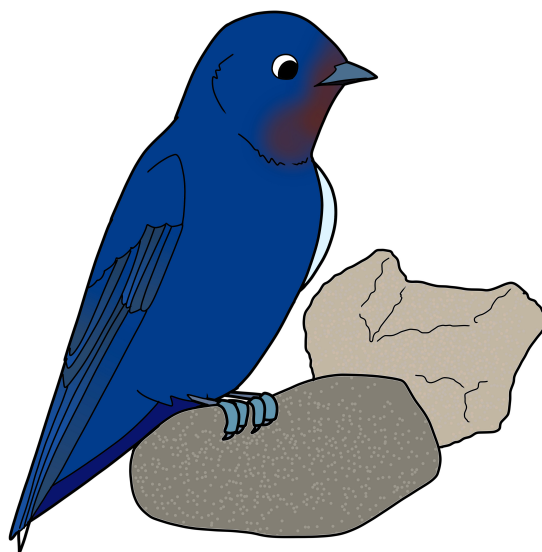


BirdSO Mini Invitational

Vivek Vajipey

11-18 December 2021



Directions:

This test has a total of 11 stations of varying numbers of rocks and minerals each. For each station, you will be asked to identify specimens and answer questions related to them. Refer to the attached image sheet, a PDF with the specimen photos for each station. Some specimen photos include a 1 cm piece of white paper for scale.

IMPORTANT: After identifying the specimens in a station, answer the following questions with the capitalized specimen letter NOT the rock/mineral name.

Please keep all answers and explanations concise.

Answer as much as you can. There is no penalty on guessing, and especially with identification, that gut feeling is sometimes right. Good luck!

Page	Points	Score
3	14	
4	15	
5	19	
6	21	
7	24	
8	5	
9	16	
10	31	
11	21	
12	10	
13	5	
14	14	
15	22	
16	27	
17	25	
18	22	
19	18	
20	2	
Total:	311	

Please see: **Image Sheet:** <https://scilympiad.com/data/org/birdso/member/toES/BirdSO 2022 rox-min c image sheet.pdf>

1 Station a

1. (1 point) Identify specimen A.

2. (1 point) Identify specimen B.

3. (1 point) Identify specimen C.

4. (1 point) Identify specimen D.

5. (1 point) Identify specimen E.

6. (1 point) Identify specimen F.

7. (1 point) Identify specimen G.

8. (1 point) Identify specimen H.

9. (1 point) Identify specimen I, the blue crystal in the center.

10. (1 point) Identify specimen J.

11. (1 point) Identify specimen K, which is sprinkled with quartz.

12. (2 points) Order specimens A, C, D, and G by increasing number of cleavage directions. (First has the fewest number of cleavage directions, last has the greatest number of cleavage directions.)
13. (1 point) Specimen G can scratch specimen D, which can in turn scratch specimen E. What can we determine about the hardness of specimen G on the Mohs hardness scale?
 - A. Only an upper bound
 - B. Only a lower bound
 - C. An upper and lower bound
 - D. A single value
 - E. Number of times greater than specimens D and E

14. (2 points) Give the value(s) for your answer to the previous question (e.g., if choosing “only a upper bound,” state the value for the upper bound).
15. (2 points) Scott runs the tip of specimen A across a streak plate and observes a white powder. Check all of the following that comprise this powder.
- ☐ Impurities from within specimen A
 - ☐ Tarnish from the surface of specimen A
 - ☐ Pure silica
 - ☐ Porcelain
16. (1 point) Scott runs the tip of another specimen across a streak plate and observes a brown powder. Which specimen was it?
17. (1 point) Scott runs the tip of yet another specimen across a streak plate and observes a red powder. Which specimen was it?
18. (2 points) When specimen C reacts with sulfuric acid, the dehydrated form of which specimen is formed?
- A. B
 - B. D
 - C. E
 - D. G
 - E. K
19. (1 point) Specimen H is notable for having a high:
- A. Specific gravity
 - B. Hardness
 - C. Solubility in water
 - D. Refractive index

