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12.479 Trace-Element Geochemistry  
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## Lecture 7, Appendix 1

### Partition Coefficient Literature (this list is not complete!)

#### I. RECENT NATURAL SYSTEMS STUDIES

##### A. Phenocryst/Matrix

Norman et al., Trace element distribution coefficients for pyroxene, plagioclase and olivine in evolved tholeiite, etc., *Am. Min.*, 9, 888-899, 2005.

##### B. Inter-mineral partitioning in upper mantle rocks

Lee, Harbart and Leeman, Extension of lattice strain theory to mineral/mineral REE partitioning: an approach for assessing equilibrium and developing internally consistent partition coefficients between olivine, orthopyroxene, clinopyroxene and basaltic melt, *GCA*, 71, 481-496, 2007.

#### II. EXPERIMENTAL STUDIES

##### A. Important Reviews:

- 1) Blundy and Wood, Partitioning of trace elements between crystals and melts, *EPSL*, 210, 383-397, 2003.
- 2) Wood and Blundy, Trace element partitioning under crustal and uppermost mantle conditions: the influences of ionic radius, cation charge, pressure and temperature, *Treatise On Geochemistry*, Volume 2, Chapter 9, pp 395-424, 2003 (available on MIT Library Web Site).
- 3) Jones, J.H., Experimental Trace Partitioning, in *Rock Physics and Phase Relations, A Handbook of Geophysical Constants*, AGU Reference Shelf 3, 73-104, 1995.

- 4) Green, T.H., Experimental studies of trace-element partitioning applicable to igneous petrogenesis, *Chem. Geol.*, 117, 1-37, 1994. Note that *Chem. Geol.* 117 is a special 1994 issue devoted to “Trace Element Partitioning With Application to Magmatic Processes”. (It contains 20 papers that are not itemized in the following lists).
- 5) McKay, G.A., Partitioning of Rare Earth Elements between major silicate minerals and basaltic melts, *Reviews in Mineralogy*, Vol. 21, *Mineral. Soc. Amer.*, B.R. Lipin and G. McKay (eds.), 45-77, 1989.

**B. Contributions from the Wood-Blundy Group:**

- 1) Blundy and Wood, Crystal-chemical controls on the partitioning of Sr and Ba between plagioclase feldspar, silicate melts and hydrothermal solution, *Geochim. Cosmochim. Acta*, 55, 193-209, 1991.
- 2) Wood and Blundy, Prediction of crystal-melt partition coefficients from elastic moduli, *Nature*, 372, 452-454, 1994.
- 3) Wood and Blundy, The effect of cation charge on crystal-melt partitioning of trace elements, *EPSL*, 188, 59-71, 2001.
- 4) Brooker et al., The “zero charge” partitioning behavior of noble gases during mantle melting, *Nature*, 423, 738-741, 2003.
- 5) Heber, Brooker, Kelley and Wood, Crystal-melt partitioning of noble gases (He, Ne, Ar, Kr and Xe) for olivine and clinopyroxene, *Geochim. Cosmochim. Acta*, 71, 1041-1061, 2007.
- 6) McDade, Blundy and Wood, Trace element partitioning on the Tinaquillo lherzolite solidus at 1.5 Gpa, *Phys. Earth & Planet. Int.*, 139, 129-147, 2003.

- 7) Wood, B.J. and Trigila, R., Experimental determination of aluminous clinopyroxene-melt partition coefficients for potassic liquids with application to the evolution of the Roman Province magmas, *Chem. Geol.*, 172, 213-223, 2001.
- 8) Hill, F., Wood, B.J., and Blundy, J.D., The effect of Ca-Tschermaks component on trace element partitioning between clinopyroxene and silicate melt, *Lithos*, 53, 203-215, 2000.
- 9) Blundy, J. and Dalton, J., Experimental comparison of trace element partitioning between clinopyroxene and melt in carbonate and silicate systems, and implications for mantle metasomatism, *CMP*, 139, 356-371, 2000.

**C. Contributions from the Salters/Longhi Group:**

- 1) Salters, Longhi, Bizimis, Near mantle solidus trace element partitioning at pressures up to 3.4 Gpa, *Geochem. Geophys. Geosystems* (electronic AGU journal) 10.1029/2001 GC 000148 (2002).
- 2) Salters and Longhi, Trace element partitioning during the initial stages of melting beneath mid-ocean ridges, *EPSL*, 166, 15-30, 1999.

