


University of British Columbia

SEG FIELD TRIP REPORT– 2009

By: Ayesha Ahmed

With contributions by: Shawn Hood, Dustin Perry, and Brad Peters

~ TURKEY ~

May 16th – June 1st 2009

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(Top- left to right) Brad Peters, Henry Awmack, Holly Keyes, Robin Black, Uwe Schmidt, Ehsan Salmabadi, Shawn Hood, Eric Ewen, Harvey klatt, Devin Tompkins, Ed Balon, Dave Nickerson, Dustin Perry, Karie Smith **(Bottom)** Marcello Imana, Francis Macdonald, Ilkay Kuscu, Ayesha Ahmed, Ezgi Unal, Kathryn Lucas, Celeste Rambaran

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OUR ITINERARY

May 16th	Depart for Istanbul
May 17th	Arrive Istanbul
May 18th	Sightseeing of Istanbul
May 19th	Pick up rental vans and drive to Bandirma for the night
May 20th	Visit Deposit #1 Halilaga Cu- Gold porphyry prospect
	Visit Deposit #2 Koru Mine
	Drive to Balikesir for the night
May 21st	Visit Deposit #3 Balya Pb-Zn deposit
	Visit Deposit#4 Samli IOGC deposit
	Drive to Ackay for the night
May 22nd	
	Visit Deposit #5 Ayazmant Fe-skarn
	Drive to Bergama for the night
May 23rd	Visit Deposit #6 Ovacik Au-mine
	Drive to Salihli for the night
May 24th	Visit Deposit #7 Kisladag Au-porphyry
	Drive to Usak for the Night
May 25th	Visit Deposit #8 Kirka borate deposit
May 26th	Visit the Kula Volcanics
	Visit the ancient city of Sardes
	Drive to Selcuk for the night
May 27th	Visit the ancient city of Ephesus
	Drive to Bodrum for the night
May 28th	Explore the Aegean sea via boat
May 29th	Visit Mugla University
	Attend a lecture on the Kirka Borate deposit
	Drive to Denizli for the night
May 30th	Visit the Pamukkale travertines and the ancient spa city of Hierapolis
	Drive to Balikesir for the night
May 31st	Drive to Istanbul
	Istanbul sightseeing
June 1st	Depart Istanbul

ACKNOWLEDGEMENTS

The University of British Columbia student chapter of the Society of Economic Geologists would like to extend sincere thanks to all the people who have been involved in the funding, organization, and execution of this year's field trip to Turkey.

We would like to thank Karie Smith for the countless hours she spent organizing this trip before we had even left Vancouver. The fruits of her labour were visible in the hotels she chose, the dinners we ate, and the activities we took part in.

A special thanks goes to Ilkay Kuscu, the geology king of Turkey. Ilkay was our geology guide, our chief navigator, our translator, and as we came to learn, our good friend. We cannot explain how educational, helpful, and useful he was on this trip. The University of Mugla is lucky to have him as a professor.

We would like to extend our appreciation to the ten members of industry who took part in this field trip. Their enthusiasm, knowledge, and expertise were both inspirational and educational.

We would especially like to thank our sponsors: Barrick Gold Corporation, Equity Exploration Consultants Ltd., the Geological Association of Canada, the Mineral Deposits Research Unit at UBC, and of course the Society of Economic Geologists. Unbelievable opportunities such as this one would not have been possible without such generous funding.

Finally, this trip would not have been possible without the cooperation and generous donation of time by the mining representatives we met.

EXECUTIVE SUMMARY

The SEG student chapter of the University of British Columbia in conjunction with 10 members of industry took part in a geological field trip to Western Turkey from May 16th – June 1st, 2009. The student body represented the diversity of the SEG chapter at UBC: undergraduates, recent graduates, and graduate students. The industry members on this trip flew from around the world to join us in Turkey, from Ghana to Finland, and all across Canada. The purpose of this international field trip was to study and understand the economic geology of Western Turkey through a focused geology and mine tour. The 16 day trip managed to inspire every person on the trip in one way or another, from the largest borate deposit in the world to the ancient ruins of the Ephesus. The SEG 2009 trip to Turkey was a real fusion of good geology and fascinating culture.

The trip commenced in Istanbul. A day was spent catching up on sleep, and visiting the many attractions of the city with 16 million inhabitants including the blue mosque, Hagia Sophia, and the grand bazaar.

(Photo) Dustin and Shawn enjoying their Fezes

We were even fortunate enough to take a boat tour along the Bosphorous river which separates Asia from Europe. Rested and rejuvenated the next day, we picked up our rental vans, drove through the hellish traffic that is Istanbul, and were on our way to Bandirma. In Bandirma we met Ilkay Kuscu, a professor of geological engineering at Mugla University. Ilkay would be our invaluable geological guide for the next week.

