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Impact of Reservoir Quality on SAGD Production – Observations from the UTF Phase B Oil Sands Pilot

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Commercially successful Steam Assisted Gravity Drainage (SAGD) operations, using current technology and proven production, have relatively thick pay intervals in association with high oil saturation (75%-85% So) and relatively high vertical permeability (2-5 Darcy Kv). The founding principle in SAGD is that the steam-bitumen emulsion flows down to the production well via gravity; hence, with net fluid flow constrained to the vertical plane, the need for uninterrupted vertical permeability becomes paramount.

The Underground Test Facility (UTF), where SAGD was first developed and piloted, provides an analog for understanding the effects of inclined heterolithic stratification (IHS) on production. The UTF Phase B deposit provides a superior data set, with delineation wells spaced 39 m to 110 m apart for detailed reservoir characterization, interpreting steam rise and understanding of associated SAGD production. This paper reviews the effects of some mudstone-dominated IHS intervals that act as a barrier to steam rise for production of the B2 well pair (Figure 1). A geological model consisting of an eastward thickening IHS-dominated succession is proposed by Strobl et al., 1997, for the Phase B pilot area (Figure 2).

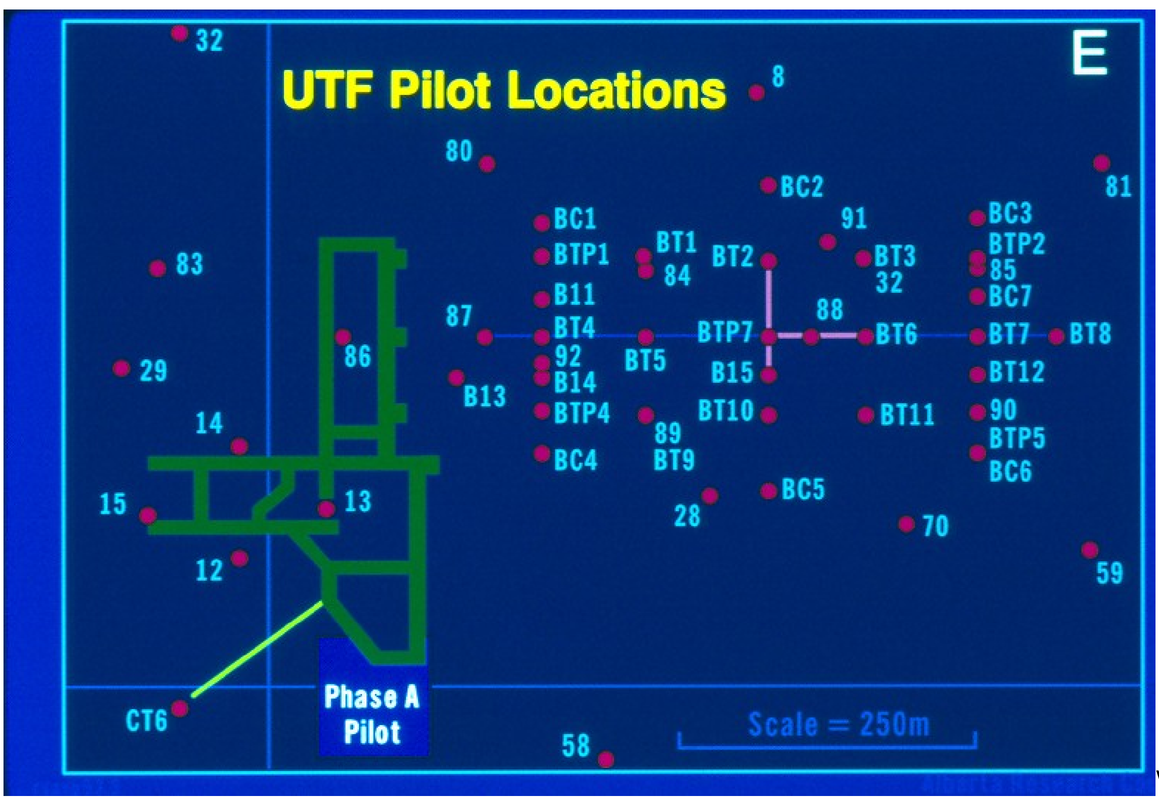

Figure 1. Location of delineation and observation wells in the UTF Phase B Pilot. (modified after Rottenfusser and Stokes, 1987).

