Canadian Tectonics Group 2022 Workshop Abstract Volume

Thank you for attending the Virtual Canadian Tectonics Group Workshop. The talk schedule and abstract can be found in this document but is also accessible on fourwaves. All times are in MDT.

Presentations

Session 1: 9:00 – 10:15 AM

9:00 – 9:20 **T. Stephan** and E. Enkelmann; What stresses the Canadian Cordillera? – A statistical analysis of the first-order intraplate stress field of western Canada

9:25 – 9:45 **D. MacLeod** and D. Pattison; Late Cretaceous to Eocene exhumation of the southern Purcell Mountains, southeastern British Columbia

9:50 – 10:10 **D. Orenstein**; The Cross-Cordilleran Excursions of the 1972 International Geological Congress, a Semi-Centennial Celebration

10:10 – 10: 30 BREAK

Session 2: 10:30 – 11:45 AM

10:30 – 10: 50 **W. Langenberg** and K. Larson; Dating of slicken-fibres on bedding and fractures of the Livingstone Thrust sheet, SW Alberta

10:55 – 11:15 **T. Cawood**, J. Peter, D. Petts, and M. Polivchuk; The effect of deformation and metamorphism on critical metal distributions in massive sulfides: Preliminary results from the Windy Craggy Cu-Co VMS deposit, northwestern B.C.

11:20 – 11:40 **L. Harris,** P. Abidan, O. Göğüş, R. Pysklywec, and R. Fischer; Critical mineral deposits localised by mantle drips and reactivated lithospheric-scale structures in Türkiye and E Canada

11:45 – 12:30 BREAK

Session 3: 12: 30 – 1:45 AM

12:30 – 12:50 **T. R. Morrell**, L. Godin, and R. Soucy La Roche; Along-Strike Diachronous Thermo-Kinematic Evolution of the Himalayan Metamorphic Core in Western Nepal

12:55 – 1:15 **D. Garcia**, L. Godin, and I. Coutand; Thermal history of the Frontenac Arch in southeastern Ontario, Canada: Constraints from low temperature thermochronology

1:20 – 1:40 **E. Gosselin**, R. Soucy La Roche, K. Larson, and A. Moukhsil; Linking titanite U-Pb, microstructural and trace element data to deformation and metamorphism in a late-Grenvillian shear zone, Saguenay-Lac-St. Jean, Québec

1:45 – 2:00 PM BREAK

Session 4: 2:00 – 2:50 PM

2:00 – 2:20 **R. Hieber** and D. Boger; The two-stage metamorphic evolution of the southern Ubendian Belt

2:25 – 2:45 **Q. Wu**, S. Lin, and A. Unger; A discontinuous Galerkin level set method applied to the modelling of deformation patterns in tectonic flow

Virtual Poster Session – Available from 8 AM to 6 P PM.

Presenters will be available at their posters from 3 PM to 4 PM

Virtual Posters

What is the Extent of the Influence of the Artemis Corona Across the Henie (V-58) Quadrangle, Southern Venus?

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Artemis, a 2400 km diameter circular feature, is one of the largest tectono-magmatic features in our solar system, proposed to have formed above a deep mantle plume. A concentric wrinkle ridge suite (13,000 km diameter) and a radiating dike swarm (12,000 km diameter) are proposed to belong to the Artemis system. Venusian graben are long extensional lineaments generally appearing in linear, radial or circumferential patterns, that are interpreted to be the surface expression of underlying dike swarms. Wrinkle ridges are sinuous, elevated contractional features. The Henie (V-58) Quadrangle, directly south of the Artemis (V-48) Quadrangle contains widespread north-south trending graben that could be related to Artemis. West-northwest to east-southeast oriented wrinkle ridges extend across much of the Henie Quadrangle. These wrinkle ridges could represent the southeastern portion of the Artemis wrinkle ridge swarm. Mapped topographical features were categorized by characterizing qualities such as orientation and trend in ArcGIS (1:500,000) on files from the Magellan mission. The northwesternmost quadrant of the Henie Quadrangle is crosscut by three graben swarms (353-173°; 340-160°; 010-190°). In the region of Latmikaik Corona there is one north-south graben swarm (015 to 195°) and two more north-south graben swarms around the Gilliani Impact Crater (Fig. 4; 351-171°; 005-185°). Wrinkle ridges have inconsistent spacings across the western margin of the Henie Quadrangle being common in the northwest, minimal to non-existent around the Latmikaik Corona and then variably spaced around the Gilliani Impact Crater in the south. The five graben swarms that extend north-south from the northwestern quadrant of the Henie quadrant through Latmikaik Corona to Gilliani Impact Crater could possibly be grouped as a single N-S trending swarm across 2400 km. It is very challenging to connect the wrinkle ridges across the entire Henie quadrangle from the northwestern quadrant to the Gilliani Impact Crater because they are discontinuous.