(Photo) A look at the highest grade drill hole from Halilaga

The first geological stop of the trip was the Halilaga Cu- Au porphyry prospect located outside the city Canakkale. Halilaga is currently a joint venture between the Turkish subsidiary of Teck, TCAM, and the Fronteer Development group. To date, 16 holes have been drilled in the region with the highest grade hole showing 100m of 1g/t gold and 1% copper. The deposit is still open to the East, however drilling this summer will explore resource expansion in that direction. Interestingly, Halilaga is the only site in Turkey where porphyry, skarn, and high sulfidation epithermal systems are seen together as possibly part of one mineralizing event. Mineralization was dominantly hosted in stockwork type veining within a porphyry ~300m x 300m. Skarn was unmineralized however the epithermal silica lithocap located at higher elevation hills within ~1km of the main deposit appear to be mineralized.

From Halilaga we traveled deep into the rolling hills of the country to the Koru Pb-Zn deposit, which was first mined by the Italians back in 1912 and is now owned by a group of four brothers. Koru is a bit of

question mark regarding deposit type. Some argue it is a low sulfidation epithermal system, others argue it is a VMS deposit. Lead and zinc are hosted within a rhyolite dome locally brecciated by later volcanism. Mineralization occurs in four separate styles: disseminated, veined, massive and stockwork. A paragenetic study has not been conducted on the various stages of mineralization to determine the style of mineralization containing the highest grade. Following crushing and milling, ore is concentrated on site by simple flotation.

The next day we drove to the town of Balya; a city very familiar with mining. The Balya lead-zinc skarn was first mined over 4000 years ago by the Troyans. Many centuries later, between 1880-1939, the French followed suit mining three shafts that are still in use today. Relics of French mining still exist and create a wonderful juxtaposition of old and new mining technology. The newest Balya mine is not yet in production but aims to produce 2400 tonnes of ore per day at a grade of 35% lead and 6% zinc. The most interesting part of this tour was the ability to see the construction of new buildings, new mills, new crushers, and new flotation devices. Balya was a real example of efficiency.

The same day we visited Samli, a deposit that has been labelled both an IOCG (iron-oxide copper gold) and a skarn. Both this deposit and the deposit we visited the next day (Ayazmant) share many similar features. They are both are located just outside of Balikesir, within the Karakaya Complex zone, situated between the Intra-Pontide Suture and the Izmir-Ankara suture in Western Turkey. The deposits share similar ages (20-25 Mya), similar alteration assemblages (sodium alteration, oxidation), and similar tectonic settings. Both deposits are related to intermediate-mafic dykes and contain iron-oxide minerals in addition to minor copper bearing sulphide phases. Visiting these two deposits back to back gave us the chance to not only develop an idea of the differences between skarn and IOGC models, but also to compare and contrast two deposits of similar origin.

The Ovacik epithermal gold deposit proved to be a real treat for unexpected reasons. Upon arrival at the minesite, we were whisked away into a conference room for what many of us agreed was the best mining movie we had seen, even if it was in Turkish! Following the movie, we took a bus tour of the open pit and learned about the overall geology. Unfortunately, we were not allowed to leave the bus for safety reasons and therefore did not get a detailed look at the rocks. Luckily, a few kilometres outside of the deposit we stumbled across some great outcrops exhibiting epithermal crack seal textures complete with colloform vein textures and intense silica replacement.

(Photo) An informal question and answer period at Kislidag

The next day we visited the Kisladag Au porphyry which sits in a belt of Oligocene volcanics ~10km x 10km. Exploration at Kisladag first commenced around 1989, but real interest in the deposit was rejuvenated in 1997 by Eldorado Gold Corp. Four phases of intrusion exist in the area, three of which host mineralization at grades above cut-

off. Gold occurs primarily as disseminated free gold but is also found in quartz veins locally occurring with minor molybdenum, galena, and sphalerite. A distinct feature of the Kisladag deposit is the abundant tourmaline present in veins associated with gold. We spent the next few hours observing the milling and concentration operations. For many of, it was the first time we had seen a leach pad…a sad fact, but true.

