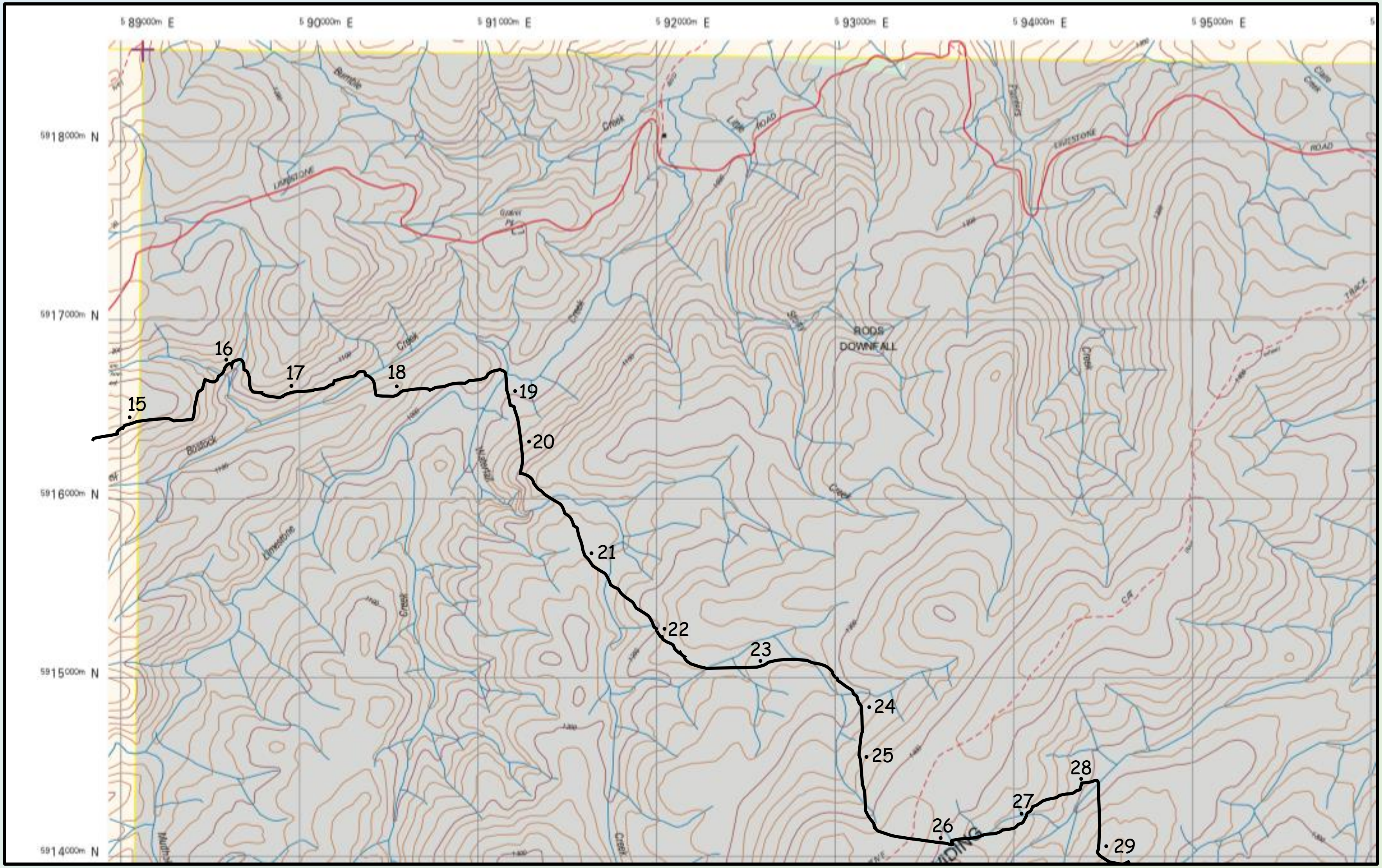
(b) recording of boundaries, station numbers etc. included on the map