Barrovian metamorphism on the eastern flank of the Monashee Complex, British Columbia: Preliminary results from mapping and petrographic analysis

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The metamorphism and structure of a portion of the Selkirk Mountains south of Revelstoke, British Columbia, has been investigated. The domain of interest is bound on its western flank by the Eocene Columbia River fault, juxtaposing it against upper amphibolite-facies gneisses of the Monashee Complex. The eastern boundary is gradational with the Selkirk fan structure, and the southern boundary is approximately coincident with south end of the Jurassic Kuskanax batholith near Nakusp.

Between Revelstoke and Beaton Arm on Upper Arrow Lake, in the hanging wall of the Columbia River fault, is a sequence of Barrovian metamorphic zones. These increase in grade from east to west, and comprise chlorite/biotite, garnet, staurolite, kyanite, and sillimanite zones developed in metapelites. Mapping of mineral assemblages reveals shallowly east-dipping isogradic surfaces. To the south, between Beaton Arm and Nakusp, metamorphic grade decreases to chlorite/chloritoid zone, suggesting a southeast-plunging isogradic antiform. Preliminary phase equilibrium modelling suggests approximate peak metamorphic conditions at 5.3-6.5 kbar and <650°C in the kyanite zone.

Structural analysis indicates three phases of deformation, termed D2 through D4; D1 is a Devono-Mississppian fabric only locally developed. D2 is characterized by kilometer-scale upright folds and a steeply-dipping penetrative foliation which developed approximately coevally with low grade metamorphic recrystallization. D3 is the dominant phase of deformation, characterized by northeast-vergent, tight to isoclinal recumbent folds and an associated penetrative crenulation to axial-planar schistosity. Barrovian metamorphic recrystallization developed approximately coevally with the development of the D3 structures. D4 increases in intensity from east to west as west-vergent crenulations. The age of D2/M2 is Middle Jurassic, bracketed by the ca. 180 Ma Kuskanax batholith that D2/M2 overprints and by the 162 Ma Galena Bay stock that cuts the D2/M2 structures. D3/M3 is likely Early Cretaceous, constrained by the post-D3 104 Ma Albert Stock. The age of D4 remains unconstrained.

Towards a new tectonic model for the late phase of the Grenvillian Orogeny. Insight from field mapping, geochronology and geochemistry along the highway 117 transect through the Grenville Province in western Quebec, Canada

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This contribution combines field-based observations with modern geochemical and geochronological data to characterize the tectonic architecture along the generally understudied highway 117 transect through the Grenville Province in western Quebec. First we compared trace elements of mafic bodies within the Parautochthonous Belt (PB) to suites known to have magmatic affinities to either the contiguous Superior Province (i.e. autochthonous) or the structurally overlying, Allochthonous Belt (AB). The results support our field observations indicating that these mafic bodies belong to the AB and are completely enveloped by the highly migmatitic PB gneisses that preserve evidence for melt-present deformation. Zircons from syn-late deformational felsic intrusions in both the PB and AB ubiquitously reveal complex morphologies, defined by inherited cores and successions of texturally distinct zones and yield overlapping Grenvillian $^{207}Pb/^{206}Pb$ weighted mean ages between 1020-960 Ma. The successive Grenvillian zones are interpreted as the result of protracted fluid-fluxed melting, which is supported by the common presence of large peritectic hornblende in leucosome. Integrating these results we suggest that the partially molten PB intruded into overlying mafic AB rocks, brecciated it and incorporated the mafic bodies as it flowed towards the foreland. In contrast to conceptual models viewing the later phase of the Grenvillian Orogeny as a cold, short orogenic wedge, our data and those from the Eastern Grenville Province rather indicate that the Rigolet was a major orogenic phase involving protracted melting and flow of the deep crust.

Mesoscopic foliation boudins in banded orthogneiss and associated amphibolite, Grenville Province of central Ontario: Field observations and their kinematic implication

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Cm- to m-scale noncylindrical foliation boudins abound in the banded orthogneiss and strongly foliated amphibolite of macroscopic high-strain zones, Grenville Province of central Ontario. Most of these mesoscopic foliation boudins are asymmetrical, like the majority of mesoscopic layer boudins identified in 2D or locally exposed in 3D. Especially in grey orthogneiss with deformed mafic layers, many foliation boudins are cored by 'parasitic' layer boudins of amphibolite.

Above the northwestern boundary of the Parry Sound domain, highly strained amphibolite is replete with mesoscopic foliation boudins, typically bounded by concordant quartz-feldspar veins with variable amounts of mafic minerals. In banded granitoid gneiss of the Muskoka domain, the boundaries of many mesoscopic foliation boudins are similarly decorated by concordant quartz-feldspar veins (see example below), conspicuous markers of synkinematic discontinuities. As suggested by the known general pattern of variable finite strain, within, and adjacent to, individual lenticular boudins derived from competent layers, such discontinuities qualify as miniature stretching faults, originally defined and modelled by W.D. Means. Concordant minor stretching faults are missing from the boundary zones of published numerical models of foliation boudins with orthorhombic or monoclinic symmetry.