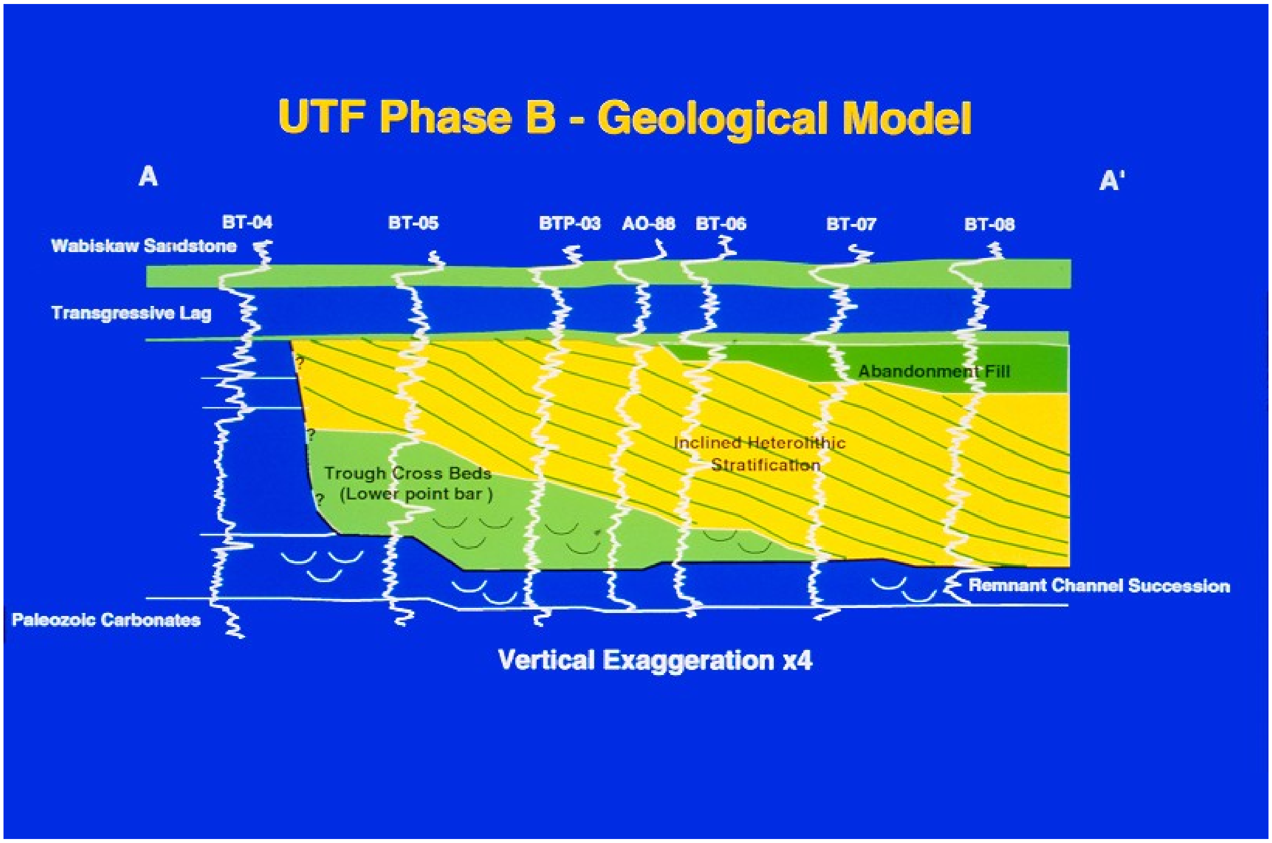

Figure 2. Geological model proposed for the B2 well pair at the UTF Phase B pilot (Strobl et al., 1997)

IHS lithofacies contain laterally continuous mudstone and sand interbeds extending more than 190 meters in the dip and strike directions, based on detailed correlations and geological interpretation. Core samples indicate that vertical air permeability of IHS mudstone beds in this reservoir, range from 0.04 to 50 md in non-bioturbated facies and from 150 to 700 md in extensively bioturbated facies. Interbedded sands within the IHS successions range from 1490 md to 2050 md, indicating that the mudstones reduce vertical permeability by 1 to 2 orders of magnitude compared to sand lithologies.

A general trend observed from vertical temperature observation wells BT04, BT06 and BT07 is that thin, discontinuous mudstones, minor mudstone clast breccias and sand-dominated IHS intervals do not appear to significantly impede vertical steam chamber growth or associated gravity drainage of production fluids to the horizontal producer. In contrast, mudstone-dominated (IHS) can negatively affect operations. Temperature data confirms that a 70-cm thick, mudstone-dominated IHS bed, did act as a barrier to steam rise over the 9 year production life if the B2 well pair except where this bed was penetrated by the injector well. The injector well penetrated and cut across this IHS bed in the vicinity of the BT07 vertical observation well, where the steam chamber was able to rise an additional 4 m to a similar mudstone-dominated barrier capping the sands (Strobl, in press).

An important consideration with regard to steam rise and SAGD production is the lateral continuity of the permeability barrier. Understanding of the 3 dimensional geometry of the reservoir is critical for prediction of optimal well pair placement and production.

Other SAGD projects may operate at higher injection pressures or may have different exploitation strategies that may reduce production risk associated with reservoir heterogeneity; however, examples from the UTF phase B reservoir provide a strong opportunity to learn about steam chamber behaviour and the potential impact of mudstone-dominated IHS beds, which represent the most common reservoir heterogeneity of the McMurray Formation and associated thermal production.

References:

Rottenfusser, B.A., and Stokes, A.W., 1987. Geology and geotechnical monitoring of The AOSTRA Underground Test Facility, CIM Third District Five Meeting preprint, Sept. 16-19, 1987, Ft. McMurray, Alberta, 26 p.

Strobl, R.S., Wightman, D.M., Muwais, W.K., Cotterill, D.K. and LiPIng Yuan, 1997. Application of outcrop analogues and detailed reservoir characterization to the AOSTRA Underground Test Facility, McMurray Formation, North Eastern Alberta, in: Petroleum Geology of the Cretaceous Mannville Group, Western Canada. S.G. Pemberton and D.P. James (eds.), Canadian Society of Petroleum Geologists Memoir 18, p.375-391.

Strobl, in press, Integration of SAGD fundamentals with reservoir characterization to optimize production, AAPG memoir, F. Hein (ed.).