



# Natural Resource

February 2019 | Edition 2 | 21<sup>ST</sup> Year of Publication



**Mijnbouwkundige Vereniging**  
Study Association Applied Earth Sciences



Dear Readers,

Now that the christmas break is over it is time for the second Natural Resource of the year. We, as the editorial board, made a new year's resolution to provide you with some new articles.

This means that in this edition you will find some new items, including mining anecdotes from our valued contributor, Koenraad Weber, a story from alumnus Douglas Gilding about the time during his bachelor years and the 'making of' the true story of Barbara according to Leendert-Jan Ursem. Hadi Hajibeygi will explain to us how to win a teaching award and the new interdisciplinary project will be thoroughly explained by the expert by experience, Danielle Bode. Finally, choosing a master track is a quite important decision, and, therefore, we decided to publish an overview of the master tracks, spread out over this and our future editions. This edition will be about Geoscience and Remote Sensing, with interviews of both the coordinator Sandra Verhagen and a second year student following this program Mark Bemelmans.

Because we, and we hope you too, are always curious about the experiences of our fellow students, we included an interview with our very own secretary Jeanne Steijn. Furthermore, Gertjan Postema will share his story about the skiing trip and Lauran de Jong will tell us everything about his time on International Student Week in Trondheim. To make sure you don't miss out on the experiences of our cosmopolitans Jaap van Duijn and Emma Zomer, they have written letters for us as well.

Of course this second edition wouldn't be complete without the Weber puzzle, and the graduation projects by Thijs Hanemaaijer and Rutger van Limborgh, MV- and science news.

To conclude, some of our critical readers, noticed some mistakes we made in the previous edition. First of all, the Maarten Schroot in de Gracht Penning, should of course be, Maarten Schoot in de Gracht Penning and secondly the tankers from the Weber puzzle were not limited to famous tankers, but also included infamous tankers.

With a warm and sincere Glück Auf,

Daniël Ernste  
*President of the Natural Resource Committee*





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*D*ear Readers,

As I'm writing this presidential, the new year has just started. After 2 weeks of Christmas holidays, students have found their way to the faculty again to prepare themselves for the February exam period. For us as the board, this also means a period with less events again. However, the fact that all students are starting to get nervous for the exams means the MV room is getting more and more crowded with students taking a coffee break, so we won't have to be afraid of getting bored. Also the fact that it's the second exam period already, means that we, as the board, are almost halfway in our year. It feels like the past half year has flown by really quickly. But hey, time flies when you're having fun, they say, right?

Since the previous issue of this magazine, we have experienced two very successful Barbaradrinks. First of all the Barbaraspeech by Leendert-Jan Ursem, during which he took the stage in het Noorden and told all the present miners about the true story of Barbara. The talk was very enjoyable and it was followed by a nice dinner at La Tasca in the city centre of Delft.

A month later, at the Barbaradrinks of January, in the new year, the attendance of alumni was high again. This, of course, makes us as the board very happy, because it shows us that alumni are still involved with the MV. During this evening, which was themed as the 'geëmancipeerde Barbaraborrel', Stephanie Lier was invited to give a speech about her experiences as a woman in the mining world. This speech was a great success as well.

Apart from these great evenings, there were a lot of other events to be enjoyed. At the beginning of December, Company Days took place again. Several companies visited our faculty to give our students a presentation about what they do. After this, it was almost Christmas time, which, of course, means time for the Christmas drinks at the faculty. Then, after Christmas, seventeen miners left to France to experience the MV skiing trip. Apart from skiing, this week included après-skiing and partying as well. It is said that Risoul is still recovering from the presence of the miners.

And so, after this week of skiing, our weekly routine as the board has started again in 2019. On behalf of the 127<sup>th</sup> board, I wish everybody a happy 2019 and I would like to conclude with a firm and harmonious,

Glück Auf!

Krijn van Alphen  
*President of the Mijnbouwkundige Vereniging*



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## A massive crater hides beneath Greenland's ice

November 14, 2018

There's something big lurking beneath Greenland's ice. Using airborne ice-penetrating radar, scientists have discovered a 31-kilometer-wide crater — larger than the city of Paris — buried under as much as 930 meters of ice in northwest Greenland. The meteorite that slammed into Earth and formed the pit would have been about 1.5 kilometers across, researchers say. That's large enough to have caused significant environmental damage across the Northern Hemisphere, a team led by glaciologist Kurt Kjær of the University of Copenhagen reports November 14 in *Science Advances*.

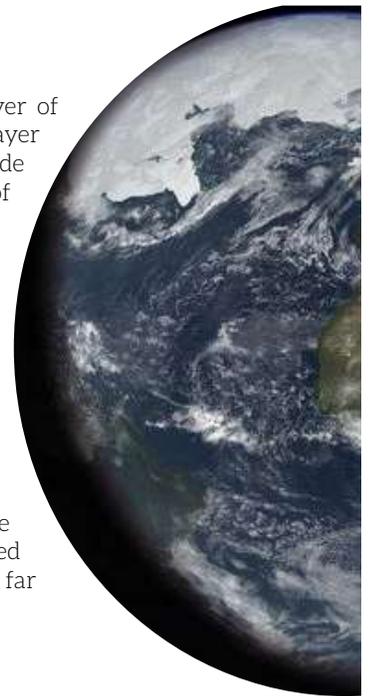
<https://www.sciencenews.org/article/impact-crater-greenland-asteroid-younger-dryas>

## Earth's magnetic field measured using artificial stars at 90 kilometers altitude

November 15, 2018

The mesosphere, at heights between 85 and 100 kilometers above the Earth's surface, contains a layer of atomic sodium. Astronomers use laser beams to create artificial stars, or laser guide stars (LGS), in this layer for improving the quality of astronomical observations. In 2011, researchers proposed that artificial guide stars could also be used to measure the Earth's magnetic field in the mesosphere. An international group of scientists has recently managed to do this with a high degree of precision. The technique may also help to identify magnetic structures in the solid Earth's lithosphere, to monitor space weather, and to measure electrical currents in the part of the atmosphere called ionosphere.

<https://phys.org/news/2018-11-earth-magnetic-field-artificial-stars.html>



## 'True polar wander' may have caused ice age

November 19, 2018

Earth's latest ice age may have been caused by changes deep inside the planet. Based on evidence from the Pacific Ocean, including the position of the Hawaiian Islands, Rice University geophysicists have determined Earth shifted relative to its spin axis within the past 12 million years, which caused Greenland to move far enough toward the north pole to kick off the ice age that began about 3.2 million years ago.

<https://phys.org/news/2018-11-true-polar-ice-age.html>



## China's fight against smog makes palladium 2018's best metal

November 16, 2018

Palladium prices are shattering record highs, and investors are betting that tight supplies mean the bull run is just getting started. The metal, used in pollution-control devices in cars, has jumped almost 9 percent this year in New York, the best performance among major metals. Demand is roaring thanks to China, which is on a mission to reduce smog emissions. Tougher pollution standards mean carmakers are using more of the commodity in catalytic converters.

<https://www.bloomberg.com/news/articles/2018-11-16/china-s-fight-against-smog-makes-palladium-2018-s-best-metal>



## Copper output to spike in world's top producer Chile

November 19, 2018

Copper output in Chile, the world's top producer of the metal, is expected to increase 2% by the end of the year and continue to grow steadily during 2019 due to stronger performance from major mines, upgrades to existing operations, and lower risk of labour strikes. According to the latest report by Fitch Solutions Macro Research, the main possible obstacle to the forecast production growth in Chile is the fact that grades continue to fall. Mining companies operating in the country have seen production costs rise as they need to dig deeper and process larger amounts of rock to obtain the same amount of copper they used to a decade ago. "Mines who saw production decreases over recent quarters cited declining ore grades as one of the main contributing factors," the report says. "This issue presents an attractive opportunity for miners to invest in new technology or upgrade equipment to improve operational efficiency," Fitch notes.



<http://www.mining.com/copper-output-spike-worlds-top-producer-chile/>

## Permian best place to be in shale oil business

November 7, 2018

The Permian Basin continues to be the best place to be in the shale oil business. That's according to Timothy L. Dove, president and CEO of Pioneer Natural Resources, who made the statement in the company's third quarter results announcement. In a comment published on Pioneer's website, Dove said the Permian provides "unmatched" resource potential and opportunity and delivers "highly productive wells, strong cash margins and robust returns". "We see this in our financial results as our return on capital employed is expected to be greater than 10 percent for 2018, benefiting from a low cost basis in our Permian Basin acreage," Dove added. Pioneer produced 288,000 barrels of oil equivalent per day (boepd) in the Permian Basin in the third quarter (3Q), which was an increase of five percent compared to the second quarter. 3Q Permian Basin production was at the top end of Pioneer's production guidance range of 278,000 to 288,000 boepd.

[https://www.rigzone.com/news/permian\\_best\\_place\\_to\\_be\\_in\\_shale\\_oil\\_business-07-nov-2018-157417-article/](https://www.rigzone.com/news/permian_best_place_to_be_in_shale_oil_business-07-nov-2018-157417-article/)

## Scientists theorize new origin story for Earth's water

November 7, 2018

Earth's water may have originated from both asteroidal material and gas left over from the formation of the Sun, according to new research. The new finding could give scientists important insights about the development of other planets and their potential to support life.

<https://www.sciencedaily.com/releases/2018/11/181107130306.htm>





## Yeardrinks

November 14, 2018

On the 14th of November all years gathered to show who can drink the best. Whilst the men of 2015 showed the Freshmen how to drink most per head, 2018 managed to win the true price in drinking most beers in total!



## Bachelor Ceremony

November 16, 2018

The past months, over 60 students finished their Bachelor programme in Applied Earth Sciences and thereby many of them received their diploma during the Bachelor ceremony on the 16th of November. This festive afternoon started with all students presenting their Bachelor thesis and a large applause for everyone's achievements. Afterwards, drinks were hosted by the MV at the faculty and students got to meet up with each other's family and friends. Congratulations to all!

## Tikibad Trip

November 22, 2018

On the 22nd of November the yearly Tikibad trip took place. On this little adventure the board and "het Zwemmesgilde" go to het Tikibad with the freshmen. As every year the trip ends with a few drinks in "De Kluis" in The Hague.



## Committee Drinks

November 28, 2018

On the 28th of november the committee drinks took place. Here all the committee members were thanked for their involvement with a pizza and some free beers followed by a pub quiz.



## Sinterklaas in het Noorden

December 5, 2018

On 5th of December, Sinterklaas and black Piet came to het Noorden. They first had some drinks in our basement before giving some pepernoten to all the well-behaving miners, while all the bad miners got a little rhyme.

## Schacht Date Dinner

*December 13, 2018*

This year, the first Schacht date dinner has been organized with great success. It resulted in a romantic evening in our very own romantic café and after drinking some wine and enjoying a fine dinner, the evening ended in the Ciccio.



## Company Days

*December 3 - 13, 2018*

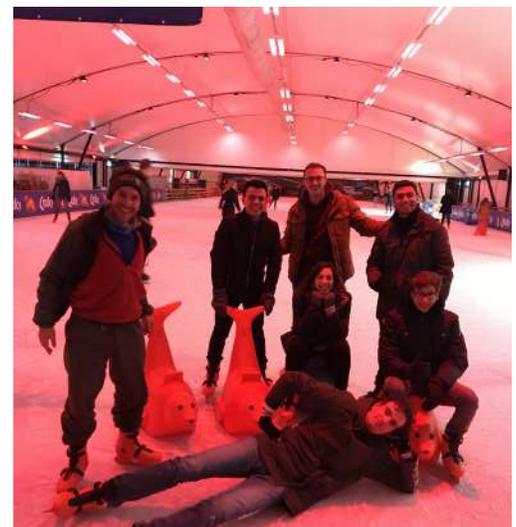
The yearly company days are quite important for the Mijnbouwkundige Vereniging, since it allows the students to develop an idea about their future careers. Likewise it gives companies the opportunity to expose themselves to a great number of potential future employees. This year the acquisition committee was founded to help the president with this event and they brought in thirteen leading companies related to our field.



## Christmas Drinks

*December 18, 2018*

On 18th of December, all the students and staff of the faculty were invited for some Glühwein to get the Christmas vibe going and celebrate the end of the beautiful and successful year.



## Ice-skating Trip

*January 8, 2019*

On this very nice day, the master students and the PhD candidates went on an amazing ice-skating trip. It was very funny to see everyone having a hard time keeping balance on the ice. This sporty event was followed by a nice and warm dinner.



**A**s secretary of the MV Jeanne's favourite habit, of course, has become sending letters. When she is not sending letters she is typing emails or welcoming people in the MV with a captivating smile. Also, once in a while you can hear her scream 'Glück Auf!' when picking up the phone. Classic secretary. However Jeanne also lacks some skills. Opening up a package of smeerkaas properly has turned out to be quite challenging for her. So is drinking more than 2 beers without getting drunk.



# MEET JEANNE STEIJN, THE 127<sup>TH</sup> MV SECRETARY

## On a cold and rainy Wednesday evening Jeanne followed Daniel, Katarina and Jolijn from the NRC to the most illustrious place in Delft; The basement of our favorite café, 'Het Noorden'.

### Let's take a look what happened:

*Katarina:* Introduce yourself.

*Jeanne:* So, I'm Jeanne, 22 years old and I am a 4th year Applied Earth Sciences student. I'm originally from Goes, but I moved to Delft after I joined student association Virgiel during my first year here. Besides my studies I like to play tennis, travel and I am into visual arts.

*Jolijn:* What inspired you to study Applied Earth Sciences?

*Jeanne:* I initially wanted to go to Art School but one time during holidays I realized I was really into geology. Social geography came to my mind but I ended up in Delft after my cousin took me to an open day here at the TU.

*Katarina:* You went to Australia for your minor, right? What was your favorite experience from there?

*Jeanne:* Yes, I did my minor in Sydney, Australia! I took courses in Oceanography that included many fieldtrips to the beaches in Sydney, so Monday mornings weren't that bad there! One cool experience was when I travelled to Tasmania. We were wearing shorts because it was pretty warm, but after a two-hour drive we ended up in the snow! This made me and my friends climb the snowy mountain in our summer clothes.

### After a few beers everyone got excited and the little interrogation continued.

*Katarina:* How was your time with NRC and as a reporter in general?

*Jeanne:* I really liked my time as NRC since we got to make a magazine all by ourselves and we got in touch with different kinds of people in order to get fun articles. We, for example, took interviews with laboratory staff

from our faculty and they had lots of interesting stories. That is also the reason I wanted to QQ the NRC this year!

*Daniel:* Which other committees did you do apart from NRC?

*Jeanne:* Before the NRC, I was part of the Annual Party Committee. When I was a freshman, we organized a party for students with a group of first and second year students.

### And now about her most important role.

*Jeanne continues:* I'm currently the secretary of the MV, which is something I really enjoy. I get in touch with lots of people everyday and it's great fun working together with the rest of my board!

*Daniel:* Why did you choose to be the secretary?

*Jeanne:* I thought the role of secretary suited me best because I like getting in touch with different people on a daily basis. This makes up for a good combination of the serious work and being the first person to contact when people have a question of any kind.

*Jolijn:* What was the weirdest email you have ever gotten?

*Jeanne:* I once got an email from Gezelschap Leeghwater in which they asked me if they could join our guild Die Elefant, because they are really into elephants. They weren't so happy when they got rejected.

*Daniel:* What has been your best experience so far as a member of the board?

*Jeanne:* I think the first weeks of our year were the craziest ones but also the most fun ones. We got to know a

new group of freshmen and showed them all the MV has to offer during the Freshmen weekend and the OWee. It's great to see how they went from complete strangers to each other to such a nice group of freshmen that say Glück Auf to me all the time!

*Katarina:* If you could send each of your board members to a country what country would that be?

*Jeanne:* I think I would obviously send Tim to Russia because of its large size, and Freek to the far-end North Groningen, because he feels most at home there on top of the Groningen gas field. Eva would probably go to our board holiday destination Dubai, because it'd be a good destination to do what she likes most: shopping, partying and tanning at the beach. Krijn would probably stay at a beach in Thailand with a beer and chill out all day, just like he does this year!

*Jolijn:* If each board member could be a dessert what would they be?