Oblique section through a pair of asymmetrical foliation boudins, eastern Muskoka domain, Grenville Province of central Ontario. Note the blue pen and its shadow at the upper right-hand corner.

Geology of the Latmikaik and Xcacau Coronae in the Heine (V-58) Quandrangle, Venus

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Venusian coronae are circular to ovular landforms with diameters up to 2500 km. Coronae have annulus borders composed of densely packed grooves, potentially grabens with overlying dykes. This geometry with the accompanying volcanic features suggest that the coronae could be the surficial expression of mantle diapirs. The topographic expression of coronae may reflect different stages of corona evolution, where elevated core regions represent retrogressive stage evolution while sunken core regions represent progressive stage evolution. In the Henie (V-58) Quadrangle the Tellervo Chasma extends between the Latmikaik Corona (345 km x 650 km) and

Xcacau Corona (120 km x 165km) which are both elongated and constrained by radar bright annulus material. Annulus material defines a topographic high around the edge of Latmikaik Corona with the core material slightly raised defining an overall W-shape. Xcacau Corona has a less well-defined annulus and a sunken core. Tellervo Chasma extends between the two coronae (striking 050-230°). Fourteen graben swarms cut across these coronae and chasma: i) Six (011-191°; 010-190°; 340-160°; 325-145°; 337-157°) cross Xcacau Corona and northern Tellervo Chasma. ii) One (025-205°) extends the length of the chasma, iii) One radiating graben system originates from the southeastern corner of Xcacau Corona, iv) Two (331–151°; 015-195°) across the southern Xcacau Corona, v) Five cut across southern Latmikaik Corona (022-202°; 027-207°; 055-235°; 353-173°; 005-185°), and vi) One (355–175°) veers west thirty degrees (325–145°) around the southwestern quadrant of Latmikaik Corona. The W- shaped profile of Latmikaik Corona suggests that this corona is in a retrogressive stage, while the sunken profile of Xcacau Corona suggests a more progressive stage. The complex system of 14 swarms suggest a prolonged history of magmatism and extension, possibly related to the formation of these two coronae in response to underlying mantle plumes.

Oral Presentations

The effect of deformation and metamorphism on critical metal distributions in massive sulfides: Preliminary results from the Windy Craggy Cu-Co VMS deposit, northwestern B.C.

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Critical metals (CMs) are essential for modern and green technology, but have at-risk supply chains. Several CMs, like Co and In, are hosted by sulfides in volcanogenic massive sulfide (VMS) deposits. Understanding the controls on their distributions is essential for effective exploration and extraction. Various factors affect the primary distribution of CMs in VMS systems, including fluid chemistry and magmatic inputs. However, textural modification and remobilization of sulfides during deformation and metamorphism can significantly change these primary distributions. Depending on the remobilization mechanism and conditions, some CMs may be expelled from their host sulfides to be incorporated into other minerals or form discrete new phases, whereas others may be further concentrated into their original sulfide host.

We combine microstructural mapping of sulfides by electron backscatter diffraction (EBSD) with compositional mapping by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) to determine how sulfide modification affects critical (and other trace) metal distributions. We use the Windy Craggy Cu-Co-(Au-Ag) VMS deposit in northwestern British Columbia as a case study as it experienced heterogenous localized deformation during greenschist facies metamorphism, so both deformed and undeformed sulfides are available for comparison.

Preliminary results suggest that pyrrhotite underwent dislocation creep and dynamic recrystallization, accompanied by a decrease in Co content from ~1050 to ~950ppm. Pyrite is relatively unstrained, preserving primary textures or occurring as coarse metamorphic porphyroblasts with significant internal variations in Ag, As, Au, Bi, Co (up to ~6%), Cu, Mo, Pb, Sb, Se, Te, and Tl contents. Ag, Bi, and Pb are also concentrated along pyrrhotite grain boundaries, either introduced by fluids during deformation and/or expelled from recrystallizing pyrrhotite. Sphalerite and chalcopyrite were remobilized by fluid-assisted dissolution-reprecipitation, with as-yet-unquantified compositional implications. In sphalerite-free samples, Ga and Ge are predominantly hosted by synkinematic chlorite, and In and Sn occur in chalcopyrite inclusions in pyrite.

