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Geological Association of Canada, Newfoundland and Labrador Section

ABSTRACTS

2021 Technical Meeting

Virtual

The Annual Technical Meeting was held virtually on February 22 and 23, 2021 from various home offices, dens, and bedrooms across St. John's, Newfoundland and Labrador and beyond.

This year the meeting kicked off on Monday with a Special Session to pay tribute to R. Frank Blackwood who passed away in the summer of 2020. Frank was a strong supporter of bedrock mapping, mineral exploration, and the mining industry in Newfoundland and Labrador which is reflected in the following abstracts. Tuesday featured a General Session with presentations on a wide range of geoscience topics.

As always, this meeting was brought to participants by volunteer efforts and would not have been possible without the time and energy of the executive and other members of the section such as Anne Westhues, Jared Butler, James Conliffe, Shawn Duquet, Sarah Hashmi, Zsuzsanna Magyarosi, Annie Parrell, and Karen Waterman. The organizers are also indebted to their sponsors, particularly the Geological Association of Canada, Department of Earth Sciences (Memorial University of Newfoundland), and the Geological Survey of Newfoundland and Labrador, Department of Energy, Industry, and Technology.

Although the abstracts are modified and edited as necessary for clarity and to conform to Atlantic Geology format and standards, the journal editors do not take responsibility for their content or quality.

THE EDITORS

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A geophysical study of the Valentine Gold Project, west-central Newfoundland, Canada

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The Valentine Gold Project (VGP) is in west-central Newfoundland and encompasses four significant gold deposits, which are structurally controlled and of orogenic origin. These deposits, which have proven challenging targets for geophysics, occur proximal to a major thrust-faulted contact between the Precambrian Valentine Lake Intrusive Complex (VLIC), which hosts most of the gold mineralization, and the Silurian Rogerson Lake Conglomerate. Although geophysical techniques are commonly used to investigate mineral prospects, their ability to delineate the ore zone at the VGP has been unsuccessful. This is primarily because the gold is scattered throughout veins within the resistive, siliceous host rocks, and the relationship between the mineralization and the property's mafic dykes is unclear. One of the principal methods employed in this study is gravity, and although this technique is often used in mineral exploration, it is not typically applied to the type of gold deposits present at the VGP, where the density contrast between lithologies is small, topography is rough, and overburden is thick and irregular. A 2018 proof-of-concept survey over the gold-bearing alteration zone revealed a small but measurable negative gravity anomaly. Encouraged by this, in August 2019, a 14.2 line-km broad-scale gravity survey was conducted over the property to map the subsurface extent of the alteration zone and delineate areas suitable for further exploratory drilling. Additional in-fill gravity stations were acquired on bogs and along lake shorelines during the winter and summer of 2020, yielding a total of 252 gravity stations throughout the VGP. The resulting property-wide Bouguer gravity map indicates that there is a measurable low gravity anomaly from the alteration zone. This result suggests that gravity is a suitable technique for assessing the mineral prospects at the VGP, and it may be applicable over similar deposit types, which are exhibited in belts across the island of Newfoundland.

A comparison of Cambrian uplifted rift shoulders in western Avalonia, Newfoundland (Canada) and the Anti-Atlas (Morocco)

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A handful of peri-Gondwanan terranes lie scattered throughout the Paleozoic orogens of the circum-North Atlantic. During Ediacaran and Early Paleozoic times, they were positioned along the northern margin of West Gondwana. After Ediacaran accretion of several of these arcs to Gondwana (Avalonian, Pan-African and Cadomian orogens), the new composite margin recorded post-collisional Cambrian rifting conditions that led, since Early Ordovician times, to the opening of the Rheic Ocean. The margins of the Cambrian rift are recognized as the Atlas-Ossa Morena Rift in the western Mediterranean region and the Avalonian Rift in the future Avalonian Microcontinent. In offshore-to-basinal rifting branches, some Cambrian episodes of carbonate production occur in shoulders (or palaeohorsts) commonly associated with tilting pulses and hydrothermal activity, leading to the development of lenticular limestone surrounded and onlapped by monotonous shale and greywacke beds. Microbial and shelly carbonate production is punctuated by the influence of hydrothermal activity, volcanism, and mass-wasting events, leading to the record of amalgamated erosive surfaces and angular discordances linked to geodynamic perturbations. A comparison of these short-term episodes of carbonate productivity embedded in monotonous successions of shale-greywacke is documented here from both sides of the Cambrian rift, based on exposures from the Avalon Peninsula (Newfoundland) and the Moroccan Coastal Meseta.

