

FINAL FIELD TRIP REPORT

# WESTERN AUSTRALIA

April 29 - May 17, 2011



SEG-GAC Student Chapter  
The University of British Columbia



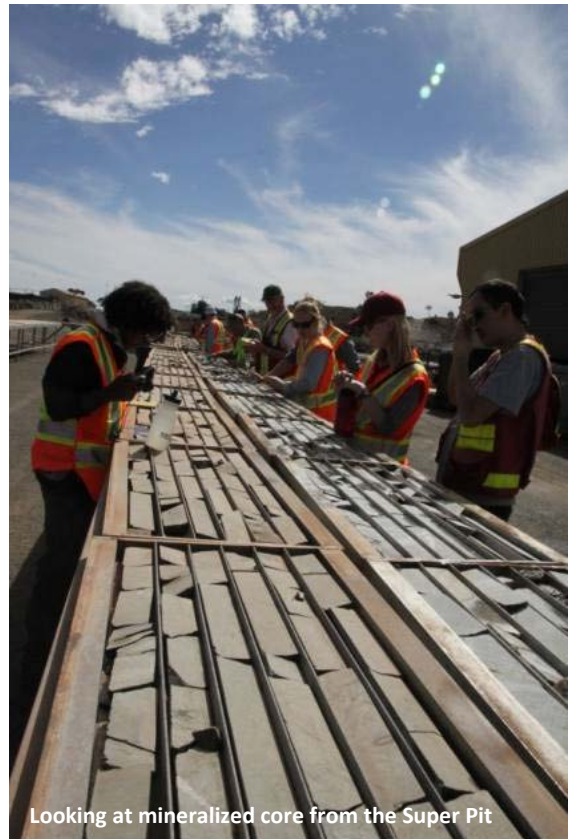
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## FOREWORD

The University of British Columbia's student chapter of the Society of Economic Geologists (UBC-SEG) seeks to promote better understanding and deeper interest in the science of economic geology. Our activities are aimed at advancing our members' comprehension of mineral deposits and how geological science is applied to exploration, evaluation and production. With this goal in mind, we organize courses, meetings, field trips, lectures and literature. We place a great value in the experience of fellow geologists and strive to develop stronger links between students and professional geoscientists in the industry, academia and government.

Over the past eleven years the UBC Ore Deposits Field Trip has enjoyed great success, creating an opportunity for enthusiastic students and industry participants to interact and experience world-class geology. It is also an opportunity to visit a variety of mineral deposits and regions while gaining a hands-on understanding in a short period of time. The 2011 trip to Western Australia was attended by ten UBC-SEG students and seven members of industry. Focuses of the 2011 trip were to understand the structure, emplacement and mineralization of the Archean Yilgarn Craton, Western Australia. To achieve this goal we visited several mines and important field locations including: Norton Goldfields' Paddington Mine, Goldfields' St. Ives Gold Mine, Kalgoorlie Consolidated Gold Mines' (KCGM) Super Pit, an outcrop of the Boulder-Lefroy Shear Zone, AngloGold Ashanti's Sunrise Dam Gold Mine, Jabiru Metals Ltd.'s Jaguar VMS Mine, BHP Billiton's Mount Keith komatiite-hosted Nickel Sulphide Mine, Talison Lithium's Greenbushes Li-Sn-Ta Pegmatite Mine, and Newmont's Boddington Gold Mine. The University of Western Australia hosted us upon arrival in Australia with an introductory presentation on the geology and mineralization of the Yilgarn Craton. We also spent several days looking at the marvellous beaches and other sites of interest in Western Australia including the World Heritage Site at Shark Bay, Monkey Mia and the Margaret River Wine Region.



The following report was written by student participants of the trip. Compilation and editing was conducted by Esther Bordet and Chris Fozard.



## SPONSORS

We would like to acknowledge support from the many sponsors who made the realization of this trip possible. Also, thank you to the industry participants to the field trip, for their financial support but also the added value they bring to such a trip by sharing their professional experience with students. We also acknowledge Golder Associates Ltd. in Burnaby for providing personal protective equipment to all student participants.



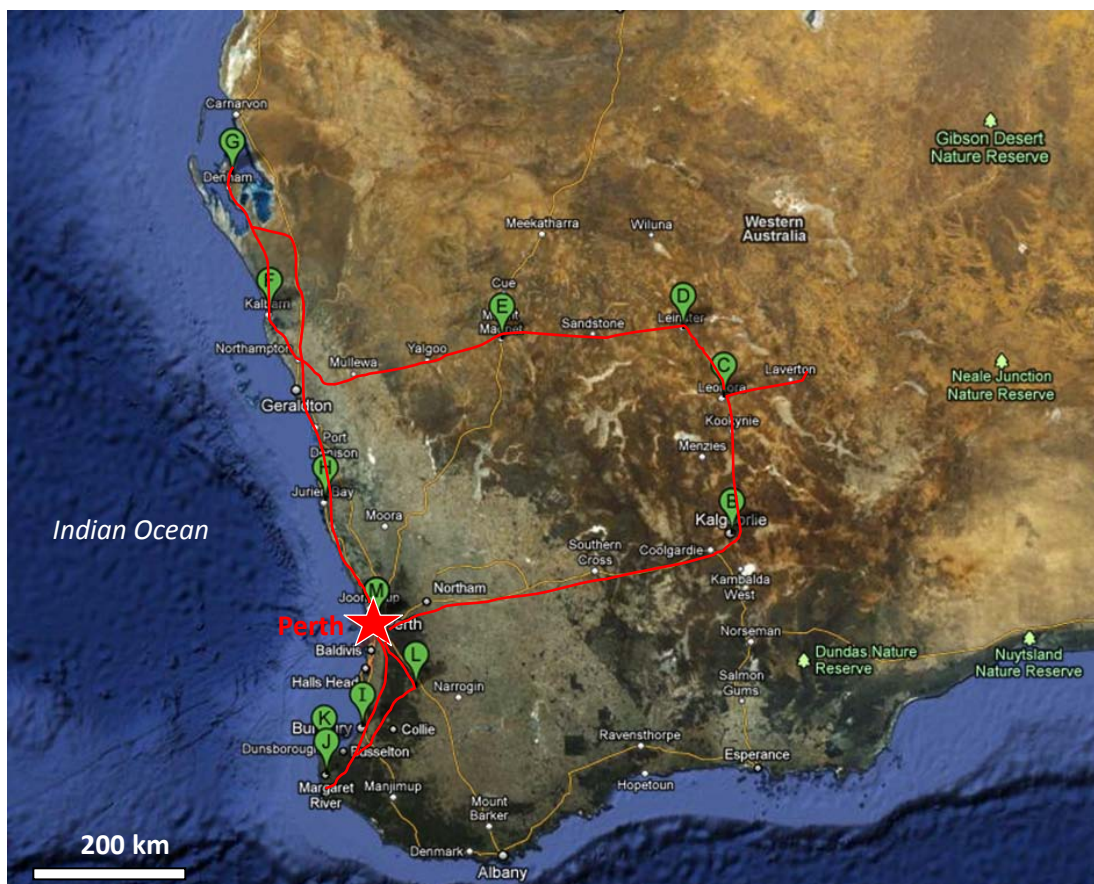
*Students proudly wearing the PPE provided by Golder Associates at the Boddington Gold Mine, WA*



