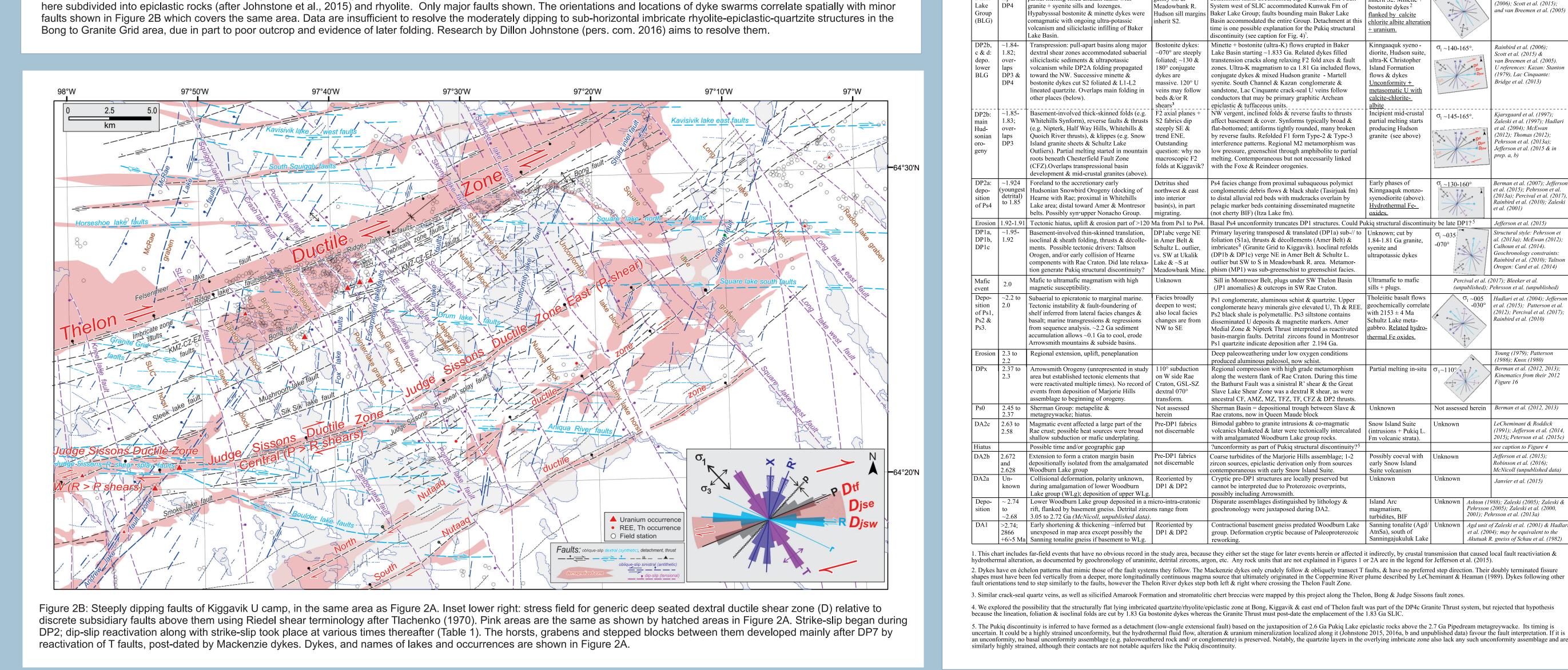
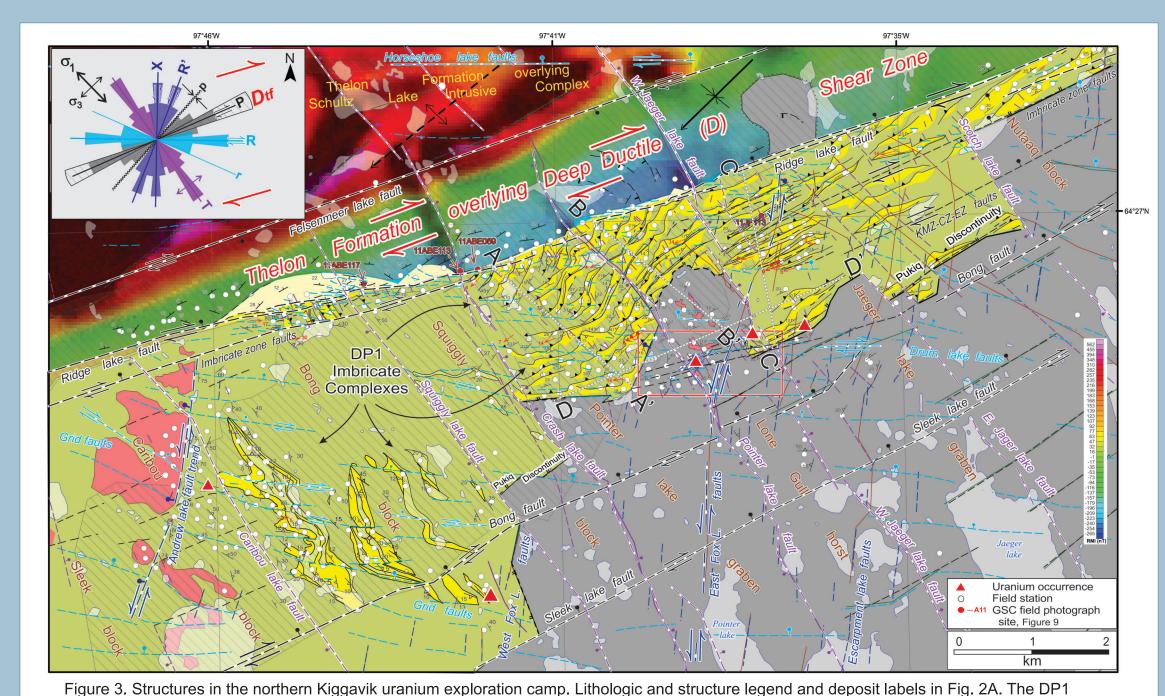


peromagnetic anomalies that transect other magnetic features and include intensely hematized outcrops, here interpreted as hydrothermal demagnetization along and extending

laterally from reactivated fault zones, after Riegler (2013) and Riegler et al. (2014). Black rectangles outline areas of detailed figures. Pukiq Lake fm (Fig. 1; Peterson et al. 2014) is



