Booklet of Abstracts

Graduate student poster presentation-2022

Department of Earth and Environmental Sciences

The event will take place:
Friday October 21
2 – 5pm pm
Room 224 of Student Union Building (SUB)

We invite all undergraduate students to join the event and enjoy free food and drinks

Presentation schedule:

2 – 3 pm	**3 – 4 pm**
Pinar Gurun	Anna Ryan
Nina Golombek	Rachel Noddle
Marina Dottore Stagna	Fernando Cordoba Ramirez
Maureen Matthew	Peteris Rozenbaks
Alireza Niksejel	Caitlin McCavour
Lydia Fairhurst	Carla Skinner

1. Pinar Gurun (pn913293@dal.ca)

Variations in Subduction Bending-Related Normal Faulting of the Incoming Juan de Fuca Plate Along the Cascadia Margin

Pinar Gurun, Mladen R. Nedimović, Suzanne M. Carbotte, Brian Boston, Shuoshuo Han, Brandon Shuck and Pablo Canales

Cascadia Subduction Zone (CSZ) is a convergent boundary between the oceanic Juan de Fuca (JdF) plate system and the continental North American plate and has ruptured in at least 19 great megathrust earthquakes over the past 10 kyr. The controlled source seismic data acquired along the margin dating back to the 1980s show along-strike variations in faulting and hydration of the incoming plate; however, the available coverage is limited. More extensive and deeper penetrating subduction bend faults and associated plate hydration within the crust is inferred in the offshore central Oregon region than offshore central Washington. How faulting patterns develop across the incoming oceanic JdF plate system in response to oblique subduction resistance and other stresses, and how these faults may impact hydration of the plate prior to subduction are not well understood. During June-July 2021, we ran the Cascadia Seismic Imaging Experiment (CASIE21) and acquired ~5347-line km of new marine multichannel seismic reflection (MCS) data covering much of the CSZ, from Northern Vancouver Island to Southern Oregon. Data processing was done by ION Geophysical to pre-stack depth migrated reflection images. To aid the interpretation of the reflection images, we use the corresponding velocity models and analyze a suite of seismic attributes such as spectral decomposition trace, instantaneous phase, envelope, and relative acoustic impedance. We then interpret the eighteen margin-normal MCS profiles with the goal to: (1) Characterize the distribution, geometry, and penetration depths of the bend-related normal faulting within the sediments, oceanic crust, and uppermost mantle; (2) Analyze the regional differences in faulting patterns of the incoming oceanic plate from the mapped normal faulting; (3) Investigate possible causes for the inferred different bend faulting patterns. For (3), we focus on (a) obliquity of convergence and hence orientation of pre-existing fault fabric to trench, (b) age of the plate at the deformation front, which varies from 4-10 Ma, (c) variations in dip of the subducting plate, and (d) proximity to accreted crustal blocks in the overriding plate.

2. Nina Golombek (nn644568@dal.ca)

Amino acid-specific analysis of N isotopes in sediment traps from Jordan Basin: Tracking nutrient-plankton dynamics throughout the water column

Nina Golombek

The Gulf of Maine, located in the northwest Atlantic Ocean, is a semi-enclosed continental shelf sea at the confluence of the northeasterly-flowing Gulf Stream and the southwesterly-flowing cold Labrador Current. Variations in the strength and position of these current systems determine the relative proportion of subtropical versus subarctic water masses entering the Gulf, thereby influencing hydrography, nutrient distributions, and productivity within the region. Hydrographic records extending back to the early 1900s indicate that the Gulf is currently undergoing some of the most rapid warming of any ocean region. Yet, there are few paleoceanographic records to put these changes into the context of Holocene scale climate variability and its impact on biological productivity. To begin to address these knowledge gaps, we analyzed sediment trap samples from Jordan Basin collected in 2010-2011 to evaluate changes in the composition of export productivity in relation to depth and seasonality. The sediment trap materials were analyzed for molecular abundance and C and N isotopes of amino acids, from which a suite of indices to investigate primary producer functional groupings, degradation, trophic position, and nutrient sources were derived. Understanding potential short-term fluctuations and baseline variability in biological productivity will ultimately help to better constrain the biogeochemistry of underlying sediments and benthic communities. Our preliminary results show distinct differences between shallow and deep sediment trap amino acid parameters including greater degradation in deep traps. We further see chemical markers of higher trophic levels in shallow trap samples and differences in source δ15N metrics, suggesting different organic matter sources for deep traps compared to shallow traps. Seasonal patterns coinciding with local pteropod blooms and implications for sediment core-based paleoceanographic reconstructions will be discussed.