New geochemical insights into dissolved element sources and aquatic processes in the Ottawa River basin, Ontario/Québec, Canada

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The Ottawa River basin (ORB) covers a catchment area of ~146 000 km^2, hosting the Ottawa River (OR) and several major tributaries, underlain predominantly by evolved Archean-Proterozoic igneous/metamorphic (central-northern areas) and Phanerozoic sedimentary (southern areas) bedrock. The OR is the collection site of the long-standing National Research Council-Conseil national de recherches Canada (NRC-CNRC) river water SLRS certified reference material (CRM) series and is often considered an ideal analogue of a pristine boreal-temperate river for geochemical studies.

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Due to the global distribution and widespread use of generations of the SLRS CRM, the OR has one of the best characterized dissolved trace element and isotopic ratio compositions in the world. This characterization, however, is built from single samples in space and time that are out of context of the dynamics of the wider ORB. This collaborative project provides the first characterization of the ultra-trace element (with emphasis on the REE and HFSE) and Mo isotope geochemistry of the central ORB, covering the OR from Chenaux, Ontario to Témiscaming, Quebec (n = 14) and 4 major tributaries (Coulonge, Noire, Petawawa, Mattawa; n = 11).

The dissolved REE+Y and Zr-Hf-Nb-Ta-Mo-W-Th-U geochemistry of the ORB waters reveal new insights into the flux of these elements from evolved crustal rocks and the extent of their relative fractionation in terrestrial aquatic environments, including newly documented fluvial Nb/Ta fractionation. The dissolved Mo of the OR has an unusual enrichment in heavy Mo isotopes compared to other rivers globally, a signature that was previously documented and interpreted to result from natural weathering processes in the catchment. This work confirms the unusual Mo isotopic signature in the OR but documents its absence in the sampled tributaries. The heavy isotope enrichment is diluted downstream, constraining its origin to an upstream source(s) that is argued to arise from anthropogenic processing of dissolved Mo in the northern ORB.

Coloured gemstones: uncharted waters in economic geology

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Coloured gemstones – gems other than diamond – are conservatively estimated to be a US$10–12 billion per year industry, and yet systematic targeted exploration for these materials is virtually non-existent. In recent decades, publicly traded companies have entered the industry, using modern methods to assess, acquire, develop, and mine deposits of ruby and emerald. Coloured gemstone deposits are also a key source of income for millions of artisanal and small-scale miners around the world. A new research program at Memorial University aims to develop new genetic models for gemstone deposits, identify their indicators, and the geologic environments likely to host them – with the goal of developing new methods to assist geological surveys, exploration companies, and small-scale miners in discovering new deposits. Recent published research has identified southern Baffin Island as highly prospective for sapphire, spinel, and lapis lazuli deposits. Occurrences of these three gemstones are related to the granulite facies (and in the case of sapphire, subsequent amphibolite facies) regional metamorphism of dolomitic marls in the Paleoproterozoic Lake Harbour Group metasedimentary sequence, where protolith geochemistry is interpreted to have had a key influence in their genesis. Coloured gemstone potential in Canada is not isolated to southern Baffin Island. In fact, many regions have excellent potential for various gemstones (e.g., ruby, sapphire, emerald, elbaite, opal, amethyst, jade, peridot, garnet, cordierite). Current research is focusing on gemstone genesis in ophiolites of the Dunnage Zone (Québec), and the geochemistry of corundum grains found in glacial tills across Canada. Good potential for several coloured gemstone varieties exists in Newfoundland and Labrador, and recent gem discoveries here will be the subject of future research.

