Learning Assessment #4: Metamorphic Rocks ANSWER KEY

Part 1 – Metamorphic Zone Map (/16) – see attached map

The Kootenay Mountains in southern British Columbia contain a wide range of metamorphic rocks. Use your knowledge of metamorphic rocks and processes with Figure 8.17 from your textbook to label the following on the map:

- Label inside each white diamond with the appropriate metamorphic grade, and type of metamorphism.

  H = High Grade
  I = Intermediate Grade
  L = Low Grade

  R = Regional Metamorphism
  C = Contact Metamorphism

- Draw a dashed-line arrow from low to high grade zones of regional metamorphism.

- Draw a solid-line arrow from high to low grade zones of contact metamorphism.

Part 2 - Metamorphic Textures (/15)

a. Use Figure 8.17. What metamorphic texture would you expect in each of the five foliated zones? What are two other metamorphic minerals might you expect to find in each zone?

Metamorphic Zone	Type of Foliation	Additional Metamorphic Minerals
Chlorite	slaty/phyllitic	quartz/feldspar, muscovite
Biotite	phyllitic/schistose	Muscovite, quartz/feldspar, chlorite (NO CLAY)
Garnet	schistose	quartz/feldspar, muscovite, biotite (NO CHLORITE)
Kyanite	schistose	quartz/feldspar, muscovite, biotite, staurolite, garnet
Sillimanite	gneissic gneissic	quartz/feldspar, biotite, garnet

Part 3 - Metamorphic History (/10)

Use the Metamorphic Zone Map to describe the geologic history of the region. Describe the metamorphic processes that caused the rocks in this area to form at the mineral-scale and the crustal scale. What tectonic environments might have existed here in the past? What igneous processes have been involved in metamorphism? How do the different metamorphic zones relate to each other? How deep might some of these rocks been buried? How did these rocks become exposed at the surface?

Metamorphic History

Mineral Scale Metamorphic Processes:
- *solid state diffusion*: no melting occurs during formation of metamorphic minerals, diffusion through the crystal structure causes mineralogical changes.

  - *recrystallization*: some minerals (e.g. quartz and feldspar) change size and shape during metamorphism.
  - *neocrystallization* : new mineral phases grow in the rock as a result of chemical reactions between existing mineral phases (e.g. chlorite, biotite, muscovite, garnet, kyanite and sillimanite).
  - Eventually some mineral phases completely disappear from these reactions (i.e. chlorite is completely gone by the garnet zone due to breaking down during progressive metamorphism)

Tectonic Scale Processes:
- Regional metamorphic rocks (foliated metamorphic zones) were caused by a continent-continent collision and mountain-building.
- Chlorite to Sillimanite zones represent a continuous sequence of prograde regional metamorphism from low to high grade.
- Contact metamorphic rocks (the zone of contact metamorphism can also be called a 'Contact Aureole') were caused by a high temperature igneous intrusion (Granite Batholith, 176 Ma).
- Within the Contact Aureole that formed around the 176 Ma granitic intrusion, higher grade non-foliated Andalusite-zone metamorphic rocks formed closest to the intrusion, and lower grade Biotite-zone rocks formed further away from the intrusion. This occurred due to higher heat conditions nearest the batholith.
- Other granitic intrusions in the region (76 Ma) did not cause metamorphic minerals to form (i.e. there is no contact aureole).
- The contact and regional metamorphic events are unrelated, separate events.

Burial Depth and Surface Exposure
- Chlorite-zone buried to 10 ± 5 km
- Each higher grade mineral zones in-between chlorite and sillimante represent increasing depth (and therefore pressure and temperature) during regional metamorphism
- Sillimanite-zone buried to 30 ± 5 km
- Contact metamorphic rocks exposed to high T, low P conditions, shallow burial usually not more than 8 km or so
- Tectonic uplift after mountain building and subsequent erosion of these mountains exposed the metamorphic rocks at the surface.

