

Geology 222b - Problem Set on Binary Phase Diagrams

The following experimental data were determined by an imaginary Smith honors student on the hypothetical chemical system A-B. Based on observations of a number of igneous rocks, it was known in advance that the minerals likely to crystallize in the experiments have the compositions A, A₃B, AB₄, and B. These are all stoichiometric minerals that have no solid solution. A number (42) of homogeneous mixtures were made by carefully weighing and grinding together glasses of pure A and pure B. These powdered glass mixes were attached to Pt loops by fusing with a torch. The mixes were held in air in the hot zone of a 1 atmosphere furnace for 24 hours. At the end of the 24 hours, the sample was quenched by dropping the Pt loop into water. The sample bead was crushed and some of the powder was examined in oil with a petrographic microscope to identify the minerals present. If some of the sample was liquid at the time of the quench, isotropic glass was observed under the microscope. In a few cases, microscopic examination was supplemented with powder x-ray diffraction data. Because the experimenter began each experiment with a homogeneous glass, not all of the results are "reversed" equilibria. Nevertheless, these results are consistent with reversed data gathered by other labs and it is believed that equilibrium was closely approached in the Smith experiments.

Your assignment is to plot the data on a temperature-composition diagram and add interpretive lines, points, and labels to summarize the phase relations. In particular, please indicate which phase (A, A₃B, AB₄, B, GL) or group of phases is stable on each part of the diagram. Show the compositions of these phases as appropriate. Separate the regions of the diagram with lines or curves to show melt saturation with minerals (liquidus curves) and mineral melting relations (congruent melting, incongruent melting, eutectic melting). Note that it is unlikely that any of the chosen experimental compositions and temperatures lie exactly on any of the saturation curves or 3-phase (horizontal) lines.

| Run # | Comp (% B) | Temp (°C) | Quenched Phases |
|-------|------------|-----------|------------------------------------|
| 1 | 20 | 800 | A + A ₃ B |
| 2 | 40 | 800 | A ₃ B + AB ₄ |
| 3 | 60 | 800 | A ₃ B + AB ₄ |
| 4 | 80 | 800 | AB ₄ |
| 5 | 20 | 1000 | A + A ₃ B |
| 6 | 40 | 1000 | GL |
| 7 | 60 | 1050 | GL |
| 8 | 80 | 1000 | GL + B |
| 9 | 20 | 1200 | GL |
| 10 | 40 | 1200 | GL |
| 11 | 60 | 1200 | GL |
| 12 | 80 | 1200 | GL |
| 13 | 25 | 1050 | A ₃ B |
| 14 | 25 | 1100 | A ₃ B |
| 15 | 25 | 1150 | GL |
| 16 | 25 | 1125 | GL |
| 17 | 80 | 950 | GL + B |
| 18 | 80 | 875 | AB ₄ |
| 19 | 80 | 900 | GL + B |
| 20 | 100 | 1100 | B |
| 21 | 100 | 1300 | GL |

| Run # | Comp (% B) | Temp (°C) | Quenched Phases |
|-------|------------|-----------|-----------------------|
| 22 | 100 | 1200 | B |
| 23 | 100 | 1250 | GL |
| 24 | 100 | 1225 | B |
| 25 | 0 | 1050 | A |
| 26 | 0 | 1200 | A |
| 27 | 0 | 1350 | GL |
| 28 | 0 | 1275 | A |
| 29 | 0 | 1300 | A |
| 30 | 0 | 1325 | GL |
| 31 | 20 | 1050 | GL + A ₃ B |
| 32 | 15 | 1050 | GL + A |
| 33 | 20 | 1025 | GL + A ₃ B |
| 34 | 80 | 1100 | GL + B |
| 35 | 80 | 1150 | GL + B |
| 36 | 60 | 1000 | GL + B |
| 37 | 40 | 900 | GL |
| 38 | 40 | 850 | GL + A ₃ B |
| 39 | 40 | 875 | GL + A ₃ B |
| 40 | 50 | 875 | GL + AB ₄ |
| 41 | 45 | 875 | GL |
| 42 | 45 | 850 | GL + AB ₄ |