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## ITINERARY



## MAY 1, 2 - PERTH AND TALKS AT THE UNIVERSITY OF WESTERN AUSTRALIA

(By Brendan Scorrar)

We landed in Perth, WA on the afternoon of May 1<sup>st</sup> having left Vancouver on April 29<sup>th</sup>. We were tired, and excited for the trip ahead of us. After picking up the rental vans we set off for the YMCA Jewell House in downtown Perth. It was the first time driving on the left side of the road for many people, but we made it to the Jewell House without any problems.

The group woke up early on the morning of May 2<sup>nd</sup>, still not adjusted to the 15 hour time change, and got ready for some introductory lectures at the Center for Exploration Targeting (CET) at the University of Western Australia (UWA).

The first talk was given by Dr Stephen Wyche a veteran mapping geologist from the Geological Survey of Western Australia. His talk was a geological overview of the Yilgarn Craton, including the possible tectonic environments that created the craton. The presentation was an excellent introduction to the area and gave us the background information we need for the following talks and the rest of the trip.



Alfonso by the spinning Orbicular Granite sphere at UWA

Dr Marco Fiorentini spoke next about Komatiites in the Yilgarn Craton. Following a quick overview, Marco jumped into the different types of komatiites found in Western Australia and the different styles of nickel mineralization they host. We heard about the geochemical and textural variations that exist in komatiites and the tectonic setting that may lead to the variation. The talk provided a lot of insight into the Mt. Keith mine that we would see later in the trip.

The third speaker was Dr Thomas Angerer who gave a talk on BIF iron deposits and his research on the Koolyanobbing Mine near Southern Cross, WA. This would be our only exposure to iron mining in WA as we were unable to get a tour at the Koolyanobbing Mine. Thomas showed the relationship between the regional deformation stages, which Stephen Wyche introduced to us, and the mineralization at Koolyanobbing. This reinforced that craton scale processes can have a major impact at the deposit scale.

Dr Campbell McCuaig gave the fourth and final presentation which covered gold deposits in the Yilgarn Craton as well as new advances in understanding large scale controls on mineralizing systems. He gave overviews, including the deposit models, of all the gold mines we would be visiting over the course of the trip. The presentation also showed the great geologic variation between deposits and how new techniques are being developed and used to explore in the area. One example of a new technique that attempts to determine large scale controls on mineralization was using model ages to map variations in the lithosphere as deposits seem to be spatially associated with certain age lithosphere. Cam's presentation left us with lots of ideas to think about over the next two weeks.



We would like to extend a HUGE thank you to CET and UWA for hosting us on the 2<sup>nd</sup>. Special thank you to David Mole for organizing them, all the talks were excellent and were the perfect start to the trip. We would also like to thank them for letting us borrow water jugs, a first aid kit and a cooler for the vans. Thank you also to Carissa Isaac who kept us on track and made sure the day ran smoothly.

### **MAY 3 – FROM PERTH TO KALGOORLIE**

(By Lindsay McClenaghan)

The UBC-SEG tour group drove 600 km from Perth to Kalgoorlie along the Great Eastern Highway, adjacent to the water pipeline that supplies the mining districts with freshwater from Kalgoorlie to Norseman. We stopped in Southern Cross for lunch, where mining and agriculture are the two major industries in the area. There is active mining of gold, nickel, gypsum, salt, and iron, while the agricultural industry focuses on grain, wool, sheep, cattle and pigs. In the late afternoon our group arrived in Kalgoorlie and settled at the historic York Hotel, then met with former UBC-MDRU colleagues Shawn Hood and Ayesha Ahmed for dinner.



Southern Cross



The group enjoying some beers in Kalgoorlie

## MAY 4 –PADDINGTON NAVAJO CHIEF AND ENTERPRISE GOLD DEPOSITS

(By Lindsay McClenaghan)

In the morning, we visited Hammond Park to see local wildlife: kangaroos and colourful birds.

Norton Goldfields' Paddington Gold Mine gave us a tour of their Navajo Chief Pit located 10 km southwest of Kalgoorlie. Our tour guides included: Mine Geologist James Crump, Graduate Mine Geologist Nicholas Louzikiotis, and Pit Technicians Bob Helm and Mel Wards. The Navajo-Chief has been in operation for one year and has been developed as a large open pit mine by amalgamation of several smaller historical open pits. The proposed pit size will be up to 170 m deep at the southern end, 1.4 km long and 345 m wide. The Navajo-Chief has a projected mine life of 18 months with possible plans to heap leach lower grade stockpiled ore. The ore is shipped by road train to be processed at the Paddington Mill 40 km north of Navajo-Chief. The Paddington mill is centrally located with respect to several other Paddington Gold Mine sites in the area. The high grade resource at Navajo-Chief is 14 Mt at 1.10 g/t Au (496,000 oz) with a 0.8 g/t cut-off grade, the low grade resource is 14.3 Mt at 0.66 g/t Au (306,000 oz), and the reserve is 6.1 Mt at 1.28 g/t Au (250,000 oz). The gold mineralization is hosted within epiclastic and volcanoclastic units and is controlled by the north-south trending Centurion fault. The mineralization is related to alteration halos surrounding shallowly west dipping quartz vein arrays. Alteration associated with these veins is a silica-haematite-pyrite-carbonate-sericite assemblage. The mineralized zone strikes to the southeast with a plunge of 10° and has variable continuity over its almost 2km strike length.



