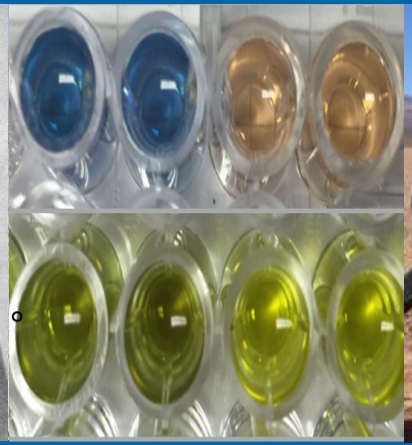
TECHNISCHE UNIVERSITÄT
BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

TU Bergakademie Freiberg and Chilean Institutions: Long-Standing Relationships in Diverse Areas and with Great Potential for the Future





Prof. Michael Schlömann, TU Bergakademie Freiberg
RedInveca meeting Freiberg 11.10.2019

Early Connections to Chile

First „Chilean“ student: Heinrich Sewell, inscription number 1614, start 1846 came from England, probably later in Chile and related to „copper family Sewell“

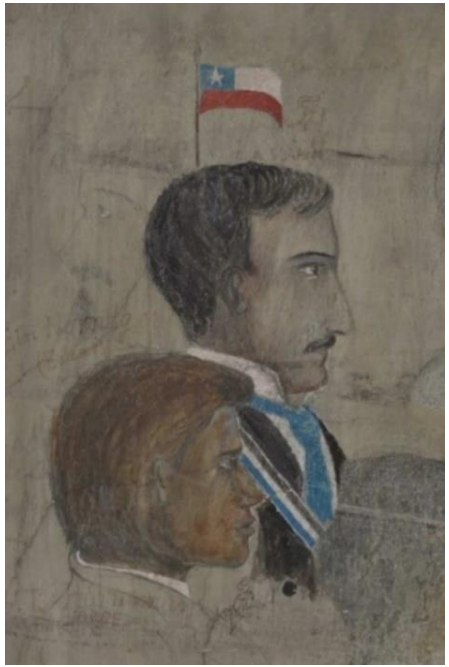
Year of Inscription	First Name	Surname
1846	Heinrich	Sewell
1852	Adolph	Eastman
1852	William	Lyon
1853	David	Montt
1854	Carlos	Durado
1855	Gustav	Smigilsky
1858	Heinrich	Stuven
1859	Emeterio	Moreno
1859	Flavio	Zuleta

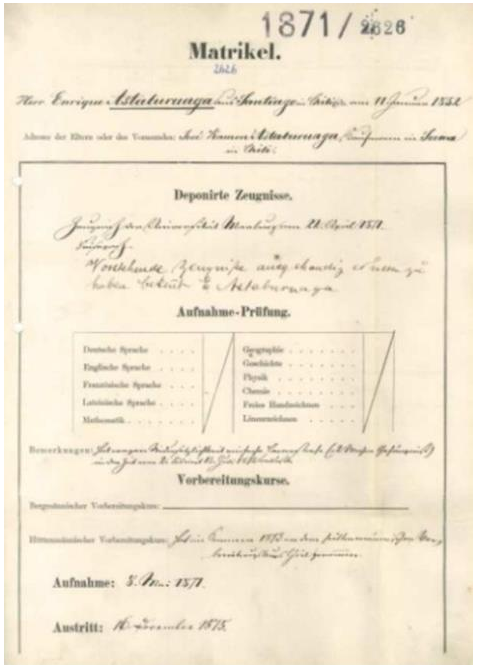
1862 request of Royal Saxonian court to „Oberbergamt“ (then supervising institution) not main give final diploma to Flavio Zuleta from Copiapó, because charged not to pay alimony for his son Paul Johannes Flavio Zuleta

Early Connections to Chile

Last inmate of the „Karzer“ (university prison): Enrique Astaburuaga (the 16th student from Chile, inscription number 2626, student 1871-1875).

Had rampaged and resisted the police when arrested, hit policeman.





1871 / 2626

Matrikel.

Deponirte Zeugnisse.

Aufnahme-Prüfung.

Vorbereitungskurse.

Aufnahme: 5. Apr. 1871.

Austritt: 16. Dezember 1875.

16 Chilean students among 1013 students
→ 1.6%
Today: ca. 0.7%

Father and Son Domeyko

IGNACIO DOMEYKO
(1802-1889)
in Freiberg in 1831

CASIMIRO DOMEYKO (1863-1922)
Student at Bergakademie 1886-1888
Picture, monument, and lane name at
Universidad de Atacama Copiapó

Recent History: Fellow Students

Christoph Breitkreuz
Professor at TUBAF

Hans Wilke
Professor at Universidad Catolica del Norte (UCN) in Antofagasta

Visit to Chile with delegation as vice-rector for external affairs ca. 2007

Request of Chilean Embassy to TUBAF and others in 2011

Background:
Study by Fundación Chile predicted shortage in educated personnel due to new mining projects

↓

Support for eduction of experts in mining and metallurgy?

