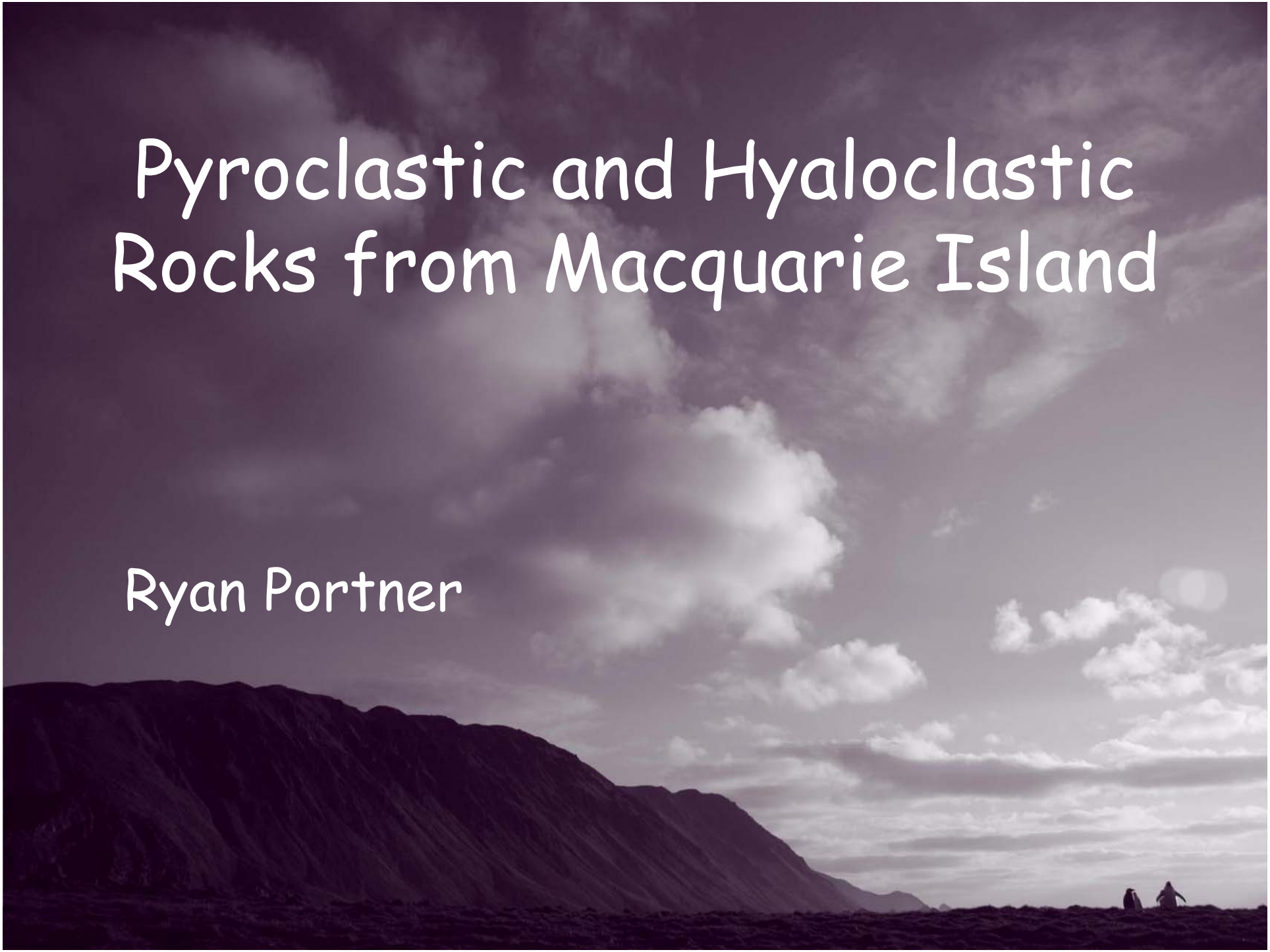
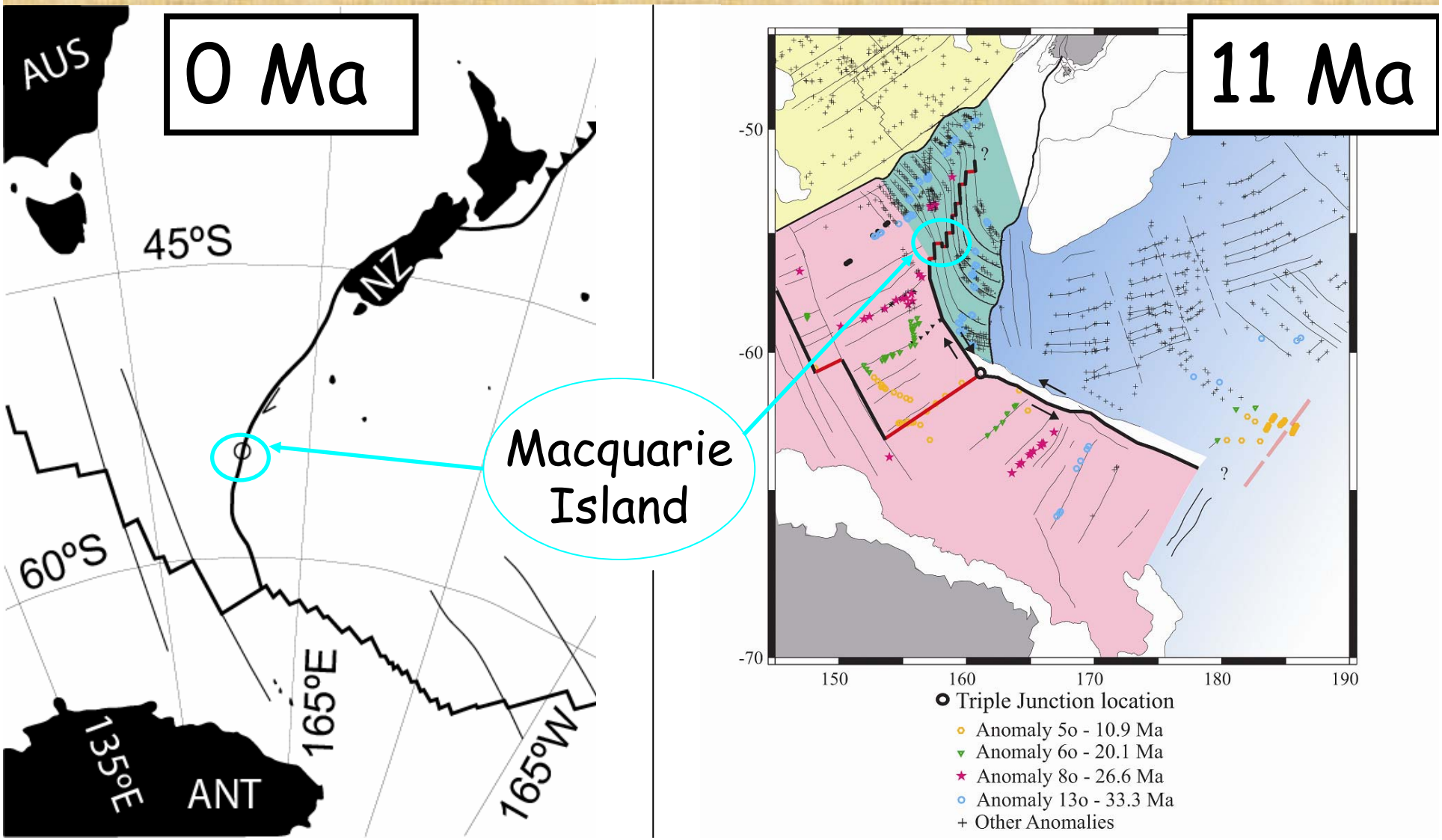


