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# Fracture formation in a crystalline basement hydrocarbon reservoir in Yemen

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Yemen, which is located in the southwestern corner of the Arabian plate, on the eastern margin of the Red Sea, represents a typical rift margin resulting from magmatism of the Afar plume, since about 30 Ma. The geology of Yemen is dominated by a Proterozoic polymetamorphic basement that is unconformably overlain by Ordovician ferruginous sandstones, Permian black shales, and early Jurassic marls and sandstones (Kohlan Formation). The late Jurassic to Early Cretaceous is characterized by a well-developed rift-related series composed of marine clastics and limestones. These series are overlain by marine and continental Middle to Upper Cretaceous and Tertiary sediments. During the Cenozoic, the geological evolution of Yemen was affected by the Afar plume and the associated opening of the Red Sea and Gulf of Aden. These trigged the development of the Cenozoic volcanics that dominate Western Yemen. The eastern part of Yemen is characterized by Paleocene–Eocene sedimentation of mainly limestone and gypsum and Oligocene–Miocene syn-rift sediments.

The Habban Field basement reservoir, lying about 320 km ESE of Sana'a, represents a rather exotic fractured reservoir type because the hydrocarbons occur in the metamorphic basement. This crystalline basement consists of quartz porphyrys and gneisses, both of which were intruded by a granitoid that is in part heavily fractured. The strongly altered roof is overlain by Jurassic fluviatile (Kholan Formation) and shallow to deep marine (Shuqra Formation) sediments.

The metamorphic rocks (fine-grained gneisses, amphibolites and several meter thick quartz veins) in particular, as well as the granite (quartz, K-feldspar, plagioclase and low amounts of biotite) record a complex evolution of brittle/ductile to brittle fracture generation, that eventually developed into proto-cataclastic fault zones. The earliest fault zones developed from several vein generations filled with albite, sericite and chlorite. A steeper fracture generation, dipping at between 70°-90° can be distinguished from a younger set, which dips with at a shallower angle (< 30°). Both sets have been reactivated and later partly healed by several generations of calcite, iron carbonates and pyrite cements, most likely associated with the infiltration of hydrocarbons. On top of the crystalline rocks, a zone of polyphase fractured and healed proto-cataclastic quartz breccias occurs. The quartz probably originated from thick vein fillings that were fractured and healed initially by epidote and subsequently by chlorite and quartz cements. A later fracture set has been filled by several generations of calcite cement, the latest of which is again associated with the formation of pyrite. Another type of opening mode fractures and neptunian dykes is filled with non-metamorphic, partially pyritiferous- and organic-material-bearing shales, marls and limestones.