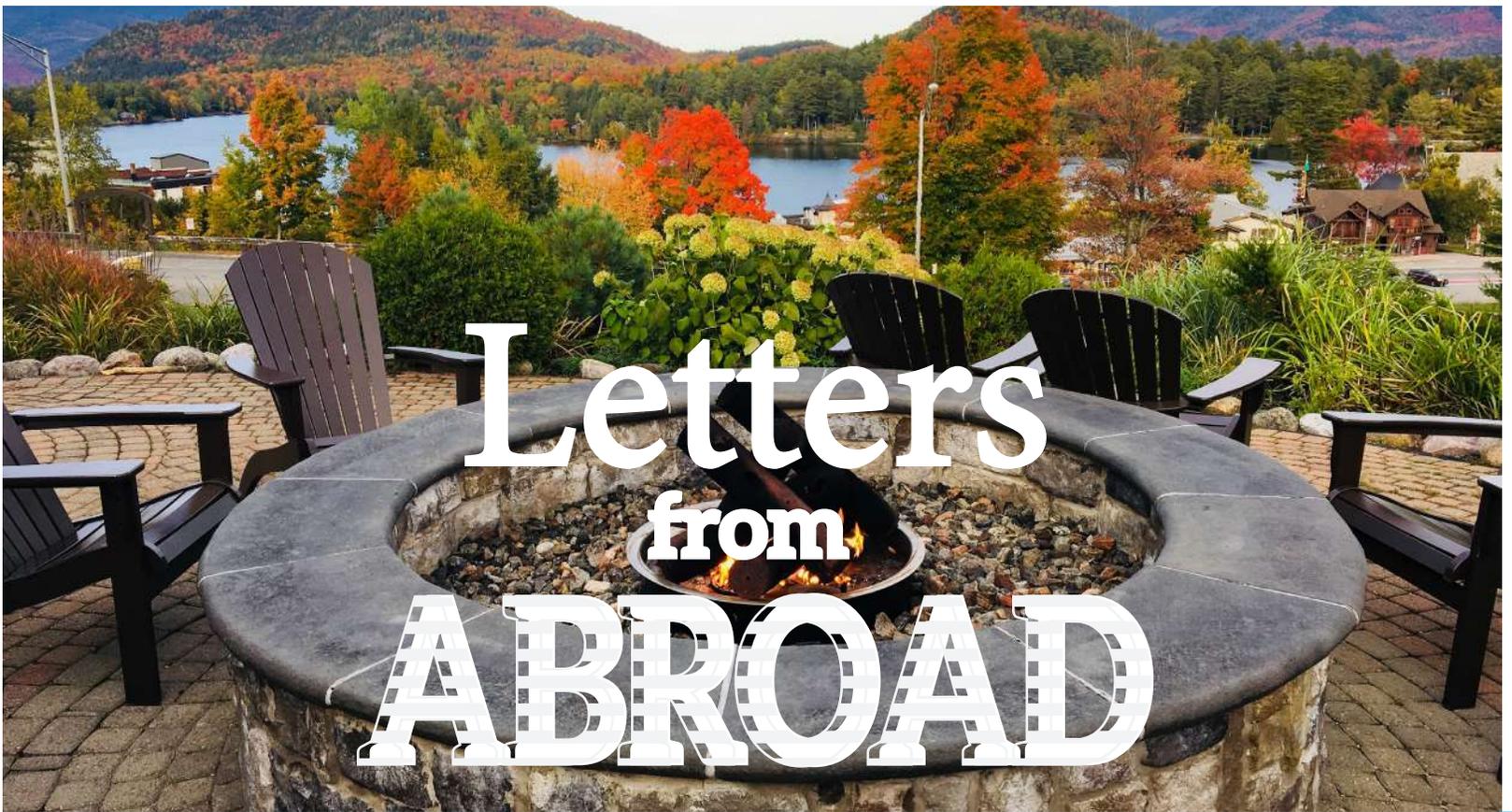
*Jeanne:* Well, I think Tim would be like the dessert buffet since he can eat most, whereas Krijn would only be a single Chupa Chup lolly because that's his favorite hungover dish. Freek is making the best cheese platters this year so he would totally be one and Eva would be a monchou cake because she is the cherry to my pie!

*Katarina:* And what would you be?

*Jeanne:* I think I would be a pear cake since my dad grows pears himself!

### The interview came to an end with the NRC knowing the deepest secrets of our secretary while she kept on dreaming about cherries and pies.





# Letters from ABROAD

## Letter from Emma

By E. ZOMER

**A**fter my bachelor in Applied Earth Sciences I started my master degree at EWU faculty in Sustainable Energy Technologies and this year I started my second master year. Part of that is doing 15 EC of electives, so I choose to do them at Clarkson University in the US, since studying there has always been a dream of mine. Clarkson University is located in Potsdam, upstate New York. It is a small country town close to the Canadian border and about 7 hour drive away from New York City. Clarkson has around 4500 students and is a private university.

Although I am not officially doing an Applied Earth Sciences master degree, my electives here still have a lot of overlap with one of our programs. My electives are in the field of Environmental Engineering and the course package contains the following courses: Industrial Ecology, Environmental Chemistry, and Environmental Policy.

In the course Industrial Ecology we learn to design industries in such a way that they function as a closed loop system. Hence, striving to an industrial system with as less waste as possible, and with efficient use of all resources, while staying economically viable. The course offers a nice mixture of social, technical and economic aspects and is very relevant to the changing energy sector. The course Environmental Chemistry goes a bit more into detail on the environmental impact side of industry, i.e. what is the impact of pollutants on our environment, which chemical equilibria are disturbed and what could be an effect of such disturbances. Environmental Policy, on the other hand, teaches everything you need to know about designing policies in the US and this is by far the course from which I learned the most. Not only does it give me insight about how an environmental policy is made, it also gives me a lot of background information about how the US government functions and how they deal with the public opinion about climate change. The state New York is, as we would say, pretty modern and progressive in their way of looking at the environment. The educational system here is very different from what I

am used to at TU Delft. Your grade depends on a lot of things, and, therefore, you have to deal with a lot of deadlines. An average course grade will be a combination of grades from your attendance, your weekly homework, a semester project and two or more exams. Therefore, the work is more spread out over the semester and you will have to keep up with all your courses to pass them. From Monday to Friday I am mostly busy with studying. Although my classes are on Tuesday and Thursday only, I have to use the rest of the week to make sure I am in time for all the deadlines. Luckily enough my courses are not too hard, and I still have the weekends and evenings off.

In between my study activities, I do a lot with my housemates. I was lucky to get an apartment with three other people that I go along with really well. I am living with two guys and another girl. The girl is from Denmark, and is here for her minor. Two guys are full time undergraduate (bachelor) students at Clarkson, one from America and the other one from Colombia. The room is in the village on campus and has a big kitchen and a living room, where we spend most of our time. Furthermore, I have a private bedroom with furniture in it, something that is not very usual in the US. Most students live in dorms and share their bedrooms with one or two other students. All undergraduate students have to live on Campus at Clarkson and therefore, there are a lot of activities here during the weekends.



Activities that we like to attend together are the ice hockey games. The season just opened and we go to a lot of games to cheer for our Golden Knights (which is our university mascot, and the name of the hockey team). Afterwards we would go to the bars in town, or search for a frat party. Next to going to games and partying you can also do a lot of sports, everything on campus is free for students and you have access to open ice hockey hours, a gym, a swimming pool and more.

Apart from campus, the environment here is really peaceful. We are very close to the Adirondacks state park, which is famous for its beautiful colors in fall. Nearly 70% of the trees are colored deep red and this gives an amazing view. Potsdam is very rural, and the nearest city is at a three hour drive away. Luckily enough I have a car here and we plan a lot of trips during the weekends.

Having said all that, you can probably conclude that I am enjoying myself a lot here, but, of course, I am also looking forward to drinking beer again in Het Noorden when I am back! See you then! ■

**Glück Auf!**



## Letter from Jaap



By J. VAN DUJN

**W**hile studying for my master degree in Delft, I wanted to do something else before starting to work. I did not take the opportunity to study somewhere abroad during my bachelor, and never left Europe. So, it was time to shift some things around and when the opportunity arose to study at Queen's University in Kingston, Ontario, it was not a very difficult decision to make.

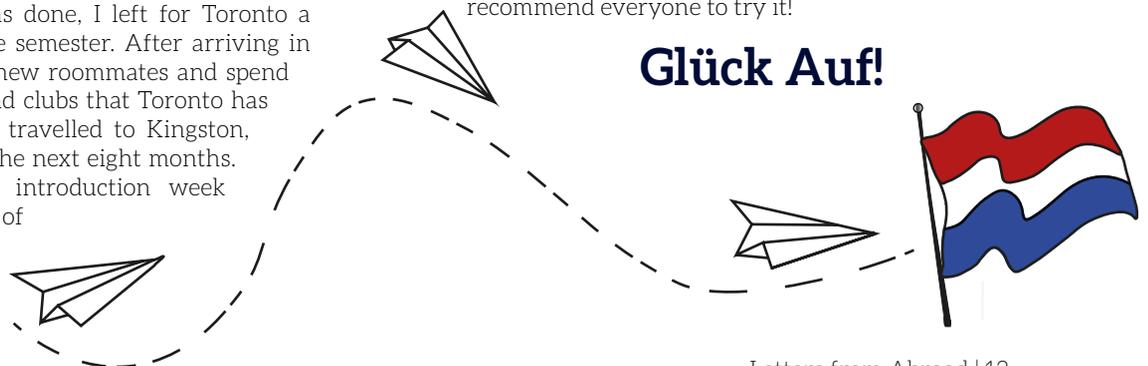
After the usual preparation was done, I left for Toronto a few days before the start of the semester. After arriving in Toronto, I met with one of my new roommates and spend some time exploring the bars and clubs that Toronto has to offer. The following day we travelled to Kingston, where I was going to study for the next eight months. When we arrived there, the introduction week started, in which I met a lot of nice people and explored the city of Kingston. This week

included introductions to the student life in Kingston, and a visit to Toronto again. In Toronto, we went to a baseball game, which was a nice experience! However, I discovered that baseball is not really my sport.

The next week things got a bit more serious again as the courses started. One of the courses that I am following here is a course about drilling and blasting. The best parts of the course are the laboratory sessions, which are on a remote blasting site. Most of those sessions included detonating charges up to multiple kilograms, which is a fun way of spending the sessions. One of the downsides of studying engineering in Kingston is the workload, which can be a bit high sometimes. Luckily, there was enough time after class to take a swim in Lake Ontario or to relax with a few beers. Another great aspect which Canada has to offer is the nature, which is beautiful and really diverse. One of the trips in which I got the opportunity to enjoy this beautiful nature, was to the 1000 islands, where we peddled from island to island in our kayaks on a very sunny autumn day, which resulted in some beautiful views.

Life in Canada is not that much different from life in the Netherlands, except a few small things. The stereotype about Canadians being very polite is true and distances in this country are like really, really huge. Driving for a few hours to get somewhere is normal and driving for a few days from one side of the country to the other side is also normal. And that driving has to be done in a F-150 pick up truck while blasting country music, which (in my opinion) all sounds the same. One of the good typical Canadian things is maple syrup, and I recommend everyone to try it!

**Glück Auf!**





# International Student Week 2018

- Trondheim -

By L. DE JONG

Last October Hein, Daniel and I (a.k.a Geology groepje 2 a.k.a. bsa strijders) went on a very special expedition to the Nordic city of Trondheim. We went to the International Student Week (ISW) organized by the Berg Student Union of the Norwegian University for Science and Technology (NTNU).

Upon arrival we met the other participants of the ISW in their version of the MV-room (not nearly as glück auf as ours but it was fine because they had half liters as welcome gift). The participants were from all over Europe - Germany, Belgium, Finland, Hungary and, of course, Norway. It is tradition for the participants to be dressed in an outfit to represent their country and/or student culture. We were wearing our 'apenpakje' which included jacquets, our MV tie and of course wooden clogs. This last item is particularly popular at ISW, as we had painted them mijnbouw-blue and applied both the MV logo and our own favorite designer brand in white.

The first night was already very crazy as we got to experience the student life of Trondheim. Their study association had their own bar, just like we have 'het Noorden'. Unfortunately, the beer in Norway is not as cheap as in het Noorden, as 8 euros for a beer is a normal price. Good thing that we were all given 10 vouchers for free. Bad thing that this, of course, is not enough for us. Good thing that the basket with vouchers was within hand reach from our side of the bar. It was also very convenient that the fuse box for the bar was in a bathroom stall and that it was not locked. This allowed

us to practice our lighting technician skills as we switched off all the electricity and everyone was confused. After we destroyed this bar it was time to go to a very large house with a lot of student bars to misbehave some more. While making good friends at first and teaching strangers Dutch drinking games, it had to go wrong again. Due to a misinterpreted translation of a Dutch saying, we got in a bit of an altercation with the bartenders and were kindly asked to leave. Then we had the joy of walking on the super comfortable clogs for an hour back home in the middle of the night.

After waking up feeling less than optimal a few hours later, it was time for some sightseeing in Trondheim. We saw the picturesque center and visited a local beer brewery to get our hands on alcohol as soon as possible again. Then we all got in the bus because it was time for a typical Norwegian cabin trip. This trip took us very close to the border with Sweden, to a famous old mining town called Røros. Our cabin was located a right next to the Olavsgruva mine. To those with an eye for detail, there is a sign of this mine in 'het Noorden'. The first night at the cabin was probably the weirdest night Hein, Daniel and I have ever experienced. The cabin included its own sauna and a small pool had been made in the ice-cold stream next to it. This allowed us to get the full Scandinavian experience, as it was customary to go naked, no matter how many people and how tiny the sauna. Another tradition that left us flabbergasted was the 'crowbar throwing'. Throwing a very heavy, 2-meter-long metal bar in subzero temperatures and hard winds, all in the same attire as we had in the sauna.



However, the night had not yet ended with this special wellness treatment. As we wanted to go on a walk, we took one of the Hungarians with us. Due to all the drinks he had enjoyed, he had some difficulties walking. Fortunately for him we were there to help him out so we gave him a stick with a sign, in the shape of a cross, to walk with. The new 'Jesus' guided us through the night as he stumbled in the pitch dark into unknown territory at 3 am.



The second day we made a trip down the Olavsgruva and were able to learn about the mining techniques and equipment used to excavate copper back in the days. This was very cool to see and luckily our feet were protected by the clogs as we went down the hundreds of steps and walked on the slippery paths. We also visited Røros to go on a stroll through the old mining town. Then we experienced another very entertaining night with more crazy stories (unsuitable for the NR) in the cabin.

The third day called for another long bus trip back towards Trondheim with the necessary alcoholic refreshments on board. We found that the place we were going to sleep at was next to an elementary school with a football field. So lucky for us we were able to get our weekly exercise in an intoxicated state by challenging 5-year-olds for some football. A very

depressing night of drinking in the large room with bright fluorescent lights, where we also slept on the floor, followed.

**“The two candidates both made it through the pain staking process of glück aufing almost 3 liters of this beer mix”**

The fourth morning we were woken up way too early and thrown into a bus to visit an aggregate quarry. This mine was owned by Franzefoss, a very large Norwegian industrial company. This was a very interesting visit as we learned a lot. The mine is operational 365 days a year, no matter the brutal Nordic weather conditions. They worked with very large machinery and explosives to excavate and crush these aggregates. We were also invited for a very appetizing lunch and a presentation about the company. After this visit we went to a new sleeping place, a cabin owned by the hard hearing and deaf association of Trondheim. In the evening that followed we witnessed a very astonishing Norwegian tradition: how they earn the hats they all wear. The water tight hats were filled to the rim with a variety of drinks by all the spectators. The two candidates both made it through the pain staking process of glück aufing almost 3 liters of this beer mix. All this had to happen outside in a snowstorm, because that saves cleaning the mess that you naturally get from chugging this amount.

The fifth morning we woke up very early again to visit another company, Elkem Thamshavn. Elkem is a silicon manufacturer and the site in Thamshavn has 2 very large smelting plants. The plant is famous for its energy recovery system as it was one of the first plants in the worlds to use such technology. It was clear that they took safety very seriously, as we were not allowed in without wearing a helmet, goggles, ear protection, dust masks and a bright yellow coat. Afterwards we received another luxurious lunch and headed back to the cabin to prepare for the final night. This night it was time to thank the people that had put a lot of time into organizing the week during the so-called Thanksgiving. The organizing committee of 7 people sat alongside each other at a long table and invited each country to come forward one by one. Each country sang a song first in their own language first and then presented a gift, a drink from their country. We gladly filled our smelly clogs to the top with Ketel1 and beer and donated them. We were very happy with the result as we got all of them to puke from drinking them. It was a perfect ending to a crazy week.



# Glück Auf!



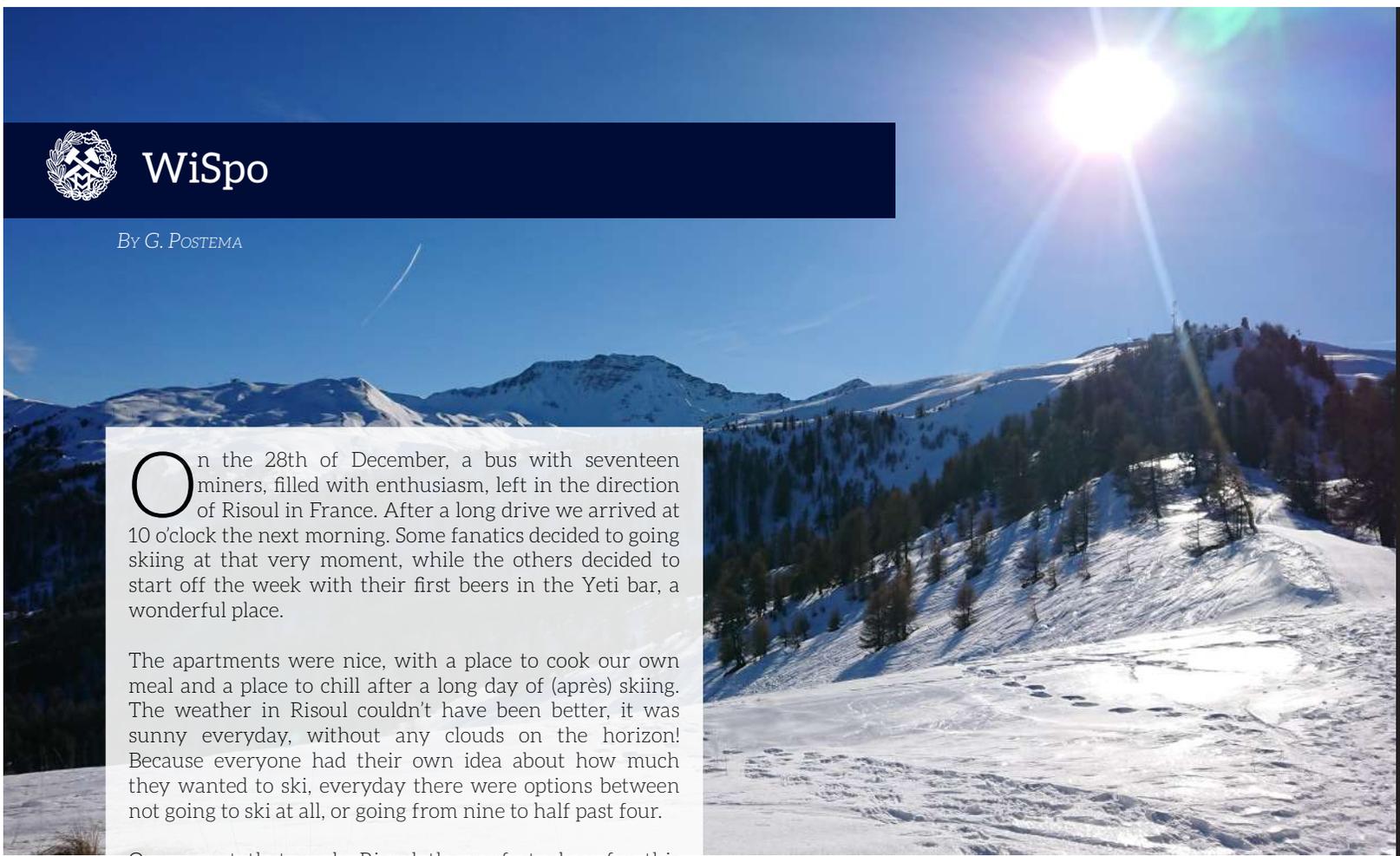
By G. POSTEMA

On the 28th of December, a bus with seventeen miners, filled with enthusiasm, left in the direction of Risoul in France. After a long drive we arrived at 10 o'clock the next morning. Some fanatics decided to go skiing at that very moment, while the others decided to start off the week with their first beers in the Yeti bar, a wonderful place.

