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Imaging reservoir fluid flow using tiltmeter-based surface deformation measurements

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Surface deformation measurements have been used for years in oilfields to monitor production, waterflooding, waste injection, steam flooding, and Cyclic Steam Stimulation (CSS). They have been proven to be a very effective way to monitor the field operations and save money for operators wishing to avoid unwanted surface breaches, casing failures and excessive subsidence due to production.

This paper discusses the design and installation of high-resolution tiltmeter monitoring arrays and demonstrates that more information can be extracted from the tiltmeter-based surface deformation measurements (tilt) by inverting them for the volumetric deformation at the reservoir level using the geophysical inversion techniques, so the areal distribution of volumetric deformation can be identified. Constraints are added into the procedure to better resolve the inversion problem as needed. Results from two horizontal well pads of Cyclic Steam Stimulation projects in the Peace River field are presented. . The results provide detailed areal coverage of reservoir dilation and compaction showing that there are non-uniform volumetric changes in both pads. The comparison of two projects demonstrates the importance of having complete array coverage of the active area. Combining this information with other geological, monitoring and surveillance data can be used to better understand the controlling factors for this distribution. Also, the inverted volumetric changes information can be integrated into a coupled reservoir simulation modeling to build a better simulation model.