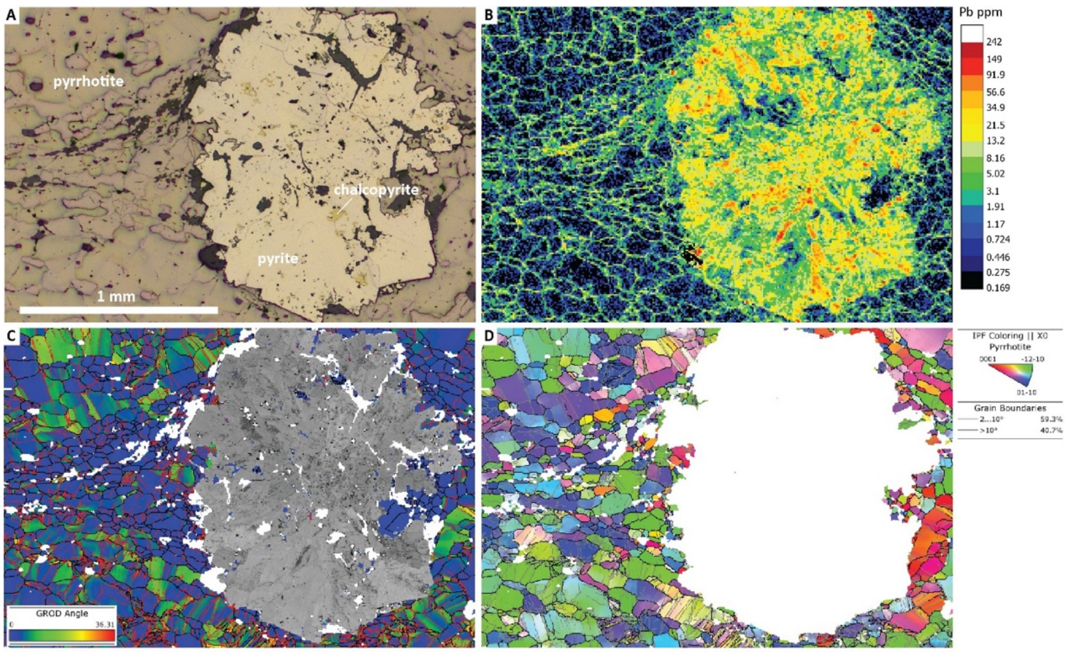

Fig. 1. A pyrite porphyroclast wrapped by foliated pyrrhotite. A) Reflected light photomicrograph. B) LA-ICP-MS map of Pb content. C) EBSD map, showing the range of crystal orientations within each pyrrhotite grain. D) EBSD map, showing the relative orientations of all pyrrhotite grains.

Thermal history of the Frontenac Arch in southeastern Ontario, Canada: Constraints from low temperature thermochronology

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The Frontenac Arch is an intraplate low-relief ridge of Precambrian rocks that connects the southeastern Ontario part of the Canadian shield with the Adirondack Massif in New York State. The NW-SE trending ridge is oriented perpendicular to the major tectonic fabric of the Grenville, Appalachian, and St. Lawrence rift systems. This research aims to constrain the thermal history and building mechanism(s) of this basement topography using apatite fission track (AFT) and

(U-Th)/He in zircon (ZHe) and apatite (AHe) low-temperature thermochronometry. Possible reactivation of orogen-perpendicular basement faults or the passage of the Great Meteor hotspot as exhumation mechanisms will be tested. Samples from other locations within the Grenville orogen (Gatineau and Muskoka) are also dated for comparison.

ZHe data yield intrasample age dispersion from the Neoproterozoic to the Lower Cretaceous with ages getting younger from the axis of the Arch towards both flanks, suggesting the onset of differential unroofing by the end of the Proterozoic. This is compatible with a nonconformity between Grenville rocks and overlying Cambrian siliciclastic Potsdam Group. AFT ages decrease SE of Rideau Lake Fault, suggesting fault reactivation in the Lower Jurassic during NW-SE extension and the break-up of Pangea. AHe age data suggest that the Arch was at near-surface temperatures in the Lower Cretaceous. Preliminary numerical inversion results predict a reheating event with thermal maxima of up to 180°C during the Ordovician, Permian, and Triassic, followed by protracted then fast cooling rates from the Lower Jurassic to the Paleogene. These models do not indicate a reheating event during the passage of the hotspot but a change in cooling rates. A crustal-scale NW-trending fault detected through gravity data correlates with brittle faults and seismic events at the western edge of the Arch, suggesting that fault reactivation played an important role in the exhumation of the Frontenac Arch.