The apartments were nice, with a place to cook our own meal and a place to chill after a long day of (après) skiing. The weather in Risoul couldn't have been better, it was sunny everyday, without any clouds on the horizon! Because everyone had their own idea about how much they wanted to ski, everyday there were options between not going to ski at all, or going from nine to half past four.

One aspect that made Risoul the perfect place for this week, was that the town was filled with students, who were all very eager to ski, but just as eager to have a good time, which resulted in great evenings. One of the amazing things we did during these evenings was the "Tour du Chambre". This meant that all the four rooms made their own signature drink, which everyone got to enjoy. We were lucky to have a club, in what you could call the basement of the building we stayed in and somehow we ended up there every night. As there was no Alev or Döner Kingdom at our disposal after the late night partying, we invented the inhouse after parties. This meant waking up all the people who were sleeping, while hunting for some left over food. We also enjoyed an unforgettable New Year's Eve together.

If you like skiing, snowboarding, tearing your cruciate ligament, sleigh riding, partying or just spending time with other miners during the holiday, I would definitely recommend joining this trip next year. It was a blast!



# MV RALLY



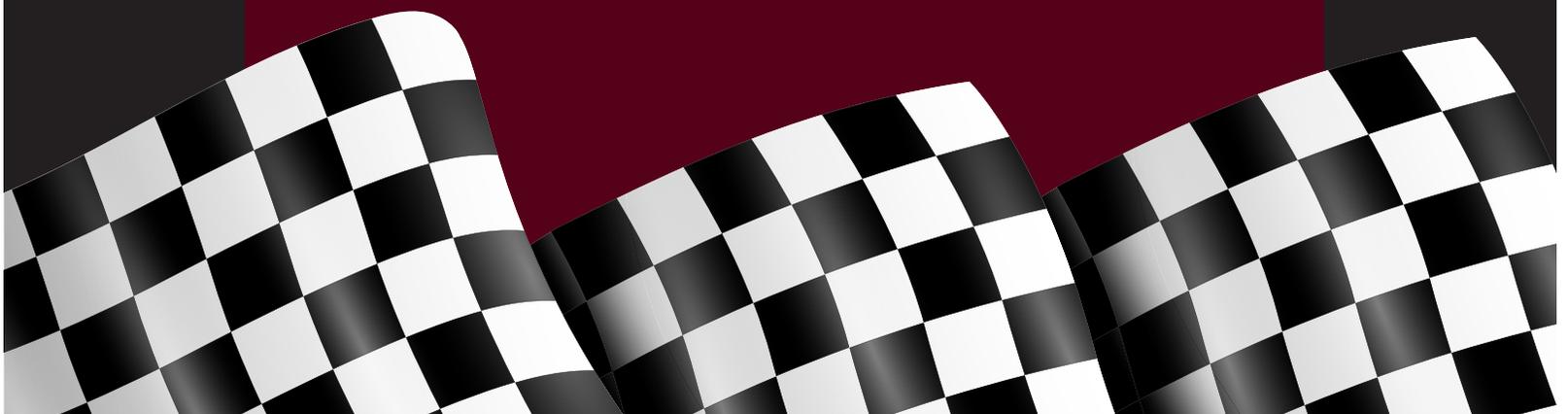
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## Lunch with the Rally Committee

By G. DRAGONAKIS

“Hein would want to be a Ferrari, but he would break immediately, so it’s gonna be an Opel Astra for him. Isabelle would be a MINI Cooper with a British flag on top of it because she likes small dogs and she is small herself so a small tiny car would be good for her. Leon is a little bit off, so he would get an offroad vehicle. And Claire, well, she would be a normal family car.”

- **Tim Meijer, Commissioner “Shock Absorber” (Qqer of RalCo)**

### Give us an introduction about the Rally committee.

**Leon:** The Rally has already been organized for some years but the last two years it used to be a rally on bicycles rather than a rally with cars. Good thing is that the car rally is returning again. It is about taking some nice cars with friends and solving something like a puzzle in order to get from a starting point and end up in a nice place, with a nice accommodation, dinner and a final party.

### What is your favourite part of this committee? Also give us two reasons for which anyone would like to participate in the rally.

**Hein:** Free lunch with the NRC.

**Leon:** Well, first of all it’s really nice to figure your own way out to the finish. We are also going to see all the alumni having fun with each other and, of course, the final party. But it does come with a price as you have to solve a puzzle which will make everything automatically more fun and exciting, in order to make sure that you reach the finishing point. It will be Saturday and Sunday morning so you ain’t gonna miss a day of work or studying, the party will be really epic. Like REALLY EPIC! Because it’s gonna be a party with all the miners where the alumni will show how partying was done in the past.



▲ Leon Ursem, Commissioner “Twin-Turbo”



▲ Hein Lafeber, Commissioner "Launch Control"

**Since this event is mostly related to a road trip. What is your affection with road trips?**

**Hein:** I think it's a lot of fun to drive with a couple of friends in the Netherlands or even across Europe especially if you need to solve a lot of puzzles. Eventually, what counts is that you arrive at some point where a party is taking place, which is of course even more amazing when you get to do that with some fellow mining friends! It is also super nice that we get the chance to meet with the alumni that are participating in this event.

**When you were asked to participate in this committee, what was your initial reaction and what did you think this committee was all about?**

**Hein:** Well, since the name says RalCo I thought it was about organizing a rally which turned out to be true! I thought it was amazing to organize and participate in it, because it is a huge event. It makes it even better when we know that others are going to be solving the puzzles that we created. It does take a lot of time to make what I mentioned since it is spread over a very big region, but it still remains very fun to do. So yeah, I felt amazing!

**What is the connection between the rally and Applied Earth Sciences?**

**Isabelle:** All I can say is that it will not only involve puzzles and activities. We are also going to visit cultural points during this trip. For example, there is a very big chance that we are going to visit a mine and that sort of things. In general it's a way to combine recreative and cultural, traditional elements.

**There are so many alumni participating in the rally. What attracts them to join this event?**

**Isabelle:** It's a cultural experience and the bonuses are a great party with the students. Of course, they have done this before meaning that they know what it is about!. That's automatically a good thing for students, if alumni go, then everyone should go too.

**Hein:** Also, alumni are gonna see their friends with which they used to study with. Eventually make a group of 4, get into car and start this amazing 'adventure'.



▲ Isabelle Llana, Commissioner "Glove Box"

**Do you think the rally is one of the events that allows participants get more involved in mining?**

**Claire:** That of course depends on the activities we're planning, which I can't give away, but I think it is an event that allows participants to get more involved in the study association culture. The interaction between bachelor students, master students and teachers in an informal and fun setting shows the closeness and active culture of the MV.

**How many people are expected to join the rally?**

**Claire:** We're aiming for around 150 people! A good mix of alumni and students.



▲ Claire Mulder, Commissioner "Windscreen Wiper"

# B arbararede

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## “The making of” Barbararede 2018

**In 2018 the President of the 127th Board of the Mijnbouwkundige Vereeniging has given me the honour to address the Barbararede to the members. The exact text of the Barbararede will be published later this year, in the 79th Yearbook 2018/2019.**

**Afterwards Katarina, part of the Editorial board of the quarterly magazine “Natural Resource”, has asked me to write a short story about the “making of” the Barbararede which is a fun experience in itself.**

The nomination for the 2018 Barbararede goes back to 2016 when the old president Rutger van Limborgh asked me after the 2016 Barbararede if I had a good story for the next year. It so happens that I was a young Drilling Engineer in Shell International and worked in Nigeria in 1994. In Nigeria I was part of the High Pressure High Temperature (HPHT) Drilling team that drilled the Well Santa Barbara Deep in the Niger Delta swamp and I still had some Drilling Programs and logs with the Santa Barbara name on it, so we agreed that I could easily convert that into a nice “rede” for the year after. Of course, everything had to be

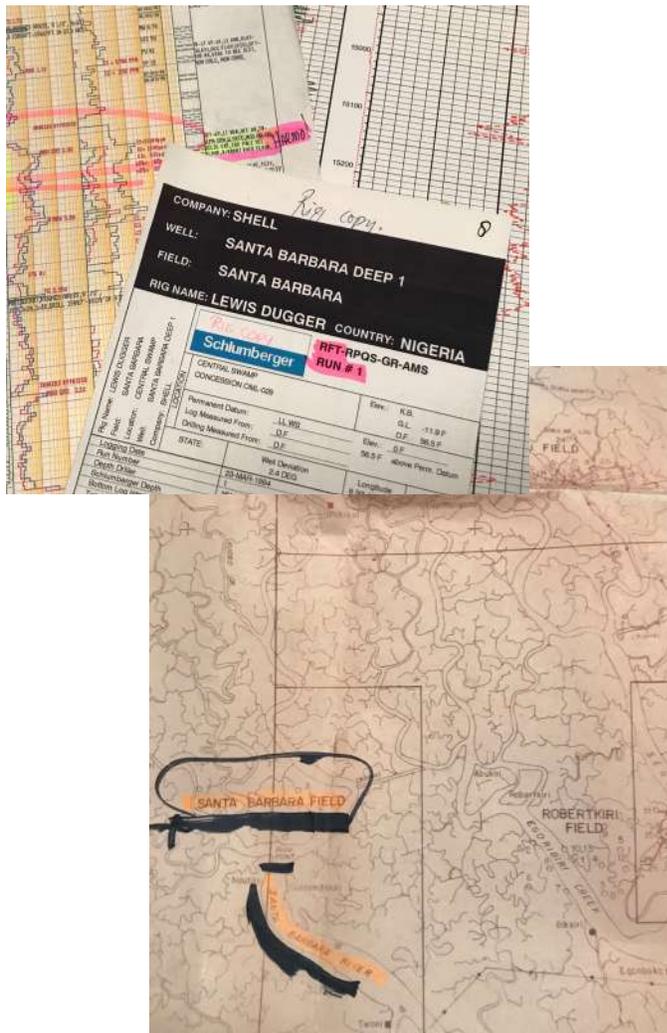
kept secret as it is paramount that no rumours will spread before the “rede” and that the identity of the speaker will not be disclosed. In 2017 Rutger kept the secret so well that the next president Steve had been doing his homework already and had invited the next speaker, so we kept the story another winter on ice to be ready for 2018. A Barbararede is like a good wine, you can let it rest for a few years and it gets better in time.

In September 2018, Krijn van Alphen, reminded me that I was lined up for the “rede” and there was no chance for another year of delay, so I started

with the research and drafting the storyline. Having heard over a dozen “Barbararedes” over the years (having been 17 years overseas doesn’t help to try and attend them all), I learned that it should not be too long and too complex as people will start talking to their buddies who they haven’t seen for a long time. I also remembered the speech by Jan Dirk Jansen who made the “rede” interactive, which worked great and caught everyone’s attention. A few props (items to show) and a good outfit would complement the mix.

Doing the research first is important, so for a few nights I locked myself up with a collection of Yearbooks (I could now prove to my wife that it made sense to carry these yearbooks over four continents, because now, the moment finally came in which I needed them), a bottle of good wine and a writing pad. The story had to have the true factual dates and places. So: Barbara was born in Nicodemia, east of Constantinople (now Istanbul) as a daughter of Dioscorus (Roman empire tradesman and antichrist) and locked up in a tower with 2 windows which she got converted to 3 windows to resemble the 3 Christian elements (the Father, the Son and the Holy Spirit) and finally she was beheaded by her father on the 4th of December in the year 306 AC.

In the original story, lightning strikes 3 times. At first it strikes to help Barbara escape from the tower, then, to kill a shepherd that lies and transform him into a rock and finally to kill her father Dioscorus after he killed Barbara.



▲ Figure 1: Santa Barbara logs & Figure 2: Santa Barbara map

“ I could now prove to my wife that it made sense to carry these yearbooks over four continents, because now, the moment finally came in which I needed them ”

Well, right, this story was already told by Professor de Wijs in the first edition of the Barbararede, so now I had to construct the “only true story” with a variance of the old story and some true factual evidence. It was now important to merge some modern and up-to-date news into the story and I chose to mix into the story cocktail some Trump statements, calling other old Barbararedes “Fake News” and to reiterate after factual statements “It’s true”.



▲ Figure 3: Old leather box and genuine antique Nigerian beats

I collected all the true evidence that I had from the Santa Barbara Deep well, including a Shell Santa Barbara location map, an old well program that I had written myself (in those days the young Drilling Engineers were thrown in the deep and got a lot of exposure), a Schlumberger log and a Sperry Sun Mudlog. I also had a collection of oil samples from well tests that I kept in little hotel shampoo bottles. This should be enough ammunition for a convincing “it’s true” story with the Santa Barbara name on the maps and logs. (Figure 1 & 2)

Now I needed an outfit, so I had to dig out the box of carnival clothes that the kids have used over the years to find some old African dresses from Nigeria. I also found an old leather box and some genuine antique Nigerian beats (Figure 3) that were brought to Nigeria in the early 19th century for trading palm

“A Barbararede is like a good wine, you drink it for years and it gets better in time”



▲ Figure 4: Prince Eze OgaChukwu Ndukwe

wine and other goods. A black afro wig and a Nigerian cap completed the outfit only to be complimented by some brown make up. The black stuff is a bit sensitive these days so we applied political correct mid brown to prevent any trouble either indoors or outdoors. (Figure 4)

Of course, a Barbararede is an official and serious event, but there should be a few practical jokes and inside jokes included in the mix. My personality was Prince Eze OgaChukwu Ndukwe of Nigeria. Prince Eze is an existing Nigerian indigenous oil and gas operator that we are actually doing business with for a Nigerian Field and a few other people in the audience in Het Noorden knew his name as well so this was already a good start for some laughs. The second name OgaChukwu was the name of our neighbours little 5 year old daughter in Nigeria, meaning “God is boss”, in the Nigerian Igbo language. Finally, Ndukwem is a common name in Nigeria but also one of the drivers that we used (not to mix up with the other driver Eddy Nweke after which Eddy the Python in Het Noorden is named).

The second practical joke was the name of the horse that Barbara was using to escape from Nicodemia. The Horse Heaven’s Wonder is my daughters horse (named after the Stallion WonderBoy and born in a year where KWPN horse names had to start with an H) that was born in our horse stable.

When Barbara did reach the Red Sea on Heaven’s Wonder, she opened up the water like when Mozes did when he escaped Egypt 5000 years ago going the other way. When Barbara crossed, the people said “Holy Mozes” and I let her say “Not Mozes this time, he was crossing to the other side and I am stupid enough to go South”.

The second thunder and lightning appeared when the shepherd at the Benue river disclosed Barbara’s route and he was transformed into a rock (according to the true story) and all his sheep where transformed into millions of Grasshoppers, which I used to link back to all the eaten crops in Sudan and Egypt during the time of the Pharaohs (seven bad years) and I could use this as evidence and say “It’s true” in Trump style.

Time runs fast during a Barbararede and I had a few more jokes planned on the #METOO discussion and Harvey Weinstein being the shepherd, but I wanted to keep it short, so skipped this part.

One of the highlights for me, was the interactive part where I explained that Barbara could not speak Nigerian but was communicating only via a short and simple song, the Aria Vika Tunga song. Depending on the tone, intensity and the mood it is possible to get some feelings through and we tried that for different styles - normal, sad, happy, smooth women and excited man. This song; “E, Ele, Aria Vika Tunga, A massa massa massa, E loué ba di Wa ba di Wé”, we used to sing more often in Het Noorden but according to Krijn it is not practised anymore, so now at least the NoCo and the current board can reintroduce this song in Het Noorden on the Wednesday evenings.

