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Dating brittle deformation in faults from central Sweden

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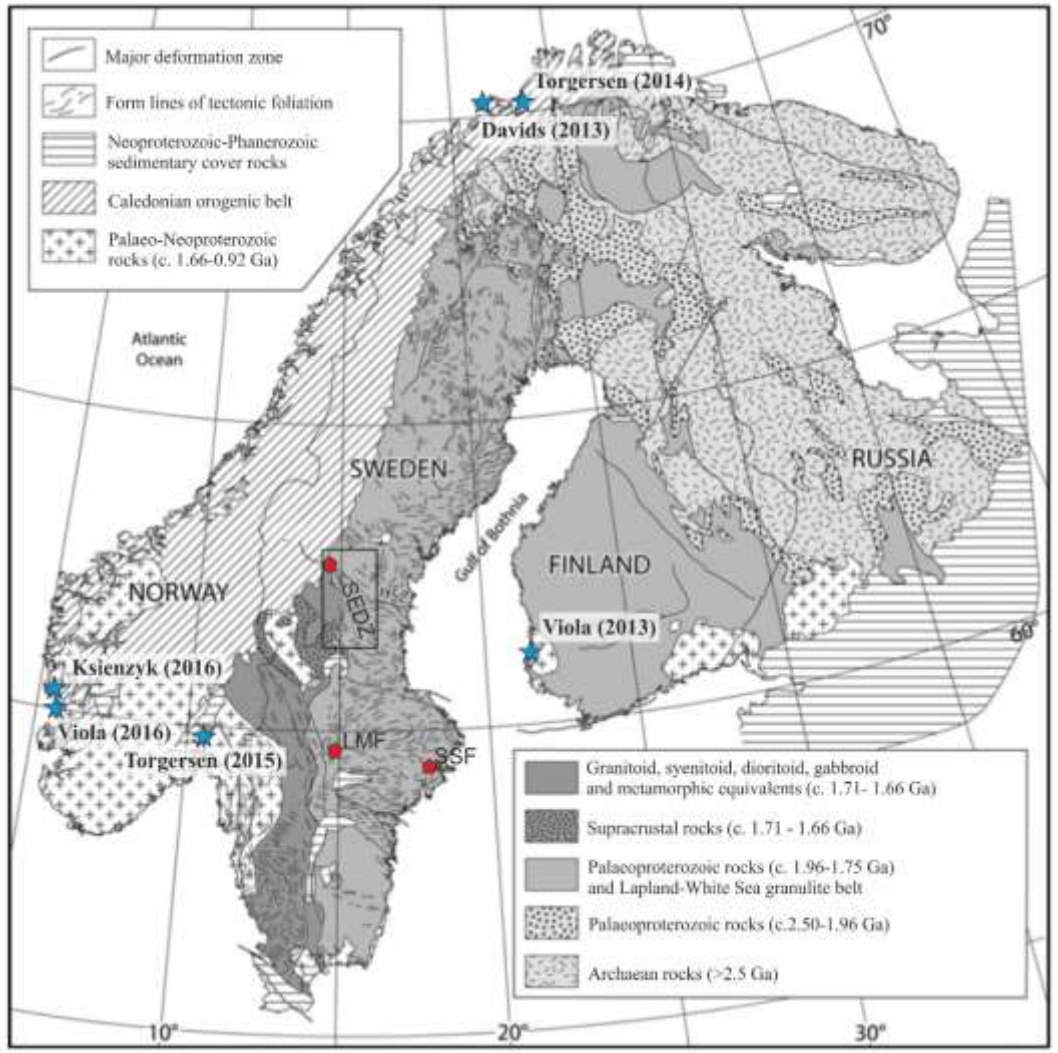
Project objectives



Modified from Bergman et al. (2006)

