The Geologic Times

Earth Science Association

ESA Newsletter

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Edited by Sara Mana

Welcome to Dr. Erkan Toraman the newest member of the GLS Department!!

Formation and Collapse of the Adirondack Mountains

By Erkan Toraman

The Adirondacks Mountains form the southern extension of the Grenville Province and is often used as an analogous model to the root zone of modern mountain belts, such as the Himalayas and Andes. The Adirondacks formed during the amalgamation of the supercontinent Rodinia in Mesoproterozoic times (ca. 1500 to 1000 million years ago) and represent a prime example of mid-crustal levels of an ancient orogen. Traditionally it is divided into two morphological and geological domains: the Lowlands and Highlands (*Figure 1*). The Highlands are predominantly made up of granulite-grade orthogneiss (a type of very high-temperature metamorphic rocks) and anorthosite. The Lowlands, on the other hand, mostly exposes upper-amphibolite facies metasedimentary rocks (a type of medium-temperature metamorphic rocks). The two domains are separated by mylonites called Carthage-Colton Mylonite Zone (CCMZ). This fault zone is believed to exhume mid-crustal rocks towards the surface at the end of Grenville Orogeny. Although the timing and the conditions of metamorphism and magmatism in the Adirondacks have been studied extensively during the last twenty years, the origin and significance of the CCMZ is still highly controversial. For instance, some early studies suggested the CCMZ first acted as a thrust fault and then as a normal fault (Metzger et al., 1992). Later investigations proposed that the CCMZ acted as a strike-slip fault in a transpressional environment. More recently, Bonamici et al. (2015) suggested that the CCMZ had an earlier oblique slip sense of motion followed by a purely extensional setting (normal fault). Uncertainties are not only restricted to the nature of deformation but also the timing of faulting in the CCMZ. The recent consensus is that the CCMZ is a long-lived geologic feature and has been reactivated multiple times between ca. 1200-1000 Ma. Details of the timing of events, however, are not clear.

My work in the Adirondacks started 3 years ago with colleagues and students from St. Lawrence University and quickly centered on the CCMZ rocks. In order to better answer questions like “how and when did the Adirondack Lowlands and Highlands behave as one geological unit?” or “what tectonic events led to the amalgamation of these two domains?”, we started a project that combines extensive fieldwork and laboratory analysis. We did detailed mapping and sampling of the CCMZ at the Stone Valley along the Raquette River near Colton, NY. In this transect the mylonite zone is very well exposed and both Highland and Lowland lithologies are present. Mylonites display a north-dipping (20-30°) penetrative foliation that is characterized by aligned mica and/or quartz and feldspar-rich domains. In most places a well-developed stretching/mineral lineation with moderate to shallow (40-3°) plunge to the north is defined by aggregates of quartz, feldspar and amphibole. Meso and microstructural observations of kinematic indicators, such as core-mantle structures, S-C surfaces, and asymmetric K-feldspars, suggest top-to-N sense of shear. Further analysis on quartz and K-feldspar microstructures are providing temperature constraints during the deformation of these mylonites.

For example, quartz and K-feldspar deformation textures, such as undulatory extinction, ribbon structures, subgrains, suggest temperature ranges of 400-600 °C.

In order to better constrain the temporal evolution of the CCMZ, we used multiple geochronometric techniques (U-Pb zircon, apatite, titanite dating) that allow us to increase the temperature range of thermal histories observed in the CCMZ. Our preliminary results show that the CCMZ is a poly-deformed shear zone. Zircon U-Pb ages reveal multiple populations over 300 Myr. The oldest ages are ca. 1330 Ma that represent pre-Grenville basement and give information on the construction of the Adirondacks. The most common ages are ca. 1150 Ma that correspond the Shawinigan magmatism and metamorphism that affected both the Lowlands and Highlands. The third group of ages are ca. 1050 Ma representing the Ottawan phase of magmatism and metamorphism. Titanite U-Pb analysis also yield ages of ca. 1050 Ma that are nearly identical to the zircon U-Pb age, which suggests a very high cooling rate during the Ottawan phase. We interpret these ages as a reflection of rapid tectonic exhumation during the collapse of the Grenville orogen. Apatite U-Pb ages, which tracks crustal temperatures of 450-550 °C, range between ca. 972 to 924 Ma suggesting either slow regional cooling or late hydrothermal alteration of the CCMZ.

