

University of Stavanger MSc-UMSA outcomes on the academic research side

• A review by

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#### Master theses – first Master

- Number: 28
- Published data: 0

#### Master theses - second Master

- Number: 32
- Published data:

8 contributions to an international conference with 7 participants representing the data of 9 students so nearly 30% of all of which 4 have been with studnets of UiS

#### Plan of publication

- 1. thorough publishable projects
- 2. sufficient data on highest level for publication
- 3. selecting publication channels
- 4. presenting data at international conferences
- 5. producing papers
- A very productive achievement: publication together with students of UiS (Norway) for future networking of importance

#### **Publication:**

#### Publication at the 11th South American Symposium on Isotope Geology (SSAGI)

- Held for the first time ever in Bolivia (Cochabamba)
- Participants: highest level of isotope geologists from all over the world working in South America and those who are located in South America
- Presentation of 9 posters together with German, Argentinian (their own teacher in the Master course) and Norwegian scientists
- Studnets got in touch with those scientists and for the first time Bolivian students participates which brought them into contact with the few Bolivian geologists

#### **Complete list presentations:**

(in bold UMSA, in itallics UiS studcents)

- Lopez V. S. S., Conde M., Cuellar K.A., Tarqui J., Zimmermann U., Ruud C., Storaas Ø., Solvang A., Berndt J., Bertolino A.R. S., 2018. Provenance of Devonian rocks of the Bolivian Altiplano. 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p. 89.
- Lopez V. S. S., Cuenca M. A.C., Silva P. J. E., Ramirez S. W., Zimmermann U., Ruud C., Berndt J., 2018. Provenance of the Oligocene to Miocene Aranjuez Formation at La Paz (Bolivia) and modern river sediments of the Bolivian Altiplano. 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p. 88.
- Lopez V. S. S., Di Pasquo M., Ruud C., Hatløy, S., Kristoffersen S., Mehus T., Skarstein G., Zimmermann U., Andersen T., Berndt J., Matos R., 2018. Provenance of Ordovician(?) to Silurian strata in the Bolivian Altiplano, 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p. 90.
- López V., S.S., Gareca Q. M. R., Mendoza S. G. C, Zimmermann U., Ruud C., Berndt J., 2018. Provenance of the Carboniferous to Permian Copacabana Formation of the Bolivian Altiplano, 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p. 91.
- Sofie K. Arntzen, Olsen, T.M., López V., S.S., Di Pasquo, M.M., Zimmermann, U., Ruud, C., Berndt, J., 2018. Devonian or Carboniferous glaciations in the Bolivian Altiplano: Constraints from detrital zircon age dating, 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p. 59.
- Zimmermann, U., Moya M. C., Berndt J., Naidoo T., Lopez V., S.S., 2018. No 'snowball earth' in Las Tenditas (South of Salta, NW Argentina). 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p.125.
- Berg-Larsen K., Hystad H., Nerhus I., Skjeldal, M., E., Ruud, C., U. Zimmermann, López V., S.S., Bertolino S. A.R., Berndt, J., 2018. Provenance of Permo-Triassic rocks in the Bolivian Altiplano. 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July -, Program and Abstracts, p. 61.
- Ramos J., Ruud, C., Zimmermann U., Silvana R.A. Bertolino S.A.R., López V., S.S., Berndt, J., 2018. Some constraints of metamorphic rocks from El Peñon in the southern Puna of Argentina. 11th South American Symposium on Isotope Geology (SSAGI), Cochabamba, Bolivia, July, Program and Abstracts, p. 111.

#### Examples of posters:



#### **PROVENANCE OF DEVONIAN ROCKS** OF THE BOLIVIAN ALTIPLANO

Shirley S. Lopez<sup>1</sup>, Mabel Conde<sup>1</sup>, Alexandra K. Cuellar<sup>1</sup>, Jimena Tarqui<sup>1</sup>, U. Zimmermann<sup>2</sup>, Caroline Ruud<sup>2</sup>, Øystein Storaas<sup>2</sup>, Andre Solvang<sup>2</sup>, Jasper Berndt<sup>3</sup>, Silvana A.R. Bertolino<sup>4</sup>

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University of Stavanger

The weathering trends for all four formations is shown above. The leas ion is the Vila-Vila Formation with moderate CI/ Chemical of alteration, after Nesbitt and Young, 1982) values and K/C atios above typical UCC. The Colpacucho and Sica-Sica Formations are plotting either similar to typical UCC or slightly enriched in felsic material with higher Zr/Ti ratios than UCC. ar with slightly lower K/Cs ratios, hence more weathered but as Some samples have lower Zr/Ti ratios and point to a d The Belén For slight alkaline composition. is of 75 to 85 and with the lowest K/Cs ra

MOST IMPORTANT SOURCE AREA AGES OF DETRITAL ZIRCON CORES 1,00-1395; 521 542 552 57 88 965 402 399 446 52 402

0,10 1,00 Colpcucho
Sica-Sica
Belen
Vila-Vila Compositionally, using trace element (after Wincheste and Floyd, 1977), the formations are quite similar and

