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Title: URANIUM EXPLORATION IN NORTHERN ARIZONA BRECCIA PIPES IN THE 21ST CENTURY: SUCCESSES AND FAILURES

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Abstract: The uranium industry has made a dramatic turnaround since 2003. Uranium reached a 30-year low in 2001 of $6.50/lb. By 2007 the price had soared to $113/lb. The highest-grade uranium deposits in the United States (average grade close to 1% U3O8) occur in solution-collapse breccia pipes in NW Arizona. As a result of the greatest uranium rush in history, over 6000 claims have been staked on the Arizona Strip alone; this does not include the land to the south of the Grand Canyon.

These uranium-rich breccia pipes have a Mississippi-Valley Type (MVT) mineral assemblage with a uranium over-print. The MVT mineral assemblage is typical of those found in the Viburnum Trend (and other MVT districts): rich in Ag, Co, Cu, Mo, Ni, Pb, V, and Zn. Moreover, fluid inclusion filling temperatures and salinities in sphalerite and dolomite are likewise consistent with values of conventional MVT ores. Temperatures range from 80-173∞C and salinities are commonly greater than 19-wt % NaCl equivalent. Sulfur-rich solid bitumen is present in the Arizona pipes and also present in the MVT deposits.

A large set of U-Pb isotopic analyses by Ludwig and Simmons date two mineralization events: 260 Ma and 200 Ma. These dates bracket the age of Pangea and are consistent with MVT deposit/district ages in a great number of districts throughout the world. The Arizona pipes lie on a craton adjoining the Mesocordilleran trough. The 2 km Paleozoic section of the craton thickens dramatically across a shelf to the west to more than 8 km. We propose that dewatering of these basin strata from Pangean heat (the stasis stage of the Wilson cycle) resulted in upward flow of fluids (brines) into the thinner Mississippian strata of the Grand Canyon region. During the period of crustal stasis it is likely that water table fluctuations created the extensive karst in the Redwall Limestone in which the breccia pipes are rooted. This upward stoping connected various aquifers and probably created an enormous subterranean fluid flow. The mixing of fluids may well have brought uranium and copper out of the red-bed sandstones, such as the Supai Group, into the pipe environment where they mixed with the metal-rich, basinal brines that also

moved upward into the pipes creating the reducing environment necessary for precipitation of uranium. Calculations can be made to show that normal ground-water uranium concentrations can readily create high-grade uranium deposits with voluminous fluid flow through a massive reductant?? (the MVT brines, H_2S, CH_4, etc.).

Our suggestion that these pipes and their ores are of MVT style and related to crustal heat, contributes to a better understanding of the uranium pipes of the Colorado Plateau. The craton setting of these ores in the genetic context considered here allows a broadened exploration perspective in other stable platform regions of the world.