The next day we visited the last deposit of the trip, the Kirka borate deposit near the town of Usak. And what a way to end it was! The Kirka deposit is the largest borate deposit in the world with a projected mine life of over 300 years. Before the 1970's nationalization of the deposit, Kirka was mined by the British. From the vast, blindingly white open pit, undeformed bedded limestone and lacustrine sediment structure were visible. Three borate lenses occur within the deposit: sodium borate (borax), sodium-calcium borate (ulexite), and calcium borate (colemenite). We were able to sample and collect these soft, water soluble minerals as we drove from bench to bench in the pit. After we'd had our fill of borate mineralogy, we took a short tour of the crushing and concentrating sites where the final product, anhydrous borax, is produced. Unfortunately the mills were closed down for annual maintenance so our tour ended there.

(Photo) A view of the Kirka borate deposit

While in the vicinity of Usak we took a walking tour of the Quaternary Kula volcanics: a suite of phonolites and tephrites: sodium rich, alkaline rocks. Interestingly, the older volcanics of Western Anatolia are much more potassium rich. It was here that Ilkay took a moment to explain the origin of these volcanics: possibly due to variations in velocities of subducting plates leading to extension. Our walk to the summit of the volcanics led us to encounter vesicular basalts, and garnet schists. The Kula volcanics were a real insight into recent volcanism.

After a good week spent intent on learning all we could about geology, it was time for a little bit of rest and relaxation. We spent the next day under real duress; sailing the Aegean sea. We explored the shallow coastal waters while snorkelling, and observed some fantastically fresh conglomerates and vein breccias. Burnt and sore that evening, we chatted and drank wine until sinking into bed for a good night's sleep.

Well rested, we made the 2hr drive from Bodrum to Mugla University where both Ilkay and his wife are part of the geological engineering faculty. After a warm reception and a tour around the beautiful campus we were treated to a thought provoking lecture on the Kirka deposit we had visited a few days before. The lecture answered some difficult questions we had been discussing over the past few days regarding the origin of the boron and the enrichment process that had lead to the world's largest borate deposit. The final answer was inconclusive. The boron could be a function of sedex type leaching of country rocks, or of partial melting of a subducting slab.

(Photo) The Pamukkale travertines

After our farewells, we headed out to the textile capital of Turkey Denizli for the night. In the morning we made the short drive from Denizli to Pamukkale where we spent the morning exploring the world renowned travertines. Unfortunately due to heavy usage of the travertines for recreational purposes in the past few centuries, the carved pools and terraces were under limited access. Nonetheless, we dipped our feet in the warm calcium rich thermal waters originating from the Curuksu graben, part of the larger Menderes graben system. But there was no time to spare, we were required to complete the 400km drive to Balikesir that night!

From Balikesir, we drove the next day back into the bustling city of Istanbul. We had come far since leaving Istanbul 14 nights before. That night, we assembled for a group dinner and discussed our experiences. For some, this was their first experience abroad, away from Canada or the United States. For others, this was one of many SEG trips they had made. No matter the level of traveler, each of us had a tale to share from the trip. The SEG 2009 trip to Turkey gave 20 geologists the opportunity of a lifetime, to visit deposits and mines that in other circumstances would have been closed doors. And as all of us know, the perks of geology abroad include tasting new foods, fumbling with a new language, and getting to know the people that form the geology industry in that country. On behalf of all the members of the trip this year, we'd like to thank the SEG and all of our sponsors for a fantastic time.

HALLILAGA PORPHYRY PROSPECT

May 20, 2009

Upon arriving at the exploration offices, we were greeted by the chief geologist and project geologist. The Halilaga prospect is a joint venture between Fronteer Development Group and the Turkish subsidiary of Teck, TCAM. TCAM has a 60% share in three ongoing projects in the region: Halilaga, Agi Dagi, and Kirazli. Soon after arriving, we were on our way to the first deposit of the tour, one of the most unique in Turkey due to the fact that there is visible porphyry, skarn, and high sulfidation epithermal alteration at one site. Halilaga is the only prospect in Turkey with all three systems present.

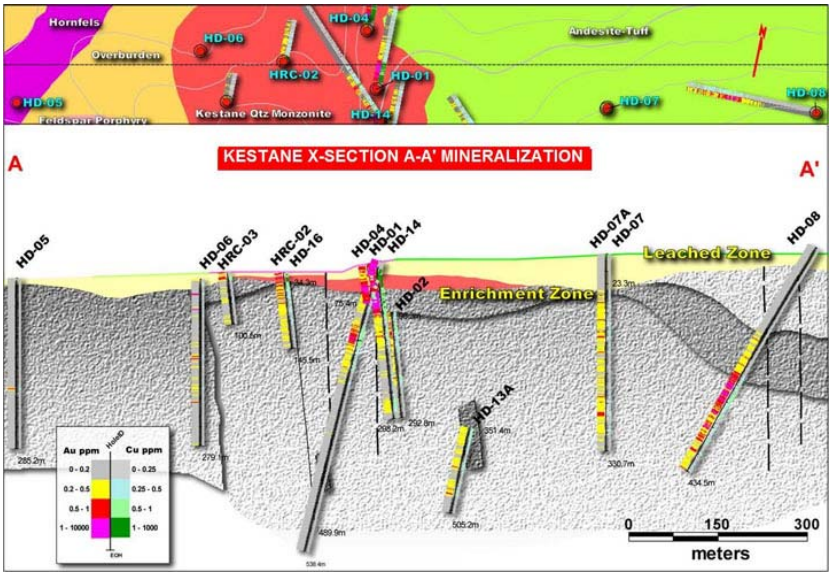
(Photo) Halilaga, Agi Dagi, and Kirazli are three porphyry prospects located in North-western Turkey.