During the afternoon we drove to the Enterprise gold deposit which had been mined historically as an open cut to a depth of 100 m. The site is located 68 km northwest of Kalgoorlie in the Ora Banda district, 38 km from the Paddington Mill. Our group stopped in at the Paddington Mill for an induction given by Peter Ruzicka Head Geologist at Paddington Gold Mine. We were met by Andrew Doecke, Project Geologist on site and taken for a tour through the open pit. The primary host for the mineralization is the Enterprise Dolerite sill, where the upper fine grained zones preferentially host higher grade. The ore body is bounded by the South Enterprise Fault and North Enterprise Fault zone. High grade gold is located in steeply plunging linear zones spatially linked with these brittle-ductile faults. Alteration zones from distal to proximal are as follows: chlorite-calcite, biotite-pyrite, mica-pyrite-



gold. There is also a minor molybdenite component related to micro-fracture alteration. There are plans to continue mining the Enterprise deposit within the next 18 months. A sub-level cave type mine design is in place, access will be through a portal in the NE corner of the existing pit. The ore material has a projected head grade of 2.52 g/t. Andrew Doecke provided us with several informative handouts and brought a pit map to assist our navigation through the lithological units and structure visible along the pit walls.



Enterprise pit

Following this pit tour our group drove 1.5km down the road to the historical Ora Banda pub for some refreshments.



The Ora Banda historic pub

## MAY 5 – GOLDFIELDS ST. IVES GOLD MINE

(By Greg McKenzie)

On May 5th, our group visited the St. Ives Gold mine which is owned and operated by Goldfields of Johannesburg, South Africa. St Ives is located approximately 80 km south of Kalgoorlie in Kambalda, historically known as a productive nickel district. We met with Gustav Nortje, Goldfields senior Exploration Geologist in Kalgoorlie. He then escorted us to the mine and introduced their security protocols.

St. Ives is a highly prospective gold camp within the Norseman-Wiluna Archean Greenstone belt near Lake Lefroy in the Eastern Goldfields region of Western Australia. The Kambalda Domain is bound by the northwest trending Boulder-Lefroy Fault and the Zuleika shear. The region has undergone four compressional events and has been metamorphosed to upper greenschist or lower amphibolite facies. The main structural feature at St. Ives is the gently south plunging Kambalda Anticline. There are several styles of gold mineralisation hosted in dolerite, an undifferentiated gabbro. Lode gold typically consists of 1 to 20 cm wide mesothermal vein complexes and of a flat lying mineralized body in weathered Archean rocks.

Production at St. Ives occurs as both open pit and underground operations. Current mineral resources are at 5.6 Moz and mineral reserves at 2.3 Moz of gold. The dedicated exploration team at St Ives is required to discover 500,000 Oz of gold each year to maintain these current reserves. What really impressed us with Goldfields exploration team was their dedication to academic research and applying what they have learned to expand the reserve potential at St. Ives.

We were given two extensive talks detailing the geology at St. Ives and the methods which Goldfields uses to explore for future deposits. We were then taken on a pit tour through the Agamemnon and Leviathan pits where we were allowed to collect samples. Finally Goldfields kindly provided us with lunch and a tour of one of their four massive core farms.



Leviathan Pit



The core farm

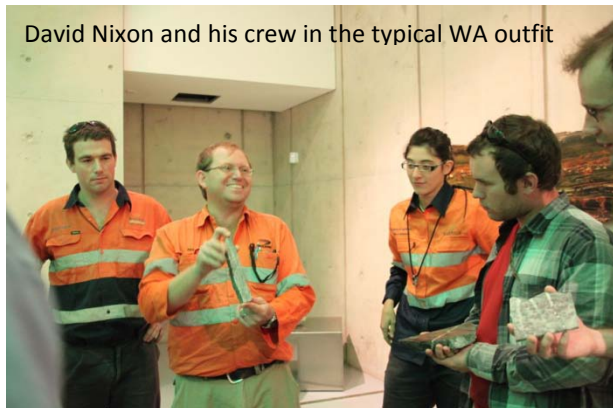
## MAY 6 – KCGM SUPER PIT

(By Chris Fozard)

Another gorgeous morning in Kalgoorlie greeted our group, and most of us enjoyed the continental breakfast on offer at the York Hotel. We drove to the east side of town for morning lectures at the Mining Hall of Fame. David Nixon, the Senior Exploration Geologist for Kalgoorlie Consolidated Gold Mines (KCGM), was held up briefly at a drill site but this gave us time to look around the many historical geology displays. Lectures were held in the conference room with walls lined in display cases hosting incredible crystal and ore specimen. David gave a fiery lecture about the history of mining along the



Admiring rocks



David Nixon and his crew in the typical WA outfit

Golden Mile, and his own thoughts on the various interpretations of the geology and the discrepancies within. As with many projects of this scale, deepening observations have contradicted certain assumptions and shown the history to be truly complex. David also brought along numerous tubs of rock slabs for our viewing, which he personally amassed over the last 15 years. Spot lights in the conference

room were in hot demand as the main lighting was oddly filtered by green panels.



The Superpit

The Superpit, formally known as the Fimiston Open Pit, and the Mt. Charlotte underground operation, are managed by KCGM and owned 50/50 by Barrick Gold Corp. and Newmont Australia.