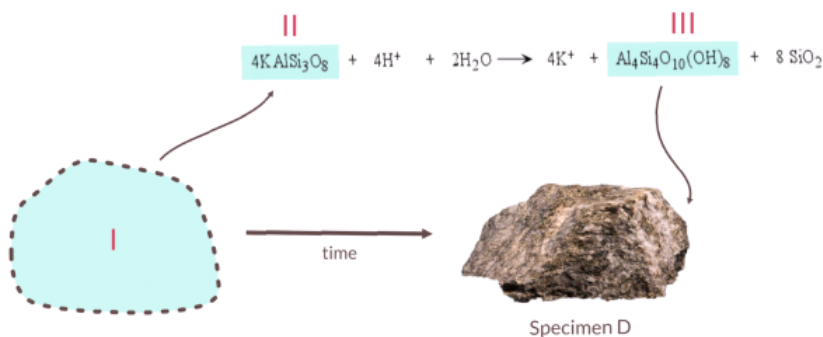
Station b

20. (1 point) Identify specimen A.
- _____
21. (1 point) Identify specimen B.
- _____
22. (1 point) Identify specimen C.
- _____
23. (1 point) Identify specimen D.
- _____
24. (1 point) Identify specimen E.
- _____
25. (1 point) Identify specimen F.
- _____

26. (1 point) Identify specimen G.

27. (1 point) Identify specimen H.

Use the diagram above to answer the following five questions.



28. (4 points) I corresponds to specimen *II, found in I, is specimen III, found primarily on the surface of specimen D, is specimen*.

29. (1 point) What general type of reaction is shown in the diagram?

30. (1 point) Describe the texture of a rock composed of the silica produced by this reaction.

31. (3 points) Another component of I is specimen F. How do the weathering products of specimen F compare to that of II?

32. (3 points) Select all of the following that is/are accurate about the formation of specimen B if little II is observed.

- ☐ Clasts were more likely derived from I than specimen D.
- ☐ Clasts were transported for relatively long before being deposited
- ☐ The prevalence of interlocking grains and II are inversely related.
- ☐ Individual grains are more angular than they are round.
- ☐ It has less matrix compared to a similar rock with more II.
- ☐ It is cemented primarily by III, which eventually recrystallizes.

33. (1 point) Compared to the ideal unfoliated form of specimen A, specimen A could be reasonably expected to have:

- A. Less feldspar content.
- B. A greater proportion of micas.
- C. Undergone more differential stress.
- D. Undergone greater confining pressure.

34. (4 points) One of the specimens in this station is being studied as a potential tool for carbon sequestration on a useful timescale.

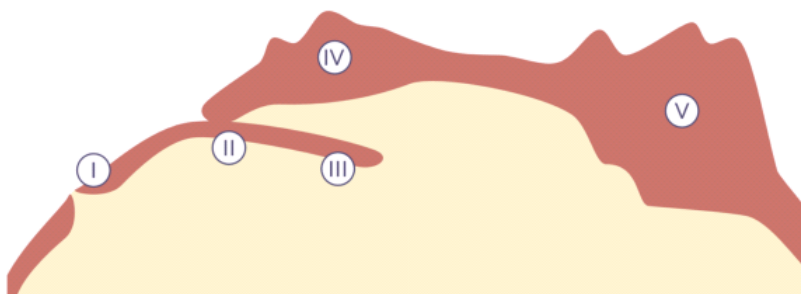
a) Briefly describe the relevant process that sequesters carbon.

b) Identify the specimen that is the best candidate for this purpose, and explain why it promotes quicker carbon sequestration.

Station c

35. (1 point) Identify specimen A. Note: While not on the official rocks and minerals list, it should be identifiable based on the questions asked.
- _____
36. (1 point) Identify specimen B.
- _____
37. (2 points) Identify the red mineral in specimen C, then identify the rock.
- _____
38. (1 point) Identify specimen E.
- _____
39. (2 points) Identify the mineral in specimen F, then identify the rock.
- _____
40. (1 point) Identify specimen G.
- _____

Use the diagram of tectonic environments (labeled I to V) below to answer the following questions.