3. Marina Dottore Stagna (mr578941@dal.ca)

Giant submarine landslide drives long-lasting regime shift in slope sediment deposition: Mafia mega-slide, a case study from offshore Tanzania

Marina Dottore Stagna, Vittorio Maselli, Arjan van Vliet

Submarine landslides and associated mass-transport deposits (MTDs) modify the physiography of continental margins and influence the evolution of submarine sediment routing systems. Previous studies highlighted the control of landslides and MTDs on subsequent sedimentary processes and deposits at spatial scales ranging from 10s of centimetres to few kilometres, leaving a knowledge gap on how, and for how long, large-scale submarine landslides (i.e., headscarps wider than 50-100 km) may affect the stratigraphic evolution of continental margins. To fill this gap, we use 3D seismic reflection data tied to an exploration well to investigate the impact of one of the largest submarine landslides discovered on Earth, the Mafia mega-slide (Mms) offshore Tanzania, on slope sediment deposition. Seismic data interpretation indicates that turbidite lobes/lobe complexes and coalescent mixed turbidite-contourite systems formed the pre-Mms stratigraphy between 38 and ~21 Ma (age of the Mms), whereas coarser-grained sheet turbidites and debrites accumulated after the Mms for ~15 Myr, primarily on the topographic lows generated by the emplacement of the landslide. We interpret this drastic and long-lasting regime shift in sediment deposition to be driven by the increase in seafloor gradient and the capture and focus of feeding systems within the broad failed area. We propose that the extensive evacuation zones associated with such giant landslides can generate major conveyor belts, trapping land-derived material or sediments transported by along-slope processes, such as bottom currents. During the progressive healing of the landslide escarpments, which lasted for several million years, sand-prone facies deposited primarily in the upper slope, filling-up the accommodation space generated by the landslide, whilst deeper-water environments likely remained sediment starved or experienced accumulation of finer-grained deposits. This study provides new insights into the long-term response of slope depositional systems to large-scale submarine landslides, with implications for the transfer of coarse-grained sediments that can be applied to other continental margins worldwide.

4. Maureen Mathew (mcwhite@dal.ca)

Rock Avalanches in Northeastern Baffin Island: Understanding low occurrence in a region with high hazard potential

Maureen Matthew, John Gosse, Reginald Hermanns, Alexandre Normandeau

In 2017, a coastal rock avalanche along a fjord in Western Greenland triggered a tsunami that devastated the village of Nuugatsiaq. Two years earlier, on the Alaskan Coast, a rock avalanche below the Tyndall Glacier triggered a tsunami in Taan Fjord that reached heights over 190 m above sea level. In the last century, similar disasters have been recorded in the fjords of western Norway. In a review, it was found that over 70% of recorded tsunamis with runups > 50 m were triggered by large landslides, often rock avalanches, in glaciated terrane (Higman et al., 2018). Do these large, catastrophic, and often cascading geohazards happen in fjords of NE Canada? If they do – where and when have they occurred? What controls their recurrence? Despite the hazard potential, few studies have focused on coastal geohazards in the fjords of the eastern Canadian Arctic. Northeastern Baffin Island, between the Inuit hamlets of Clyde River and Pond Inlet, is located directly across Baffin Bay from the 2017 Greenland event, with similar fjord relief. The region is potentially vulnerable to rock avalanches given the steep coastal cliffs, active seismicity, accelerating deglaciation, and rapidly thawing permafrost. As a result, the area is well-suited to investigate current knowledge gaps around controlling mechanisms of rock avalanches in high-relief glaciated terrane. To develop an understanding of the prevalence, location, and characteristics of rock avalanches and large-scale debris slides in the region, systematic mapping of onshore deposits was carried out using high-resolution (<0.5 m) optical satellite imagery and 2 m digital elevation models. Mapping was extended with available multibeam bathymetry throughout the study area to identify potential submarine deposits from coastal events. The results of this study suggest that rock avalanche deposits are scarce throughout the study area. Only 6 deposits have been identified through the mapping of the onshore and offshore study area (60,000 km2, or 0.0001 deposits/km2) that meet the volume and mobility criteria of a rock avalanche. We hypothesize that comparatively fewer rock avalanche deposits are observed among the fjords of Baffin Island for the following reasons: 1) some deposits remain masked underwater in very deep and steep walled fjords, 2) persistent permafrost