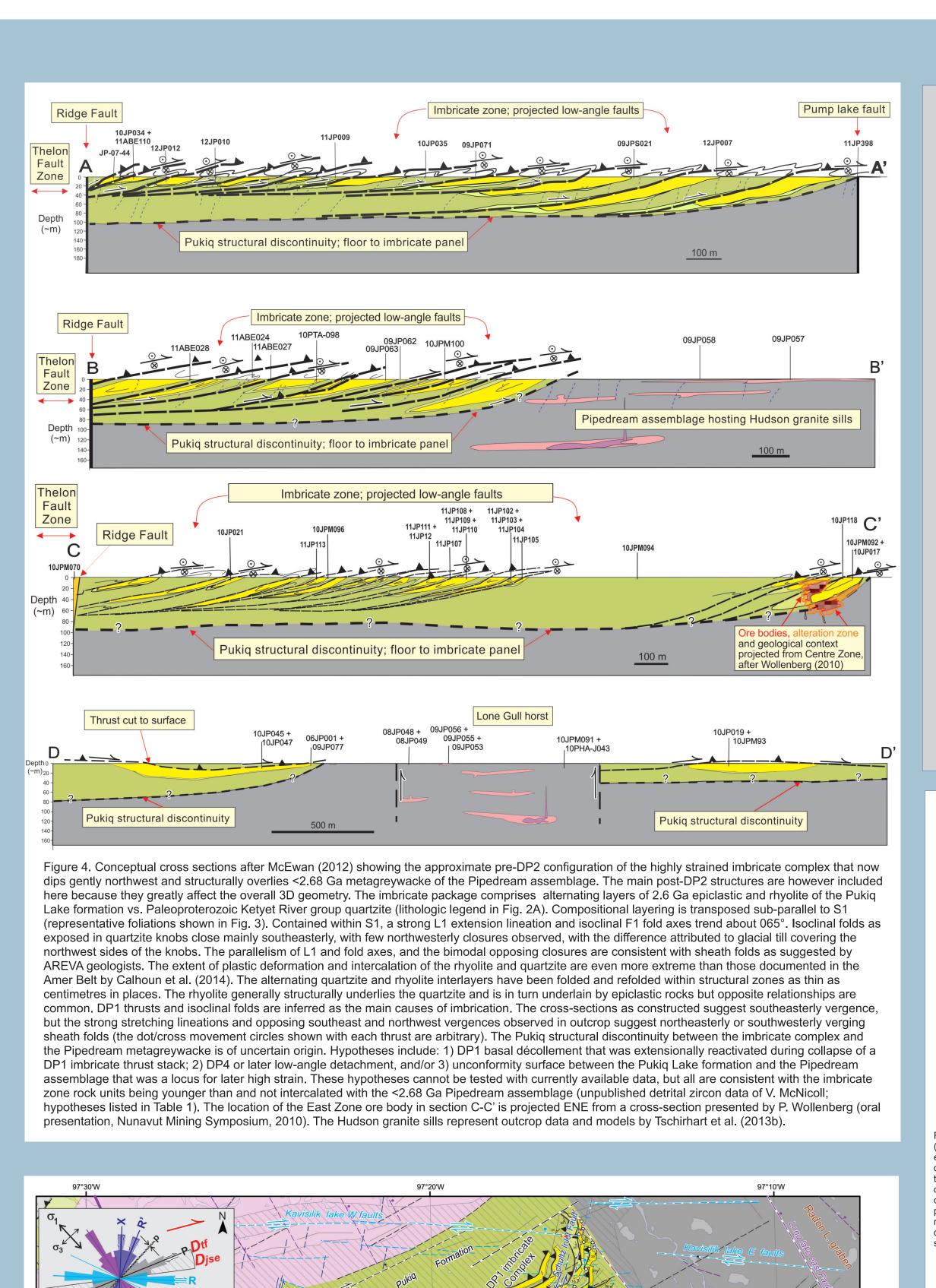


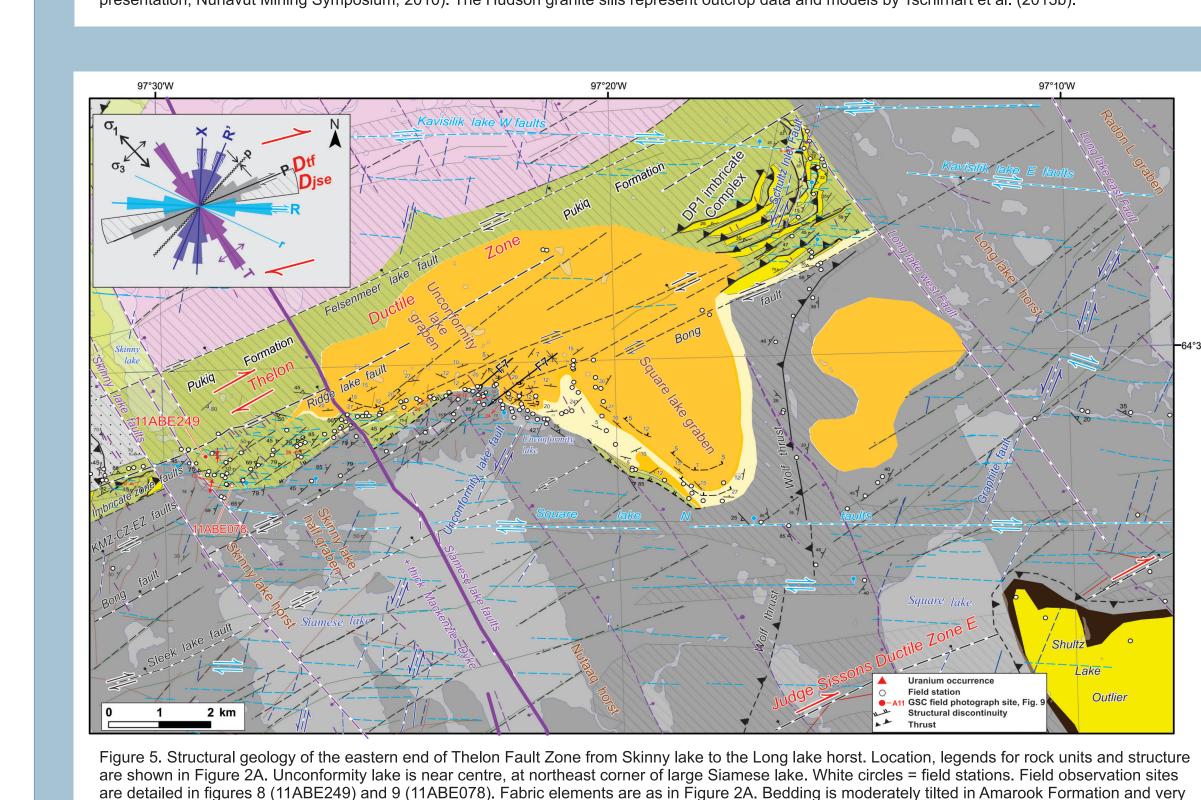
mbricate complex (Discussion) is transected by ductile to brittle steeply dipping strike- and dip-slip faults and dykes, and bounded on the southeast

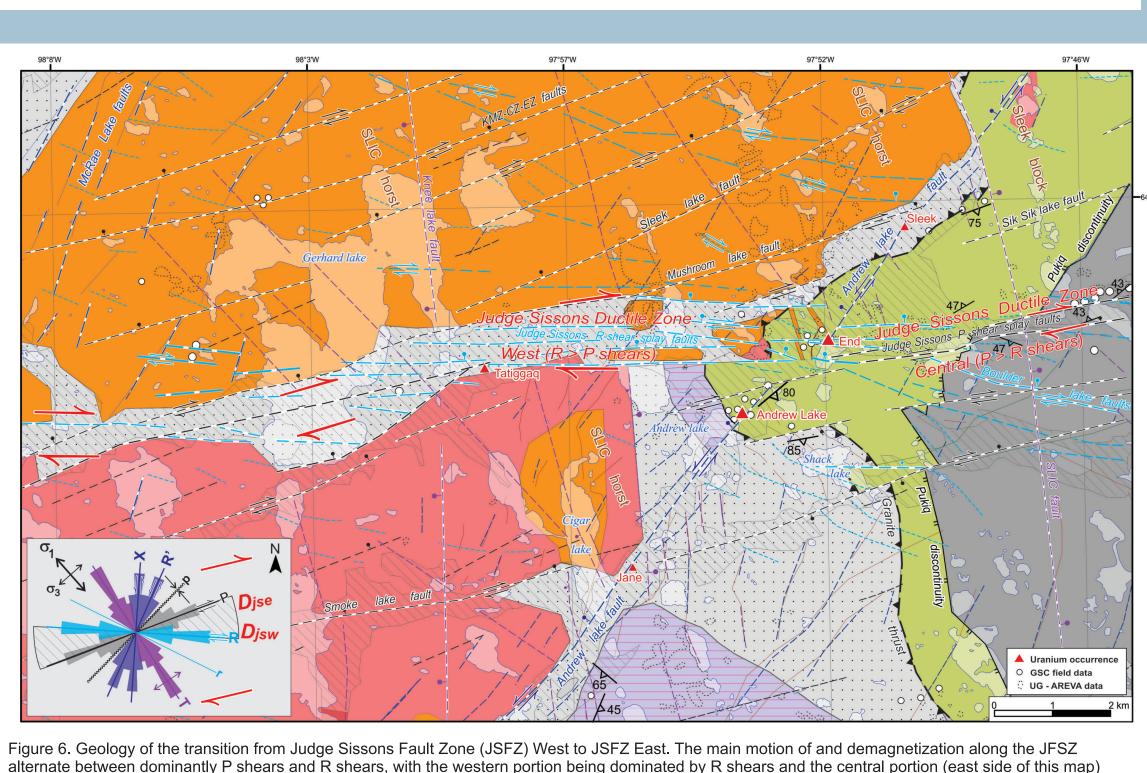
by the Pukiq discontinuity. Lines A-A' through D-D' show locations of structural cross sections (Fig. 4). Red stations are represented in Figure 9. Red