(c) field map data transferred on to a field sheet as basis for final map

Geological mapping on aerial photographs



Geological mapping on a topographic map using GPS



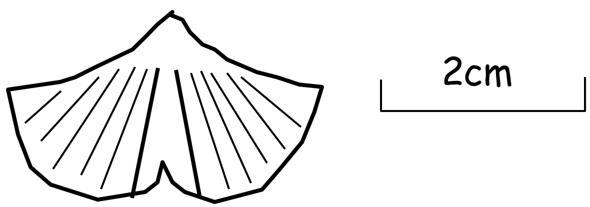
Recording information in notebook

- At key localities geologists create a station on base map
- information for that locality is recorded in notebook e.g. rock identification, fossil types, important minerals, description and measurements of structural elements
- where appropriate → sketches or photograph number with scale included
- information on samples collected including sample number and any analyses to be carried out
- this data combined with map enable geologists to compile a 3-D reconstruction of the geology of the area

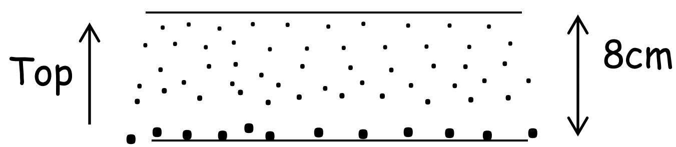
Maintenance of notebook

#73

brachiopod
Spinella yassensis (?)

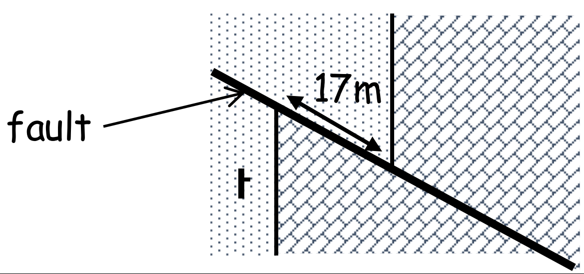


74



graded bedding in ss

#75



Saturday September 19th 1992
Weather: Cool and windy

Following the boundary between sandstone and overlying lmst. from Wet Ck towards N

#73 Lmst crops out strongly on ridge exposure. Fossilif. muddy interbed in lmst 2.3m above lower boundary ~80cm thick. Abundant Spinella yassensis (?)

#74 Sandstone locally weathered with limonite staining. Outcrop thickens ~35m. Graded bedding at top of unit. Grain-size decr. from ~0.8mm at base of bed to~0.2mm at top. 020/65E

#75 Fault trends 132°. Right lateral displacement ~17m. Brittle fracture in lmst with calcite infilling fractures.

Mapping equipment

Geologists require many items for use in field mapping:

(1) Geology hammer – to sample rocks and other geological materials

(2) Geology compass – for measuring orientation of geological structures

(3) Hand lens – for detailed examination of fine-grained textures/minerals

(4) Dilute HCl solution - used to distinguish between carbonate and non-carbonate rocks

(5) Global Positioning System (GPS) – to determine location in the field

(6) Sample bags – to collect samples for geochemical analysis or microscope examination

(7) Field notebook – for taking notes and making sketches

(8) Topo map or aerial photo – forms base map upon which data is plotted

(9) Digital camera – for photographing outcrops and geological structures

(10) Safety gear – safety glasses, first aid kit, water, sun cream etc.

Measuring orientation of structures

- Measured using geological compass → combination compass and clinometer
- Two types in common use:
  - (1) simple type (e.g. Suunto)
  - (2) Freiberger

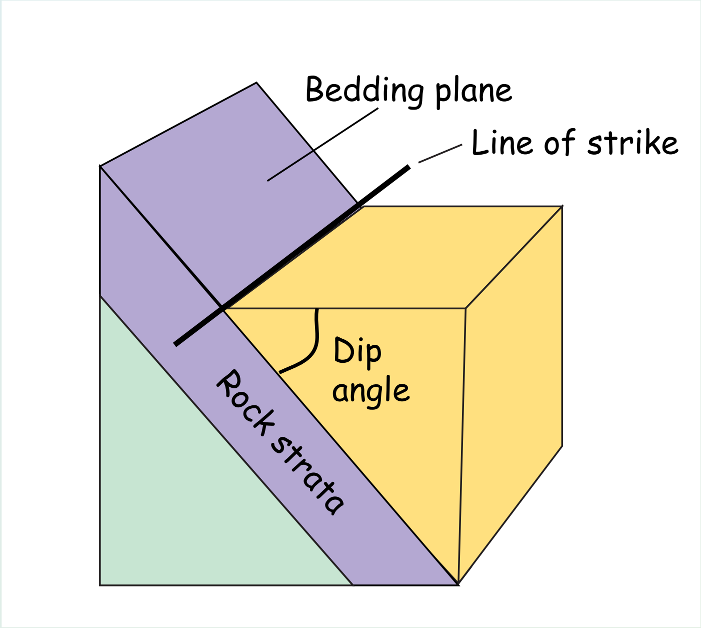
Suunto compass

Freiberger compass

Measuring strike

Measuring dip

- Dip is measured perpendicular to strike using the clinometer function
- in addition to dip angle, dip direction must also be specified (angle between horizontal line perpendicular to strike and line in plane of bed perpendicular to strike)



