Azi-Frac™ Technology

Azimuth Well Stimulation for Enhanced Production in Weakly Cemented Formations
Enhanced Steam Assisted Gravity Drainage

Background

GeoSierra introduces the **Azi-Frac** technology, an azimuth controlled well stimulation process for installing vertical planar inclusions in weakly cemented formations on particular azimuths from either a horizontal or vertical well.

The technology was developed from GeoSierra's earlier groundwater remediation expertise, enhanced in a joint collaborative effort between Halliburton and GeoSierra called X-Drain™, and now recently refined and extended to provide the technology in either a horizontal or vertical well for oil field applications.

The Azi-Frac technology involves initiating a vertical fluidized plane on a particular azimuth to form a preferential direction for the injection and propagation of the inclusion from the wellbore. The injection process is not a fracturing mechanism, and is not applicable to hard brittle rock, instead it creates a self propagating inclusion on azimuth in weakly cemented formations.

For horizontal well initiation, an Azi-Frac open-hole stimulation tool dilates and creates an extension zone in the formation, creating a vertical fluidized plane orthogonal to the wellbore axis for inclusion injection and propagation. In a vertical well, Azi-Frac casing segments are cemented in the well, then mechanically expanded to split the casing and cement along pre-aligned vertical planes, with each propagating vertical wing of the completion stimulated independently by the treatment tooling.

Field trials of the technology have demonstrated that on azimuth, vertical, permeable planes can be constructed from a single well down to depths exceeding 500m. The technology is formation strength limited, but is not depth limited.

Azi-Frac Enhanced Conventional SAGD

Conventional steam-assisted gravity drainage (SAGD) involves a horizontal well pair typically spaced 5m apart vertically with the injector well located above the producer well as shown in Figure 1. The wells are connected hydraulically during a steam re-circulation phase, followed by the SAGD production mode, i.e. continuous injection of steam and the continuous extraction of liquids.

Performance of conventional SAGD can be significantly impacted in formations with low vertical permeability and interbedded mudstone layers impeding vertical drainage and hindering or delaying the startup phase.

The Azi-Frac horizontal open-hole stimulation method installs vertical propped planes from the injector well at ~50m spacing along the wellbore, thus hydraulically connecting the injector and producer wells. The vertical propped planes orientated orthogonal to the injector wellbore are propped with a high permeable 12/20 garnet sand proppant. The injector well is completed following the open-hole stimulation with a conventional slotted liner.

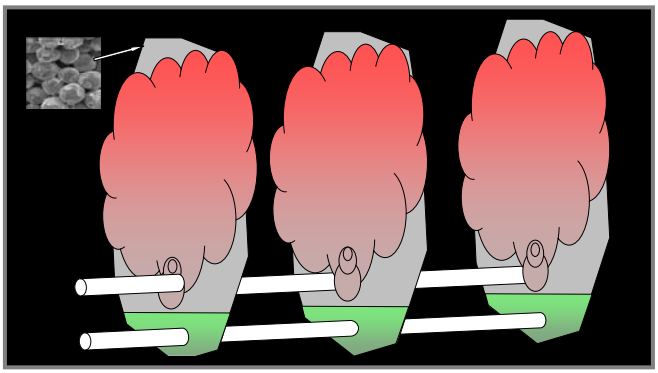

Figure 1: Azi-Frac enhanced conventional SAGD.

Reservoir simulations of conventional SAGD can be highly unreliable due to the difficulty in estimating formation vertical permeability under steam and its significant impact on SAGD performance. The frac enhanced SAGD being virtually independent of formation vertical permeability, enables reservoir simulations to be conducted with a high degree of confidence.

Reservoir simulations of the frac enhanced SAGD in 35m thick McMurray formation containing Athabasca bitumen, show that the frac enhanced SAGD outperforms the best SAGD well pair in a clean McMurray channel sand by a factor of 3 in production rate, see Figure 2, operated at 1,750kPa. The CSOR differ by a significant factor, 1.8 compared to 2.5. The frac enhanced SAGD has a NPV_{10} of 4x conventional SAGD in a clean McMurray channel sand.