ctangle outlines the area of Figure 11. Note: Quartzite vs rhyolite-epiclastic units are diagrammatic; refined by Johnstone (2015, unpublished).							
Tabl Event 1	e 1. Co	Tectonic and/or depositional setting, and kinematics  Uplift; Ordovician preserved in graben	Fault and shear orientations  T at 120°	natic & alteration events in the NE Th  Main features: structures, fabrics, metamorphism, deposition <sup>2</sup> Aberdeen faults reactivated	Magmatic, hydro- thermal events U remobilization	Stress model	Sources (reference list in digital attachment)  Jefferson et al. (2015)
Ph1 P12 P11 P10	0.447 ~1.04 ~1.12 ~1.27	Ordovician marine transgression Post-Grenville. Crustal relaxation Grenville Orogeny Mackenzie plume centred in Coppermine	Quiescent Unknown T at 160° T at 140°	Shallow marine platformal fossiliferous limestone Mini-roll front uranium remobilization U disseminated along previous foliation planes Reactivated Bathurst faults from DP4 were commonly	Quiescent U remobilization U-thermal re-setting Mackenzie diabase	$ \begin{aligned} &\sigma_{l} \sim & 120^{\circ} \\ & \text{Not determined} \\ & \text{Not determined} \\ & \text{Na} \\ & \sigma_{1} \sim & 160^{\circ} \end{aligned} $	Bolton & Nowlan (1979) Sharpe et al. (2015) Sharpe et al. (2015) LeCheminant et al. (1989); Buchan & Ernst (2013)
P9 P8	<1.54	River area Regional cratonic subsidence and marine marine transgression Focused subsidence & eruption of Kuungmi	Quiescent  D at 075°	followed approximately by the Mackenzie dykes.  Berthoud Orogen far to the south. Deposition of marine stromatolitic carbonate of the Lookout Point Formation.  Sharpe et al. interpret Stage "1" uranium at Bong.  Reactivated T (Bathurst) faults from Dp4 amplified some	dykes Plume transected Laurentia, thermal resetting of U minerals Ultrapotassic mafic	Unknown, suspect as for DP8	Gall et al. (1992); Bridge et al. (2013); Sharpe et al. (2015) Ramaekers pers. comm 2007;
P7b	1.63-	Formation at intersection of reactivated main Bathurst & McDonald faults. Extension by Bathurst fault array propagated across Rae Craton  Gentle overall dextral boundary conditions		previous structures, e.g. Lone Gull horst uplifted Kiggavik deposits, SLIC horst further increased original uplift from mid- to upper-crustal depth by Granite Thrust.  Kiggavik MZ pods dip steeply NW along 055° faults	Kuungmi lavas; silicification & calcite alteration, U remobilization Unconformity U.	σ <sub>1</sub> ~140°	Tschirhart et al. (2011a,b; 2013 a,b,c,d; 2014; 2016); Pehrsson et al. (2013b); Chamberlain et al. (2010); Peterson (1995) Fuchs & Hilger (1989);
, 0	1.54	& reactivated broad deep fault zones; stress fields within broad faults are rotated ~10-20° mostly represented by extensional reactivation of pre-existing fault arrays. Compression to west from Racklan Orogeny. Overlaps DP7a	T at 140° broad D zones	between 075° faults (Fig. 11). Tattigaq U pods dip steeply SE at intersections of P, Tmicro shears along major D zones. Qavvik shoots dip steeply SE. See discussion in caption for Fig. 11 on relative ages of faults controlling Kiggavik MZ	SiO <sub>2</sub> dissolution, bleaching, clay alteration, specular hematite.	000	Hunter et al. (2012, 2014, 2015) Alexandre et al. (2009); Pehrsson et al. (2013b); Sharpe et al. (2015); Riegler (2013); Riegler et al. (2014)
7a	<1.68 to 1.63	Gentle overall dextral reactivation of the fault arrays that were established & reactivated during DP4 through DP7, gentle drag folds adjacent to Thelon & Bong faults. Overlaps DP7b.	Same as DP6b + fluorapatite cement along 150-165° trends	Thelon Formation folded into gentle synclines & anticlines along the Thelon Fault: elongate syncline north of Kiggavik & multiple folds N of Unconformity lake. Reactivated faults focused diagenetic & hydrothermal alteration before & during DP7b U.	U-bearing fluorapatite cemented all Thelon Fm 1.68- 1.67 Ga.	σ <sub>1</sub> ~120-140°	Rainbird et al. (2003); Gall & Donaldson (2006); Davis et al. (2011, 2012); this map
P6b: elon rma- n	1.73 to 1.63	Regional thermal subsidence with dextral trans-extension. All fault arrays from DP4 & DP5 were reactivated, forming intersecting horsts & grabens. Fault-bounded to subtle subbasins were filled by quartz-cemented polymict conglomerate, red desiccation cracked mudstone & feldspathic sandstone.	015° Thelon, 055° Turqavik & 120° Aberdeen Lake arrays, 070° & 140° horsts & grabens.	D & P shears reactivated, dip-slip > dextral, N-side-down in the Kiggavik area (Judge Sissons, Bong, Thelon arrays); opposite farther south. R' & X faults reactivated dip-slip. Fault scarp breccias flanked broad (~20 km) conglomerate-based alluvial channels with 3 upward-fining siliciclastic sequences recording soft & brittle faulting. Turqavik horst was reactivated.	Thelon Fm Sequence 1 silicified along fault zones, e.g. Turqavik & Thelon.	0	Hiatt et al. (2003); Davis et al. (2011)
6a 5c:	~1.73- 1.77 to ~1.73	Broad uplift & subaerial erosion at the Matonabbee Unconformity surface Linear & broad deep-crustal gravity lows are aligned with intrusive & extrusive intra-	unknown  T at ~120-150°; gravity lows at 030,	Erosion, oxidative paleoweathering, peneplanation  Rapakivi granite & diabase dykes²; broad gravity low underlies main Pitz Fm. (upper Wharton Gr.). 20 km R'	paleoweathering  Magmatic units constitute the bimodal	Unknown $\sigma_1 \sim 120^\circ$ .	Gall (1992, 1994)  KIS from Jefferson et al. (2013) & Peterson et al.
va-   Ig- ous  ite  IS)	~1.73	continental magmatic rocks along dextral trans-	913 of the second of the secon	trend of McRae L. dykes + graben + gravity low. Thelon R. dykes record extension along P & R. Nueltin granite fingers & pancakes later offset by P & R shears. Surface effects include phreatic breccias, hot spring stromatolites and silicification of Amarook Formation. Faults initiated during DP5c were reactivated from DP 7 through DP11.	Kivalliq Igneous Suite (KIS) with attendant tectonism & silicic hydrothermal Ag+Au at Mallery Lake.	1380	(2015) & Feerson et al. (2015a). "Late DP5" here = the original DP5 of Pehrsson et al. (2013a); Mallery Lake Ag-Au described by Turner et al. (2001, 2003) & placed in KIS context by Peterson et al. (2014, 2015b)
5b: arook m. asal arton oup).	1.785- 1.77	Overall thermal subsidence + dextral transextension reactivated most DP4 structures as dip-slip & low-angle extensional faults formed narrow to broad sedimentary basins, e.g. precursor to Aberdeen Sub-basin.	Gentle NW-SE compression, SW- NE extension on 120° Aberdeen array	Local block faults with small offsets flanked by quartz- pebble-dominated polymict alluvial conglomerate and sandstone; aeolian sand plains filled basins between. Extension may have generated or reactivated the Pukiq structural discontinuity. <sup>5</sup>	Hematite diagenetic cement.	ON CONTRACTOR OF THE PARTY OF T	Early DP5 as introduced by Pehrsson et al. (2013a). The Pukiq discontinuity could be a strained unconformity, or a detachment, now or during DP3
5a 4b	1.785- 1.77 1.81 to	Broad uplift, subaerial erosion & paleoweathering -Late Hudsonian reactivation of deep seated	unknown  Deep dextral (D)	Deep erosion, oxidative paleoweathering (earthy hematitization), peneplanation  NNE- & NW-trending upright folds, crenulation	Nil Hudson granitoid	Unknown  σ <sub>1</sub> ~120-135°.	Gall (1994); Rainbird et al. (2006) =DP4 of Pehrsson et al. (2013a). Amer Plutonic
nd per ker ke ce pup	1.785 over- lap DP3	strike slip systems, dextral-compressional in the study area, with oblique, reverse components.  -The master dextral (D) faults include: Amer Mylonite Zone, Amer Belt Medial Zone, Thelon Fault, Judge Sissons Fault & Nutaaq Fault. Important associated faults include the Bathurst fault array with normal offsets in the X (extensional) orientation, the Andrew Lake Fault with minor sinistral shear in the R' (antithetic) orientation, & numerous subparallel faults interpreted as P shear faults.	reactivated 065- 075° faults. Drag structures: 020- 045° & ~120° conjugate upright kink folds, axial planar crenulation cleavage + minor faults.	cleavage, kink bands & short dextral axial planar faults (Granite Grid photo IMG_400, station 11JP341) localized near the D faults. The major D faults splayed into lesser D faults as well as ENE-trending en échelon P faults. Compressional P faults should have a convexupward shape, but few of these are observed because of later extensional reactivation. The main D, & subsidiary D & P faults show left stepping en échelon patterns. Strong ductile S\C fabric is focused near the main D faults; farther away the strain is localized along brittle subsidiary D & P faults. Little fabric is preserved along the R & X/R' (Riedel) shears. Upper Kunwak sandstone & travertine deposited.	plugs at fault bends (Amer Plutonic Complex, Granite Grid, Lone Gull, Paliak Islands). Contact metamorphism with late granite in Kinngaaquk Core Complex. Calcite travertine @ 1785 +/-3 Ma pins upper Kunwak deposition.	S de de	Complex in Tella (1994); Jefferson et al. (2015); Scott et al. (2015). Lone Gull Pluton & Granite Grid plugs in Scott et al. (2015). Kinngaaquk Core Complex in Zaleski et al. (2001). Kunwak age in Rainbird et al. (2006)
ew; t a - ete ent?)	1.80 to 1.78	Apparently east-directed Granite thrust <sup>4</sup> emplaced Marjorie Hills assemblage (MHA) para- & orthogneiss (previously intruded by SLIC during DP2-3) on top of 2.6 Ga epiclastic rocks, & truncated the Half Way Hills Thrust. The Wolf & Schultz Inlet thrusts may also have developed at this time.	E-W compression. Could explain why macroscopic F2 not observed in Kiggavik area (see DP2A).	Granite thrust <sup>4</sup> juxtaposes exotic MHA on 2.6 Ga Pukiq Lake fm (drill core at An drew Lake shows E-vergent isoclinal folds & thrusts in banded orthogneiss & supracrustal gneiss). Wolf thrust is a well exposed mylonite zone. Schultz Inlet thrust inferred beneath string of lakes: sub-horizontal Pipedream metagreywacke on west vs. steeply dipping Amarulik wacke on east.	Unknown	01 -090- 110°	Unpublished data of Urangesellschaft (1980s) & Jefferson (2006-2012, e.g. Andrew Lake_10-03 & Sleek core). Detailed gravity + aeromagnetic data integrated with the above & modelled by Tschirhart et al. (2013b)