Ambassador
Jorge O‘Ryan Schütz
and Monica Cuevas
at TUBAF in May 2013

„Domeyko Initiative“

März 2012 Fact finding mission
(Antofagasta, Copiapo,
Santiago, Chuquicamata…)
DAAD and BMBF funding

October 1st 2012: Signing of MOU in Santiago
in presence of: BM Prof. A. Schavan
Minister Prof. de Solminihac

Minister for Mining Prof. de Solminihac | Michael Schlömann | Gerhard Heide

Participating universities:
U Catolica del Norte, Antofagasta
U de Atacama, Copiapo
U de Concepcion
TFH Georg Agricola, Bochum
TU Bergakademie Freiberg

Memorandum of Understanding for a Chilean-German Center for Mining-Related Teaching & Research in honor of *Ignacio and Casimiro Domeyko* in Northern Chile

➡ Significant increase in exchange of students and doctoral students

Casa Chile: Opening 19.10 2017

Ambassador Patricio Pradel

Dr. Krüger

Rector Barbknecht

Singing miners‘ song

Jointly Awarded Double Doctorate

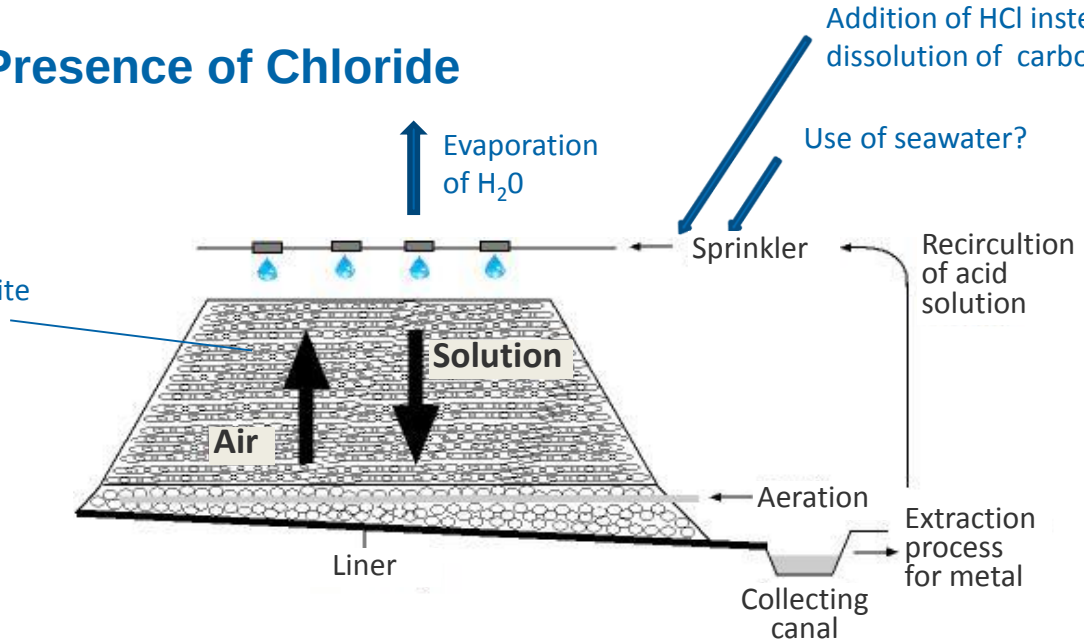
Contract with U de Santiago de Chile 19.10.2017

First defense by Gerardo Retamal on 5.12.2018

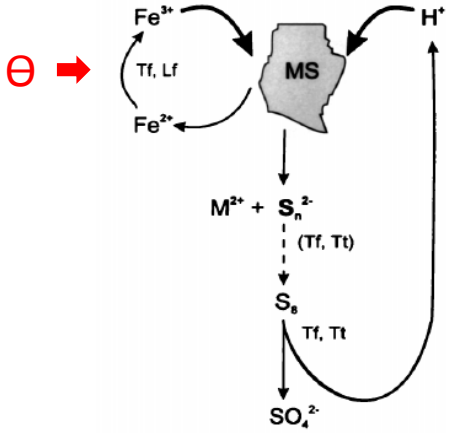
Institute of Biosciences: Prof. Michael Schlömann

Bioleaching in Presence of Chloride

Cooperation:
G. Levicán USACH



Relevance of iron oxidizing microbes



Problem: Inhibition of iron oxidizing microbes by chloride

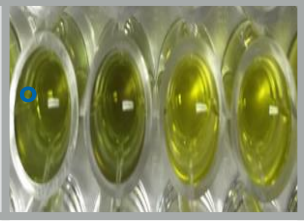
Strategies:

