PRELIMINARY THERMOBAROMETRY OF LUNAR DUNITES AND LHERZOLITES

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Introduction: Buoyed by our success in calculating the equilibration temperature and pressure of a clast of lunar dunite in meteorite Northwest Africa (NWA) 11421 [1], we've applied the same method to other lunar rocks. Calculated pressures are surprisingly high.

Thermobarometry: Equilibration temperatures are calculated from published two-pyroxene Ca-Mg-Fe exchange thermometers, which feed to multi-equilibrium barometry using the THERMOCALC code [2] and the calibration of [3] which is validated from 0.06 to ~1 GPa. The most pressure-sensitive equilibrium in lherzolites (plagioclase+olivine+augite+orthopyroxene) is

$$CaAl_2Si_2O_8 + Mg_2SiO_4 = CaAl_2SiO_6 + 2\ MgSiO_3$$

Anorthite + forsterite = CaTs(aug) + enstatite;

where CaTs is the Ca-Tschermak's component in augite. Calculation of the CaTs component activity in augite requires knowing Al abunances on its tetrahedral (IV) and octahedral (VI) sites. In turn, this requires highly precise and accurate EMP analyses because, in the 4-cation augite formula, Al(IV) = [2-Si], and Al(VI) = Al(total)-Al(IV). Following [1], we calculate equilibration p & T for some clasts in NWA 11421 and its pairs, and selected other lunar samples.

Results: The Figure shows our results here and those for the NWA 11421 dunite clast [1]. Results for several samples and clasts were inconsistent with mineral chemical equilibria and are not shown. The point for NWA 10401 is for minerals in a dunititic clast [4]. NWA 11303 is paired with NWA 11421; the graphed point is for a feldspathic granulite [5]. 76535 is the famous troctolite [6]; the NWA 5000 point is for its leucogabbronorite lithology [7].

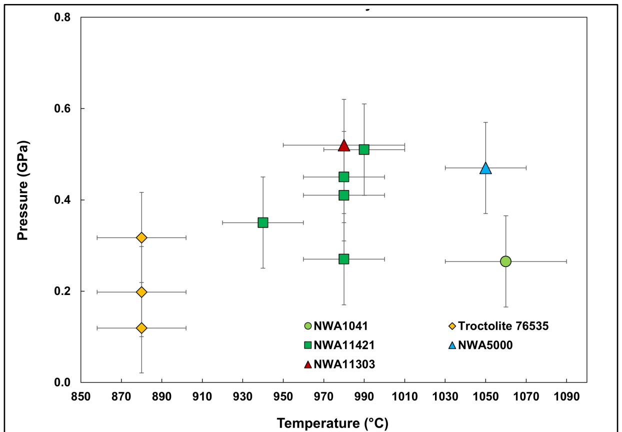

Figure. Calculated equilibration temperatures and pressures for selected lunar samples.

Caveats: Accurate thermobarometry requires high-quality EMPA mineral analyses, and many in the literature could profitably be redone with better calibrations. The thermobarometric calibration used here [3] was established for pressures somewhat above those obtained here, and oxygen fugacities significantly above lunar values. It seems likely that the calculated pressures are close to (if not completely) accurate; it is not obvious that oxygen fugacity affects calculation of CaTs activity in augite.

Implications: The calculated p-T for the dunite in NWA 11421 is (within uncertainty) on the estimated selenotherm [1], but the dunite in NWA 10401 is nearly 100°C hotter than the seleotherm (at calculated p). Pressures for the feldspathic NWA 11303 granulite and NWA 5000 leucogabbronorite are high enough to be in the lunar mantle [8]. If confirmed, they suggest significant lithologic heterogeneity and feldspathic rock at those depths [9], i.e., that the Moon's crust-mantle boundary is somewhat arbitrary.

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