Week 4 (July 4 - 10, 2016) Report

Updated August 7, 2016

Week four began on Sunday July 3rd, which was an off day for the students as they prepared to travel the next day to China University of GeoScience's Field Campus in Zigui City. Many of the Students took the additional time to do some last minute shopping, as well as eat one last meal with the friends they made in Wuhan.



Left: The bus that took the students to Zigui and survey locations. Right: The beautiful limestone mountains on the way to Zigui.

Monday morning the students boarded a small bus with Dr. Zhou, the CUG professor who will be their guide and teacher at the Field Campus in Zigui. The 6-hour drive passed through rich green farmlands north of the Yangtze river until the road arrived at the city of Yichang. From that point forward, the land was dominated by high mountains that are characteristic of Yangtze river valley, until it reaches Sichuan Province. The bus made several stops allowing the students to

stretch their legs and purchase refreshments at one of the many rest stops along the route. Upon arrival to the CUG Field Campus, the students were happy to find that many of the same accommodations and amenities they enjoyed in Wuhan were available at the Field Campus in Zigui. There is a canteen, a campus store, and easy access to the town right out the front gate. The only notable difference at Zigui is the lack of laundry service; the students had to hand launder their own clothes. After settling into their rooms and acquiring a meal card, the students were given a tour of the town by Dr. Zhou's students,



The view overlooking Zigui from the CUG field campus.

Liang and Li Pan. Zigui, like most Yangtze river towns, is built on the side of a mountain. After the tour, the students went to their rooms for much needed rest.



The Entrance Gate of CUG Field Campus in Zigui was a welcomed sight to the students after the long drive.

After breakfast on Tuesday, July 5th, the students travelled with Liang and Li Pan to the Three Gorges Dam, a 30-minute drive from the Field Campus. During the tour the students took in scenic views, which included sights of the shipping locks and a mockup of the dam and surrounding facilities. While access to the actual dam was limited, the group was able to visit a simulation platform and experience what standing on the Three Gorges Dam would be like. Many of the students also purchased souvenirs and t-shirts for themselves and family back home. The tour ended with a trip to the Three Gorges Dam Park Area, located down river of the dam. The students were able to view some examples of large Russian tractors and feed koi fish in a pond bordered by large tetrahedral cement anchors used during construction of the dam. Several students were adventurous and took a steep walk to greet and observe local fishermen at the edge of Yangtze River. They were met with smiles and requests for pictures, as many of the fishermen had never met Americans before. Instead of going back to campus for lunch, the students ate just outside the park gate in order to head directly to their next destination, the Qu Yuan Memorial. Qu Yuan's Hometown Memorial is located halfway between Three Gorges Dam and the CUG Field campus. It is home to over 800 artifacts and includes a library of literature collected about Qu Yuan and the works he wrote over 2,200 years ago. Qu Yuan, an administrator and famous poet of the Chu Sate, committed suicide once his state was taken over and is now best remembered for his patriotism and as a symbol of the dragon boat festival. The original memorial for Qu Yuan was built in 820 AD, but has been rebuilt several times and moved to higher ground due to flooding caused by the Three Gorges Dam project. While at the park, the group also visited a teahouse and found four-leaved clovers before heading back to campus.



Top Left: Students purchase tickets to the Three Gorges Dam. **Top Right:** Shasta sits atop the main viewing area and poses with the Three Gorges Dam. **Middle Left:** A local fisherman at the Yangtze River. **Middle Right:** The main entrance to the Qu Yuan Memorial home. **Bottom Left:** An imposing statue of Qu Yuan sits atop a pavilion in the Qu Yuan Memorial temple for those who wish to pay homage to this great figure. **Bottom Right:** The students pose alongside large machinery used to build the Three Gorges Dam.

Wednesday the students crossed the Yangtze river to the north side in order to study the local geology with Dr. Zhou. The group was able to make it most of the way to their final destination, however the road became inaccessible by vehicle as it had given out. The students



Students Rob Able, Jennifer Welch, Janice Navarro, Wanda Crupa, Valeria Smith, Benjamin Miller, Katherine Sorrows and Jacob Kratavil pose in front of the Three Gorge Dam.

went by foot up the mountain road the rest of the distance. The final leg was not traversable because the recent rain had caused overspill of a small dam. Instead, Dr. Zhou took the students down the road they came up from and gave them an outdoor lecture on the types of rocks found in the Three Gorges Reservoir region and the formations they are associated with. The students were able to see the metamorphic Mian Wan and Xiang Yu Cun formations dominated by Amphibolite and Greenschist facies, as well as the igneous Huang Ling group consisting of primarily Diorite. The group also made a stop by a Chromite mining site and observed large Serpentinite deposits. After returning to campus, the students were happy to find that Wen Guo had arrived from Beijing to join them in their research at the Huangtupo landslide area. Later that evening, some of the students went to purchase SIM cards and eat some of the local food.