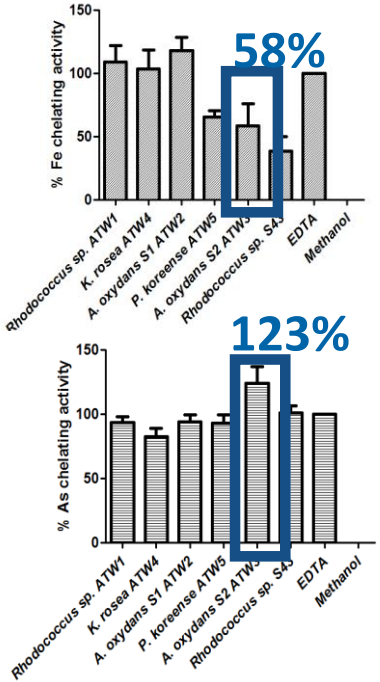
- Adaptation of known iron oxidizers
- Isolation of new strains
- Genome analyses: search for mutations or genetic peculiarities

Institute of Biosciences: Prof. Michael Schlömann
Arsenic Tolerance

Cooperation: G. Levicán,USACH

Problem: arsenic from arsenopyrite (FeAsS) and increasingly from enargite (Cu_3AsS_4)
possible liberation from smelters
Leaching of copper instead of smelting
Purification of As-contaminated waters
Screeing test for arsenic tolerance from excreted metabolites

	pH= 6.5	pH= 13
Fe CAS		
As-$_m$CAS		

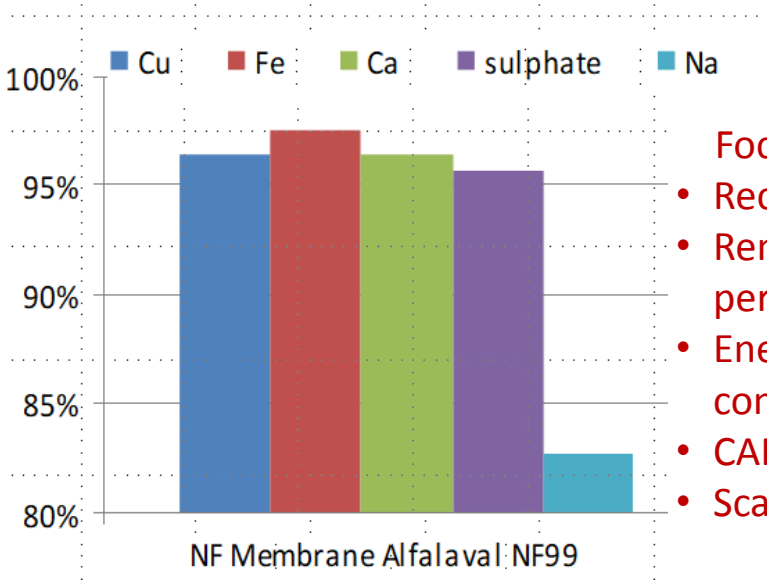


Institute of Thermal, Environmental, and Recources-Process Engineering
Dr. Roland Haseneder

Membrane technology - treatment of Acid Mine Drainage

Cooperation: Siemens Mining / Minera Los Pelambres

Selective separation of multivalent ions



Focus on:

- Recovery
- Removal performance
- Energy consumption
- CAPEX
- Scaling effect

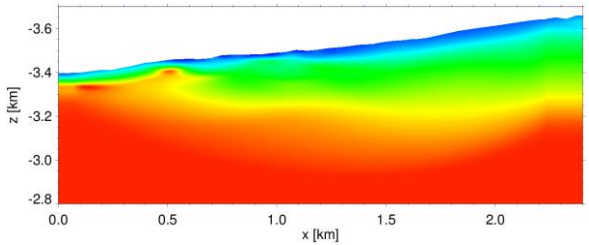
Development of an on-site pilot plant

Institute of Geophysics and Geoinformatics: Prof. Stefan Buske

Seismic Imaging of Geological Structures on Different Scales

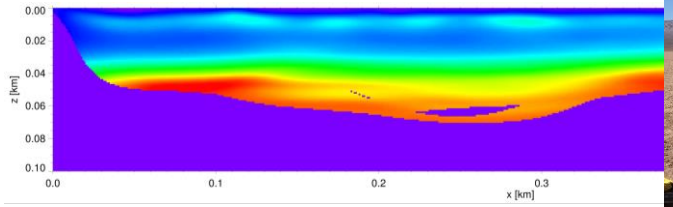
Groundwater prospecting (Atacama Desert)

2014 - Cooperation partner: Pablo Salazar (UCN)