Linking titanite U-Pb, microstructural and trace element data to deformation and metamorphism in a late-Grenvillian shear zone, Saguenay-Lac-St. Jean, Québec

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The use of U-Pb geochronology on titanite to date shear zone deformation is promising, but uniquely linking grain portions or populations to specific deformation and/or metamorphic events remains complex. We investigated the age, trace element and microstructural characteristics of titanite in three ca. 1075 Ma mangerite samples containing mylonitic to ultramylonitic bands to date a late-Grenvillian shear zone. Titanite outside of the ultramylonite portion in the first sample analysed is rare, partially replaces ilmenite and is interpreted as metamorphic titanite. These titanite grains yield a lower intercept age of 1016 ± 11 Ma. The microstructural characteristics of titanite within the ultramylonite (*i.e.* increased grain size, intracrystalline deformation, polysynthetic deformation twins and asymmetric magnetite wings) are consistent with syn-shearing (re)crystallization. These grains yield a lower intercept age of 1002 ± 10 Ma. There are no systematic variations in geochemical compositions between the two textural settings. The second sample investigated is wholly from within a high-strain zone. The titanite age populations therein correlate with trace element contents (Eu anomaly, Th/U, LREE/MREE, Zr), grain morphology and/or within-grain position. The youngest population (1036 ± 5 Ma) is characterized by individual asymmetric grains and overgrowths in low-strain quadrants on ca. 1060 Ma igneous and/or metamorphic titanite, and is therefore interpreted as

syn-shearing. In the third sample analyzed, titanite populations identified based on Th/U, Zr and LREE/MREE do not yield singular dates, consistent with decoupling of U-Pb dates and trace elements. The geochronological data, further, do not correlate with grain size, morphology or position relative to the ultramylonite band, which impedes identification of syn-shearing titanite based on microstructural evidence. The results of this investigation highlight the necessity to use a combination of trace element and microstructural characteristics to interpret dates as deformation ages, and they demonstrate the common decoupling between U-Pb dates and trace element signatures.

Critical mineral deposits localised by mantle drips and reactivated lithospheric-scale structures in Türkiye and E Canada

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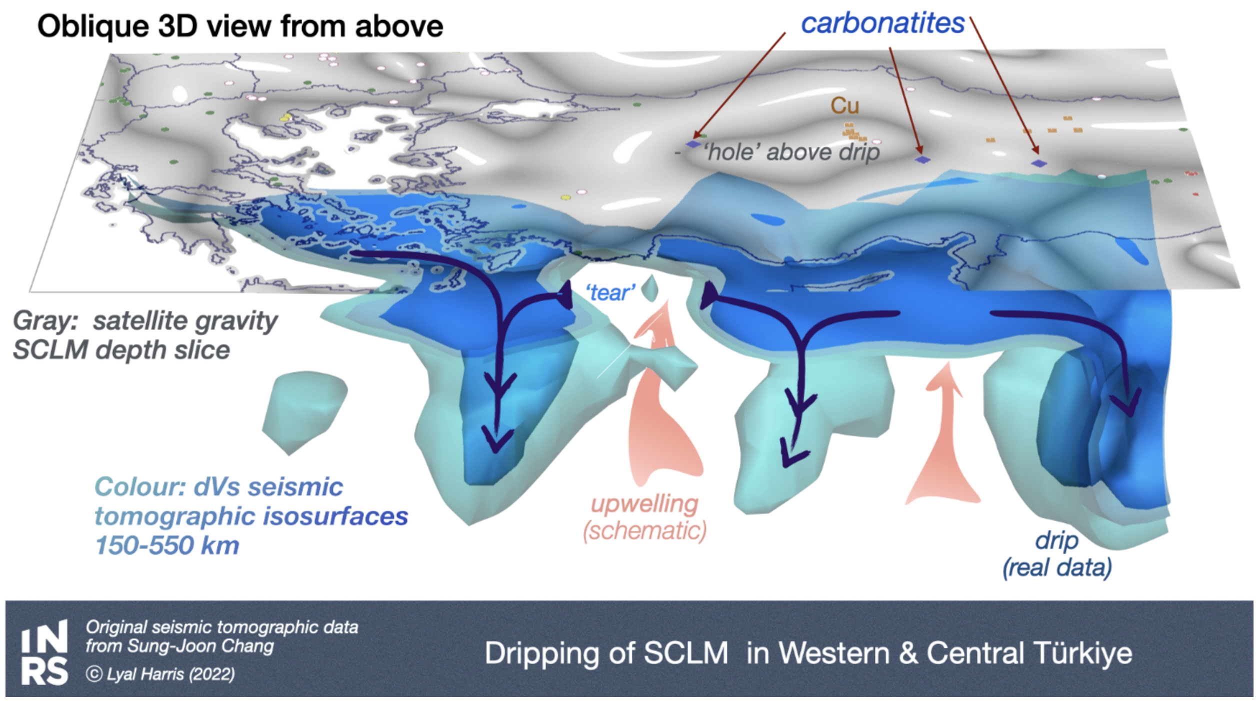
Integration of enhanced geophysical data with numerical models illustrates tectonic and structural controls on many minerals critical for a transition towards 'clean' energy and increasing future technological demands. Carbonatites and (per)alkaline intrusions, commonly attributed to melting above mantle plumes, are shown to (also?) form by secondary mantle upwellings commensurate with dripping of sub-continental lithospheric mantle (SCLM). Long wavelength satellite gravity reveals that the 25–24 Ma Kizilçaören F-REE-barite deposit, Türkiye (recently purported to contain the world's second-largest REE reserve after China) is situated close to a suture zone and overlies the margins to a kidney-shaped SCLM domain 200 x 500 km. Other F-REE occurrences overlie the opposite margin to this and other SCLM domains; all are peripheral to mantle drips imaged by seismic tomography. Geophysical data also support numerical models that Central Anatolian plateau uplift is due to dripping of thickened SCLM.