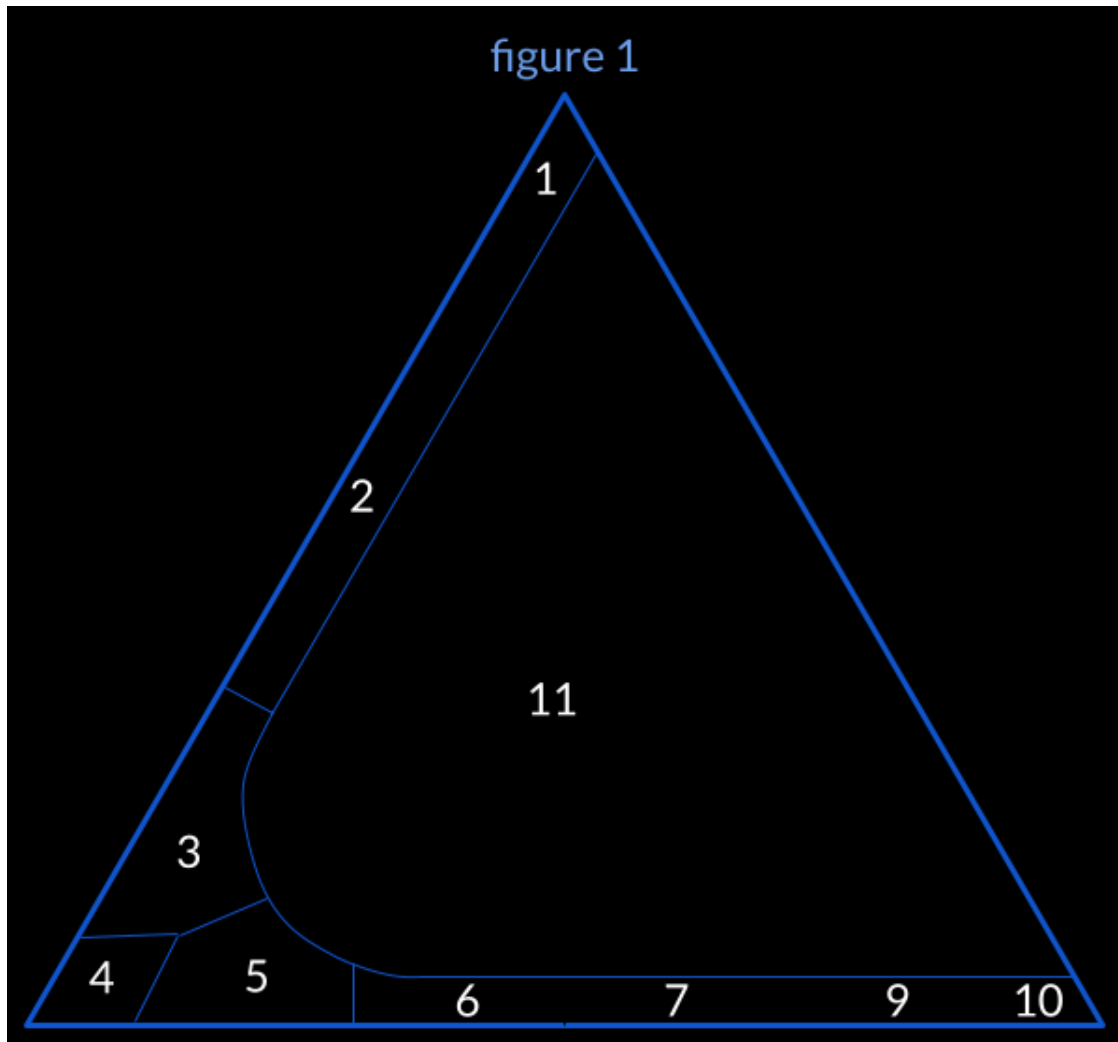


41. (3 points) Match each of the following with one tectonic environment: a) regional metamorphism, b) hydrothermal metamorphism, c) contact metamorphism.
42. (3 points) Specimen D contains glaucophane, pyrite, and chlorite.
- a) What metamorphic facies does it belong in?
- b) In which tectonic environment (I-V) would it most likely be found?
43. (3 points) a) The formation of which specimen drives melt formation beneath IV?
- b) How does this change affect the subducting plate?
- .5.5.5
44. (3.5 points) a) Which two specimens have the formula Al_2SiO_5 ?
- b) What is the name of the other polymorph of this specimen that is not at this station?
- c) In what general pressure and temperature conditions does each of the three polymorphs form?
- .5.5.5
45. (1.5 points) Some minerals can be used as indices for metamorphic grade. Order specimens B, E, and G by increasing metamorphic grade.

46. (1 point) The texture of C is best described as:
- A. Phaneritic
 - B. Porphyritic
 - C. Porphyroclastic
 - D. Porphyroblastic
47. (2 points) Suppose specimens C and F formed under the same pressure and temperature conditions.
- a) What facies are they in?
 - b) What mineral appears abundant in specimen F but is not present in specimen C?
48. (4 points) As seen in the previous question, rocks can undergo similar metamorphic conditions yet be very different from one another. In a few sentences, account for this difference in specimens C and F using their respective protolith compositions.
