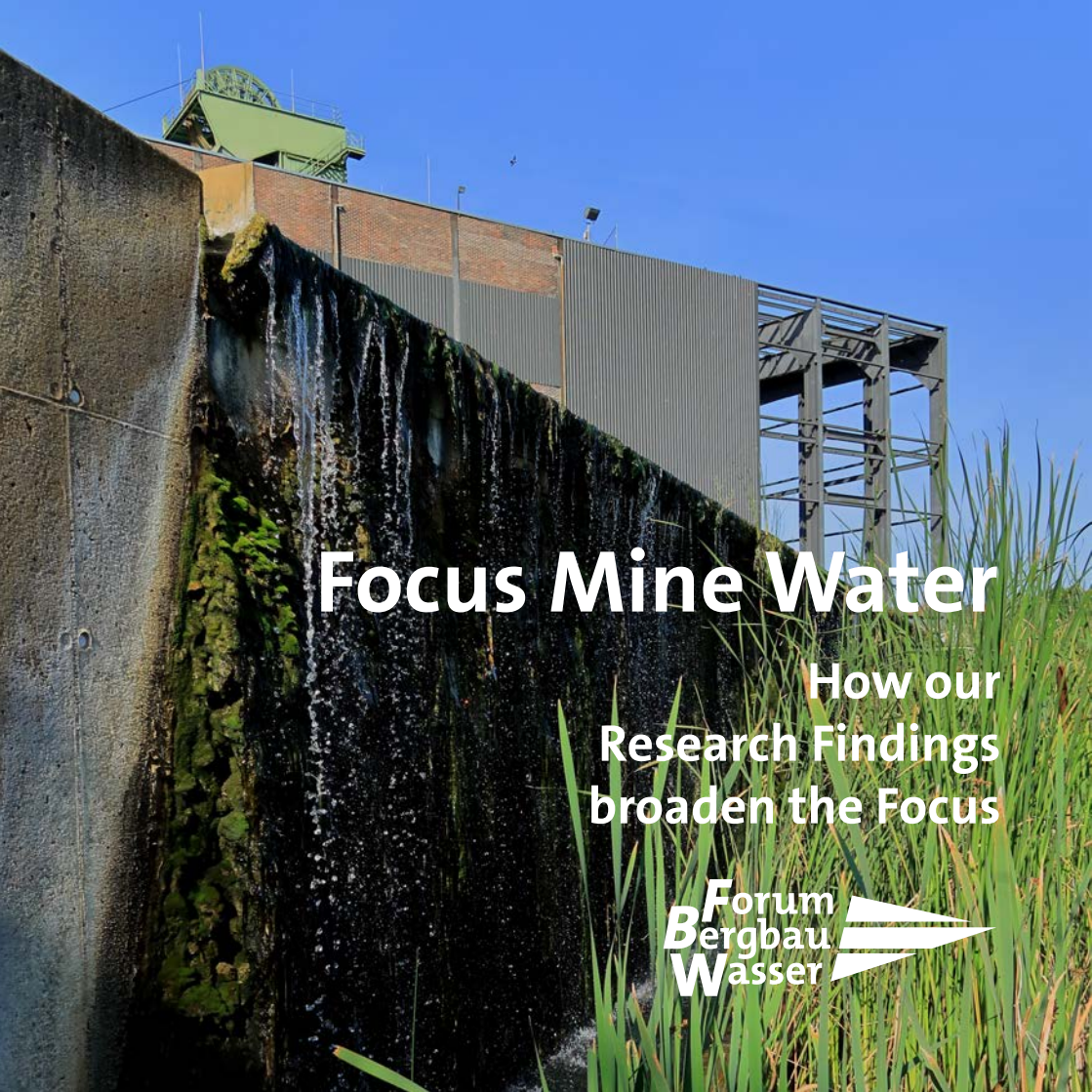




Focus Mine Water

How our
Research Findings
broaden the Focus

Forum
Bergbau
Wasser 



Arnold Shaft (Robert Muser Colliery, Germany)

Focus Kick-off

This second brochure from the “Forum Bergbau und Wasser” highlights the outcomes of the 19 projects carried out since 2017. Building on the topics covered in the first brochure, we present how we have implemented them here. These projects were either carried out internally by curators and their staff or externally by scientists working on broader topics. Read on to find out what the 36 scientists have been working on. Join us as we explore the diverse world of mine water in Ibbenbüren, the Ruhr Area, and the Saarland.