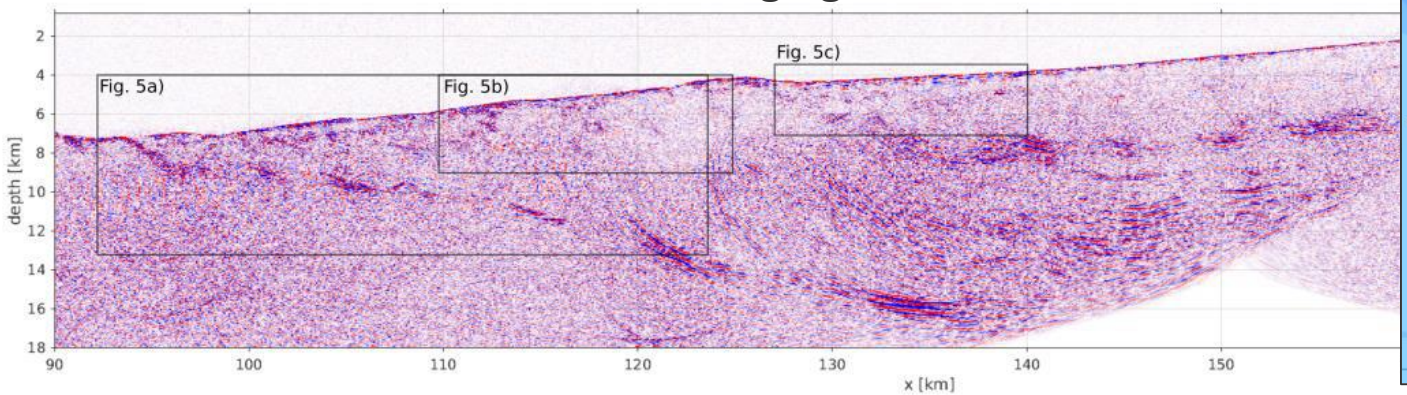


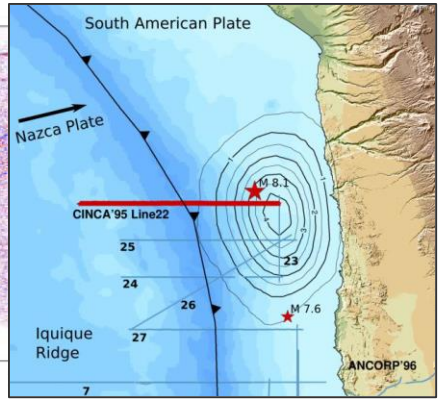
Clay pan investigations (Atacama Desert)

2018 - Cooperation partner: Eduardo Campos (UCN)



Seismic imaging of subduction zones



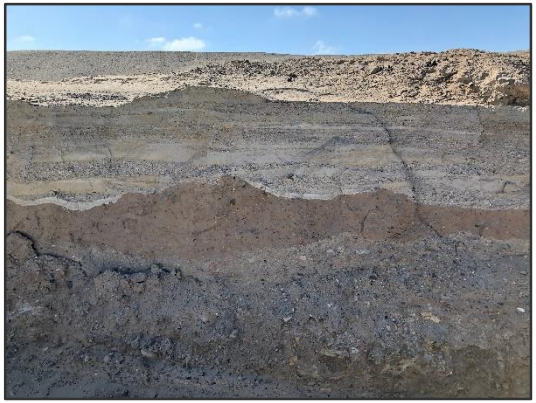


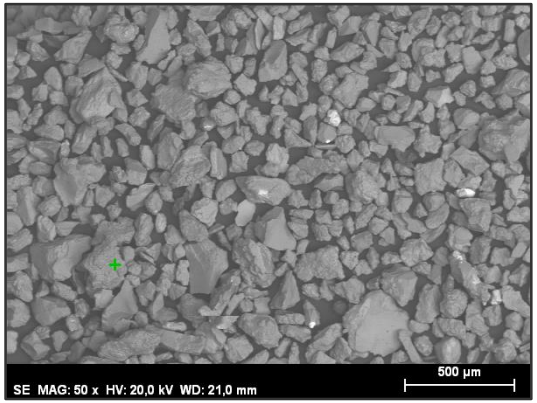
Institute of Mineralogy: Prof. Gerhard Heide

Study of Heavy Elements in the City of Chañaral, Chile, and their Distribution in Water, Soil and Air

Cooperation:
Universidad de Atacama

PhD project of Cassandra Contreras Fischer financed by:





Institute of Mineralogy: Prof. Gerhard Heide and Carolina López

Study of Chilean Copper Slags

Cooperation (1 University and 5 Smelters):

Universidad de Concepción

CODELCO

ENAMI EMPRESA NACIONAL DE MINERIA

ANGLO AMERICAN

GEA **Caletones-Potrerillos-Chuquicamata** **Hernán Videla Lira** **Chagres**

Mineralogical Analysis of Chilean Copper Slags and their Behaviour in Aqueous Solutions focused on Environmental and Economic Criteria

Institute of Geology: **Prof. Lothar Ratschbacher**
Institute of Minerology: **Prof. Thomas Seifert**

Mineralogical Zonation and New Geochronology in the Giant Río Blanco – Los Bronces Porphyry Copper Deposit, Central Chile

PhD student:
Michael Hohf

Project Partners:

CODELCO Andina

RB-LB: Resources of 6.99 (Gt) at 0.75 % Cu (mainly breccia hosted)

Tourmaline Breccia Complex
(host most of the ore)