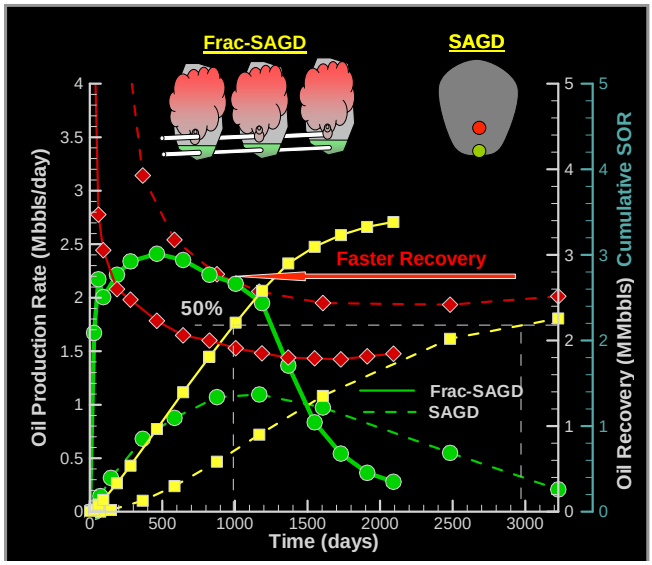

Figure 2: Azi-Frac enhanced vs conventional SAGD.

Frac enhanced SAGD performance in low vertical permeability and/or multiple low-permeability horizontal

layers, indicate that the vertical drainage efficiency of the system is virtually independent of geology, provided the propped vertical planes are constructed continuously throughout the pay thickness.

Azi-Frac Vertical Single-Well SAGD

Azi-Frac technology is used to enhance in-situ recovery in a vertical single-well SAGD injector/producer as shown in Figure 3. The multi-azimuth, vertical, propped planes are constructed from the bottom to the top of pay and consist of a high permeable 12/20 garnet sand proppant. A vertical SAGD well may be preferred to horizontal SAGD in pay of varying thickness, undulating basement and/or bottom water.

The vertical single-well SAGD is completed as a single injector/producer with steam injected continuously at the top of pay and liquids extracted from the bottom. The well operates immediately in SAGD mode. The single-well SAGD injector/producer is completed as two parallel strings, with the annulus filled with blanket gas. Steam is injected via 4-1/2-in. vacuum insulated tubing and liquids are produced via 2-7/8 or 3-1/2-in. tubing under natural or artificial lift, being either gas lift, PCP or ESP.

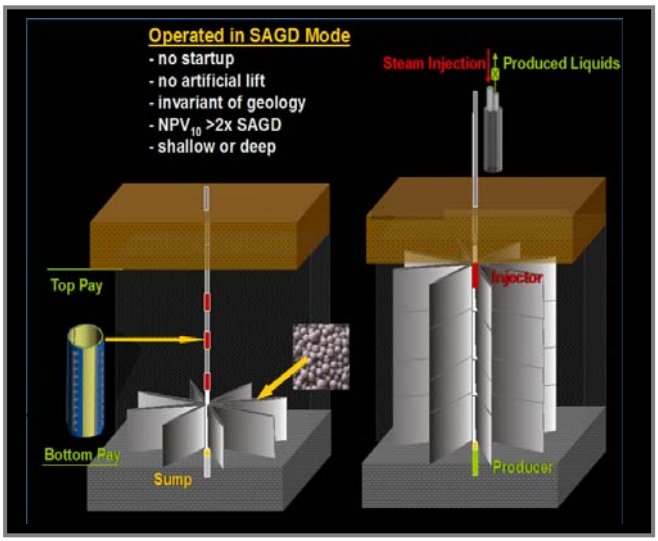

Figure 3: Azi-Frac vertical single-well SAGD.