In the end of the story, father Dioscorus, inevitably finds his daughter (with the help of the bad guys from Boko Haram introduced) and kills her with his sword, when immediately the third thunder and lightning takes place and when a 15.200 ft crater is formed. Barbara’s blood fills up the crater until it closes from the top. This happened in the year 306 AC and then, the story continues in 1994 when we drill the Well Santa Barbara Deep with Shell and hit the oil at 15.200 ft, with a very high content of Haemoglobin (It’s True) and we had the oil tested with SGS Horizon (inside joke since I started the wells group for Horizon after my Shell career and we sold this company to SGS). A true evidence that the blood of Barbara has created the oil in Nigeria and that concluded the fact finding mission based on the Dutch Engineering principle “meten is

I can let it rest for a few in time.”

weten” (you know it for sure, when you measure it). I, then, handed over the money for which Royal Dutch Shell bought the license. This was a golden 10 guilder coin (“gouden tientje”) with the shape of queen Wilhelmina when she was the new Dutch queen at the age of eighteen and she had her hair loose which was the only coin ever of a Dutch queen with loose hair. The year of the golden coin was 1892 (Figure 5 & 6) and this is exactly, as we all know, the year the Mijnbouwkundige Vereeniging was founded.



▲ Figure 5 & 6: Golden guilder coin

After giving this to the MV Board for them to display in Het Noorden (probably on the ceiling so it does not go missing), the President of the MV invited me to blow the horn to start some serious drinking. I still remembered this from 1988, exactly 30 years ago when I was MV Vice President and had to blow the horn on a few occasions in absence of the President, but the horn was in a much better condition. With limited fear, I attempted to blow the horn and, thanks to OgaChukwu, I got a respectable sound out of the horn and the drinking could begin. (Figure 7)



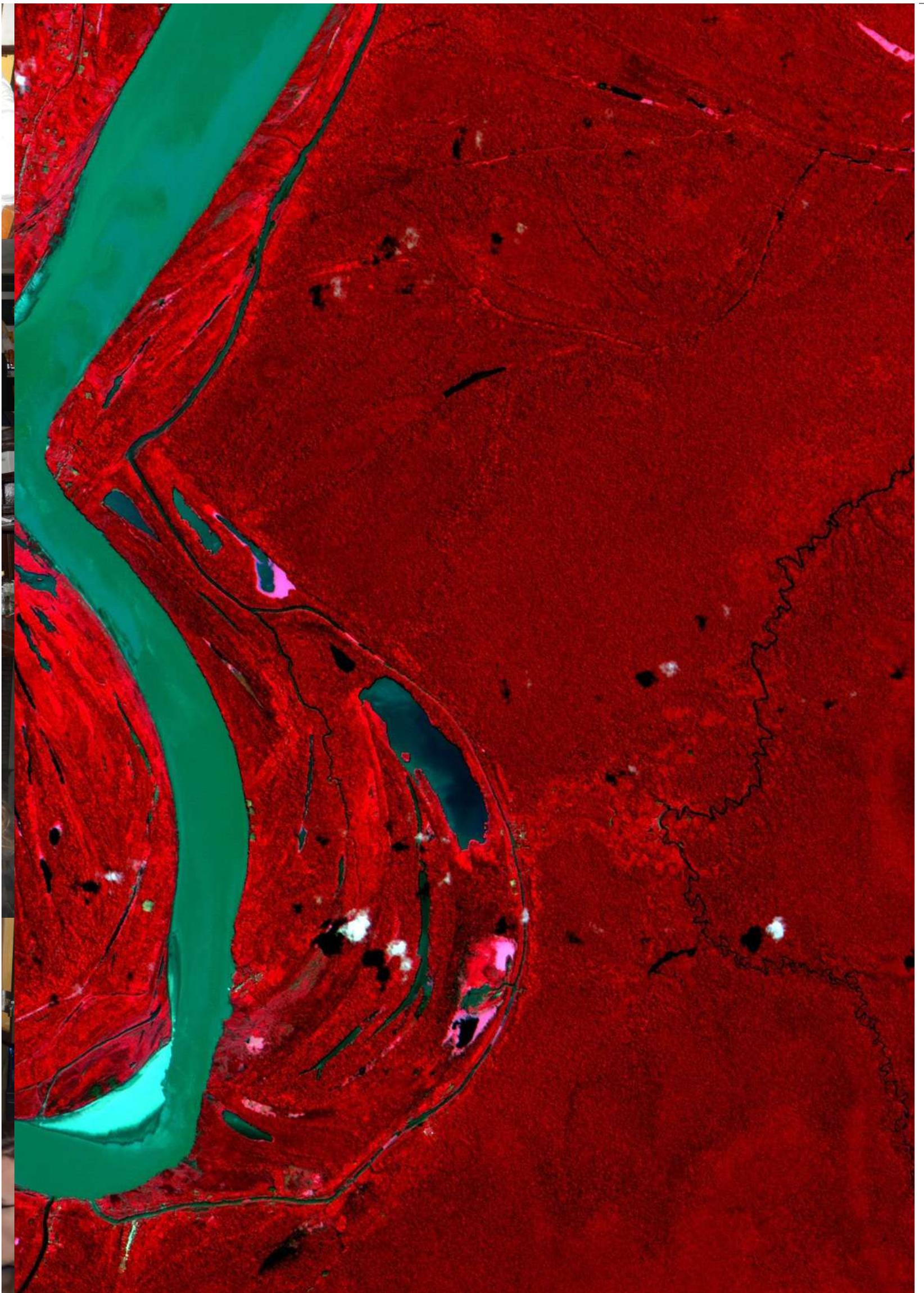
▲ Figure 7: Blowing the horn

During the drinking afterwards, I could explain to my friends why I was so late in Het Noorden as no one knew I was the mystery guest, but they all saw it pretty quick when I entered the table as my big smile is a bit of a giveaway despite of the wig and the makeup. My son Leon, as part of the NoCo 46, had to be an insider as all the dressing up in the house and all the Yearbooks on the table for two weeks had blown my cover internally, but externally no one knew until the last day.

A nice dinner was enjoyed afterwards including the (Golden) Ereleden, the Board, alumni members and (MSc and PhD) students. A great evening to remember and I hope many people after me will enjoy this experience (even though I explained this was the last Barbararede, as the only true story was now told, It's True!)

## Glück Auf!





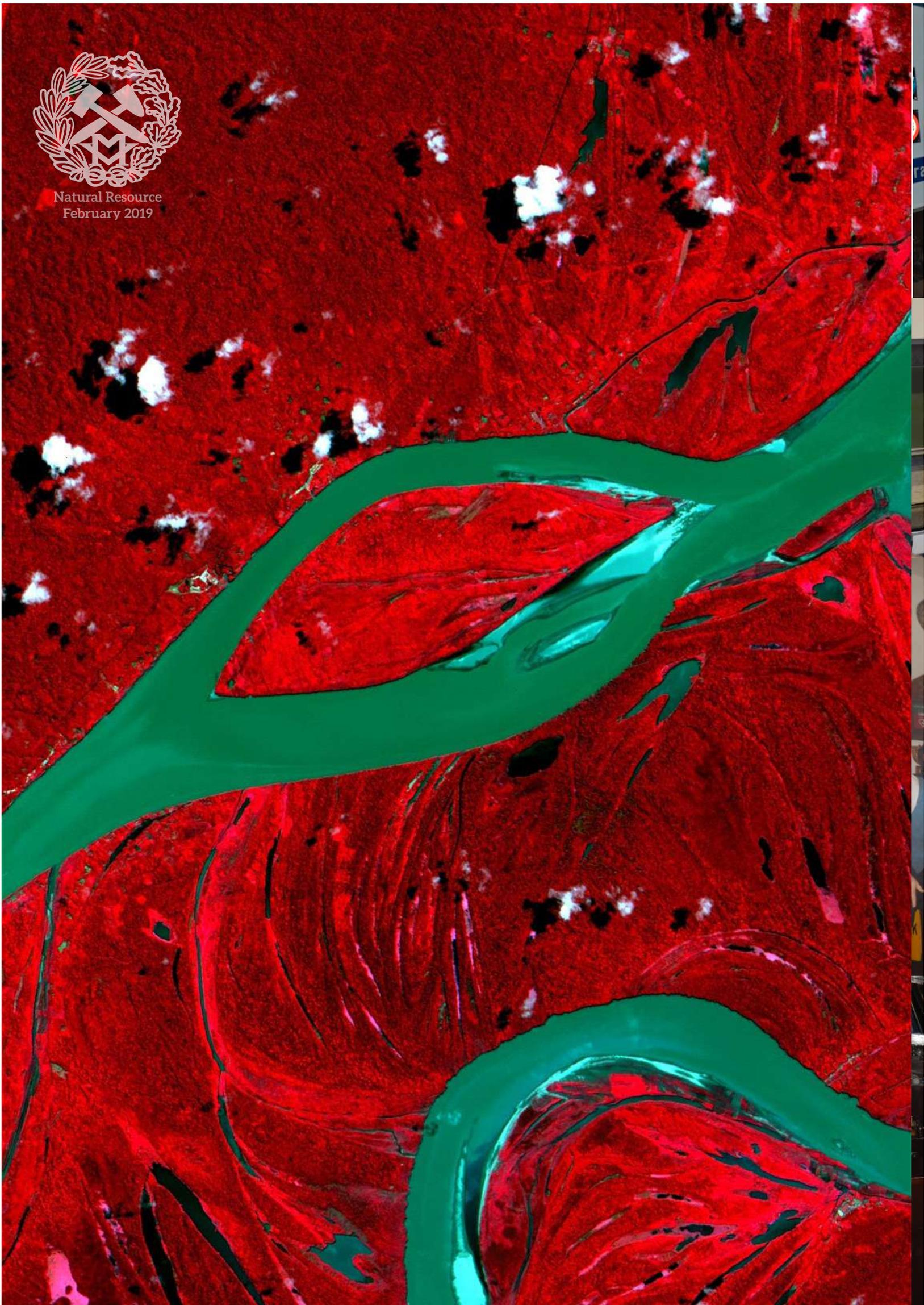


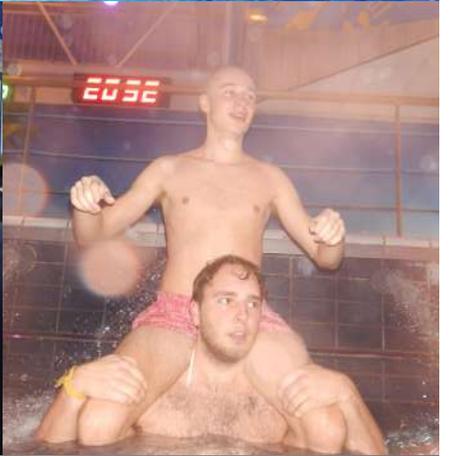


Natural Resource  
February 2019



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February 2019







By D GILDING



## Douglas Gilding about his student days

**I**f there is a Olympic medal for mijnbouw students it is the 'De Maarten Schoot in de gracht penning'. During a recent Barbara borrel whilst drinking out of the special Maarten 'pul' a student asked me if I could write about some highlights from my university days to inspire all of you.

Walking into a beautiful faculty building at the Mijnbouwstraat 120 was an amazing experience. The building was buzzing with activity as I was lead through the hallways for the first time. The study, the people and the building gave me a feeling of adventure, tradition and magic. Important business was being done; research in the form of crushing or sorting of rocks and minerals, separation of liquids, or the modelling of something either big or very small. All were willing to inspiringly tell me the full future impact of their hypothesis. The study appealed to me as a nice mix of the subjects of maths, chemistry, physics, and earth sciences combined with a healthy dose of outside fieldwork and excursions and a diverse group of professors, staff and students. Not to forget the important outlook of a prosperous future and easy life after graduation.

The last of a dying breed, is what they called the year of 2002. With only 23 admissions into the study it was a new low after the high numbers in the 1990s. After becoming a member of the DSC, I found a small room, costing 70 euros per month on the Brasserskade. With the MV Lustrum in November

2002 I was exposed to the full colour and force of the MV. In the initial years I was lucky to find a lot of guidance from other students. I gained a lot asking about the study experience of senior students in het Noorden. After spending so much time being in Het Noorden I was asked to be part of the NoCo 2003-2004. I made a lot of friends in these early years and they even let me steer the Glück Acht around the ringvaart.

Throughout my university years I was very involved with extracurricular activities in several commission, boards and councils. To name a few: NoCo, Het Zwemmersgilde, 69th Yearbook, 23rd Lustrum Committee, the SVR and Stichting DAP. I held the position as the CFO for DAP BV. I grasped many opportunities, like six weeks of working in the German coal mine Lohberg, an ISW in Helsinki, attending several world class conferences and an unforgettable three week tour through mines in China. Few will remember the 1200 sponsor request letters that were rejected. The 1000s of telephone calls with no result. The application to study funds or subsidies that were rejected, the projects that never materialised, the dispute for reservoir geology that was dissolved into the AAPG. Failure is all part of the game, however nothing beats the feeling of a brand new yearbook in your hands, five hundred students going out of their minds dancing on the famous Gunther in Delft, several sold out (geothermal) symposia or making the University of Delft an official registered mining company by obtaining an exploration licence. Other achievements were funding the CATO-2 project and staff directly as an industry partner whilst being a student and seeing geothermal energy interest grow at the faculty to what it is today. And most important of all having fun with so many special and fantastic people whilst you fail and succeed.

**“ Failure is  
all part of the game ”**

During the year of 2006-2007, at the time the 69th Yearbook was just finished, it was time to move the faculty. The board of the MV was set with the task to move the MV to the new building and secure a quick integration of the students with their new surroundings. Additionally most of the archive and the old attic full of photos, mining memorabilia and old yearbooks needed to be sorted and moved. These were busy times, because did had to happen together with the start of the organisation of the 23rd Lustrum planned in November 2007. Together with a hand full of active students we quickly assessed what was critical to bring to the new building and made the transition as easy as possible for the students. The move of the faculty was big news and created a lot of emotions and engagement with the 3rd of June reunion and the opening of the new building as big highlights. The Lustrum Committee tried to unify the stakeholders of the MV and strengthen their bonds as well as find new partners in a time of transition. This was important for the future of the MV. As you read this, you



“ One of the main things I learned during my years being part of several fantastic committees is the value of diversity in a group ”

probably have heard the rumours that the university has put the building up for sale. It was a shame to see us leave the old faculty but there was light at the end of the shaft. The board set up office in the current MV room, while the committees took office in a room at the end of the 3rd floor. Close to the staff, it was a lot easier to align new ideas, gain support and spread the news of the next developments. This improved the interaction of staff and students even more than we had in the old building, creating a special new atmosphere amongst staff, professors and students. Studying was something I did in the weekends and when it was necessary to pass the next exams.

One of the main things I learned during my years being part of several fantastic committees is the value of diversity in a group. I am so grateful to have had the opportunity to work with such a diverse group of people. As a diverse group we had more, better and more creative ideas, we were able to be inclusive and deliver better results. I am proud of what we achieved together and I think it is a pity that there are so few diverse leadership teams and executive boards within our industries. During a KIVI Mijnbouw organised workshop in Russian negotiations, together with Andries Wever, the idea of a geothermal doublet for heating the university was founded. The main goal was to show that Applied Earth Sciences and fellow students could positively and actively contribute to making the university more sustainable and support the interest in sustainable subsurface engineering and research. The project grew fast and soon a foundation, a company, and license application were formed. This resulted in four wells being drilled to heat large greenhouse complexes in Pijnacker. The students asked the department to organise the master course of geothermal energy and later Duco Drenth orchestrated the alumni to finance a geothermal professor. The dream of geothermal energy heating the TU Delft is still alive and being worked on today, strengthened by the recent announced sponsored 5-year tenure track position. What a bottle of vodka or two can do.

## Glück Auf!



## Geoscience & Remote Sensing (GRS) MSc Track

A large background image showing a sunset over a wide body of water, with a green field in the foreground. The sky is filled with dramatic, golden and blue clouds, and the sun is low on the horizon, reflecting on the water.

**D**iscover what Geoscience & Remote Sensing (GRS) at the TU Delft has to offer. This master track focuses on the underlying Earth processes, while using advanced remote sensing technology and modelling techniques to make important decisions for the future. We asked Sandra Verhagen, the coordinator of this master track, and Mark Bemelmans, second year GRS student, about their experiences and impressions in this field.



## Coordinator's Perspective

By G. DRAGONAKIS

### **Please give us a little introduction of yourself. What is your field of expertise?**

My name is Sandra Verhagen, I have a background in Geodesy, which is about measuring and monitoring the Earth using all kinds of observations sensors, either on the Earth or in space. That is what we do in the Geoscience and Remote Sensing department. We mostly look what is on the Earth's surface and in the atmosphere by trying to observe and model all the processes going around which are mostly natural processes but, also, human induced processes alongside the living environment as such. Therefore, in contrast with the other MSc tracks it is not so much about the subsurface. However, we observe the gravity field as well, which is about the mass of the Earth and the changes in it, but also the surface of the Earth and for what lies above it.

### **What are the most important requirements somebody should satisfy before he starts with this course?**

In order to participate comfortably you need to be able to process many data, for which you need a solid foundation in mathematics (e.g. calculus, linear algebra, probability and statistics). On the other hand it is also a lot about modelling and physical processes, so physics is also important, aspects of which are thermodynamics, fluid dynamics, classical mechanics as well as electromagnetism. That means that people with backgrounds such as mechanical, aerospace and civil engineering would be able to attend this MSc track as well. In addition, programming skills are required since what we do is working with simulation models and a lot of data processing. At the start of the programme you should have some basic programming skills (preferably in Matlab or Python), which we will further develop.

### **What are the greatest challenges we are facing from the perspective of Geoscience and Remote Sensing?**

Climate change for sure, since it has a lot of impact on the Earth and the atmosphere. Therefore, we work on a lot of monitoring techniques and many prediction models to see what the consequences of climate change are. By observing phenomena as such, we are able to model them and predict how they will evolve in the future but also understand the atmospheric physics behind it. An example can be how the air quality changes and the processes in the atmosphere, which can provide information about climate change and the effect, that Carbon Dioxide (CO<sub>2</sub>) quantity can have on the weather. In a nutshell, we are dealing with quite important challenges.