On Thursday, July 7th, the students had their second day of class on the geology of the Three Gorges Reservoir Region with Dr. Wang and Dr. Zhou. The students travelled along the south side of the Yangtze river, making a total of nine stops throughout the day, and learned about the Huang Ling igneous group, Xiang Yu Cun metamorphic formation, and the Dong Yin sedimentary formation. The Huang Ling group and the Xiang Yu Cun formations form the base, with the Dong Yin formation forming a cover over these rocks. While traveling along the mountain side, students were able to see coal deposits, thick Dolomite beds, and fossiliferous Limestones



Top Left: Recent rain caused overspill of a small dam. **Top Right:** Student learn about the Small Fish Village Formation. **Bottom Left:** Students stop by a Chromite mine and examine Serpentinite. **Bottom Right:** Student examine a metasomatic deposit of Serpentine.

of the Dong Yin formation. At stops five and eight, students saw fossil sponges in Cambrian Limestone and large nautiloid fossils, identified as *Orthoceras Chinensea*, in Ordovician Limestone. Stop nine was at Chain Park Scenic Area, home to Liangzi Cliff ("Chain" Cliff) and directly opposite the Xintan landslide. The Xintan landslide was caused by coal mining and deposited over 30 million m³ of rock and sediment on the town of Xintan on June 12, 1985. However, thanks to the monitoring system that has been in place since the early 1970's, everyone was evacuated and there were no fatalities.

Left: Students explore Zigui geology with Dr. Zhou. Right: Students explore several faults along the roadside

The group made their way up to Liangzi Cliff, stopping to see the large fractures in the cliff side and to catch their breath. Like Xintan landslide, Liangzi Cliff was also showing signs of creep due to coal mining and developed over 700 fractures along the cliff face. After efforts were made to stabilize the base of the cliff, creep slowed down significantly, however monitoring is still ongoing. The group then descended and headed back to campus after the long hike of the day.

The summit of Liangzi Cliff with a chain across one of the main fissures.

Friday morning, the students checked out of their rooms and said goodbye to Zigui city as they began their 5-hour journey to Badong. The trip took a little longer than expected because the fastest route on the south side of the Yangtze river was blocked by a landslide, and when they took the northern route the main road leading to Badong was also impassible. The students finally reached Badong by taking a scenic route through the mountains and down into the city. The students will be spending the next week at Jinyuan Hotel as the planned CUG field campus for Badong is still under construction. After checking in, the students immediately hopped back onto the bus to observe the Huangtupo landslide from across the river. The students made a total of

Left: Students pose after reaching the summit of Liangzi Cliff summit. Right: Students make their way back down the Liangzi Cliff.

three stops, picking out possible survey locations and observing different aspects of the landslide, as well as stopping to see the Ground Based Synthetic Aperture Radar (GBSAR) station already in place to monitor the landslide. After returning from the field, the students received some time off to explore the town of Badong.

Left: An area around the Yangtze river where the student will spend the next week working. **Right:** Students learn more about the area that will be surveying from Dr. Zhou and Dr. Wang.

Saturday July 9th, marks the start of the research portion of the UH students visit to China and the start of data acquisition. That morning, the students were accompanied by Dr. Wang, Dr. Zhou, and two engineers from Chengdu, driving to a total of six stops to find possible survey locations and to showcase the Badong formation and the Badong Fault zone. Stops one through four were located above, or close to the upper boundary of the Huangtupo landslide and meant to be possible scanning positions. Stop six was directly below the Huangtupo landslide and located in the CUG investigative tunnel, the only observation and monitoring tunnel of its kind in the world. The tunnel is approximately 1 km in length with five smaller sub-tunnels that intersect the main passage and can look into the landslide zone directly. During their tour, the students saw the different lithologies within the Huangtupo landslide, which consists of various Limestones and Mudstones: weak interlayers that allow for slip. The group then returned back to the hotel

Top Left: Students father at the entrance of the CUG tunnel. **Top Right:** A view of the CUG tunnel exit near the Yangtze river. **Bottom Left:** Students wait at the entrance of the CUG tunnel until the poisonous gasses are removed from the tunnel. **Bottom Right:** A view of the substation located on a small part of the Hungtupo

and a smaller group headed out later to start the surveys, while some students stayed behind to finish up promotional work for the program. In the evening everyone went out for dinner to celebrate the new engineers joining our team and to say goodbye to Dr. Zhou, as it was his last evening with the UH group.