Semisupervised machine learning applications to geoscience problems

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In recent years, many disciplines have been challenged with trying to efficiently extract value out of datasets. Manually recognizing patterns from data with many features is difficult, and the advances in data storage and data acquisition capabilities exponentially growing our data volumes only makes this more challenging. However, machine learning provides us with tools to extract value from our datasets more efficiently. Supervised learning techniques are designed to learn a direct mapping going from the data to the known classes, using a training dataset. This mapping can then be used to infer the class labels for data points without labels. Generally, the training dataset needs to be sufficiently large to ensure supervised methods learn a robust mapping. However, many geoscience problems inherently have limited training data because obtaining labels/classes can be expensive and time-consuming. In these situations with scarce training data, supervised methods are prone to generalize poorly to the unlabeled data.

Rather than use supervised machine learning methods for insufficient training data situations, an alternative approach is to use semisupervised learning (SSL) techniques. SSL methods benefit from incorporating both the labelled and the unlabeled data into the learning process; this has

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been shown to make improved predictions compared to supervised techniques in minimal training data situations. Many geoscience problems are inherently challenged with limited training data, and semisupervised methods have been relatively unexplored in the literature. We consider a few semisupervised techniques that are conceptually simple and trivial to implement, and we apply these techniques to three scenarios: well log classification, seismic classification, and mineral prospectivity mapping.

Finding fault in a shear zone

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Marathon Gold Corporation's Valentine Gold Property is in west central Newfoundland. The property has four known gold deposits in early exploration stages along 20 kilometers of north-east to south-west trend. It is a future site for an open-pit gold mine, and upon completion, will be the largest gold mine in Atlantic Canada. The Valentine Lake property contains orogenic-type quartz-tourmaline-pyrite veins which are gold-bearing. These veins are structurally controlled, occurring along or proximal to the Valentine Lake Shear Zone. The mineralization is found only on one side of the shear zone in intrusive rocks and is rare in the conglomerate on the other side. The area has numerous basaltic dykes, which show up well when conducting a magnetic survey due to their proportions of magnetite. Though their relationship to the mineralization is uncertain, these dykes can help indicate structure. To further constrain the location of the shear zone (and hence the mineralized region), a detailed magnetic survey was conducted over a 200 m × 300 m section of a larger-scale magnetic study completed in 2014 using a GPS-enabled Overhauser magnetometer. Sixteen lines were traversed all together through a heavily wooded area with thick soil and moss cover. The survey area also contained two roads and several anthropogenic objects such as trucks, fuel tanks, and culverts. Magnetic susceptibility measurements of surrounding rock types were taken to supplement data provided by Marathon Gold. With the collected data, total magnetic intensity maps were created and further processed using pole reduction and first vertical derivative computation. This helped identify a zone where the pattern of linear magnetic highs is offset, with lesser magnetic intensity near the offset. This zone has been identified as a fault offset to the shear zone, as the loss in magnetic intensity could be due to alteration or thinning of the basaltic dykes at the fault boundary.

Structural style of the Kashan-Ardestan syn-tectonic sedimentary basin in Central Iran, Arabian-Eurasian collision zone

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The Kashan-Ardestan sedimentary basin in Central Iran formed by back-arc extension due to the subduction of Neo-Tethys oceanic lithosphere beneath the Iranian Plate during Eocene time. During subsequent continental collision in the Oligocene, the basin was infilled by continental clastic and evaporitic sediments (Lower Red Formation). Later subsidence produced a shallow marine environment for the accumulation of Qom Formation carbonates and shales in the late Oligocene–early Miocene. The Qom Formation is the most significant hydrocarbon target in Central Iran. Continental collision triggered the reactivation of pre-existing fault systems during the deposition of the Miocene Upper Red Formation and overlying Pliocene–Quaternary sediments. This long-lasting and multi-episodic tectono-sedimentary evolution of the Kashan-Ardestan Basin has led to the formation of complex structures, which must be resolved for future resource exploration.

Here, several transverse and longitudinal 2D seismic lines were interpreted to define the deep-seated geometry of the basin. The seismic lines were tied to the data from three exploration wells, reaching depths of ~4 km. In addition, ~15 000 gravity and magnetic stations were integrated into our model.