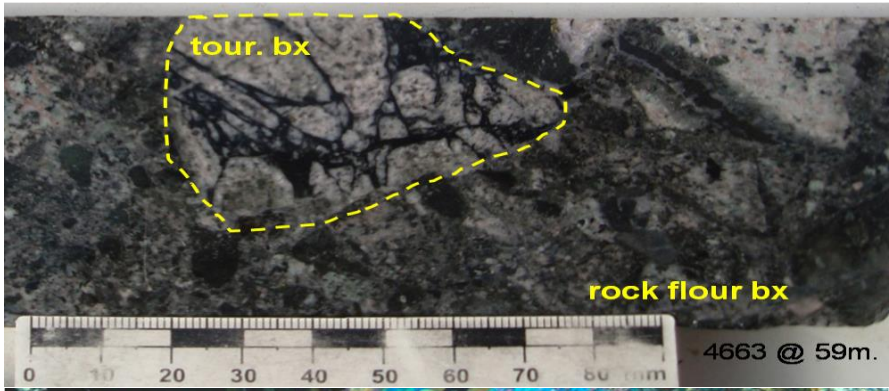
AIM: Understand the genesis of the different tourmaline breccias and the relation to porphyry style mineralization

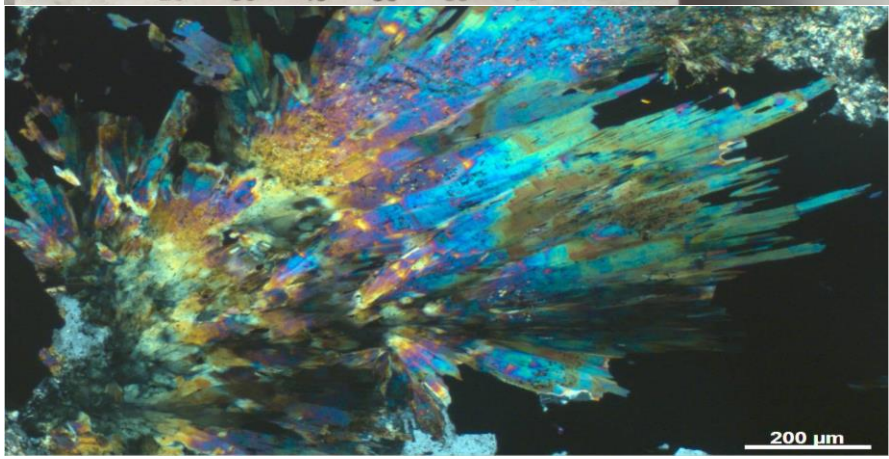
Mineralogy: characterization of the ore & alteration assembleges of the breccia

- Reflected & refracted microscopy
- MLA (SEM+EDS)
- EMPA + SIMS

Dating: magmatic & hydrothermal events

- Ar/Ar in biotite & K feldspar
- U-Pb in zicon





TU-Freiberg: Prof. Dr. Gerhard Heide

Student exchange between Atacama University and TU-Freiberg
Cooperation: Dr. Wolfgang Griem and Dipl.-Geol. Gustavo Miranda-Díaz

Student from Atacama University to TU-Freiberg:

- Vicente Gerding Barudi – Exchange for 1 semester - April to October 2015
- Sebastian Rojos Colville – Exchange for 1 semester - April to October 2015
- Esteban Zuñiga Puelles – Exchange for 1 semester - September 2016 to April 2017
- Milton Veliz Rivas – Exchange for 1 semester - September 2016 to April 2017
- Pablo Vega Olivares – Exchange for 1 semester - April 2017 to October 2017
- Patricia Vivanco Chavez – Practice in the Mineralogy institute – January and February 2017
- Johan Segovia Chacoff – Practice in the Mineralogy institute - February 2018
- Fabrizio Fuentes Galaz – Practice in the Mineralogy institute - February 2018

Student from TU-Freiberg to Atacama University:

- Hannes Reichel – Practice and Bachelor Thesis in Geology Department and Mineralogical Museum UDA – March to May 2016
- Hendrik Nachbarschulte –Exchange for 1 semester – August to December 2017

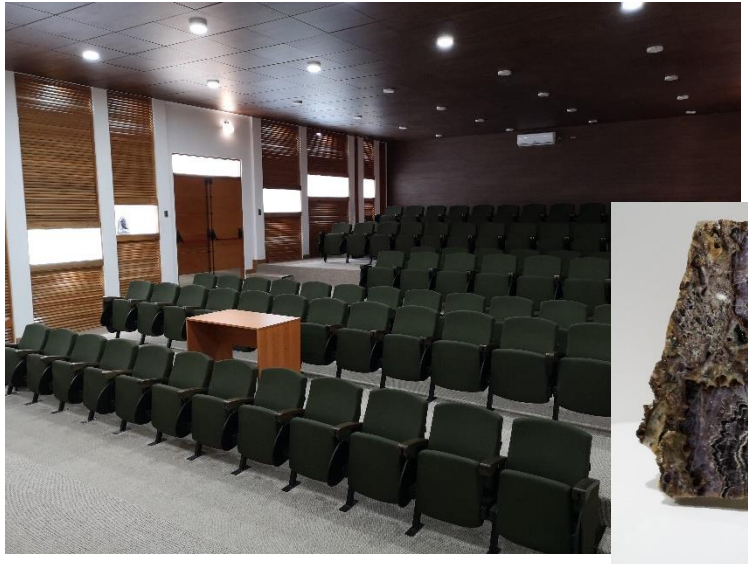
Institute of Mineralogy: Prof. Dr. Gerhard Heide

Mineralogical Donation: Exhibición in Geology Department UDA – April 2019.