23 +: posit per ker ke oup LG)	1.78; over- lap DP4	detachment faults. Unroofing, pressure drop & partial melting filled dilatant faults with granite + syenite sills and lozenges.	SE-vergent, open to tight fold trains. Axial planes dip gently SE at Meadowbank R. Hudson sill margins inherit S2.	Further bostonite & minette flows & clastic filling of Baker Lake Basin. M3 retrograde metamorphism, e.g. chlorite alteration of amphiboles & biotite. Major detachment faults documented, e.g. Wharton Lake Fault System west of SLIC accommodated Kunwak Fm of Baker Lake Group; faults bounding main Baker Lake Basin accommodated the entire Group. Detachment at this time is one possible explanation for the Pukiq structural discontinuity (see caption for Fig. 4) <sup>5</sup> .	Sheets to laccoliths of Hudson granite + Martell syenite partly inherit S2. Minette + bostonite dykes <sup>2</sup> flanked by calcite chlorite albite alteration + uranium.	σ <sub>1</sub> ~020- 030°	As in Pehrsson et al. (2013a). Alternatives in Jefferson et al. (in prep. b); Peterson et al. (2011, 2014); Rainbird et al. (2006); Scott et al. (2015); and van Breemen et al. (2005)
2b, d: o. eer G	~1.84- 1.82; over- laps DP3 & DP4	Transpression: pull-apart basins along major dextral shear zones accommodated subaerial siliciclastic sediments & ultrapotassic volcanism while DP2A folding propagated toward the NW. Successive minette & bostonite dykes cut S2 foliated & L1-L2 lineated quartzite. Overlaps main folding in other places (below).	Bostonite dykes: ~070° are steeply foliated; ~130 & 180° conjugate dykes are massive. 120° U veins may follow beds &/or R	Minette + bostonite (ultra-K) flows erupted in Baker Lake Basin starting ~1.833 Ga. Related dykes filled transtension cracks along relaxing F2 fold axes & fault zones. Ultra-K magmatism to ca 1.81 Ga included flows, conjugate dykes & mixed Hudson granite - Martell syenite. South Channel & Kazan conglomerate & sandstone, Lac Cinquante crack-seal U veins follow conductors that may be primary graphitic Archean	Kinngaaquk syeno - diorite, Hudson suite, ultra-K Christopher Island Formation flows & dykes <u>Unconformity +</u> <u>metasomatic U with</u> <u>calcite-chlorite-</u>	σ <sub>1</sub> ~140-165°.	Rainbird et al. (2006); Scott et al. (2015) & van Breemen et al. (2005). U references: Kazan: Stanton (1979), Lac Cinquante: Bridge et al. (2013)
2b: in d- ian - y	~1.85- 1.83; over- laps DP3	Basement-involved thick-skinned folds (e.g. Whitehills Synform), reverse faults & thrusts (e.g. Nipterk, Half Way Hills, Whitehills & Quoich River thrusts), & klippes (e.g. Snow Island granite sheets & Schultz Lake Outliers). Partial melting started in mountain roots beneath Chesterfield Fault Zone (CFZ). Overlaps transpressional basin development & mid-crustal granites (above).	shears <sup>3</sup> F2 axial planes + S2 fabrics dip steeply SE & trend ENE. Outstanding question: why no macroscopic F2 folds at Kiggavik?	epiclastic & tuffaceous units.  NW vergent, inclined folds & reverse faults to thrusts affect basement & cover. Synforms typically broad & flat-bottomed; antiforms tightly rounded, many broken by reverse faults. Refolded F1 form Type-2 & Type-3 interference patterns. Regional M2 metamorphism was low pressure, greenschist through amphibolite to partial melting. Contemporaneous but not necessarily linked with the Foxe & Reindeer orogenies.	albite Incipient mid-crustal partial melting starts producing Hudson granite (see above)	σ <sub>1</sub> ~145-165°.	Kjarsgaard et al. (1997); Zaleski et al. (1997); Hadlari et al. (2004); McEwan (2012); Thomas (2012); Pehrsson et al. (2013a); Jefferson et al. (2015 & in prep. a, b)
22a: 00- on Ps4	~1.924 (youngest detrital) to 1.85	Foreland to the accretionary early Hudsonian Snowbird Orogeny (docking of Hearne with Rae; proximal in Whitehills Lake area; distal toward Amer & Montresor belts. Possibly syn-upper Nonacho Group.	Detritus shed northwest & east into interior basin(s), in part migrating.	Ps4 facies change from proximal subaqueous polymict conglomeratic debris flows & black shale (Tasirjuak fm) to distal alluvial red beds with mudcracks overlain by pelagic marker beds containing disseminated magnetite (not cherty BIF) (Itza Lake fm).	Early phases of Kinngaaquk monzo- syenodiorite (above). Hydrothermal Fe- oxides.	°L~130-160°	Berman et al. (2007); Jefferson et al. (2015); Pehrsson et al. (2013a); Percival et al. (2017), Rainbird et al. (2010); Zaleski et al. (2001)
osion Pla, Plb, Plc	1.92-1.91 ~1.95- 1.92		DP1abc verge NE in Amer Belt & Schultz L. outlier, vs. SW at Ukalik Lake & ~S at Meadowbank Mine.	Basal Ps4 unconformity truncates DP1 structures. Could Pu Primary layering transposed & translated (DP1a) sub-// to foliation (S1a), thrusts & décollements (Amer Belt) & imbricates <sup>4</sup> (Granite Grid to Kiggavik). Isoclinal refolds (DP1b & DP1c) verge NE in Amer Belt & Schultz L. outlier but SW to S in Meadowbank R. area. Metamor- phism (MP1) was sub-greenschist to greenschist facies. Sill in Montresor Belt, plugs under SW Thelon Basin	Unknown; cut by 1.84-1.81 Ga granite, syenite and ultrapotassic dykes  Ultramafic to mafic	σ <sub>1</sub> ~035 -070°	Jefferson et al. (2015)  Structural style: Pehrsson et al. (2013a); McEwan (2012); Calhoun et al. (2014). Geochronology constraints: Rainbird et al. (2010); Taltson Orogen: Card et al. (2014)
po- ion Ps1, 2 & 3.	2.0 ~2.2 to 2.0	magnetic susceptibility.  Subaerial to epicratonic to marginal marine. Tectonic instability & fault-foundering of shelf inferred from lateral facies changes & basalt; marine transgressions & regressions from sequence analysis. ~2.2 Ga sediment accumulation allows ~0.1 Ga to cool, erode Arrowsmith mountains & subside basins.	Facies broadly deepen to west; also local facies changes are from NW to SE	(JP1 anomalies) & outcrops in SW Rae Craton.  Ps1 conglomerate, aluminous schist & quartzite. Upper conglomerate heavy minerals give elevated U, Th & REE. Ps2 black shale is polymetallic. Ps3 siltstone contains disseminated U deposits & magnetite markers. Amer Medial Zone & Nipterk Thrust interpreted as reactivated basin-margin faults. Detrital zircons found in Montresor Ps1 quartzite indicate deposition after 2.194 Ga.	Tholeitic basalt flows geochemically correlate with 2153 ± 4 Ma Schultz Lake metagabbro. Related hydrothermal Fe oxides.	(unpublished); $\sigma_1 \sim 0.05$	Pehrsson et al. (unpublished)  Hadlari et al. (2004); Jefferson et al. (2015); Patterson et al. (2012); Percival et al. (2017); Rainbird et al. (2010)
osion Px	2.3 to 2.2 2.37 to 2.3	Regional extension, uplift, peneplanation  Arrowsmith Orogeny (unrepresented in study area but established tectonic elements that were reactivated multiple times). No record of events from deposition of Marjorie Hills	on W side Rae Craton, GSL-SZ dextral 070°	Deep paleoweathering under low oxygen conditions produced aluminous paleosol, now schist.  Regional compression with high grade metamorphism along the western flank of Rae Craton. During this time the Bathurst Fault was a sinistral R' shear & the Great Slave Lake Shear Zone was a dextral R shear, as were	Partial melting in-situ	σ <sub>1</sub> ~110°	Young (1979); Patterson (1986); Knox (1980) Berman et al. (2012, 2013); Kinematics from their 2012 Figure 16
) 2c	2.45 to 2.37 2.63 to 2.58	assemblage to beginning of orogeny.  Sherman Group: metapelite & metagreywacke; hiatus.  Magmatic event affected a large part of the Rae crust; possible heat sources were broad shallow subduction or mafic underplating.	transform.  Not assessed herein  Pre-DP1 fabrics not discernable	ancestral CF, AMZ, MZ, TFZ, TF, CFZ & DP2 thrusts.  Sherman Basin = depositional trough between Slave & Rae cratons, now in Queen Maude block  Bimodal gabbro to granite intrusions & co-magmatic volcanics blanketed & later were tectonically intercalated with amalgamated Woodburn Lake group rocks.	Unknown  Snow Island Suite (intrusions + Pukiq L. Fm volcanic strata).	Not assessed herein Unknown	Berman et al. (2012, 2013)  LeCheminant & Roddick (1991); Jefferson et al. (2014, 2015); Peterson et al. (2015c)
2b	2.672 and 2.628 Un-	Woodburn Lake group  Collisional deformation, polarity unknown,	Pre-DP1 fabrics not discernable  Reoriented by	?unconformity as part of Pukiq structural discontinuity? <sup>5</sup> Coarse turbidites of the Marjorie Hills assemblage; 1-2 zircon sources, epiclastic derivation only from sources contemporaneous with early Snow Island Suite.  Cryptic pre-DP1 structures are locally preserved but cannot be interpreted due to Protegozaic overprints	Possibly coeval with early Snow Island Suite volcanism Unknown	Unknown	see caption to Figure 4  Jefferson et al. (2015); Robinson et al. (2016); McNicoll (unpublished data)  Janvier et al. (2015)
epo-	~ 2.74 to ~2.68	during amalgamation of lower Woodburn Lake group (WLg); deposition of upper WLg. Lower Woodburn Lake group deposited in a mrift, flanked by basement gneiss. Detrital zirco 3.05 to 2.72 Ga (McNicoll, unpublished data). Early shortening & thickening –inferred but	nicro-intra-cratonic ons range from	cannot be interpreted due to Proterozoic overprints, possibly including Arrowsmith.  Disparate assemblages distinguished by lithology & geochronology were juxtaposed during DA2.  Contractional basement gneiss predated Woodburn Lake	Island Arc magmatism, turbidites, BIF Sanning tonalite (Agd/	Pehrsson 2001); Pe	988); Zaleski (2005); Zaleski & (2005); Zaleski et al. (2000, chrsson et al. (2013a) of Zaleski et al. (2001) & Hadlari