### **What are different research projects someone can take part in the field of GRS?**

It can differ quite a lot. For example, I mentioned climate change earlier, which could be about looking at very specific aspects in the atmosphere. An example can be how clouds are formed or how the droplets inside them can be formed and evolve with time. Additionally, observing with different techniques how the glacier or the ice cap in Greenland is melting and the balance between the different factors that influence the ice melting and the sea level rise. Nevertheless, of course, it can also be completely different. We have students that use sensors on cars to help us develop autonomous driving capacities in the future, since sensors are used to look at the environment in order to see what is nearby or to predict if a target is closing by. Groningen is another example of where somebody can find himself. There different techniques are used in order to monitor surface deformations (GPS, satellite radar remote sensing, gravity), which, in the end, could help predicting any consequences of the human induced earthquakes due to the gas extraction in that region. Having a good analysis of the case could give us something to rely on when thinking of future activities.

**What are special opportunities somebody can benefit from?  
For example: Internships, fieldwork or studying abroad?**

A nice aspect of this track is that a compulsory fieldwork is included. Until now, it has been a trip to Iceland for two weeks in the first year where we do all kinds of deformation measurements, which are caused by, for example, the plate spreading and volcanic activity. There is also a geothermal power plant, which is extracting groundwater and then injecting it to other places. That means there is a lot of motion, which students have to measure, monitor and predict by themselves during the fieldwork. Apart from that, students go abroad for internships or for an additional thesis or even their final thesis. For example, they can look at tsunami predictions in Chile or environmental monitoring in the coastal region of Australia, which means that you can certainly have the opportunity to go abroad.

**Does the TU Delft provide an exclusive specialization in the field of remote sensing and, if yes, what is that?**

For sure, it is unique in the Netherlands. Although in Wageningen you can do, something more related to the Agricultural aspects and in Twente they do not focus a lot on climate change and remote sensing, as they are rather dealing with what we call general geomatics. Therefore, what is unique about Delft is that it combines the observation and modelling of the Earth and the atmosphere. That is something you would not be able to find anywhere in the Netherlands in a particular track. You also have the freedom to apply this knowledge into different aspects such as mining and geology

if you are studying in Delft.

**In what industries can someone find himself after he graduates from this track?**

I have been looking into that and it turns out that most of the students go to what we call engineering companies like Fugro, Sweco, Thalys or even Shell. Others follow a more research-oriented direction either in universities or inside industries or even in the government where our monitoring skills and applications are used to measure sea level rise, our altitude or deformation.

**Finally, when a student makes a decision and joins this track what should his priorities be and how can he benefit from the environment here at the TU Delft?**

You can really get personal attention in this department through the open door policy that we apply, where you can always come to our office and ask questions and be provided with a lot of assistance. What we also like is hands on experience, which means that we do not want you to sit in a lecture hall and follow instructions but rather follow the Delft approach of working with your hands. Of course, you do not fix something with your hands in this case, but you are working with real data and real problems so you get a feeling of what problem solving means. About the priorities, you should be prepared to work hard and be ready to do many hands on work throughout the period and not focus solely on the exams.

## Student's Perspective

By G.DRAKONAKIS

**Please introduce yourself.**

Hello, my name is Mark and I'm one of those mysterious Geoscience and Remote Sensing students. I'm here to resolve the mystery and let everyone know, through my experience what this track is all about! I myself came from the Applied Earth Science bachelor and would like to help everyone make the right choice for his or her master. I'm currently in my last year and will be starting my master thesis soon. I'm also the commissioner of education of Snellius, the study association of the master track which organizes activities and company visits much like the MV.

**What inspired you to join the Geoscience and Remote Sensing master track?**

Even from before starting my bachelor here I already wanted to know how the Earth worked. The bachelor was mostly about knowing how sedimentary layers are formed and how the tectonic plates move to create oceans and mountains. GRS, it is more about the processes and how they influence each other. An example of this is the influence of volcanoes on the climate, especially if the volcano is located near the equator. From this little bit of knowledge I would like to know how volcanic eruptions influence the climate and why volcanoes at the equator have a greater effect than those near the poles. Another example is the fact that globally sea level is rising, but in Scandinavia, the water level in the harbors is getting lower and lower each year. What is going on? And, with our knowledge of the earth, can we explain why this is happening? These questions interest me a lot.

**When and how did you come to the final conclusion to choose the GRS track?**

I finally decided on Geoscience and Remote Sensing when I did my minor at UBC in Vancouver. There, I followed a course about Physics of the Earth and Other Planets. This course is all about understanding the processes on the surface and inside the Earth and other planets and it lets you decide what you wanted to research within this field. I liked this course and I think I spent about half my time there working on it and not so much on my other four courses. When I came back to Delft, I wanted to do the master that was closest to this course and GRS is quite a close match. It contains all the parts of the course with a stronger focus on the Earth and not so much on the other planets and there is a lot of freedom in deciding what you want to study and specialize in.

“ In one word:  
Fieldwork! ”



**Which bachelor courses are mostly related to the GRS track?**

There are not too many courses related to this track. The best ones would be the pure Remote Sensing course given by Roderick Lindenberg in the second year and the associated part of the Vesc fieldwork. Second would be the course Introduction to Geophysics and Remote Sensing and especially the part not connected to seismic reflection geophysics. Third, and this might be controversial, is actually the field development project of the third year. With this course, you are truly put into this problem solving mindset in trying to figure out what are the best ways to get to the solution. You also work with real data, which is done with every course of GRS master track as well.

**What has been your favorite experience so far?**

In one word: Fieldwork! As part of the master track, everyone needs to do a two-week fieldwork in a remote, volcanically active, plate spreading part of Iceland. Firstly, it is Iceland, one of the most beautiful countries in the world. Then there is the location, an old volcano that still shows some activity. You are in the part of Iceland that is spreading apart due to plate tectonics. A few geothermal power plants directly in your fieldwork location are changing the surface and subsurface constantly. Therefore, many processes are going on and it is your team's task to provide an explanation for the observations you have done in the field and during your visit and all previous visits.

This really got me going. But ultimately, this is not the why it is my favorite experience as you are already figuring stuff like this out in Delft. It was the bonding with everyone there. It was like nothing I have ever experienced before. You are sleeping in tents around a central building where you will

have dinner and where you will spend your (mostly) free evenings. You basically start to behave like roommates with your entire year and you will make friends for a lifetime. This is why it is my favorite experience.

**What are the most important skills you need for the track?**

You should know how to work in small groups, work towards doing an equal amount of work all while being involved with every component of that activity. Be it a presentation or a programming assignment. You need to be able to do all the skills yourself so you don't hide behind other students just because they are better at, for example, programming.

The master track also has a lot of data processing and therefore a good amount of programming. Because of that, I do recommend to get yourself familiar with a programming language. I know that you can get away with minimal programming in the bachelor, but this will not stand in the master and you should already know some programming before starting the master. We are, however working towards helping the students and will be developing a short programming workshop and some more help with the programming around the first few assignments.

**Can you name and quickly explain a couple of projects or assignments that you have done and liked?**

One assignment springs to my mind. It was one of the first assignments and we had to do it for the first quarter course Geo-measurement Processing. This assignment was to work in pairs and develop a model describing the vertical movement of the surface directly above a volcano on Iceland. You are working with real vertical movement data and you have to find the best estimate for the position and size of the magma

chamber and how much volume it will have to have lost or gained in order to generate those measurements. However, when you dig deeper you find that this is not the only thing that is going on. The whole area is also affected by the ice sheet, which was present there 20.000 years ago and is still causing uplift in the area. It was a lot of fun to figure out how to do this and how to get towards a working model that can accurately describe what is going on below the surface.

**Since you are 2<sup>nd</sup> year and almost ready to begin your thesis, are you willing to share some information about it with us?**

I want to start my thesis sometime in February and the topic is not totally set yet. I will most likely be looking at data from the Mauna Loa volcano on the Big island of Hawaii. In 2015, there was most likely a volcanic intrusion and thus a large movement of magma below the surface. The researchers have reached this explanation by taking GPS measurements, looking at InSAR images, deploying tilt sensors and having gravimeter campaigns. Most of the data seems to line up, but the gravimeter data seems to be off. This should have given quite a clear signal in the data so there might be something else going on. I will be re-evaluating the data and from my own conclusion to see if there was indeed an intrusion in 2015 or not.

**What do you see yourself doing after you graduate?**

Asking the real questions. I am not completely sure yet, I want to keep some options open but I am looking very much towards applying for a PhD either here in Delft or abroad (probably UBC if I can manage). If a PhD is not available, I will look for a job as a remote sensing and GIS specialist at a company or organization interested in the interaction between different components of system Earth.

**Do you have some advice for our fellow bachelor students that tend to go towards GRS?**

My advice for everyone interested in joining the GRS track is to truly start looking at the world around you and asking yourself the questions. How does that work? Why did that happen like that? To get a sense of how system Earth interacts with itself.

Now I have focused a lot on system Earth, but the master is also about the more human and societal side of things. We are also working towards developing the software for self-driving cars. Or how to determine exactly where to build a large office building or a dam. How do you make sure that these structures are not built 2 meters to the East and rotated by 1.5 degrees due West. These questions are also very interesting and important. This master really has something for everyone that is interested in the world around us.

## GENERAL INFORMATION

**Degree:**

Master of Science in Civil Engineering or Applied Earth Science

**Language:**

English

**Start:**

September and February

**Credits:**

120ECTS, 24 months Full Time

**Percentage of International Students:**

25%



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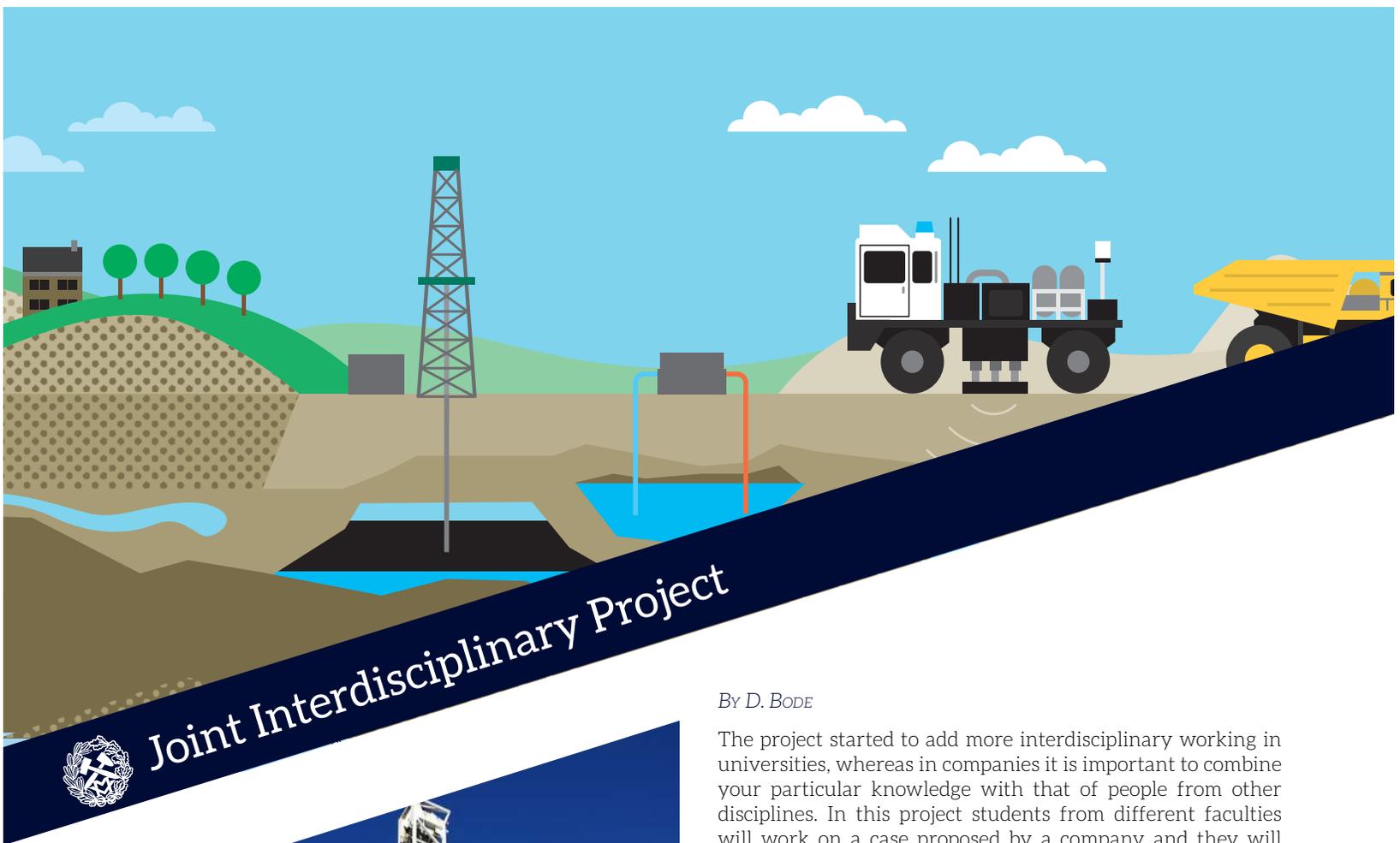
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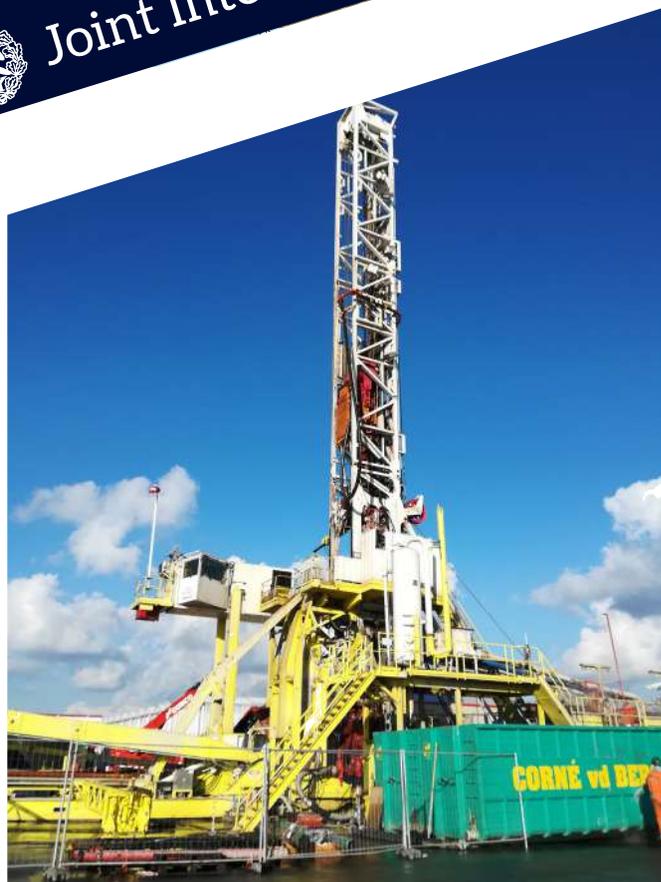
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## Joint Interdisciplinary Project



The first quarter of this year I joined the interdisciplinary project that is set up by Birgit de Bruin, Aldert Kamp and Hans Hellendoorn together with the study associations VSV, TG, Leegwater, Curius and the Mijnbouwkundige Vereniging. The first pilot of this project was focused on bachelor students and took place in 2016. In the time after this first pilot many changes were made and it resulted in a second years master project which is worth 15 ECTS. Last September the first version of this Joint Interdisciplinary Project for master students started and I was one of the students to participate in one of the interesting projects.

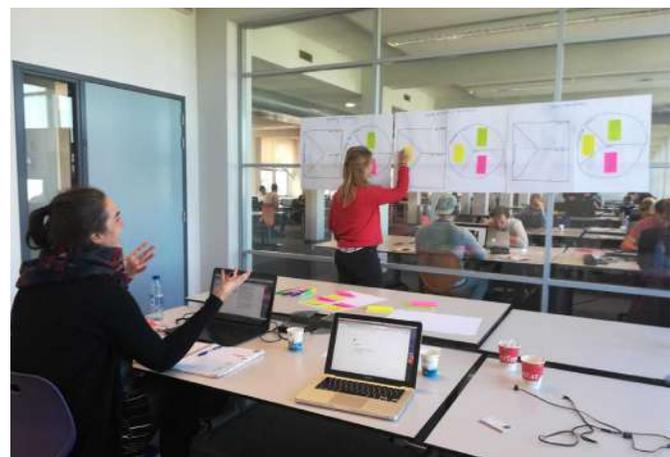
By D. BODE

The project started to add more interdisciplinary working in universities, whereas in companies it is important to combine your particular knowledge with that of people from other disciplines. In this project students from different faculties will work on a case proposed by a company and they will be guided throughout the project by a professor from our university and by a coach from the company. By working together in an interdisciplinary team it is expected that students can end up with new insights in the problem.

During this edition there were four groups of three or four students that worked together on a case for one of the companies that were involved in the projects, namely Huisman, Royal HASKoning and Feadship.

My team was working on a study on geothermal heat for Huisman. For students from Applied Earth Sciences this is of course not a totally new topic. Karlijn and Abhinav, the students I worked with, are doing their master at 3Me and TPM and they did not know much about the technique of geothermal heat.