The results of our study indicate that two major strike-slip fault systems, in the south and north of the basin, control the geometry and evolution of the Kashan-Ardestan Basin. Both basement-involved and thin-skinned faults resulted in different types of fault-related anticlines. Compressional reactivation of pre-existing strike-slip faults has produced positive flower structures. In addition, several thin-skinned detachment folds are observed above the evaporites of the Lower Red Formation at the base of the sedimentary cover. Mapped syn-tectonic thickness variations allow us to define the geometric evolution of the basin through time, allowing for the burial history of the source rock and timing of trap formation at the reservoir level to be described.

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One city's trash is a geophysics student's treasure

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The Robin Hood Bay landfill is in the northeastern part of St. John's, Newfoundland. It is the solid waste management facility for the City of St. John's and the greater Avalon region. It has been in use since the 1940s, first by the American military before it was turned over to the City of St. John's in 1963. In the past, there have been concerns of leachate penetrating groundwater at the site and draining into the ocean and adjacent streams. In 2009, the landfill underwent large-scale renovations. They included adding a geosynthetic cover, creating regulations governing residential dumping, and adding gas and groundwater monitoring wells to the site to counteract leachate seepage. The southeastern corner of the landfill, an area that has not been infilled with new waste since the 2009 renovations, has been chosen as a site for geophysics surveys. This is the first geophysical study that has been performed over the landfill, despite being common practice in other landfills. It is the first step in the process of monitoring long-term changes to the subsurface of Robin Hood Bay. The area studied is flat and grassy with an underlying layer of cobblestone. Magnetics and DCR surveys were performed among other techniques. These non-invasive geophysical studies provide a method by which to interpret the subsurface environment for ground structure, water flow patterns, and environmentally concerning anomalies. The latter include past improper disposal of large metal objects and iron debris. The magnetics surveys used a GEMGSM-19GW Overhauser Magnetometer in a grid formation to identify localized magnetic materials. The DCR surveys were conducted with both a Schlumberger Vertical Electrical Sounding and Wenner Constant Separation Transverse array in a south-west to north-east colinear manner in the study area.

The science (and art) of regional bedrock mapping: lessons from Labrador and life

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Although essential research elements and core field skill requirements have not changed, there have been some fundamental changes in the field of bedrock mapping over the last 20 years. A complex, multidisciplinary approach is required to unravel the evolution of complex tectonic regimes. We need to apply a full suite of analytical techniques to a map area, such as field mapping, structural analysis, lithogeochemistry, isotope geochemistry, petrography, and geochronology to decipher its lithological, structural, and metamorphic history.

The advent of digital data capture systems and portable tablets has altered the way data are collected, integrated, and published. These advances in technology allow the full integration of GIS into bedrock mapping. We now utilize digital geologic mapping to improve our field efficiency and problem-solving capabilities. Basic digital mapping is just the beginning of new and evolving capabilities with true 3D mapping (i.e., mapping through a 3D interface as opposed to building a 3D model post field mapping). With the aid of unmanned aerial vehicles (UAVs), we are developing and applying high-resolution, photo-realistic terrain models as a base surface for 3D mapping. The integration of these new technologies into digital field workflows and 3D visualizations is transforming the practice of bedrock mapping by making it more accessible and visually realistic.

Pre-Confederation geoscience in Newfoundland: the legacy of Alfred K. Snelgrove and the Princeton connection

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The late Frank Blackwood well understood the impact of one of his predecessors, Alfred Kitchener Snelgrove, who effectively created our modern Geological Survey in the 1930s. Snelgrove laid a solid foundation of new geological knowledge, and he brought awareness of it to the wider geoscientific community, but these contributions are not always fully recognized.