Our efforts of evaluating the timing, conditions, and the rate of events that created these mylonitic rocks is ongoing. We are currently working on the zircon geochemistry, which can help us understanding zircon crystallization history, and quartz electron backscatter diffraction and Ti-in-quartz thermobarometry that can provide precise constraints on quartz deformation.

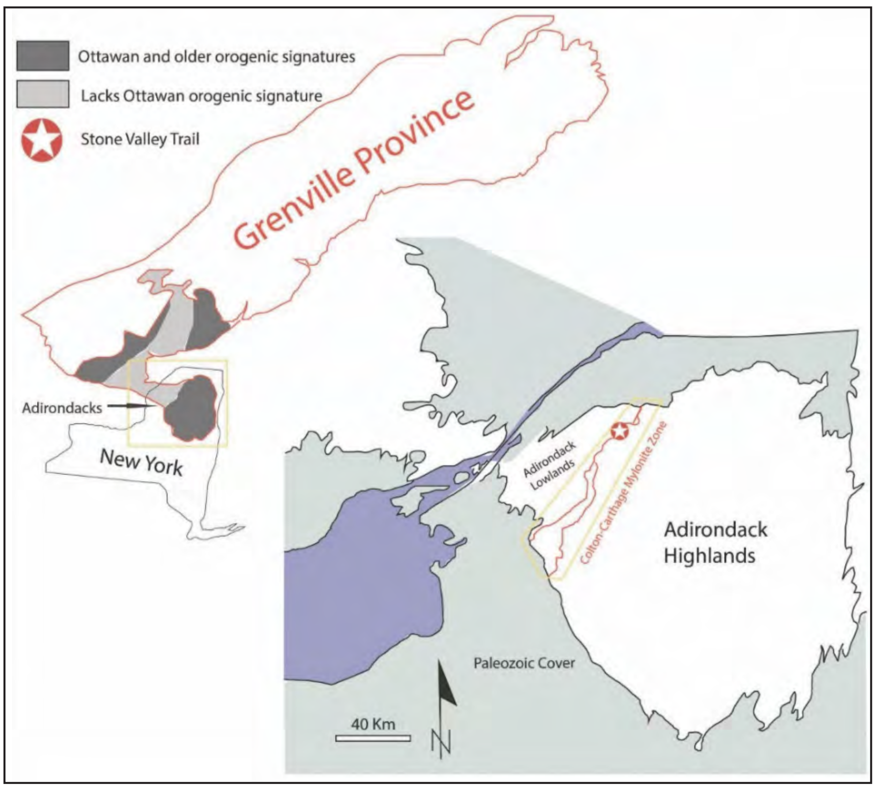

Figure 1. Simplified map of the Grenville Province and the Adirondack Mountains.

Sources: (1) Bonamici, C.E., Fanning, C.M., Kozdon, R., Fournelle, J.H., and Valley, J.W., 2015, Combined oxygen-isotope and U-Pb zoning studies of titanite: New criteria for age preservation: Chemical Geology, v. 398, p. 70-84.

(2) Mezger, K., van der Pluijm, B.A.., Essene, E.J., and Halliday, A.N., 1992, The Carthage-Colton Mylonite Zone (Adirondack Mountains, New York): The Site of a Cryptic Suture in the Grenville Orogen? The Journal of Geology, v. 100, p. 630-638.

(3) Streepey, M., Johnson, E., Mezger, K., and Van Der Pluijm, B., 2001, Early History of the Carthage-Colton Shear Zone, Grenville Province, Northwest Adirondacks, New York (USA): The Journal of Geology, v. 109, p. 479-492.

Figure 2. (a) To the left, Arenal volcano; (b) to the right, wind mills in Costa Rica. Photo Credit: Pablo Ruiz Cubillo.

Living sustainably with active volcanoes: hazards and resources

By Sara Mana

I think that one of the best parts of being a geologist is field work. Seen firsthand phenomenon that we have learned in class has an invaluable role in the formation of a well rounded geologist. It helps us better understand those processes and enables us to question them more critically. This coming Spring semester I will lead a trip to Costa Rica looking at volcanic features as well as natural resources. The trip is open to both geology majors (**GLS 328**) and non-majors (**GLS 199**). This might be a once in a lifetime opportunity for you and I encourage anybody that has the means to participate.