Its, hence all grain sizes have been sample

On the left: Schematic abundance oif CONCLUSIONS: the most prominent source ages in the detrital record:

Nearly an entire absence of Devonian and Silurian aged grains Dominance of the active continental margin event(s) from Ordovician to

Nb/Y versus Zr/Ti

0.01

Ediacaran High abundance of Mesoproterozoic (mainly < 1,2 Ga) aged grains besides in sample Belén1

Solid provenance form ransamazonian sources

The vast difference in detrital record for two samples of the Belén Formation (orange and red)



identify possible recycling of sedimentary rocks, the ratio Zr/Sc h been successfully used and plotted against Th/Sc as an indicator of felsic versus matic compositions (after McLennan et al., 2006). The

figure above shows the results for the rocks of the Devonia ons Some samples from the Vila-Vila Formations contai Similaria. Some samples from the VIA-VIA Formation contains reprove procycle metalical, othera are monitorial with Thick relation reprove the second second second second second second relation to the samples. The second second second determine to of the samples. The rock have 2016 relation to take are quite upon the second second second second second second UCC, the flow grained ones. The Stac Sica Formation tocks are quite and in terms of sonthing the contains arrows the second s

diate or mafic components are absent in the detri record according to this graph by Bhatia and Crook (1986). The fin grained samples are rather typical in their composition to UCC (se continental crust is symbolised by a blue star aft Micliennen et al. 2006) which points to the concent that the material may derived from stronger reworked sources sedimentary processes sorted the material as such. Differ however, clear as the rocks of the Belén Formation are tho

Devonian rocks are mostly poorly to moderate sorted and fine-grained and suggesting a shallow marine depositional area with few turbiditic successions

The geochemical fingerprint points to moderate to significant weathering and a mixing of strongly recycled detritus (mainly Belén and Sica-Sica Formations). The absence of a significant mafic to intermediate source component and shows sorting effects.

Detrital zircon ages suggest that Devonian and Silurian detritus is nearly insignificant and the most abundant source components are related to the active margin of Gondwana (from Ordovician to Ediacaran) and Mesoproterozoic (but younger than 1,2 Ga). Paleoproterozoic input is stable and may represent most of the identified the recycled components.

Alarming is the significant difference between the two samples of the Belén Formation, although the sample used was composed of all grain sizes in the two outcrops (Belén1 and Belén2). This suggest to be very careful in interpreting 'too far' using detrital zircons only. and especially when using only one single-rock sample. Here, the fractions older than 1,2 Ga are still but Belén4 contains much more Mesoproterozoic detritus than Belén1 and vice versa for the active margin detritus.

#### Example of results:

Ages of zircon minerals in modern rivers and in young rock formations of La Paz (Aranjuez) 50 45 40 35 30 25 20 15 10 2800VICANEDIA CRAM DEVONANSILIRAN ONIAN IANITA RCHEAN ~50101C 2268 72260 ■ HUILAOUF 1 ■ HUILAOUF 2 ■ ARANIUF7

The altiplano river Huillaque and red sandstones in La Paz were sampled.

The red sandstones record recent volcanism very well with ages as young as 13 Ma and the oldest grains as old as 2,2 Billion years (so-called Transamazonian). Modern rivers are mainly devoid of minerals younger than 80 Ma although heavy volcanism and granite formation took place. This is spectacular as the volcanic and intrusive rocks (granites) are today exposed.

That shows that composition of sediments do not necessarily reflect the surrounding geology, which is often taken for granted. A major finding and very worth to be published.

### Collecting of the data



- UMSA students carried out at UMSA/Boliva:
- Sampling under supervision (UZ) partly together with Shirley Lopez and students from UiS
- Manufacturing so-called thin sections (slabs of rocks) to be analysed with a microscope (UMSA; laboratory was financed by EnPe)
- Separation of heavy minerals (which started at UMSA) to describe the composition of the rocks (UMSA students carried out this work at UiS)
- Analyses of heavy minerals with electron microscopy (UMSA students carried out this work at UiS)
- Some UMSA studnets visited laboratories to date the separated minerals
- Dating was performed by students/staff of UiS because of training issues (to really 'press the button' a long training on machinery is necessary or will not be allowed)

#### Rationale of the work flow

- 1. UMSA students learned how to sample and prepare rocks and received a firsthand possibility to investigate the nature of the rocks: all this can be applied to all rock types of the region – few of them are investigated – hence, there is an enormous potential for future research publishable on a national level using UMSA equipoment
- 2. UMSA students were trained to separate and to describe and analyse minerals with electron microscopy – some of these machines do exist within industry in Bolivia (I had two visits with those companies to make them aware of the students from UMSA trained on the same type of machinery they own)
- 3. Dating of the minerals
- 4. Compiling all data to write a contribution in English to a conference and to design a poster they need to show at the confernece – all this was novel to all participants: NEVER Bolivian students presented on this prestigious conference data