This is the English translation of the original German brochure with the title “Fokus Grubenwasser”.

Wilhelm Struckmeier, Chairperson

What is the focus of this brochure?



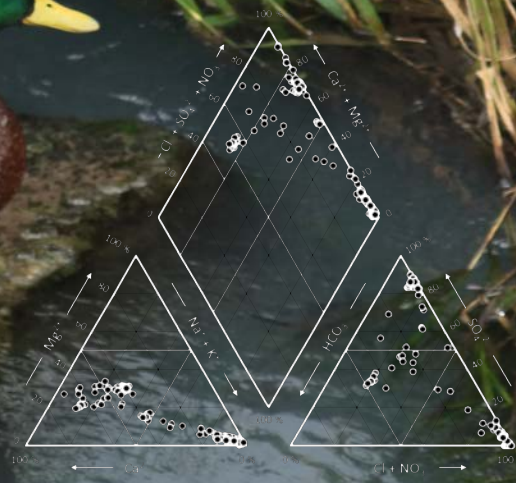
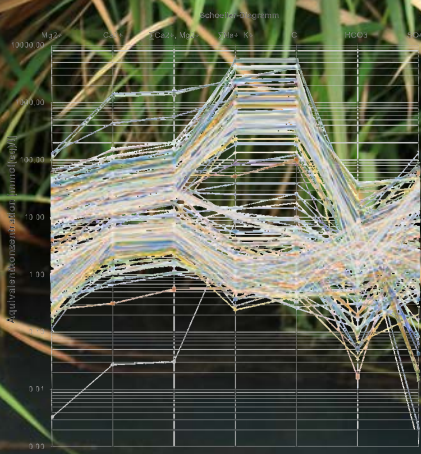
Well water management Walsum, Ruhr Area, Germany

Focus Board of Trustees

Focus on mine water

The non-profit foundation “Forum Bergbau und Wasser” (FBW) promotes scientific research in hydrogeology, particularly with regard to mine water. We pay particular attention to the opportunities and risks associated with mine flooding following the closure of coal mines, as well as its ecological and economic effects on the Saar, Ruhr and Ibbenbüren mining areas. This second brochure focuses on the results of our projects to date. Full project details and the final reports can be found on our website: www.forum-bergbau-wasser.de

"Forum Bergbau und Wasser" is funded by RAG Aktiengesellschaft, the former mine operator which abandoned active mining in December 2018.



Water Constituents

Focus Assessment

Extensive chemical analysis of mine water is important in order to assess its effects on the soil, water and biology. The interactions between pollutants, existing ecological stressors, and other protected resources must be considered. Statistical studies help authorities and mine operators make transparent decisions on permits and communicate these effectively. Concentrations of trace elements in mine water can help identify pump locations where critical raw materials, such as lithium and rare earth elements, could potentially be extracted.

Assessment criteria for mine water

Georg Wieber, Marion Sternke, Peter Quensel



Stollengraben canal, Ibbenbüren, Germany

Focus Hydrochemistry

The origin of mine water can be determined with relative accuracy using isotope and hydrochemical analyses. In the case of Ibbenbüren, the composition of the mine water is influenced by both deeper rock layers and surface water. In some areas, natural attenuation has even been demonstrated. Overall, the results obtained provide a solid foundation for a geochemical monitoring system and a better understanding of flow paths, catchment areas, and interactions within the mine. The iron oxide deposits in the mine water channels are useful for this purpose, among other things.