in the region continues to act as a stabilizing factor, and 3) overall rock mass quality is high in the areas of extreme relief contrast. A comparison of global analogues is provided to further investigate these hypotheses.

5. Alireza Niksejel (al747153@dal.ca)

A generalized transfer-learned OBS phase picker

Alireza Niksejel, Miao Zhang

Machine learning (ML)-based phase picking methods have shown promising results in land earthquake monitoring. whereas there is no available ML phase picker to handle seismograms recorded at Ocean Bottom Seismometers (OBS) due mostly to insufficient labeled data and low signal-to-noise ratios. However, OBS-recorded submarine earthquakes are critical to studying subduction zones and mid-ocean ridges. Although land ML-based phase pickers roughly work on OBS data, they introduce a large number of false negatives and false positives. In this study, we develop a generalized OBS deep-learning phase picker using the Transfer Learning (TL) approach. The EQTransformer (EQT; Mousavi et al., 2019) is adopted as our base model because of its broad spectrum of earthquake distributions and distances. To transfer learn the model, I collect and label ~60k local and regional earthquake waveforms with various magnitudes (ML 0.0-5.8), source depths (0-250 km), and epicentral distances (0-3 deg) in different tectonic settings and geographic locations including the Cascadia subduction zone, Alaska subduction zone, the Mariana subduction zone, and the Quebrada Transform Fault System. To consider various ocean environmental conditions, we adopt seismic noises recorded at 14 worldwide OBS networks for the training augmentation instead of the commonly used gaussian noises. Priliminary results show that the transfer-learned OBS phase picker outperforms the EQTransformer base model in both accuracy and precision.

6. Lydia Fairhurst (ly593526@dal.ca)

Reaction products on ilmenite and chromite macrocrysts from kimberlites: implications for emplacement of class 1 kimberlites and diamond preservation

Lydia Fairhust, Yana Fedortchouk, Ingrid Chinn, Philippe Nomandeau

Kimberlites are the deepest mantle-derived melts that reach the surface of the Earth and carry mantle cargo including diamonds. They are commonly emplaced in the interior of Archean cratons as pipe-shaped structures, and their size, shape, and facies distinguish different types of kimberlite pipe. Multi-phase bodies of class 1 kimberlite are large, deep, steep-sided and consist of coherent kimberlite (CK) and different pyroclastic facies, including diatreme Kimberley-type pyroclastic kimberlite (KPK). The composition(s) of primary kimberlite melt and the modes of emplacement are not well constrained. However, they are important in understanding diamond preservation during the ascent in the hot kimberlite magma. This study develops a new method which uses composition of reaction products on ilmenite and chromite macrocrysts to: (1) assess variation in these reaction products between different kimberlite facies and their relation to the dissolution surface features of diamonds, (2) examine variation in melt composition and crystallisation parameters (temperature, T, pressure, P, oxygen fugacity, fO2, and silica activity, a_(SiO_2)) and (3) determine emplacement processes of different kimberlite facies and implications for diamond preservation. Development of this method uses mantle-derived ilmenite and chromite macrocrysts from four kimberlite facies in two kimberlites from Orapa kimberlite cluster (Botswana). The study showed that these oxide minerals develop reaction rim assemblages unique to their host kimberlite facies, owing to the differences in emplacement conditions. In hypabyssal kimberlite facies diamonds show dissolution features indicating volatile-undersaturated melt, and ilmenites are completely replaced with perovskite-magnetite symplectites and reaction rims and show high dissolution rates of chromite. On the contrary, all kimberlite facies (CK and KPK) in which diamond resorption indicates presence of fluid, have ilmenite macrocrysts preserved but surrounded with coronae of different composition. Perovskite is a stable phase in CK facies but can be replaced with later anatase during hydrothermal alteration. Titanite becomes a stable phase in KPK due to increase in a_(SiO_2)during assimilation of crustal xenoliths or extensive CO2 degassing. We use the Fe-in-