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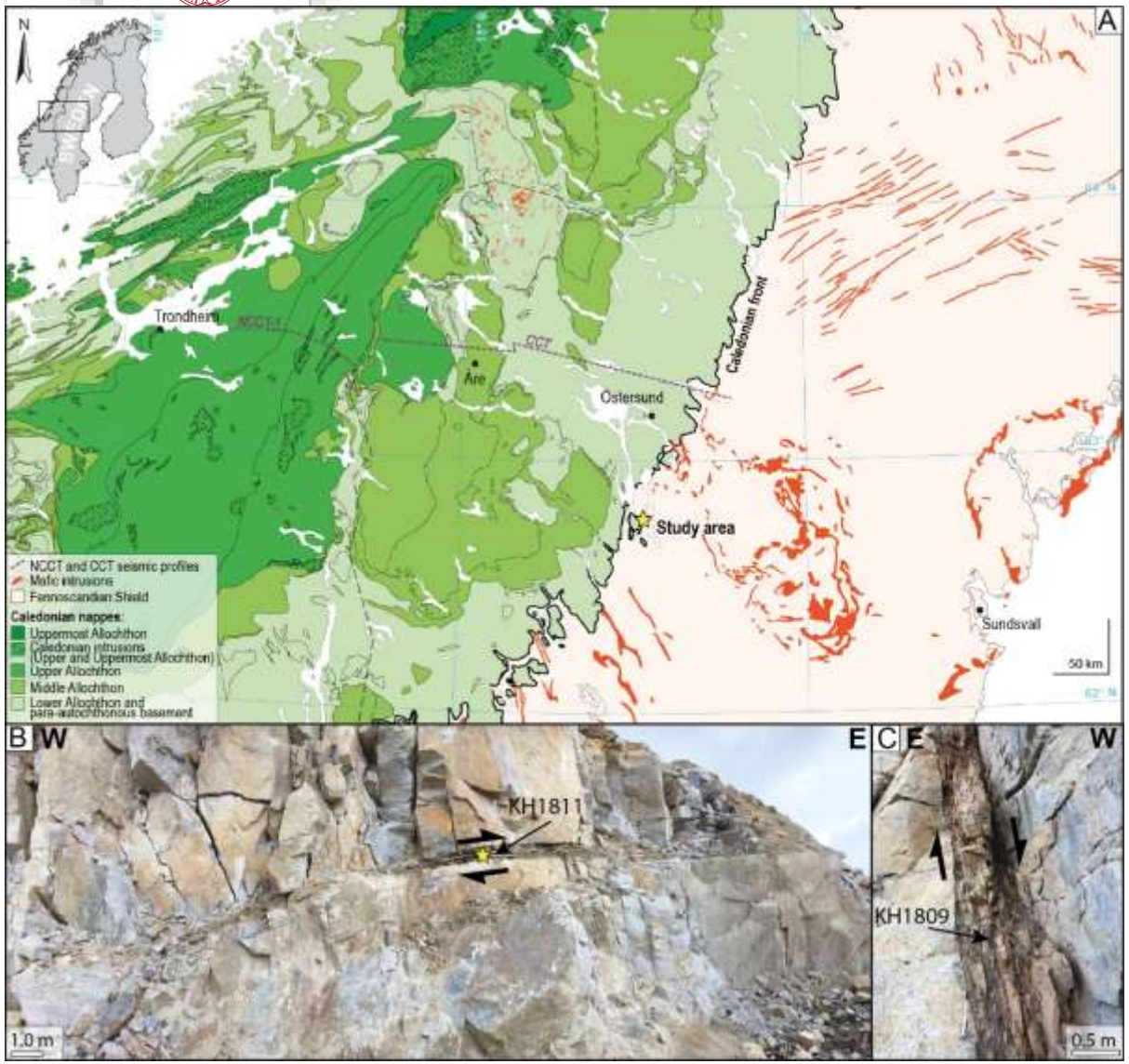
Sample Parameters				$^{40}Ar^*$				K			Age Data		
Analysis Dat	Run #	Sample Name	Fraction	Mass mg	mol/g	σ (%)	$^{40}Ar^*$ %	Mass mg	wt %	σ (%)	Age (Ma	σ (Ma)	Notes
2018-11-30	18/112.06	SGL18-0003A Söderström	<0.1	2.070	######	0.31	86.5	51.1	###	1.38	449.0	±8.0	
2018-12-03	18/112.07	SGL18-0003A Söderström	0.1-0.4	1.962	######	0.32	90.5	49.9	###	1.53	554.2	±7.5	
2018-12-03	18/112.08	SGL18-0003A Söderström	0.4-2	2.376	######	0.30	92.3	50.5	###	1.53	669.5	±8.7	
2018-11-30	18/112.09	SGL18-0003A Söderström	2-6	2.116	5.387E-09	0.31	95.2	49.5	###	1.53	794.3	±10.1	
2018-11-30	18/112.10	SGL18-0003A Söderström	6-10	2.094	6.015E-09	0.31	95.8	49.7	###	1.54	755.1	±9.7	
2018-11-30	18/112.01	SGL18-0001A Söderström	<0.1	3.352	1.365E-09	0.28	84.3	12.4	1.961	1.53	362.4	±5.1	
2018-12-04	18/112.02	SGL18-0001A Söderström	0.1-0.4	4.520	1.380E-09	0.26	88.2	49.9	1.815	1.53	392.6	±5.5	
2018-12-03	18/112.03	SGL18-0001A Söderström	0.4-2	3.650	######	0.27	95.8	53.7	2.757	1.53	497.5	±6.8	
2018-12-03	18/112.04	SGL18-0001A Söderström	2-6	3.170	6.421E-09	0.28	99.2	49.8	4.751	1.53	647.7	±8.5	
2018-12-03	18/112.05	SGL18-0001A Söderström	6-10	3.346	######	0.27	99.3	48.7	4.881	1.53	661.2	±8.6	
~~2019-06-13~~	~~2018.0112 3_01~~	~~KH1811 Bingsta~~	~~<0.1~~	~~0.386~~	~~######~~	~~0.47~~	~~90.6~~	~~47.8~~	~~2.171~~	~~1.66~~	~~552.6~~	~~±8.2~~	1
2020-10-15	*2018.0112.3_01Re*	*KH1811 Bingsta*	*<0.1*	*1.578*	*######*	*##*	*90.8*	*14.6*	*##*	*##*	*591.7*	*±6.1*	1
2019-06-13	2018.0112 3_04	KH1811 Bingsta	0.1-0.4	1.470	######	0.35	93.5	49.9	3.631	1.41	425.3	±5.5	2
2020-10-14	*2018.0112.3_04Re*	*KH1811 Bingsta*	*0.1-0.4*	*1.952*	*######*	*##*	*93.6*	*50.7*	*##*	*1.41*	*425.0*	*±5.4*	2
