Oil and Gas in Fractured Crystalline Igneous and Metamorphic Rocks: Global Overview and Examples from Texas

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Abstract

Oil and gas resources in fractured crystalline igneous and metamorphic reservoirs are well documented globally and in Texas. We identified and categorized over 190 oil and gas fields and accumulations with recoverable hydrocarbons in crystalline 'basement' or volcanic rocks. Of the fields and discoveries with reported hydrocarbon volumes, we estimate a total recoverable hydrocarbon resource of more than six billion barrels of oil equivalent (boe) from crystalline reservoirs with 13 of these fields having more than 100 million boe recoverable. Oil was first discovered in igneous rocks in 1915 in Texas at the Thrall Field in central Texas, a Cretaceous-aged volcanic mound. Circa 1920, gas and oil were discovered in Precambrian basement in the Amarillo uplift. In the 1990s gas was found and produced from fractured Precambrian basement in the Fort Stockton high of the Central Basin Platform. Globally, trap types include "buried hills" and volcanic mounds; structural fault blocks, intrusive sills and laccoliths, and rarely, meteor impact structures. Of these, the "buried hills" traps are most common with many showing later structural deformation or reactivation. Productive reservoirs are largely dependent on hydraulically conductive fractures and fault zones, and to a lesser extent inter-particle and secondary porosity. Most basement reservoirs show evidence of deep paleo-weathering alteration beneath the nonconformity. Top and lateral seals for most of the accumulations are marine or lacustrine shales and marls, although low permeability volcanics, evaporites, or carbonates have also acted as seals. Seals are observed directly overlying the crystalline reservoirs as well as overlying sedimentary reservoirs in pressure

communication with the basement hydrocarbon accumulations. Shallow crystalline basement aquifers are well documented around the world, most notably in sub-Saharan Africa and India where they provide critical water supply. Basement is a proven minor aquifer in the Llano uplift in central Texas. Porosity and permeability profiles from these shallow basement aquifers show strong similarities to described profiles from “buried hill” hydrocarbon reservoirs, and provide insights on the origin and nature of these reservoirs in the deeper subsurface. One key insight is that surficial and near surficial weathering processes including paleo-aquifer flow during period(s) of subaerial exposure enhanced porosity and permeability development in basement.

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