perovskite and two-oxide thermometer and oxygen barometer to obtain T and fO2 estimates for the four kimberlite units and compare them to T and fO2 estimates worldwide. We show progressive reduction trend in the studied class 1 kimberlites possibly due to extensive serpentinization. The results from this study are integrated with diamond data from the same kimberlite bodies to examine the correlation between reaction products on oxide minerals and diamond resorption. The method will now be applied to Gahcho Kué kimberlites (Northwest Territories) of class 1, which serve as an ideal natural laboratory containing different kimberlite facies exposed at the surface.

7. Anna Ryan (an476478@dal.ca)

Remote transport of microplastic by hurricane

Anna Ryan, Deonie Allen, Steve Allen, Dusan Materic, Amber LeBlanc, Liam Kelleher, Stefan Krause, Tony R. Walker1, Vittorio Maselli

Large quantities of microplastic (MP) deposited from the atmosphere have been documented in several remote areas around the globe. The atmosphere is able to transport large amounts of MPs relatively quickly compared to riverine or oceanic transport and can deposit MPs to locations inaccessible directly by these other transport mechanisms. Major atmospheric events, such as hurricanes, have been proven to pick up and transport particulate matter such as salt, dust, and pollutants; however, major storm influence on transport and deposition of atmospheric MPs to remote locations is still in its infancy. We collected samples of atmospheric fallout from Hurricane Larry as it passed over Newfoundland in September 2021. During the peak of the storm, 1.13 x 105 particles m-2 day-1 were deposited, with a gradual increase in particle deposition leading up to the storm and rapid decrease after the storm passed. This suggests that hurricanes function as a major driver of MPs to remote locations in the North Atlantic. Back-trajectory modelling suggests that the majority of MPs deposited are picked up from the ocean. This assessment of an Atlantic hurricane transport of predominantly marine entrained atmospheric MPs provides an early insight to one, potentially key, method of remote terrestrial MP occurrence.

8. Rachel Noddle (rc468568@dal.ca)

Investigating the Nitrogen Biogeochemistry of Sewage Organic Materials Using Compound-Specific Isotope Analysis

Rachel Noddle, Carly Buchwald, Amina Stoddart, Owen Sherwood

Microbial degradation of particulate organic matter (POM) plays a critical role in the biogeochemical cycling of nitrogen in the oceans. However, the magnitude and pathways of microbial degradation of POM are poorly understood. A novel geochemical proxy for microbial degradation, based on the stable nitrogen composition of amino acids (□15NAA), has been proposed but has not been validated under experimental conditions. This project uses samples collected from primary and secondary wastewater treatment plants (WWTP) as quasi-controlled chemostats to evaluate changes in δ15NAA patterns associated with microbial degradation of POM. This study compares the novel compound-specific isotope analysis of amino acids (CSIA-AA) to more traditional amino acid abundance and racemization indices to elucidate the pathways and extent of microbial alteration of POM during critical steps in the wastewater nitrogen cycle. The results show a distinct pattern of de novo synthesis of AAs at the primary treatment plant and a pattern of extracellular hydrolysis at the secondary treatment plant. By comparing δ15NAA values of POM across two different facilities, this study provides the first identification of microbial AA processing mechanisms leading to N isotopic fractionation of sewage POM. These results are anticipated to provide new insights to the interpretation of natural abundance δ15N data in biogeochemistry and paleoceanography contexts, and to have practical implications for □15N-based monitoring of coastal eutrophication.