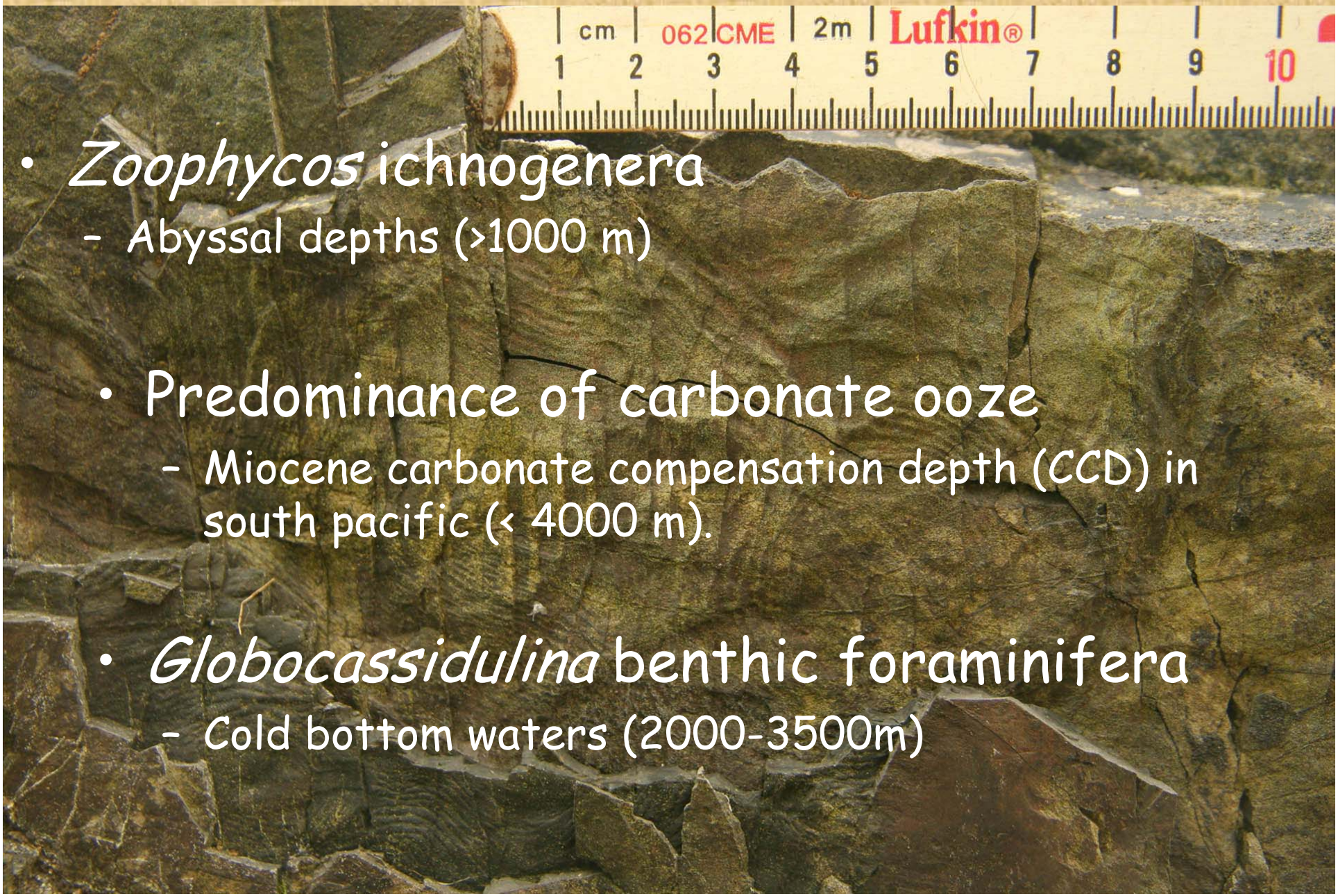
Pyroclastic and Hyaloclastic Rocks from Macquarie Island

Ryan Portner

The Macquarie Island ophiolite formed in a Miocene spreading center at ~56°S



Water depth 2000-3500 m



- *Zoophycos* ichnogenera
  - Abyssal depths (>1000 m)

- Predominance of carbonate ooze
  - Miocene carbonate compensation depth (CCD) in south pacific (< 4000 m).

- *Globocassidulina* benthic foraminifera
  - Cold bottom waters (2000-3500m)

Purpose

Is there any evidence for explosively derived pyroclastic material on Macquarie Island?

Importance

Subaqueous explosive volcanic eruptions are generally restricted to shallow depths (<500 m in subalkaline magmas to <1800 m in highly alkaline magmas)

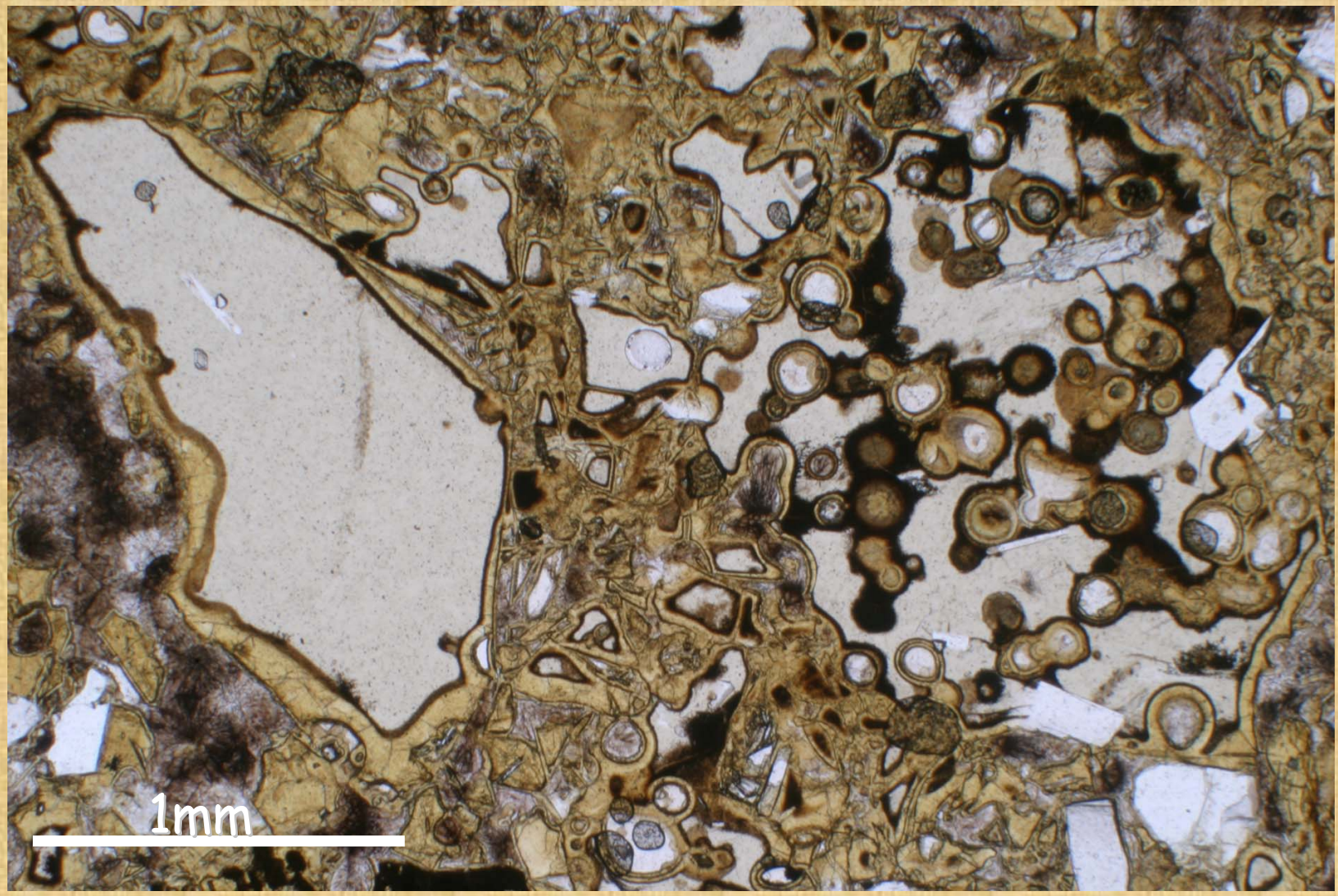
Significance

Recent submersible studies in modern day ocean basins document anomalous deep-marine (~4000 m) pyroclastic deposits (e.g. Davis and Clague, 2006), but evidence in the geologic record is sparse.