- Station d
49. (1 point) Identify specimen A.
- _____
50. (1 point) Identify specimen B.
- _____
51. (1 point) Identify specimen D.
- _____
52. (1 point) Identify specimen E.
- _____
53. (1 point) Identify specimen F.
- _____
54. (1 point) Identify specimen G.
- _____
55. (1 point) Identify the blue-green parts in specimen H, which appears more pale than a typical example.
- _____
56. (2 points) a) What is the term that describes when different crystals share lattice points symmetrically?
- b) Which specimen exhibits this phenomenon?
57. (3 points) a) Which specimen is the namesake of the term used to describe oceanic conditions with a high Mg/Ca ratio?
- b) Which specimen is the namesake of the term used to describe oceanic conditions with a low Mg/Ca ratio?
- c) Between these two specimens, which forms at higher pressures?
58. (2 points) a) What property is being exhibited by specimen D?
- b) Briefly explain the cause of the property in terms of index of refraction
59. (3 points) Specimen C is a mineral known as coesite, which forms in pressure conditions of 2 to 3 gigapascals.
- a) Coesite is a high pressure polymorph of which specimen?

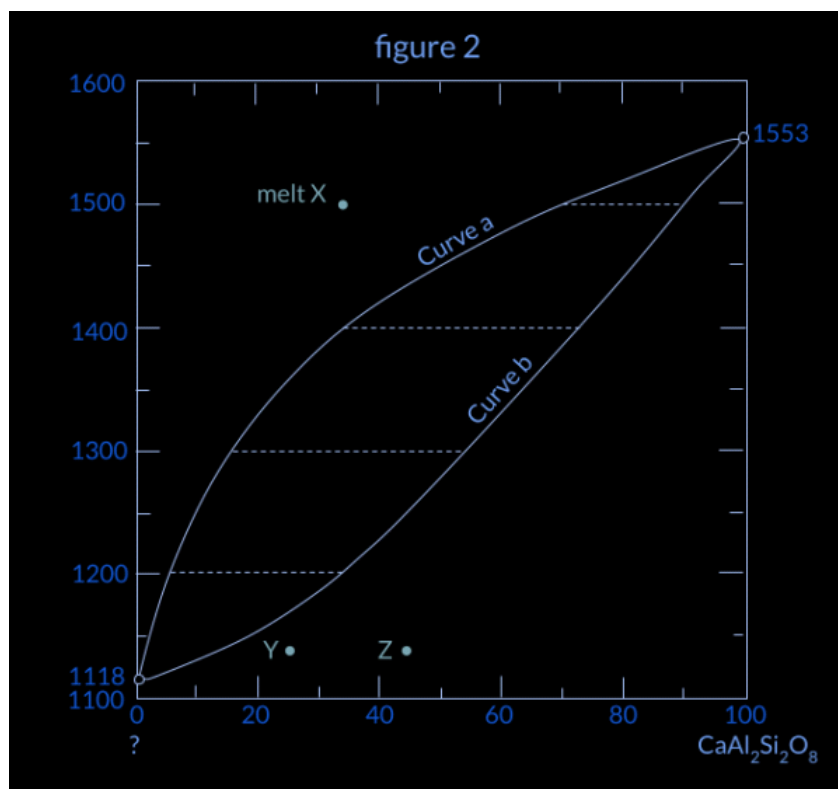
- b) What is the name of the polymorph of coesite that forms at pressures greater than 10 gigapascals?
- c) At what locations would you expect to find coesite and the higher pressure polymorph?