In the Western Superior Province, orogenic ('lode') Au and the majority of Cu, Zn, U, Ni and Co occurrences occur (i) where upper crustal faults overlie the margins to SCLM domains in long wavelength satellite gravity, as seen in Türkiye, and (ii) above N-S to NNW-SSE trending faults in the mid- to deep crust imaged by enhanced aeromagnetic data, i.e. at a high angle to mapped structures. The geometry of SCLM domains is identical to numerical models of cylindrical and sheet-like dripping in the Archean. In the Proterozoic Grenville Province, emplacement of anorthosites (which may host Ti, Ga, Zn, and REEs) is also related to SCLM removal through dripping.

Quebec's WNW-ESE Waswanipi-Saguenay Corridor, in which Archean to Neoproterozoic alkaline intrusions containing REE±Nb±Ta were emplaced in the Superior and Grenville provinces, is presented as an example of how reactivated lithospheric-scale structures are also important in localizing some critical mineral occurrences.

Research was funded by NRCan (TGI-5), Laurentian Goldfields, and SOQUEM.



The two-stage metamorphic evolution of the southern Ubendian Belt

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Malawi is located in the central-eastern part of Africa and records a long and complex metamorphic history. It lies within the East-African-Rift-System which controls the present-day topography of the country, although it experienced at least three major metamorphic events beforehand: the Palaeoproterozoic Ubendian-Usagaran Orogeny (2200-1800 Ma), the Mesoproterozoic Irumide Orogeny (1050-950 Ma) and the Neoproterozoic Pan-African Orogeny (800-500 Ma).

Thermodynamic modelling of metapelitic granulites of the southern Ubendian Belt in central Malawi suggests a generally clockwise *P-T-t* path. The granulite facies metamorphism and *P-T-t* path reflect crustal thickening and subsequent exhumation of this belt in the Palaeoproterozoic.

These granulites are crosscut by steeply dipping shist zones that formed shist zones that were retrogressed under similar pressure conditions but significantly lower temperature. Electron probe microanalyser (EPMA) U-Th-Pb dating of monazite of these schists yields three age populations which correspond to previously reported tectono-metamorphic events in the area:

Irumide Orogeny, rift-related magmatism and Pan-African Orogeny. Combined with textural relationships, these ages reveal that these schistose zones experienced peak metamorphic conditions during the Irumide Orogeny and were overprinted and retrogressed in localised shear zones during the Pan-African event.

Following a model of the Broken Hill area in southern Australia, the schists in this work are interpreted to have formed in normal faults in the Ubendian basement during Mesoproterozoic transgression after the Ubendian Orogenesis. Overlying sedimentary strata of the Palaeo- to Mesoproterozoic Muva-Supergroup have been responsible for a re-burial of the schist zones and acted as a source for fluids that percolated down the steeply dipping faults. These allowed to re-hydrate the dehydrated basement rocks (granulites) which then underwent retrogression to schists under greenschist to amphibolite facies conditions.

Dating of slicken-fibres on bedding and fractures of the Livingstone Thrust sheet, SW Alberta

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Slickensided carbonates of the Wileman Member of the Mississippian Mount Head Formation in a section along Highway 3 near Blairmore were sampled. This section is in the Livingstone Thrust sheet of the Blaimore West map sheet of the Crowsnest Pass area. Calcite U-Pb geochronological analysis of those slicken-fibres was carried out via laser ablation inductively coupled plasma mass spectrometry in the Fipke Laboratory for Trace Element Research (FiLTER) at the University of British Columbia, Kelowna.

Calcite slicken-fibres on a bedding plane with top to the east movement indications average ~11 ppm U and define a lower intercept date of 32.37 ± 0.63 Ma (mean squared weighted deviates [MSWD] = 1.65; n = 25/31) on a Tera-Wasserburg concordia plot, indicating contractual movement around that time.

Calcite slicken-fibres on an a-c fracture were also analyzed. These fibers have an average U content of 0.3 ppm and yield a severely over dispersed lower intercept date of 18 ± 13 Ma (MSWD = 15.6, n = 57/60) in Tera-Wasserburg space. Applying a ^{208}Pb-based common Pb correction (after Parrish *et al*., 2018) and plotting the data in ^{208}Pb/^{206}Pb versus ^{238}U/^{206}Pb space defines a ^{238}U/^{206}Pb date of 50 ± 19 Ma.

