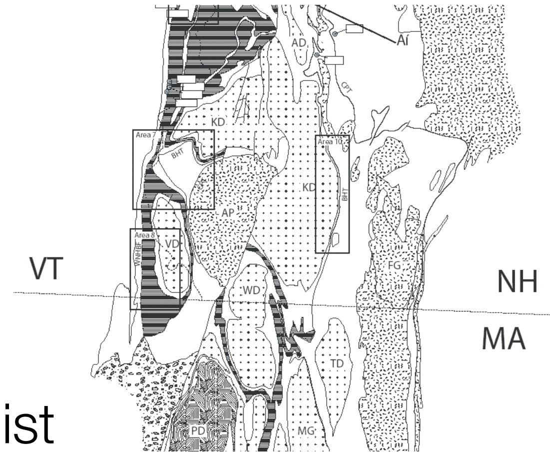

A day in the life of a metamorphic petrologist

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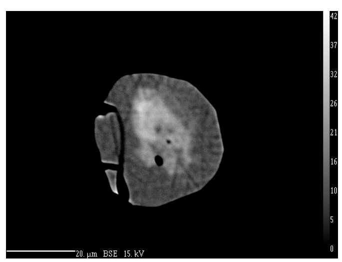
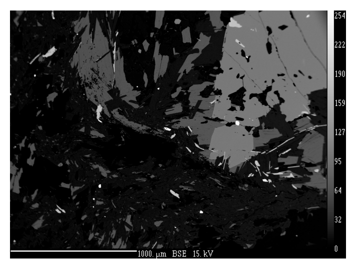
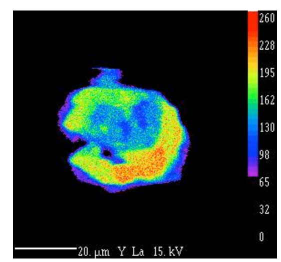
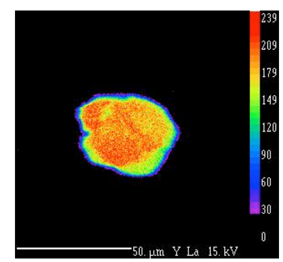
Rensselaer Polytechnic Institute









Metamorphic Petrology

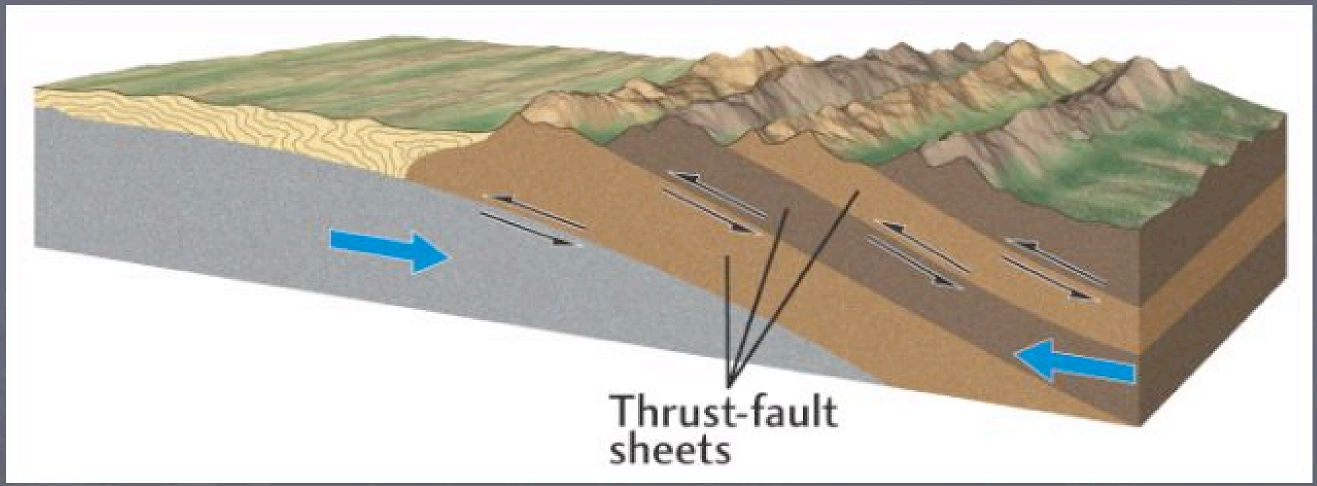
- Metamorphic petrology (MetPet) involves the study of rocks from ancient and modern mountain belts.

- MetPet focuses on transformations of Earth materials that have taken place in the solid state through changes in the pressure, temperature, state of stress, or addition and removal of material - a process called "metamorphism".

- The changes in temperature, pressure and stress come about when the plates that comprise the Earth's surface collide to form mountain chain in a process called "orogeny".

