# Observation of Crustal Deformation around the Pärvie Postglacial Fault, Lapland, Sweden, using InSAR techniques

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ABSTRACT.
The Pärvie postglacial fault is a 155 km long fault that probably snapped in one single and anomalously steep reverse-slip event at the end of the Pleistocene glaciation about 9,500 ybp. Still today the seismicity, limited to roughly one magnitude-3.5 event per 15 years, one M=2 event per year, is anomalous and events have been attributed to the fault system by seismologists. In this project we try to find signatures of deformation using different interferometric Radar Remote Sensing techniques. A stack of ERS and ENVISAT acquisitions straddling over 15 years has been analysed with multi-baseline interferometric stacking (MB) and with the Short Baseline (SBAS) method. Also Persistent Scatterer methods have been attempted, but with less success owing to the lack of strong and sharply confined reflectors. In our findings we notice correlation between mm-sized Displacements in outlined zones near the fault; they appear to correlate with the variations of seismicity that seismologists of the Swedish National Seismic Network have determined. In addition, rockfalls and slumps in areas of typically 1-3 km diameter could be found. The results of SBAS and MB techniques show comparable signatures of deformation. Our results may bracket the range of the ratio of "aseismic" to seismoc slip in this area. The fault scarp itself is not visible in the deformation patterns. Thus we expect rather low values for this ratio.

RESULTS
The estimated deformation of the sector of the fault ranges between 1-2.5 mm/yr.
Good agreement is found between classical DInSAR analysis and PS technique.
Higher rates are fund for the more recent ENVISAT datasets that assess the deformation in 5 mm/yr.
Landslide recorded displacement are in the order of 3 mm/yr.

CONCLUSIONS AND REMARKS
Promising results have been achieved so far in the application of the differential interferometry technique over the Pärvie fault. Deformation fringes attributed to crustal deformations have been detected over a segment of the fault and several slopesinstabilities associated to the generation of the fault have been discovered. Providing complementing insight into the current state of stability of the zone this work aims to contribute to the Swedish Deep Drilling Program, Post-glacial Fault Drilling Project and to the ILP Project DynaQlim.

Pärvie fault scarp, seen looking east.
Location 34 km west of Kiruna and north of Nikaluoktra valley

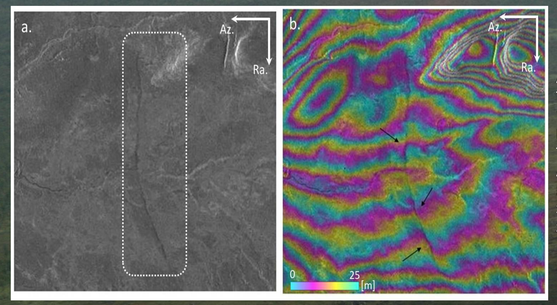


**Figure 1**. Detection of the Pärvie fault from an amplitude image (a) and a synthetic interferogram generated through the use of a 10m resulution DEM. The scarp is highlited by a white rectangle (a) and black arrows (b).

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SAR processing was performed using Gamma Software

DInSAR ANALISYS
Images processed :
72 ERS (track 251 – 480, frame 2223)
12 ENVISAT (track 251, frame 2223)
Period of analysis:
17 years (1992-2009)
Techniques applied:
Stacking
SBAS
PS
Interferograms generated
More than 150

Table 1. Specifications of themulti baselines interferograms used in the PS analysis