2019-06-13	2018.0112 3_2	KH1811 Bingsta	0.4-2	1.702	######	0.33	94.0	49.9	2.951	1.51	476.7	±6.5	
2019-06-13	2018.0112 3_6	KH1811 Bingsta	2-6	1.848	2.815E-09	0.31	94.4	50.9	2.377	1.59	579.0	±8.0	
2019-06-13	2018.0112 3_10	KH1811 Bingsta	6-10	1.636	3.281E-09	0.33	94.0	50.1	###	1.60	652.2	±8.9	
2019-06-17	2018.0112 4_01	KH1809C Bingsta	<0.1	1.022	1.046E-09	0.48	90.3	17.4	1.204	2.44	442.1	±9.7	
2019-06-17	2018.0112 4_04	KH1809C Bingsta	0.1-0.4	1.266	1.708E-09	0.40	93.5	50.0	1.676	1.76	508.6	±8.0	
2019-06-17	2018.0112 4_2	KH1809C Bingsta	0.4-2	1.860	2.178E-09	0.31	95.8	50.1	1.660	1.76	632.0	±9.5	
2019-06-17	2018.0112 4_6	KH1809C Bingsta	2-6	3.374	######	0.25	97.3	50.0	1.725	1.75	769.3	±11.1	
2019-06-18	2018.0112 4_10	KH1809C Bingsta	6-10	1.896	3.218E-09	0.31	97.8	50.0	1.780	1.73	822.7	±11.6	
2019-06-17	2018.0112 6_01	BH1502_212.1	<0.1	0.896	1.248E-09	0.52	89.8	24.9	###	2.54	891.1	±18.2	
2019-06-18	2018.0112 6_04	BH1502_212.1	0.1-0.4	2.240	3.108E-09	0.29	92.4	50.0	1.204	1.91	1085.8	±15.7	
2019-06-18	2018.0112 6_2	BH1502_212.1	0.4-2	1.334	8.108E-09	0.37	97.3	50.0	###	1.56	1244.6	±14.4	
2019-06-18	2018.0112 6_6	BH1502_212.1	2-6	2.538	1.199E-08	0.27	98.7	50.2	###	1.42	1322.9	±13.6	
2019-06-18	2018.0112 6_10	BH1502_212.1	6-10	1.688	1.319E-08	0.33	98.8	49.8	3.831	1.39	1339.2	±13.5	
2019-06-18	2018.0112 7_01	BH1502_316.7	<0.1	1.650	1.932E-11	5.66	5.3	7.2	###	4.58	295.3	±19.8	
2019-06-18	2018.0112 7_04	BH1502_316.7	0.1-0.4	1.680	2.359E-11	4.60	2.5	50.0	###	3.59	430.1	±22.3	
2019-06-19	2018.0112 7_2	BH1502_316.7	0.4-2	2.124	1.031E-10	0.90	5.9	50.0	###	3.22	784.6	±21.3	
2019-06-18	2018.0112 7_6	BH1502_316.7	2-6	1.706	3.185E-10	0.47	21.2	50.4	0.157	2.82	900.6	±20.2	
2019-06-19	2018.0112 7_10	BH1502_316.7	6-10	1.818	3.906E-10	0.44	11.0	50.6	0.183	2.74	937.1	±20.3	