Gold is hosted in shear zones and structures, generally within the Golden Mile dolerite but is not confined to one unit. The dolerite is a major feature in the region, and appears variably as a medium grained mafic intrusive or alternatively a ponded basalt. Over 2000 lodes have been identified in an area 5 km long, 2 km wide, and 1 km deep. A lode must be at least 10 x 6 m in area for economic mining. Areas where stopes have been back-filled actually contain former waste (with visible gold) that is higher grade than the current bedrock ore. Bedrock grades range from <0.5 g/t (sub-economic), to >1.5 g/t (high grade). Ore is often refractory, held in pyrite now that most of the 'green leader' telluride ore has been mined out. This target gets its name from the vanadium mica roscoelite which gives characteristic emerald green colour, plus pyrite and ankerite. Sericite alteration is common



and appears to precede regional deformation of the 2.64 Ga Mt. Charlotte metamorphic event. The telluride alloy gave grades as high as 100 kg/t. KCGM aims to produce 800,000 oz/yr from their Fimiston plant and Gidji roaster. Ore can be run through two circuits in the plant, and refractory ore is sent on to be roasted. The gold is poured into bullion for shipping which ranges 65-80% Au, plus Ag. Overall it is calculated that the Golden Mile at Kalgoorlie had 2500 t total gold, ~88.2 Moz (Weinberg et al., 2004). Well over half of this has now been mined from what continues to be a world-class and progressive operation.

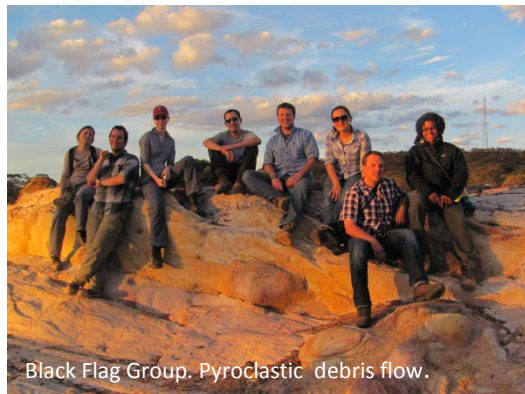
Our tour wrapped up with a view of the Superpit from a public platform on the west side of the mine, and a visit to the core yard. The scale was certainly impressive, and other geologists from Barrick came along to host and answer questions. Pit size is set to increase further by hundreds of meters in all directions, and a large buttress was pointed out which will be taken from surface to the full depth of the pit in coming years. Surface mining is projected to be complete in 2018, with mine life lasting until 2021 as a number of declines are explored from the base of the pit. David had out a number of drill holes for us to view, showing the difficulty in identifying contacts and indeed the units themselves. As a parting gift he hauled out even more buckets of rock, offcuts and slabs from mineralized blocks removed from the pit. These were upended on the tables and left to the merciless pickings of our unending appetite for rock samples.



The group in a giant shovel bucket

## MAY 6 – MOUNT HUNT AND OUTCROP OF THE BOULDER-LEFROY FAULT

(By Alfonso Rodriguez Madrid)



**Tour guides from the Geological Survey of West Australia:**

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### Geological Site visit:

This geology tour was guided by two geologists of the GSWA in the Kambalda domain within the Kalgoorlie terrane. The visit was important since the Kambalda Domain hosts gold deposits at Kalgoorlie and nickel deposits at Kambalda. The SEG group was guided through a traverse from Serpentine Bay on Hannan Lake, across Mount Hunt, to the Goldfields Highway, about 10 km south of Kalgoorlie–Boulder, passing by the Boulder-Lefroy Fault zone (Figure 1). Outcrop here showed a greenstone sequence between 2710 to 2680 Ma. We had the opportunity to see spinifex textures in the Kambalda Komatiite (Figure 2), pillow basalts of the Paringa basalt formation, silicified carbonaceous rocks, and pyroclastic debris of the Black Flag Group.

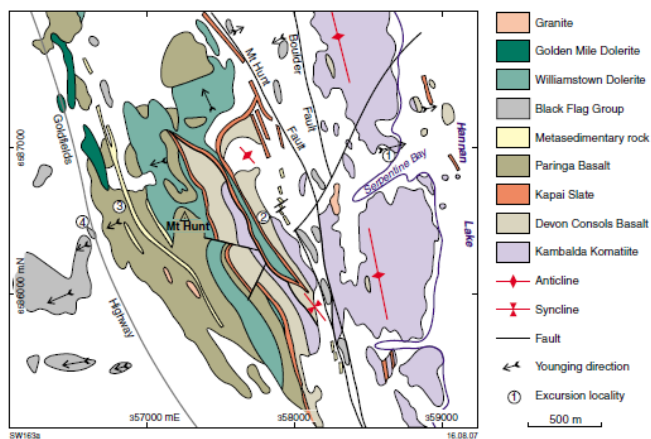


Figure 1. (Left) Outcrop sketch of the Mount Hunt – Hannan Lake area (adapted from Griffin et al., 1983; Keats, 1987) showing sites visited during the geology tour. (Adapted from Wyche, 2007).



Figure 2 (Right). Spinifex texture in the Kambalda Komatiite, Serpentine bay, location 1 on figure 1.

Recommended reference: Wyche, S. 2007. Stratigraphy and structure of the Kalgoorlie Terrane at Hannan Lake and Mount Hunt - a field guide. Geological Survey of Western Australia. Perth, 2007. Found at:

<http://geodocs.doir.wa.gov.au/viewer/multipageViewerAction.do?documentId=137744&viewMarkId=0&ct=true&at=none&btv=true&atv=false&vmtv=false&ac=ff0000&cabinetId=1101&pg=0&scl=64&bds=0|0|2560|3584>

## MAY 7 – ANGLO ASHANTI SUNRISE DAM GOLD MINE

(By Kathryn Lucas)

On Saturday May 7, we left Kalgoorlie and made our way out to AngloGold Ashanti's Sunrise Dam gold mine, near Laverton, WA. Arriving at 1:00 p.m., we were treated to a talk on the geology of the mine by Mike Nugus, the Exploration Manager.

Sunrise Dam is a shear zone hosted deposit in the Laverton Tectonic Zone, located near the eastern edge of the Eastern Goldfields Province. Faults in this area have a dominant NW-SE trend and are dextral transpressional faults. However, almost all of the gold mineralization is concentrated in sites where fluid flow was focused under extensional conditions. The mineralized veins, thus, are thought to be extensional jogs linking predominantly compressional fault arrays. The primary controls on mineralization are: changes in lithofacies, changes in rheological domain, fluid overpressurization and fault-valve failure leading to instantaneous devolatilization of auriferous fluids, and fold axial surfaces and intersections.