The following questions will refer to the diagram below as "figure 1"



60. (3 points) a) Which specimens at this station would be plotted in figure 1?
- b) Which number in figure 1 does each specimen correspond to?
61. (2 points) a) What is the term used to describe number 11 in figure 1?
- b) Briefly describe the significance of this portion (number 11) of figure 1.

The following questions will refer to the diagram below as "figure 2".



62. (2 points) a) The chemical formula of which specimen at this station belongs in the bottom left corner of figure 2 where the “?” is?
- b) What is its chemical formula?
63. (3 points) a) Which type of substitution occurs between the two endmembers in figure 2?
- b) Describe this substitution in terms of the ion(s) exchanged.
64. (2 points) a) What value is plotted on the x-axis of figure 2?
- b) What value is plotted on the y-axis of figure 2 and what are the units?
- c) What is the name of Curve a in figure 2?
- d) What is the name of Curve b in figure 2?
65. (5 points) a) What are the conditions (x and y values) currently plotted for melt X?
- b) At this point, melt X is in what phase(s)?
- c) After some more time, melt X’s x-coordinate remains the same but its y-coordinate changes to 1300. At this point, melt X is in what phase(s)?
- d) What is/are the x-coordinate value(s) of the phase(s) after the change?
66. (2 points) a) After even more time, would you expect melt X to end up at point Y or point Z?
- b) Briefly justify your answer to part a.
- Station e
67. (1 point) Identify specimen A.
- _____
68. (1 point) Identify specimen C.

69. (1 point) Identify specimen D.

70. (1 point) Identify specimen E.

71. (2 points) Identify the green mineral in specimen F, then identify the rock.

72. (1 point) Identify specimen G.

73. (1 point) Identify specimen H.

74. (1 point) Identify specimen I.

75. (1 point) Identify specimen J, which is identical in composition to another sample.

76. (2 points) Identify the primary mineral in specimen K, then identify its inclusions.

77. (9 points) Classify each specimen (A - K) as a inosilicate, nesosilicate, phyllosilicate, sorosilicate, tectosilicate, or none.

78. (3 points) Why might one inosilicate in the station have a higher silicon-oxygen ratio than another specimen on the list (give the names of both)?

79. (3 points) Order the following specimens in increasing silicate structure complexity: F (mineral), A, C, K, B.

80. (2 points) Which of the following best relates the answer to the previous question to Bowen's reaction series?

- A. The least complex specimen melts at the highest temperature while the most complex specimen melts at the lowest temperature.
- B. The most complex specimen melts at the highest temperature while the least complex specimen melts at the lowest temperature.
- C. Silicate structure becomes more complex with increasing metamorphic grade.
- D. Since minerals like feldspars seem to deviate from the apparent trend, structure complexity is mostly unrelated to melting temperature.

81. (2 points) Rank specimens I, J, and K by increasingly orderly microstructure.

Station f

82. (1 point) Identify specimen A.

83. (1 point) Identify specimen B.

84. (1 point) Identify specimen C.

85. (1 point) Identify specimen D.

86. (1 point) Identify specimen E.

87. (1 point) Identify specimen F.

88. (1 point) Identify specimen G.

89. (1 point) Identify specimen H.

90. (1 point) Identify specimen I.

91. (1 point) Identify the black crystals in the front face of specimen J.

92. (1 point) Identify specimen K.

93. (4 points) For each rock at this station, list the specimen letter and its texture.