9. Fernando Cordoba Ramirez (fr450518@dal.ca)

Electromagnetic characterization of freshened offshore aquifers on the formerly glaciated continental shelf of Prince Edward Island.

Fernando Córdoba-Ramírez, Vittorio Maselli, Mladen Nedimović, Graeme Cairns, Sebastian Hölz

Freshwater scarcity is a global problem. Groundwater is the main source of water for more than two billion people globally, but today more than 30% of the world´s largest groundwater systems are in distress, threatened by overexploitation and climate warming. In recent years, freshened offshore aquifers (FOAs) have been proposed as an unconventional source of water, particularly for coastal zones where 40% of the global population lives. Since the first discovery of FOAs about 60 years ago offshore Florida, only three marine electromagnetic (EM) studies have been conducted to detect them, and none of these has focused on regions occupied by an ice sheet during the Last Glacial Maximum. EM techniques are a powerful tool for detecting FOAs due to their sensitivity to the electrical properties of rocks, such as the electrical resistivity that is a function of porosity and pore fluids content. As part of the SOURCE project, we carried out an electromagnetic survey in the Gulf of St. Lawrence offshore Prince Edward Island (PEI) to investigate the presence of FOAs.

10. Peteris Rozenbaks (pt870531@dal.ca)

Vanadium partitioning between apatite and biotite in natural felsic rocks

Peteris Rozenbaks

Vanadium is a multivalent element, present in terrestrial magmas as V3+, V4+, V5+ in proportions reflecting the magmatic oxidation state. Biotite and apatite are common minerals, often co-crystallizing in a wide variety of rocks. Vanadium partitioning into the two minerals is expected to be redox-sensitive with V5+ anticipated to enter the apatite structure and V3+ and V4+ favouring the partition into biotite. Therefore, the total vanadium partitioning between apatite and biotite is expected to change as a function of the proportions of V species in the magma and the magmatic oxygen fugacity (fO2), which controls them. The hypothesis is tested by analyzing the V abundance in coexisting apatite and biotite from a suite of reduced and oxidized natural rocks. The oxidation state of the rocks ranges from -3.1 to 4.3 log units relative to the fayalite-magnetite-quartz mineral buffer, which represents the majority of redox conditions in the Earth's upper crust. The revealed vanadium partitioning systematics in apatite and biotite support the proposed hypothesis: over the seven orders of magnitude of fO2, the vanadium partition coefficient between apatite and biotite (D_V^(ap/bt)) varies by approximately 2 orders of magnitude (from below 0.004 in the most reduced conditions to ca. 0.371 in the most oxidized magma). This suggests that the fO2-D_V^(ap/bt) relationship could be applied in an empirical oxybarometer if the temperature, pressure, and compositional effects on V partitioning are accounted for. Further analyses of additional rock suites of intermediate oxidation state will be carried out to further constrain the fO2-D_V^(ap/bt) relationship. The potential oxybarometer would be particularly important for research and mineral exploration in Fe-poor peraluminous granitoids, to which the conventional Fe-Ti oxide oxybarometry methods are not applicable

11. Caitlin McCavour (ct907746@dal.ca)

Early effects of helicopter liming on soil and vegetation in two acidified forest stands in Nova Scotia, Canada

