Merrihue, Turner, and Reynolds: Of Xe, I, Cl, and Ar

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In the 1960s, the Berkeley group around John Reynolds developed the I-Xe dating method by stepwise heating of irradiated samples. They used three-isotope correlation diagrams to identify Xe derived from ^{129}I, ^{244}Pu and U, together with its carrier phases. Three-isotope correlation plots for other rare gases in meteorites later led to identify presolar grains (SiC, graphite) as carrier phases of Ne-E.

After a few years of successful xenology, the game changer for cosmochronology was a spin-off of I-Xe, an abstract promising "trace-element determinations and K-Ar dating" by Merrihue. After his untimely death, the approach was upheld by Turner, and the dating method now called $^{40}Ar/^{39}Ar$ came into existence. Initially, Merrihue & Turner [JGR 71 (1966) 2852] used correlation diagrams. Later, the age spectrum was perceived as a more immediate visualization and became very successful. The shift from isotope correlation diagrams to age spectra put all emphasis on a single isotope, ^{39}Ar. As graphics limit how much we extract from data, this curtailed Merrihue's intuition that rare gas isotopes (9 for Xe, 6 for Kr, 5 for Ar) in irradiated samples reveal concentrations and carriers of trace elements such as I, Ba, Br, Cl, Ca and K. Even if Turner et al [EPSL 12 (1971) 19] proved that a lunar basalt had a reduced discordance after removal of mesostasis by hand-picking, few studies on terrestrial samples realized that carrier phases out of diffusive equilibrium can have different ages [Onstott et al, Chem. Geol. 90 (1990) 145], as ^{38}Ar and ^{37}Ar as fingerprints of the chemically heterogeneous mineral generations are not taken into account by age spectra alone.

The potential of halogen-derived ^{128}Xe and ^{38}Ar lies in the detection of heterochemical phases, which nowadays can be identified with imaging techniques (CL, BSE, EPMA). This forces the conclusion that discordance in K-Ar, just as in U-Pb and I-Xe, is due to mixed mineral generations [Hanchar & Villa, this session]. Indeed, intracrystalline age gradients in monomineralic samples give concordant age spectra [Hodges et al, Geology 22 (1994) 55]. Mixed mineral generations are typical in retrogressed rocks, in which replacement reactions resulted in petrologic disequilibrium unaccompanied by diffusive re-equilibration. Element maps can quantify their characteristic patchy textures. Mineral chronometers (micas, amphiboles, K-feldspar) showing secondary reactions also show Ca/Cl/K signatures that correlate with step ages. Correlation plots linked to EPMA successfully unravel ages of each mineral generation.