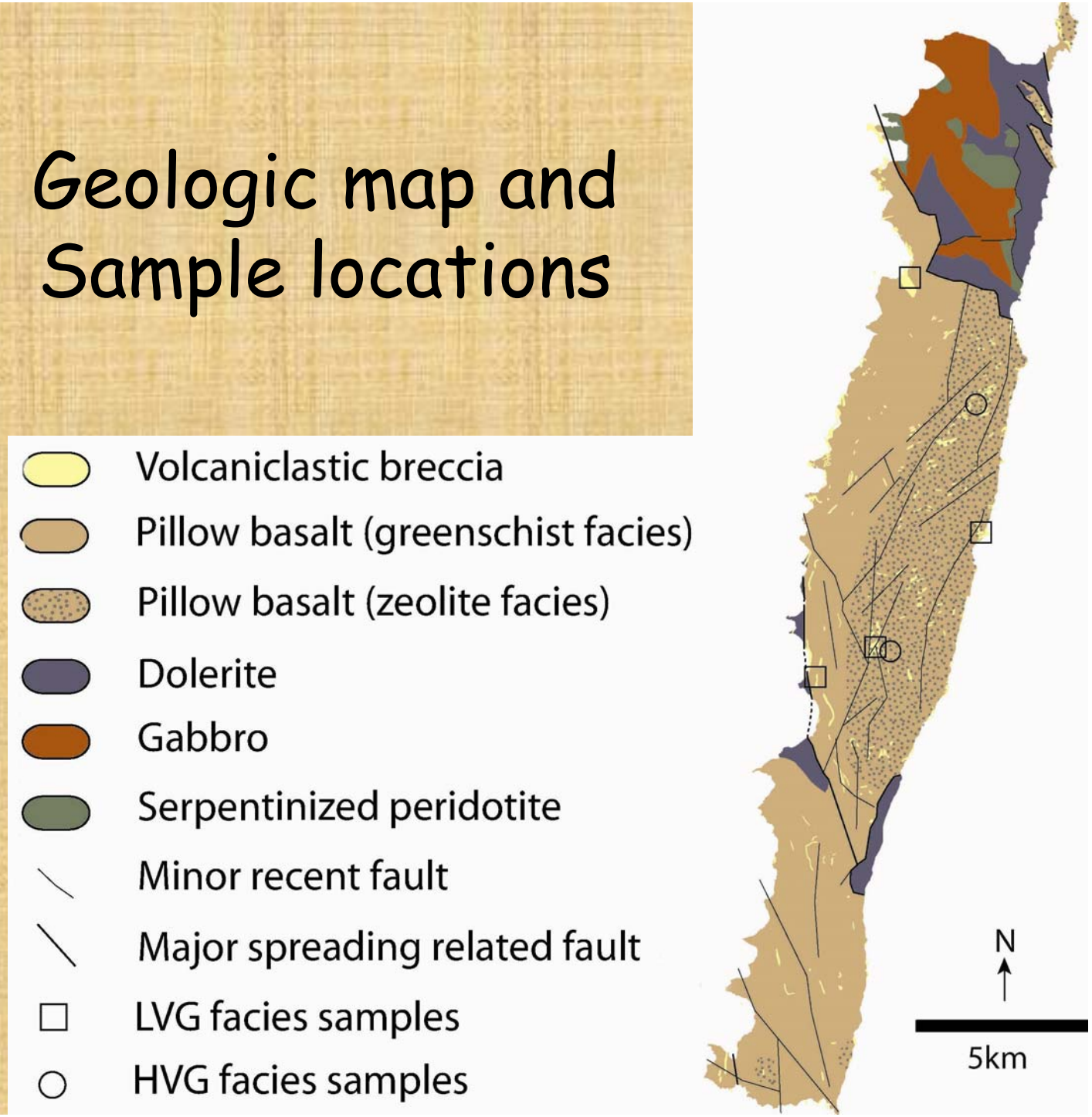
Methodology and insights

- Glassy volcaniclastic lithofacies analysis
  - Depositional Processes
  - Eruptive mechanisms
- Electron microprobe analysis of glass
  - Magmatic controls on eruption style
- Spreading Ridge Evolution

Low (LVG) "vs" High (HVG) vesicular glass (~30%)



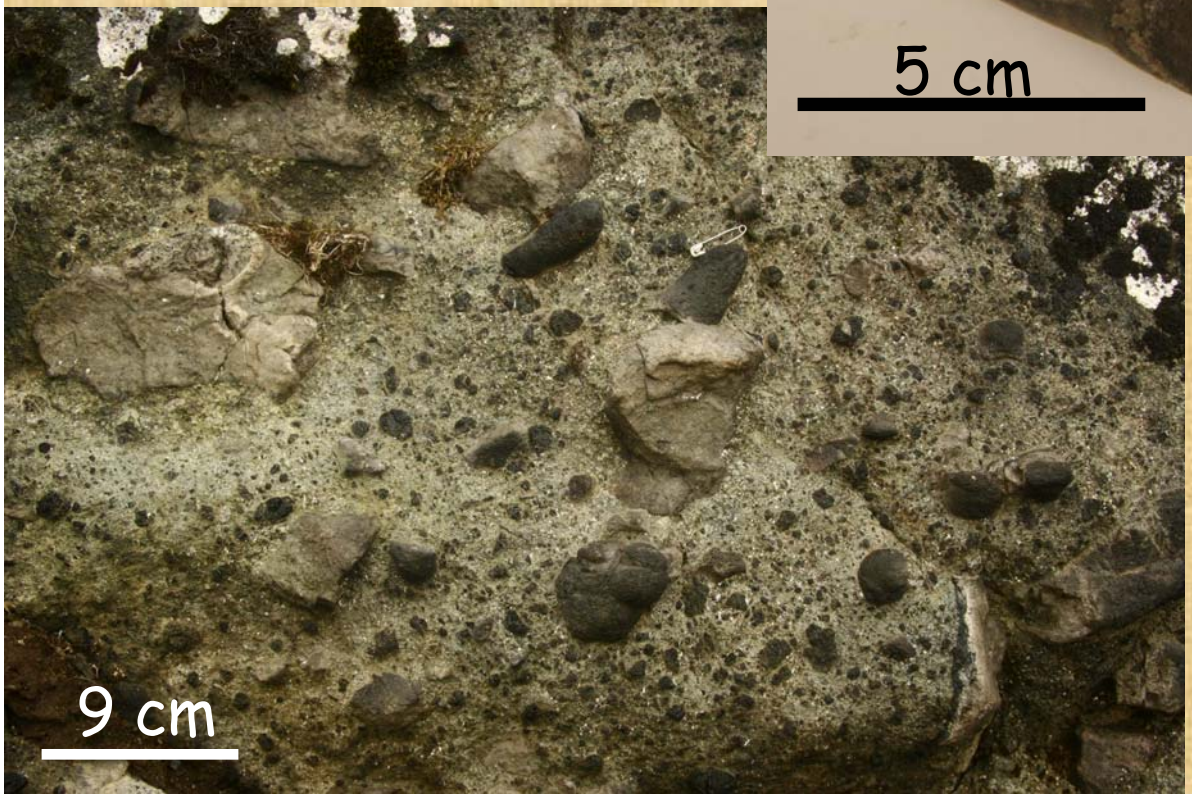
Geologic map and Sample locations



LVG-pillow fragment breccia facies

- boulder sized pillow fragments
- isolated "mini" pillows
- monomict
- massively bedded

LVG-
glass globule
breccia facies

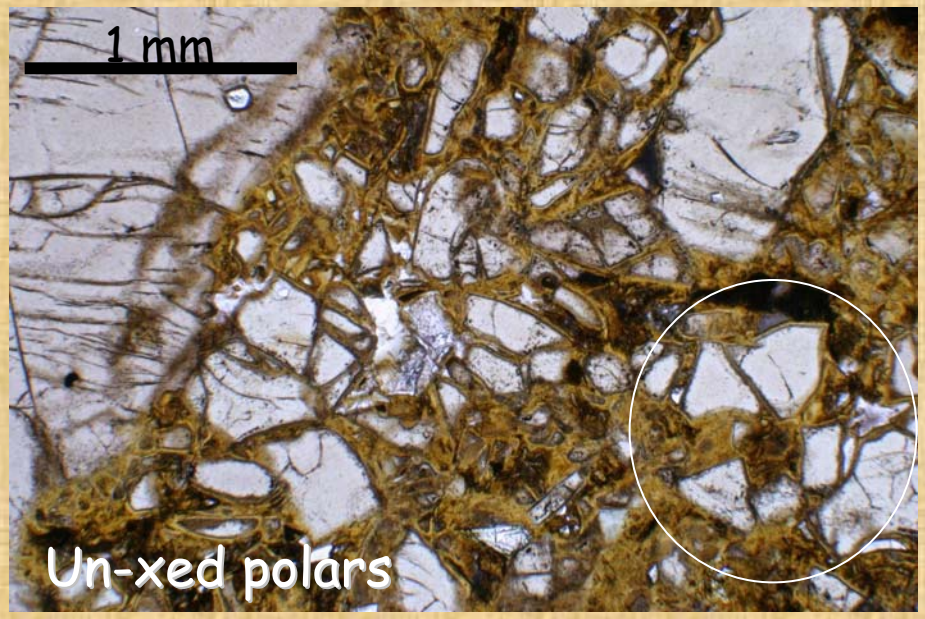


- lapilli sized spherical glassy basalt clasts
- striated surfaces
- monomict
- massively bedded

LVG-sandstone facies

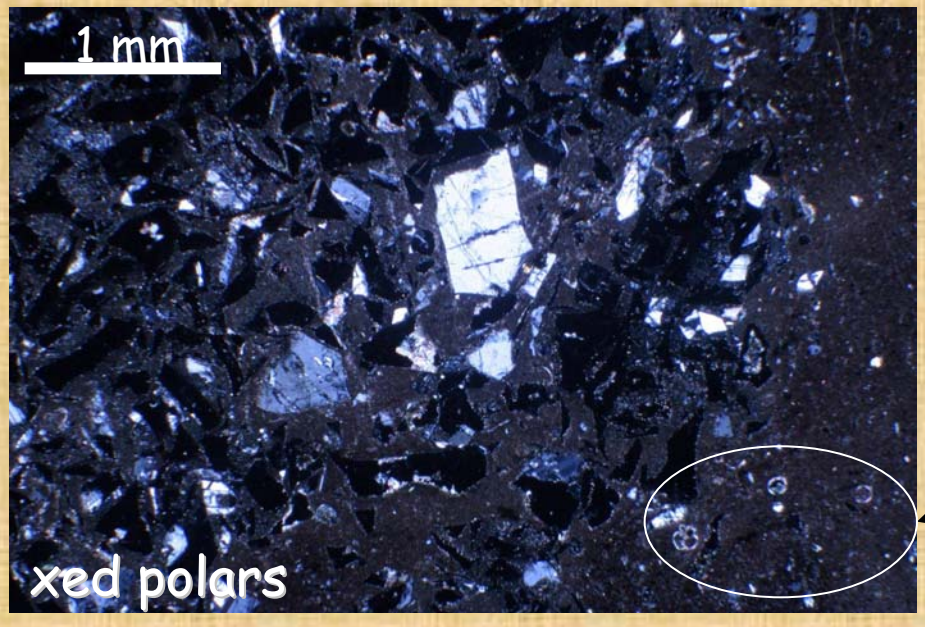
- coarse-fine sand
- normal grading
- thin well-defined laminations
- associated with red pelagic mudstone