Notes

1) There was a suspected problem with the original data reported on 28.06.2019 for the <0.1 µm fraction of KH1811 Bingsta.
To verify the sample, both K and $^{40}Ar^*$ concentrations were re-determined in October 2020.
The previously reported K concentration and age, are erroneous. We recommend to use the new measurement values (in italic) for data interpretation.

2) To confirm reproducibility, K and $^{40}Ar^*$ concentrations from the 0.1-0.4 µm fraction of KH1811 Bingsta were also re-measured.
The recalculated age is indistinguishable from the previous value, and either age can be used in interpretations.

K-Ar geochronology in the Jämtland area: Faults along dikes in the Baltica basement



Tectonostratigraphic map modified from Robinson et al. (2014)

Study area is in central-eastern Jämtland (Bingsta, ca. 30 km south of Östersund)

Faults have localized along dikes of ~1250 Ma ages (Central Scandinavian Dolerite Group; CSDG) in Svecofennian granites.

Fault gouge was readily apparent and collected along and within the faulted dikes.

Sample KH1811 along a shallow dipping fault with thrust-related top to S(E) movement.

Sample KH1809C along a steep fault with inferred top to the W movement.

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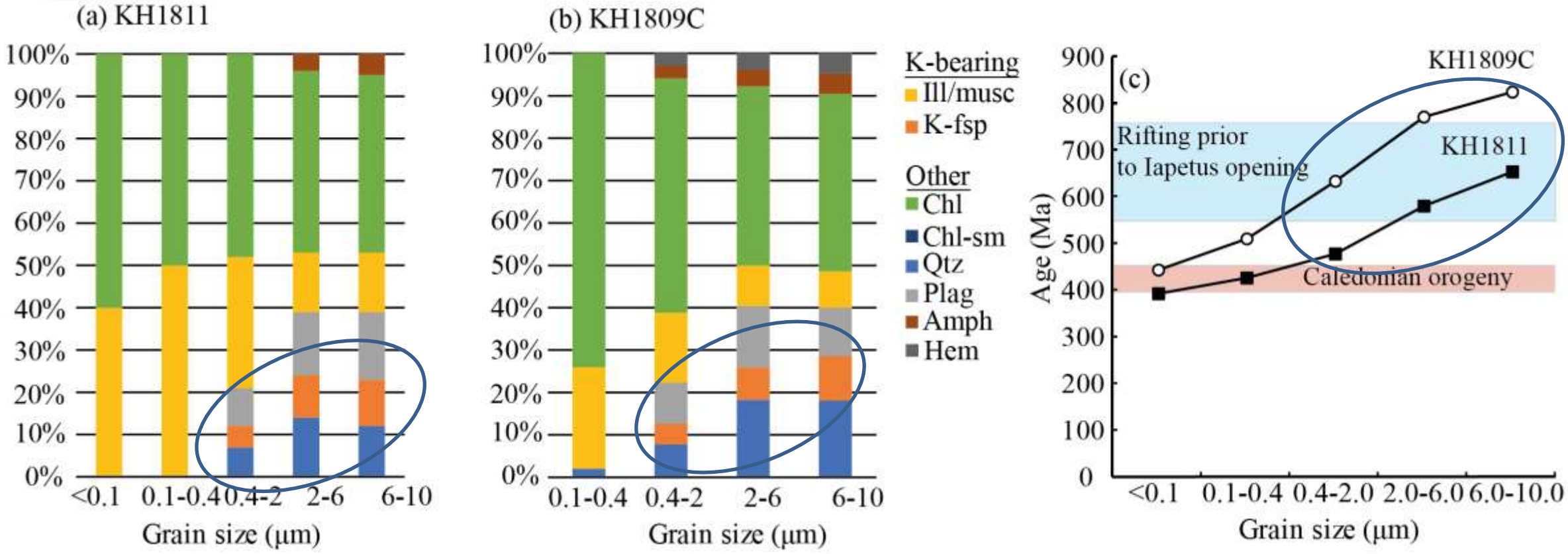
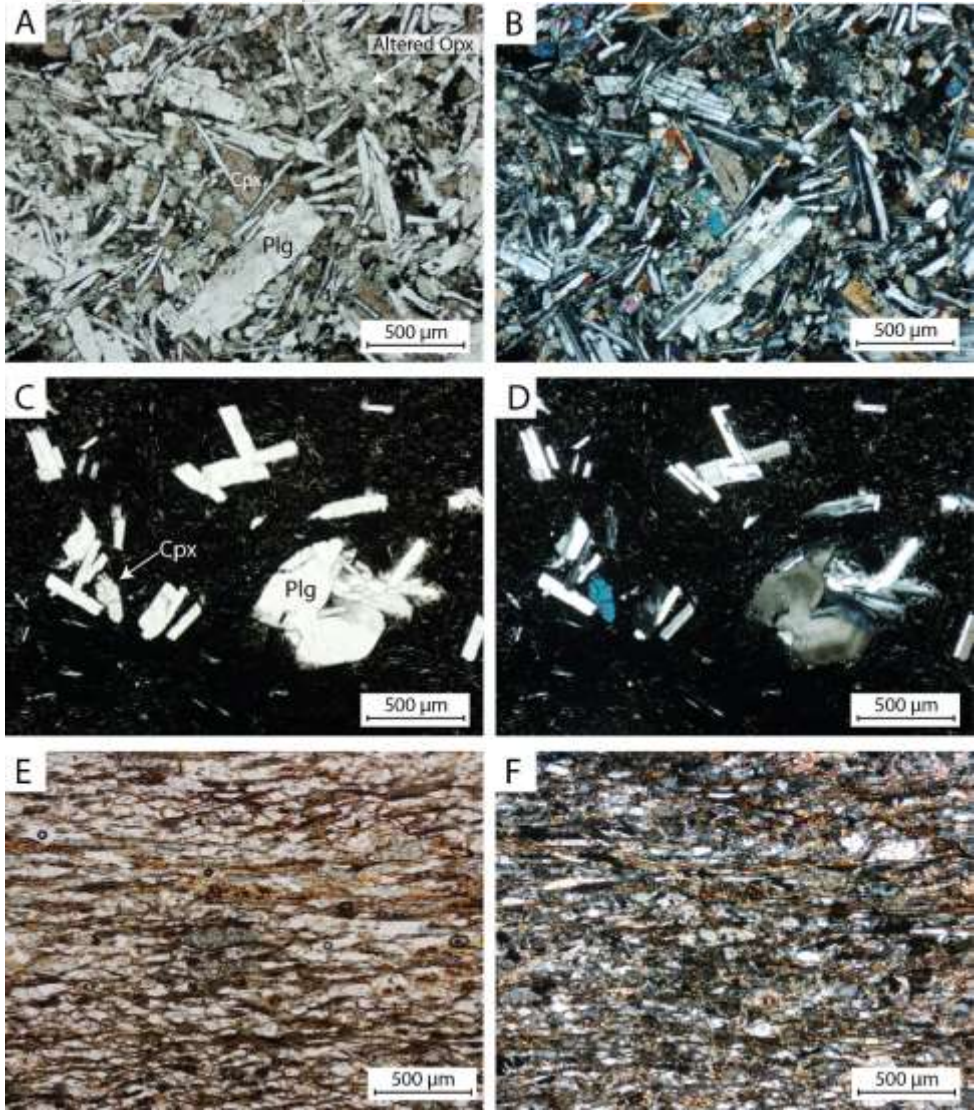
XRD mineral composition and K-Ar ages



Coarser grain size fractions include K-feldspar (skews results to higher ages)

Finer fractions are dominated by 1M polytype illite, formed during faulting

Dike alteration and deformation



PPL CPL

Dike center with minor alteration of orthopyroxene. Pristine plagioclase and clinopyroxene.