Donation of 15 examples from TU-Freiberg collection to Atacama University

Cooperation: Museo Mineralógico - Universidad de Atacama

Dipl.-Geol Gustavo Miranda-Díaz



MUSEO MINERALÓGICO

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
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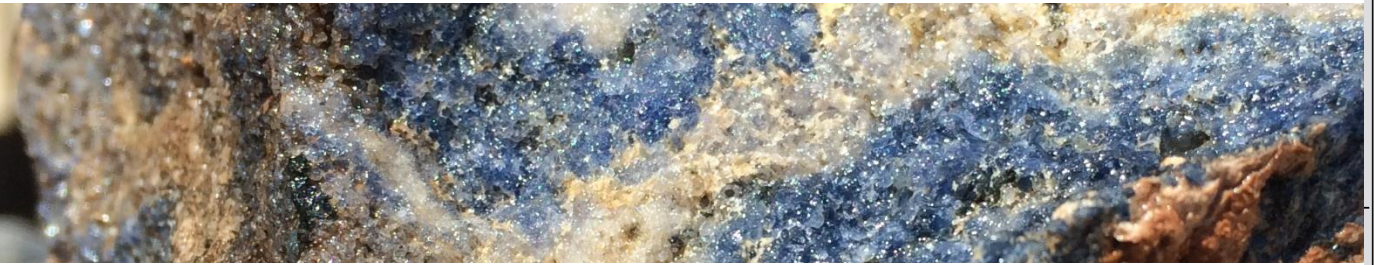
DAAD
Deutscher Akademischer Austauschdienst
German Academic Exchange Service

UNIVERSIDAD DE ATACAMA
FACULTAD DE INGENIERÍA
Departamento de Geología

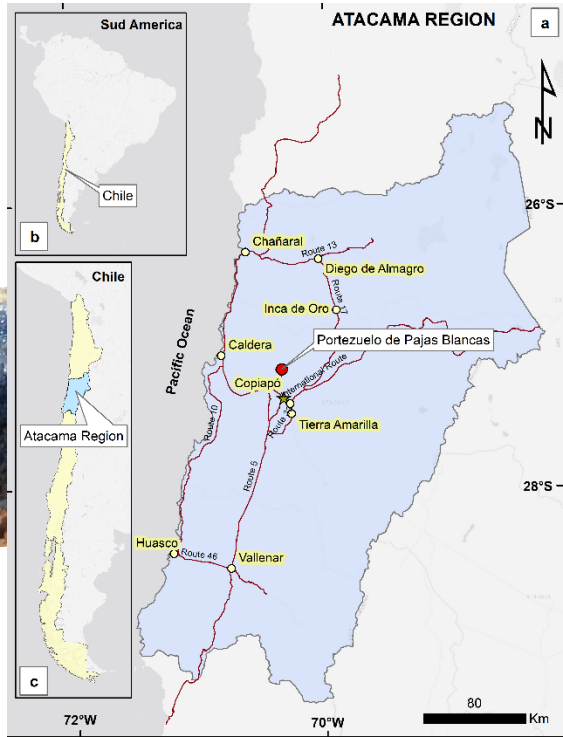
Origin of corundum deposits, Portezuelo de Pajas Blancas area: mineralogical, geochemical and crystallographic aspects – Atacama Region – Chile.

Project funded by DAAD Scholarship

Through geological, mineralogical and petrological information will be determined the formation conditions of this unusual deposit located in the Atacama Desert.



PhD Student: Dipl.-Geol. Gustavo Miranda-Díaz (Atacama University)
Supervisor: Prof. Dr. Gerhard Heide (TU-Freiberg – Mineralogy Institute)
Co-Advisor: Dr. Wolfgang Griem (Atacama University – Geology Department)
Dr. Karl Riveros Jensen (Atacama University – Geology Department)



Mineralogy: Prof. G. Heide
Glass : PD Martin Kilo
U Leuven/Belgium: J. P. Gueneau de Mussy