Snelgrove's family came from Trinity Bay, but he was born and educated in St. John's. His first exposure to minerals was through working in the Resources Department of the Reid Newfoundland Company. He went on to McGill, obtaining his B.Sc. in 1927 and his M.Sc. in 1928. He obtained his doctorate from Princeton just two years later and remained on its faculty for the next 10 years. Although settled in New Jersey, Snelgrove soon returned to his home island in a different capacity and played a key role in an ambitious

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research program. Following the depression and a dire economic collapse, the Newfoundland Commission of Government set up its Department of Natural Resources in 1934, and Snelgrove was appointed as Director of the Geological Section, assisted by Claude K. Howse. Its prime focus in the 1930s and 1940s was to document and assess our mineral resources as a route towards economic development, and Snelgrove – who remained a faculty member at Princeton – enthusiastically engaged his colleagues and students in his mission. Among those who worked here were the famous petrologist A. F. Buddington, and a much younger man destined for fame as a founder of plate tectonics. Young Harry Hess wrote perceptive papers on what we now call the Bay of Islands ophiolite, pointing out inconsistencies in the purely magmatic theories of the day. A young Québécois named Joseph Retty pursued his graduate studies at Princeton and went on to help define the world-class iron deposits of western Labrador. Other research projects investigated key areas and problems across Newfoundland. These careful and systematic studies, especially of our mineral deposits, remain key sources of descriptive information, and some were influential in developing new theories of 'metallogenesis', as it came to be called. In 1940, Snelgrove joined the faculty of Michigan Technical University, where he spent the rest of his career, but he continued to advise the Newfoundland Government during the war and even after Confederation. His contributions to our geological knowledge are truly too diverse and numerous to list individually. Following retirement, he remained active in science during the plate tectonics revolution and received a Fulbright scholarship. He travelled extensively, working in Hong Kong, Pakistan, India and Turkey, and eventually wrote a paper entitled 'Metallogeny and the New Global Tectonics' in 1971. But this was not his last effort, for in his late 70s he developed novel research on the effects of plate tectonic motions on the evolution of major river systems.

In this session, we rightly celebrate Frank Blackwood's many achievements and his legacy to Newfoundland, but Frank would surely ask us to look further back in time and honour those who made it all possible in the first place. Frank wrote eloquently about the "poetry of geology", but he was adamant that its many verses were written collectively and sequentially and should not be attributed to any one individual. We should always remember that perspective.

3D geological and velocity model building for the Hebron Field, offshore Newfoundland, Canada

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The Hebron Field located within the Jeanne d'Arc Basin, offshore Newfoundland, is the newest producing hydrocarbon field in the area. For any producing hydrocarbon field, there is a push to increase the recovery rate of the field. Generally, time-lapse (4D) seismic is a method used to monitor the depletion of a field's reserves. 4D seismic methods require both a pre-production velocity model (baseline model) and a post/during production velocity model (monitor model(s)). This work constructs the 3D geological model for the main producing reservoir within the Hebron field and the baseline velocity model for the Hebron Field. These models are built from seismic data interpretations, and well log data from within and surrounding the Hebron Field. These models accurately represent the subsurface of the Hebron field before any production. Through fluid substitution, these models will be perturbed in the future to quantify the uncertainty associated with a synthetic 4D seismic change within the main producing reservoir of the Hebron Field.

New discoveries from old fossils: a novel view on the Ediacaran of Newfoundland, Canada

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Newfoundland is renowned worldwide for its significance to palaeontology as it is home to the oldest complex multicellular organisms on the planet, the Ediacaran biota. The most famous localities, which are key to furthering our understanding of the evolution of life, are in the Spaniard's Bay area of the Avalon Peninsula and on the Memorial University of Newfoundland surface (MUN Surface) near Port Union on the Bonavista Peninsula. Through recent fieldwork, new observations and discoveries have been made that challenge our preconceived assumptions of these enigmatic organisms.

Despite being relatively common in Ediacaran outcrops in Newfoundland, not much is known about the extinct clade rangeomorph, which constitutes the principal component of the Ediacaran biota. Rangeomorphs normally appear as a more-or-less coordinated arrangement of multi-ordered branches in a frondose habitus, a unique Bauplan that does not allow for certain phylogenetical placement. Exceptionally preserved specimens of *Culmofrons plumosa*, a multifoliate rangeomorph from the MUN

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Surface, present previously undocumented structures that might be interpreted as reproductive structures, offering the opportunity to investigate this taxon's life cycle and paleobiology.