We started with a meeting with our company coach from Huisman, so he could tell us more about the project and what questions needed to be answered. The project was not so much about the technical aspect of geothermal heat itself, but was more focused on implementing this technique on large scale in the Netherlands to provide heat for households. In order to get a grip on the research topic we decided to start by gathering information on energy transition, household heating, hot water reservoirs in the Netherlands, and transporting heat. This information was not only considered



“It was fun to see more of Abhinav’s culture and the Indian dancing class we took was quite a challenge for our stiff Dutch bodies.”

for geothermal heat, but also for other energy sources like solar energy, wind energy and biomass. In the end we made a comparison between these different sources to see in what aspects the energy source is a good alternative for the gas that is mostly used nowadays and in what aspects it needs improvement. Some of the aspects that we considered are the ease of implementation, costs, social impact, environmental impact and reliability of the source. To get all information we needed we did a lot of literature search, which I never did so thoroughly before. This was a very useful part of the project, but also a bit boring now and then. Luckily, we also planned some conversations with stakeholders, to get away from the literature search sometimes. Stakeholders we spoke with are geothermal plant owners and representatives of energy companies, municipalities and housing corporations, researchers from TNO as well as professors in geothermal heat, energy policy and built environment. During appointments with these stakeholders we discussed what we found in literature and got their points of view on problems we came up with. This resulted each time in renewed insights or even in changes in our research scope.

The freedom during this project is an aspect that I really appreciated. As a team you can decide how often you need a meeting with your company supervisor and we were free to contact and meet stakeholders of our choice. On the other hand, at the start of the research it was difficult to define a scope, because of the freedom we got in the research topic. However, forming the definition of the scope and not moving away from this scope again is a part of the project that we all learned a lot from. Once the scope was defined it was easier to work towards specific goals and we had a meeting once a week with our company supervisor to discuss the progress. Next to these weekly meetings there are some lectures organised in the Buccaneer. During these lectures all groups needed to be present and one of the company coaches or a professor would give us a lecture. For example, we had a lecture on value proposition for different stakeholders which is really useful to use in the start of a feasibility study like ours. We also had an ethics lecture, which was about value sensitive design, which is about considering the consequences on society by implementing a certain technique. Another lecture was about basic calculations, which is apparently a test that every employee of Huisman needs to pass. We took the test as well and we got some more time to finish it than employees of Huisman. However, the teams of JIP were the worst graded group of all times... So during this project we also learned which of our skills need some further improvements. Luckily, the two teams of Huisman were still allowed to go to the Huisman office for meetings, although we did not pass the test. Next to the new knowledge that was obtained during these lectures at the Buccaneer, it was also possible to see what the other project groups achieved so far. All projects were very different, so also the way the project was approached was very different for each group. All in all, I can say I have learned a lot about difficulties behind the implementation of a technique, like some renewable energy sources. Next to that we learned a lot from



each other and we had a lot of fun working together. Next to the project we also learned a lot from Indian culture and we told Abhinav more about the Dutch people and their habits. Living in the Netherlands during November asks for some tasting of boerenkool, pepernoten and oliebollen and maybe some explanation on the zwarte Pieten discussie. And we were happy to explain Abhinav all about these things. After we finished our project we celebrated Diwali together, which is an Indian holiday. Abhinav was in the organization of this party which took place at the culture centre in Delft, so he invited us. It was fun to see more of his culture and the Indian dancing class we took was quite a challenge for our stiff Dutch bodies. However, we managed to dance along at the party once the Bollywood DJ played some tunes that everyone in the room could sing along. To work together with students from other cultures is not a totally new thing in our bachelor, since the AES students are of many different nationalities. So I think this part of the project is especially an interesting extra for students of other bachelor studies in Delft where only Dutch students participate in.

For coming year JIP has already some new ideas to expand the project by involving other universities or include projects from abroad. If you have interest in joining this project next year or have questions on what the projects will look like next year, you can always ask Jeanne for more information!





## Innovative Teaching Award

**Hadi Hajibeygi is an associate professor and lecturer on Reservoir Simulation and Rock Fluid Physics at the Faculty of Civil Engineering and Geosciences. In November 2018 he won the Innovative Teaching Talent Award. Therefore, we asked him to give us an insight about his vision on integrated approach for effective development.**

*Photo credit Moe Zoyari*

Educating young talents to increase prosperity and wellbeing of our planet Earth inhabitants is our core responsibility as teachers at universities. Even conducting research at universities is part of our educational activities, in the sense that we, professors, train young talents to develop the necessary skills for conducting research on a new subject, and to disseminate its findings transparently and comprehensively. Studies on university professors have shown that being a good researcher does not correspond to being a good educator [Rev. of Edu. Res., doi: 10.3102/00346543066004507]. Therefore, we, professors, need to improve our teaching skills constantly, and take this task very seriously. After a couple of years of study, our graduates leave us with the hope that their education has made them ready to pick up their role responsibly and effectively in the society.

Our societies develop and face new challenges. Our graduates, therefore, will also face predictable and unpredictable challenges in their professional careers. They may end up changing their careers a few times before their retirement. One of the main components of our society development is related to the technological revolution, which is expected to broaden its scope and enter new areas that interfere even further with classical human technical skills. At the same time, these technological advancements offer enormous opportunities such as convenient connectivity between people and swift access to massive amount of information. The need to be innovative in education is, as such, essential due to the 'intellectual evolution' of the human societies. The society asks more for a proactive professionals who invent innovative solutions in their jobs, rather than passively perform their well-described structured job responsibilities. It is seriously doubtful whether classical university education methods and in-the-box professionals will get any place in the future; e.g. the necessity of a knowledge-based university diploma for a job may soon indeed fade away. It is questionable, now more than ever, that based on what skills universities should license their graduates such that they

*By H. HAJIBEYGI*

can place themselves in the right position in the society after graduation.

With this introduction, I would like to express my view on education. Before doing so, let me first share with you an experience that happened to me a while ago. It was in winter of last year, when I was in my backyard garden planting a dead dry plant. Soon after, in spring, I found it had become a beautiful flower full of blooms. I could not believe it was the same dry plant in the winter. A complete surprise!

That made me wonder isn't it what we want to achieve with our students: "having them flourish"? Not only the smart ones whom can lead their own success, but also those we do not expect (like my dry plant in winter) and, specially, those who don't expect (believe in) themselves!

To achieve this goal, we often look into our course as the source of nutritious (soil of my garden)! So we plant our students in our course, with the hope that they flourish. And if they don't, hopefully, we invest a lot of effort to improve our course (more fertilizer in the soil). But we all know for a flower to flourish it takes the right 'environment for growth!' Soil is just one component, and certainly necessary but not enough!

**Community**



**Research**

**Course**

▲ Figure 1: Education environment

Education to me is an integration of all activities, thus an environment, that we design at universities to facilitate students to develop; and unless in balance, harmony and connected, we cannot achieve our goal, i.e. flourishing students, who are ready for unexpected future challenges. Those who generate scientific solutions (like an apple tree), rather than memorizing solutions or skills in their minds (holding apples in their baskets). The environment leads to growth, not the isolated courses we teach! The education environment has other components beside the 'course': 'research' and 'community'. (Figure 1)

Research can be seen as the series of activities that a student performs under supervision of a professional to absorb a complex problem (capacity), find its relation with (possibly many) disciplines and stakeholders, decompose it into logically connected smaller modules, design or synthesize or invent an applicable solution, and disseminate it comprehensively to the stakeholders. In fact, in our MSc curriculum, only after successfully conducting a final research project we offer the students with a diploma.

Another component of educational environment is the 'community'. Community is the network of people who share challenges, goals, and concerns. Their connection and team makes them stronger, more effective, and increases the chance of their success. It gives them identity, and makes them be units of a big whole. The crucial role of community in the education environment cannot be disregarded, nor can it be left out of the focus and scope of the teachers. Note that the community should not stay only among students' peers within their departments (like student associations etc.), but with students and teachers and also technology owners and policy makers. Unless the community is in place and connected to other education components, the environment is incomplete.

Let me provide an example on how I create the educational environment. The first component is effective course development. I teach "Rock Fluid Physics" and "Reservoir Simulation" MSc courses. I also contribute in "Grand Challenges in Applied Earth Sciences" course, which is a BSc 1st quarter course. The topics I teach are mainly about physics of flow and transport in porous media, more on the modeling and simulation side. I have designed my course contents, even for these fundamental topics, based on "affordable experience of science". In my courses, we experience the science by designing an easy (affordable) yet creative setup inside the class to curiously study what we model. We engage together to discover, justify, debate and develop collectively fundamental modeling science for predicting the fluid dynamics and heat transfer in porous media. I distribute syringes to the students, with sand, a thermometer and a bottle of water. Of course, they need their phones (to measure, for example, discharge time of water and some physical properties from the internet) but that's pretty much it! I avoid



▲ Figure 2: Experiencing flow in porous media in the class

fancy isolated experiments, as they are not affordable in our daily life! In simulation course, I connect my laptop to the projector while students are behind their computers too, and we develop codes together based on the scientific bases and discussions. (Figure 2, 3 & 4)



▲ Figure 3 & 4: Experiencing flow in porous media in the class

As for the research and community development, I have established Delft Advanced Reservoir Simulation (DARSim) research group in 2013 and several activities around it. DARSim hosts several graduate and PhD students who work on simulation of flow and transport (mass, energy, momentum) in porous media (mainly geoscience applications). Now together with my colleagues, we host several DARSim lectures to invite external experts to come to Delft so our students get engaged with their research and visions. I explicitly ask our invited lecturers to present their materials understandable for an average MSc student. We also send our students outside to connect with external collaborators, whether at industry (through internships or visits) or other universities. We chair international events, and involve our students to connect with our network. This has made DARSim connected to the international research community, which has increased our students' visibility and impact, and finally has helped them to secure a proper position for themselves after graduation. (Figure 5)



▲ Figure 5: DARSim lecture 2014

To end, my example is, of course, one way of constructing the healthy 'teaching environment', and definitely there can be several other ways to make it. Nevertheless, my main message to all is: for flourishing students, create an integrated environment for growth! Do not put all your efforts only on one local isolated course. Education is a global, integrated, and environmental activity. The right environment makes students flourish, even those who don't believe in themselves!



# Master Thesis: On Automated Dig-limit Optimization through Simulated Annealing

By T. HANEMAAJER

## Automated dig-limit optimization through simulated annealing.

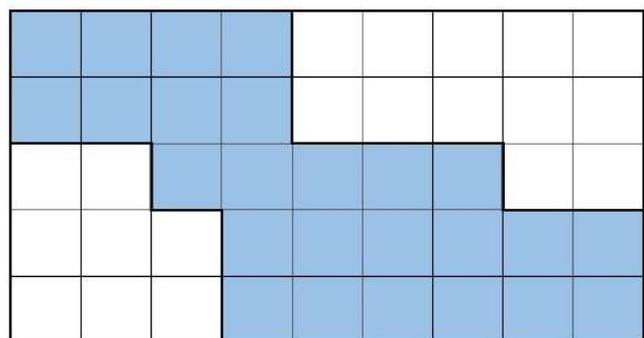
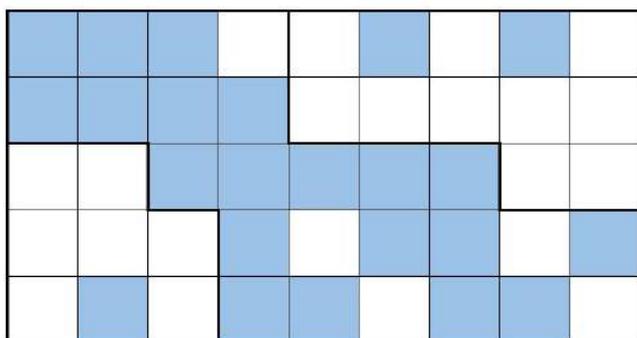
As ore-bodies become more complex and difficult to extract, mining operations need to increase their efficiency and performance. Dig-limit design is part of the short-term mine planning in open pit mines. Dig-limits are the boundaries between material destinations in a mining bench. Common practice in the mining industry is that these are created manually by a mining engineer, however, this results in subjective and sub-optimal dig-limits. In this thesis an automated optimization program was written to optimize these dig-limit designs. The optimization of dig-limits is a combinatorial optimization problem which has proven to be NP-hard, it cannot be solved exact in a reasonable time-frame (Sari et al., 2017). Therefore, the meta-heuristic method of simulated annealing has been used for the optimization program. An heuristic optimization method uses a smart method to search the solution space without the need to go through all possible solutions. These methods cannot guarantee that the global optimum is found but will find a near-optimal solution within a reasonable computing time.

## Dig-limits

After the drilling of blast-holes, more detailed grade distribution information is available about the mining bench. These blast-hole data enable more precise scheduling of mining sequences and ore-waste classification. The data are assigned to mining blocks called selective mining units (SMU's). However, in reality an ore-waste classification on SMU-scale is not practicable. Firstly, the mining equipment is very large to mine single SMU's and send them to different destinations (Sari et al., 2017). Secondly, if it was possible to mine individual SMU's there would be a significant dilution and ore-loss due to frequent ore-waste boundaries, and thirdly, this frequent switching between ore and waste mining will have a great impact on the production rate (Ruiseco et al., 2016). For this reason, dig-limits are created. Dig-limits group SMU's together complying to the spatial constraints of the mining equipment and assigning them to a certain destination. The dimensions of this minimum group of SMU's will from now on be called the minimal mining unit (MMU). Dig-limits are the boundaries separating the material in the mining bench that is sent to different destinations, for example to the processing plant, the leach heap or the waste dump. This grouping of SMU's and sending them to a single destination will automatically result in the misplacement of certain SMU's. Some high-grade SMU's initially classified as ore will be sent to the waste dump, which is called (ore)loss, and the other way around, some low-grade SMU's classified as waste will be sent to the processing plant, which is called dilution. Figure 1 illustrates a grid that is divided on SMU basis, and the same grid that is divided by dig-limits, with a clustering size of 2x2 SMU's.

The molecules in the solid will rearrange themselves in a way to minimize the Gibbs free energy, this minimizes the number of dislocations of the molecules changing the metals ductility and hardness (Van Laarhoven and Aarts, 1987).

Simulated annealing starts with an initial solution for the problem, from here it makes a change into a neighbouring solution, called a perturbation. The new solution is then accepted or rejected based on the difference in the objective value. In the dig-limit problem, this objective value is the profit of the solution minus the penalty applied to the solution for constraint violations. If the objective value increases, the solution is always accepted, if it decreases, the solution may still be accepted with a certain probability, this prevents the solution to get stuck in local optima. The probability of acceptance depends on the magnitude of the difference in objective value, and on the 'temperature'. The temperature is a control parameter for the acceptance of worse solutions and is regulated by a 'cooling schedule'. Initially the temperature will be high, such that most of the worse solutions are accepted, and the algorithm makes a broad search of the solution space. During the course of the algorithm, the temperature is lowered, and less bad solutions are accepted. This will make the algorithm converge into the found local optimum (Eglese, 1990). The mining constraints in the simulated annealing program are enforced by applying a penalty to the objective value for constraint violations. Different varieties for the simulated annealing program have been tested to investigate their applicability for dig-limit optimization and their performance. These options are

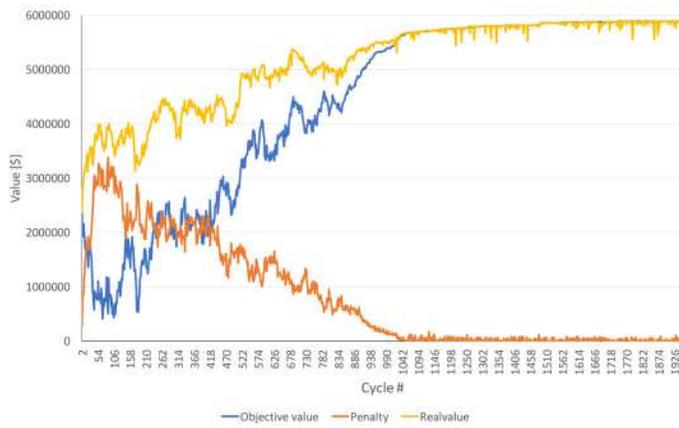


▲ Figure 1, Dig-limit clustering

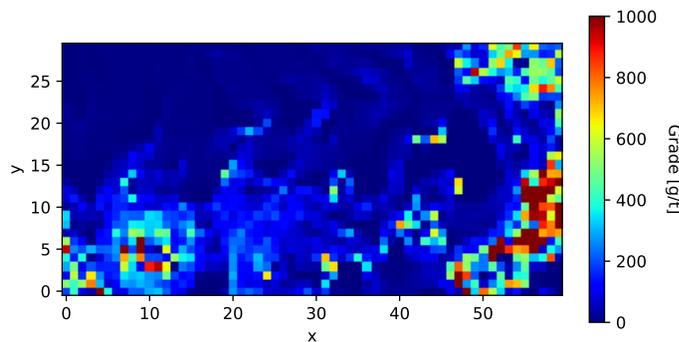
## Simulated annealing

Simulated annealing is a meta-heuristic optimization method that is often used for the optimization of combinatorial problems. It is based on the annealing of solids, a process where metals are first heated to their melting point, and then slowly step-wise cooled down following a cooling schedule.

written as interchangeable modules which are all compatible to each other and can easily be implemented in the program. Different methods were investigated for the initial solution, the constraint penalty, the cooling schedule, the perturbation mechanism and the stop criteria of the algorithm.



▲ Figure 2, Course of the algorithm.