LVG petrography



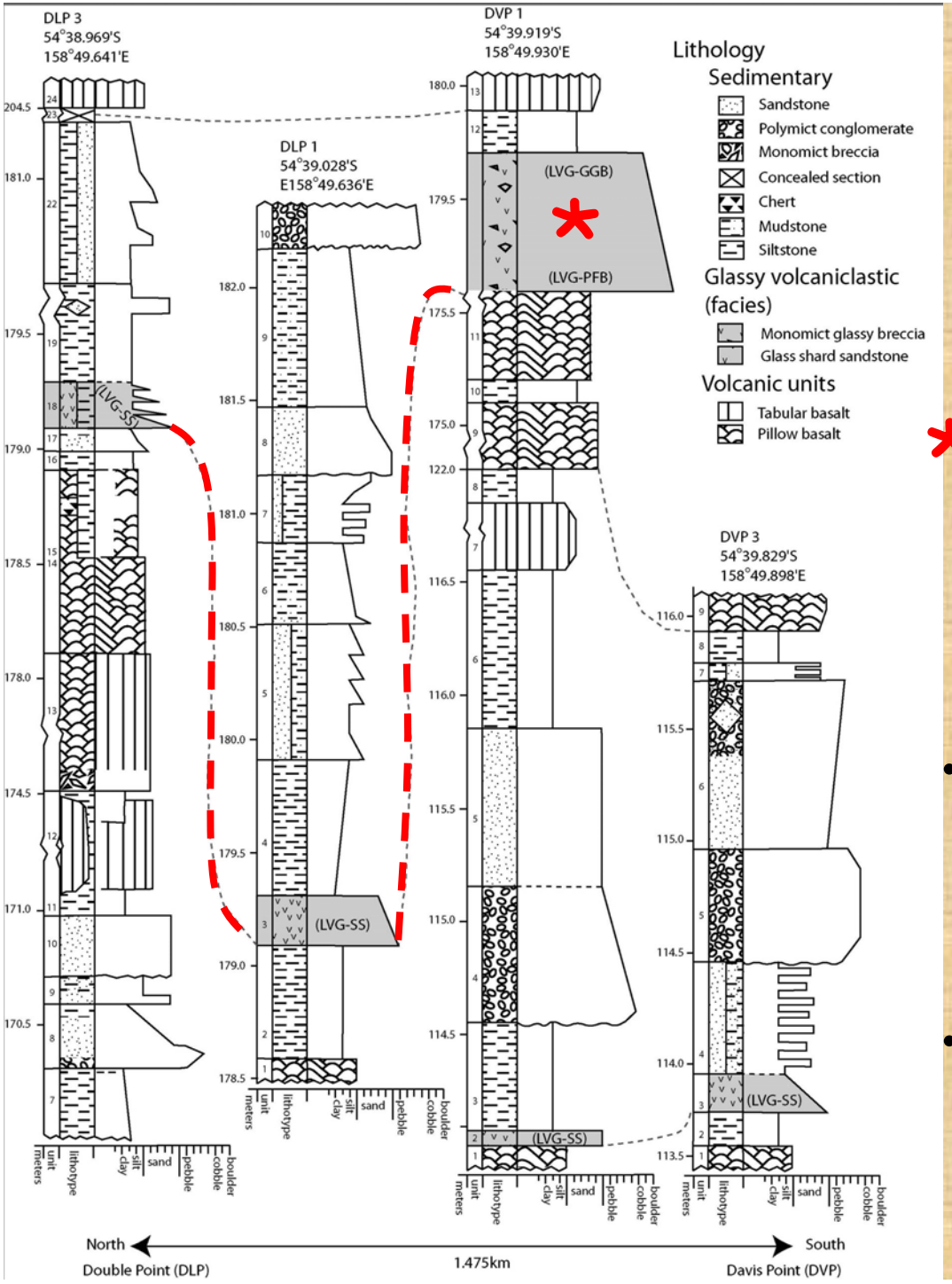
LVG-breccia matrix

- > 1mm grains
- palagonite/zeolite cement
- blocky-curviplanar shapes
- jig-saw fit texture



LVG-sandstone

- < 1mm grains
- carbonate/clay cement
- wedge to planar shapes
- microfossil bearing



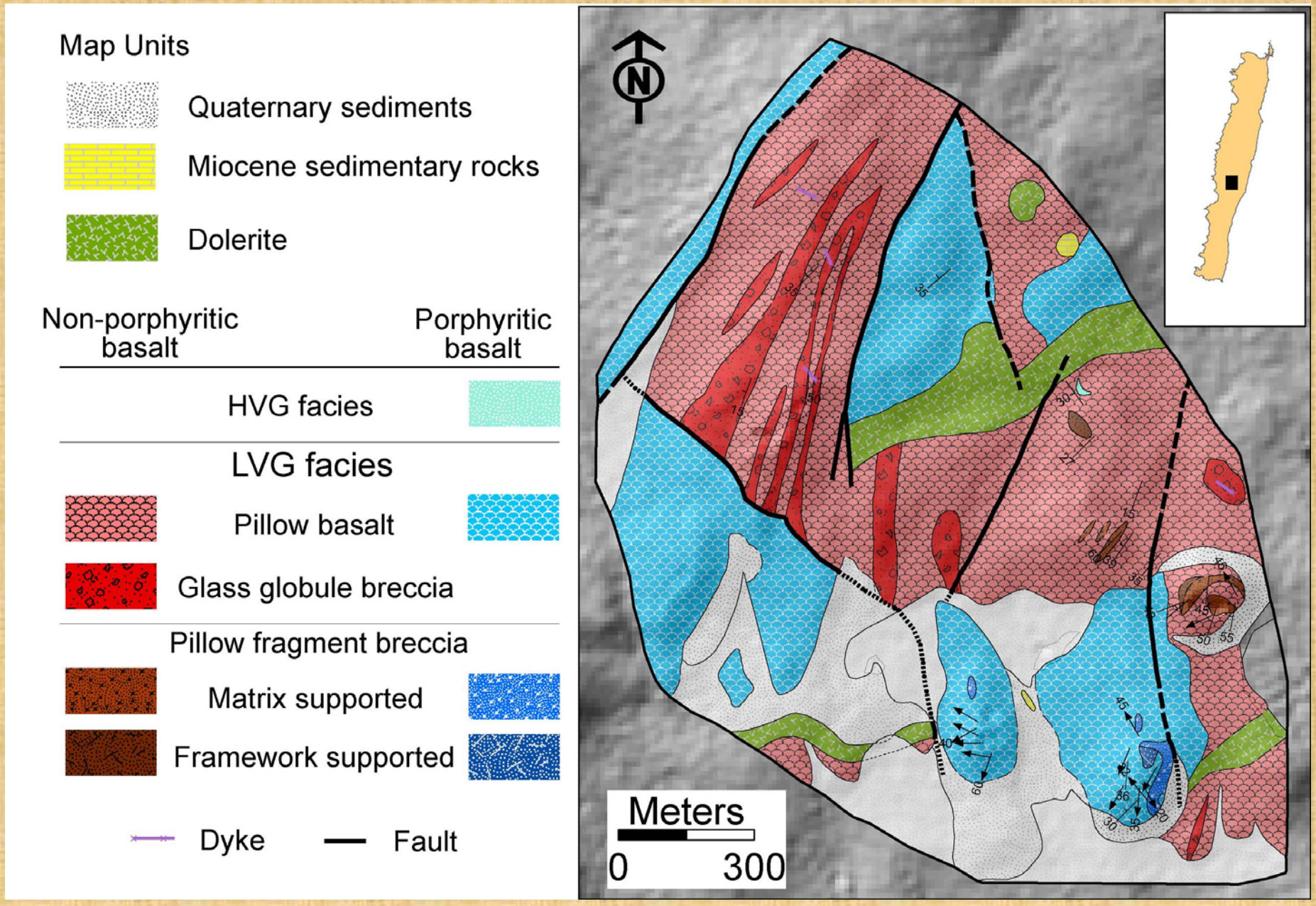
Stratigraphic facies associations

* Pillow fragment breccia (PFB) facies grades up ward into glass globule breccia (GGB) facies