This deposit was discovered by anomalous concentrations of gold in soil samples collected from the epithermal prospect at higher elevation to the south-east. The soil lines were extended down topography to the North. Assay results returned concentrations of 1g/t gold and 1% copper. Subsequent magnetic geophysical surveys indicated a large bull's eye around what is now considered the main porphyry; a body ~300 x 300m. Drilling of the epithermal lithocap did not intersect the porphyry. Drilling of the porphyry prospect returned impressive results. Grade appears near surface in the area and supergene enrichment ~25-50m below surface produced a chalcocite blanket. An E-W cross-section shown below exhibits the overall geology and grade in the area. Drill hole HD-1 is the highest grade hole returning 100m of 1g/t gold and 1% cooper. Located 1km to the East of HD-1, HD-8 returned

(Photo) The skarn system at Halilaga is represented by a grossular and almadine alteration assemblage.

50m of 0.5g/t and 0.3% Cu. The deposit remains open to the East, however a strong drilling program during the summer of 2009 is intended to identify and constrain grade in this region.

The porphyry mineralization is bordered by the Kaslag massif to the South, an intensely calc-silicate altered skarn zone to the Northwest, and sediments to the west. A large fault unconformably separates unmineralized volcanics from underlying mineralized porphyry. Although currently awaiting age dates, the broad age of mineralization is suggested to be between Eocene and Oligocene. Given that this deposit outcrops near surface, and that typical porphyry deposits occur between 3-5km depth, Halilaga has undergone at least 3km of erosion in a maximum of ~40 million years. Ilkay (personal communication, 2009) suggests that porphyry mineralization in Turkey is the result of large detachment faults and partial melting of the mantle asthenosphere. This type of tectonic environment is much different than the typical subduction related porphyry models.



(Photo) (http://www.fronteergroup.com/sites/fronteer_admin/Fronteer_HalilagaMineralization_large.jpg)

KORU Pb-Zn DEPOSIT

May 20th, 2009

An arduous drive through winding roads and rolling hills lead us to the Pb-Zn Koru deposit located high within the hills of Western Turkey. The mine is owned and operated by Canakkale Madencilik Ltd., a group of four Turkish brothers. Two geologists from the mine took us through the open pit geology of the Koru deposit. Unfortunately, we were unable to visit the underground mine. Mining at Koru began in 1912 by the Italians and production continues today. 350 000 tonnes of lead and zinc mineralization is hosted within a rhyolite dome, locally brecciated by later volcanics. There are four styles of mineralization: veining, stockwork, disseminated and massive. The geologists have not been able to distinguish whether grade is higher in one style of mineralization than another. Volcanic rocks which host the vein type mineralization can be divided into two types. The first are the Oligocene basement volcanics, which are widespread in the study area, and cut by spherulitic rhyolite of early-middle Miocene as a second type. Three main faults occur within the deposit, but only one, an East-west trending fault controls mineralization. Alteration is dominantly silicification with a strong chlorite envelope.

Basement rocks consist of pyroclastics: tuffs and agglomerates, trachytic, dacitic and rhyolitic in composition. Spherulitic rhyolite is associated with mineralization and it was emplaced as a dome cutting basement volcanics. Silicification and sericitization appear to be the early hydrothermal alteration phase followed by argillic alteration and intense kaolinization. Adularia is associated with quartz in both veins and wall-rocks.

(Photo) Mineralization is associated with pervasive illite and kaolinite clay alteration (white).

Following our trip through the geology, we were able to tour the site of ore processing. First, the ore is crushed into 2-3cm pieces. The crushed ore is then refined in a large ball mill to a much finer sand size fraction. Koru has its own flotation plant to separate and concentrate lead and zinc. Yearly production is 12 000 tonnes ore with 40% zinc and 20 % lead as bulk concentrate. Tailings are disposed by pumping into an area far from the Koru creek. Following a water filtration process, the water is returned to the flotation plant and recycled.

