Calcium in olivine as an indicator of water content of magma

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Olivine phenocryst in volcanic rocks generally includes 0.1-0.6 wt% CaO. The olivines observed in arc basalts are characterized by low-Ca content (less than 0.25 wt%) compared with those in MORB and OIB (0.2-0.6 wt%). Calcium partitioning between olivine and silicate liquid is examined based on published data of hydrous (N=77, T=940-1290C, P=517bar-20kbar) and anhydrous (N=411, T=1055-1520C, P=1bar-30kbar) experiments for basalts and andesites. Partition coefficients of Ca between olivine and liquid decrease with increasing water content of coexisting silicate liquid at constant T and P. Therefore, it is apparent that the lower CaO content in olivine phenocryst in arc basalts is attributed to the higher water content in subduction-related basalts. By combining H2O dependence of olivine liquidus temperature and of CaO partitioning, we formulated olivine-liquid geothermometer and geohygrometer. The water contents of representative arc basalts and basaltic andesites, picritic basalts of Hawaii and MORBs calculated using olivine-liquid geohygrometers are consistent with those of several basalts reported by previous studies and H2O contents estimated from Ca-Na exchange partitioning between plagioclase and liquid. The CaO content of olivine at given CaO content of melt increases with increasing pressure and Na2O+K2O content of liquid and decreases with increasing temperature and water content. The calcium content of olivine in subalkaline basalts at constant pressures is apparently independent of the degree of magma evolution, because the CaO content of basaltic liquid usually decreases with decreasing magmatic temperature. Consequently, the partitioning behavior of Ca in olivine is only affected by water contents, and the CaO content of olivine can become a useful indicator of water content of basaltic magma.