Sylke Hilberg, Thomas Rinder

Catchment areas of mine water



Bulembu (eSwatini) Mining Museum, Archive

Focus Isotopes

Historical data, not necessarily from water analyses, can provide valuable insights into previous mine water levels and its constituents. Additionally, historical experience and museum exhibits can be leveraged to enhance the robustness and efficiency of modern control strategies. Isotope analyses of old mineral specimens can validate forecasts and improve the assessment of technical risks. Data and documents on mining history from a variety of sources provide a foundation for knowledge-based mine water management and improve our understanding of water chemistry.

Data from the past

Thomas Kirnbauer, Leanne Schmitt, Kai Westhues, Michael E. Böttcher



Shaft Reden IV, Pump Pipe 1

Focus Monitoring

Sustainable monitoring requires a multi-stage approach based on risk analysis, standardised measurement points and continuous data collection. This integrated approach to monitoring enables the early detection of unwanted developments in mine flooding, taking into account both mining and ecological factors. This flexible concept improves the transparency, controllability and environmental compatibility of mine flooding in different locations. Additionally, parameters such as the ratio of two elements or isotopes can help identify unexpected developments at an early stage.

Christian Melchers, Henning Jasnowski-Peters

Monitoring of mine water rebound



$$b_4 t^4) S + (c_0 + c_1 t + c_2 t^2) S^{3/2} + d_0 S^2 \quad (13)$$

$$c_0 = -5.72466 \text{E-}3$$

$$c_1 = +1.0227 \text{E-}4$$

$$c_2 = -1.6540 \text{E-}6$$

Coffee Latte

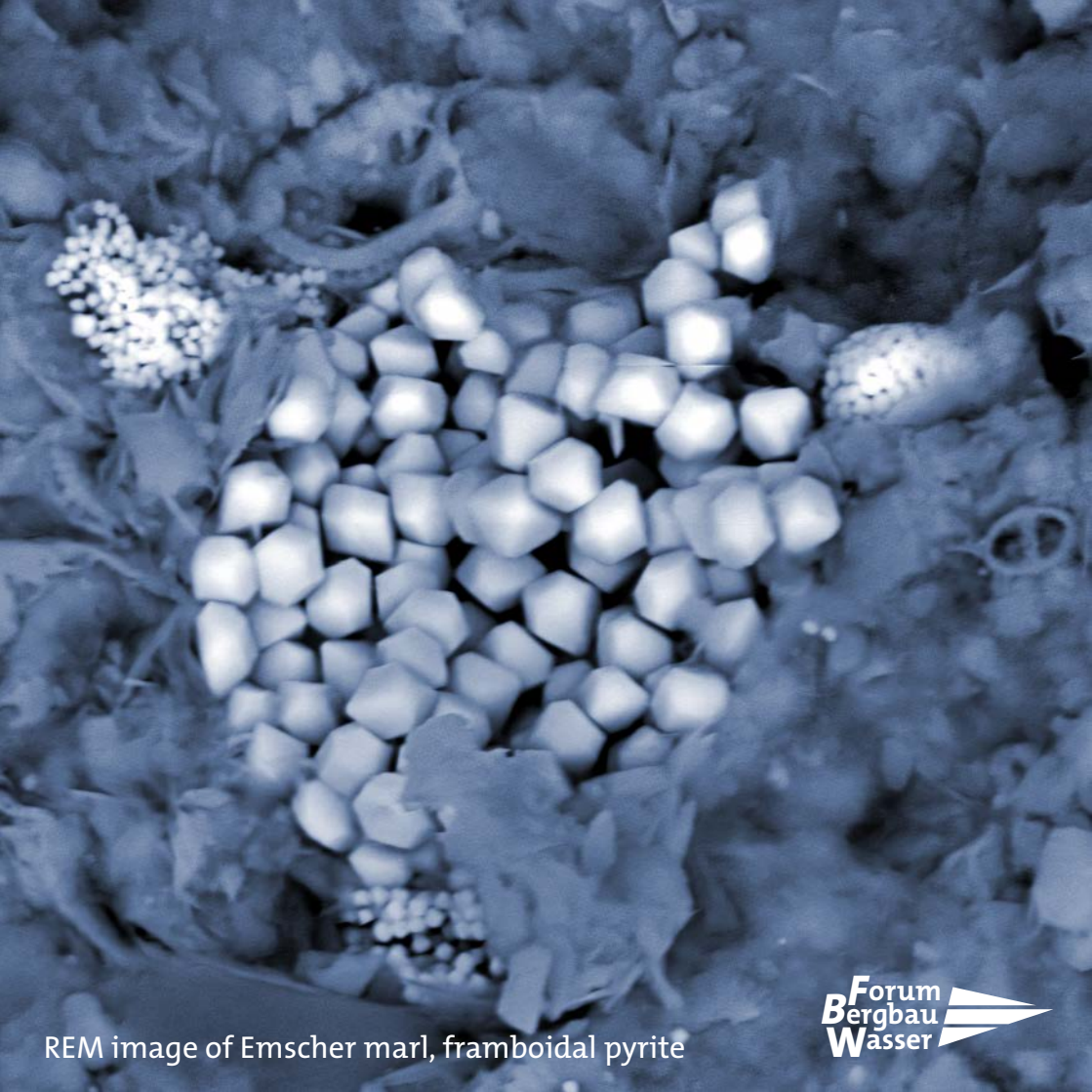
adapted from stockking – de.freepik.com

Focus Density Layering

In flooded mines, stable density layers often form. Mineralised mine water accumulates at the deepest point, while less “salty” groundwater occurs in the upper areas. This stratification can be detected using temperature or conductivity profiles. Analogue and numerical modelling demonstrate the stratification’s good long-term stability, provided it is not disturbed. Current research aims to exploit density stratification to remediate mine water underground. To this end, various scenarios have been investigated to determine the conditions under which stratification builds up and breaks down.