BALYA-BALIKESIR (Pb-Zn-Ag deposit)

May 21st, 2009

After spending the night in Balikesir, we drove approximately 50 km northwest to the town of Balya, located in the Balya district of the Balikesir Province in the Marmara region of Turkey. The Balya Pb-Zn-Ag deposit has been mined since ancient times and most likely was the location where the lead and silver for the ancient city of Troy was collected. More recently, from the mid-late 1880's through the mid-late 1900's a French company operated a mine with 3 shafts at the Balya deposit and produced approximately 4 Mt of ore, leaving behind the remains of old stone buildings and the historic workings, in addition to contributing to the town of Balya in the form of electricity and medical surgeries. Currently under development by Eczacibasi Holding Co., this is the company's first venture into the Pb-Zn-Ag mining sector, and may not be their last. Founded by Dr. Nejat F. Eczacibasi (1913-1993), the company's cardinal principal is to contribute to a "healthier society".

We began our tour at the site of the old French buildings for an introduction to the Balya region and the local geology. The geology surrounding the Balya deposit consists of Permian limestone, Triassic shale, sandstones and conglomerates, and Tertiary volcanics consisting of altered and unaltered porphyritic andesites. Tectonic events that may have affected the area include 1) Hercynian folding etc. of the Permian formations 2) Alpine folding and faulting (including thrusting) 3) Displacement of rocks during the extrusion of lavas and 4) Lateral inconsistencies of sedimentary facies, as well as well as repetition

(Left) Our host Ilham explaining the history of Balya. **(Right)** Old French mine buildings on the Balya property.

of facies with time. Two fold axis in the Balya region have been identified, one trending roughly N-S and the other trending roughly E-W. Folding appears to be complex from the literature and the presence of the Permian limestone overlying the Triassic sediments to the south of the mine suggests the possibility of recumbent folding. Observations by GJELSVIK in 1956 of intercalated limestone and sedimentary units and intraformational quartz pebble conglomerate within a sandy limestone series suggest that the contact is roughly conformable. These observations support the idea that the overlying Permian limestone to the south of the mine is a result of recumbent folding and not due to overthrusting of the Permian limestone. Recumbent folding is associated with the N-S trending striking fold axis.

(Photo) Galena and sphalerite within host andesite

Mineralization is found associated with contacts between the Permian limestone and the Tertiary volcanics, as well as in veins within the andesite. Alteration covers approximately 1500m in diameter and consists of an outer propylitic shell with a phyllic/argillic central core that has been overprinted by advanced argillic alteration.

Construction of the new facilities has been underway for 2 years now and is nearing completion. Management of the environmental concerns remaining from previous mining activities has been completed and a new waste water treatment facility is nearing completion. Draining the mine of water was recently completed and construction of the remaining facility is estimated to be approximately 2 months away.

We were guided through the new facility and shown the floatation plant that is nearing completion, with the new mills, mixers, filters and floatation cells. We were also permitted to poke around is some of the piles of ore to see firsthand the Pb-Zn-Ag mineralization. We then returned to the main staff and dining areas where we watched a presentation on the mine that was followed by a delicious lunch of lamb, rice and tea with more discussion.

SAMLI and AYAZMANT Fe-SKARNS (or IOCG)

May 21st /22nd, 2009

(Photo) One of two open pits at the Samli depoist

The Samli and Ayazmant Fe-skarn deposits are similar in both appearance and genetic model. Both are located just outside of Balikesir, within the Karakaya Complex zone, situated between the Intra-Pontide Suture and the Izmir-Ankara suture in Western Turkey. The deposits share similar ages (20-25 Mya), similar alteration assemblages (sodium alteration, oxidation), and similar tectonic settings (Colackoglu and Murakami, unpublished). Both deposits are related to intermediate-mafic dykes and contain iron-oxide minerals in addition to minor copper bearing sulphide phases.

Similar to Halilaga, intrusive bodies responsible for mineralization at these two properties are suggested to be a function of partial melting of the asthenosphere due to large-scale detachment faulting. At Ayazmant, mineralization is hosted within an andesite porphyry (endoskarn), which is also responsible for much of the sodium alteration at the contact between the andesite and an adjacent granodiorite body. Similarly at Samli, the quartz diorite host intrusive rock has been completely altered to albite and scapolite. In the Ayazmant open pit, magnetite is replaced by late sulphide veining. Reserves at Ayazmant are estimated to be a combined (proven and probably) 5.5 Mt ore, at a grade of 0.8% Cu, 65% iron with a recovery of 65%.