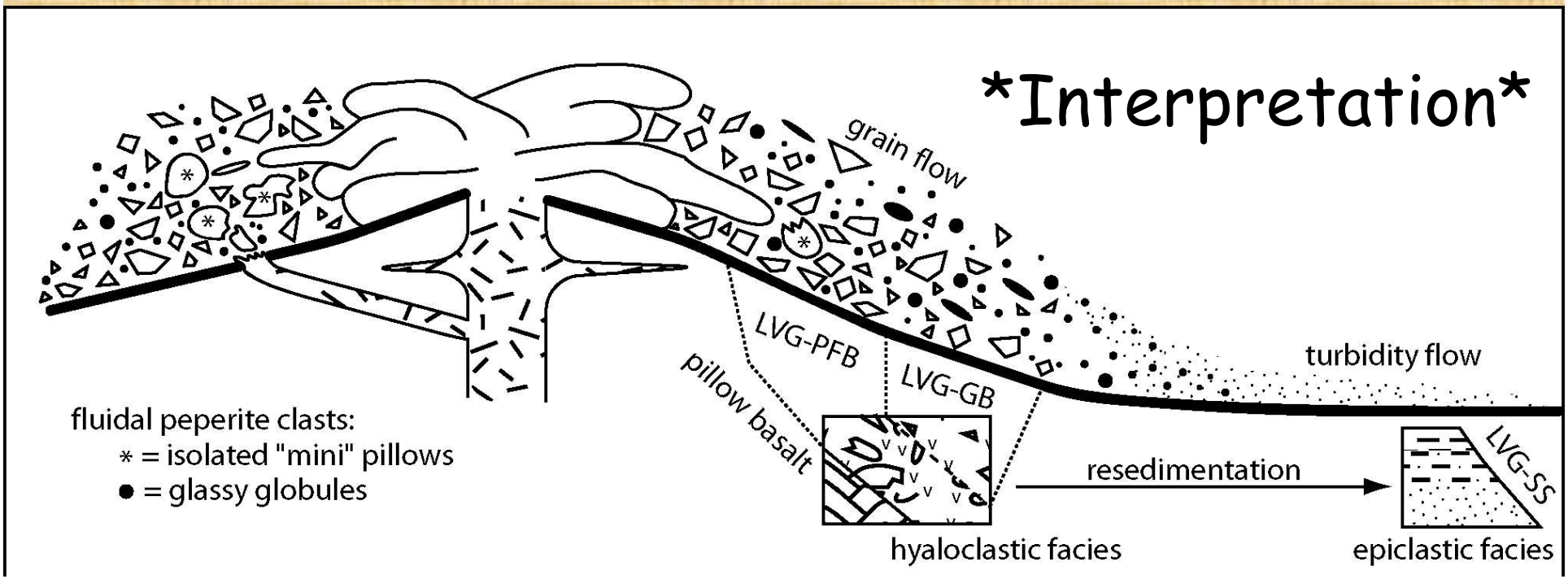
- Breccia facies laterally grade into LVG-sandstone (LVG-SS) facies

- Can correlate up to 1.5 km with distal fining of LVG-SS

Lateral facies associations



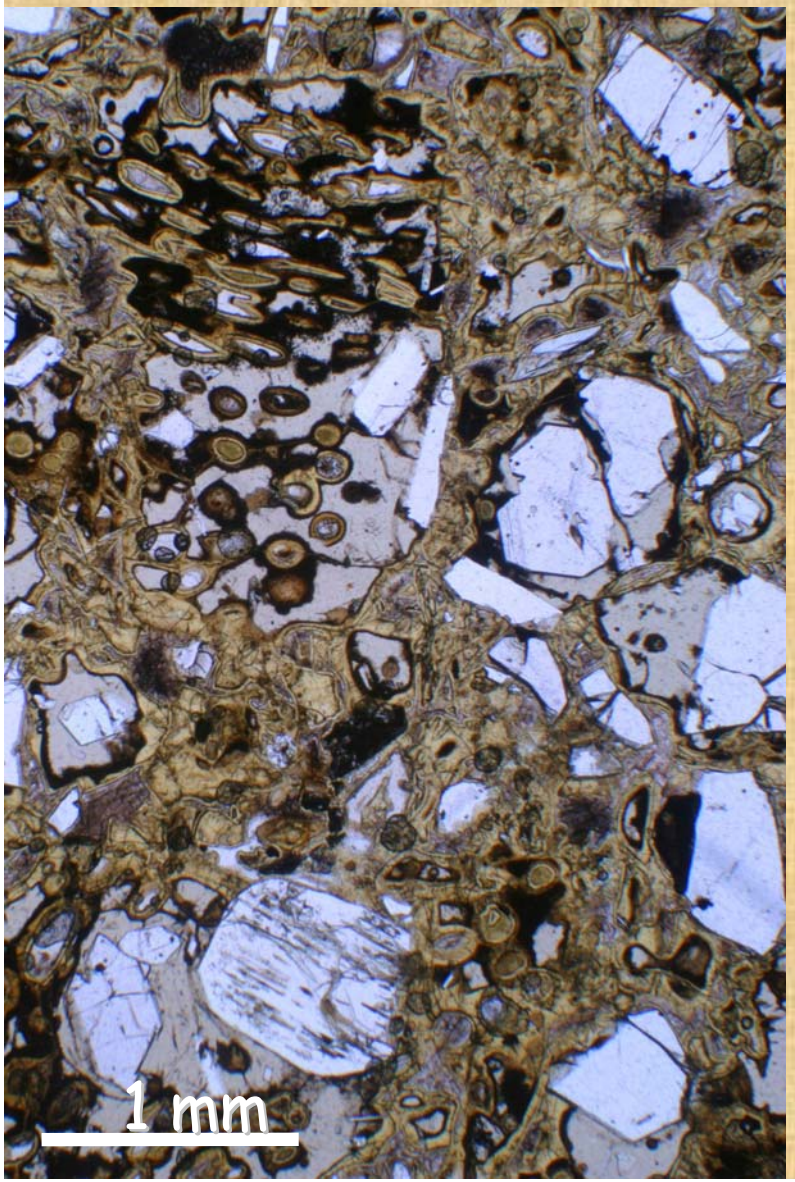
- Hyaloclastic, LVG - Breccia facies:
  - Pillow fragments and breccia matrix
    - cooling contraction-quench granulation
- Epiclastic, LVG - Sandstone facies:
  - re-working by ocean bottom currents into distal turbidites and contourites
    - proximal transport via short lived grain flows
    - "Mini" pillows and glass globules
    - co-magmatic pepperite

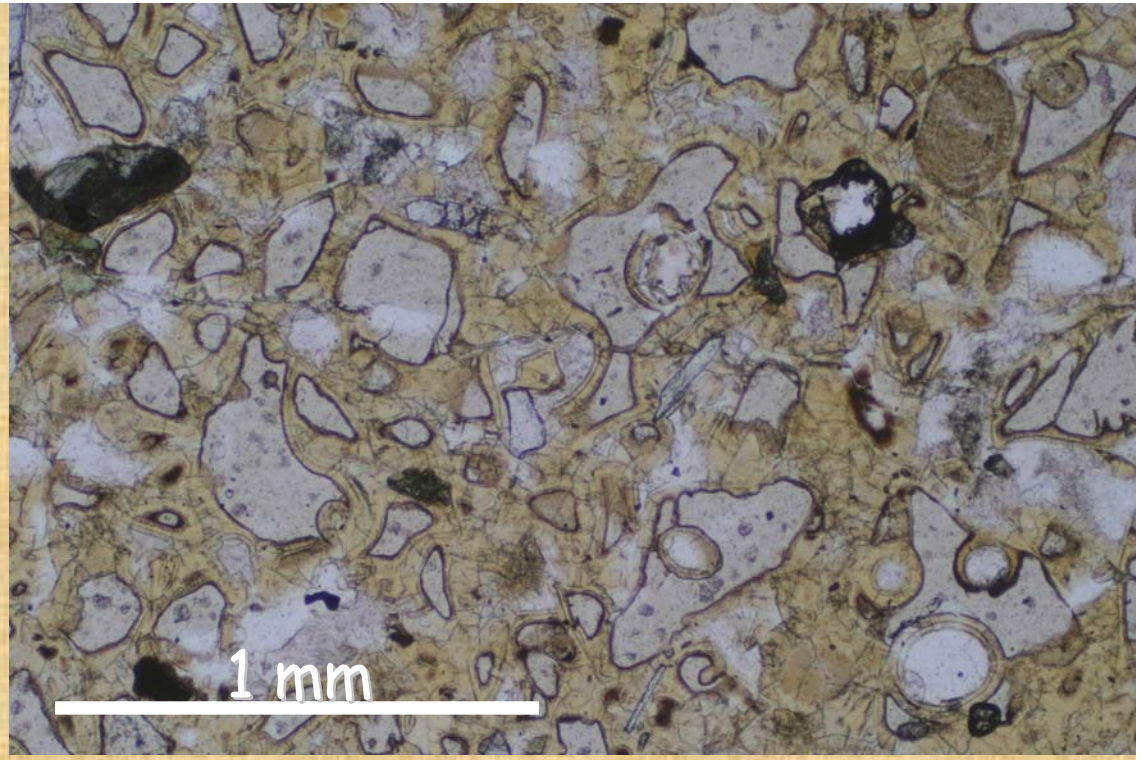


Laminated HVG-sandstone

- pebbly sandstone
- reverse and normal grading
- poorly defined planar laminations
- rare dolerite clasts (polymict)
- planar grain fabric