Other types of maps useful in geology

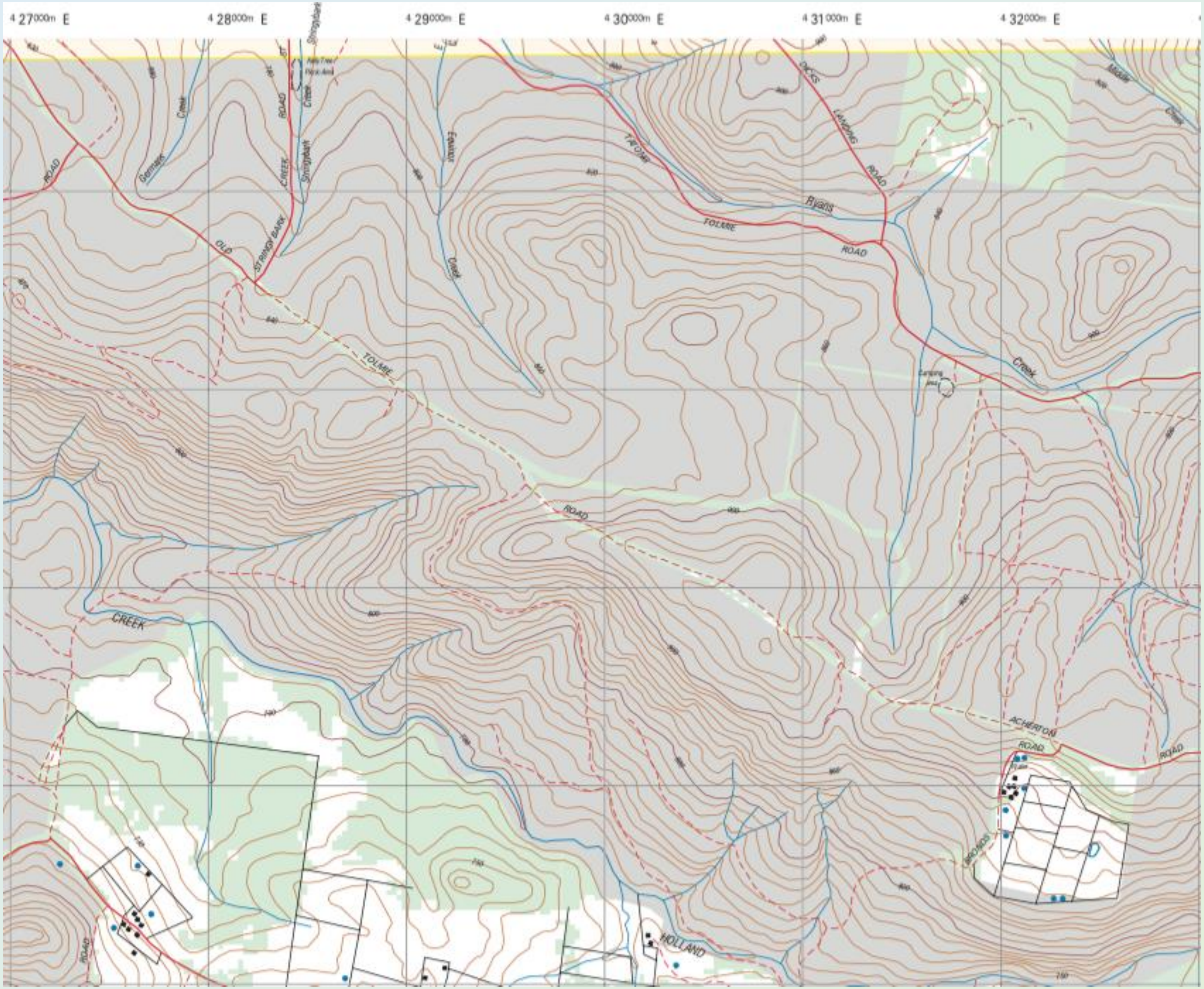
Topographic maps

Gravity anomaly maps

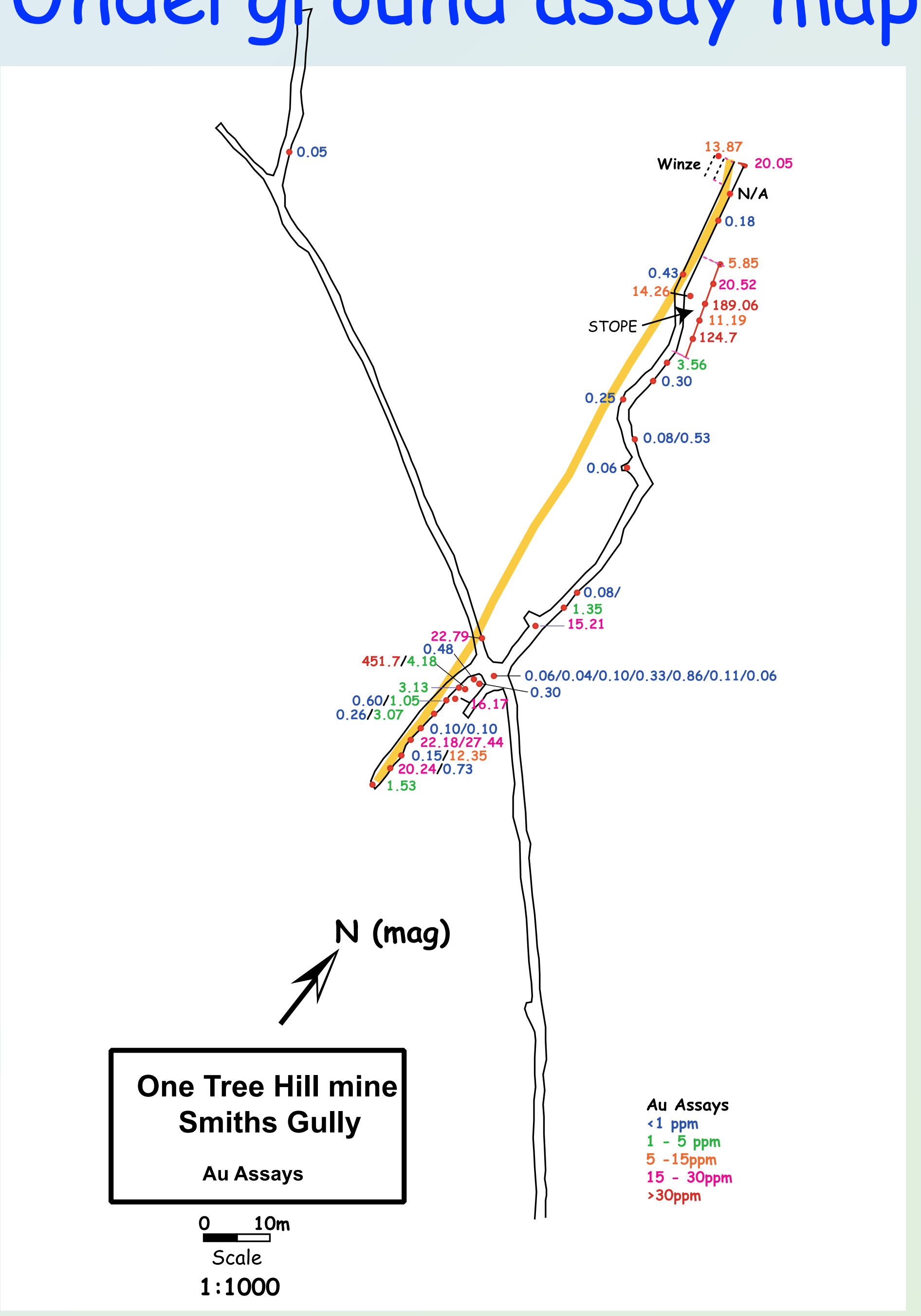
Magnetic intensity maps

Radiometrics maps

Topographic map



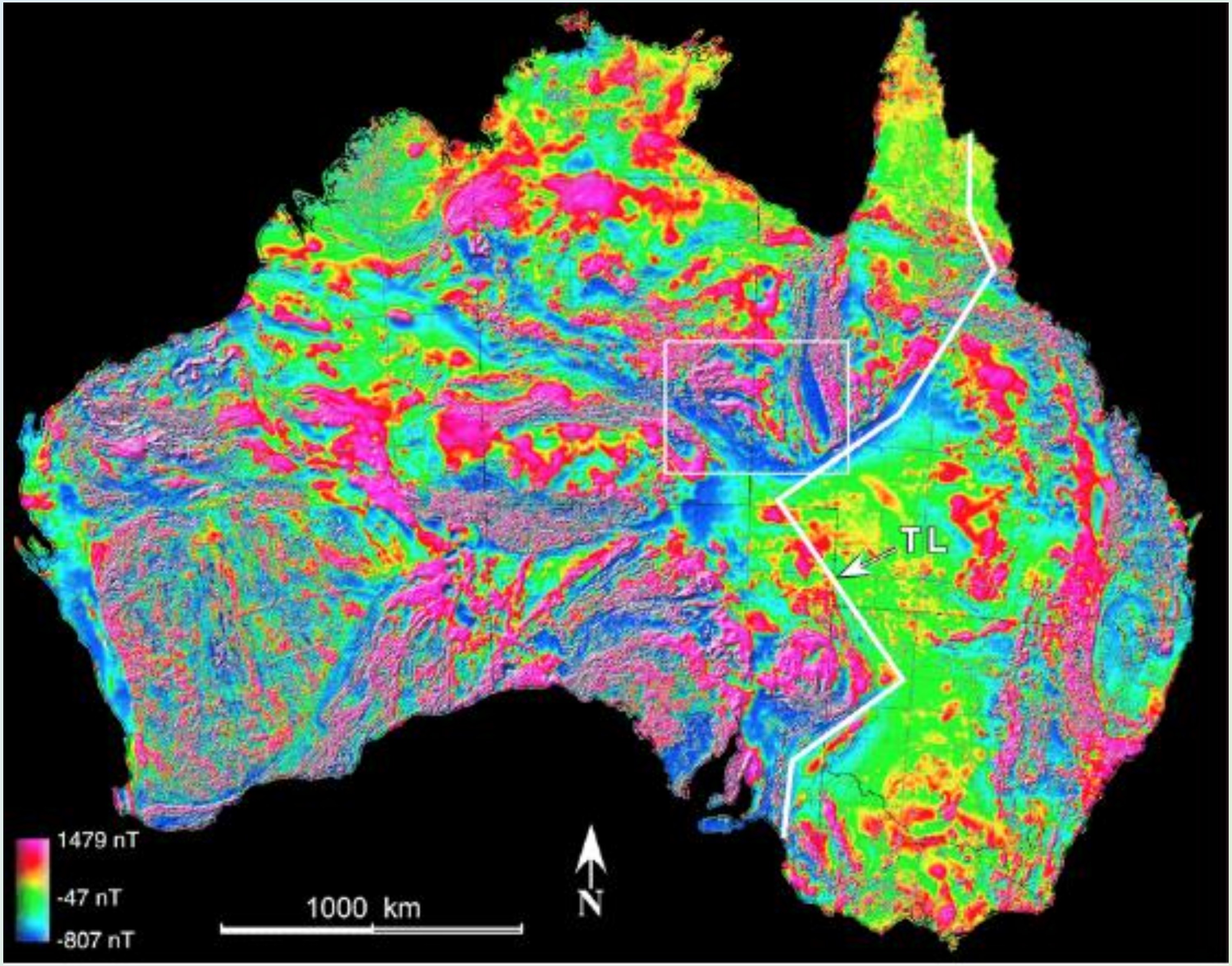
Underground assay map



Magnetic intensity maps

- The Earth's magnetic field magnetises susceptible rocks in the Earth's crust, parallel to the Earth's magnetic field → magnetic induction
- geomagnetic surveys measure the total magnetic intensity of the Earth's local magnetic field
- measurements can be made on the Earth's surface from an aircraft
- magnetic variation maps show small-scale deviations in magnitude from the magnetic intensity calculateded for the area
- small scale magnetic variation maps are used to locate ore deposits that contain ferrimagnetic minerals e.g. magnetite, pyrrhotite → Que River, Tasmania