Previous taphonomic models are also being reassessed, based upon new field observations and our developing understanding of the rangeomorph clade. Spaniard's Bay is a unique site within the Avalonian assemblage as it is the only locality to feature three-dimensional preservation of the Rangeomorpha. Recent sedimentological and taphonomic observations made at this locality have led to the development of a new taphonomic model for the site. This model highlights clear issues with preconceived assumptions regarding the lifestyle of these enigmatic organisms as the preservation observed at the site cannot be explained by the currently accepted mode-of-life.

The work conducted thus far has shown the need for a reassessment of our understanding of the Ediacaran biota. Over the next few years, the work conducted at MUN will allow us to further develop our understanding of this important, yet poorly understood, group.

Reconnaissance investigation of rocks of the Bull Arm and Big Head formations from the Long Harbour area, western Avalon Peninsula, and comparison to possibly correlative, age-constrained units of Bonavista Peninsula, Canada

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Reconnaissance lithogeochemical investigation of volcanic rocks in the Long Harbour area, western Avalon Peninsula, has identified three chemically distinct volcanic assemblages within the Bull Arm Formation. Assemblage 1 includes green to brick-red, calc-alkaline basalt breccia, and mafic and intermediate tuff, all chemically characterized by relatively steep multi-element (XREE) slopes and prominent Nb troughs. They are similar to basalts of the Cannings Cove Formation (lowermost Musgravetown Group) on Bonavista Peninsula, locally constrained to ca. 600 Ma. Assemblage 2 includes green, amygdaloidal, plagioclase- and clinopyroxene-phyric, tholeiitic basalt flows with flatter XREE patterns and less pronounced Nb troughs than those of Assemblage 1, similar to continental tholeiites of the ca. 592 Ma Plate Cove volcanic belt on western Bonavista Peninsula. Assemblage 3 includes green-grey amygdaloidal basalt, agglomerate, and northwest-trending mafic dykes that cut Assemblage 2 basalt. Assemblage 3 rocks are alkaline, have the highest Mg#s, TiO_2, V, Cr and Ni contents, and exhibit smooth XREE patterns with steep slopes that lack Nb and Ti troughs. They are chemically similar to alkaline basalts on the northeastern and southwestern Bonavista Peninsula, which occur below and above, respectively, the ca. 580 Ma glacial diamictite known as Trinity facies. The Big Head Formation overlies the Bull Arm Formation at Long Harbour, and includes a distinctive diamictite unit, similar to the Trinity facies, containing faceted, bullet-shaped, and flat-iron clasts consistent with a glacial origin. If correlative with the ca. 580 Ma Gaskiers Formation (eastern Avalon Peninsula) and Trinity facies (Bonavista Peninsula), then the Big Head diamictite provides a minimum age for alkaline magmatism at Long Harbour and demonstrates the vast areal extent of Ediacaran glacial deposition. Deep-seated alkaline magmatism and concomitant crustal thinning and extension may have helped induce the widespread deglaciation (Gaskiers event) evident across much of Avalonia in Newfoundland.

Grenville and Appalachian controls on modern tectonics in the Labrador Sea, Canada

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Rifted segments of continental lithosphere preferentially occur in orogenic zones of crustal weakness along continental margins that are repeatedly deformed during supercontinent cycles. Pre-existing structural heterogeneities play a significant role in accommodating extension at continental margins due to fracturing and faulting in the brittle upper crust. A prominent feature of the Atlantic continental margin is a series of crustal-scale structural boundaries in Proterozoic and Paleozoic rocks and their seaward prolongations that coincide with fracture zones in the modern ocean crust. The spatial relationship between the Grenville Front and Dover Fault and fracture zones of the Labrador Sea implies the dominant role of tectonic inheritance. Four observations, however, are inconsistent with mechanisms involving only ancient collisional events: (1) the structural fabric in older orogens is parallel to the vector direction of transform motion and seafloor spreading; (2) the offshore trace of transforms is colinear with major crustal boundaries; (3) pre-existing faults are not reactivated inboard of the rifted continental margin; and (4) transform faults do not extend outboard from suture zones. Several lines of evidence suggest that uplift and collapse are associated with terminal phases of the Grenville and Appalachian orogens. I propose that