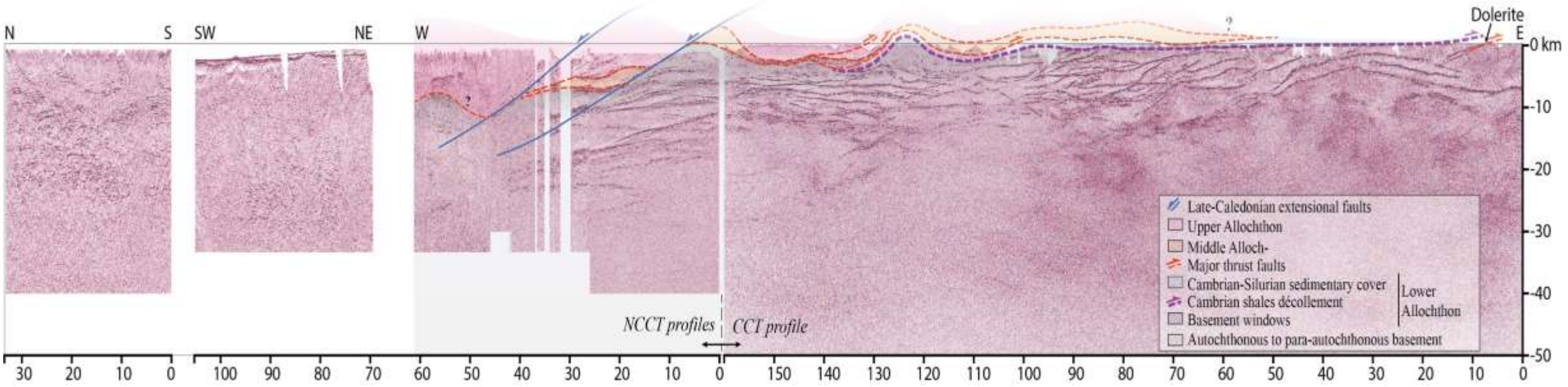
Undeformed dike located within 10 km from Bingsta

Dike margin with heavy alteration of ground mass. Some survivor grains of plagioclase and clinopyroxene.

Sheared dike from location of sample KH1811. Chlorite/Chloritoid and possible adularia present.
Top to S(E) shear sense.

Deformed dike KH1811

The role of dikes underneath the Caledonian allochthons...



Significant reflectivity exists beneath the decollement; potentially these reflectors can be linked to dikes and deformation structures (for example horses) that formed during Caledonian contraction.

The origin and timing of these structures are important to determine and will provide a more direct insight into the role and extent of involvement of the basement during orogeny.

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Discussion and summary

- Fault gouge have been dated through K-Ar geochronology from three different localities in central Sweden.
- In the Baltica basement, just east of the Caledonian front in Jämtland, ages are distributed from c. 823 Ma to 392 Ma.
  - Older ages are ascribed to presence of K-feldspar (potentially adularia forming during a hydrothermal event)
  - Caledonian ages recorded by finer fraction illite, ranging from 440 Ma to 392 Ma.
- Results indicate that brittle deformation localized along and within mafic dikes (CSDG) underneath the decollement.
- Although Caledonian ages have been recorded in other brittle structures (for example fractures) in Sweden, the new results provide evidence that faulting and kinematics can be directly linked to the Caledonian orogeny.
- Although more work is needed, it appears that the basement is significantly involved throughout the Caledonian orogeny. Structural inheritance involving faulting along dikes may represent a pretty unique aspect of the Scandinavian Caledonian orogeny.

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Things to complete

- Final report for SGU. Final K-Ar ages and thin sections arrived in late October. (The K-Ar ages were measurements to confirm earlier obtained ages)
- Manuscript is about to be submitted, on faulting in the Jämtland basement along dolerite dikes.
- Manuscript in preparation on a review of brittle deformation ages in Scandinavia, from faults and fractures (collaboration between Sweden, Norway and Finland).