Answer Organization

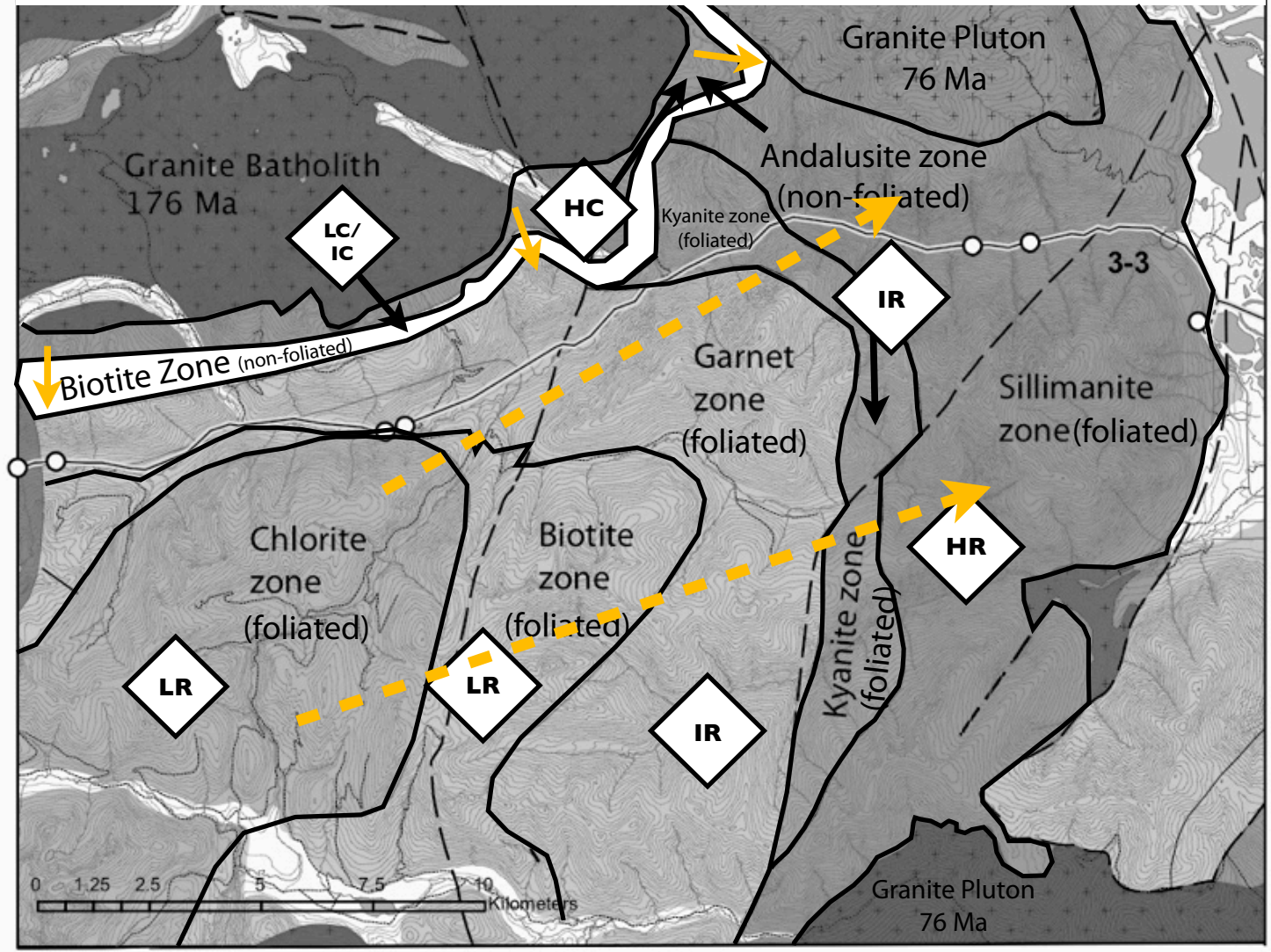
- Answer is organized into a bulleted or numbered list

/ 1

Total for Section

/ 10

Metamorphic Zones of the Southern Kootenay Mountains, British Columbia, Canada



Base Map Derived from Doughty et al, 1997 Metamorphism of the Creston map area, southeastern British Columbia (82F/ British Columbia Ministry of Energy, Mines and Petroleum Resources Open File 1997-5, scale 1:50 000, 14 p.

Legend

- Major Fault
- Road
- Metamorphic Zone Boundary