3. Similar crack-seal quartz veins, as well as silicified Amarook Formation and stromatolitic chert breccias were mapped by this project along the Thelon, Bong & Judge Sissons fault zones.



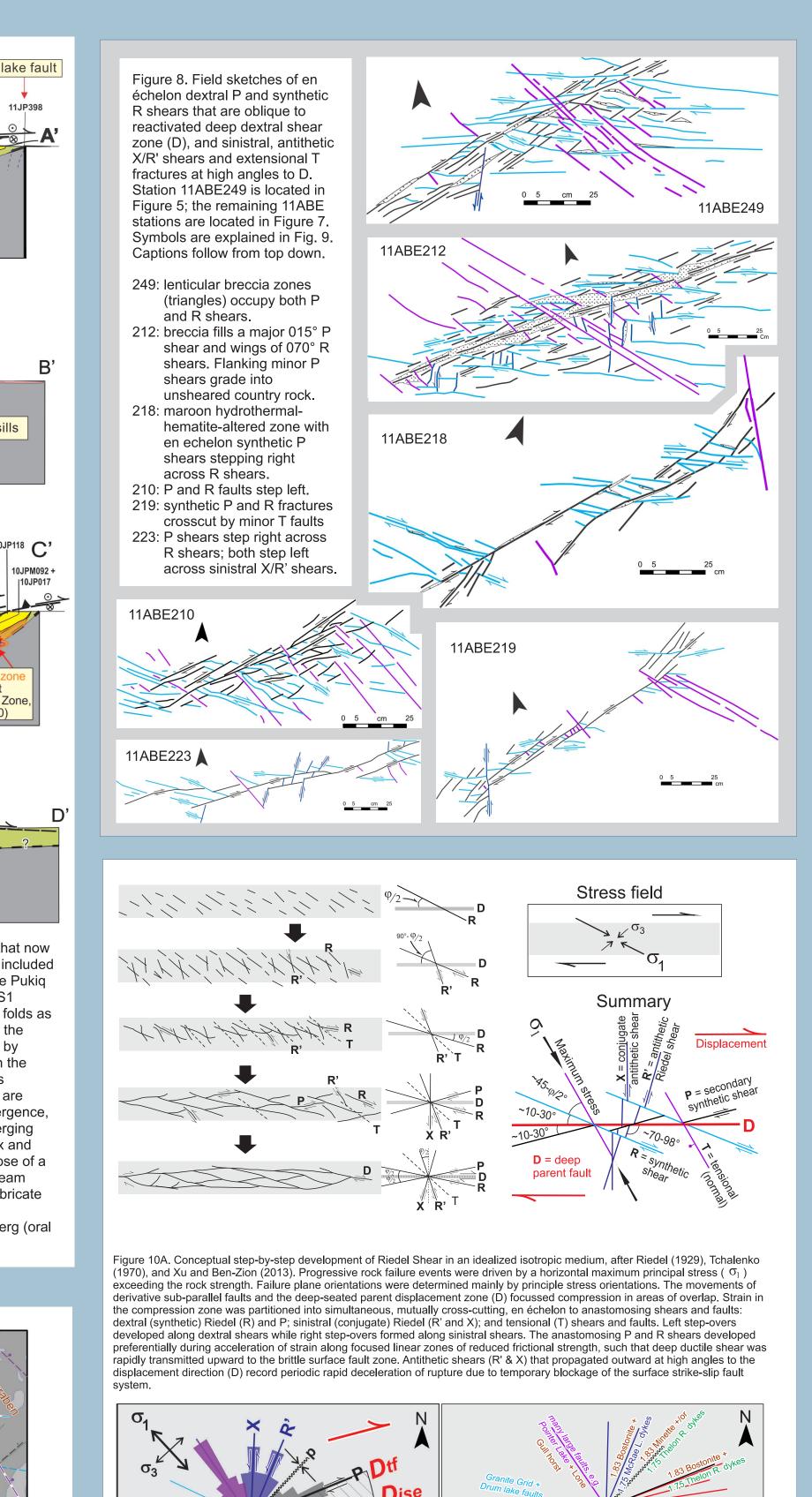


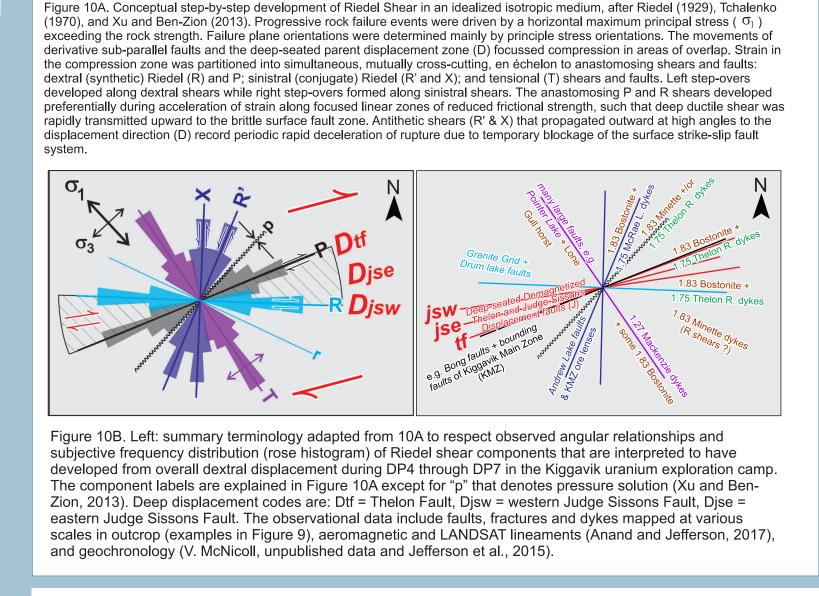


dominated by P shears. The Andrew Lake and End Grid deposits are located not only at the intersection of the Andrew Lake R' fault with the JSFZ but also at

the transition between dominantly R shears to the west and P shears to the east. Lithologic and structural legends and location of this figure are in Figure 2A.

gently folded in Thelon Formation sandstone. Compositional layering is parallel to steep foliation in basement supracrustal rocks in contrast to the gently





This report documents basement structures relevant to unconformity U deposits in the Kiggavik camp (Figure 1). Anand and Jefferson (2017) regionally mapped lineaments that are here interpreted as deep ductile to

reactivated brittle-ductile surface faults (Fig. 1, 2A, Table 1) developed during DP2 (~1.83 Ga) through DP7

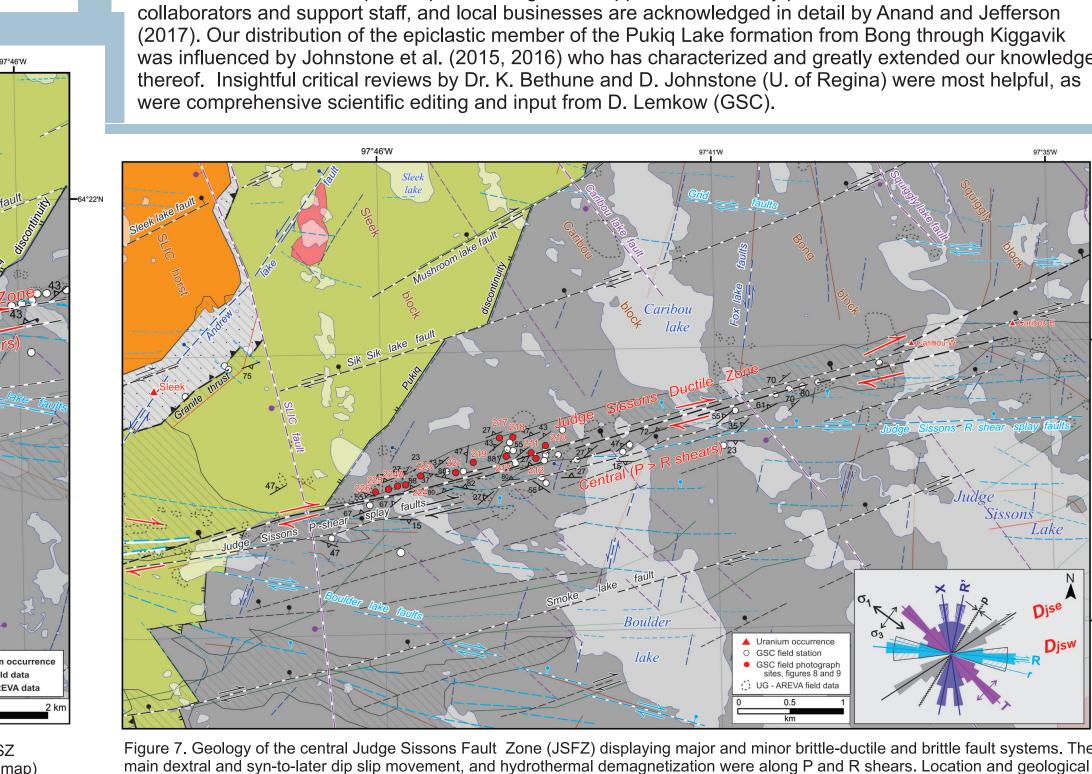
(~1.67 Ga) by Riedel shear (Riedel, 1929; inset A of figure 2B). Here we document Riedel shear structures in

outcrop, their effects upon imbricated Paleoproterozoic quartzite, 2.6 Ga volcanic rocks and underlying 2.71

Considerable data, conceptual inputs and logistical support from industry partners, academic and fellow GS