Costa Rica is located along an active convergent boundary making it a location prone to both seismic and volcanic hazards. It contains over 60 volcanoes, which are considered extinct or dormant plus five that are still active (Arenal (*Figure 2a*), Poás, Rincon de la Vieja, Irazú, Turrialba). The heat from magma that has risen close to the surface has resulted in hot springs and opportunities for geothermal energy production. Costa Rica currently generates 97-100 percent of its electricity using five different renewable sources; hydropower (78±2%), wind (10%, *Figure 2b*), geothermal energy (10%), biomass and solar (1%) and is aiming to become one of the first carbon-neutral country in the world by 2050 following a staggered plan as announced in their "Plan Nacional de Descarbonización"(https://presidencia.go.cr/comunicados/2019/02/sintesis-plan-nacional-de-descarbonizacion-2018-2050/). In 2018, Costa Rica broke its own record by using only clean energy for 300 consecutive days for the fourth year in a row.

This class will expose students to the risks and opportunities connected to living close to active volcanoes and modern advancements in renewable energy. We will visit Poás National park, Arenal National park, Irazú National park, Miravalles geothermal plant, Rincon de la Veja volcano, wind farms, hydroelectric plants, primordial forest, waterfalls and hot springs. Students will have an opportunity to experience a diverse cultural environment and practice speaking Spanish if they wish to do so. Please email me if you have any questions smana@salemstate.edu.

NODE COUNTRY FOR OLD MEN

By Cora Van Hazinga

The Kodiak Archipelago of Alaska is one of the most geologically fascinating regions of the world. I was lucky enough to travel there in June 2019 with the Alaska Amphibious Community Seismic Experiment (AACSE, *Figure 3*). In this week long experiment, I took a crash course in seismology, geophysics, and the tectonic history of Alaska. I was introduced to tools like IRIS, MATLAB, and JWEED. We also conducted long days of fieldwork under the midnight sun, retrieving seismic nodes from the wilderness of Kodiak Island.

Poised over the Aleutian subduction zone forearc, Kodiak is a remarkably complex tectonic environment. Kodiak Island is an accretionary prism, formed in the Cretaceous and Eocene periods. Turbidites, oceanic basalts, and pelagic sediments were accreted, or scraped from the downgoing oceanic plate onto the overriding continental plate (*Figure 4*). This resulted in graded beds of akrosic wacke, shale, and pebbly conglomerate. Beautiful thin turbidites are visible all over the island, especially along road cuts. The island was subsequently carved by glaciers, making a dramatic landscape. Most plates are made of small blocks or micro-plates. Along the Aleutian subduction zone, some blocks are subducted steadily over time (i.e. creep). This results in long period tremors, called slow slip events, often undetectable by seismometers. These slow slip events can last almost a decade. Other blocks are locked by friction and do not move. Here, stress and strain accumulates, and is released through violent seismic activity like the 1964 Good Friday Earthquake.

Figure 3. Cora on Pillar Mountain. Photo Credit: Elize Chavez

In 2018, the AACSE began a community seismic experiment, focusing on this subduction zone. The AACSE collected seismic data remotely using aquatic and land based seismic nodes. This project is unique compared to other studies because data is made immediately available to the public. Scientists and universities all over the world can study this dynamic area using AACSE data. Nearly 400 compact seismic instruments, or nodes, were deployed along the road system in Kodiak Island. This dense nodal array provides a high resolution look into the plate interface of the eastern side of Kodiak Island. The nodes were buried about a foot deep and the location was marked by a small zip tie.

Our team was given the task to recover those nodes. Using GPS coordinates and sometimes cryptic notes, we navigated to each node site. If we were lucky, nodes were easy to find. We would remove the cap of vegetation over the node, check to see if the node was still recording and deactivate it. When nodes were deployed in May 2019, Kodiak received about 16 hours of sunlight a day. In June, days were nearly 19 hours long. Vegetation grows fast during the long days and would often cover the sun-bleached zip tie. Some notes left

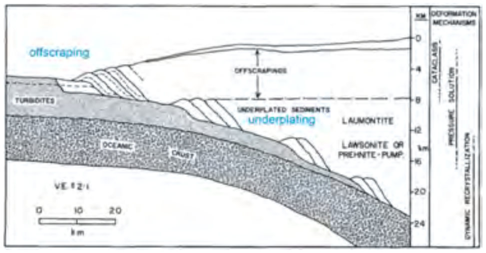

Figure 4. Accretionary Wedge. By Connor Drooff, USGS

by the deployment team were mysterious and enigmatic: “Under log, near spruce tree” (in a field filled with logs and spruce trees), “Directly across bay from blue house” (all the houses were blue), “east south southeast ??? of stop sign” (at a four-way stop). By the fourth day, about 20 nodes still needed to be recovered. In desperation, we rented a metal detector. After searching an area for an hour, we dug up a piece of metal that may have sat rusting in the turf since World War II. It was a triumphant moment when we finally found the node, three meters away from where it should have been. After all nodes were accounted for, they had to be cleaned. The Alaska Fish and Game office allowed us to use their labs as a cleaning station. Dirt and mud had to be removed from all nooks and crannies. Once the nodes were clean and dry, they were packed in their bags and readied for shipping. Playing hide and seek with nodes would be challenging anywhere, but what a privilege it was to do it in a unique, geologically rich, and beautiful setting at the top of the world.