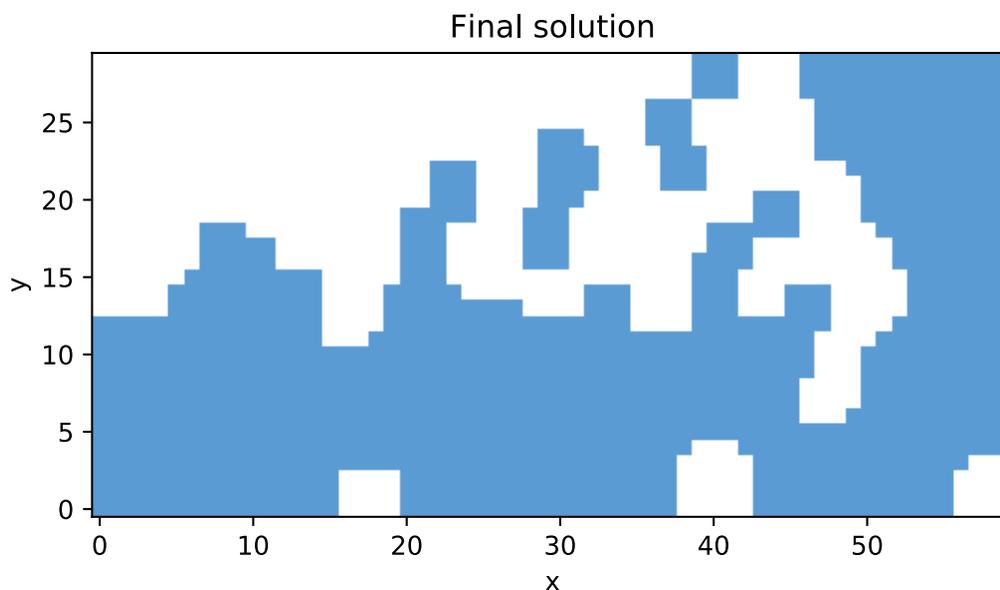
▲ Figure 3, Grade-map of the test-case.

### Conclusion

The resulting automated dig-limit optimization program was successful in creating near-optimal dig-limit designs. The program is flexible and can be adjusted for multiple material destinations, multiple ore-types and different shapes and sizes for the spatial mining constraints. The objective function can be adjusted for different optimization goals. This makes the program potentially applicable for different types of open-pit mining operations.

### Results

The best performing combination of modules was a random initial solution, with a quadratic cooling schedule, a random perturbation mechanism, which stops after a certain number of consecutive rejected perturbations. Figure 2 shows the objective value, the penalty value, and the real value of the solution in the course of the algorithm run. It can be noticed that the objective value gradually increases, and that the magnitude of the decreases in the objective value are becoming smaller as the temperature decreases. In the end of the temperature schedule at cycle 1000 there are no more worse solutions accepted and the algorithm converges into the found local optimum. At the end of the algorithm there is no more penalty assigned to the solution, meaning the mining constraint is not violated anymore. The algorithm was tested on a case which is a part of the artificial Walkerlake data-set. Figure 3 shows a grade map of the 60x30 SMU's in the test grid. Figure 4 shows the final solution of the algorithm, where the blue blocks are assigned as ore, and the white blocks as waste. When comparing the final dig-limit design to the grade-map of the test case it is clear that the ore in the dig-limit designs match the high-grade areas of the grade-map. The value of the final solution deviates by 1.96% from the free-selection value of the grid. The free-selection value is the profit of the data-set if every single SMU is sent to its optimal destination. This means that this value is always higher than the unknown global optimum of the dig-limit problem, where SMU are grouped together, and some SMU's are sent to a not-optimal destination.

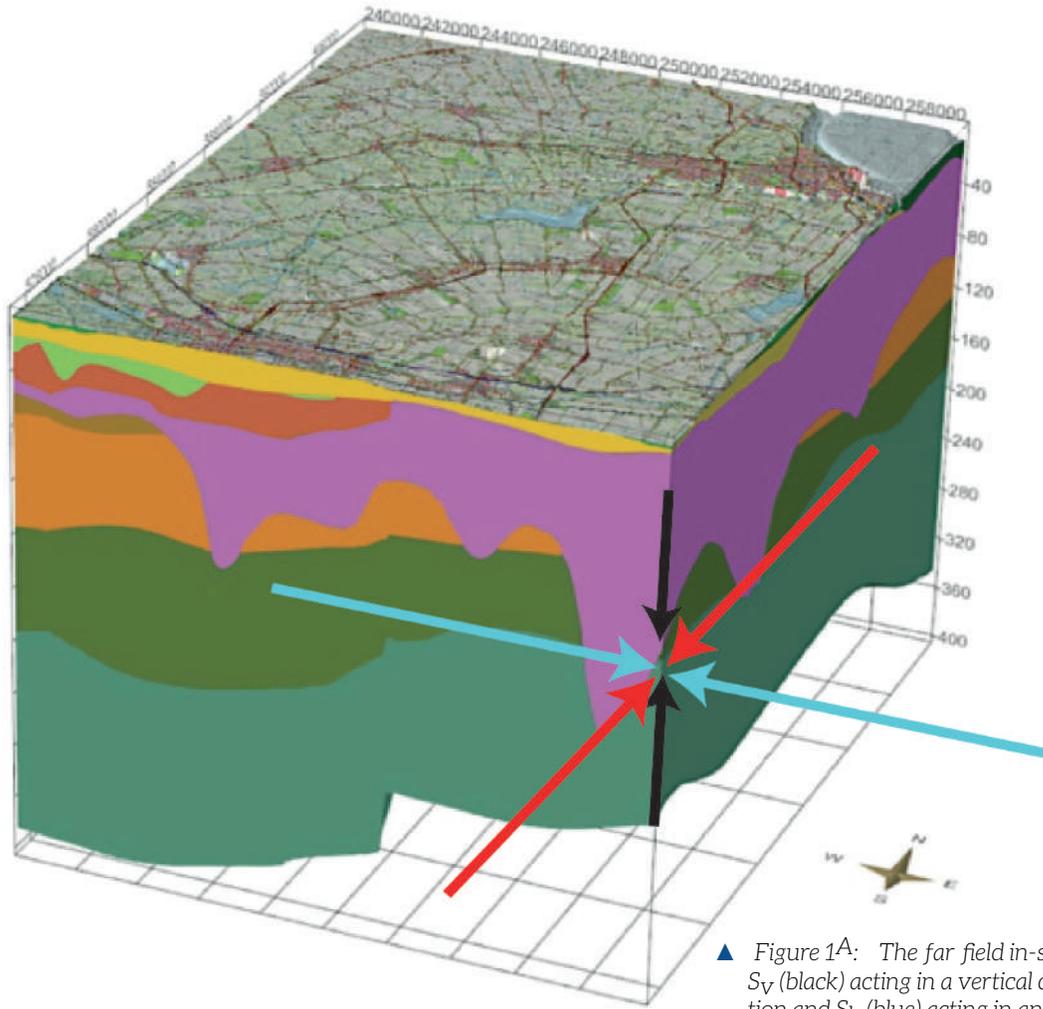


▲ Figure 4, Dig-limit of the final solution.

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A



▲ Figure 1A: The far field in-situ stresses located in the subsurface.  $S_V$  (black) acting in a vertical direction,  $S_H$  (red) acting in a N-S direction and  $S_h$  (blue) acting in an E-W direction.



## Bachelor Thesis: On the Relation between Borehole Breakouts in Deviated Wells and the Far Field In-Situ Stresses

By R. VAN LIMBORGH

SUPERVISORS: DR. IR. D.J.M. NGAN-TILLARD & DR. A. BARNHOORN

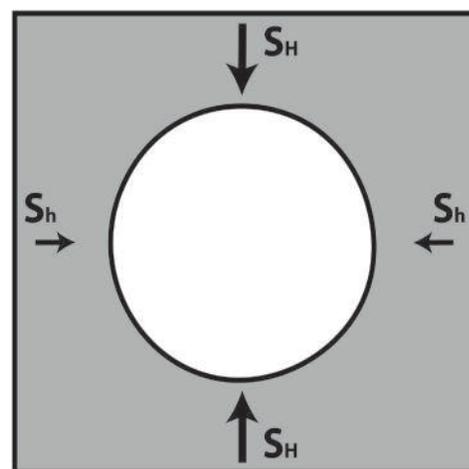
Last year I chose to participate in a research project for my minor. This project focused on the structural geology of an anticline located in the West of Morocco.

During this project, in which I studied geology on a large scale (1-10km) it became clear to me that a lot of the clues for this large-scale geology where in small scale fractures (1m<) located in the area. I got more interested in these small geological features and decided to focus on small-scale rock mechanics for my BSc thesis.

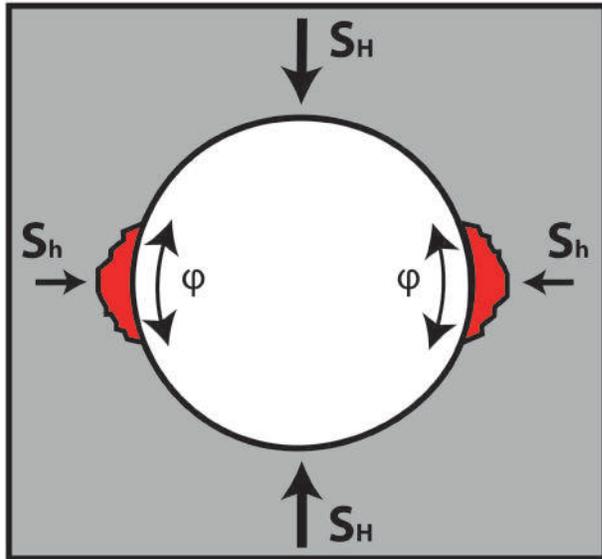
Dominique Ngan-Tillard, the supervisor for my thesis pointed me at several papers on far field in-situ stresses, which can be a cause for the fractures I found in Morocco. In these papers, borehole breakouts were mentioned a lot as stress indicators and that is in a nutshell how we ended up with the subject I will try to explain in the sections below!

Stress is a concept which is fundamental to rock mechanics principles and its applications. The stress state at a given point in a rock mass is generally presented in terms of the magnitude and orientation of three 'principal stresses' acting perpendicular to each other (Hudson and Harrison 2005). If the orientation of these stresses is constant in a larger area, these three principal stresses are called the 'far field in-situ stresses'.

Proper characterization of the present-day far field in-situ stresses is of crucial importance to understand geo-mechanical processes in the subsurface. The magnitudes and directions of the far field in-situ stresses are of key importance to optimize the design and construction processes of civil engineering works, such as tunnels. Knowledge of the in-situ stresses is used extensively in the development and



▲ Figure 1B: Horizontal stresses in the subsurface when looking vertically downwards in a borehole.



▲ Figure 1C: Locations where breakouts develop in vertical boreholes, with angular width  $\phi$  indicated.

production of hydrocarbon and geothermal projects as well as it is of large essence to understand the influence of the far-field in situ stresses during the process of well planning and well drilling. This is, because these stresses play a key role in the stability of wellbores. At this point the concept of 'borehole breakouts' comes in.

### Breakouts in vertical wells

Although my thesis focuses on breakouts in deviated wells, I will use the concept of breakouts in vertical wells to introduce the relation between far field in-situ stresses and breakouts.

Within 1 or 2 kilometers of the Earth's surface, in areas of low topography, one principal stress is generally considered to be vertical (Mastin 1988). Keeping in mind that the principal stresses act perpendicularly, this means the other two principal stresses will be acting in a horizontal plane. We will call the vertical stress  $S_V$ , and the two horizontal stresses  $S_H$  and  $S_h$ , assuming  $S_H > S_h$ .

When a borehole is drilled the forces previously carried by the removed rock are to be carried by the surrounding rock (Kirsch 1898). This change produces stress at the borehole wall. At locations where the compressive stress concentration at the borehole wall, the so called 'hoop stress', exceeds the rock strength, failure occurs in the form of breakouts (Peska and Zoback 1995). The width and location around the borehole of the breakouts is strongly controlled by the magnitude and orientation of the far field in-situ stresses (Zoback et al. 1985).

The hoop stress reaches a maximum value at the point where it intersects with the smallest principal stress ( $S_h$ ). This means that the location of the breakout can be used as an indicator for the orientation of the smallest principal stress  $S_h$ , as well as for the other far field in-situ stresses, since they are orientated perpendicular to each other (Mastin 1988). The angular width of the breakout ( $\phi$ ) can be used as an indicator for the magnitude of the far field in-situ stresses (Barton, Zoback and Burns 1988).

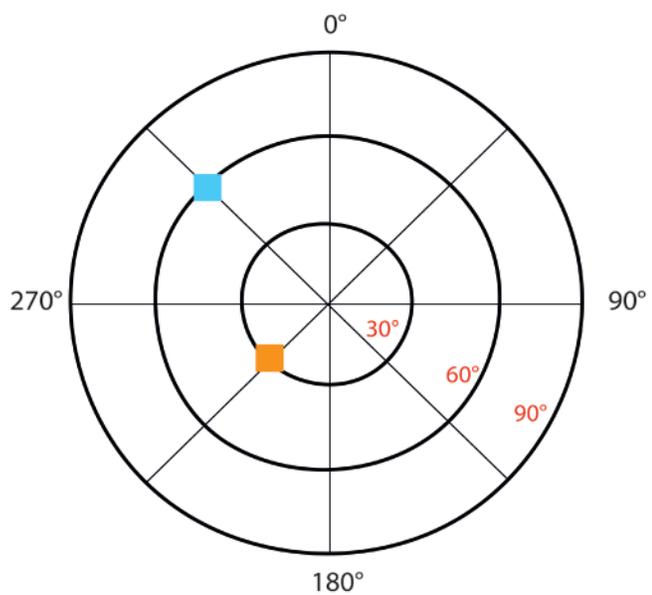
The relation between far field in-situ stresses and borehole breakouts in vertical wells is visualized in figure 1. This relation however is only possible because in this case the borehole orientation.

### Breakouts in deviated wells

To relate the orientation and magnitude of far field in-situ stresses to the location and the width of breakouts in deviated wells the in-situ stresses must be rotated into the coordinate system of the deviated borehole.

Stress is acting as a 'tensor', described by nine components giving information on magnitude, direction and the plane under consideration in a three-dimensional space. A tensor is built up as a 3x3 matrix, of which all values will change when the tensor is rotated. The rotation of tensors is done using transformation matrices.

After the rotation of the in-situ stresses to the coordinate system of the deviated borehole, one is able to determine the stresses acting at the borehole wall (Zoback et al. 2003), which are related to the orientation and the width of the breakout.



▲ Figure 2: The lower hemisphere projection method used to display the results. The black degrees give the orientation of the well ( $0^\circ$ - $360^\circ$ ) and the red degrees give the deviation of the vertical of the well ( $0^\circ$ - $90^\circ$ ). Examples: the blue square has an orientation of  $315^\circ$  and a deviation of  $60^\circ$ . The orange square has an orientation of  $225^\circ$  and a deviation of  $30^\circ$ .

### Simulation and results

Data on the magnitude and the orientation of the far field in-situ stresses and rock properties (Poissons ratio, UCS, pore pressure) can be relatively easily gathered from vertical boreholes. Combined with the rotations mentioned above and the derivation of the stresses acting at the borehole wall of the deviated well we are able to derive breakout characteristics in boreholes deviating in any direction in any angle.

The simulation is based on artificial far field in-situ stress data and rock properties based on the subsurface of the North of the Netherlands.  $S_H$  is acting on a N-S azimuth and  $S_h$  is acting on a E-W azimuth. The simulation is at a depth of 3000m. The rock mass is assumed to behave in a linear elastic way and to be homogeneous isotropic.

The results are visualized using a lower hemisphere projection method, of which an example is given in figure 2.

To show that there is a relation between the far field in-situ stresses and the stresses at the borehole wall in deviated wells the minimum stress at the borehole wall (figure 3A) and the maximum stress at the borehole wall (figure 3B) are plotted. Figure 3A and figure 3B show that both the minimum stress and the maximum stress at borehole wall stay smaller in the direction of  $S_H$  than in the direction of  $S_h$ .

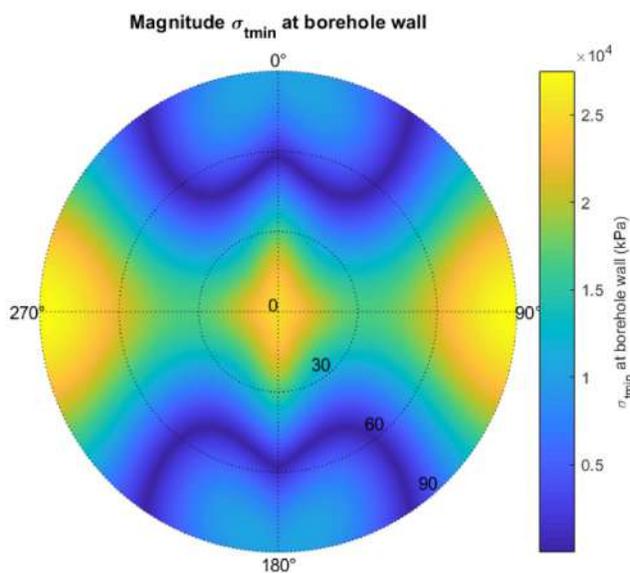
Figure 3C shows that also the breakout width is dependent on the far field in-situ stresses as well as on the deviation of the borehole. Wells deviated along  $S_H$  (N-S) show little to no breakouts until the angle of deviation is  $35^\circ$ . Wells deviated along  $S_h$  (E-W) however show large breakout widths already at  $20^\circ$  deviation angle.

The results show that there is a link between far field in-situ stresses and borehole breakouts in deviated wells. Simulations can be done to derive breakout characteristics from knowledge on the far field in-situ stress and rock properties.

