THE CRYSTALLOGRAPHY OF PIGEONITES FROM BASALTIC VITROPHYRE 15597, G.E. Brown, B.A. Wechsler and P.W. Weigand, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540.

Basaltic vitrophyre 15597, collected from the rim of Hadley Rille, is composed of 60% acicular clinopyroxene crystals, less than 1% chromian spinel with the remainder a dark brown quench glass. In a detailed microprobe and petrographic study, Weigand and Hollister (1) found evidence suggesting that this rock reached the lunar surface in an entirely liquid state and that pigeonite and augite nucleated in a rapid, metastable fashion before final quenching. The pigeonites from rock chip 15597,28 should therefore exhibit cation ordering and domain and exsolution textures representing one extreme of pigeonite cooling history on the moon.

Some twenty pyroxene crystals were separated from chip 15597,28 and examined using the Buerger precession technique. All were found to be pigeonites. Because of the small size ($< 100\mu$) of most of the crystals, long $\underline{h}0\underline{l}$ exposures (up to 100 hours) were necessary to check for intergrown augite. A number of crystals examined contain glass cores rimmed by expitaxial (100) augite and/or are overgrown by (100) augite rims. Pigeonite compositions estimated from the $\underline{b}$-β nomogram (2) are grouped at $Wo_5En_{69}Fs_{26}$ which agrees well with the "inner" pigeonite composition from the study of Weigand and Hollister. The (100) augite is estimated to be of composition $Wo_{32}En_{52}Fs_{16}$. Little if any (001) augite was detected in precession photographs exposed up to 100 hours. Chemical zoning resulting from rapid nucleation is indicated in a number of the pigeonite crystals by several sets of weak pigeonite reflections between the main pigeonite and (100) augite reflections.

Roughly half of the crystals examined are twinned on (100). Probe analysis of twinned and untwinned crystals show that both types have similar pigeonite core compositions, $Wo_6En_{68}Fs_{26}$, with epitaxial augite rims ranging in composition from $Wo_{31}En_{44}Fs_{25}$ (twinned) to $Wo_{29}En_{20}Fs_{51}$ (untwinned). The similarity in compostion of the core pigeonite in each case suggests that the twinned and untwinned crystals were derived from the same melt. Because the twinning is on a rather coarse scale, because inversion from protoenstatite to clinoenstatite

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commonly produces diffuse streaks along a* (3) which were not detected in our twinned pigeonites, and because the composition of our sample is more iron-rich than experimentally produced proto-phases, it is unlikely that the twinning was produced by inversion from a protopyroxene precursor. Rather, the twinning may indicate inversion from an orthopyroxene at a temperature near 1150°C for the pigeonite composition listed above. (M. Ross, personal communication). A similar conclusion was reached by Takeda and Ridley (4) for twinned pigeonites from rock 14310.

An untwinned pigeonite crystal with a small glass core rimmed by (100) augite constituting roughly 10% of the crystal's diffracting volume was used to collect intensity data. Precise cell parameters of the pigeonite are a=9.698(3), b=8.895(2), c=5.2459(7), β =108.61(1). The final weighted R=0.052 using 812 reflections. Mean M1(VI)-O and M2(VII)-O bond lengths are 2.082 and 2.341 Å, respectively. Comparison of Si-O2 bond lengths indicates that ~ 0.07 Al is located in the SiB tetrahedron. The cation distribution is 0.829(5) Mg + 0.171 Fe in M1 and 0.411 Mg + 0.469 Fe + 0.12 Ca in M2 yielding a K_D=0.18. This is one of the highest K_D values yet determined for a lunar pigeonite indicating a relatively high degree of disorder resulting from rapid cooling. The temperature at which the Fe/Mg distribution of 15597 pigeonites equilibrated is roughly estimated to be 1050°C using the plot of K_D versus T from Hafner et al. (5).

Peak diffuseness measurements on a 4-circle diffractometer showed that h+k (odd) reflections are more diffuse than adjacent h+k (even) reflections. The differences are similar to those determined for a terrestrial pigeonite from the Isle of Mull (5) suggesting small domains on the order of several hundred angstroms in diameter.

Chemical and crystallographic evidence is indicative of rapid crystallization and cooling of 15597 pigeonites from an erupted melt. Cooling below ~ 1050°C was too rapid to allow further diffusion of Fe and Mg between octahedral sites. It is also probable that subsequent reheating if any of 15597 basaltic vitrophyre has not exceeded ~ 500°C for long durations.

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