Christian Wolkersdorfer, Elke Mugova

Deep insight into density layering



REM image of Emscher marl, framboidal pyrite

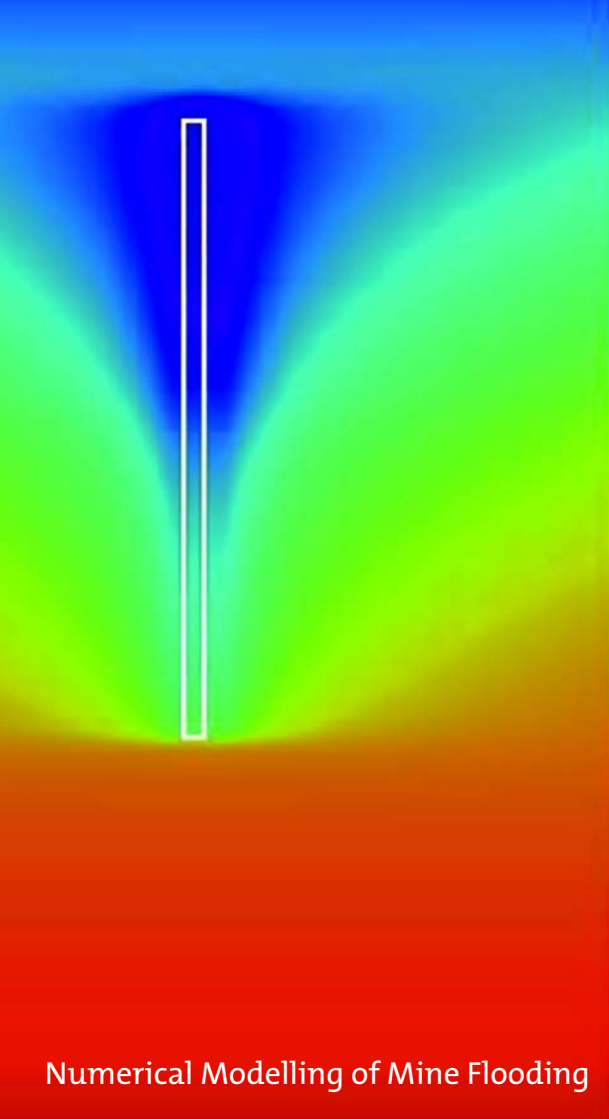
Focus Barrier

In the Ruhr area, the Emscher Formation acts as a hydraulic barrier, preventing mine water from reaching the close-to-surface aquifers.

Laboratory and field data confirm its heterogeneity, but swellable clay minerals seal off any potential faults. Despite its comparatively high porosity, the formation exhibits low permeability and high density over large areas. This reduces the risk of mine water rising uncontrollably into near-surface aquifers. These results form the basis for assessing hazard potential and communicating with the public and authorities.

Permeability of the Emscher Formation

Christian Melchers, Henning Jasnowski-Peters, Lisa Rose, Til Genth



Numerical Modelling of Mine Flooding

Focus Modelling

Numerical models are essential for providing a quantitative and qualitative description of mine water rebound. Although simplified box models suffice under certain conditions, finite element models are more appropriate for complex geological situations. Calibrating the models with real data improves prediction accuracy. Depending on the location, a graduated model selection tailored to the specific issues and spatial complexity of the mine is recommended. The German Westfalen mine is a good example of how mine water levels can rise rapidly, with the effects in the surrounding rock only becoming apparent after a long period of time.

Maria-Theresia Schafmeister, Timo Kessler

Reliability of numerical models



Neuhoffnung Adit, Bad Ems, Germany

Focus Mass Transport

During the initial flooding of a mine, there is a temporary mobilisation of dissolved constituents in the water, primarily iron, sulfate and trace elements. After the initial rise phase (“first flush”), their concentrations typically stabilise at a lower level. The substances transported depend heavily on the geochemical environment and flow velocity, and can be modelled numerically if the rock parameters are known. These findings are important for designing treatment plants, predicting pollutant discharges and assessing possible environmental impacts.

Reactive mass transport during initial flooding

Maria-Theresia Schafmeister, Diego A. Bedoya Gonzalez, Sylke Hilberg



Water wheel, Sigmund Adit, Schwaz, Tyrol, Austria

Focus Energy

Mine water can be used to generate electricity through geothermal processes and pipe turbines, as well as in pumped storage facilities. There are many locations with flooded mines that offer attractive economic conditions. This creates new opportunities for a sustainable energy supply based on existing infrastructure. However, in individual cases, technical feasibility studies and model projects are necessary to determine the optimal combination of components for energy generation. Despite the variety of methods available for generating energy from mine water, its application remains limited to date.

Stefan Wohnlich, Rolf Schiffer, Dmytro Rudakov (Слава Україні!)

Energy use of mine water



Robert Müser Colliery, Bochum, Germany

Forum
Bergbau
Wasser

Focus Geothermal Energy

Depending on its location, mine water can be used to generate energy from geothermal heat. As this heat originates from the deepest parts of the mine, the temperature remains stable throughout the seasons, which is advantageous for heat exchangers and heat pumps. However, complex flow conditions must sometimes be taken into account when designing extraction and discharge points. Overall, using mine water for geothermal energy is technically feasible and ecologically advantageous. To extract more energy, several geothermal probes can be installed in a shaft.