A 52 Ma Ar/Ar age on fault gouge has been derived for thrusting along the Lewis Thrust about 15 km west of the present sample. The circa 32 Ma (Oligocene) calcite U-Pb date from the Livingstone Thrust sheet indicates it formed after movement along the Lewis Thrust. The possible 50 Ma movement along the fracture may indicate that movements in the Livingstone Thrust sheet started in the Eocene before final folding and thrusting of this rock mass in the Oligocene.

Late Cretaceous to Eocene exhumation of the southern Purcell Mountains, southeastern British Columbia

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The Purcell Mountains of southeastern British Columbia form part of the hinterland to the Canadian Cordillera and host intrusive granitic rocks that were emplaced during mountain building in the mid-Cretaceous. This study examines the extent and timing of Cretaceous and younger rock uplift of the southern Purcell Mountains by utilizing, metamorphic petrology, U/Pb in zircon geochronology, and low to mid temperature thermochronology.

The southern Purcell Mountains host two granitic intrusions previously assumed to be emplaced during the Early Cretaceous, the Fry Creek and White Creek batholiths. We date these intrusions to 59.7 ± 1.1 Ma and 98.1 ± 1.4 Ma respectively using U/Pb zircon geochronology. Petrographic analysis of the contact aureoles of these intrusions has revealed Crd-And bearing mineral assemblage sequences in the White Creek contact aureole and both Crd-And and And-St bearing assemblages in the Fry Creek. Phase equilibrium modeling has constrained the pressure of the contact metamorphism in both aureoles to 2.5-3.5 kilobars. The pressures of metamorphism and the age of the intrusions provide a point in depth and time upon which the low to mid-temperature thermochronology is then built. Existing Ar/Ar biotite (closure temperature ~350°C) and new apatite and zircon (U-Th)/He (closure temperature ~60°C and ~180°C) data from five samples across the Fry Creek and White Creek Batholiths elucidate the Late Cretaceous to Eocene exhumation history of the region following magma emplacement. Preliminary apatite and zircon (U-Th)/He data reveal older ~40-60 Ma cooling ages on the eastern flank of the Purcell Mountains in the hanging wall of the Rocky Mountain Trench fault, and younger ~30 Ma cooling ages on the western flank located in the footwall of the Gallagher Fault Zone. Additional apatite and zircon (U-Th)/He age-elevation profiles from both sides of these bounding normal faults will be analyzed later this year.

Along-Strike Diachronous Thermo-Kinematic Evolution of the Himalayan Metamorphic Core in Western Nepal

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The influence of pre-orogenic (inherited) upper crustal features is emerging as a key process invoked to explain along-strike variations in metamorphism, deformation, and exhumation in orogenic systems. The Precambrian Indian lower plate of the Cenozoic Himalayan orogen contains basement structures that are oriented perpendicular to the Himalayan orogenic front.

This setting provides the opportunity to test if, and how, these cross-strike Indian structures influenced the pressure-temperature-time-deformation evolution of the overlying Himalayan orogen.

Our study focuses on an orogen-perpendicular transect along the Seti Khola across the Himalayan metamorphic core in western Nepal. New results from quartz crystallographic preferred orientation (CPO), monazite petrochronology, and preliminary phase equilibria modelling reveal differences compared to equivalent transects along-strike in western Nepal. Quartz CPO results indicate a typical increase in deformation temperature structurally upwards from 325-425°C at the base to 650-750°C at the top of the Himalayan metamorphic core. Preliminary phase equilibria modelling suggests that peak metamorphic temperatures also increase structurally upwards. Monazite Th-Pb petrochronology indicates that prograde, peak, and retrograde metamorphism lasted from 31 to 28 Ma, 30 to 22 Ma, 22 to 16 Ma, respectively, with <5 Myr age variations and overlap in the timing of metamorphic stages recorded by different samples along the transect. However, peak metamorphism along the Seti Khola is 10-15 Myr older than metamorphism from equivalent transects along-strike in western Nepal. The diachroneity of metamorphism between comparable transects in western Nepal is interpreted to result from the reactivation of an Indian basement structure perpendicular to the strike of the Himalayan metamorphic core, which allowed the Seti Khola rocks to escape the younger metamorphic overprint, resulting in along-strike heterogeneity of the Himalayan metamorphic core.

The Cross-Cordilleran Excursions of the 1972 International Geological Congress, A Semi-Centennial Celebration

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Fifty years ago, Canada hosted the 1972 International Geological Congress (IGC) in Montréal. Delegates and their families were offered well over 100 excursions across Canada, before, after, and during the Congress sessions.

There were several excursions through the Cordilleran Region of Alberta, British Columbia, and Yukon.

