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Oil prospection using the tectonic plate model

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Tectonic plate models are an intellectual setting to understand why oil deposits are so uncommon and unequally distributed and how models can be used in actual oil and gas prospection. In this case, we use the example of the Ghawar deposit (Saudi Arabia), one of the largest producing well in the world.

In the first step, physical properties of rocks composing the oil accumulation are studied by laboratory experiments. Students estimate the porosity of limestone and clay by comparing their mass before and after water impregnation. Results are compared to microscopic observations. Thus, students come to the conclusion that oil accumulations are characterized by superposition of rocks with very different properties: a rich organic source rock (clays of the Hanifa formation), a porous reservoir rock to store the petroleum in (limestones of the Arab formation) and above an impermeable rock with very low porosity (evaporites of the Tithonien).

In previous lessons, students have seen that organic matter is usually mineralized by bacteria and that this preservation requires particular conditions. The aim is to explain why biomass production has been so important during the deposit of the clays of the Hanifa formation. Tectonic plate models make it possible to estimate the location of the Arabian Peninsula during Jurassic times (age of Hanifa formation). In order to understand why the paleo-location of the Arabian Peninsula is important to preserve organic matter, students have different documents showing:
- That primary production of biomass by phytoplankton is favored by climatic conditions,
- That the position of continents determinate the ocean currents and the positions of upwelling zones and zones where organic matter will be able to be preserved,
- That north of the peninsula there was a passive margin during Jurassic times. An actual seismic line is studied in order to highlight that this extensive area allowed thick sedimentary deposits to accumulate and that fast sedimentation rate is necessary to bury organic matter and to restrict the mineralization.

Consequences of crustal extension are also studied by using an experimental sand box model. The creation of faults is related to the subsidence of the margin. This subsidence allows the crossing of the oil window, leading to pyrolysis of organic matter and its transformation into oil.

Afterwards, students compare the structures obtained after extension in their sand box to the actual organization of the Ghawar oil accumulation (seismic line). They can see that faults created by extension forces have not been preserved and can assume that compression forces have caused formation of the traps. An animation of paleo-location of continents during the upper Jurassic helps them to think that compression forces are linked to the closure of the Tethys Sea. A model using gravel and clay is used to show the principle of oil trapping.

This way, students understand how the tectonic plate models explain the actual location of oil deposits and then how it can be used to look for new deposits.