Caitlin McCavour; Shannon Sterling; Kevin Keys; Edmund Halfyard

Fossil fuel burning from increased industrial practices in the 1900's caused high levels of acid deposition in northeastern North America. Acid deposition depletes base cations (Ca2+, Mg2+, K+) and increases toxic aluminum (Al3+) concentrations in forest soil and drainage waters. Base cation depletion impairs forest growth, regeneration, and ecosystem health. Despite decreases in acid deposition after the enactment of the Clean Air Act and Clean Air Act Amendments, little to no improvement in soil base cation concentrations over the last 30 years has been reported. The application of calcium-containing soil amendments, known as liming, such as dolomitic limestone (CaMgCO3), can increase base cation

concentrations in terrestrial ecosystems and help restore forest health. Terrestrial liming studies in Europe and northeastern North America have shown variable but promising results; however, gaps exist in our knowledge of terrestrial liming such as the short-term (one-year) effects of terrestrial liming on soil and plant tissue chemistry on acidified forests in Nova Scotia (NS). This study conducted a terrestrial liming trial at the Otter Ponds Demonstration Forest in Mooseland, NS, where 10 t ha-1 of dolomitic limestone was deposited via helicopter over mature acidic hardwood and softwood forests and assessed one year after liming using a before-after-control-impact experimental design with six and five plots at the hardwood and softwood sites, respectively. Lime collection boxes evaluated the lime distribution. Collection of soil, foliage, and ground vegetation samples before and after liming in the softwood and hardwood stands was conducted and assessed for chemical analysis. Chemical analysis of the samples focused on acid-indicating properties such as pH, base saturation, calcium (Ca2+), magnesium (Mg2+), and aluminum (Al3+) concentrations. The results show that despite a non-uniform distribution of lime over the treatment sites, soil Ca2+, Mg2+, percent base saturation (%BS), and pH increased, and total acidity decreased in the forest floor in response to liming. Upper mineral soil pH, %BS, Ca2+, and Mg2+ increased significantly at the hardwood site, and %BS and Mg2+ increased significantly at the softwood site. No significant increases or decreases in Al3+ were observed in any soil horizons at either site; however, a non-significant decrease was observed in the upper forest floor of the softwood site. Foliar Ca increased in red spruce and sugar maple trees but not red maple. Ground vegetation Ca, and Al increased while potassium (K) decreased in the ground vegetation at the softwood and hardwood sites. First-year results indicate that liming initiated the restoration of depleted base cations in forest soil and increased important tree species' nutritional status in NS acidified forests. The initial response from liming acidified forest stands in NS indicates that helicopter liming can promote recovery from soil acidification and increase the value of currently acidified forests in NS.

12. Carla Skinner (chdickso@dal.ca)

Heat beneath your feet: Expanding the footprint of geothermal energy

Carla Skinner, Grant Wach, Adam Donaldson, Tom Martel, Miao Zhang

As climate change continues, low carbon renewable energy will be required to support the transition away from hydrocarbons while meeting rising energy demands. Access to reliable sustainable energy from diverse sources including solar, wind, and geothermal will need to be increased. Geothermal energy has proven successful for both production of electricity and direct heat in high temperature regions, and until recently was not considered commercially viable in moderate to low temperature regions. Technological advances have improved the opportunities for geothermal energy in previously eliminated regions, lowering the potential temperature range. Salt is an evaporite with unique characteristics in the subsurface, able to mobilize and flow under suitable conditions, and form structures (e.g., diapirs, canopies). The thermal conductivity of salt is two to four times higher than other lithologies, so the geothermal gradient is expected to be higher in sediments above salt structures and are termed positive temperature anomalies. Research on whether positive temperature anomalies are potential targets for geothermal energy development is in its early stages. There are more than 100 salt-dominated basins globally, including the Scotian Basin in Nova Scotia. This basin has seismic and well data available for analyses, therefore is an appropriate study location for geothermal assessment of positive temperature anomalies. This study aims to provide new insights on geothermal energy in low temperature basins, the role of salt structure configurations and compositions, and novel application of petroleum systems modelling software. This research will investigate the salt and post-salt sediments in the Maritimes and Scotian basins with the goal of identifying halokinetic (salt-influenced) versus allocyclic (not salt-influenced) sediments. It will also clarify whether the configuration or composition of salt structures has more influence on the overlying positive temperature anomalies using temperature field models based on integrated seismic and wells logs. Finally, this research will provide the first assessment of geothermal targets associated with positive temperature anomalies above salt structures in Canada. The results achieved can be applied to other salt-rooted basins to increase understanding on geothermal potential in low temperature regions.