**D. The Henry's Law Problem**

- 1) Drake, M.J. and Holloway, J.R., "Henry's Law behavior of Sm in a natural plagioclase/melt system: Importance of experimental procedure, *Geochim. Cosmochim. Acta*, 42, 678-684, 1982.
- 2) Drake, M.M. and Holloway, J.R., Partitioning of Ni between olivine and silicate melt: the 'Henry's Law Problem' re-examined, *Geochim. Cosmochim. Acta*, 45, 431-437, 1981.

- 3) Navrotsky, A., Thermodynamics of element partitioning: (1) Systematics of transition metals in crystalline and molten silicate and (2) Defect chemistry and the “Henry’s Law Problem”, *Geochim. Cosmochim. Acta*, 42, 887-901, 1978.
- 4) Harrison, W.J. and B.J. Wood, An experimental investigation of the partitioning of REE between garnet and liquid with reference to the role of defect equilibria, *Contrib. Mineral. Petrol.*, 72, 145-155, 1980.
- 5) Watson, E.B., Henry’s Law behavior in simple system and magmas: Criteria for discerning concentration-dependent partition coefficients in nature, *Geochim. Cosmochim. Acta*, 49, 917-923, 1985.
- 6) Prowatke and Klemme, Rare earth element partitioning between titanite and silicate melts: Henry’s Laws Revisited, *Geochim. Cosmochim. Acta*, 70, 4997-5012, 2006.

#### **E. Beta-Track Mapping Procedure**

- 1) Mysen, B., Seitz, M.G., Trace element partitioning determined by beta-track mapping: an experimental study using carbon and samarium as examples, *J. Geophys. Res.*, 80, 2627-2635, 1974.
- 2) Mysen, B., Trace-element partitioning between garnet peridotite minerals and water-rich vapor: experimental data from 5 to 30 kbar, *Am. Miner.*, 64, 272-287, 1979.
- 3) Mysen, B., Experimental determination of rare-earth element partitioning between hydrous silicate melt, amphibole and garnet peridotite minerals at

upper mantle pressures and temperatures, *Geochim. Cosmochim. Acta*, 42, 1253-1263, 1978.

- 4) Wendlandt, R.F. and Harrison, W.J., Rare earth partitioning between immiscible carbonate and silicate liquids and CO<sub>2</sub> vapor: results and implication for the formation of light rare-earth enriched rocks.
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- 6) Tingle, An evaluation of the Carbon-14 Beta track technique: Implications for solubilities and partition coefficients determined by beta track mapping, *Geochim. Cosmochim. Acta*. 51, 2479-2487, 1987.

### **III. SPECIFIC MINERALS**

#### **A. Clinopyroxene:**

- 1) Wood and Blundy, A predictive model for rare earth element partitioning between clinopyroxene and anhydrous silicate melt, *Contrib. Mineral. Petrol.*, 129, 166-181, 1997.
- 2) Lundstrom, Shaw, Ryerson, Williams and Gill, Crystal chemical control of clinopyroxene-melt partitioning in the Di-Ab-An system: implications for elemental fractionations in the depleted mantle, *Geochim. Cosmochim. Acta*, 62, 2849-2862, 1998.
- 3) Blundy, Robinson and Wood, Heavy REE are compatible in clinopyroxene on the spinel lherzolite solidus, *Earth Planet. Sci. Letts.*, 160, 493-504, 1998.

- 4) Hill, F., Wood, B.J., and Blundy, J.D., The effect of Ca-Tschermaks component on trace element partitioning between clinopyroxene and silicate melt, *Lithos*, 53, 203-215, 2000.
- 5) Wood, B.J., and Trigila, R., Experimental determination of aluminous clinopyroxene-melt partition coefficients for potassic liquids with application to the evolution of the Roman Province potassic magmas, *Chem. Geol.* 172, 213-223, 2001.
- 6) Pertermann and Hirschmann, Trace element partitioning between vacancy-rich eclogitic clinopyroxene and silicate melt, *Amer. Mineral.*, 87, 1365-1376, 2002.
- 7) Schosnig and Hoffer, Compositional dependence of REE partitioning between diopside and melt at 1 atmosphere, *Contrib. Mineral. Petrol.*, 133, 205-216, 1998.
- 8) Johnson, Experimental determination of partition coefficients for rare earth and high-field strength elements between clinopyroxene, garnet and basaltic melt at high pressures, *Contrib. Mineral. Petrol.*, 133, 60-68, 1998.
- 9) Gaetani, G.A. and Grove, T.L., Partitioning of rare earth elements between clinopyroxene and silicate melt: crystal chemical controls, *Geochim. Cosmochim. Acta*, 59, 1951-1962, 1995.
- 10) Lundstrom et al., Compositional controls on the partitioning of U, Th, Ba, Pb, Sr and Zr between clinopyroxene and haplobasaltic melts: implications for uranium series disequilibria in basalts, *EPSL*, 128, 407-423, 1994.
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- 12) Hart, S.R. and Dunn, T., Experimental cpx/melt partitioning of 24 trace elements, *Contrib. Mineral. Petrol.*, 113, 1-8, 1993.