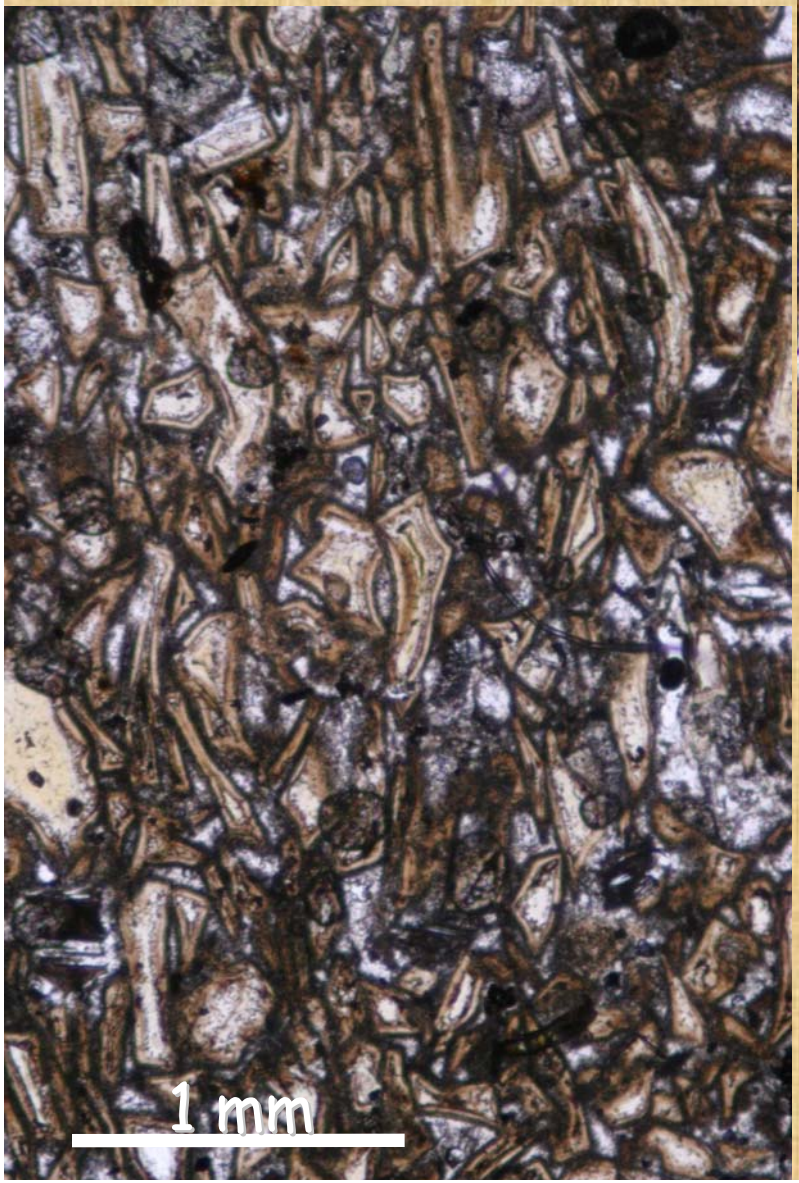
Laminated HVG-sandstone

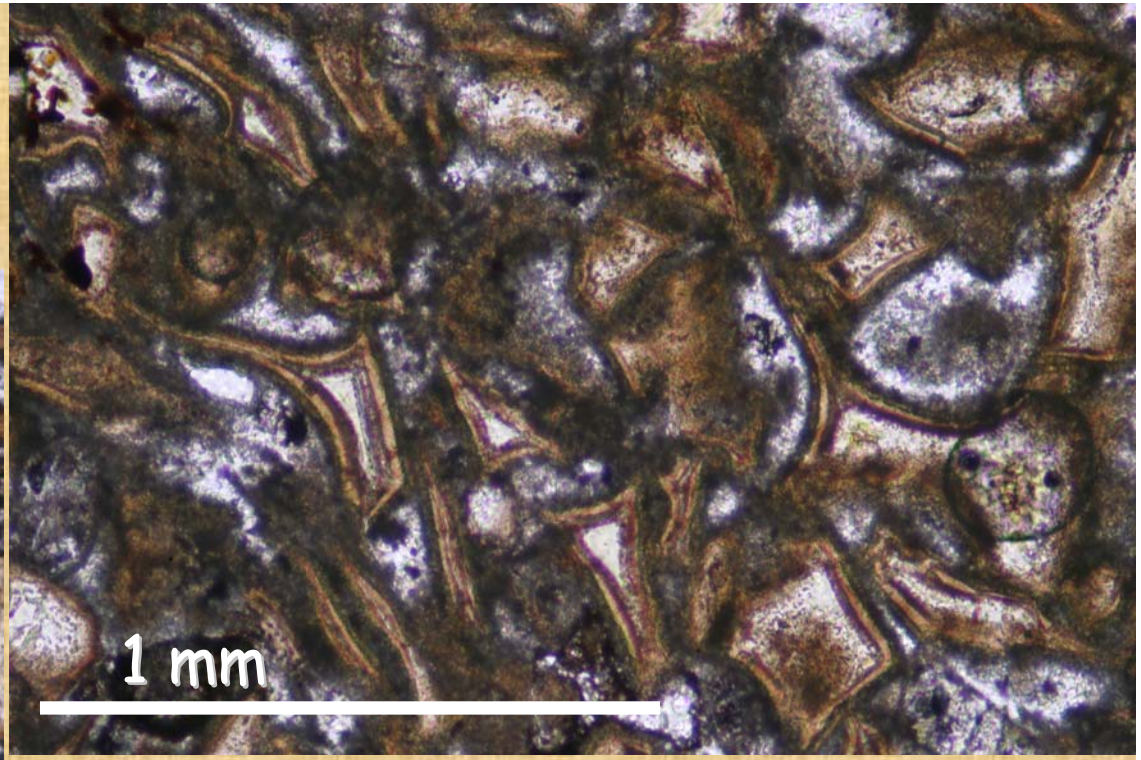




- stretched vesicles common
- poorly to moderately sorted
- polymict (rare LVG grains and microfossils)
- abundant phenocryst fragments