Students enjoy a dinner party with Dr. Zhou and the two engineers assisting with the LiDAR scans.

Geology Field Trip and Visit to Lianziya Landslide

By Wanda Crupa

On Thursday July 7, 2016, the UH students headed out with Dr. Wang and Dr. Zhou to further explore the local geology and get an understanding of the study area. The group made a total of nine stops throughout the day, stopping first to review the geology covered in the previous days' outing.

The first stop was near a construction site besides a large outcrop showcasing the Huang Lin intrusion. The Huang Lin intrusion has a composition of mostly Diorite and Tonalite. It was also noted to contain more felsic type Granites and an approximately 800 Ma (million year) amphibolites rich mafic igneous rock. While age relationships are still unclear, cross-cutting relationships suggests that the Diorite body is the oldest and the Granite is the youngest, however, it is believed that this intrusion underwent magma separations and all rock types are of the same age. This large calc-alkaline intrusion is also indicative of plate spreading.

The UH students gather round Dr. Zhou a he showcases the Huang Ling intrusion at stop 1. The large outcrop is primarily of Diorite composition (light gray rocks) with a mafic Amphibolite rich body cross-cutting it (black rocks). Both of these bodies are cross-cut by large Granite dikes (light pink rocks).

The second, third, and fourth stops showcased the Huang Ling intrusion, the Xiang Yu Cun formation, the Dong Yin formation, and their relationships. The Xian Yu Cun (small fish village formation) is made up of metamorphosed rock either in the Greenschist or Amphibolite facies. Typical rocks in this formation are rich in Biotite, some Amphibole (Tremolite is most common), possible Garnet, Quartz veins, and granitic intrusions from the Hang Ling. The Dong Yin formation is made up of sedimentary rocks ranging from Limestone, Coal, Dolomite, and thin layers of interbeded Chert. The Huang Ling intrusion and the Xiang Yu Cun formation form what is known

as a dome, with the contact between the two being poorly defined. The Dong Yin formation forms a cover over these formations; however faults have juxtaposed the three together in some places as seen at stop 4.

Students observe the Xiang Yu Cun metamorphic rocks at stop 3, identifying the mineral assemblage, rock type, metamorphic facies, and parent rock. Here the students are presented with a typical rock of this formations, rich in Biotite, Amphibolite, and intrusions from the Huang Ling group.

From left to right: 1) A student at stop 4 presenting a large fault in the Dong Yin sedimentary formation, where matching numbers on the hanging wall and footwall are used to show displacement. 2) UH students get their hands dirty on a large coal bed in the Dong Yin formation at stop 4.

Dr. Zhou points out thin layers of Chert interbeded within large Dolomite beds. The Dolomite is highly folded and corners the coal deposits beneath.

Stops 5 and 6 were further along the main road, where the students walked parallel to the Limestone Mountains. Here the students were able to see both Cambrian and Ordovician fossiliferous Limestones, some of which was highly folded and deformed. Stop 7 was next to some old fashioned coal landing docks which had been recently abandoned. Here the students saw more Ordovician Limestone with a well preserved plant fossil. Stop 8 was in a small village and required the group to climb uphill though farmed terraces. The students reached an outcrop of Ordovician Limestone rich in nautiloid fossils, identified as *Orthoceras Chinense*, and various fragmented bivalves.

From left to right: 1) Mountain made of Ordovician Limestone showing high deformation and folded structure as seen from stop 6.2) Abandoned gravity-driven coal loading docks which have been replaced my more modern equipment.

From left to right: 1) Stops 5 and 6 showcasing fossiliferous Limestone rich in Cambrian fossil sponges identified as *Archaeocyaths*. These specimens measured approximately 1 cm or less in diameter. 2) A large nautiloid fossil in Ordivician Limestone identified as *Orthoceras Chinensea* at stop 8. This specimen measured around 10 cm long and clearly shows the different septa (living chambers) along the phragmocone.