**B. Garnet:**

- 1) Van Westrenen, Blundy and Wood, Crystal-chemistry controls on trace element partitioning between garnet and anhydrous silicate melt, *Amer. Min.* 84, 838-847, 1999.
- 2) Van Westrenen, Wood and Blundy, A predictive thermodynamic model of garnet-melt trace element partitioning, *Contrib. Mineral. Petrol.*, 142, 219-234, 2001.
- 3) Klemme, Blundy and Wood, Experimental constraints on major and trace element partitioning during partial melting of eclogite, *Geochim. Cosmochim. Acta*, 66, 3109-3123, 2002.
- 4) Van Westrenen et al., HFSE/REE fractionation during partial melting in the presence of garnet: Implications for identification of mantle heterogeneities, *Geochem. Geophys. Geosyst.* 2, 2000 GC000133.
- 5) Petermann, et al., Experimental determination of trace element partitioning between garnet and silica-rich liquid during anhydrous partial melting of MORB-like eclogite. *Geochem. Geophys. Geosystems*. doi:10.129/2003GC000638, 2004.
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- 1) Schwant and McKay, Rare earth element partition coefficients from enstatite/melt synthesis experiments, *GCA*, 62, 2845-2848, 1999.



- 2) Taura, Yurimoto, Kurita and Sueno, Pressure dependence on partition coefficients for trace elements between olivine and co-existing melts, *Phys. Chem. Minerals*, 25, 469-484, 1998.
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- 4) Beattie, P., Ford, C. and Russell, D., Partition coefficients of olivine-melt and orthopyroxene-melt systems, *Contrib. Mineral. Petrol.*, 109, 212-224, 1991.
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- 6) McKay, G., Crystal/liquid partitioning of REE in basaltic systems: extreme fractionation of REE in olivine, *Geochim. Cosmochim. Acta*, 50, 68-79, 1986.

**D. Plagioclase:**

- 1) Bedard, Trace element partitioning in plagioclase, *GCA*, 70, 3717-3742, 2006.
- 2) Bindeman, Davis and Drake, Ion microprobe study of plagioclase-basalt partition experiments at natural concentration levels of trace elements, *Geochim. Cosmochim. Acta*, 62, 1175-1193, 1998.
- 3) Bindeman, I.N. and Davis, A.M., Trace element partitioning between plagioclase and melt: Investigation of dopant influence on partition behavior, *Geochim. Cosmochim. Acta*, 64, 2863-2878, 2000.

- 4) Vander Auwera, J., Longhi, J., and Duchesne, J.C., The effect of pressure on  $D_{Sc}$  (plag/melt) and  $D_{Cr}$  (opx/melt): Implications for anorthosite petrogenesis, *EPSL*, 178, 303-314, 2000.
- 5) Miller, Asimow, and Burnett, Determination of melt influence on divalent element partitioning between anorthite and CMAS melts, *Geochim. Cosmochim. Acta*, 70, 4258-4274, 2006.

**E. Amphibole:**

- 1) Hilyard, Nielsen, Beard, Patino-Douce and Blencoe, Experimental determination of the partitioning behavior of rare earth and high field strength elements between paragonitic amphibole and natural silicate melts, *Geochim. Cosmochim. Acta*, 64, 1103-1120, 2000.
- 2) Dalpe, C. and Baker, D.R., Experimental investigation of large-ion-lithophile-element-high-field-strength-element- and rare-earth-element-partitioning between calcic amphibole and basaltic melt: the effects of pressure and oxygen fugacity, *CMP*, 140, 233-250, 2000.
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- 4) Oberti, R., Vanucci, R., Zanetti, A., Tiepolo, M. and Brumm, R.C., A crystal chemical re-evaluation of amphibole/melt and amphibole/clinopyroxene  $D_{Ti}$  values in petrogenetic studies, *Am. Mineral.*, 85, 407-419, 2000.