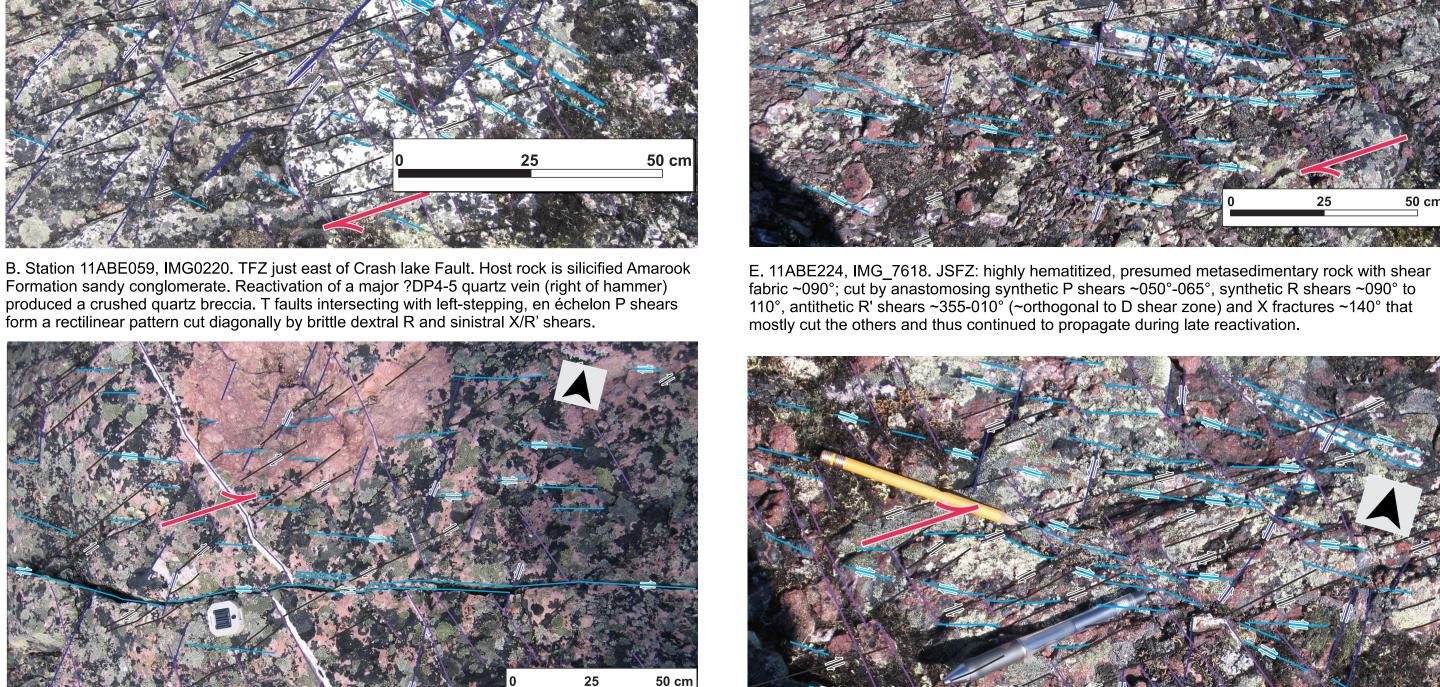
legend in Figure 2A. Faults and movement arrows explained in inset lower right from Figure 10. GSC field photograph sites (abbreviated to

Ga metagreywacke, and discuss these relationships with respect to uranium deposits.



3 digit numbers) detailed in Figures 8 and/or 9 are show in red.





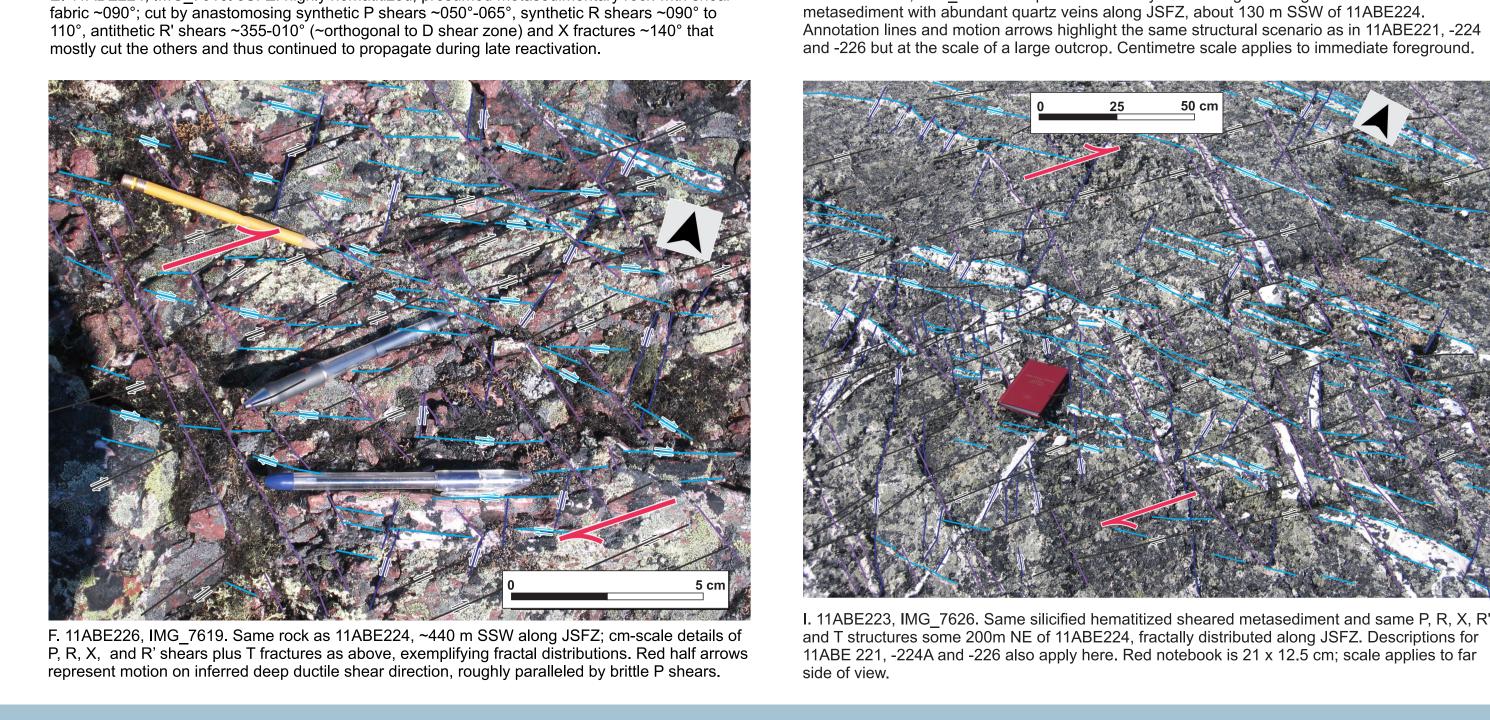
C. Photo IMG 0213 taken near 11ABE117. Brecciated, pink silicified feldspathic sandstone and

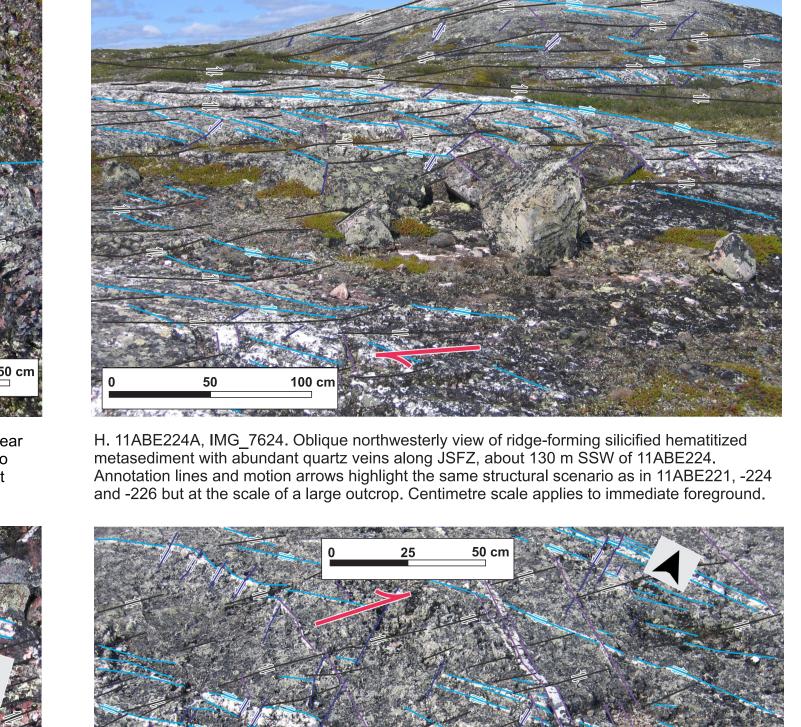
onglomerate of the Amarook Formation trends ENE along the south edge of TFZ, dissected by

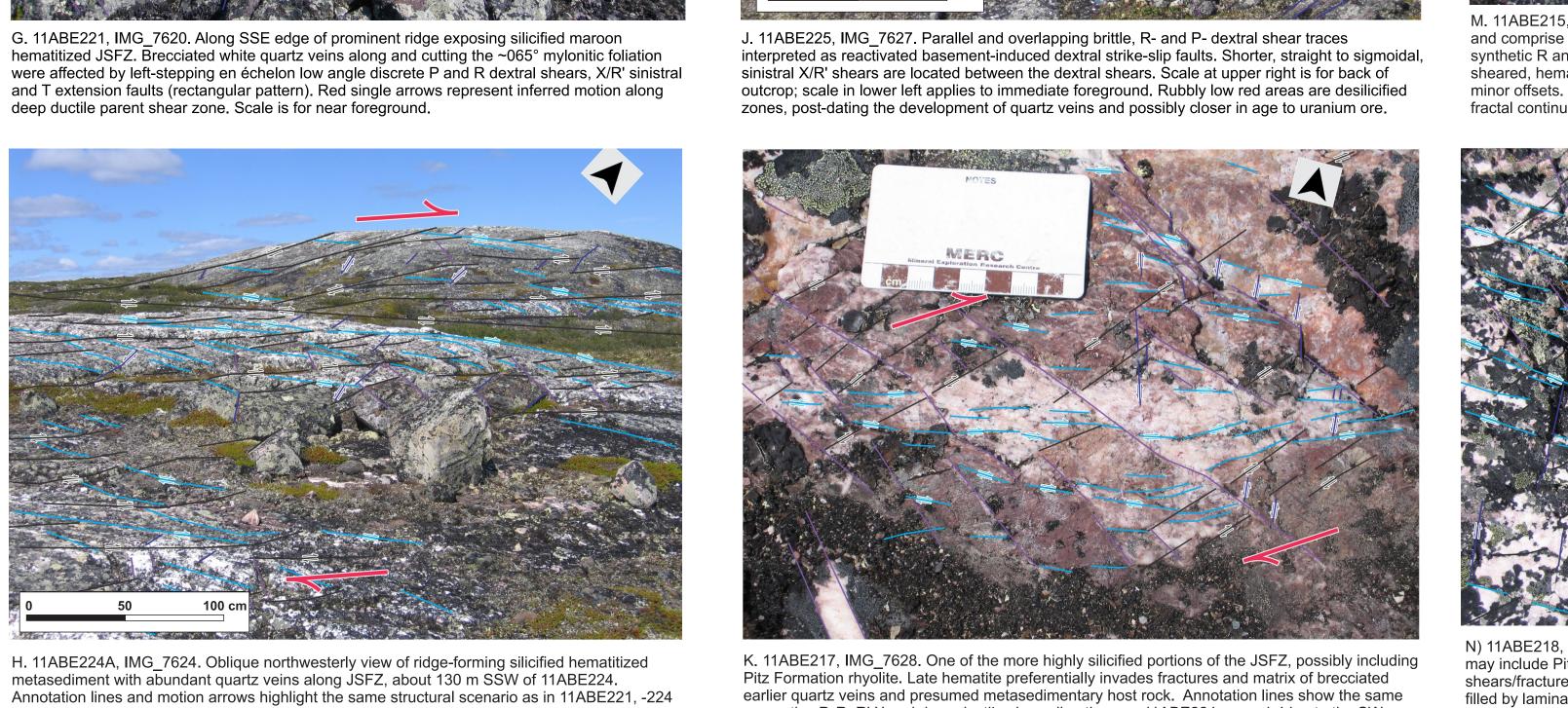
extral P, R and sinistral X/R' shears. En échelon T faults filled by laminated quartz veinlets cut