Sunrise Dam has produced 7 Moz of gold in total. Mining is carried out by contractors, and ore is treated in a conventional gravity and leach process plant.

After the geology talk we were split into two groups. One group went for a tour underground, while the other group looked at core, mineralized rock samples, and maps of recently drilled areas of the underground operations with Don McDonald, Senior Project Geologist. Sunrise Dam is both an open pit



and an underground operation, and until recently it was mining both. The open pit has reached its final depth and only a north wall cutback was in operation until March 2011. That month, however, the open pit operation ceased due to a rather large translational slide along one of the pit walls immediately following blasting. The underground operation has continued unhindered, while clean-up and geotechnical reassessment of the open pit is conducted. The group looking at core did not get a chance to go underground that afternoon, as blast time was quickly approaching.



Saturday night we were treated to dinner in the camp mess and drinks at the camp pub, where we met Michael Erickson, the General Manager of Sunrise Dam. At the pub, we continued to socialize with Mike Nugus, Don McDonald and other personnel we had met earlier in the day. To our delight, Mike Nugus informed us that the second group would get to go underground the following morning before our departure for Jabiru Metals' Jaguar/Bentley mine. So early Sunday morning, the second half of our group got to visit mineralized intersections in the Dolly and Vogue zones. We greatly appreciate the hospitality shown us by the group at Sunrise Dam and how hard they worked to give everyone the chance to go underground - the only mine on the trip where we had that opportunity.



Don McDonald, Senior Project Geologist, giving explanation about the core



Southern sky at Sunrise Dam Camp

## MAY 8 – JABIRU METALS (INDEPENDANCE GROUP) JAGUAR BASE METAL MINE

(By Esther Bordet)

The Jaguar mine is located along the Goldfields Highway, between Leonora and Leinster. The mine is located along the eastern segment of the Yilgarn Craton, at the eastern margin of the Leonora-Wiluna greenstone belt. The mine comprises the Jaguar, Bentley and Teutonic Bore massive sulphide deposits, hosted in a west dipping sequence of rhyolite, basalt, andesites, and sediments locally intruded by dolerite dykes. This sequence is 2.69 to 2.67 Ga old.

During our visit of the Jaguar mine, our group enjoyed an excellent geological presentation given by Graham Sweetman (Geological Superintendent), together with fresh orange juice and delicious fried calamari and fish. We didn't have a chance to visit the underground workings, because our group was almost as large as the number of people actually working in the mine! Instead, Craig Garrett (Senior Geologist) guided us through the core farm where we could observe four sets of drill hole cores from the Bentley and Jaguar deposits.



The proposed tectonic model for the Jaguar deposit involves voluminous, high-calcalkaline bimodal magmatism associated with VHMS mineralization. The Bentley and Teutonic Bore deposits sit at the contact between the felsic and mafic volcanic rocks, whereas Jaguar is off the contact. No surface expression of these deposits exists, as they are located several hundreds of meters below surface.

At Jaguar, the footwall is characterized by a thick sequence of massive to flow-banded feldspar phyric rhyolite with quartz-sericite alteration, overlain by tholeiitic, pillowed and locally brecciated basalt flows. The mineralized horizon consists of highly permeable tholeiitic to calc-alkaline dacitic breccias, domes and flows and minor sedimentary rocks. The hanging-wall is formed of andesitic lava flows, mudstone and black shales, and flow-banded quartz-rhyolite. Late dolerite intrusions dissect the ore body. Three mineralized lodes are recognized at Jaguar, characterized by pyrite, pyrrhotite, sphalerite, chalcopyrite, galena and magnetite. In addition, a far-side mineralized zone has been newly defined.

Mining of the Teutonic Bore deposit started in 1981. This deposit is now active for exploration only. Production resumed in 2006 at the Jaguar deposit and 1,240,000 t of ore were milled so far. The Jaguar project has three more years of reserve. The Bentley project has only been active for the past year.

## MAY 9 – BHP BILLITON MOUNT KEITH MINE

(By Leif Bailey)

On May 9 we visited BHP Billiton's Mt. Keith nickel mine and mill, located 80 km north of Leinster. During our visit we were guided primarily by mine engineer Sean Church, with assistance from several other BHP Billiton employees.

Our visit began with a safety induction and a welcome from Stuart, the mine manager. Sean Church then presented an overview of Mt. Keith mining operations. The Mt. Keith ore body is hosted in the



Overview of the southern pit from the south

central part of an olivine cumulate intrusion with interstitial chromite and sulfides. The ore body is steeply-dipping, 300 m thick, approximately 3.5 km long, with an average grade of 0.5% nickel. The deposit is mined as a single large open pit, which is currently 1.5 km wide, 2.8 km long, and 520 m deep. The mine is currently undergoing a large cutback to increase the length of the pit to 3.5 km, and the current strip ratio is 6:1. Projections for 2011 are to mine 21.3 million bank cubic meters (cubic meters prior to blasting) of rock; 11.5 million tons of which will be sent to the concentrator to produce 40 kilotons of nickel concentrate. The concentrate is transported by road and rail to a nearby smelter. From the smelter, the final product is transported to the coast for shipping. Much of the final product is shipped to ports in Asia.

In addition to the ongoing open-pit cutback, BHP Billiton is currently upgrading their milling facility to better handle talc-bearing ores. Talc is a problematic component in some of the ore types currently being mined. To alleviate this problem, BHP Billiton has developed technology for processing talc-bearing ores, and invested 160 million dollars to upgrade the Mt. Keith milling facility. Although our guides did not provide many details on this proprietary technology, they seemed confident that this upgrade would greatly improve the mine's ability to process talc-bearing ores. Mt. Keith has a current minimum mine life of 12 years. If the upgrade to handle talc-bearing ores is successful, this mine life could be extended up to 40 years.