Stop 9, the last stop of the day, was at Chain Cliff Scenic Park, home to Liangzi Cliff ("Chain" Cliff). After much hiking, the UH group enjoyed a short rest of tasty green peaches on the upstairs balcony of an old-fashioned wooden tea house. The students were also able to observe evidence of past landslides while overlooking the Yangtze River. Just opposite of Liangzi Cliff lies the site of the Xintan landslide, a major landslide which completely destroyed the town of Xintan on June 12, 1985. The Xintan landslide deposited around 30 million m³ of sediment, of which 2 million m³ went into the Yangtze River and created a small scale tsunami. Instability in the cliff side was due to coal mining, however signs of potential landslides were evident in the 1970's and the area was highly monitored. Due to such measures, all residents of Xintan were evacuated before the landslide struck and no lives were lost.

From left to right: 1) A student enjoying peaches in the old-fashioned tea house. 2) The site of Xintan landslide as seen from the tea house balcony.

After consuming two peaches a piece, the students then embarked to see Liangzi Cliff. The first part of the trip was a leisurely stroll on a fairly horizontal path. The students got to see a typical Magmatite of the Kong Ling formation with strong evidence of partial melting as exposed on the side wall. Eventually the group arrived at a historical replica of a Guixiang Temple which is currently submerged due to the Three Gorges Dam. A small stop to observe the colorful Koi fish,

or "baby dragons" as they are also known in China, was greatly appreciated. Moving on, the group then started to climb what appeared to be a short series of steps. Before long all the students were tired, drenched in sweat, and quite thirsty. Unfortunately, after becoming accustomed to multiple short stops earlier that day, very few had though to bring their waters with them. Despite this setback, the group continued to climb further up the cliff until we reached a small gazebo just before the last leg of the climb. Two students were too exhausted to continue, while the rest of the group continued up to summit Liangzi Cliff.

From left to right: 1) The group makes their way up to Liangzi Cliff. 2) A student poses with the chain from which Liangzi Cliff gets its name.

From left to right: 1) Dr. Wang (left) and Dr. Zhou (right) pose with the UH students after the long hike up to Liangzi Cliff. 2) Thinking that the journey to Liangzi Cliff would be a leisurely stroll, few though to being their water with them. After the long hike up to the summit of Liangzi Cliff, all were tired and quite thirsty. Here the group poses with a local woman that sold water to the thirsty climbers at the summit of Liangzi Cliff.

After a long day of hiking the group poses with Dr. Zhou (on left) besides the entrance of Chain Cliff Scenic Area. From left to right: Dr. Zhou, Ben Miller, Jennifer Welch, Jacob Kratavil, Valerie Smith, Janice Navarro, Wanda Crupa, Katherine Sorrows, and Robert Abel.

Liangzi Cliff is made up of a Permian ages Coal layer at its base, followed by Limestones of increasing thickness interbeded with Shales and Mudstones. As was the case for Xintan landslide, Liangzi Cliff was also destabilized due to intense coal mining activity. Approximately 60 fissures/tension cracks measuring 700 m long and 30-180 m wide divided the cliff into three discontinuous zones and were used as evidence of creep. Efforts made to stabilize the base of the cliff and back-filling old mine shafts have reduced movement and stabilized the cliff. However monitoring efforts still continue as seen by the presence of GPS and Synthetic Aperture Radar (SAR) stations at the summit of Liangzi Cliff.

Even after being reinforced and having creep significantly slowed down, monitoring on Liangzi Cliff is still ongoing. Pictured above is a Synthetic Aperture Radar (SAR) scanner (yellow rod with white cylindrical top), GPS monitoring station (large block on the right-most side), and a water level sensor (large block in the center). All are powered using solar and wind energy. Becoming familiar with the local geology and touring these prominent landslide locations allows the students to have a greater understanding of the mechanics of Huagtupo landslide. Huangtupo landslide is the volumetrically largest, approximately 70 million m^3 , complex, and economically significant landslide in the Three Gorges Reservoir Region. The local geology is the Badong Formation (T₂) which is comprised of Mudstones, Siltstones, and argillaceous Limestones with weak interlayers that dip towards Yangtze River and are ideal for slope failures. Huangtupo landslide poses a threat to civilians and property, as well as the shipping industry along the Yangtze River. By using GPS and Light Detection and Ranging (LiDAR) scans to create a digital elevation model (DEM) this project will help identify the boundaries of the landslide and set up baseline differentials for future research in the coming years.

UH students visit a CUG site for Huangtupo observation. Pictured above is a SAR sensor which scans the affected areas multiple times a day and allow for a time series analysis. This data is then used to identify the kinematic behavior of the landslide, locate active boundaries, identify displacement patterns, and causes for increased creep.