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crustal boundaries formed by collisional orogenesis were reactivated during orogenic collapse and are responsible for partitioning strain throughout the lithosphere and producing a pervasive fabric of aligned olivine crystals in the mantle. Heterogeneous zones of weakness in the mantle act as structural guides that remain tectonically active over long-time scales and indicate that tectonic processes in the continental crust can generate fabrics in the mantle lithosphere that are subsequently duplicated in the oceanic crust. The persistence of a zone of mantle anisotropy associated with orogenic collapse suggests that the structure of the modern Labrador Sea was predetermined by tectonic processes in the Proterozoic.

The Dog Bay Line in northeast Newfoundland, Canada: an overview of the current state of knowledge

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The Dog Bay Line was defined in 1992–1993 by H. Williams, K. Currie, and M. Piasecki following mapping of the Carmanville-Comfort Cove Map sheets in northeastern Newfoundland. The strongly deformed rocks exposed in and around Dog Bay indicated the presence of a major fault zone. On either side of this fault, differences in the lithological associations and depositional facies of Silurian overstep sequences (volcanic rocks and subaerial red beds of the Botwood Group to the northwest vs. shallow marine limy siltstone of the Indian Islands Group to the southeast) were interpreted to indicate distinctive depositional settings on either side of the fault. Along the fault zone, Williams and others noted a corridor of intensely deformed black shale enveloping sparse, large blocks of mafic volcanic and gabbroic rocks that were interpreted as evidence that the fault zone is a tectonized olistostromal mélange, formed by the southeastward obduction of intraoceanic sequences onto Ganderia's margin. At Dog Bay Point this unit was termed the Garden Point mélange, and its southward extension was subsequently termed the Duder Complex. These two units were correlated with the Ordovician, westward-lying Dunnage and undated eastward-lying Carmanville mélanges. All Ordovician to Silurian rock units were interpreted to be unconformably overlain by an overlap unit of weakly deformed, thick-bedded red micaceous sandstone of the Ten Mile Lake Formation. Based on these observations, the Dog Bay Line was inferred to represent the suture along which the Tetagouche-Exploits back-arc seaway finally closed in the Silurian.

This presentation summarizes field, geochronological, and paleontological evidence garnered since the seminal contribution by Hank Williams and others in 1993. These observations necessitate re-interpretation of several critical geological relationships that require clarification of the nature of the Dog Bay Line and its role in the final amalgamation of composite Laurentia with Ganderia and Avalonia.

Investigating the structure and stratigraphy of the Carboniferous onshore-to-offshore Bay St. George subbasin, Western Newfoundland, Canada, using seismic data and potential field modeling

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The Carboniferous Bay St. George subbasin is in southwestern Newfoundland, south of the Port au Port Peninsula. The Bay St. George subbasin is an onshore-to-offshore basin with a geologically complex history that has undergone significant deformation resulting from Appalachian orogenic events. Despite the complexity of its geological history, southwestern Newfoundland represents an important area of petroleum prospectivity as hydrocarbon seeps and staining have been observed. To date, there has been little success from past petroleum exploration and drilling in the Bay St. George subbasin, partly due to a poor understanding of the subsurface. The correlation between the onshore-to-offshore stratigraphy and the Bay St. George subbasin structure is poorly understood as few studies have been completed.

This project uses high-resolution geophysical data, including seismic, well log, and potential field data, to investigate the structure and stratigraphy of the Bay St. George subbasin. A comprehensive seismic interpretation, with support from well ties, reveals variations in stratigraphy from onshore-to-offshore. Significant thickening of Carboniferous strata is observed at the onshore-to-offshore transition. The major faults interpreted from the seismic data trend northeast–southwest and are also observed with magnetic data. The northeast–southwest regional faults (St. George Bay Fault and Mid-Bay Fault) delimit a significant stratigraphic transition, truncating offshore carbonate platform successions. The gravity modeling (forward and inverse) undertaken in this study has resulted in a 3D Earth model of the Bay St. George subbasin. The gravity modeling is constrained by the seismic interpretation and reveals an average depth to Moho of 46 km. From the 3D density

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model, cross-sections can be generated for regions with no corresponding seismic profiles to inspire future exploration. The updated density model and seismic interpretations offer new insights into the complex tectonic history of the Bay St. George subbasin.