### Strategy of research based learning

- In contrast to the first Msc program we decided to invite UMSA studnets for a short while 2-4 weeks to carry out their research at UiS
- This had several advantages:
- Their knowledge and introduction to research falls immediately back on UMSA when commenting students and authorities about research infrastructure
- They qualify to og on the specific field of their expertise
- They were able to do close networking
- They were highly motivated as they worked on 'their' issues
- The research ends in international publications a rare honor for Bolivian graduates

#### Further research and achievements

- MSc thesis about Water geochemistry should be published in a national journal
- Applying 3D software for grain analyses (training at UiS) this is included in all upcoming peer-reviewed publications
- Winners of two grants of the prestigious (and the <u>only</u> research-based grants in Bolivia) program '100 personal grants from the President of Bolivia Evo Morales' to study or to do research in the exterior'
- Winner of the South American competition of the Laurie Dake challenge and invited to compete in Copenhagen in 2018 organised by the EAGE (European Association of petroleum geologists and engineers) - the 'equivalent' of the AAPG (visa issues with the Swedish Embassy in Bogotá made it impossible to aprticipate)
- LIDAR laser application to understand rock formations done for the first time ever by a Bolivian student and will be published in Norwegian Journal of Geology

#### 2019:

- Manuscripts for geological journals will be finished for:
- MSc thesis about the Copacabana and Kasa Formations (3 students UMSA) – Journal of South American Earth Sciences
- MSc thesis Cancañiri Formation (1 student UMSA) Level 2 journal Paleogeograhy Paleoclimatology Paleoecology)
- MSc theses Devonian rocks of the altiplano (4 students UMSA) Journal of South American Earth Sciences
- MSc theses of young rock and river sediments (4 students UMSA) -Sedimentology
- Last sampling and rock data acquisition for second Master thesis cycle

#### 2020:

Further publications of MSc data sets:

- Water chemistry of hot spring analysis of water quality for small communities (1 UMSA National Journal of Bolivia)
- Review paper about the Paleozoic formations of Bolivia
- LIDAR application to rock formations in Rogaland (1 UMSA student) Norwegian Journal of Geology
- Conference publications of the MSc theses of the second cycle (4 planned contributions)

# Master theses of cycle 2 with potential to be published:

- Provenance of the Ravelo Formation (2 students)
- Provenance of the Tiahuanaco Formation (2 students)
- Provenance of the Bermeja basin (2 students)
- Palynology of the rock formations of the Bermeja basin (2 student with S. Lopez)

Supported by MSc gradaute of teh first cycle (S. Lopez)

The lower number of the MSc theses of the second cycle is intended to involve MSc graduates in thesis projects instead of external organised projects to use the installed labnoratories and data bases

### **Conclusion:**

- The second Master program financed by EnPe generated/s:
- a) several international conference publications (extremely rare at UMSA) in front of an international audience
- b) Various international publications with only UMSA students
- c) Various international publications with UMSA and Norwegian students
- d) Facilitated 13 UMSA studnets to visit UiS for the purpose of doing research for their MSc theses
- e) Already two winners of the only research-based grant in Boliva in the program of the '100 personal grants from the President of Boliva Evo Morales' to study or to do research in the exterior'
- f) Winner of the South American competition for Laurie Dake Challenge organised by EAGE (European equivalent of the AAPG) winning three rounds of selections and were qualified for the final in Copenhagen on 10.6. 2018 with 8 teams left Visa issues by the Swedish Embassy in Bogotá made it impossible to participate physically
- g) Will add until 2020 more contributions to international conferneces and publish on national level MSc results

#### **Recent outcomes**

- This networking led to various application to our PhD program in the field of Petroleum Engineering by Bolivians, which can also be related to the very fruitful collaboration on student level
- Graduates got already jobs in different parts of Bolivia in industry and goivernmental institutions
- Graduates are and were able to apply successfully for highest level of grants in Bolivia
- Graduates do apply for international jobs and an academic futuree already

### FUTURE

- As shown the collaboration is very fruitful now since several years:
- We propose to consider a follow-up project with a

#### **MASTER in**

#### **RENEWABLE AND LOW-C ENERGY SCIENCES**

 This would hit the exact political strategy of Bolivia and could be organised in close work relation ship to UiS where a similar – governmental based – strategy has been implemented

# Preliminary plan

- Courses:
- Introductory courses:
- Societal transition and transformation Energy and climate change
- Energy, energy technologies, and energy system integration
- The geopolitics of energy and environmental policy
- Economics of Energy Markets

# Specific and applied courses:

#### **Specific courses:**

- Low-C energy
- CO2 sequestration
- Solar energy
- Wind energy
- Water energy
- Geothermal energy
- Other energy forms (biogas, fractional energies, atomic, etc.)

#### **Applied courses:**

- Smart houses Smart campus smart cities
- From hydrocarbons to renewable energies: case studies

# Thank you for your attention!