94. (2 points) Order the following specimens in increasing specific gravity: A, B, D, F

95. (2 points) Order the following specimens in increasing crystallization temperature: C, E, G, I. If two specimens have very similar crystallization temperatures, either order will be accepted.

96. (2 points) Order the following specimens from first to weather to last to weather at surface conditions: C, E, G, I. If two specimens have very similar crystallization temperatures, either order will be accepted.

97. (1 point) Which of the following specimens is traditionally used to make arrowheads?

A. A

B. C

C. D

D. G

E. I

F. K

98. (1 point) Which of the specimens constitutes the majority of the Earth's continental crust?

A. A

B. B

C. D

D. H

E. I

F. K

99. (1 point) Which of the specimens constitutes the majority of the Earth's oceanic crust?

A. A

B. B

C. D

D. H

E. I

F. K

100. (1 point) What is the term used to describe the way that specimen K breaks?

For each of the following three specimens, determine whether it is more likely to be found in specimen A or specimen B.

101. (1 point) Specimen E is more likely to be found in Specimen:

A. A

B. B

102. (1 point) Specimen G is more likely to be found in:

A. A

B. B

103. (1 point) Specimen J is more likely to be found in:

A. A

B. B

104. (4 points) Specimen H has an interesting texture.

a) What is the general term for the specimen's light gray component of this texture?

b) What is the general term for the specimen's black component of this texture?

c) Identify the black component

d) Briefly explain the cause for this texture

For the next seven questions, select the specimen which is most likely to be found in the environment.

105. (1 point) Olympus Mons, a shield volcano on Mars

A. A

B. B

C. D

D. H

E. I

F. K

106. (1 point) Aconcagua, a stratovolcano in the Andes mountain range

- A. A
- B. B
- C. D
- D. H
- E. I
- F. K

107. (1 point) Lunar maria, the younger, darker regions of the moon

- A. A
- B. B
- C. D
- D. H
- E. I
- F. K

108. (1 point) Near the bottom of an ophiolite suite

- A. A
- B. B
- C. D
- D. H
- E. I
- F. K

109. (1 point) In a laccolith near an explosive volcano

- A. A
- B. B
- C. D
- D. H
- E. I
- F. K

110. (1 point) Near the margins of a very viscous lava flow

- A. A
- B. B
- C. D
- D. H
- E. I

F. K

111. (1 point) Near an underwater felsic volcano.

A. A

B. B

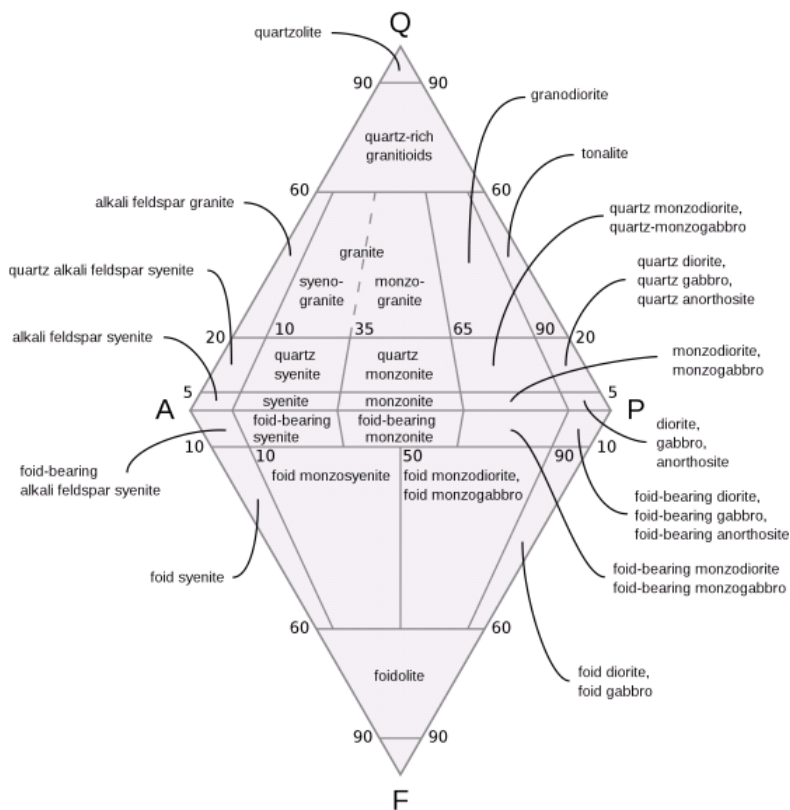
C. D

D. H

E. I

F. K

Use the diagram below to answer the next four questions.