Kinematic models for the northern Appalachians and Caledonides

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Appalachian-Caledonide orogen development has been traditionally illustrated using cross-sections showing terrane accretion and collision over time. This approach is valuable but involves implicit assumptions: subduction was initiated at passive continental margins; convergence was mainly orthogonal; terranes had ribbon-like geometry parallel to continental margins; and present-day orogen geometry is a valid "end point" for reconstructions. Post-Pangea tectonic evolution provides little support for these assumptions.

We will include in this analysis several previously under-utilized data sets: (1) Estimates of late Paleozoic and Mesozoic plate motions, to restore a valid mid-Devonian geometry from which to build back in time; (2) Reviews of legacy biostratigraphic data using calibrated timescales to place sedimentary units relative to isotopically dated igneous units; (3) A review of paleomagnetic information including declinations, so as to evaluate systematic vertical-axis rotations as well as latitude changes; (4) A compilation of detrital zircon data using new display techniques to show proximity of terranes to major continental blocks that are best candidates for sedimentary provenance.

Preliminary results suggest that terranes attributed to Ganderia and associated Gondwana-derived arcs crossed Iapetus in several groups, arriving at the Laurentian margin at different times from Ordovician to Devonian. Portions of "Ganderian" and "Avalonian" continental crust may have been juxtaposed during Penobscottian convergence on the margin of Gondwana. The Taconian orogeny is explained as the result of diachronous arc-continent collision that involved both Laurentia-derived and Gondwana-derived units, followed by subduction-polarity reversal at the Laurentian margin. Salinian deformation resulted from subduction-accretion at this margin, over a period of time from Late Ordovician to nearly the end of the Silurian. Acadian deformation resulted from sinistral and convergent motions at an Early Devonian along-margin boundary that may have varied from transpressional in New England to ideal strike slip in Britain and Ireland.

Reassessing the structure and tectonics between the Flemish Cap and the Irish Atlantic margins during oblique rifting

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Studies of the Newfoundland-Irish and Flemish Cap-Goban Spur conjugate rifted margins of the southern North Atlantic have been plentiful. However, the rift-related domains along these margins have remained poorly defined partially due to limited data coverage. Currently, the well-accepted conjugate relationships between these magma-poor margins are increasingly questioned. Furthermore, extension obliquity has failed to be considered in previous studies of the rifting between Flemish Cap and the Irish Atlantic margin.

In this study, significant margin-parallel and margin-perpendicular structural variations are observed from newly acquired seismic reflection data and these are used to map the crustal architecture in terms of rifted margin domains. Northwestward increasing volcanism and related reflectivity patterns support the transition from magma-poor rifting in the southeast to magma-rich rifting in the northwest along the Irish Atlantic margin. The reactivation of pre-existing inherited Caledonian and Variscan structural fabrics are proposed to have influenced the variable geometries and distributions of the crustal domains along the Irish Atlantic margin. Based on inferred seismic constraints and published plate reconstructions, we create deformable plate tectonic models in GPlates to assess the impact of orogenic pre-rift crustal basement terranes on the tectonic evolution of the Newfoundland-Irish Atlantic margins. The preferred deformable plate model proposes the subdivision of the Porcupine Bank into four blocks with each block

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experiencing polyphase rotation and shearing prior to final continental breakup, implying strong inheritance and segmentation of the Porcupine Bank and Porcupine Basin. The reconstructed paleo-positions of the Flemish Cap and Irish Atlantic margin within deformable regions also reveal evolving conjugate relationships during rifting. Finally, quantitatively restored extensional obliquity between both margins shows time-variant orientations due to the rotation and shearing of associated continental blocks.

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