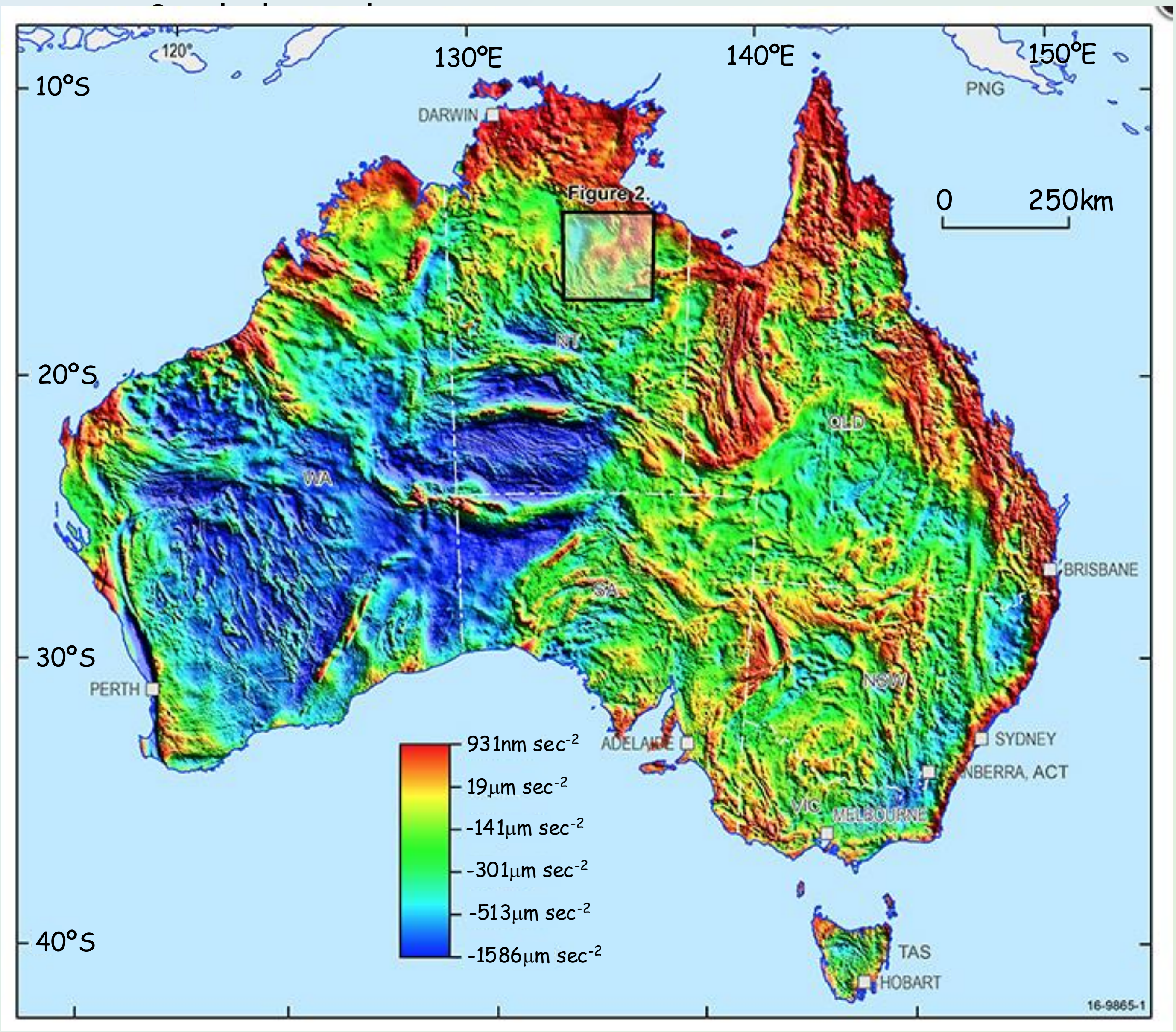
Magnetic anomaly map



Gravity anomaly maps

- Gravity maps show density variations in the Earth's crust
- gravity anomalies are differences between the observed gravity at the Earth's surface and that predicted by the Earth's gravity field
- high anomalies (red colours) → above average crustal densities or thinner crust
- low anomalies (purple/blue colours) → below average crustal densities or thicker crust