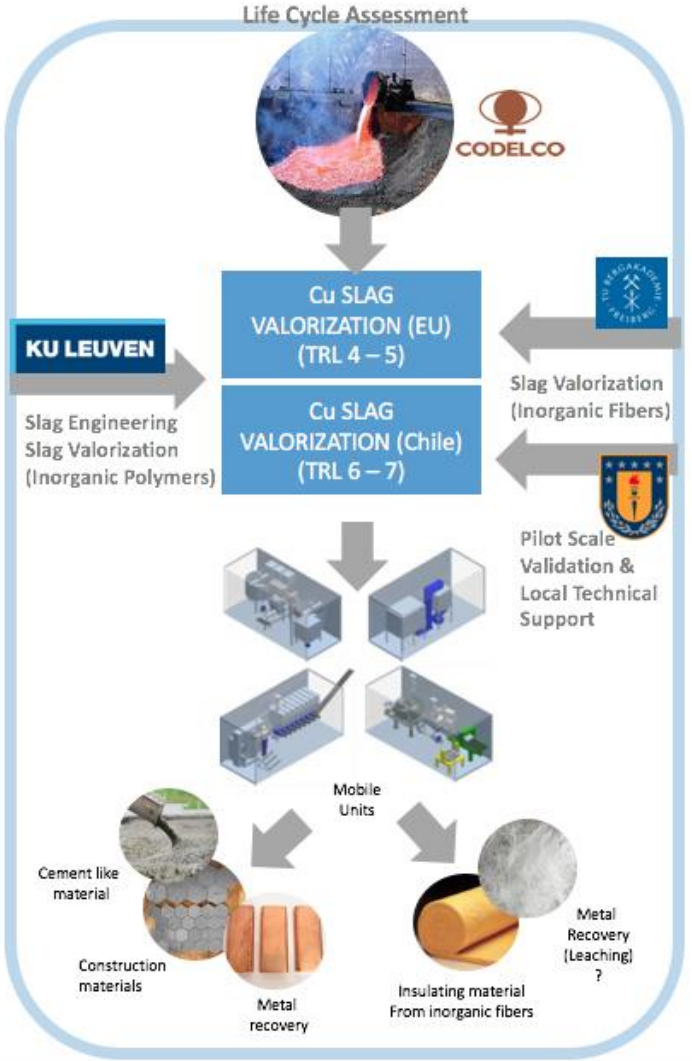
Glass-fibers from copper slag

Cooperation: I. Wilkomirsky, F. Parada, E. Balladares and R. Parra
DIMET/UdeConcepción, Chile

Motivation: combined extraction of remaining copper and use of copper slag for building application => recovery and reuse

Approach : Use of liquid slag for glass fiber production, copper extraction after fiberisation. Modular approache for different slag systems

Challenges : Efficient copper leaching technique, fiberisation techniques for variable compositions



Current Situation

Global challenges:

- Climate change
- Trend towards electromobility → higher demand for Cu, Li, Co
- Energy consumption by mining and metallurgy
- Water consumption and other environmental problems from mining and metallurgy

Situation of Chile:

Potential:
- largest copper producer, largest copper reserves
- largest lithium reserves
- highest solar irradiation (twice as high as in Germany)

Problems:
- low share in value-added chain within the country
- still relatively small buildup of renewable energies, but currently very dynamic
- partly old technologies

Aims: - Adressing the global challenges
- Economic development of Chile

Basic Idea

- **Creation of a new institute in the Antofagasta region, which until 2030 in its working areas will be visible worldwide**

- **Use of 193 mio USD until 2030 from contract of CORFO**

- **Two-step procedure:**
  Request for Information: deadline 20.5.2019
  Request for Proposals: originally planned for 24.6.2019 → not yet published
  originally planned for 23.10.2019

Impacts and Results Expected by CORFO

- Development of new materials and innovations that add value to lithium, salts and other materials for electromobility and green growth.

- Development of photovoltaics and concentration energy technologies adapted to extreme desert climates.

- Development and transfer of a set of technologies for the mining industry to achieve by 2030 that
  - „zero-emissions-fuels“ displace 50% of the diesel,
  - in some mines solar energy is the main source of energy,
  - process innovations and use of solar heat.

- Training of at least 100 highly qualified professionals through development of master‘s and doctoral theses, postdoctorate internships etc.

- Support of at least 100 business ideas and/or startups and creation of an innovation and entrepreneurship ecosystem.

Rolls and Functions of the CCTI

- **Research and development**
  Generation of IP assets, development of prototypes and pilots, creation of new companies etc.

- **Provision of technological services**
  Industrial piloting testing and demonstration of technologies, develop standards and certification of products and services, technological consultancies etc.
  (differentiating from what market offers in the field of R & D consultancies)

- **Development and strengthening of human capital**
  Training activities and training of technical and advanced human capital, postgraduate studies, doctorates, post-doctorates, and internships, etc.

- **Diffusion and extension**

- **Promotion of entrepreneurship and technology-based innovation**
  Creation of jobs, local value etc.

Working Areas

1. Solar Energy

CHALLENGE 1: Solar electricity:
Integration of solar electricity generation solutions from Photovoltaic (PV) and Concentrating Solar Power (CSP) technologies, covering from the current state of technology to the challenges and opportunities presented by the solar resource in Chile to competitively supply the industry.