Geothermal energy in flooded mine shafts

Peter Rosner[†], Michael Heitfeld, Norbert Klitsch, Thomas König



Poecilia reticulata in the Reden water gardens, Saarland

Focus Hydroecology

Implementing RAG Aktiengesellschaft's current mine water concept will predominantly have positive ecological and water management effects on the river Rhine. Improvements in river flow, fewer technical interventions and new opportunities for ecological development are expected. However, supplementary measures are necessary in some areas. Discharging mine water will increase the temperature by 0.1 degrees and the chloride concentration by 10 milligrams per litre. Neither of these changes will substantially affect the survival or growth rates of fish.

Mine water and the ecology of the Rhine

Carola Winkelmann, Lothar Kirschbauer, Syliva Moenickes



How artificial intelligence views mining water law.

Focus Law

When flooding mines in Germany, requirements under both mining and water law must be met. This is because the discharge of mine water constitutes “water use”. This mine water, which is sometimes highly mineralised, must not pose any risk to people or the environment. The *Erblastenvertrag* (“legacy agreement”) secures the long-term financing of the flooding costs. Overall, the mining and water authorities are responsible for the procedures. It is important to have legally secure approval procedures in place and to incorporate environmental considerations into mine flooding and water management.

Georg Wieber, Marion Stemke



Flooded Rhine River meadows at Walsumer Hof

Focus Water Level

If mine water rebounds unimpeded, it can relieve the pressure on the polder measures. Under no circumstances will increasing mine water levels lead to buildings becoming waterlogged, as this is prevented by the polder measures. In many areas, it will even be possible to restore the water balance to a more natural state. However, regional differences require a differentiated approach. The existing large-scale groundwater model can be used to illustrate the effects on water management and inform planning decisions.

Unimpeded rise in mine water

Michael Getta, Johannes Meßer, Florian Werner, Sandra Kons,
Maj-Britt Ottenjann, Patricia Göbel

Was ist ein nachhaltiges
Flutungsniveau?

Pumpaufwand so gering
wie möglich

Bevölkerungsumfrage

Keine negative Beein-
flussung des Trinkwassers

Grubenwasserqualität so
gut wie möglich

Metsämonttu/Finnland

Keine „nassen Füße“

Effekt der Erstspülung
(*first flush*)

Königstein/Sachsen (Wismut)

Straßberg/Harz

Wie bildet sich
Schichtung?

Nikolaus-Bader-Schacht/Österreich

Wo bildet sich Schichtung
aus?

El Entrego & El Sorriego/Spanien

Wie und wann bricht die
Schichtung zusammen?

Niederschlema/Sachsen (Wismut)

Sankey-Diagramm

Schichtung als potentielle

Agricola Mine Model/Südafrika

Focus Sustainability

Based on international experience, target levels for mine flooding have been defined that consider ecological and technical requirements. This enables a balance to be struck between costs, environmental protection, and long-term risks. The presence of geological barriers and the ability to influence the course of flooding are particularly important factors. It is important to minimise pumping costs, prevent drinking water contamination and improve mine water quality. This can be achieved by flooding the mines as high and as fast as possible to allow natural density stratification to occur.

Christian Wolkersdorfer, Elke Mugova

Sustainable mine flooding levels

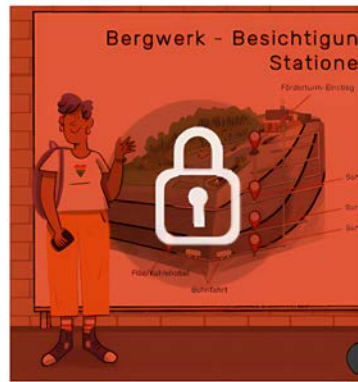


What do you associate with the term mine water?

Focus Public

Many people lack information about mine flooding and are therefore uncertain. This is often because of the technical language used by those involved. At the same time, however, there is a high level of public interest in clear, transparent communication. Citizen dialogues and early education are essential for conveying information and building trust. Information events and formats with active citizen participation are considered particularly effective. When it comes to solutions for mine water, the population trusts the former mine operator RAG Aktiengesellschaft the most and politicians the least.

