Ge 212 Problem Set 7

Due Friday December 6, 2019

**Binary Systems**

This is real experimental data (well, fudged a bit to make the interpretation unique and consistent) on the system MgO-SiO2 between 16 and 26 GPa. The experimental configuration consisted of multi-chamber Re capsules such that multiple compositions across the binary could be run at certifiably the same temperature and pressure. Your goal is to work up a complete *P*-*T*-*X* description of phase relations in this system within the studied region of *P*-*T* space (say, 14 to 28 GPa and 2400 to 3000 K).

1. Begin by constructing, as accurately as you can, isobaric *T*-*X* sections at 16, 20, 23, 24, and 26 GPa

* the *X*-axis should be mole fraction SiO2 running from 0 to 1.
* Assume that the melting points of periclase and stishovite are at > 3000 K at all these pressures, so the liquidus goes off the top of your diagrams at both ends.
* The solid phase compositions are fixed: Periclase (Pc) is MgO. Anhydrous phase B (AnhB) is Mg14Si5O24. Ringwoodite (Rw) and Wadsleyite (Wd) are both Mg2SiO4. Majorite (Mj) and Perovskite (Pv) are both MgSiO3. Stishovite (St) is SiO2.
* The locations of some univariant reactions are bounded but not specified by the data. You should allow yourself to possibly adjust these later once you see how the *P*-*T* diagram works up. So, work in pencil or on a computer screen.
* Keep in mind that anytime the sequence of stable phases across the diagram changes in any way, there must be a univariant reaction separating the different assemblages.

1. Now construct a *P*-*T* projection, showing all univariant reactions that occur within the *P*-*T* space defined above, and the invariant points where they meet. Adjust temperatures of univariant reactions at the experimental pressures so that they are smooth curves in *P*-*T* space. Label each univariant curve with the involved phases or phase assemblages on the sides where they are stable. Label the divariant fields by the sequence of one- and two-phase fields observed there as XSiO2 goes from 0 to 1. Finally, provide a blow-up of each invariant point (hint, there are 7 of them, I claim) large enough to see that the Schreinemaker’s relations and metastable extensions there are correct. Two of the invariant points involve four phases that are all different in composition. The other five all involve a reaction between two phases of equal composition, which affects their appearance in P-T space.

Here are the data:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| P (GPa) | T (K) | XSiO2Bulk (mol %) | Phases | XSiO2Liquid (mol %) |
| 16 | 2533 | 62.5 | Mj + St |  |
|  |  | 50.0 | Mj |  |
|  |  | 45.8 | Liq + Mj | 44.7 |
|  |  | 41.7 | Wd + Liq | 44.5 |
|  |  | 15.0 | Pc + AnhB |  |
| 16 | 2593 | 100.0 | St |  |
|  |  | 62.5 | Liq + St | 51.1 |
|  |  | 50.0 | Mj |  |
|  |  | 37.5 | AnhB + Liq | 42.3 |
| 16 | 2637 | 51 | Liq | 51 |
|  |  | 44.3 | Liq | 44.3 |
|  |  | 42 | Liq | 42 |
|  |  | 25.0 | Pc + Liq | 40.1 |
| 16 | 2643 | 62.5 | Liq + St | 54.9 |
|  |  | 50 | Liq | 50 |
|  |  | 33.3 | Pc + Liq | 39.5 |
| 16 | 2733 | 52.8 | Liq | 52.8 |
|  |  | 44.6 | Liq | 44.6 |
|  |  |  |  |  |
| 20 | 2544 | 37.5 | Wd + Mj |  |
|  |  | 45.8 | Wd + Mj |  |
| 20 | 2596 | 41.7 | Wd + Liq | 43.6 |
|  |  | 45.8 | Liq + Mj | 44.0 |
| 20 | 2642 | 45.8 | Liq | 45.8 |
|  |  | 41.7 | Pc + Liq | 41.0 |
| 20 | 2750 | 50.0 | Liq | 50.0 |
|  |  | 42.9 | Liq | 42.9 |
|  |  | 37.5 | Pc + Liq | 40.8 |
|  |  |  |  |  |
| 23 | 2493 | 41.7 | Rw + Pv |  |
| 23 | 2593 | 41.7 | Wd + Pv |  |
| 23 | 2693 | 41.7 | Wd + Liq | 43.5 |
|  |  | 48.5 | Liq + Maj | 44.1 |
|  |  |  |  |  |
| 24 | 2450 | 25.0 | Pc + Rw |  |
| 24 | 2673 | 33.3 | Pc + Pv |  |
|  |  | 50.0 | Pv |  |
|  |  | 62.5 | Pv + St |  |
| 24 | 2764 | 33.3 | Pc + Liq | 43.0 |
|  |  | 43.7 | Liq | 43.7 |
|  |  | 50.0 | Pv |  |
| 24 | 2800 | 43.3 | Liq | 43.3 |
|  |  | 48.5 | Liq + Pv | 46.6 |
|  |  | 60 | Liq + St | 50.9 |
| 24 | 2830 | 33.3 | Pc + Liq | 41.7 |
|  |  | 43.1 | Liq | 43.1 |
| 24 | 2873 | 33.3 | Pc + Liq | 41.8 |
|  |  | 49.5 | Liq | 49.5 |
|  |  |  |  |  |
| 26 | 2800 | 37.5 | Pc + Liq | 41.7 |
|  |  | 45.8 | Liq + Pv | 42.8 |
| 26 | 2850 | 48.5 | Liq + Pv | 45.0 |
|  |  | 60.0 | Pv + St |  |
| 26 | 2873 | 42.6 | Liq | 42.6 |
|  |  | 48.5 | Liq + Pv | 47.8 |
|  |  | 60.0 | Liq + St | 52.0 |