112. (1 point) This diagram is used to classify rocks at this station with what texture?

113. (1 point) What is the name of the other diagram that is used to classify rocks with the texture opposite to the texture described in the diagram above?

114. (2 points) What do the letters Q, A, P, and F stand for?

115. (9 points) Long ago, Yuchen was studying two of the rocks at this station and estimated the total Q, A, P, and F content for both rocks. You find his field notebook and look at the data he collected (shown below).

Specimen	Q	A	P	F
1	20%	20%	40%	0%
2	30%	15%	15%	0%

a) Use the diagram above to classify Specimen 1 and Specimen 2 to the most specific level. Show any relevant calculations used.

b) Based on the classifications, Specimen 1 is Specimen (letter from this station) and Specimen 2 is Specimen (letter from this station).

Station g

116. (1 point) Identify specimen A.

117. (1 point) Identify specimen B.

118. (1 point) Identify specimen C.

119. (2 points) Identify the mineral and native element in specimen D.

120. (1 point) Identify specimen E.

121. (1 point) Identify specimen F.

122. (1 point) Identify specimen G.

123. (1 point) Identify specimen H.

124. (1 point) Identify specimen I.

125. (1 point) Identify specimen J.

126. (1 point) Identify specimen K.

127. (1 point) Identify specimen L.

128. (3 points) a) Which specimen is commonly found in lacustrine shales?

b) Explain why decaying organic matter in this environment would further favor the formation of this specimen.

129. (3 points) Which three specimens can be produced from the hydrothermal alteration of ultramafic rocks?

130. (1 point) The process in the previous question was named after specimen _____.

131. (1 point) One of the three specimens in question 129 oxidizes to produce which other specimen?

132. (1 point) Chalcopyrite is an ore of which specimen?

133. (1 point) Specimen B is:

- A. anhedral
- B. euhedral
- C. subhedral
- D. dihedral

134. (2 points) Which of the mineral specimens contain the S^{2-} ion ?

135. (2 points) Which of the mineral specimens contain the CO_3^{2-} ion?

136. (2 points) Which of the mineral specimens contain the OH^- ion?

137. (2 points) Mark all of the following that is/are true about the occurrence of specimen E.

- ☐ Just as abundant as specimen J
- ☐ Just as widespread as specimen J
- ☐ Often found with calcite
- ☐ Often found with specimen B
- ☐ Makes up the oxidized exteriors of some statues

138. (2 points) Briefly describe the redox conditions of the Earth's interior as compared to the surface.

139. (3 points) Consider a sedimentary rock listed in the event sheet containing specimen C. How does it mark a transition in the answer to the previous question?

Station h

140. (1 point) Identify specimen A.

141. (1 point) Identify specimen B.

142. (1 point) Identify specimen C.

143. (1 point) Identify specimen D.

144. (1 point) Identify specimen E.

145. (1 point) Identify specimen F.

146. (2 points) Identify both minerals in specimen G.

147. (1 point) Identify specimen H.

148. (4 points) a) Which two specimens are in a solid solution series?

- b) What is the name of the gem-quality, green variety of these specimens?
- c) Would these specimens be found near a sedimentary basin, a dike, or an accretionary wedge? Briefly justify your choice.

149. (1 point) In which of the following environments would you expect to find specimen B?

- A. Arid
- B. Hydrothermal
- C. Volcanic
- D. Rainy
- E. Snowy

150. (5 points) Identify the crystal habit of specimens A, B, D, E, and F

Station i

151. (1 point) Identify specimen B.

152. (1 point) Identify specimen C.

