EVALUATING THE EFFECT OF INITIAL ISOTOPIC DISEQUILIBRIUM ON U-Pb AGES OF QUATERNARY SEDIMENTARY CARBONATES FROM OLDUVAI GORGE, TANZANIA. J. M. Cole1, E. T. Rasbury2, G. N. Hanson2, and G. M. Ashley2; 1Interdepartmental Doctoral Program in Anthropological Sciences, State University of New York, Stony Brook, NY 11794-4364, U.S.A. (jenna@pbisotopes.ess.sunysb.edu), 2Department of Geosciences, State University of New York, Stony Brook, NY 11794-2100, U.S.A. 3Department of Geological Sciences, 610 Taylor Rd., Rutgers University, Piscataway, NJ 08854-8066, U.S.A.

Introduction: Ludwig [1] recognized that initial intermediate daughter isotopic disequilibrium could offset apparent uranium-lead (U-Pb) ages of young minerals. Richards et al. [2] documented this in Pleistocene speleothem calcite. Thus in order to use U-Pb to date Quaternary samples such as those from Olduvai Gorge, it is necessary to identify initial isotopic disequilibrium and establish a method to correct for offset in apparent U-Pb ages.

Geologic Setting: Olduvai Gorge is a well-known archaeological site located in northern Tanzania just west of the East African Rift Valley. The geology [3] and geochronology [4] of the area are well studied. Precise argon-based dating of the deposits provides a crosscheck for U-Pb results. Recent excavations at Olduvai have provided sedimentary carbonate samples dating between ~1.70 and 1.75 million years (Ma) [5].

U-Pb Results: We measured a range in $^{238}\text{U}/^{204}\text{Pb}$ ($\mu$) from 50.5 to 880 on a small number of aliquots of carbonate samples from Olduvai. This range in $\mu$ exceeds the range of 100 suggested by Getty and DePaolo [6] as the minimum required to date igneous minerals with age uncertainties between ±15-20 thousand years (ka). Therefore, it seems likely that the Olduvai samples have the potential to provide precise U-Pb ages.

Isotopic Disequilibrium: Isotopic disequilibrium has been found in recent stromatolites deposited in East African Rift lakes [7-9]. These lakes are likely analogous to the paleo-lake recognized at Olduvai. The $^{230}\text{Th}/^{238}\text{U}$ activity ratio (AR) is variable and can be high in these stromatolites, ranging from 1.9 to 27.8 [7-8]. The effect of disequilibrium in the $^{236}\text{U}/^{238}\text{U}$ AR on $^{238}\text{U}/^{206}\text{Pb}$ ages can be calculated using an equation similar to that published by Schärer [10] and derived by one of us (G.N.H.):

\[
T_{\text{xs}} = (T_{1/2} / \ln 2) \times (^{230}\text{Th}/^{238}\text{U} \text{ AR} - 1)
\]

$T_{\text{xs}}$ is the excess in $^{238}\text{U}/^{206}\text{Pb}$ apparent age and $T_{1/2}$ is the half-life of $^{230}\text{Th}$.

Table 1 shows the effect of initial $^{230}\text{Th}/^{238}\text{U}$ AR on apparent $^{238}\text{U}/^{206}\text{Pb}$ age. An initial $^{230}\text{Th}/^{238}\text{U}$ AR of 1 is at secular equilibrium and does not offset the U-Pb age. An initial $^{230}\text{Th}/^{238}\text{U}$ AR of 28 would cause the $^{238}\text{U}/^{206}\text{Pb}$ age to be almost 3 Ma too old. This amount of offset would have a huge effect on the apparent U-Pb age of a Quaternary sample.

<table>
<thead>
<tr>
<th>$^{230}\text{Th}/^{238}\text{U}$ AR</th>
<th>$^{238}\text{U}/^{206}\text{Pb}$ age difference (ka)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>+ 970 ka</td>
</tr>
<tr>
<td>28</td>
<td>+ 2.9 Ma</td>
</tr>
</tbody>
</table>

It is not possible to know the initial $^{230}\text{Th}/^{238}\text{U}$ AR in the Olduvai samples since the U-Pb system approaches secular equilibrium over time. We therefore cannot directly calculate the offset using the previous equation. Using published data from carbonates in the East African Rift [7-9], a positive linear trend exists between the $^{230}\text{Th}/^{238}\text{U}$ AR and Th/U, even for carbonates deposited in different lakes. This relationship is similar to that described by Ludwig and Titterington [11] and can be used to predict the initial $^{230}\text{Th}/^{238}\text{U}$ AR from the measured Th/U in Quaternary samples and calculate the offset in the $^{238}\text{U}/^{206}\text{Pb}$ age.

Summary: Initial intermediate daughter isotopic disequilibrium can offset apparent U-Pb ages in young minerals. Published data shows that East African Rift lake carbonates can be in isotopic disequilibrium. The relationship between $^{230}\text{Th}/^{238}\text{U}$ AR and Th/U is a positive, linear trend in modern samples. This trend can be used to predict the initial $^{230}\text{Th}/^{238}\text{U}$ AR and to evaluate the effect of initial disequilibrium on U-Pb ages for Quaternary carbonates from Olduvai Gorge, Tanzania.