OVACIK Au –EPITHERMAL DEPOSIT and the ACROPOLIS

May 23rd. 2009

On the night of the 22nd we drove through the ancient city of Bergama, known in the modern day as a carpet Mecca. The next morning we set out to tour the Ovacik Au-Ag epithermal open pit deposit but to our misfortune we were met with complications, and the tour was postponed until the afternoon. What a sacrifice! We spent the morning exploring ruins dating back to 300 B.C. including well preserved marble columns, and steps carved out of hydrothermal breccia. The setting made it very easy to imagine Roman life.

Following a refreshing cup of fresh squeezed orange juice at the Acropolis, we ventured back to the Ovacik mine to try our luck again. The tour began with an extremely well produced informational Turkish-language video. A recurrent theme in the video was the environment and the steps the Ovacik mine has taken to adhere to local and international environmental standards. Their tailings pond, which is on par with USA drinking water standards is so clean that the mine manager is said to have gone swimming in it on several occasions. Finally, they highlighted their social contributions to the surrounding community with 90% of the 526 employees being local.

Ovacik is operated by the Kaza Mining Corporation and has been producing since May 2001. The Ovacik deposit consists of gold-bearing epithermal quartz brecciated veins hosted by subaerial andesite porphyries. Rocks have been altered to adularia, which is typical of low-sulfidation epithermal deposits and temperatures of mineralizing fluids ranged from 150-300°C. Production has been 500,000 tonne/year (t/y) with 5 t/y Au and 5 t/y Ag being produced. Ilkay, our geological tour director for the afternoon, gave us a brief synopsis of the deposit. Unfortunately, safety regulations precluded us from stepping off the tour bus during our round of the mine. As such we weren't able to get out and really observe the geology. Luckily, just outside the property we found good vein exposures showing epithermal textures such as crustiform banding and multiphase breccias.

(Photo) Ilkay explaining the overall geology of Turkey.

(Photo) Francis Macdonald hunting for native gold at the Kisladag gold mine.

KISLADAG Au PORPHYRY DEPOSIT

May 24th, 2009

Kisladag gold mine is located north of the city of Usak, on the western edge of the Anatolian Plateau. Formal exploration at the Kisladag deposit started between 1989 and 1990. The deposit was discovered after an intense stream sediment sampling program that returned gold values between 50-160ppb. Open pit mine production began in 2006 by Tuprag Mining, a subsidiary of Eldorado. The property itself is ~157km^2, (the largest gold mine in Turkey), with a combined (proven and probable) ore reserve of 5.523 million ounces

gold. The total ore throughput is 10 million tonnes per year and the strip ratio is currently 1:1. Last year (2008) approximately 190, 334 ounces of gold were produced by heap leach process.

During our visit to Kisladag, we were first shown around the property. Kisladag sits within an Oligocene volcanic complex, one of many that is related to subduction along the Hellenic Trench. Basement rocks consist of Mesozoic schist. Four latitic intrusive bodies cut the aforementioned rocks, with three of the four intrusions hosting mineralization at grades above cut-off. The earliest intrusive phase is also the coarsest grained and hosts the bulk of gold mineralization. The second and third intrusive phases hold gold at grades between 0.3 and 0.8g/t. The youngest intrusive hosts gold, but at a grade less than 0.3 g/t. While in the open pit, we were able to observe much of the alteration associated with mineralization. Gold is associated with multiple phases of tourmaline, and quartz-tourmaline-pyrite veins. Mineralization occurs as disseminated free gold, but also in veins. Minor molybdenite, galena, and sphalerite are locally associated with gold.

We took a break from the rocks at around noon and ate a delicious lunch in the mine canteen. After that break from the sun we took a tour of the processing side of the mine. The most interesting part of this tour was seeing how gold ore is processed in a cyanide heap leach facility. None of us students had ever seen the process in real time. Kisladag uses a method involving separate leach cells. Separating the cells allows for leaching to continue in one cell if problems are encountered in another. The crushed ore is transported to the cells from the crushing circuit, consisting of a gyratory crusher and four cone crushers, via conveyor system. The pregnant solution is piped to a carbon absorption facility where the carbon is treated and the gold is recovered and poured into gold bars. Unfortunately, the plant where the pregnant solution was piped to from the heap leach pads could only be observed from a distance and our hopes of seeing (and maybe holding) a bar of gold were dashed. However, we had a very informative day at Kisladag.

KIRKA BORATE DEPOSIT

May 25th, 2009

The state-owned Kirka mine is the largest borate deposit in the world. The mine sells its product, borax pentahydrate, to over 48 countries, and interestingly Canada is 22nd on this list. The current mine has been in production since 1970 and employs 1250 workers. Pre-1970's, underground mines were operated by British companies. We were fortunate to receive a thorough tour of the mine from the open pit, to the processing.