nany other shears and are interpreted to have formed by extensional hydrofracturing, but are in

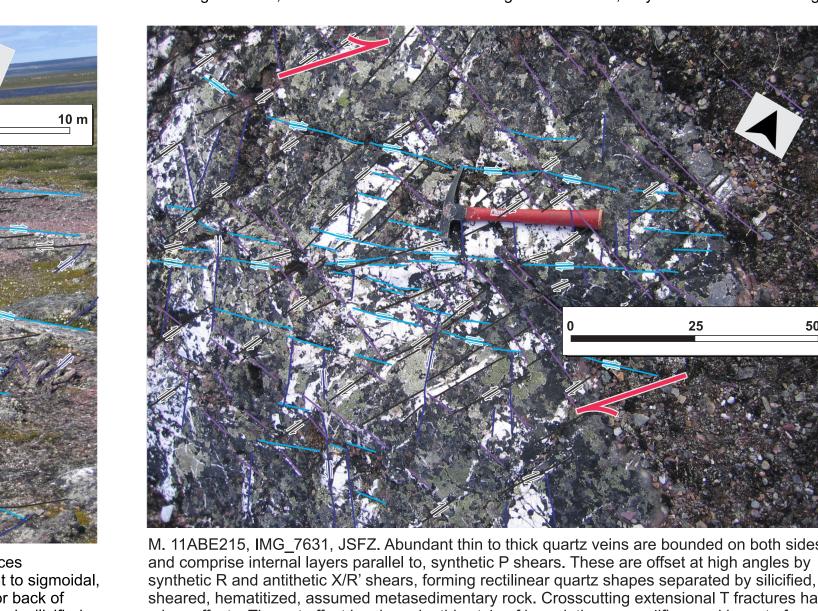
rn offset dextrally by reactivated R shears in places (e.g. just above compass).



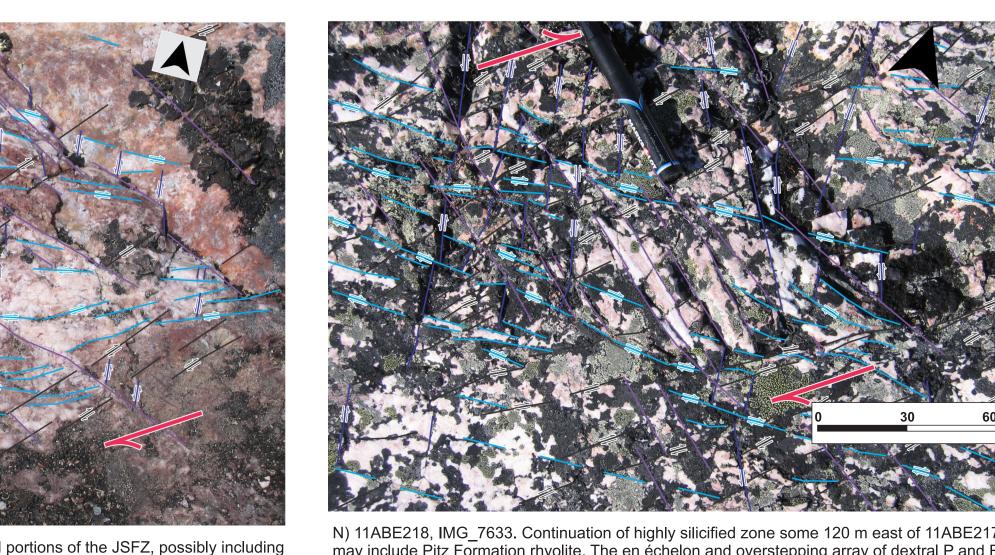




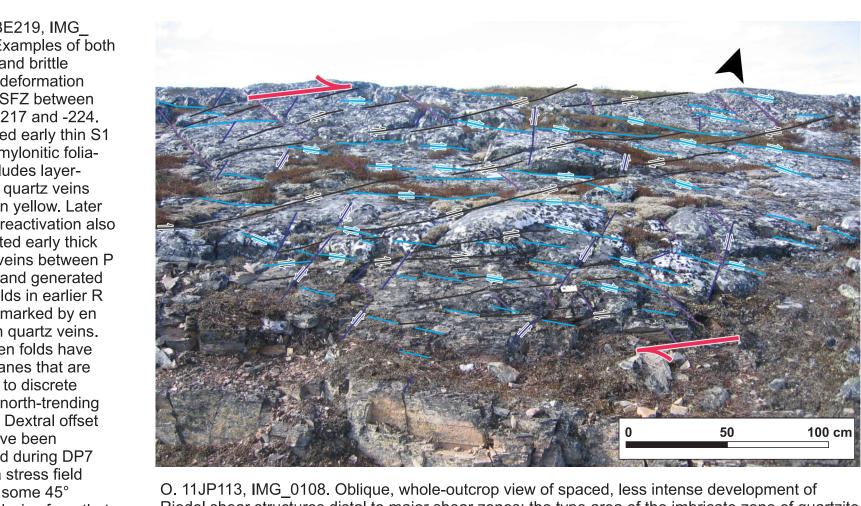




minor offsets. The net effect is a breccia; this style of brecciation exemplifies, and is part of, a



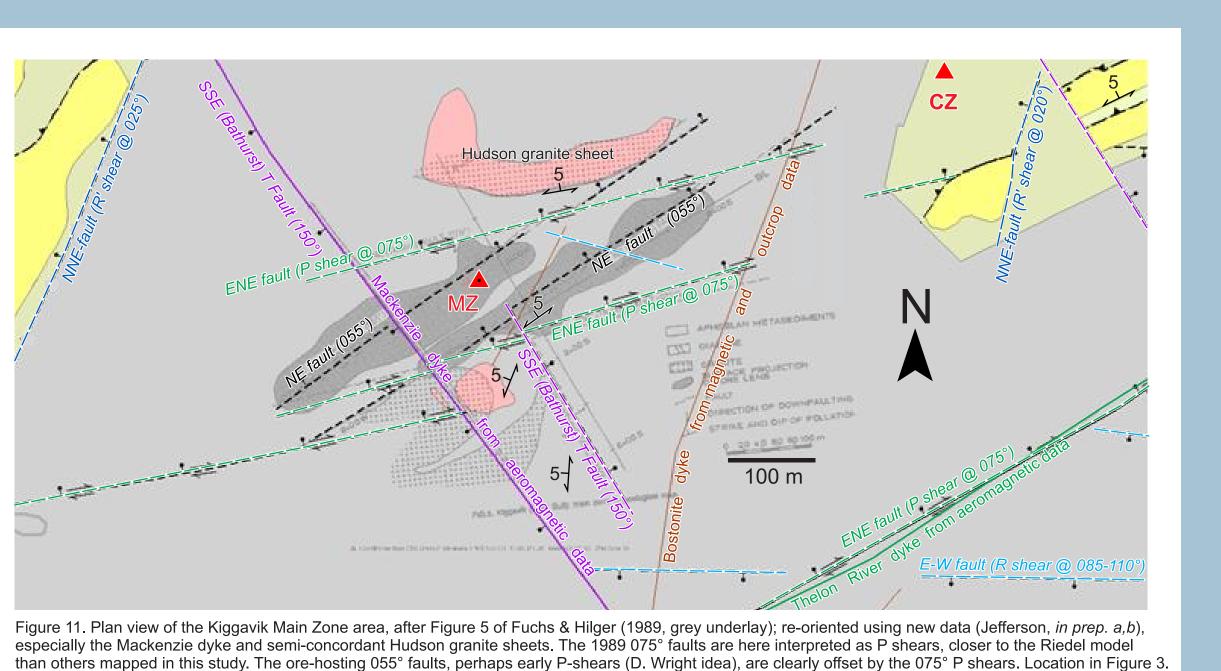
may include Pitz Formation rhyolite. The en échelon and overstepping array of dextral P and R shears/fractures here both offset, and are in turn offset by, extensional T faults, some of which are filled by laminated crack-seal quartz veins (e.g., at centre). Discrete antithetic X/R' shears tend to



Riedel shear structures distal to major shear zones: the type area of the imbricate zone of quartzite and rhyolite, located some 1.5 km north of Kiggavik Centre Zone and 625 m southeast of the TFZ. The shear structures are best expressed in the Proterozoic quartzite (white, with black lichen). The quartzite structurally overlies highly foliated 2.6 Ga rhyolite of the Pukiq Lake formation (pale salmon pink). The compositional layering in both units is highly transposed parallel to S1 which dips gently to the northwest, away from the viewer.

