The crystal chemistry of macfallite

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The crystal structure of macfallite (ideally-$Ca_2Mn^{3+}{}_3Si_3O_{11}(OH)_3$) from the Keweenaw Peninsula, USA, was refined by single crystal X-ray diffraction. The distribution of cations between the three independent octahedral sites *M*1, *M*2 and *M*3 were determined in order to investigate the nature of the cation substitutions and the crystalchemical properties of macfallite and related minerals. The chemical composition of the macfallite crystal in this study in terms of oxide wt.% is 33.14 SiO_2, 2.49 Al_2O_3, 0.09 V_2O_3, 35.80 total Mn_2O_3, 0.05 total Fe_2O_3, 0.45 CuO, 0.69 MgO, 20.53 CaO, 0.07 SrO, and 0.03 Na_2O. The structure [a = 10.218(4), b = 6.072(2), c = 8.959(3) Å, β = 110.75(3)º] was refined using 1717 unique reflections that converged to a *R* factor of 4.2%. The site-populations at the *M*1, *M*2 and *M*3 sites were determined from their site-scattering values. The structural formula $Ca_2{}^{W}(Mn^{3+}{}_{0.77}Al_{0.23})^{M1}(Mn^{3+}{}_{0.84}Al_{0.04}Mg_{0.09}Cu_{0.03})^{M2}(Mn^{3+}{}_{0.96}Al_{0.04})^{M3}Si_3O_{10.88}(OH)_{3.12}$ results. Divalent cations are located at the *M*2 site. This is consistent with the fact that the volume of the $M2O_6$ octahedron is the largest among the three octahedral sites, and that the bond valence sum for the *M*2 site is about 2.75 v.u., which is less than those for *M*1 and *M*3. Aluminum is essentially partitioned onto the *M1* site, which is consistent with the proposal of Moore *et al*. (1985) ($(Mn^{3+}{}_{0.7}Al_{0.3})^{M2}$). However, the present study also shows that small amounts of Al are located at the *M*2 and *M*3 sites. The calculated bond valence sums of 1.69, 1.26, 0.99 and 1.18 v.u. for OH1, OH2, OH3 and O5, respectively, suggest that hydroxyl groups are located not only at the positions of OH1, OH2 and OH3 (Moore *et al*., 1985) but also at O5. The values for OH3 and O5 are close to 1.0, while those for the OH1 and OH2 are greater than 1.0. The substitution of $M^{2+}{}_{M2} + H^{+}{}_{OH1} + O^{2-}{}_{OH1} \leftrightarrow M^{3+}{}_{M2} + O^{2-}{}_{OH1}$ may act to reduce the number of hydrogen atoms in the structure. This substitution has been suggested for pumpellyite (Yoshiasa and Matsumoto, 1985).

References

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Geochemistry of basalts from intra-transform spreading centers: Implications for melt migration models

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The advantage of studying basalts from intra-transform spreading centers is that they provide well-defined locations of melt delivery and crustal formation. Also, magmatism in fracture zones is not supported by long-lived magma chambers or along-axis transport of melt from other parts of the spreading system. Thus lavas from fracture zones represent pre-aggregated melts and their compositions provide insight into models of melt generation and transport processes beneath mid-ocean ridges.

The Quebrada/Discovery/Gofar (QDG) transform fault system offsets the fast-spreading East Pacific Rise (3°-5°S) by approximately 400km and is composed of 7 active intra-transform spreading centers ranging in length from 5 to 70km. Forty-seven dredges of young intra-transform basalts were collected from this area and analyzed for volatiles, major and trace elements.

QDG basalts exhibit varying degrees of differentiation, which correlate with the estimates of crustal thickness of each ridge segment derived from gravity models. The incompatible trace element ratios (e.g., Th/La) of these lavas range significantly from ultra-depleted to extremely enriched compositions. Furthermore, the level of enrichment correlates well with both ratios of volatiles to similarly incompatible refractory elements (e.g., H_2O/Ce) and indicators of depth of melt segregation (e.g., Sm/Yb). Overall, the chemical variation of these basalts is greater than that previously found in fracture zones (such as Siqueiros and Garrett FZ) and is similar to the compositional range defined by northern EPR seamounts.

Models of mantle flow and melt delivery in the QDG study area predict significantly different compositions and crustal thicknesses at the various intra-transform spreading centers. We will test the validity of the different models by comparing the observed and predicted lava compositions.