Appendix

The pre-etched basal area of a hemispherical etch-pit has one-half the surface area of the hemisphere described by Equation 2. Even if the hemispherical etch-pit were produced by ever-smaller circular cross-sections working from the initial base inward rather than from radial retreat of the etch-pit wall, the area of surface from which mass is removed would vary by only a factor of two from Equation 2.

Velbel (2009) showed that the characteristic etch-pit formed during natural low-temperature aqueous weathering of olivine is a cone (Fig. 1, arrows). Pairs of cones joined at the base are common; cross-sections through these bicones are diamond-shaped (Velbel 2009). Two-dimensional cross-sections through these etch-pits in polished sections are often triangular wedge or notch-shaped. These cross-sections, and secondary-electron images of intact grain-surface topography suggest, that most etch-pits exposed at olivine grain surfaces are either single cones or halves of bicones (Fig. 12 in Velbel 2009). Two ideal cross-section geometries are possible. In one, the (obtuse) apex of the wedge is the apex of a single cone; in the other, the (acute) apex of the wedge is the edge along which the two cones of a (truncated half of a) bicone are joined (Fig. 12 in Velbel 2009). In either ideal case, the surface area of the etch-pit wall is one-half the surface area of a bicone.

For a circular right cone (or half of a bicone) with radius *r*, height *h*, and slant height *s*, the surface area of the walls is given by

$$A_{\text{cone,walls}} = A_{\text{half-bicone,walls}} = \pi rs = \pi r(r^2+h^2)^{0.5}$$

Nowicki and Velbel (2011) empirically determined that the shapes of olivine etch-pit cross-sections vary around an average of $r{:}h = 1.78$. Substituting $r/1.78 = h$ (from $r = 1.78h$),

$$A_{\text{half-bicone,walls}} = \pi r_{\text{half-bicone}} s = \pi r_{\text{half-bicone}}[r^2_{\text{half-bicone}}+(0.562\ r_{\text{half-bicone}})^2]^{0.5}$$

$$A_{\text{half-bicone,walls}} = \pi r_{\text{half-bicone}}(r^2_{\text{half-bicone}}+0.316\ r^2_{\text{half-bicone}})^{0.5}$$

$$A_{\text{half-bicone,walls}} = \pi r_{\text{half-bicone}} +(1.316 r^2_{\text{half-bicone}})^{0.5} = \pi r_{\text{half-bicone}} 1.15\ r_{\text{half-bicone}} = \pi 1.15 r^2_{\text{half-bicone}}$$

Given that

$$A_{\text{hemisphere}} = \pi r_{\text{hemisphere}}^2$$

a circular right conical or half-biconical olivine etch-pit of radius *r* with the observed average geometry of natural olivine etch-pits has only 15% more surface area than a hemispheric etch-pit of the same radius. Etch-pits on artificially or experimentally etched olivines exhibit various different geometries and different surface-area and volume relationships, but do not deviate from equancy much more than do observed etch-pits on naturally weathered olivine.

Different assumptions about the specific geometry of an etch-pit result in surface-area estimates that vary by less than a factor of two from a simple hemispherical pit. Given that other sources of uncertainty in mass-time relationships of silicate-mineral dissolution during natural weathering can be up to four orders-of-magnitude, the effects of differing geometric assumptions about the shapes and surface areas of the etch-pits are trivial for this application. Only if other parameters are known to within much less than a factor of two will details of etch-pit shape discernibly affect etch-pit formation times estimated using the approach presented here.