CHALLENGE 2: Solar fuels:
Development and integration of production solutions and efficient use of fuels produced by solar energy, including, among others:

- Production, storage, transport and distribution of **solar hydrogen** through electrolysis on an industrial scale, in extreme desert and high altitude conditions.
- Production, storage, transport and distribution of **synthetic fuels** based on solar energy through photochemical, electrochemical, thermochemical processes or others.
- Development and scaling of technological solutions using **solar fuels for transportation**, inputs and processes that reduce emissions from mining industries and others.

Working Areas

1. Solar Energy

CHALLENGE 3: Solar heat:
Developing systems that allow the use of solar energy to supply the thermal requirements of industrial and mining processes for different levels of temperature and pressure, with special attention to solutions that minimize the effects of solar radiation variability, including, among others:

- Technological innovations to **integrate solar heat in mining and industrial processes**.
- Technological innovations for the application of direct **solar energy in mineral transformation processes** (systems for drying, calcination, smelting and transformation of minerals and/or metals).

CHALLENGE 4: Desalination and water treatment using technologies based on solar energy.
Development, scaling and integration of technological solutions that use solar energy as the primary source for water treatment, provided that this represents a challenge of applied research or cutting-edge technological development.

- Desalination and solar power concentration systems.
- Small-scale desalination outside the electric grid.
- Solar detoxification and water disinfection systems.

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Working Areas

2. Low-Emissions Mining

CHALLENGE 1: Energy sustainability and reduction of the carbon footprint in metal mining, with a circular economy approach

Reduction of emissions in the production of metals, so that they are inserted in the value chain of electromobility and green growth, among others. This challenge includes aspects such as:

- Technological development for energy efficiency; energy recovery and fossil fuel substitution.
- Focus on eco-efficiency in the production of copper and other minerals, valuing waste and generating valuable by-products, with a minimum carbon and water footprint.

CHALLENGE 2: New low emissions mining-metallurgical processes.

Increasing the value and/or producing new products with the minimum carbon footprint, through new approaches for mineral processing and disruptive innovations in the value chain ems.

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Working Areas

2. Low-Emissions Mining

CHALLENGE 3: Innovations for the traceability of greenhouse gases emissions.
Providing verifiable evidence of emission reductions in the production of copper and other materials complementary to lithium in the electromobility industry and green growth.

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CHALLENGE 4: Innovations for the sustainability of the non-metallic mining industry that operates in the "salares".
Supplying technologies for the extraction and processing of lithium and other relevant products from the salar, with low water consumption, low Greenhouse gases emissions and minimum environmental impacts

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Working Areas

3. Advanced Materials of Lithium and other Minerals for Electromobility and Energy Storage

CHALLENGE 1: Innovations in advanced materials based on lithium, salts and other strategic minerals

Offering a competitive supply to the electromobility and energy storage industries, advancing in the value chain, with emphasis on the creation of opportunities for local productive investment, including aspects such as:

- Development of new compounds and alloys, based on lithium and/or other strategic minerals that reduce costs and extend the useful life of the components for electromobility, as well as for the storage and conduction of energy.
- Development of production methods and processing of advanced materials and products based on lithium and/or other strategic minerals, through the manufacture of new nanoparticles, laminates or other products.
- Development of materials based on salts and other products of the mining properties, which achieve greater efficiency for thermal storage of solar energy

CHALLENGE 2: Development of technologies to more efficiently extract and concentrate scarce products used in batteries and storage, such as cobalt.

Consortia

Applying Consortia – among others

ASDIT: Consortium of the leading Chilean universities and those relevant for mining
Other members: Association of Industrialists of Antofagasta, MIT as “associate”, European Lithium Institute (with Fraunhofer ISC Würzburg), TUBAF possibly as “constituent”
Exclusivity

Fraunhofer Chile + CSIRO (Australia)
Other members: e.g. KIT
Argument: TRL
Deficit: no relevant Chilean university

Fundación Chile
Other members: e.g. DLR
No own research and development, basically distribution of funds
Deficit: no relevant Chilean university

Expectation that through specification of the conditions in RFP phase other composition of consortia

Requirement for Consortia

- Chilean non-profit institution for research, development and innovation
- Participation of Chilean universities or other bodies of the Administration of Chile
- Participation of institutions from the Antofagasta region
- International cooperation
- 30% minimum private con-financing, comprising at least 60% “pecuniary contribution”
- Orientation to on solve industrial problems, focuses on key technological areas and with dedicated human capital

Chances for Germany

For companies:
- **Suppliers of equipment for mining and energy installations**
- **Engineering services**
- **Production in Chile?**

For universities and research institution:
- **Research question and partners**
- **Attraction of young scientists**
- **Publicity, also in neighboring countries**
- **Chile as attractive partner country**

Strategic:
- **Securing supply of resources**
- **Securing markets for products**
- **Latin-America as strategic partner region**

Thank you for your attention!

Glückauf!