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Additional Information

Probabilistic determination of the role of faults and intrusions in helium-rich gas field formation

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Abstract

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.