Sean Church's presentation highlighted two significant challenges faced at Mt. Keith: mining competitively and retaining employees. Mt. Keith's low grade reserve makes competition for financing difficult compared to other higher-grade Kambalda-type nickel deposits in Western Australia. Mt. Keith was able to remain open during the 2008 global financial crisis, but only by reducing their fleet of trucks and shovels by half. To be competitive, the mine must operate efficiently and without lost-time accidents. As seen at many mines during our trip, employee turnover is high at Mt. Keith, and the mine endeavours to provide competitive benefits and bonuses to employees.



After the mining presentations, our group visited two pit overlooks and visited the core yard. The ultramafic rocks being mined at Mt. Keith necessitate less-steep pit walls, with the upper part of the pit sloping 45 degrees, and the deeper parts sloping 60 degrees. The overlooks provided an excellent opportunity to observe the ongoing mining operations and to observe the steeply dipping geology. At the core yard we had the opportunity to look at relatively high-grade intersections through the main cumulate ore body, as well as the opportunity to look at recent exploration drill core from the nearby Cliffs deposit. Cliffs higher grade deposit located ~8 km south of Mt. Keith, and is currently being mined underground. The Cliffs deposit better fits the classic model of Kambalda-type nickel deposits, and is thought to be the extrusive equivalent of Mt. Keith. Highlights from the core yard included the observation of stichtite, a hydrated magnesium chromium carbonate mineral, which is believed to replace chromite. The bright pink stichtite was easily spotted in drill core. At Mt. Keith, this mineral is apparently associated with low-grade or barren zones within the ore body, providing a good visual tool for estimating grade.



Overview of the southern pit from the west wall

## MAY 10 – KALBARRI

(By Leif Bailey)

On May 10th our group left from Mount Magnet and traveled to Kalbarri National Park. The park consists of a plateau of grass and small trees, and marks the transition from the dry outback to the relatively wet coastal environment. The Murchison River cuts a spectacular 80 km long gorge through the park. The river gorge has many scenic viewpoints, and the rocks preserve excellent sedimentary geologic features.

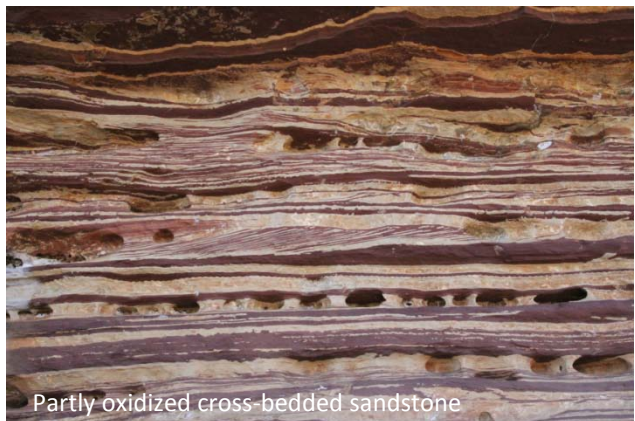


View of the Kalbarri National Park

While in the park we waded in the Murchison River, visited several viewpoints, and did a short hike to see a rock feature called Nature's Window. Driving through the park was also a bit of safari- we saw kangaroos, emu, wallabies, and a variety of birds. The day was warm and sunny, and it was great to see running water again after ten days in the bush.



Murchison River



Partly oxidized cross-bedded sandstone

After enjoying the park we did one more short section of driving to the town of Kalbarri. Kalbarri is a small, sleepy beach-side town, except when the town is overrun by visitors on a holiday weekend. We were fortunate to be there when the town was quiet, and we had the beaches mostly to ourselves. We watched an excellent sunset over the Indian Ocean, and had the first of what would be many barbecues over the next several days.



## MAY 11 – SHARK BAY

(By Esther Bordet)

On May 11, we visited the Shark Bay World Heritage area, located about 800 km north of Perth along the coast. At Hamelin Pool, we had the chance to observe the most diverse and abundant examples of living stromatolites in the world.



Hamelin Pool



Observation deck at Hamelin Pool

The shallow waters of Hamelin Pool evaporate quickly and create a super-salty environment favourable to the development of cyanobacteria. Cyanobacteria appeared on earth about 3.8 Ga ago, and are able to synthesize oxygen by photosynthesis. They are probably responsible for massive oxidation of iron dissolved in the oceans at about 3.5 Ga, followed by saturation of marine water in oxygen, and finally progressive oxygenation of the earth atmosphere. Therefore, these organisms played a critical role for the evolution of life on earth. Stromatolites are layered limestone rock built by single-celled cyanobacteria which trap and bind sediments. Some build craggy towers, others build flat spongy mats.



Tower-shaped stromatolites



Spongy-mat-shaped stromatolites

After our visit of Shark Bay, we drove further north to Denham. There, we had the opportunity to swim in the salty water of the bay. No sharks were seen. Later on at the Bay Lodge, Brendan improved his practice at one of the Australian national sporting venues: the barbecue.



Brendan cooking



## MAY 12 – MONKEY MIA

(By Alfonso Rodriguez Madrid)

Monkey Mia Reserve at Shark Bay is also called the 'house of the dolphins'. The museum of Monkey Mia taught us about marine life, especially the dolphins but also sharks, dugongs, manta ray, and different types of fishes. There were also explanations about the culture of Malgana and Nhanda aboriginal people who lived for thousands of years at Gadhaagudu (Shark Bay). The visit to Monkey Mia gave the group the opportunity to see a beautiful view of the Indian Ocean in the morning. We met a not so grumpy pelican, a turtle, and friendly dolphins, one of them being a survivor of a fight with a shark. People interacted with the dolphins and Peter even had the opportunity to feed one of them. It was an unforgettable experience for all of us.



People interacting with dolphins (Left). Shark Fight survivor (middle). Peter was chosen one to feed them!!! (right)

## MAY 13 – JURIEN BAY AND THE PINNACLES

(By Chris Fozard)

Clear skies and an extra hour before departure led to a number of solo dips in rolling ocean water as the SEG group awoke in Jurien Bay, north of Perth. Meat pies and apples rings were had with another steaming mug of powdered coffee at the caravan park. Our first stop was at Pinnacles National Park, where we viewed a curious geological formation of sandy spires (see pictures below). The visitor's centre gave us the skinny on various geological interpretations, and a good look at the desert fauna; bobtail skink and the honey possum to name a few. The odd towers were examined on our walk through, and all manner of geological fantasy entertained. There were emu sightings and kangaroo tracks along the way.