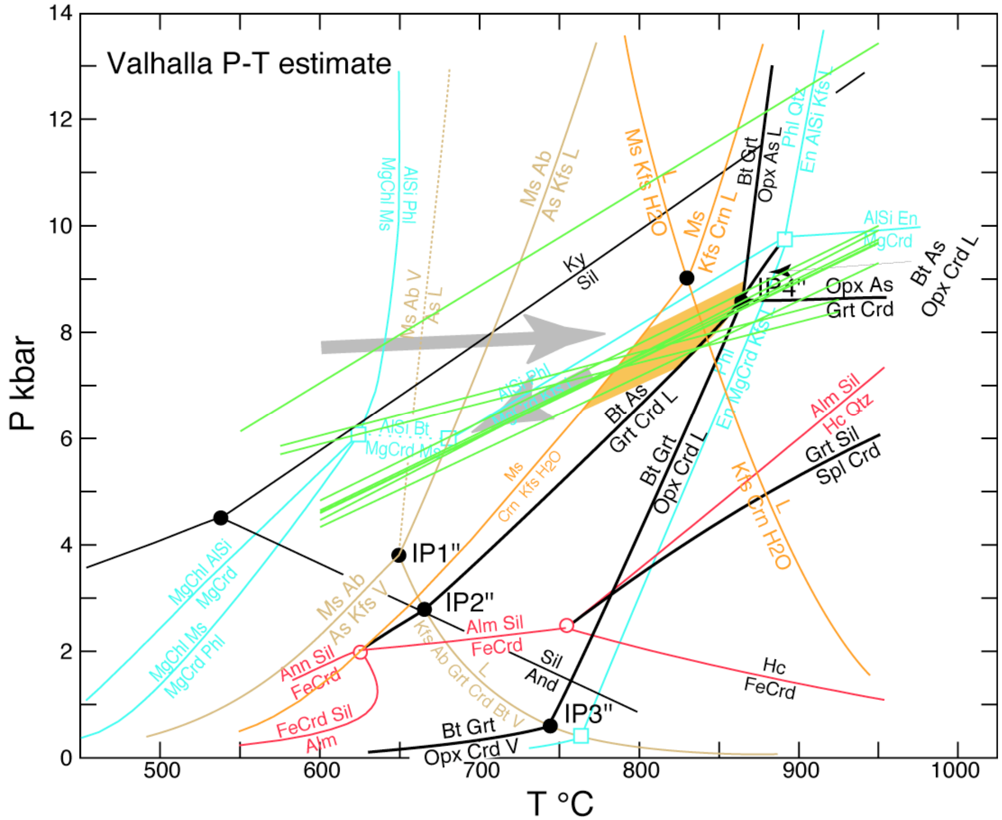
Modification of continents by orogeny

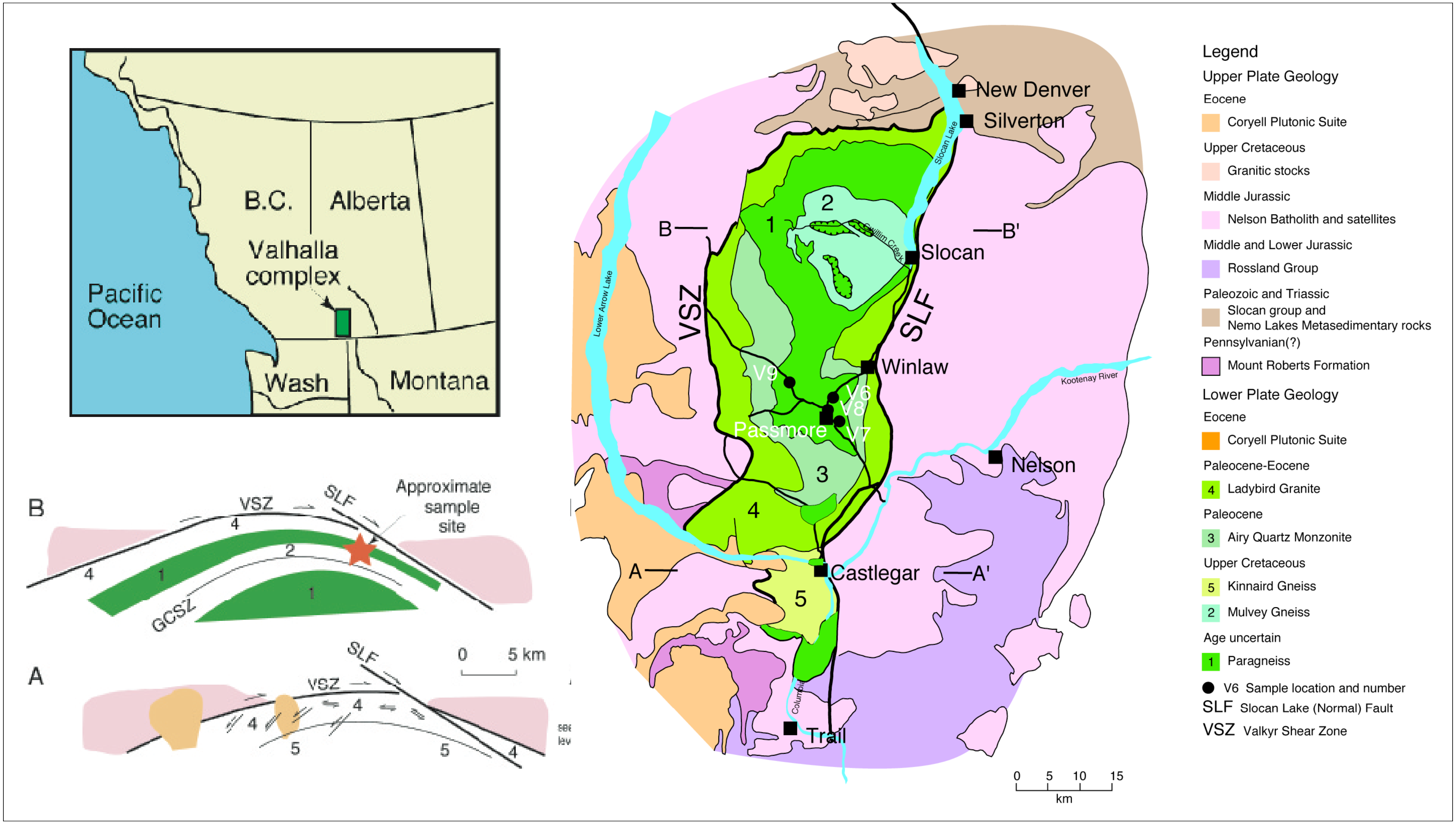
Plate collision resulting in mountain building



Rocks tell a story

- The rocks within them experience increases in pressure (sometimes enormous increases) and temperature.
  - The rock reacts by forming new minerals, the chemistry of which is strongly controlled by the pressure and temperature.
  - Some minerals, such as garnet and plagioclase, quite faithfully retain their composition from the time at which they were produced.
  - These minerals are a type of "chemical tape recorder" that can be used to decipher the pressure-temperature history, or P-T path, of the rock during its evolution.