The Field Camp experience...

By Emily Doyle

Field camp is an integral part of becoming a geologist. It has been a part of the Geological Sciences curriculum at SSU for several decades now and its effects on the undergraduate experience are enormous. It is the first taste of real life a college student gets. At SSU, there are two field camps: Field Camp 1 takes place in Salem and Saugus, Massachusetts, focusing on mapping and environmental projects; while Field Camp 2 takes place in Montana, where students learn how to generate geologic maps of deformed structures . Both of these field camps give undergraduates a taste of what a professional geologist could work on (*Figure 5 a, b*). That’s not the only benefit. Perhaps the most impactful effect is the friendships it creates. Field camp throws you into the belly of the beast. You’re working on real-life projects with hard deadlines and long hours, either out in the field, the lab, or the classroom. Therefore, the people in your field camp group become your coworkers, your confidants, your friends. The bonds forged in the fires of field camp last long after the experience is over, and while some people do not love field camp, there is one thing we can all agree on: friendship.

“Field camp was rough, but I definitely got closer to everyone here” someone said. This sentiment is common. The camaraderie gets you through the long nights and the moments where you think your work isn’t good enough. Looking back, I enjoyed both of my field camp experiences. When I was there, there were definitely ups and downs. During Field Camp 1, I had the opportunity to bond with students whom I only knew in passing. Now, I can’t imagine not having them as friends. Field Camp 1 required a lot of time in the computer lab, while the field work requirements were not as rigorous. On the contrary in Montana, we were required to hike tall ridges for roughly seven hours a day. There, you are mostly working on your own, whereas in Field Camp 1 most work is produced in teams. Hence, Field Camp 2 pushes you further and shows you what you can do on your own. In this learn-as-you-go experience, I learned a lot about myself. I learned to trust my instincts and to have confidence in my inferences. Most of all, I learned that I could be a geologist. Before going, I had doubts about the physical aspects of Field Camp 2. I was terrified that I would fail the class and the major itself. But once I got there, I forced that fear away and focused on doing my best. I hiked ridges much slower than my comrades, but I still hiked them. I did the work myself. There were times I

Figure 5. (a) Group photo of the Field Camp 1 crew 2019 in Marblehead, MA; (b) Group photo of the Field Camp 2 crew 2019 in front of Block Mountain (Glen, MT). Photo Credit: Lindley Hanson and Sara Mana.

wanted to quit, but I didn't. I finished the three weeks and all of us succeeded. I left Montana with much more than a passing grade. I left with a new sense of self confidence. Given the chance, I would go back again.I asked one of my field camp cohorts if she had fun in Montana. "If you asked me on June 9th, I wouldn't have the same answer," she joked "but would I go back? In a heartbeat." I think that is the common theme regarding both field camps. When you look back on it you see the immense value of these experiences. You appreciate the friendships you made in Field Camp 1, as well as the independence you gained in Field Camp 2. If I could give one piece of advice to incoming geology majors, it would be: believe in yourself because you never know what you can accomplish without your fears and insecurities in the way.

What is new in the ESA community?!

• A ESA Google calendar has been created where ALL field trips and fun activities will be announced. This calendar is designed so that you can create your event - know what is going on - be part of the ESA community - engage others and participate!
Make sure you link it to your own personal calendar using the link below: https://calendar.google.com/calendar?cid=dGplbmVoYTZ1bmQzZjRqMWNlYW03bmJ0ZDhAZ3JvdXAuY2FsZW5kYXIuZ29vZ2xlLmNvbQ

• To keep track of what is going on you might also want to check out the GLS Facebook webpage "*Viking Geology*" and the ESA Facebook webpage "*Earth Science Association at Salem State University*"

• Are you interested in having a more active role? Apply for the new ESA position for social-media liaison by emailing a statement of interest to *esa.salemstate@gmail.com*

• ESA is looking for volunteers to write short summary article for future newsletters. If you want to participate please contact us at *esa.salemstate@gmail.com*