Gravity anomaly map



Radiometrics

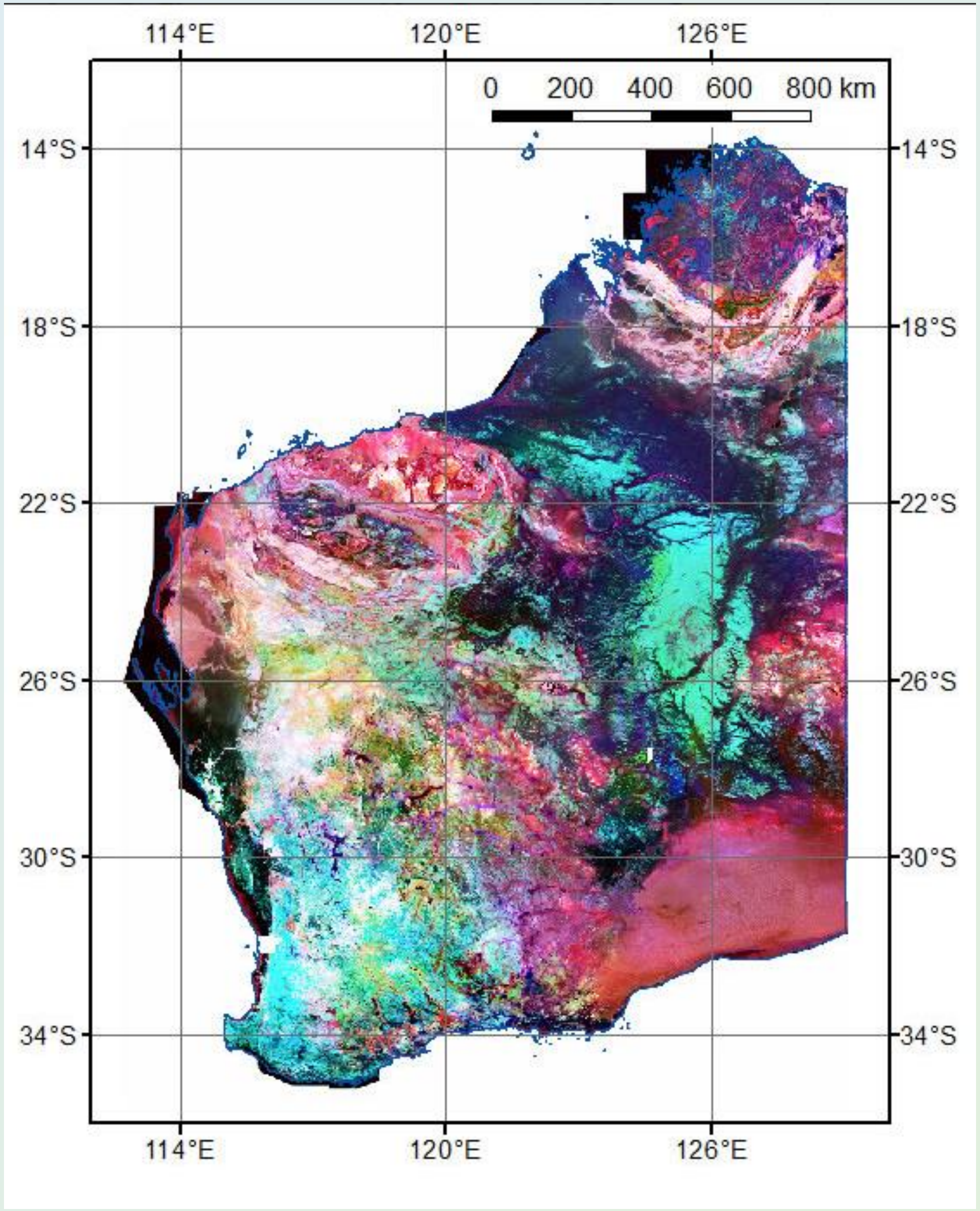
- Radiometrics involves measurement of terrestrial radiation produced by radioactive decay
- products of radioactive decay :

  alpha particles (two protons, two electrons)

  beta particles (high energy electrons)

  gamma rays
- radioactive decay can come from decay of ^{40}K or from thorium or uranium or their daughter products
- radiometric responses reflect the surface geochemistry and mineralogy of the bedrock and regolith materials

Radiometrics map Western Australia



Uranium detection using radiometrics