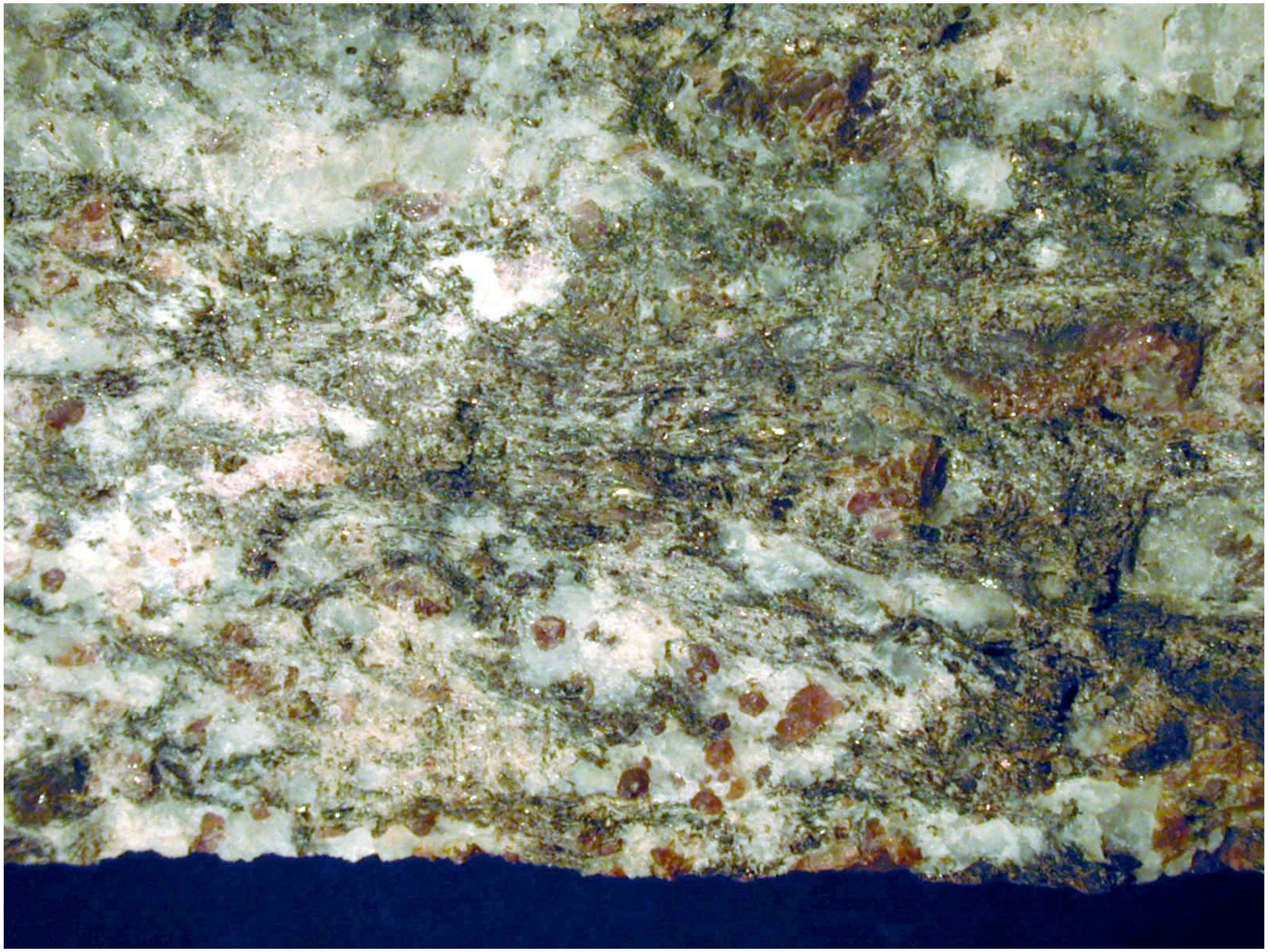


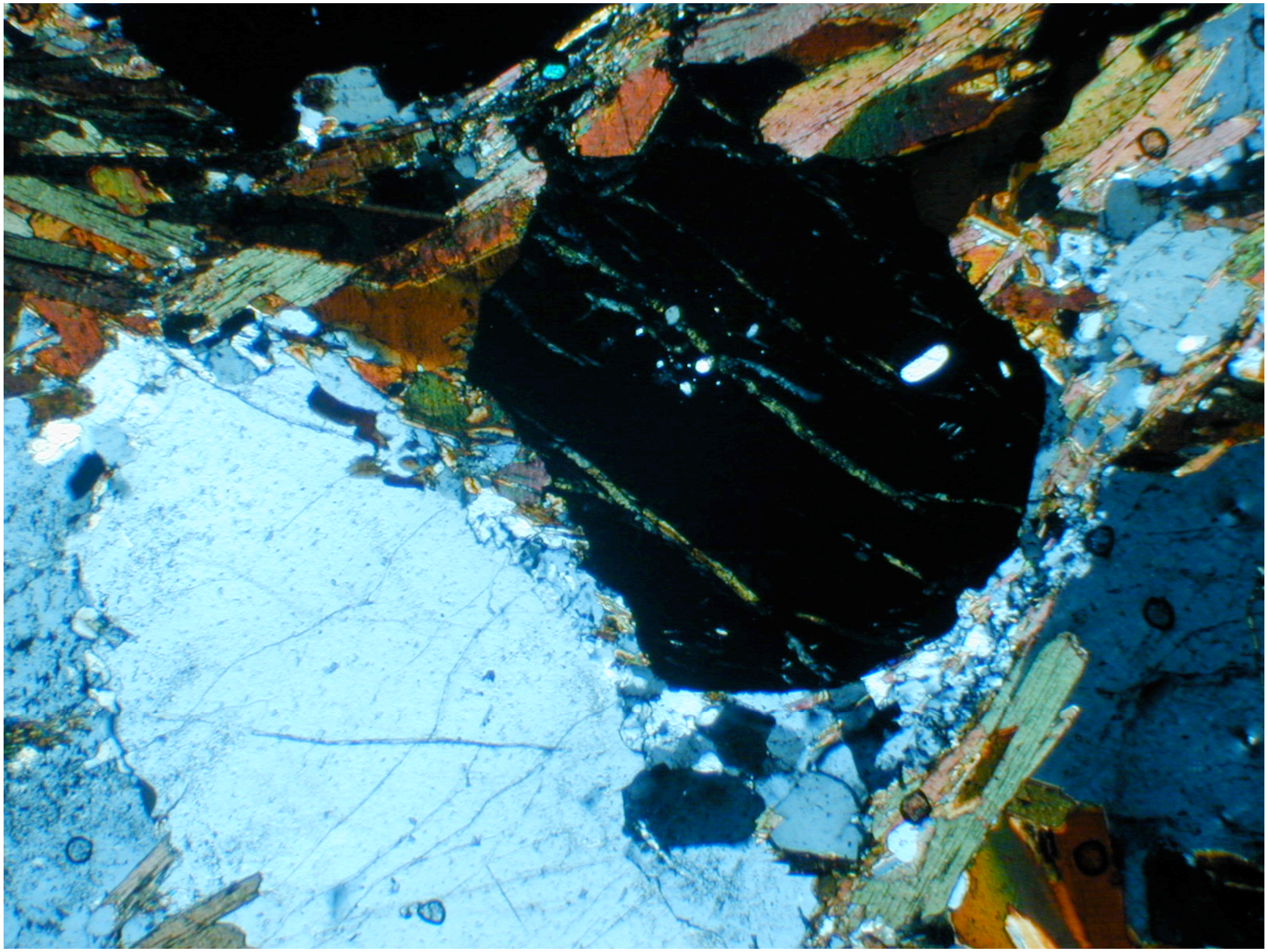


B.C.
Alberta
Valhalla complex
Pacific Ocean
Wash
Montana
B
VSZ
SLF
Approximate sample site
GCSZ
A
0
5 km
New Denver
Silverton
Slocan Lake
Slocan
Winlaw
Passmore
V9
V6
V8
V7
Nelson
Castlegar
Trail
Kootenay River
Lower Arrow Lake
B'
A'
0 5 10 15
km
Legend
Upper Plate Geology
Eocene
Coryell Plutonic Suite
Upper Cretaceous
Granitic stocks
Middle Jurassic
Nelson Batholith and satellites
Middle and Lower Jurassic
Rossland Group
Paleozoic and Triassic
Slocan group and
Nemo Lakes Metasedimentary rocks
Pennsylvanian(?)
Mount Roberts Formation
Lower Plate Geology
Eocene
Coryell Plutonic Suite
Paleocene-Eocene
4 Ladybird Granite
Paleocene
3 Airy Quartz Monzonite
Upper Cretaceous
5 Kinnaird Gneiss
2 Mulvey Gneiss
Age uncertain
1 Paragneiss
V6 Sample location and number
SLF Slocan Lake (Normal) Fault
VSZ Valkyr Shear Zone