Reservoir simulations of the vertical single-well SAGD system in Athabasca bitumen in 35m thick McMurray formation, shows it outperforms the best SAGD well pair by a factor of 2, as shown in Figure 4 for both systems with the same reserve base and installed capital cost. The CSOR of both systems are comparable, resulting in the vertical single-well SAGD having a NPV_{10} of 2x conventional SAGD in clean McMurray channel sand.

Thermal reservoir simulations of the Azi-Frac vertical single-well SAGD completion in variable geology, indicate that the drainage performance of the system is virtually independent of geology, provided the permeable planes are constructed through the entire pay thickness.

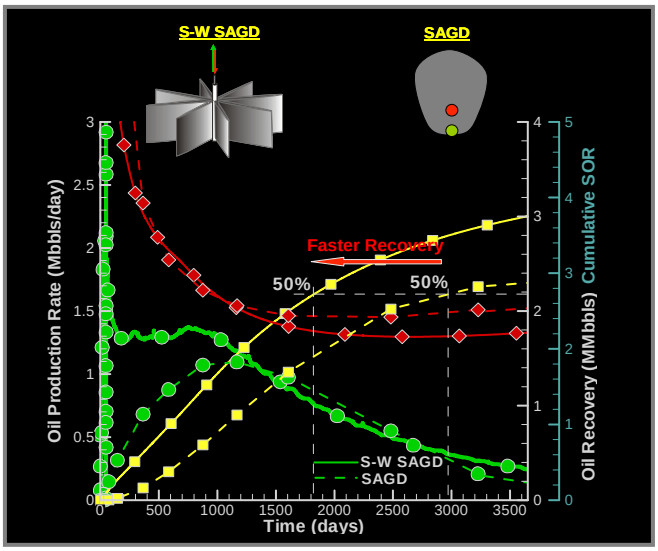

Figure 4: Azi-Frac vertical single-well SAGD versus conventional SAGD in 35m thick Athabasca bitumen pay.

Single-Well SAGD with Multiple Producers

An enhancement to the vertical single-well SAGD injector/producer is the addition of circumferential producer wells, connected to the central well by the vertical propped planes. Steam is injected continuously in the central SAGD well with liquids produced continuously from all wells.

Reservoir simulations, see Figure 5, show that the system outperforms the best SAGD well pair in a clean McMurray channel sand by a factor of 4, with CSOR of 1.5 compared to 2.5, for a NPV_{10} of 6x conventional SAGD.

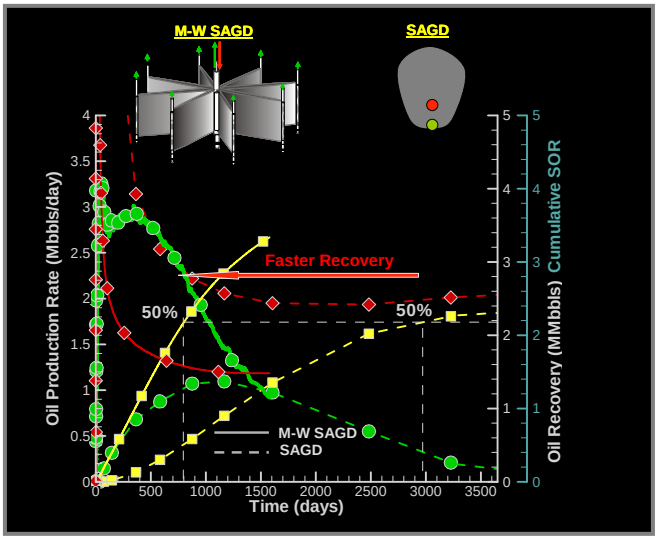

Figure 5: Azi-Frac vertical single-well SAGD with multiple producers (M-W SAGD) versus conventional SAGD in 35m thick Athabasca bitumen pay.

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Azi-Frac™ – is a pending trademark of GeoSierra LLC.
X-Drain™ – is a trademark of Halliburton.

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