| n. | Master | Slave | Baseline [m] | Delta T [days] | n. | Master | Slave | Baseline [m] | Delta T [days] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 19920813 | 19930520 | 22.801 | 280 | 29 | 19931007 | 19950930 | -68.643 | 723 |
| 2 | 19920813 | 19990905 | -1.458 | 2579 | 30 | 19931007 | 19951001 | 131.216 | 724 |
| 3 | 19920917 | 19921022 | -247.573 | 35 | 31 | 19931007 | 19960707 | 120.807 | 1004 |
| 4 | 19920917 | 19931007 | -93.096 | 385 | 32 | 19931007 | 19990627 | 76.790 | 2089 |
| 5 | 19920917 | 19950826 | -250.195 | 1073 | 33 | 19931007 | 19990801 | 216.330 | 2124 |
| 6 | 19920917 | 19950930 | -161.739 | 1108 | 34 | 19950617 | 19950722 | 203.560 | 35 |
| 7 | 19920917 | 19951001 | 40.119 | 1109 | 35 | 19950617 | 19950723 | 168.994 | 36 |
| 8 | 19920917 | 19960707 | 27.711 | 1389 | 36 | 19950617 | 19950826 | 263.814 | 70 |
| 9 | 19920917 | 19990627 | -16.306 | 2474 | 37 | 19950722 | 19950723 | -34.566 | 1 |
| 10 | 19920917 | 19990801 | 123.234 | 2509 | 38 | 19950722 | 19950826 | 60.254 | 35 |
| 11 | 19921022 | 19930729 | -282.924 | 280 | 39 | 19950722 | 19950930 | 148.710 | 70 |
| 12 | 19921022 | 19931007 | 154.477 | 350 | 40 | 19950722 | 19990627 | 294.143 | 1436 |
| 13 | 19921022 | 19950617 | -266.436 | 968 | 41 | 19950723 | 19950826 | 94.820 | 34 |
| 14 | 19921022 | 19950722 | -62.876 | 1003 | 42 | 19950723 | 19950930 | 183.276 | 69 |
| 15 | 19921022 | 19950723 | -97.442 | 1004 | 43 | 19950826 | 19950930 | 88.456 | 35 |
| 16 | 19921022 | 19950826 | -2.622 | 1038 | 44 | 19950826 | 19951001 | 290.314 | 36 |
| 17 | 19921022 | 19950930 | 85.834 | 1073 | 45 | 19950826 | 19960707 | 277.906 | 316 |
| 18 | 19921022 | 19951001 | 287.692 | 1074 | 46 | 19950826 | 19990627 | 233.889 | 1401 |
| 19 | 19921022 | 19960707 | 275.284 | 1354 | 47 | 19950930 | 19951001 | 201.858 | 1 |
| 20 | 19921022 | 19990627 | 231.267 | 2439 | 48 | 19950930 | 19960707 | 189.449 | 281 |
| 21 | 19930520 | 19990905 | -24.259 | 2299 | 49 | 19950930 | 19990627 | 145.432 | 1366 |
| 22 | 19930729 | 19950617 | 16.488 | 688 | 50 | 19950930 | 19990801 | 284.973 | 1401 |
| 23 | 19930729 | 19950722 | 220.048 | 723 | 51 | 19951001 | 19960707 | -12.409 | 280 |
| 24 | 19930729 | 19950723 | 185.482 | 724 | 52 | 19951001 | 19990627 | -56.426 | 1365 |
| 25 | 19930729 | 19950826 | 280.302 | 758 | 53 | 19951001 | 19990801 | 83.115 | 1400 |
| 26 | 19931007 | 19950722 | -217.353 | 653 | 54 | 19960707 | 19990627 | -44.017 | 1085 |
| 27 | 19931007 | 19950723 | -251.919 | 654 | 55 | 19960707 | 19990801 | 95.523 | 1120 |
| 28 | 19931007 | 19950826 | -157.099 | 688 | 56 | 19990627 | 19990801 | 139.540 | 35 |

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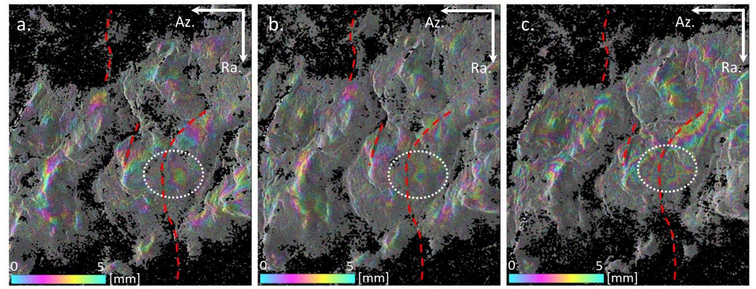


**Figure 2**. Differential interferograms (in dange-doppler coordinates, East is to the left) generated from images: 1992-09-17 and 1996-07-07, ERS track 480 (a); 1992-07-28 and 1995-07-06, ERS track 251 (b); 2007-08-03 and 2009-08-07, ENVISAT track 251 (c). The red line represents the segments of the Pärvie fault, the dotted white ellipse highlights the deformation area.

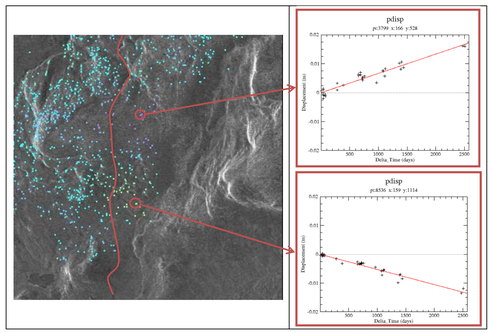


**Figure 3**. PS map : blue dots are stable scatters. Purple dots are uplifting, yellow dots are subsiding. Graphics on the right of the image represents the linear regression line interpolating the displacement recorded at 2 representative points. The deformation speed for point 3799 is + 2.43 mm/yr while for point 8356 is -1.92 mm/yr.

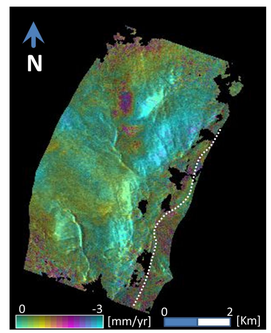


**Figure 4**. Stacked interferograms superimposed to a geocoded intensity image of a sectors of the Pärvie fault (white dotted line). White arrow highlight the deformations due to a landslide.