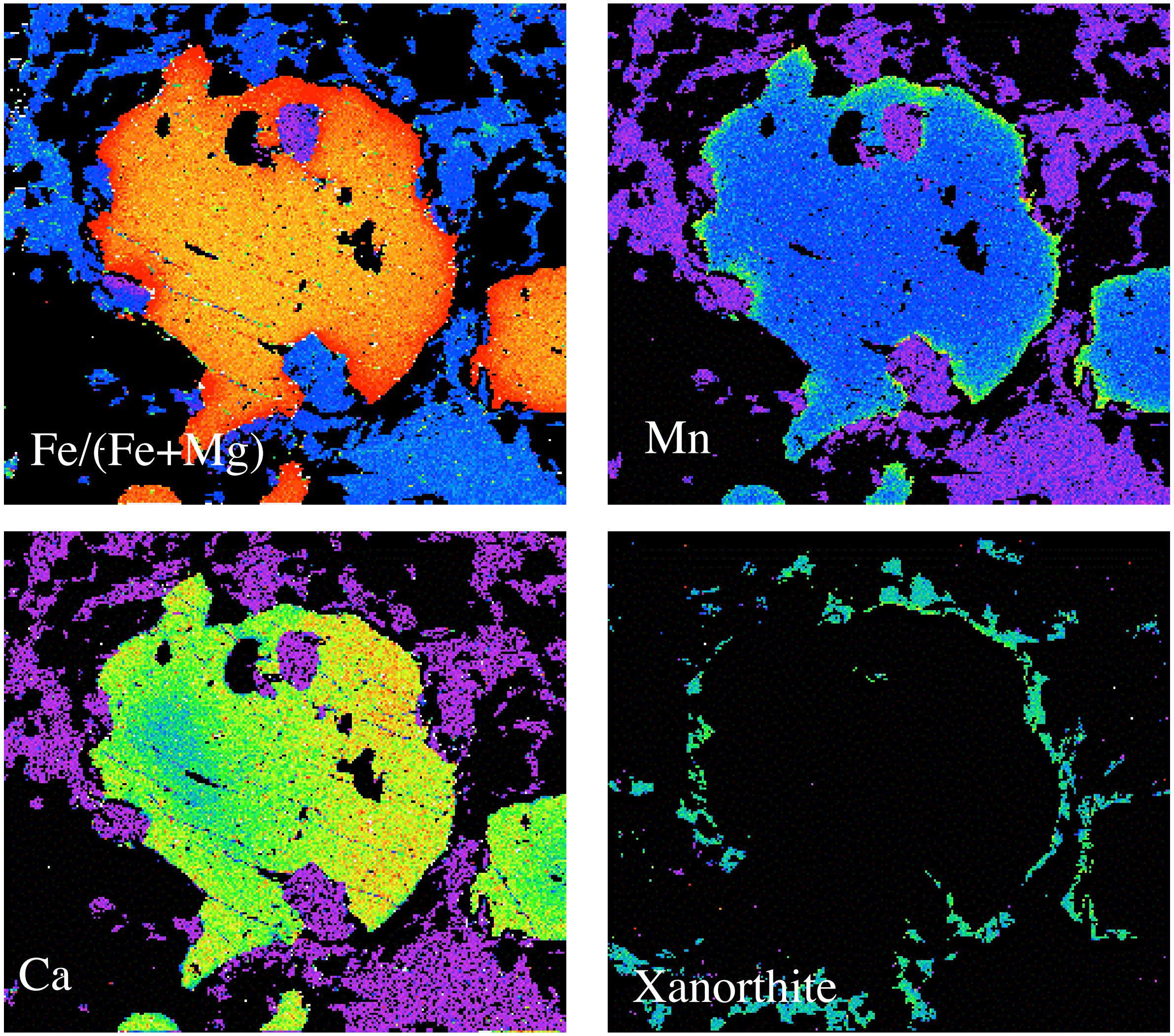

Sample location V6

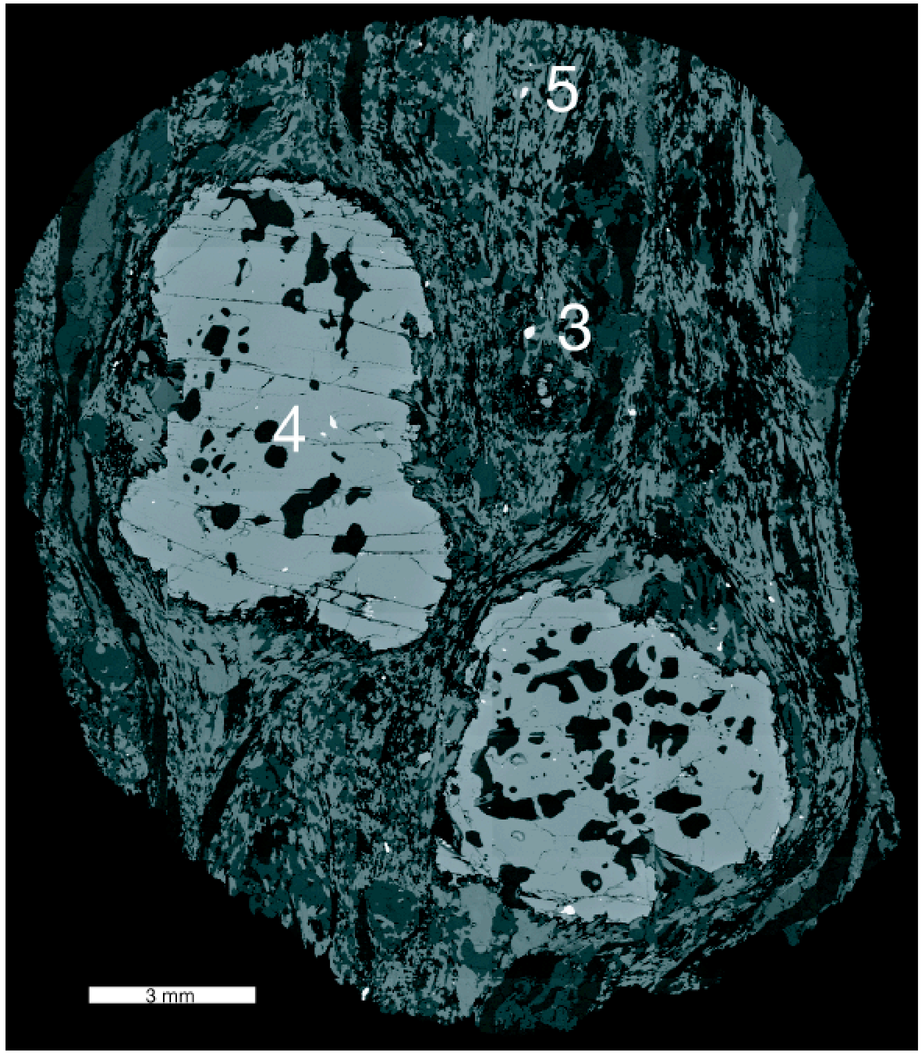

V6B

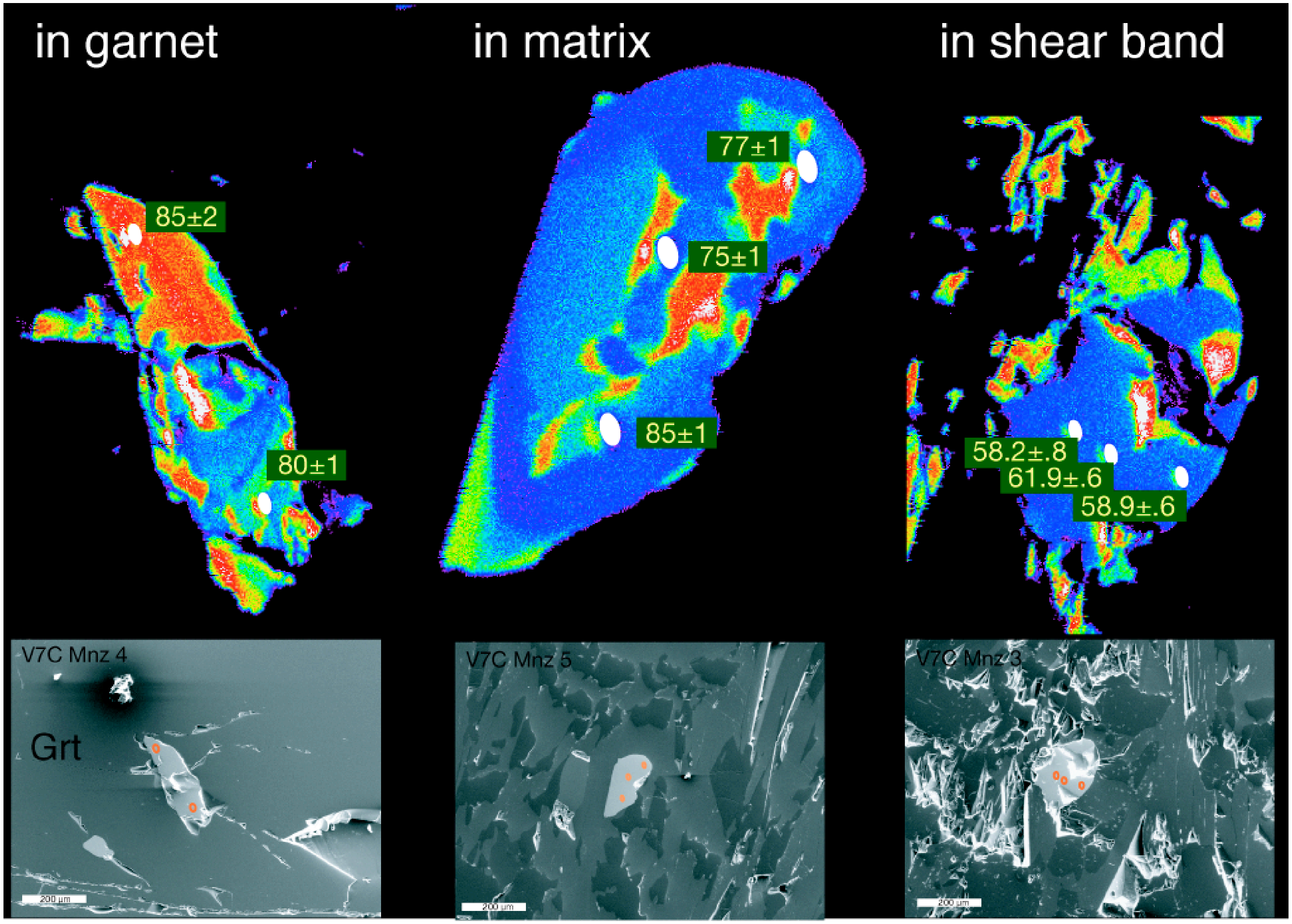