A proper lunch stop was required after too many gas station lunches and hurried meals. We found a marvellous pub in Lancelin on the coast and everyone sat outside in the salty air. Leif and Esther used the adjacent ocean, and Brendan settled on a nearby island to purchase immediately for fort development. The food was great and we hit the road again refreshed and ready for the open highway.

Rush hour through Perth lived up to its name, as if the city were asserting itself beyond the sometimes sleepy feel and relative isolation. After crawling south along the #2 we were released and on to Bunbury, arriving after dark for the only time during the trip. The downtown area was close to the motel, so many people headed in for a few hours of dinner and drinks. The beach also beckoned just across the road with constant wash and booming waves. When we were filled with Thai food and Aussie specials, we congregated at the Irish pub, the only establishment that would welcome our sandal clad feet. We took our leave after the partygoers and hooligans dissipated, heading back to camp where the boys trickled onto the beach. A night of revelations and wisdom ensued sip by sip, culminating in new monikers for everyone and the formation of a band. The music is still playing.



## MAY 14 – TALISON LITHIUM GREENBUSHES MINE

(By Jessica Norris)

The Greenbushes Mine, owned by Talison Lithium, is a rare-metal zoned pegmatite and associated mineralization which has been mined since the late 1880's. Upon arrival at the Greenbushes Mine site, adjacent to the town of Greenbushes, Western Australia, our group was met by Senior Geologist Clark Ward and Assistant Geologist Patricia Martin, who kindly came into work on their days off to give us a tour. We were treated to tea and biscuits prior to a presentation on the history, geology and production of the Greenbushes Mine.



Overview of the pit at Greenbushes mine

Historically mined for tin in alluvial channels between 1888 and 1969, production moved to tantalum in the 1990's. In 2007, the current owner Talison Minerals took over the mine and is currently mining Lithium in the form of spodumene, a lithium-bearing pyroxene mineral ( $\text{LiAlSi}_2\text{O}_6$ ). While tin is a by-product from current mining, lithium is the main focus of the mine. Lithium from the Greenbushes mine is sold to the chemical and ceramic markets which use the lithium for batteries, ceramics, glass, pharmaceuticals, lubricants and refrigeration purposes. Lithium improves the forming properties of materials, reduces viscosity, and increases strength. At Greenbushes, pure spodumene is white in colour, is a pink colour if it contains any magnesium (Mg) to be called kunzite, or may be green due to the presence of iron (Fe), called heddenite.



Looking for Tourmaline crystals

The Greenbushes pegmatite is ~2.5-2.3 billion years old, and strikes north-northwest, dipping 30-70°. Granofels occurs in the footwall of the pegmatite and amphibolite in the hangingwall. Dolerite intrusions of 1100 million years in age cross-cut the pegmatite. Greenbushes is the largest known pegmatite, but yet does not exhibit traditional pegmatite characteristics. There is no granitic host to the pegmatite, nor is there a quartz core. Greenbushes is not symmetrically zoned and there is interfingering between the Li-rich and Ta-rich zones. There are five major mineral zones at Greenbushes. The contact zone contains quartz, albite, muscovite and tourmaline. The K-Feldspar zone contains quartz, microcline, perthite and muscovite. The albite zone contains quartz, albite, muscovite, tourmaline and apatite. The mixed zone contains quartz, albite, k-feldspar, spodumene, tourmaline, mica and apatite. The lithium zone contains quartz, spodumene, muscovite, albite, microcline and perthite. Commonly there is a central lithium zone with a K-feldspar zone towards the hanging-wall and a number of albite zones on the hanging-wall and footwall proximal to the host rocks or in central zones adjacent to xenoliths.



The Greenbushes Mine consists of four open pits, the first and deepest being the Cornwall Pit. Other pits are the C1, C2 and C3 pits of the central lode. Current production of the mine is 600,000 tpa of ore. Greenbushes produces 50-60% of the world's supply of lithia (Li<sub>2</sub>O). A current resource estimate of 70.4 million tonnes of Li<sub>2</sub>O at 2.6% Li and a reserve of 31 Million tonnes of Li<sub>2</sub>O at 3.1% Li allow for a predicted 20 year mine life remaining at Greenbushes. A mill on site processes the spodumene by gravity and magnetic separation whereby concentrate is shipped by road-train to the nearby port of Bunbury. Tantalite is currently being stockpiled, as the tantalum resource is owned by a separate company, Global Advanced Minerals.

Following lunch, our group was shown the Cornwall pit and the C1 pit, where we are allowed to collect mineral and rock samples. As Greenbushes is a pegmatite mine, we were able to collect samples of megacrystic tourmaline, muscovite and spodumene. Deep blue apatite and trace amounts of beryl were observed in some samples of the pegmatite.



## MAY 15 – WINE TASTING AT MARGARET RIVER

(By Jessica Norris)

Margaret River is world renowned wine region in south-western Australia. Our group ate dinner at the Settler's Tavern on the evening of Saturday May 14th, 2011 and were able to sample some of the wines the region has to offer. On the morning of Sunday May 15th, 2011, our group visited Yallingup, Western Australia on the south-western coast, about 40 minutes north of Margaret River. Yallingup is a well known surf spot and a marvellous beach with crashing waves and stunning scenery. Several of the group participants braved the surf and thoroughly enjoyed the water at Yallingup.



We then proceeded to the Swings and Roundabouts Winery just south of Yallingup for a wine tasting and lunch. The staff at the winery treated us to a wonderful tasting of several of their locally grown and produced wines. There are three different labels of wine that the Swings and Roundabouts winery produces, including Kiss Chasey, Swings and Roundabouts and the Backyard series. After a delightful wine tasting a mini-lesson on the use of egg-whites and fish products in wines, we had a wonderful lunch of pizza made in a wood-fire oven in addition to other delectable treats. After lunch we enjoyed the lush grounds of the winery which are open to customers and their families to enjoy and play a variety of backyard games. A selection of our group took this chance to play Frisbee! We then said our goodbyes to the beautiful Margaret River region and headed north and east to our next mine visit in Boddington.



