The Recognition and Exploitation of

Fracture Systems in a Carbonate Reservoir

Slide 1: The Issaran Oil Field is an example of fracture flow in a porous carbonate system. Although there appears to be adequate porosity and permeability to consider this to be a conventional depletion reservoir, the evidence shows that the fracture system is the controlling aspect for fluid flow within the reservoir.

Slide 2: The Issaran Field is located on the west flank of the Gulf of Suez. It is a heavy oil field (API 8^0 to 12^0) trapped as part of the extension system associated with the opening of the Gulf of Suez.

Slide 3: The field is divided into several pools and is over one billion barrels (in-place) of heavy oil. There is both 2D and 3D seismic over the field

Slide 4&5: The field is divided into cold flow production out of the Nukhul Formation and a thermal project out of the Upper and Lower Dolomite.

Slide 6: A cross-section across the Gulf of Suez show a classic structural style of extension with crystalline basement rock exposed on the flanks of the sedimentary basin which is filled with a complex array of evaporites, carbonates and siliclastic units.

Slide 7: 2D Seismic data across the Issaran Field. The extensional system is down to the east, consistent with the opening of the basin. However, there are numerous anttithetic faults that create a trapping mechanism. This trapping mechanism requires the faults to be sealing faults.

Slide 8 – 10: Schematic development of the Miocene section with early reef development on highs related to faulting. Eventually the basin fills with a sabkha-dolomite section. The faults remain active throughout and act as a fluid conduit that brings both diagenetic fluids as well as petroleum. Fluid migration is likely through fractures.

Slide 11: Stratigraphic section of the Miocene in the Issaran Area

Slide 12: The main features of the Issaran Field

Slide 13: Evidence of the importance of natural fractures within the reservoir.

Slide 14: Time structure of the shallow Zeit horizon showing a relay ramp transferring displacement from a northwest trending fault in the south to a sub-parallel fault along strike

Slide 15: Time structure at the Nukhul Horizon showing closure against a sealing fault trapping hydrocarbons at Issaran as well as South Issaran.

Slide 16: Schematic cross-section across the Issaran Pools. The hydrocarbon migration is likely related to faulting and shows exploration potential at deeper horizons (Nubian Sandstone).

Slide 17: Porosity vs. Permeability plot showing a range of core measured permeabilities not exceeding 1.0 darcies.

Slide 18: Pressure Transient Analysis showing curve matching at 3.0 darcies. The discrepency between the core data at the pressure analysis is due to the fact that the core plug measures only por-to-pore conectivity but does not measure the true flow potential of the rock. Pressure transient analysis measures the change in build-up pressure over time, which more representative of the fluid transfer in the system.

Slide 19: Image log showing fractures from Well #49

Slide 20: Detailed cross-section through well #49. Fracture analysis shows that the flow potential in the Upper and Lower Dolomite is superior to other places due to an intense fracture network. Pressure information indicates that the fault is sealing.

Slide 21: Time Structure on the Upper Dolomite event

Slide 22 - 25: Curvature analysis can be used in a variety of ways. One method is to estimate the dip of fault. By mapping both the positive and negative curvature and placing it on the same map one can estimate the dip of faults

Slide 26 & 27: Using 3D data can also lead to simple techniques used to find small displacement faults. In this case a 1 ms trend is identified and interpreted as a fault to help explain the difference in fluid recovery between well #25 and well #30.

Slide 28: Curvature data – most positive High Frequency

Slide 29: Dominant fracture sets from well bore image logs

Slide 30: Comparison of the High Frequency Curvature data to the image logs

Slide 31: Cross-section of the Issaran pool with schematic fracture distribution

Slide 32 - 33: Results of the Cyclic Steam Project and some problems associated with fractures