V6B: Chemical zoning maps of garnet

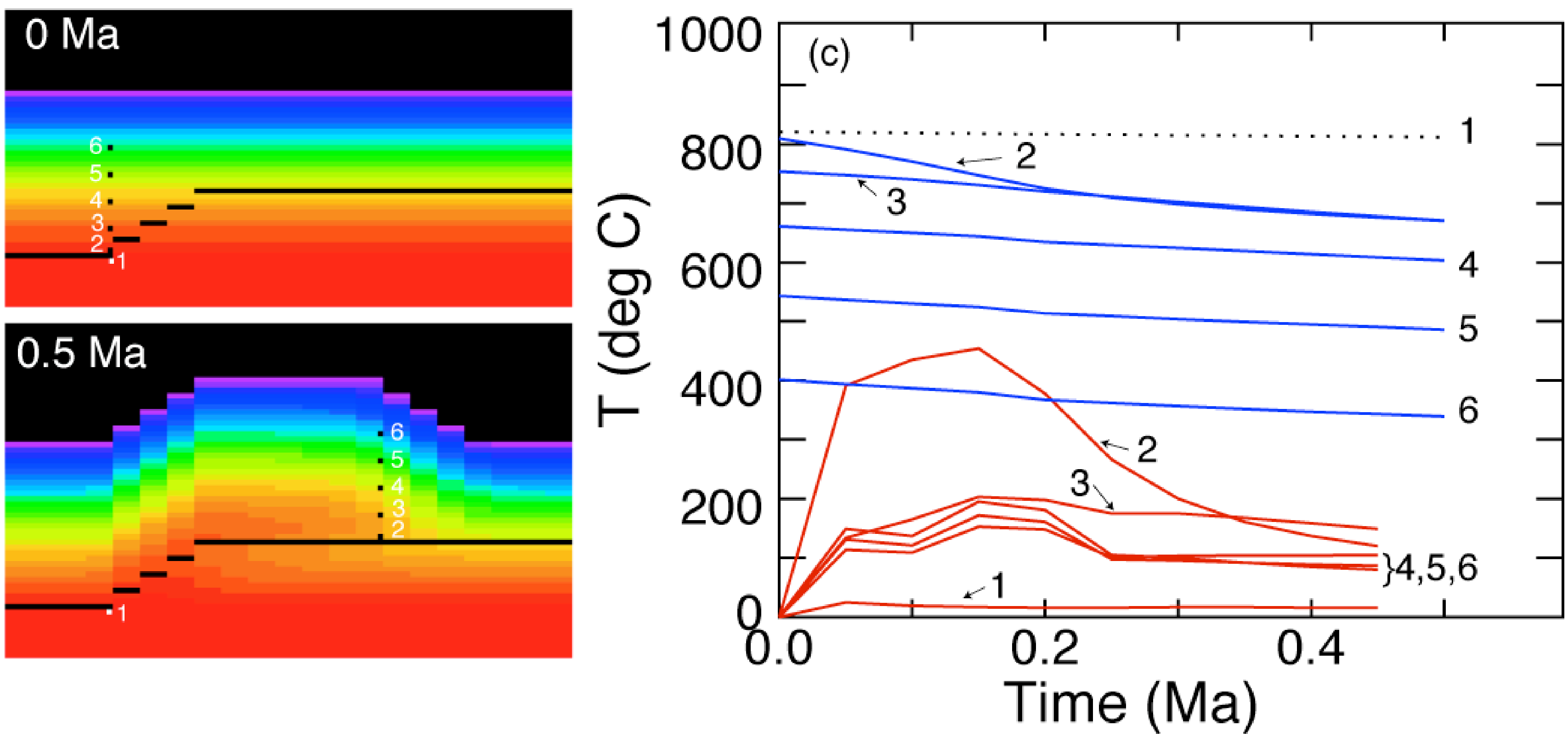



5
3
4
3 mm



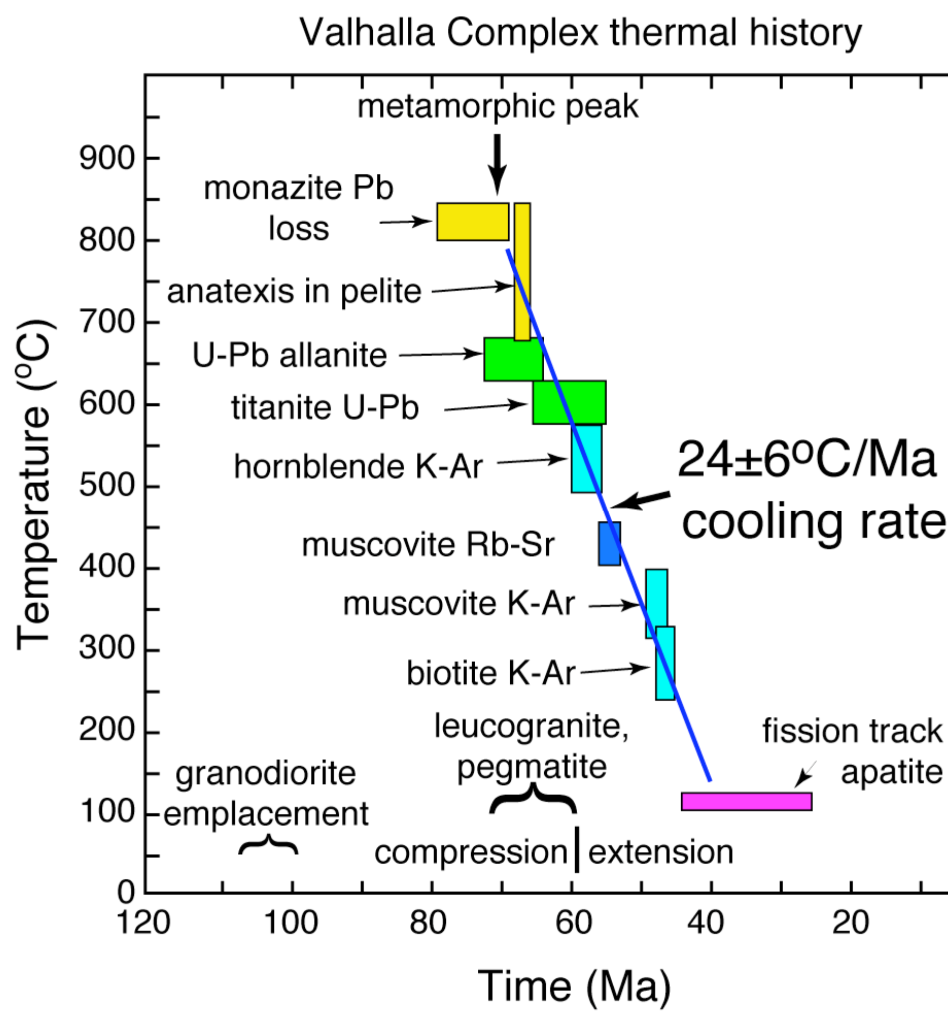
in garnet
in matrix
in shear band
85±2
80±1
77±1
75±1
85±1
58.2±.8
61.9±.6
58.9±.6
V7C Mnz 4
Grt
V7C Mnz 5
V7C Mnz 3

Thrust velocity = 10 cm/year for 0.5 Ma (=50 km shortening)