- 5) Tiepolo, M., Vannucci, R., Oberti, R., Foley, S., Bottazzi, P. and Zanetti, A., Nb and Ta incorporation and fractionation in titanium pargasite and kaersutite: crystal-chemical constraints and implications for natural systems, *EPSL*, 176, 185-201, 2000.
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- 8) Klein et al., Partitioning of high field strength and rare-earth elements between amphibole and quartz dioritic to tonalitic melts: an experimental study, *Chem. Geol.*, 138, 257-271, 1997.
- 9) LaTourette et al., Trace element partitioning between amphibole, phlogopite and basanite melt, *EPSL*, 135, 13-30, 1995.
- 10) Brenan et al., Experimental determination of trace-element partitioning between pargasite and a synthetic hydrous andesite melt, *EPSL*, 135, 1-11, 1995.
- 11) Adam, J., Green, T.H., and Sie, S.H., Proton microprobe determined partitioning of Rb, Sr, Ba, Y, Zr, Nb and Ta between experimentally produced amphiboles and silicate melts with variable F content, *Chem. Geol.*, 109, 29-49, 1993.

#### **F. Micas: Phlogopite and Biotite:**

- 1) Guo and Green, Experimental study of the partitioning between phlogopite and silicate liquid, *Lithos*, 93-96, 1990.

- 2) La Tourette, et al., Trace element partitioning between amphibole, phlogopite and basanite melt, *EPSL*, 135,13-30, 1995
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- 4) Melzer and Wunder, K-Rb-Cs partitioning between phlogopite and fluid: experiments and consequences for the LILE signatures of island arc basalts, *Lithos*, 59, 69-90, 2001.
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**G. Rutile:**

- 1) Brenan et al., Rutile-aqueous fluid partitioning of Nb, Ta, Hf, Zr, U and Th: Implications for high field strength element depletions in island arc basalts, *EPSL*, 128, 327-339, 1994.

- 2) Stalder et al., Mineral aqueous fluid partitioning of trace elements at 900°-1200°C and 3.0-5.7 Gpa: New experimental data for garnet, clinopyroxene and rutile and implications for mantle metasomatism, *GCA*, 1781-1801, 1998.
- 3) Foley, Barth and Jenner, Rutile/melt partition coefficients for trace elements and an assessment of the influence of rutile on the trace element characteristics of subduction zone magmas, *GCA*, 64, 933-938, 2000.
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#### **I. Magnetite:**

- 1) Nielsen and Beard, Magnetite-melt HFSE partitioning, *Chem. Geol.*, 164, 21-34, 2000.

#### **J. Apatite:**

- 1) Prowatke and Klemme Trace element partitioning between apatite and silicate melts, *Geochim. Cosmochim. Acta*, 70, 4523-4527, 2006.

### **III. Effects of Liquid Composition and Temperature**

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#### **B. Role of H<sub>2</sub>O:**

- 1) Green, Blundy, Adam and Yaxley, SIMS determination of trace element partition coefficients between garnet, clinopyroxene and hydrous basaltic liquids at 2-7.5 Gpa and 1080°-1200°C, *Lithos*, 53, 165-167, 2000.

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- 3) Gaetani, Kent, Grove, Huthcheson and Stolper, Mineral/melt partitioning of trace elements during hydrous peridotite partial melting, *Contrib. Mineral. Petrol.*, 145, 391-405, 2003.

**C. Role of Melt Composition in Controlling Partition Coefficients:**

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- 3) Gaetani, The influence of melt structure on trace element partitioning at the peridotite solidus, *Contrib. Mineral. Petrol.*, 147, 511-527, 2004.
- 4) Mysen, B.O., Element partitioning between minerals and melt, melt composition and melt structure, *Chem. Geol.*, 229, 162-172, 2004.
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#### **D. Mineral-Aqueous Fluid Partitioning**

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#### **IV. Controls on Core Formation**

- 1) Corgne, Keshav, Fei, and McDonough, How much potassium is in the earth's core? New insights from partitioning experiments, *EPSL*, 256, 567-576, 2007.
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## **V. Metamorphic Processes**

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