Non-laminated HVG-sandstone

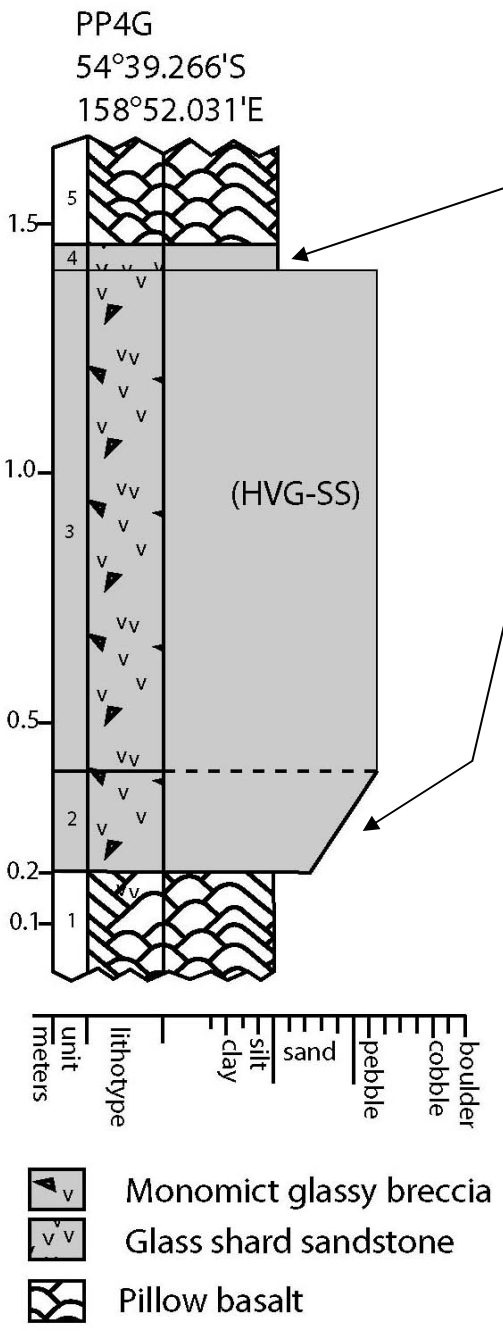


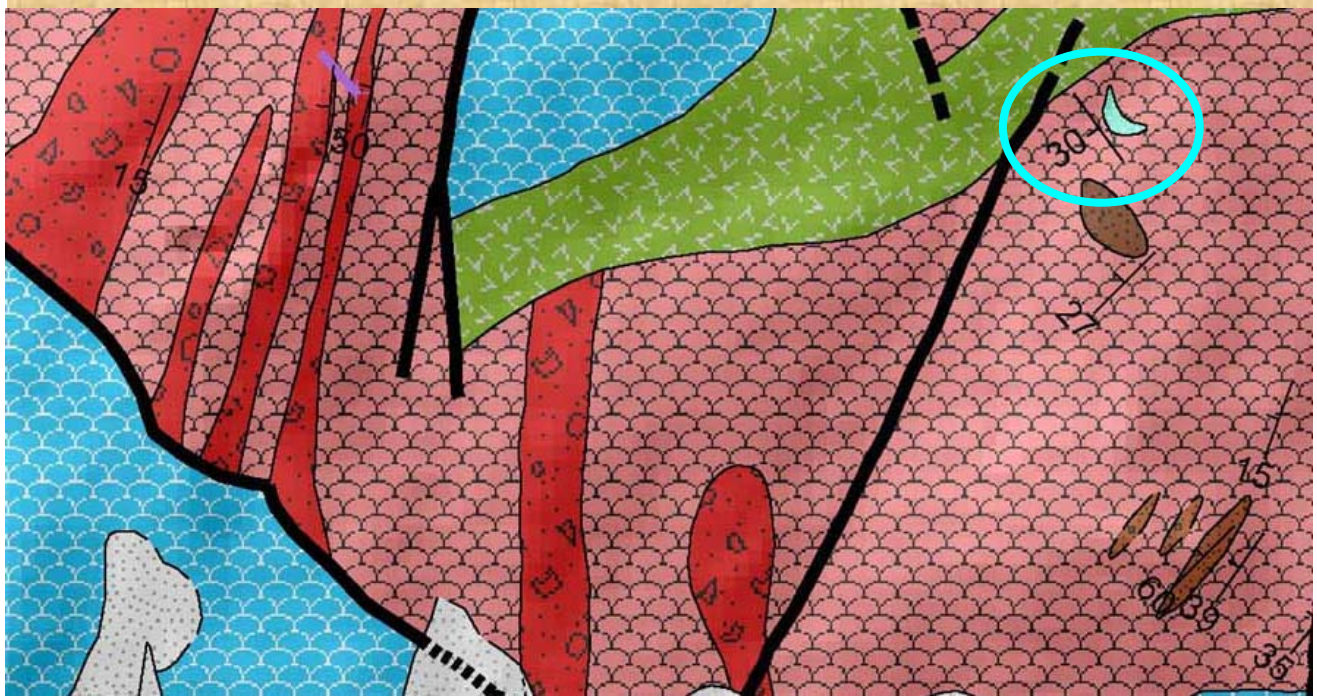


- Very fine to fine grained
- no phenocrysts
- well-sorted
- bubble wall shards

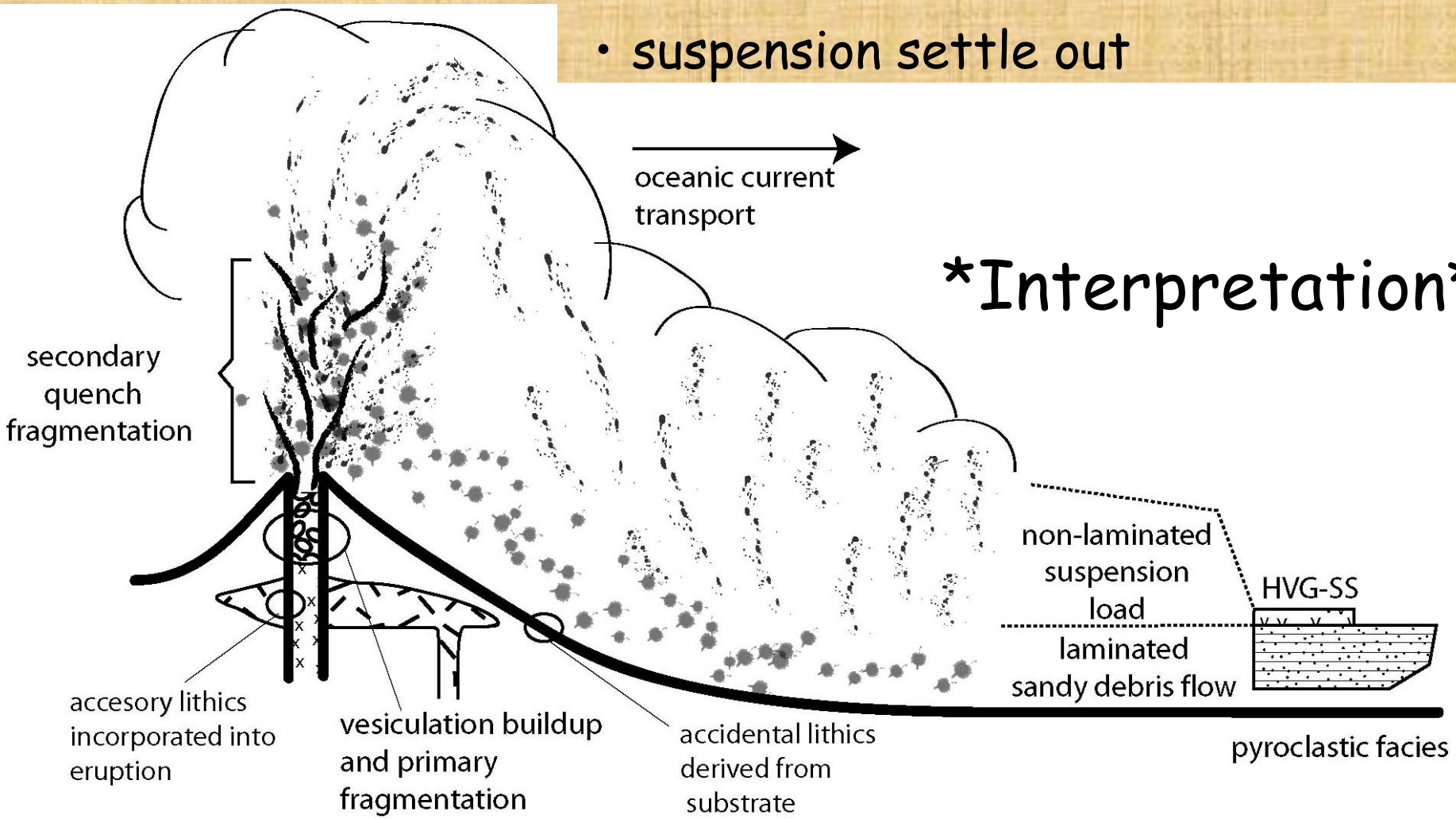
Pyramid Peak section

- Non-laminated bubble wall shard bed
- Laminated HVG-pebbly sandstone with basal reverse grading
- Interbedded with non-porphyritic pillow basalt



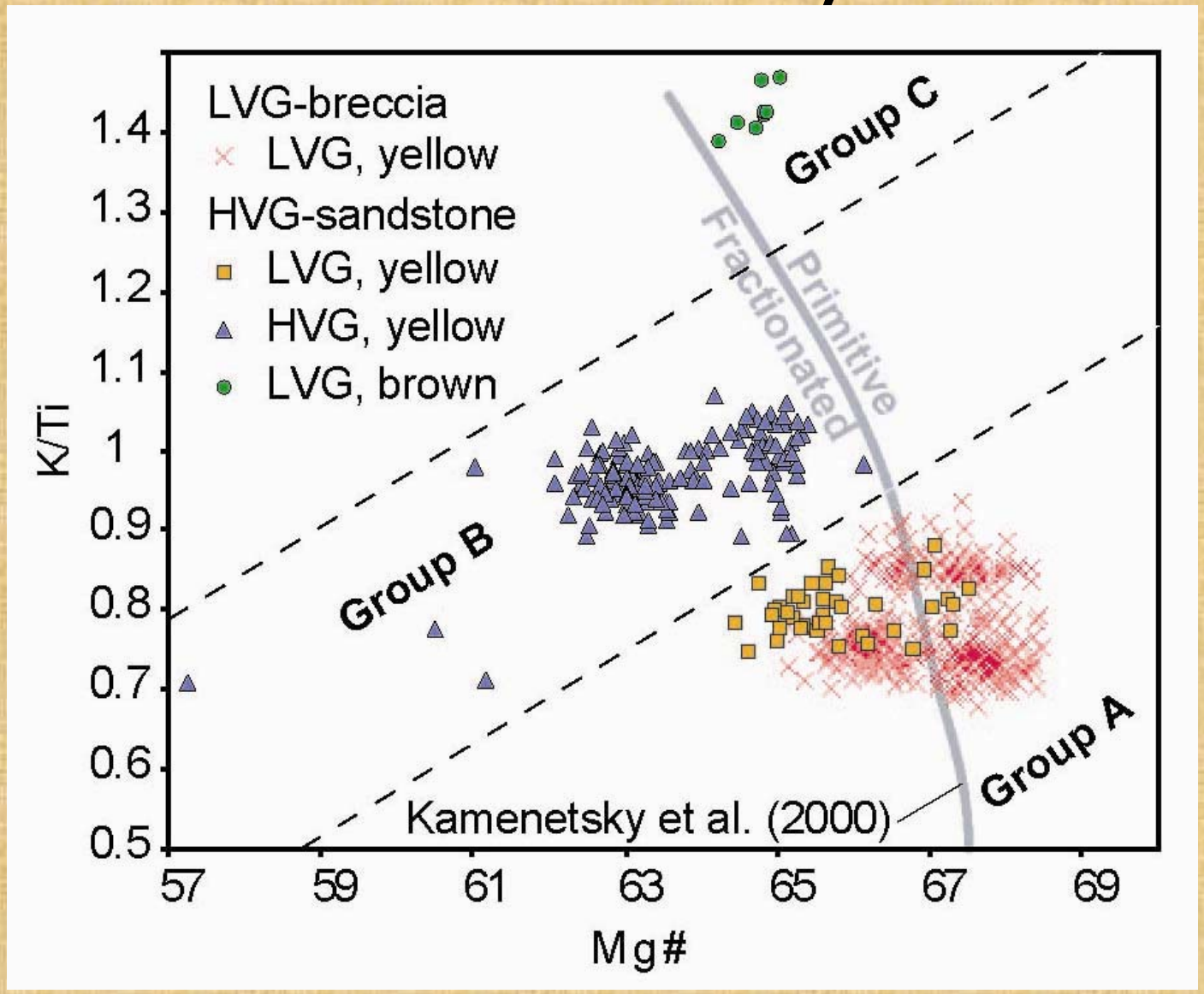


- Pyroclastic, HVG - sandstone facies:
  - Bubble wall shards, stretched vesicles, and fine grain size
    - Magmatically explosively fragmented
    - Non-laminated bubble wall shards
    - suspension settle out