(Left) Ayesha Ahmed and Shawn Hood on an upper bench of the Kirka deposit. **(Right)** Overview of the Kirka deposit.

The vast open pit exposes the geology of the Kirka mine. Three separate ore horizons are hosted within Tertiary lacustrine sediments: a main Na-borate (borax) horizon, a middle zone of Na-Ca borate (ulexite) and a marginal Ca-borate (colemanite). The different types of borate were distinguishable in hand sample texturally. Ulexite appeared in medium grained to massive soft, clear crystals and colemanite which occurred as a clear tan brown mineral in fine to coarse grained crystals. A review of the formation of the Kirka deposit follows in the section entitled 'Mugla University'.

KULA VOLCANICS, SARDES, and EPHESUS

May 26th and 27th, 2009

(Photo) Vesicular basalt sample from the Kula volcanics

Following our last formal ore deposit/ mine tour, we spent a half day looking around a part of the Kula volcanics. The Quaternary Kula volcanics are a suite of phonolites and tephrites or sodium rich, alkaline rocks. Interestingly, the older volcanics of Western Anatolia are much more potassium rich. It was here that Ilkay took a moment to explain the origin of these volcanics: possibly due to variations in the velocities of subducting plates leading to extension. Our walk to the summit of the volcanics led us to encounter vesicular basalts, and garnet schists. The Kula volcanics were a real insight into recent volcanism.

We spent the rest of that day and part of the next day culturing ourselves by visiting the ancient cities of Sardes and Ephesus. Both trips were a nice balance to the time we'd been spending in open pits and conference rooms. While touring the modern mines it was easy to forget the thousands of years of history that have been preserved throughout Turkey.

BODRUM BOAT TOUR

May 28th, 2009

(Photo) Well bedded sedimentary units on the Bodrum Peninsula.

In the coastal town of Bodrum we were given the amazing opportunity to take a boat tour around parts of the Aegean and along the south-western coast of Turkey. Luckily, Ilkay's wife, a volcanologist from Mugla University was able to accompany us on the trip and gave us a brief lesson on the rocks forming many of the peninsulas along the coast. Upper Miocene volcanism is dominant along the peninsulas and is recorded as andesitic lava flows and pillows, with minor andesitic and dacitic lava domes and associated block and ash flows. A caldera collapse near the peninsula and subsequent slumping of the caldera walls lead to the formation of ignimbrite units. Thick, fresh sedimentary conglomerate beds line the coastal seafloor. I think a few of us decided that geology by boat may be the key to future exploration!

MUGLA UNIVERSITY

May 29th, 2009

After a week spent under the guidance and wisdom of Ilkay, we were finally able to visit the university at which both he and his wife Gonca teach: Mugla University. Mugla University was established in 1992 amidst sprawling green hills and tall stark mountains. Unlike North American universities, Turkey does not offer a pure geology program. Instead, the geological engineering faculty produces geological engineers that serve as both geologists and engineers. What was once a small division of the larger engineering umbrella has morphed into a strong group of professionals. During our visit, we had the opportunity to see the new civil engineering building currently under construction. Ilkay and the rest of the geological engineering faculty moved into this building in June 2009.

Aside from a tour of the Mugla University campus, the main purpose of the visit was to learn more on the Kirka borate deposit from an academic perspective. Assistant professor Cengiz Demirci presented a very well organized, thought provoking lecture on the genesis of borate deposits, specifically in lacustrine environments. The Kirka deposit is an example of a lacustrine borate deposit. Cengiz suggests that there are two models for the formation of lacustrine deposits. The first model is similar to that of a

sedimentary exhalative deposit where boron is leached from wall rocks by a hydrothermal fluid and precipitated at the water table. The second model involves the enrichment of a hydrothermal fluid from some unknown source, possibly near sites of subduction related to slab rollback extension. Interestingly, Cengiz emphasized the importance o f detachment faults and core complexes in the evolution of borate deposits. In fact, he argued that wherever a detachment fault is observed, a borate deposit can be identified. The Kirka deposit is no exception. A large detachment fault or ramp structure separates the lower, laminated ore body from the upper ore body.