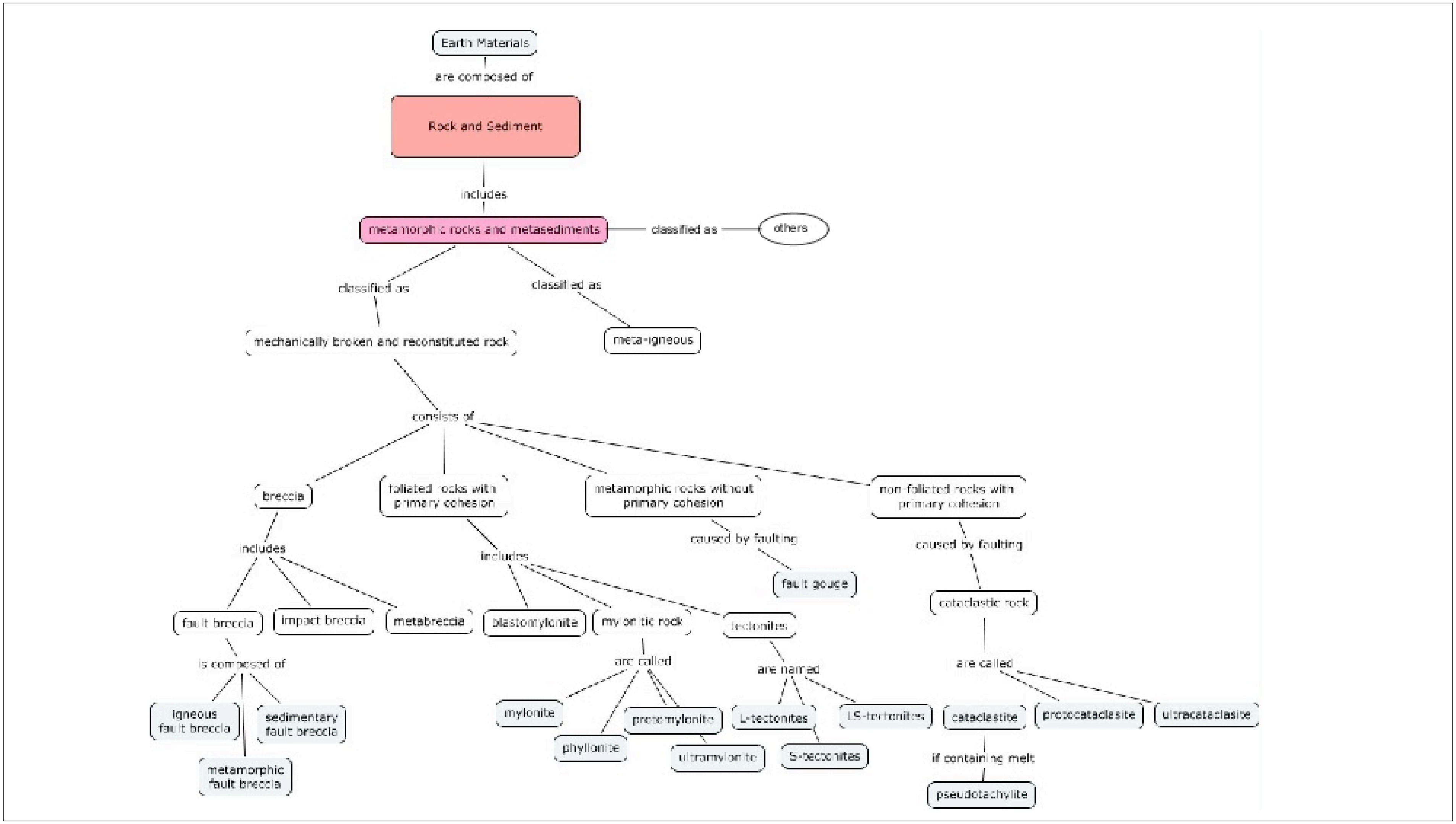
Interpretive results

- Valhalla complex cooled very rapidly initially (ca 200 C/Ma at 60 Ma)
- Rapid cooling commenced at the metamorphic peak (with melts present)
- Cooling rates require a quench mechanism (tectonic quenching)
- Rate of transport around 5 cm/year
- Tectonic stacking may have been triggered by melting (low rheology)



Data management problems

- Metamorphic petrology requires
  - Large quantities of visual data, images of different types
  - Access to many analyses over this data and interpretive results
- There is a great need to build the necessary infrastructure for Earth Sciences including
  - Ontologies and tools for importing data
  - Interoperability between data sources
  - Integration of data with existing analysis tools
  - Visualization tools
- Some work in this area is already on its way in Earth Sciences and petrology, public databases and ontologies


Earth Materials
are composed of
Rock and Sediment
includes
metamorphic rocks and metasediments
classified as
others
classified as
classified as
mechanically broken and reconstituted rock
meta-igneous
consists of
breccia
foliated rocks with primary cohesion
metamorphic rocks without primary cohesion
non-foliated rocks with primary cohesion
includes
includes
caused by faulting
caused by faulting
fault gouge
cataclastic rock
fault breccia
impact breccia
metabreccia
blastomylonite
mylonitic rock
tectonites
is composed of
are called
are named
are called
igneous fault breccia
sedimentary fault breccia
metamorphic fault breccia
mylonite
phyllonite
protomylonite
ultramylonite
L-tectonites
LS-tectonites
S-tectonites
cataclastite
protocataclasite
ultracataclasite
if containing melt
pseudotachylite

Metamorphic Petrology Database

- The metamorphic petrology database we are building integrates
  - raw data from tests with all the auxiliary data such as images of the location, maps, etc.
  - interpretive results in the form of assertions.
- Our initial data model revolves around the way the scientific tests are performed
  - From location to sample, subsample, spots and chemical analyses.
  - The location of all objects with respect to each other and the time attributes are very important
  - The way results are derived should also be recorded together with the data

Metamorphic Petrology Database

- Tools are needed to analyze and visualize data in its context
  - Geo context to sample context
  - Sample context to analysis context
  - Set of tests to interpretive results context
- Provide an environment that allows researchers to
  - gain access to data across the world, and
  - exchange and annotate data between collaborators

Metamorphic Petrology Database

- What type of help can the system provide to the user?
  - Keep track of all data access paths
  - Summarize and present these to the user
- Use of data access paths
  - Show me what I or my collaborator have done last
  - Show me the usual path through the data for me or my collaborator
  - Teach me how to navigate the data
  - Based on my current path and my past behavor, preselect the most promising objects that I should look at

Metamorphic Petrology Database

- Use of data access paths methodology
  - Mine the frequent access patterns at file/concept levels
    - Mining allows us to remove infrequent states
    - Concept level allows us to collapse similar events
  - Use the frequent patterns to generate a Hidden Markov Model (HMM)
  - Use Viterbi on the a given sequence of clicks to find the most likely current state
  - Find the distribution of the next likely stages

Conclusions

- A framework for integrating data at various scales in the area of Metamorphic Petrology
  - Need to incorporate context at many levels
  - Need to incorporate implicit semantics
- In the process of developing an end-to-end application for incorporating this information and enabling collaboration between researchers


Questions?
EASTMAN