Interpretation

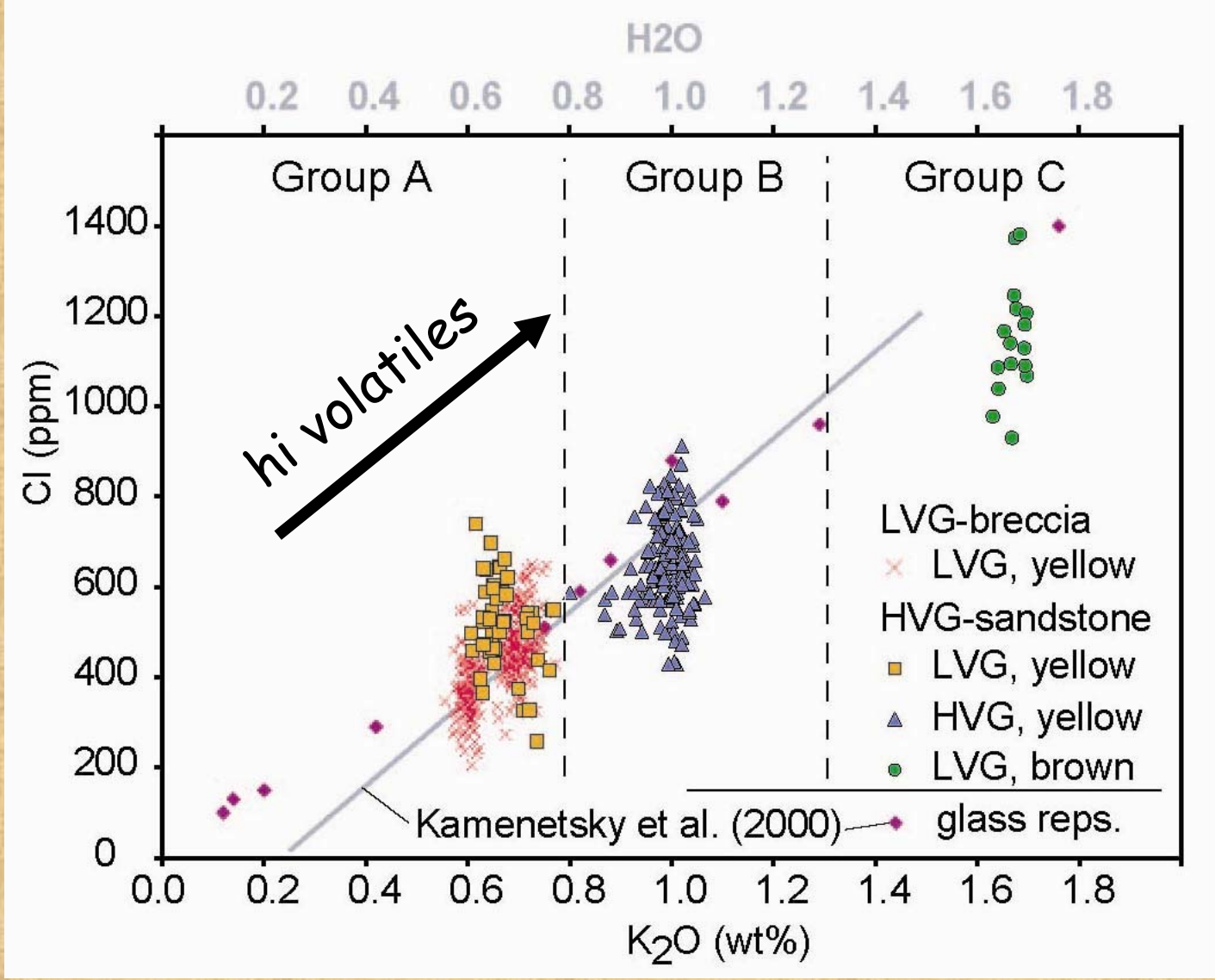
Geochemistry



Enriched

Evolved (fractionated)

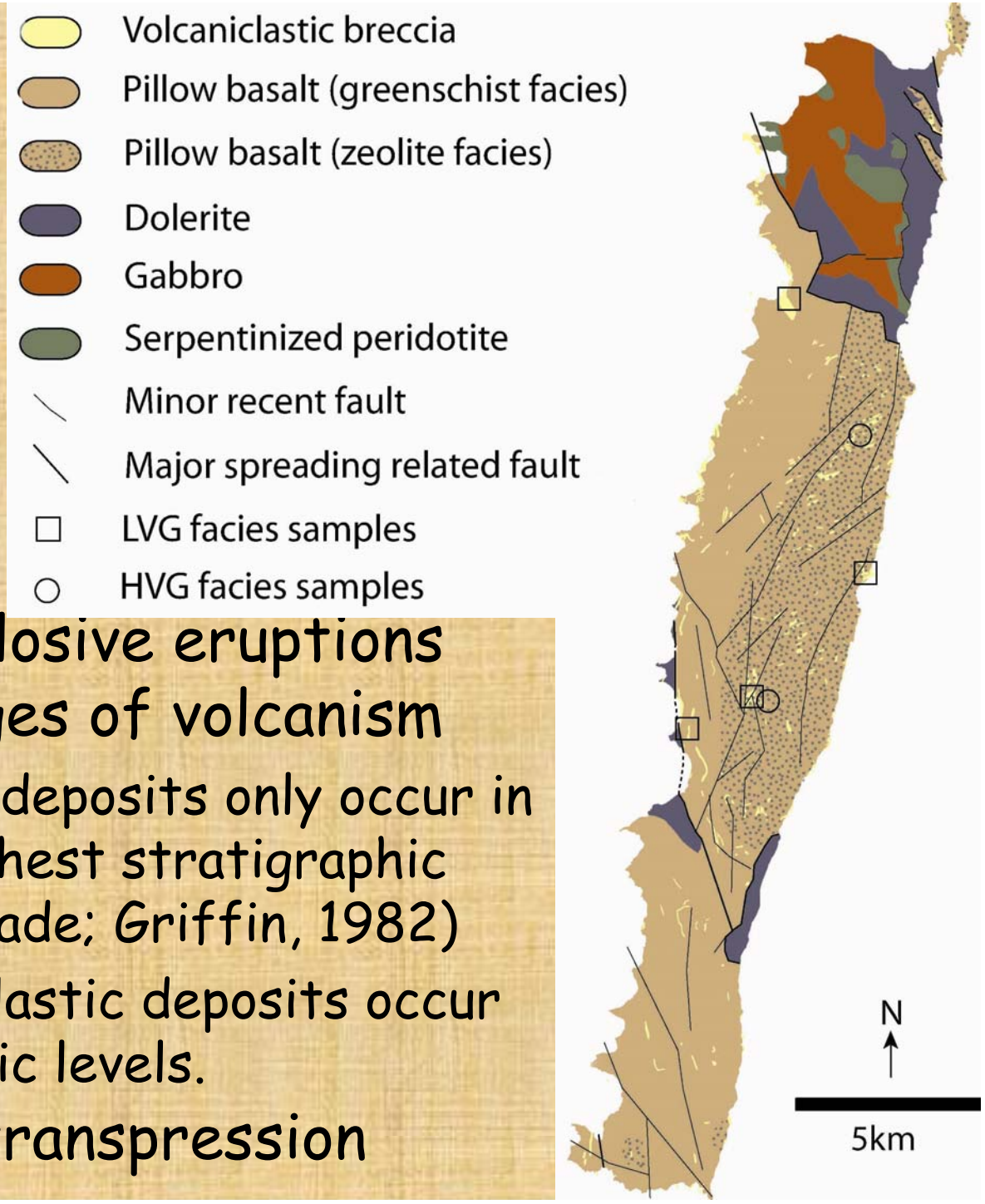
Geochemistry



Magmatic controls on eruption style

- Fractionated-enriched magmas are associated with rare explosive eruptions
  - buildup of volatiles in deep marine confined conduit (Head and Wilson, 2003)
- Highly enriched primitive compositions preserved by rapid ascent from mantle (Kamanetsky et al., 2000)
  - by pass required crustal resonance time for build up of explosive? magmatic foam

Spreading ridge evolution



- Deep marine explosive eruptions mark waning stages of volcanism
  - Rare pyroclastic deposits only occur in more alkaline highest stratigraphic levels (zeolite grade; Griffin, 1982)
  - Abundant hyaloclastic deposits occur in all stratigraphic levels.
- Transtension to transpression

The end

Davis A, Clague D (2006) Volcaniclastic deposits from the North Arch volcanic field, Hawaii: explosive fragmentation of alkalic lava at abyssal depths. Bull Volcanol 68:294-307

Griffin BJ (1982) Igneous and metamorphic petrology of lavas and dikes of the Macquarie Island ophiolite complex. PhD thesis, University of Tasmania

Head JW, Wilson L (2003) Deep submarine pyroclastic eruptions; theory and predicted landforms and deposits. J Volcanol Geotherm Res 121:155-193

Kamenetsky VS, Everard JL, Crawford AJ, Varne R, Eggins SM, Lanyon R (2000) Enriched end-member of primitive MORB melts; petrology and geochemistry of glasses from Macquarie Island (SW Pacific). J Petrol 41:411-430

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