Christian Wolkersdorfer, Elke Mugova, Stefanie Walter



Focus Education

This interactive educational game on the subject of mine water is aimed at young people aged 15 and over. It educates them in an age-appropriate manner about mining, mine water and the perpetual obligations associated with it. The content is presented in three chapters and supplemented by 3D scenes, professionally narrated text and quizzes. These digital learning methods offer pupils a contemporary way to learn about mining and mine water. Tests with school classes have shown that the game increases understanding of and acceptance for mine water in former mining regions.

Sylke Hilberg, Susanne Meerwald-Stadler

(1 von 3)

Grube Meggen

DE0009: Grube Meggen # Sicilia-Schacht

(underground mine 1890-1992 in Deposit Meggen, Germany)

Flooding Status: fully flooded (1996 to 1999)

Most recent water level: 270 mSL in 1998

Commodities (Main / Sec.):

pyrite zinc lead

Locality information:

Mine local name: Grube Meggen

Mine activity: continuous

Owner / Contact: Bergbaumuseum

[Zoomen auf](#) [Bearbeiten](#)

[Route ermitteln](#)

[Zugehörige Datensätze anzeigen](#)

Focus Data Platform

The “Mine Flooding” internet portal is an international geodatabase in English that centrally compiles information on over 120 flooded mines in Europe. As well as location, operating and flooding data, it also stores geological, hydrogeological and physico-chemical information. The web-based database displays search results in pop-up windows. All chemical analyses are linked to locations and can be evaluated alongside historical data. Overall, the database provides a comprehensive basis for research and comparative studies. The aim is to continuously expand it with global participation.

Christian Wolkersdorfer, Christian Melchers, Bastian Reker



Deisenried Adit, Fischbachau, Germany

The Focusers

Diego A. Bedoya Gonzalez, Michael E. Böttcher,
Til Genth, Michael Getta, Patricia Göbel, Michael
Heitfeld, Sylke Hilberg, Henning Jasnowski-Peters,
Timo Kessler, Thomas Kirnbauer, Lothar
Kirschbauer, Norbert Klitsch, Thomas König,
Sandra Kons, Susanne Meerwald-Stadler, Christian
Melchers, Johannes Meßer, Syliva Moenickes,
Elke Mugova, Maj-Britt Ottenjann, Peter Quensel,
Bastian Reker, Thomas Rinder, Lisa Rose,
Peter Rosner[†], Dmytro Rudakov, Maria-Theresia
Schafmeister, Rolf Schiffer, Leanne Schmitt,
Marion Stemke, Stefanie Walter, Florian Werner,
Kai Westhues, Georg Wieber, Carola Winkelmann,
Stefan Wohnlich, Christian Wolkersdorfer

Who provided the content?

SAN-FERNANDO



1915

San-Fernando Adit, Herdorf, Germany

Fokus Makers

Legal

Publisher Forum Bergbau und Wasser | Deutsches
Stiftungszentrum GmbH im Stifterverband |
☎ +49 201 8401-248 | ✉ kontakt@forum-
bergbau-wasser.de ∞ Lara Vanessa Straatmann
Texts Christian Wolkersdorfer, DeepL.com & ChatGPT
Design ∅ Layout Christian Wolkersdorfer
Photos The authors & Ch. Wolkersdorfer
Board Members Wilhelm Struckmeier Chairperson,
Burgdorf | Sylke Hilberg until 2023, Salzburg |
Rainer Lüdtke Essen | Christian Melchers Bochum |
Maria-Theresia Schafmeister Greifswald | Georg H.
E. Wieber Mainz | Christian Wolkersdorfer Pretoria
Responsible for Content Christian Wolkersdorfer

ISBN 978-3-948431-06-8
www.forum-bergbau-wasser.de
© 2025, Forum Bergbau und Wasser

V2.0 2025-09-15 en



Holy Barbara, Oybin Monastery, Saxony, Germany