Presented @ RMAG North American Helium Symposium in Denver, Colorado, 3/23/2022, & Submitted For Publication to Geological Society of America Journal Geology, 2/2023:

Probabilistic determination of the role of faults and intrusions in helium-rich gas field formation
By Halford, D.T.¹, Karolytė, R.¹, Andreason, M.², Cathey, B.³, Dellenbach, J.T.⁴, Cuzella, J.J.⁴, Sonnenberg, S.A.⁵, Cheng, A.¹, McCaffrey, K.J.W.⁶, Gluyas, J.G.⁶, Ballentine, C.J.¹

¹ University of Oxford, Oxford, Earth Sciences, OX1 3AN, England, UK
² Navajo Nation Oil and Gas Company, St. Michaels, Arizona, 86511, USA
³ Earthfield Technology LLC, Richmond, Texas, 77406, USA
⁴ Division of Energy and Mineral Development, Lakewood, Colorado, 80401, USA
⁵ Colorado School of Mines, Geology and Geological Engineering, Golden, Colorado, 80401, USA
⁶ Durham University, Earth Sciences, Durham, DH1 3LE, England, UK

Natural gas fields with economic helium (>0.3 He%) require geological periods of quiescence to generate He from the radioactive decay of crustal uranium (U) and thorium (Th) and tectonic and structural regimes favorable to releasing and concentrating He. A key unknown of the He system is determining the role of faults and structural features in focusing deep-seated He sources to shallow accumulations. We test the correlation between high-He wells (n=138) and structural features using a new high-resolution aeromagnetic survey in the Four Corners area, USA. A depth-to-basement map with basement lineaments/faults, an intrusion map, and a flattened basement structural high map, were created using Werner deconvolution algorithms by combining magnetic, gravity, and topography data, with magnetic and gravity depth profiles. We show quantitatively (via ANOVA) that a non-random process controls the relationship between He (>0.3%) and both basement faults and intrusions: 88% of high-He wells occur <1 km of basement faults; and 85% of high-He wells occur <1 km of intrusions. As He% increases, the distance to the structural features decreases. Strong spatial statistical correlations of He wells to both basement faults and intrusions suggest advective transport via faults/intrusions facilitates He migration. The role of gas phase buoyancy and structural trapping is confirmed: 88% of high-He occurs within basement structural highs; and 91% of the remaining wells are <1 km from intrusions (potential local structural high). We present a composite map to illustrate how a probabilistic approach can be used as a predictive model to improve He exploration success by targeting zones of intersection of basement faults and intrusions within basement structural highs.