Interferometric Synthetic Aperture Radar (Insar): An Emmerging and State of Art Technique for Milimetre-Scale Ground Deformation Chracterization and its Potential Applications in Hydrocarbon Production Operations

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In the last fifteen years InSAR (interferometric synthetic aperture radar) has developed from theoretical concept to a technique that is being utlized at an increasing rate for a wide range of Earth science fields. Despite the fact that none of the currently deployed imaging radar satellite platforms was designed with interferometric applications, the high quality and vast quantity of exciting results from this technique have demonstrated their potential as powerful ground deformation measurement tools. In the last few years their capability has been considerably improved by using large stacks of SAR images acquired over the same area, instead of the classical two images used in the standard configurations. This multi-image InSAR technique was introduced as Permanent Scatterer (PS) (Ferretti et al., 1999, 2000, 2001). With these advances the InSAR techniques are becoming more and more quantitative geodetic tools for deformation monitoring, rather than simple qualitative tools. The goal of the paper is to introduce this state-of-the-art technique to petroleum geologist using an example of milimetre-scale ground deformtion monitoring of the Frank Slike, Southeast Alberta.

Although InSAR has been widely used in many other fields, we discuss potential applications of InSAR related to hydrocarbon production operations. These operations include, naming a few:

- Steam Injection: monitoring of steam movement and areas of faults and fractures by monitoring ground surface heave related to cyclic steam stimulation (CSS) and SAGD. The surface movement could also be integrated with the 4-D seismic data to search for anomalies and nonconformance and determine the architecture of reservoir and horizontal steam conformance from surface heave data.

- Gas Injection and Withdrawal: With the ongoing development and commercialization of C02 and Acid gas injection fields and studies into the removal of methane from coal beds, the understanding of the impacts of this change in the volume of material in the subsurface pore space on the ground surface and associated infrastructure are important.

There is a potential that large area deformation trends associated with these activities could be tracked using InSAR.

- Water and Gas Floods: many oil fields in Alberta are in tertiary production using water and gas floods. Where the fields are shallow, it is potentially possible to monitor and compare subsidence with predicted areas of hydrocarbon production. There is the potential that the terminal gas blowdown could be monitored using InSAR data of the land's subsidence.

- Pipeline risk assessment: In transporting products for refinement and to market, thousands of kilometers of pipelines are required and can cross minor and major watercourses where ongoing slope movements exist. As many of these critical areas are isolated remote monitoring techniques are attractive, especially where there is minimal requirement for access to the site to make readings. The use of PS-InSAR and artificial corner reflectors are being utilized to map subcentimetre deformation trends, which are being used to evaluate pipeline integrity and risk.

- Waste Containment structure monitoring: As InSAR can be used to map deformations over a large footprint on a semi-monthly basis, there is the potential that the onset of the development large area deformations over waste impoundment structures could also be detected and tracked with, in some cases, millimeter precision.

We hope this presentation will stimulate those in the Earth science community who have not yet experienced the excitement of ''fringes'' appearing before them on their computer screen. As the community embraces this technology, new applications and ideas that have not yet been considered will arise. New SAR satellite systems currently in production or on the drawing boards promise a rich source of high-quality interferometric data.

References

Ferretti, A., Prati, C. and Rocca, F., 2000, Nonlinear subsidence rate estimation using permanent scatterers in differential SAR interferometry ; IEEE Transactions on Geoscience and Remote Sensing **38(5)**, 2202-2212.

Ferretti, A., Prati, C. and Rocca, F., 2001, Permanent scatterers in SAR interferometry: IEEE Transactions on Geoscience and Remote Sensing **39(1)**, 8-20.

Ferretti, A., Prati, C. and Rocca, F., 1999, Permanent scatterers in SAR interferometry. International Geoscience and Remote Sensing Symposium, Hamburg, Germany, 28 June-2 July, 1999. pp. 1-3.

Mei, S., Poncos, V. and Froese, C., 2007 (in press), InSAR Mapping of land Deformation over Frank Slide, Turtle Mountain, Alberta: Alberta Energy and Utilities Board, EUB/AGS Earth Sciences Report **2007-##**.