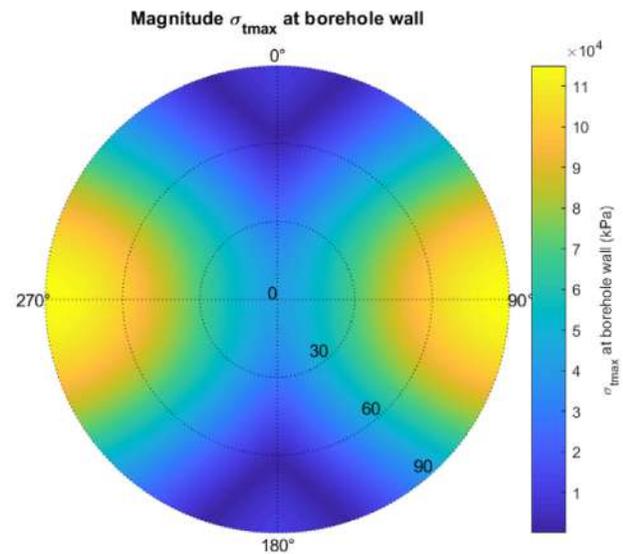
The results can be used as a starting point to develop a more advanced method which will include more field parameters. This can be used to make more specific predictions on borehole stability, improving the process of well planning and drilling.

Another application could be to try to reverse the simulation and the derivations in order to gather more data on far field in-situ stresses in certain cases. These stress derivations can contribute to a better understanding of the far field in-situ stress regimes, as most knowledge is based on stress analysis from vertical wells at this moment.

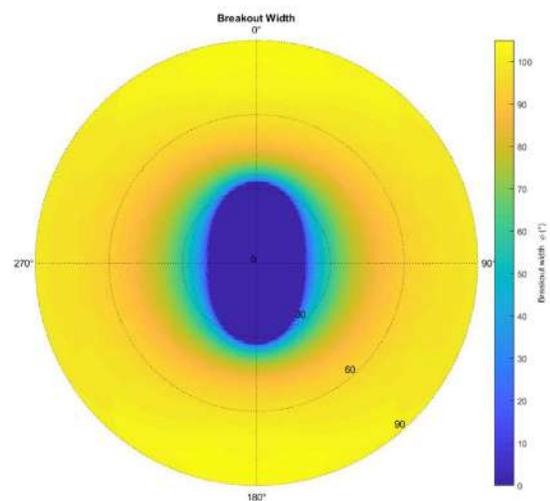
▲ ▼



▲ Figure 3A: Results of simulation from far field in-situ stresses to borehole and breakout characteristics in arbitrarily deviated wells, displayed in lower hemisphere plots. The magnitude of the minimum principal stress at the borehole wall in kPa.



▲ Figure 3B: The magnitude of the maximum principal stress at the borehole wall in kPa.



▲ Figure 3C: The breakout width ( $\Phi$ ) in degrees.

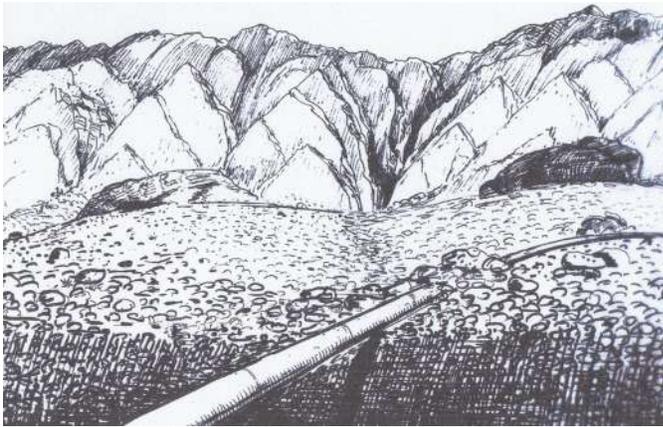
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# ADVENTURES IN IRAN IN 1961

By K. WEBER

**M**y first business trip for Shell had as purpose to collect well data from the giant Gach Saran field.



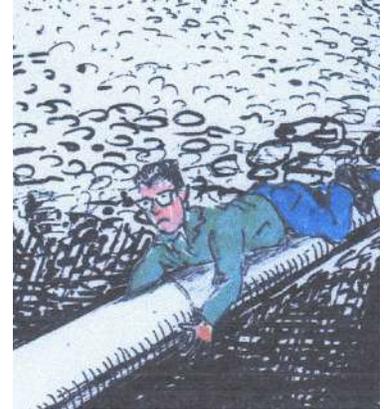
In the Shell exploration and production laboratory (KSEPL) we had already carried out the analysis of several cored wells, but more data was required to determine a realistic oil-in-place volume.

This was my task. Shell was a partner in the Consortium of companies that had taken over from Anglo-Iranian after the demise of Mosadegh. The Shah was back in power and everything seemed peaceful.

After arriving at the guesthouse in Gach Saran, I went out for a stroll to stretch my legs. Behind the guesthouse to the north a long slope ran up to the foot of the outcropping flank of another giant anticline. On this slope there were several large blocks of limestone that had slid down from the broken mountain flank. In one of them I noticed a large cave. Being an ardent archaeologist decided to climb up to inspect this cave.



After a few hundred meters I hit upon a deep steep-sided gully that appeared to run parallel to the mountain flank. Some distance away I saw a thick pipeline crossing the gully. In my eagerness to get to the cave I didn't hesitate but walked over it.



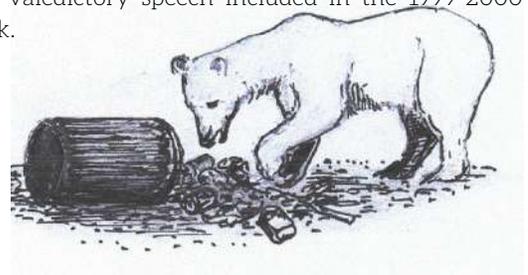
The cave was indeed large and behind the entrance several corridors branched off. However, the stench that came out of the cave was so nauseating that I decided to leave the possible artifacts in peace and return. After all I was very thirsty and the guesthouse had a well-stocked bar in these pre-Khomeini days. Walking back I could only think about

the pipeline and my courage was disappearing rapidly. Hoping that nobody would see me, I crawled back across the pipeline on my belly.

I also kept wondering where the horrible smell in the cave was coming from. I remembered visiting an abandoned copper-mine in Ireland where a sheep had fallen in with a similar result. The next night I was woken up by some loud crashes outside my window. At breakfast I asked the steward what the origin of the crashing sounds might be. "Oh yes" he said, "this is the bears searching for food by throwing over our garbage cans, they live in that big cave you can see over there"

Having just recovered from this shocking news there came a loud honking noise and a large bus stopped in front of the door. Immediately about a dozen ladies tumbled out obviously in an agitated state and ran inside to the toilets. They later complained that there were no bushes along the road for hours! They were on their way to New Delhi. This was a regular bus service starting in London and proceeding via the Balkan, Turkey, Iran, Afghanistan and Pakistan to India. This illustrates how the world has changed because this bus service would not come very far nowadays!

The Gach Saran well data gathering resulted in a great disappointment. The system used to collect cuttings and make thin section was so flawed that nothing of value could be derived. This rather hilarious episode is recounted in some detail in my valedictory speech included in the 1999-2000 MV Yearbook.





## WeberPuzzle: Marine Hazards for the Unwary

By K. WEBER

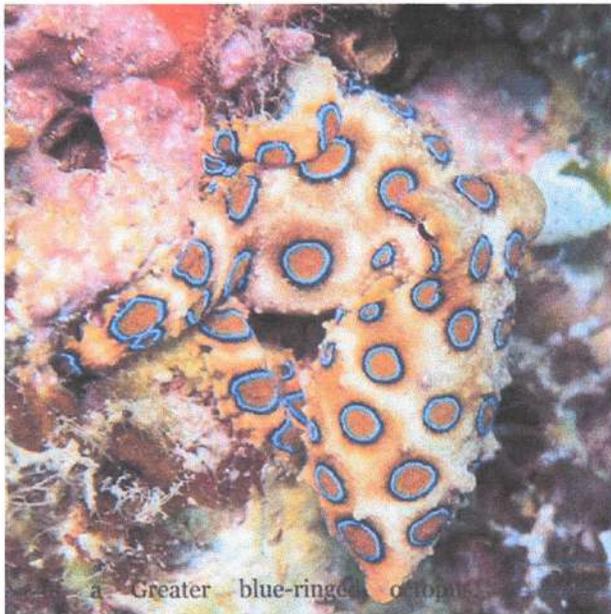
Tropical coral reefs are favourite sites for excursions. They are teeming with a great variety of wildlife. Among these creatures however there are quite a few that can cause severe injuries which are sometimes even fatal. Especially walking around in shallow places or grabbing interesting specimen can be hazardous. Below you see six animals that you shouldn't touch or step upon. Can you name them (Latin name is not required) and specify the danger they represent?



1



2



3



4



5



6



## WeberPuzzle Solution: Famous and Infamous Tankers

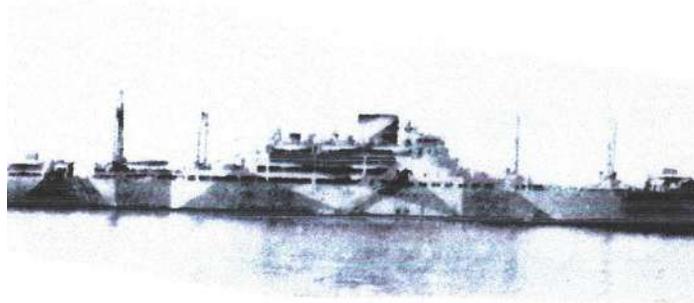
By K. WEBER

1. Glückauf, built at the yard of Armstrong Mitchell in Newcastle upon Tyne for the German entrepreneur Riedeman. She was the first ship with compartments specifically for oil. Ready in 1886 she could transport 2307 tons of oil.

2. Murex, a Shell tanker launched in 1892 in London and able to transport 3564 tons of oil. She was scheduled to transport oil from the Black Sea to the Far East. She was the first tanker to pass through the Suez Canal in August 1892. She was torpedoed in 1916 and sank off the coast of Port Saïd.

3. The Ohio. This American tanker formed part of an important convoy to Malta during the critical period of August 1942. Although being provided with a large escort including aircraft carriers, only five of the fourteen fast merchant ships reached Malta because of the continuous attacks by planes, submarines and MTB'S. The Ohio suffered torpedo and bomb hits while a crashed German plane lay wrecked on the deck. Eventually she was towed into the harbour by a destroyer in sinking condition. She was beached and her vital cargo could be pumped ashore.

4. The Ondina. This Shell tanker left Western Australia destined for India with a cargo of fuel and grain. She was escorted by the 400-ton minesweeper 'HMS Bengal'. Near Christmas Island they were intercepted on the 11th of November 1942 by two Japanese auxiliary cruisers: the Hokoku Maru (10.400 Tons) and the Kumikawa Maru (7.000 Tons). They were fast modern motor ships, armed with 15 cm guns and torpedoes. Turning away they were gradually overhauled and under fire. Captain Horsman ordered to open fire with the single 10,2 cm gun at the stern of the ship. After only a few shots a lucky hit caused an explosion on the Hokoku Maru, so violent that the ship broke in two and sank! On the approach of the Kumikawa, captain Horsman ordered 'abandon ship' but for him it was too late, he was killed by a hit on the bridge. The crew got away on three sloops and two rafts. The Kumikawa approached to a distance of 400 meters and fired two torpedoes that both hit the Ondina, causing a list increasing to about 35 degrees. After the sailing away of the Kumikawa, leaving the apparently sinking tanker, the crew got back on board. They levelled the ship by counterflooding and managed to restart the engine. They reached Fremantle on November the 18th.



▲ The Hokoku Maru

5. The Amoco Cadiz (28.513 DWT) stranded on the 16th of March 1978 about 5 kilometers in front of the coast of Portsall at the NW-tip of Bretagne, while sailing from the Persian Gulf to the port of Le Havre. During a storm a problem with the steering installation rendered the ship unmanageable and it drifted to the rocks spilling some 200.000 tons of crude oil, fouling the Breton coast over at least 300 kilometers.

6. The Seawise Giant, largest tanker ever built, 657.000 tons after lengthening. Built in Japan by Sumitomo in 1976, length originally 458 meters, beam 69 meters and draft + 25 meters after lengthening by Nippon Kokan in 1980. She was eventually scrapped in 1980.



▲ Seawise Giant on the sea trails after she was lengthened

7. The Atlantic Empress with 275.00 tons of crude oil on board, collided on the 19th of July 1979 with the Aegean Captain which carried about 200.00 tons of oil. After the collision the Atlantic Empress caught fire all over the ship while on the other tanker only the bow caught fire. This ship could be salvaged and was towed to Trinidad. The Atlantic Empress kept on burning and was racked by a series of explosions. She sank on the 3rd of August 1979, leaving a vast burning oil slick.



▲ Coming Soon

8. The Exxon Valdez, left the oil terminal at Valdez in Alaska for the 29th time following a southern route through Prince William Sound. A steering error made her hit Bligh Reef on the 23rd of March 1989. She didn't sink and was later salvaged, but a volume of some 100.000 tons of crude oil was spilled. This polluted 1.900 kilometers of shoreline and killed over half a million birds, 5.000 sea otters and many seals.

# GRADUATION SUBJECTS

**Dr. D.V. Voskov**

Yuan Chen:  
"Optimization Strategies of CO2 injection for Sequestration and EOR"

**Prof. dr. W.R. Rossen**

Herru As Syukri:  
"Experimental Study: Foam Generation and Propagation in Flow Across a Permeability Contrast"

**Dr. H. Hajibeygi**

Rhadityo Bhaskoro Arbarim:  
"Algebraic dynamic multiscale simulation of single phase flow in heterogeneous geothermal reservoirs"

**Prof. Dr. G. Bertotti**

Nasar Pragt: "Geological history and fracture network characterization in unconventional reservoirs of the McArthur Basin (NT Australia)"

**Prof. Dr. P.L.J. Zitha**

Azeddine Toutouh:  
"Drag Reduction in Turbulent Flows by Polymers and Surfactants"

**Prof. Dr. W.R. Rossen**

Rayner D'Silva:  
"Multi-objective CT core floods study and simulation: Oil displacement by Foam"

**Dr. A. Barnhoorn**

Tijmen Chorus:  
"Hydraulic fracturing under waterflooding conditions in unconsolidated sand"

**Prof. Dr. Ir. P.L.J. Zitha**

Luiza Queroga Caldas:  
"Salt cavern volume estimation from pressure response: compressibility-based method"

**Dr. M.E. Donselaar**

Haryo Dwi Prabowo:  
"Reservoir Architecture Model of Triassic Sandstones in Drechtsteden, The Netherlands"

**Dr. D.V. Voskov**

Keshav Kala:  
"Parameterization of element balance formulation in reactive compositional flow and transport"

**Prof. Dr. K.G. Gavini**

Willemijn Foursoff:  
"Investigation into a CPT-based design method for large diameter monopiles in sand"

**Prof. Dr. K.G. Gavin:**

Jay Srigopal:  
"Comprehending the behaviour of a Muller Verpress pile under tensional loading"

**Prof. Dr. P.L.J. Zitha**

Abdulaziz Al Mutawa:  
"Evaluation of Foam-Assisted Chemical Flooding at Reservoir Conditions"

**Dr. H.A. Abels**

Jasper de Lanoy:  
"Lateral persistency of precession-driven floodplain cycles and their relation to fluvial sandbodies"

# UPCOMING Events



## February 2019

Freshmen Drinks  
Studytrip  
BLAF

FEBRUARY 21<sup>ST</sup>  
FEBRUARY 21<sup>ST</sup> - FEBRUARY 24<sup>TH</sup>  
FEBRUARY 28<sup>TH</sup>

## March 2019

Barbara Drinks  
LATEX Workshop  
BALV  
Open Days  
Rally  
Master Information Week  
126 Week  
Master/PhD Bowling Trip  
NoCo Theme Night

MARCH 01<sup>ST</sup>  
MARCH 05<sup>TH</sup>  
MARCH 06<sup>TH</sup>  
MARCH 08<sup>TH</sup> - MARCH 09<sup>TH</sup>  
MARCH 09<sup>TH</sup> - MARCH 10<sup>TH</sup>  
MARCH 11<sup>TH</sup> - MARCH 15<sup>TH</sup>  
MARCH 18<sup>TH</sup> - MARCH 22<sup>ND</sup>  
MARCH 26<sup>TH</sup>  
MARCH 27<sup>TH</sup>

## April 2019

Barbara Drinks  
Study Breakfast  
Exam Week

APRIL 05<sup>TH</sup>  
APRIL 03<sup>ND</sup> - APRIL 12<sup>TH</sup>  
APRIL 15<sup>TH</sup> - APRIL 19<sup>TH</sup>

### Colophon

The Natural Resource is the periodical of the Mijnbouwkundige Vereeniging, the study association for students of Applied Earth Sciences at Delft University of Technology. The periodical is released four times a year and is sent to all members of the Mijnbouwkundige Vereeniging free of charge. Furthermore 100 copies are used for promotional purposes. Most of these will go to Dutch high schools and partners.

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### Poster

Photo taken by: Coordenação-Geral de Observação da Terra - INPE  
Location: Ucayali River mouth on Marañón River, Peru

### Poster

Photo taken by: Coordenação-Geral de Observação da Terra - INPE  
Location: Mata Atlantica at São Paulo and surroundings

### Cover

Photo taken by: Stacy William Head  
Location: Athabasca Falls in Jasper National Park, Alberta, Canada