## MAY 16 – BODDINGTON GOLD MINE

(By Santiago Vaca)



The South pit at Newmont's Boddington operation May, 2011 (Photo by Alfonso Rodriguez)

The group arrived at the town of Boddington in the late afternoon of May 15th, where accommodation and dinner at the Boddington Hotel had been organized. The following day, we were ready for our final mine tour, visiting the Boddington Gold Mine (BGM), a Au-Cu open pit operation (re-opened in 2009), 100% owned by Newmont Mining Corporation and representing Australia's largest gold producer. The mine is located about 16 km from the Boddington town centre and 130 km south southeast of Perth.

After crossing the security gates and watching the visitor's induction video, Graeme Reynold (Geology Superintendent), Bryan Bowden (Senior Exploration Geologist) and Daniella DePretis (Resource Development Geologist) drove us to the south pit operation's lookout for a geological overview of the deposit. Afterwards, a tour through the processing facilities took place and finally Newmont's staff gave us informative presentations about the geology and processing of the BGM.

Graeme Reynold and Bryan Bowden told us about the deposit's history. Back in 1976, the Saddleback Greenstone Belt (ca. 2700 Ma) was discovered, and was followed by the identification of gold anomalies in surface laterites. The BGM is hosted in Archean volcanic, volcanoclastic and shallow level intrusive rocks that form the northern part of the belt, located in the southwestern corner of the Yilgarn craton, representing a structural-controlled Au-Cu deposit, for which three different genetic models have been proposed: (1) A deformed and metamorphosed porphyry deposit; (2) A post-peak-metamorphism, shear-zone hosted deposit, and (3) An intrusion related Au-Cu deposit. Despite these models, the origin of the BGM mineralization is still enigmatic. The main zone of gold mineralization occurs continuously over a strike length of more than 4 km (N-S), ~1 km wide and in places reaching 1 km deep, with mining in two massive pits. Supergene and hypogene mineralization are present with an average grade of 0.8 g/t Au and 0.1% Cu. The mineralization consists of two different mineral assemblages, the major one related to clinozoisite and actinolite veins, and a minor one to quartz-biotite veins. Gold is associated with chalcopyrite, pyrrhotite and molybdenite, high uranium content





has been found associated with the latter. Current reserves at BGM are 29 Moz Au + 1300 kt Cu. If new exploration targets are added, the life of mine is expected to be 40 years.

Julian Hurst (Engineer), Kara Watson (Metallurgist) and Erin Marriot (Ore control geologist) explained the mining and ore treatment processes. This big scale operation is mined with an average stripping ratio of 1.7:1. 220-ton haul trucks are loaded with blasted material using big shovels at the pits, the material is hauled to the primary crusher (<150 mm size), an overland conveyor transports the crushed ore by 2.2 km to the processing plant. The ore drops from a 45 m high conveyor onto the stock pile and then it goes to the secondary crusher (<50 mm size), after that, the ore falls into the high pressure grinding rolls (first in the world) (<12 mm size), and finally, four ball mills (8 m in diameter) powder the ore. In this stage, recycled water is added to produce a slurry, which is sent to the flotation plant, here 100,000 tons of ore are processed daily. The flotation concentrate (100 ppm Au and 16% Cu) is stored prior to be sent to the Bunbury Port for smelting and commercialization overseas. The waste slurry moves from the flotation cells to tanks, where gold is extracted by being absorbed into carbon and subsequently melted in a furnace for producing gold bullions on site.

Following the presentations, the Newmont's geology team led us to the core shack, where Glenn Pickens (Project resource development geologist) and Dhammika Perera (Senior resource development geologist) explained and showed us the different types and zones of mineralization and alteration in core. Also, Matt Gordon guided us through the core cutting facility which is a state-of-the-art technology.

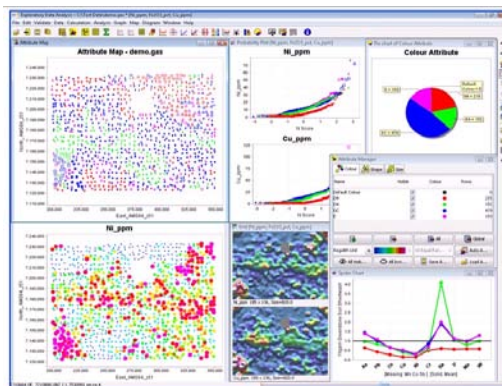


Gibbsite-rich Bauxite from Boddington

Another interesting aspect about the geology in the Boddington area, pointed out by Graeme Reynold, is the presence of a gigantic gibbsite-rich bauxite (grading ~30% Aluminum) deposit, owned by BHP Billiton, containing a mineable resource for more than 200 years, being a highly economic project.

After a warm thanks to the Newmont's team for their hospitality, and a special gratitude to Stephanie Cornish (Business assistant to general manager operations) who was the primary contact prior to our visit, we headed to Fremantle to visit the ioGlobal office.

In Fremantle we were hosted by Rob Wall and James Pinakis of ioAnalytics (the ioGAS development branch of ioGlobal), who cordially offer us some snacks and cold drinks. Then, Rob gave us a presentation about the features and benefits of the ioGAS software. This versatile and friendly software is a powerful tool to work with geochemical data sets, which permits to generate a wide variety of diagrams and maps used for geoscientist and economic geologist to aid in an appropriate data interpretation.



Some plots generated in ioGAS software from [www.ioglobal.net](http://www.ioglobal.net)

Afterwards, Rob and James invited us for a dinner at the famous Little Creatures Brewery, where we spent a wonderful time tasting its delicious food and drinks, after which we had to say good-bye to ioGlobal and the amazing Western Australia. We flew back home on May 16th at 11:00 pm from Perth's airport.



UBC-SEG and ioGLOBAL Dinner at Little Creatures Brewery in Fremantle.

