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Numerical results on sills as fractured reservoirs for hydrocarbons

Zoe Barnett and Agust Gudmundsson
Egham, United Kingdom (Zoe.Barnett.2007@live.rhul.ac.uk)

Sill emplacement has been studied for many years both in volcanic provinces and sedimentary basins. When sills are emplaced into a sedimentary basin there are thermal perturbations that accelerate the maturation of organic matter into oil and gas. The ability for a sill to act as a fractured reservoir depends on a number of factors including the following: (1) Sill geometry; sills exhibit a variety of geometries, commonly either a concave or straight geometry. (2) Sill thickness; sills vary in thickness from a few centimetres to hundreds of metres. For example, the thicknesses of the sills that currently act as fractured reservoirs in China are around 100 m. (3) Sill margins: sills form glassy margins that may remain intact during subsequent tectonic events or, alternatively, rupture. Here, we present numerical models on the potential for a sill to act as a fractured reservoir in its own right. Many numerical models were made, based on geophysical data and field data with results summarised as follows. Firstly, sills have two margins, namely (1) a chilled 'glassy' selvage and (2) a baked margin, both of which form because of a thermal contrast between the molten sill and cool host rock when the sill is emplaced. Originally, these margins have a low permeability. However, when subject to subsequent changes in loading during tectonic events the margins may become ruptured. If a sill is to act as a fractured reservoir then the lower margin must become ruptured, thereby allowing the hydrocarbons to migrate into the sill. At the same time, the upper margin must remain intact and form a seal, so that the hydrocarbons do not escape from the sill. The tectonic regime, i.e. the loading conditions, determines whether the stresses will concentrate at the margins of the sills, allowing them to rupture or within the sill itself, increasing the sill fracture density. Also, the geometry of the sill plays a role as to whether the upper or lower margin of the sill will rupture or not. Secondly, if the lower margin of the sill remains intact, the sill can act as seal and a trap for oil and gas, in which case a fractured reservoir may form at the contact between the sill and either a nearby fault or a dyke. For a fault to participate in the trapping mechanism the fault must normally maintain its low permeability and therefore not be reactivated. However, even if the fault initially becomes reactivated, the geothermal fluids generated by the emplacement of the sill could contribute to 'healing' and 'sealing' of the fault over time, thereby lowering its overall permeability. The two main factors, the loading conditions and geometry (including thickness) of sills have large implications as to whether sills have a chance functioning as fractured hydrocarbon reservoirs.