Of special interest are the Excursions A-03 (August 5 – 19) and C-03 (August 31 – September 13), pre-Congress and post-Congress, respectively. They voyaged by bus from Calgary to Victoria, under the co-leadership of Jim Monger, active CTG member and GSC retiree, and Vic Preto, of what is now the Geological Survey of British Columbia. They led a team of ten friends and colleagues who helped with the *Guidebook* and with specific local sub-excursions.

The itinerary included the Interior Platform, the Foothills, the Rocky Mountains (both the Front and Main Ranges), the Rocky Mountain Trench, the Purcell Mountains and anticlinorium, Stops included Blairmore, Alta., Fernie, B.C., Kimberley, Cranbrook, and Creston, just as in 2022, before continuing westward through the Selkirk, Monashee, Cascade, Coast, and Insular Mountains.

Also close in itinerary to our 2022 CTG Fall Excursion, were A-15 (August 8 – 19) and C-15 (September 1 - 11), “The Canadian Rockies and Tectonic Evolution of the Southeastern Canadian Cordillera”. R.A. Price and H.A.K. Charlesworth had three colleagues supporting them.

Other Cross-Cordilleran Excursions included AX_01 and A-01 "Structural Style of the Southern Canadian Cordillera...." and A-10 "Stratigraphy and Structure..., Northeastern British Columbia".

There were many Russian geologists in Excursion C-03, who enjoyed the Canadian leg of the 1972 Canada-USSSR Hockey Series, along with their Canadian colleagues, on September 2, 4, 6, and 8, with the last game played at the Pacific Coliseum in Vancouver: a Soviet victory: 5-3. The excursion was then 150 km to the east, at Pinewoods Lodge in Manning Park, B.C.

What stresses the Canadian Cordillera? - A statistical analysis of the first-order intraplate stress field of western Canada

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Alaska and the Canadian Cordillera are currently affected by widespread seismicity and diffuse deformation. The complex distribution of strain and the transfer of stresses through a hot and thin, and thus, weak lithosphere are the subject of ongoing research. To better understand lateral variations of stress and strain and their underlying cause, we present a technique to statistically analyze the first-order, lithospheric stress field. Our model is based on the empirical link between the orientation of both the horizontal stresses and displacements and the direction of relative plate motion. This simple assumption predicts the stress orientation using only parameters of the relative motion between two neighboring plates. We can show that modeled direction of interplate stresses is generally in good agreement with the present-day stresses at almost all plate boundaries, indicating that lateral plate boundary forces are the dominant stress source. Thereby, the model also allows for identifying intraplate stress anomalies when in-situ stresses significantly deviate from modeled stress trajectories.

In the Pacific realm of Alaska and the Canadian Cordillera, the modeled stress trajectories fit the orientation of most of the observed, maximum horizontal stresses. This indicates that stresses are transferred from the North American plate boundary to the Yakutat block and the Pacific plate. Crustal stress in the midplate area of western Canada, however, is parallel to trajectories modeled from the relative plate motion between Eurasia and North America. This alignment suggests that ridge-push forces are transferred from the Arctic-Atlantic throughout the North

American lithosphere. Moreover, the analysis reveals areas where far-field stresses significantly deviate from plate boundary stresses and where further, more detailed investigations are required.

A discontinuous Galerkin level set method applied to the modelling of deformation patterns in tectonic flow

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We propose a numerical method to simulate the structural patterns emerging from the long-term large-deformation tectonic flows in both two and three spatial dimensions. The domains of different material properties are each represented by a level set function, which is discretized on a stationary mesh with the discontinuous Galerkin method and is advected by a velocity field provided by a coupled Stokes flow solver. Our method accurately captures the material interface by the adaptive mesh refinement, reduces the computational expenses compared to the traditional particle-in-cell method and offers straightforward handling of geometric splitting and merging. Under the unified finite element framework, our methods promises the flexibility in the choice of mesh geometry as well as the potential for extending to more complex rheological models. Furthermore, with passive tracers generated near areas of interest, the finite strain of the flow field can be integrated through arbitrary time interval within the total simulation time. The strain ellipsoids thus obtained offers the possibility to ground-truth the simulated deformation patterns with the field structural analysis. Our results demonstrate identical physical behavior when compared with established structural geology and geodynamic benchmarks.

We apply the modelling method to the 3d simulation of the deformation patterns resulting from the synchronous vertical and horizontal tectonism, which is postulated to be the likely dominant tectonic regime in the late-Archean granitoid-greenstone terranes as the transition in crustal dynamics took place from diapirism and sagduction of the early earth to modern style plate tectonics. The modelling results compares favourably with the structural patterns obtained from the field studies in the Swayze greenstone belt, northern Ontario. Our results also show that under various viscosity contrast and horizontal shear strain rate, the numerical model reproduces a range of map patterns and kinematics comparable to those of the granitoid-greenstone terranes in the Superior Province.