Regarding exploration, Cengiz expressed his doubt in the usefulness of geochemistry in targeting borate deposits. Although arsenic, lithium, and strontium are closely associated with many borate deposits, this is not a universal geochemical signature. Additionally, groundwater geochemistry sampling methods may turn up results consistent with the signature of borate deposits, but the data may not provide a vector toward mineralization due to the highly mobile nature of borate. Cengiz suggested the only useful method to explore for borate deposits is by identifying borate pseudomorphs at surface. Borate pseudomorphs form when borate minerals are replaced by minerals in equilibrium with the hydrothermal fluid causing alteration. The replacement mineral retains the same crystal shape as the precursor borate mineral.

Following an insightful question and answer period, we continued discussion with Cengiz over a delicious lunch in the university cafeteria. And what afternoon would be complete without a customary cup of Turkish coffee. We chatted and enjoyed the beverage in the open veranda of one of Mugla University's beautiful cafes. Incidentally, upon returning to our vehicles we saw that our large vans were trapped in a sea of diplomatic and Turkish dignitary vehicles. After a little fuss, and some coaxing by Ilkay, we were able to get the cars moved and we were on our way to Denizli for the night.

PAMMUKKALE TRAVERTINES and HIERAPOLIS

May 30th, 2009

(Photo) Ancient spa city Hierapolis

Following a restful night in the textile capital of Turkey, Denizli, the group was on to another adventure. Located approximately 17km from the town of Denizli in south-western Turkey, are the spectacular white terraced travertines. From the small city of Pammukkale, meaning ‘cotton castle’, the man made terraces and pools are in stark contrast with the lush green surroundings of the area. Although naturally beautiful, the pools

themselves were carved out of the travertines by the Romans as part of a large spa city called Hierapolis. Cleopatra herself is rumoured to have benefited from the suggested restorative qualities of the calcium and magnesium rich waters. Signs leading into the 'Antique Pool' boasted that the waters were the cure to many ailments and diseases including obesity, respiratory dysfunctions, and circulatory problems. Unfortunately after half an hour in the pool, none of us appeared any slimmer.

Hierapolis was a small city spread over an area of approximately 1.5 x 1.5km. Certain parts of Hierapolis were extremely well preserved including the amphitheatre. The Hierapolis museum recounted different aspects of Roman life including theatre, war, birth, and death. In addition to the travertines, the now commercialized antique pool was a really unique experience. Within the pool were large boulders and broken ancient columns, reminiscent of an underwater museum. For a day, we felt like Roman royalty.

(Photo) Pools were sculpted by the Romans in to the travertines.

Semset et al (2000) describe the geology of the travertines. Chemical and isotopic data suggest a dominantly meteoric origin for the hydrothermal fluid with a residency time between 20-30 years. The thermal springs originate at the Curuksu graben, part of the larger Menderes graben system. Basement rocks in the area are part of the Paleozoic Menderes massif composed of quartzite, schist, and marble overlain by mica-schist, quartzite and marble. The basement rocks are overlain by Pliocene sediments and Quaternary alluvium. The main aquifers for the calcium rich hydrothermal fluids are Paleozoic karstic marble and Mesozoic limestone. Pliocene sediments form an impermeable cap to the aquifer. C^{13} analyses indicate that the source for CO_2 is consistent with the decomposition of marine carbonates (marble and limestone). According to Semset et al (2000) the travertine is deposited when the saturation of calcium within the fluid is approximately four times the concentration at the thermal spring outlet. Maximum travertine deposition occurs at the rims of terraces due to the out-gassing of CO_2 caused by turbulent flow.

Due to the designation of the Pamukkale travertines as a UNESCO world heritage site, increased measures are being taken to limit the amount of tourist activity within the travertines themselves. Many of the terraces and pools are closed, and the pools that do exist are very shallow (< 0.25m). The pollution is due to a number of factors: (i) the use of geothermal water by hotels for swimming pools causes less travertine to be deposited and therefore less renewal (ii) the overuse of the travertines by tourists causes the growth of algae on the travertine surface due to human caused organic contamination (iii) hotel sewage systems that have been dug into the travertines leak waste that subsequently flow downstream contaminating the travertine waters and depositing large amounts of algae.

Hierapolis and the Pamukkale travertines are worth the measures being taken for preservation. The ability for our group to observe a modern, producing epithermal system was not only impressive but highly educational.

CONCLUSIONS

The 2009 SEG field trip to Turkey was a real success. From the feeling of awe we felt during our first night in Istanbul, to the excitement of visiting the world's largest borate deposit, to the adventure of exploring the ancient ruins of Ephesus, students and industry professionals were able to come together and collaborate. During our stay, we were also able to connect with a variety of professionals from Turkey including mine geologists, strategic planners, and university professors. Returning from sixteen days in Turkey has left us only wanting more of the same. The SEG student chapter at UBC looks forward to the educational and inspiring adventures that the SEG will bring to our university in the future.