153. (1 point) Identify specimen D.

154. (1 point) What crystal habit does specimen A exhibit?

155. (1 point) The black mineral in specimen A is most similar in composition to what mineral in the hydroxide or oxide family?

156. (1 point) How is the matrix of specimen C used to distinguish it from a similar rock?

157. (3 points) a) What are the veins in specimen B likely composed of?

b) These veins likely formed from the fracturing of the specimen. Propose one reason why one vein is much thicker than the rest.

158. (2 points) Compare the depositional environments of specimens B and D.

159. (2 points) An outcrop of alternating beds of specimens B and D is found. Which of the following is most accurate about the formation of this outcrop regarding sedimentary facies?

- A. One particular type of sedimentary facies has two distinct depositional environments within it.
- B. The facies for each specimen were adjacent to one another and migrated laterally over time.
- C. One facies morphed gradually into the other with climate fluctuations.
- D. Sedimentary facies at the outcrop displayed vertical variations to produce the alternating beds.

160. (4 points) If bodies of specimen B and D were placed under identical conditions with contact metamorphism,

a) what rock would each be metamorphosed to?

b) Would one of the rocks from part a be more likely to preserve its fossils than the other, and if so, which?

161. (2 points) Suppose a rock similar to specimen B was found as a part of a turbidite—lithified deposits from turbidity currents—containing clasts ranging from clay-sized to cobble-sized. Which of the following best describes its relative position?

- A. Beside a sandstone
- B. Bedside a conglomerate
- C. Directly below a sandstone
- D. Directly below a conglomerate

162. (1 point) What characteristic of turbidites does the previous question illustrate?

163. (1 point) What name is given to sandstones like the one from question 161?

Station j

164. (1 point) Identify specimen A.

165. (1 point) Identify specimen B.

166. (1 point) Identify specimen C.

167. (1 point) Identify specimen D.

168. (2 points) Identify two minerals in specimen E.

169. (1 point) Identify specimen F.

170. (1 point) Identify specimen G.

171. (1 point) Identify specimen H.

172. (1 point) Identify specimen I.

173. (1 point) Which specimen has experienced radiation damage?

174. (1 point) What is the nickname for specimen A?

175. (1 point) Specimen C is the state gemstone of which US state?

176. (2 points) a) Which specimen can form hopper crystals?

b) Briefly describe how hopper crystals are formed

177. (1 point) What is an alternate name for specimen H?

178. (1 point) What color will specimen D fluoresce under ultraviolet light?

179. (1 point) Which specimen is a source of the element commonly used in fireworks?

180. (2 points) Specimens A and F appear similar in color. In 1-2 sentences, explain a difference in how each interacts with light and gives its color.

181. (1 point) Which specimen at this station has the greatest hardness?

182. (1 point) What is the crystal habit of specimen E?

Station k

183. (1 point) Identify specimen A.

184. (1 point) Identify specimen B.

185. (1 point) Identify specimen C.

186. (1 point) Identify specimen D.

187. (1 point) Identify specimen E.

188. (1 point) Identify specimen F.

189. (1 point) Identify specimen G.

190. (1 point) Identify specimen H.

191. (1 point) Identify specimen I.

192. (1 point) Identify specimen J.

193. (1 point) Identify specimen K.

194. (1 point) Identify specimen L.

195. (1 point) Identify specimen M.

196. (1 point) Identify specimen N.

197. (1 point) Identify specimen O.

198. (1 point) Identify specimen P.

199. (1 point) Identify specimen Q.

200. (1 point) Identify specimen R.

Conclusion:

Thanks for taking these 50 minutes to think about rocks and minerals, we hope you found it a decent challenge. Credits to Dr. Wendy Mao and Dr. Ayla Pamukcu for letting us photograph the samples used in this test.

If you are interested in further pursuing Earth science, we encourage you to take a look at the US Earth Science Olympiad (<https://www.useso.org/>) for an opportunity to meet others with similar interests and deepen your Earth science skills. This test was written by USESO/IESO alumni.

Lastly, here are some real ruddy turnstones for your viewing pleasure.