## Poster layout and associated data release

This camp-scale structural analysis considers detailed outcrop maps, structural measurements and field sketches for selected stations along the Thelon and Judge Sissons fault zones. Figures 2A and 2B provide geological and structural frameworks respectively, names used throughout, and locations of detailed maps. The Thelon Fault Zone is re-defined as a demagnetized deep ductile zone mainly covered by a 2 km-wide synclinal finger of Thelon Formation, bounded by the shallow Ridge lake (formerly named Thelon Fault) and Felsenmeer faults. The Bong to Kiggavik area (Figure 3) exemplifies intersections between the shallowly dipping imbricate complex and steeply dipping fault arrays. Schematic cross sections (Figure 4) illustrate the pre-DP2 configuration of the imbricate complex. Figures 5 to 9 document selected outcrop data on the strike- and dip-slip fault networks that dissected the imbricate complex and other parts of the study area (see Discussion for possible relevance to mineralization). Figure 10 shows how these data fit the Riedel shear model. Elements of each fault array have various dips, therefore rather than following the right hand rule, directions are labelled as in the NE or SE guadrants, Figure 11 places work by Fuchs and Hilger (1989) into this context. References and figures are included in the accompanying digital files. Individual field station data and ArcGIS geology shapefiles will be published in Jefferson et al. (in prep. a, b).



Faults mapped at surface are relevant to the location and development of unconformity-associated uranium ore deposits in multiple, yet indirect and conceptual ways. The study area was subject to repeated anisotropic deformation from at least 1.83 Ga to the post-Ordovician (Table 1). Reactivated faults, key for unconformity U deposits (Jefferson et al., 2007a, b, c), have long been recognized in this region (e.g. Fuchs et al., 1986; Fuchs and Hilger, 1989; Hunter et al., 2012, 2014, 2015; Jefferson et al., 2011a, b; Miller and LeCheminant, 1985; Miller and Peterson, 2015). Second, the stress regime changed with, and/or between, each deformation event (codes in Table 1). Third, metallogenic studies cited above and in Table 1 have shown that different types of alteration and mineralization are linked to each deformation and magmatic event. Such linkages suggest age constraints on the various styles of steeply dipping structures pervading the Kiggavik Camp.

Many of the fault zones and adjacent rocks are altered by pervasive hematite and quartz cement and cut by numerous cross-cutting quartz veins and veinlets (Fig. 9). Both veins and cement comprise drusy and cryptocrystalline quartz such as documented by Turner et al. (2001) at Mallery Lake. We interpret the silicification as part of event DP5C that Peterson et al. (2014, 2015) link with heating during the Kivallig Igneous Event. The relatively early nature of most quartz veins is consistent with observations by AREVA that much of the silicification and quartz veins predate de-quartzification and clay alteration associated with uranium mineralization (Riegler, 2013; Riegler et al., 2014; Sharpe et al., 2015). Nonetheless multiple generations of quartz veins (Fig. 9) and quartz cement in the Thelon Formation allow that some quartz veins may be contemporaneous with ore, accepting distal silica from de-quartzification and silicate alteration at the site of uranium precipitation.

Most of the fault zones that were silicified during DP5C were selectively dequartzified during mineralization which, through regional metallogenic context, we ascribe to DP7A through DP7B. We have insufficient information to define the exact stress regime during mineralization, but uraninite is intergrown on a sub-microscopic scale with felted clay minerals that fill millimetre-scale veinlets; and clay mineral foliations form strain shadows around uranium-bearing fluorapatite crystals that are replaced by uraninite (Robinson et al., 2016). Spatial geometric analysis of such fabrics in oriented core samples could provide information to better understand deformation during mineralization.

Regardless of the timing of fault reactivation and reorientation of the stress field. several empirically mappable structural features likely influenced the paths of hydrothermal fluids that dissolved quartz, altered mafic minerals to hematite and clavs, and precipitated uraninite in favourable sites. One large factor is the aquitard effect of the imbricate complex that may have formed a cap over

**Discussion and Questions for the Future** ydrothermal fluid flow systems and thereby promoted lateral flow. The imbricated complex of quartzite, rhyolite and epiclastic rock (Fig. 3, 4, 7) is interpreted as a result of isoclinal folding and thrusting during DP1 (Table 1) Thin-skinned thrust imbrication within the complex records various states of internal plastic deformation, refolding and structural intercalation along lithologic contacts down to the millimetre scale. This imbricate panel dips gently to the NNW and is thought to have been an aquitard that was breached

some shears and especially where they branch, step and intersect with other contemporaneous structures. Some compressional clay-filled shears may have been aguitards that cut off fluid flow while intersecting extensional structures may have enhanced fluid flow, as suggested by Figure 11. Multiple lines of evidence show that repeated reactivation through time generated strain along previously established zones of weakness rather than along ideal planes of an homogeneous model. Timing is provided by the above-noted alteration types and by dykes (Fig. 1, 2A) whose magnetic lineaments were used by Anand and Jefferson (2017) as evidence for faults and fractures with respect to the stress model (Fig. 9). The 1.83 Ga minette and bostonite dykes fill all fracture orientations of the stress model. Of the 1.7

Ga dykes, the McRae Lake dykes occupy only R' shears, only west of the SLIC. The Thelon River dykes fill both P and R shears. The 1.27 Ga Mackenzie diabase dykes fill only X faults and, in many places, cross over an are beside the most significant X faults, clearly post-dating ore-related faulting Brittle surface structures were mapped along the 1-3 km wide, broadly demagnetized deep crustal ductile shear zones (D) of Tschirhart et al. (2013a, b) and Anand and Jefferson (2017) (pink in Fig. 2B). The Thelon and Judge Sissons faults offset the SLIC by 25 and 10 km, respectively. The Andrew Lake fault is a large R' structure with little apparent sinistral offset. Renewed dextral offset along Thelon Fault offset the 1.75 Ga McRae Lake dykes by a few 10's of m. The recessive, broad, desilicified, demagnetized fault zones are mostly

covered: Thelon by a finger of Thelon Formation; Judge Sissons and Andrew Lake by till. Their margins were reactivated as narrow, discrete but still complex fault and breccia zones some 10's to 100's of metres wide. Late slickensides on the Ridge lake fault (southernmost strand of the Thelon Fault) record north-down motion, consistent with drilled offsets of 100's of metres (Davis et al., 2011). The brittle surface structures predictably follow Riedel (R and R'), P and X shears. En échelon dextral R shears strike ~17° to 28° clockwise to D. En échelon dextral P shears strike ~10-15° anticlockwise of D These are linked into continuous anastomosing fault zones parallel to D. Between the D zones discrete medium-scale faults (Fig. 2B) are spaced some 2 km apart and also record strike-, then dip-slip offsets shown by north-

down steps in magnetic intensity. Scales range down to microscopic in a fractal continuum, including block to grain rotation and formation of breccia to cataclasite along all orientations, contained within much less deformed zones. Faults decrease laterally away from intense zones, grading into relatively unfractured rock. All shear orientations cut all others from place to place. The ductile-brittle to brittle Riedel, P and X structures (Figure 10) fit classic

definitions by Riedel (1929). Tchalenko (1970). Wilcox et al. (1973). Rutter et al. by the steeply dipping arrays of Riedel shears, somewhat along the length of (1986), Davis et al. (1999), Nova (2003), Schmocker et al. (2003) and Xu and Ben-Zion (2013); experimental results simulating primary and reactivated deformation (Cloos 1928; Riedel 1929; Tchalenko 1970); field studies (e.g. Moore 1979; Davis et al. 1999; Ahlgren 2001; Katz et al. 2004); analogue modelling with clay (e.g. Cloos 1955; Wilcox et al. 1973; Tchalenko 1968; Smith and Durney 1992; Marques 2001) and sand (e.g. Naylor et al. 1986); direct shear experiments (e.g. Bartlett et al. 1981; Moore and Byerlee 1992; Schreus 1994) and numerical modelling (e.g. Dresen 1991; Braun 1994; McKinnon and Garrido de la Barra 1998). Many structural questions remain. Regional DP2 transpression generated dextral

> shear zones, open to tight box folds broken by reverse faults and thrusts. The Schultz Lake outlier (Fig. 2) may be a klippe (Hadlari et al. 2004, Tschirhart et al. 2013a, McEwan 2012) but more work is needed along its margins. Late in DP2 to DP3 trans-extension exhumed the 1.83 Ga Hudson suite. Extension along the Wharton Lake fault system west of Kiggavik and major faults to the southeast accommodated the Baker Lake Group. Extension also generated F3 folds with subhorizontal axes and drove retrograde metamorphism. Questions abound regarding the inferred Pukig Lake discontinuity - we prefer a DP3 and/or younger extensional structure but it could be a highly strained unconformity surface between the younger Pukiq Lake formation and older Pipedream assemblage. Reversed strike slip motion along some P and R shear faults has yet to be explained. Renewed transpression during DP4 reactivated the long-lived, deep and pervasive, ductile dextral strike-slip systems from DP2 and developed proximal ENE-trending folds and thrusts. How important are DP4 folds measured at Granite Grid and just north of the Lone Gull camp for constraining ore? Which brittle-ductile to late brittle DP4 faults reactivated weaknesses from previous deformations, and which are new? During DP5, 6 and 7 successive dextral trans-extension events accommodated the Wharton and Barrensland groups, punctuated by erosion during quiescence and uplift. Do the Figure 11 structures documented by Fuchs and Hilger

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(1989) reflect DP5 to 7? What generation are their ore-constraining 055° faults and





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north-dipping foliation/layering in the Bong to Kiggavik area (Fig. 3).



do they fit the Riedel shear model?