Conservation - Headframe Friedrich-Wilhelm (Kegel) in Tsumeb, Namibia

Screenshot Google Earth oct 2019

Konservierung – Friedrich – Wilhelm – Fördergerüst (Kegel) in Tsumeb, Namibia

project : HTW Berlin, MA-Conservation Program Industrial Heritage

financed by : Federal Foreign Office of Germany, Heritage Conservation Program

Presentation by Prof. Ruth Keller, HTW Berlin

Team and main responsibilities:

Ronny Jaßmann(team leader, metal construction, welding),

Lennart Hollweg (surface conservation documentation),

Florian Pohlmann (metal cleaning, documentation),

Eva Wentland (climbing security + cleaning.

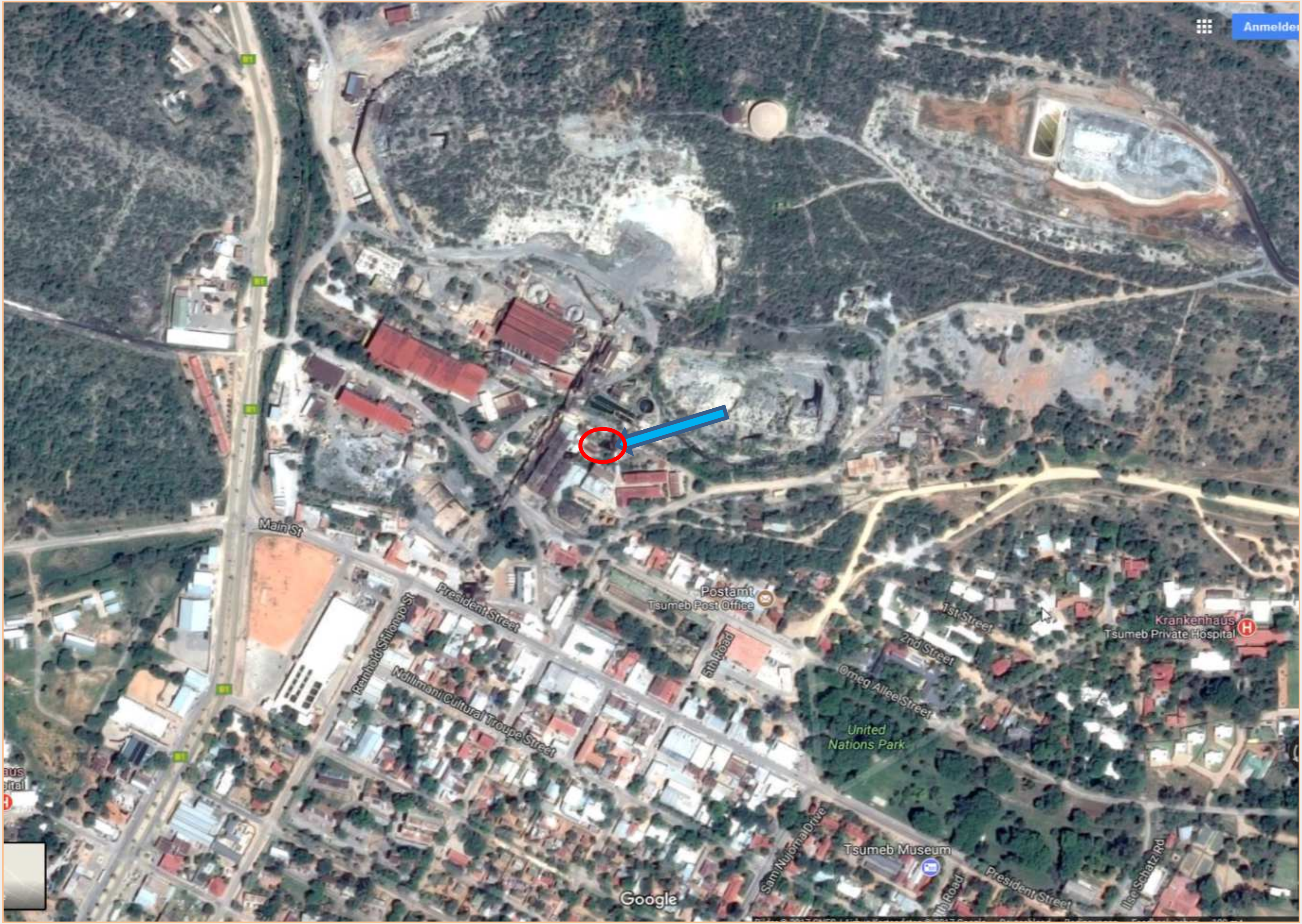
Veronika Zanner (wood work, documentation)

Prof. Dr. Thomas Böllinghaus, BAM, Judith Fait, Jens Frautschy,

Dipl. Rest Dietmar Linke MA, Diipl. Ing. Arthur Scholz

pictures: google earth + Frautschy + HTW-Team.

LOCALISATION OF SHAFT 1, FRIEDRICH WILHELM



Screenshot Google Earth Oct. 2019

TOWN AND LANDSCAPE: TSUMEB STAMPED BY ITS MINING HISTORY; SHAFT 1 (BLUE FLESH)

HTW Berlin, BAM Berlin, Dundee Precious Metals, Museum Tsumeb: all rights reserved

SHAFT 1, FRIEDRICH WILHELM – NAMED IN HONOUR OF SOUTHAFRICAN DIRECTOR OF OTAVI F. W. KEGEL 1922-32

HEADFRAME MAKE PROMNITZ, FÖRDERGERÜST TYP PROMNITZ, BEFORE CONSERVATION.

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SITUATION AROUND SHAFT 1, DE WET SHAFT IN BACKGROUND

during conser-
vation process

De Wet Shaft

Foto Frautschy 2020

NIMT, NAMIBIAN INSTITUTE OF MINING AND TECHNOLOGY

PULLEY WHEELS ON PLATFORM
Seilscheiben, -bühne
WORK IN PROGRESS, NOV. 2020

ENGIN HOUSE, DRIVING WHEEL
Fördermaschinenh., Treibscheibe

POWER PLANT PALL 1
Halle 1 des Kraftwerks

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SITUATION AROUND SHAFT 1, NAMIBIAN INSTITUTE OF MINING AND TECHNOLOGY, **NIMT**

VIEW FROM PLATFORM: TECHNICAL EDUCATION, NIMT, IN FORMER HOUSE OF THE DEPUTY OF MINE [„STEIGERHAUS“] - DURING A BREAK

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Situation around shaft 1, Power Plant Hall

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View from platform: Power plant hall with added constructions - power machines from different periods and countries; *Maschinenhalle mit angefügten Funktionseinheiten, Sicht von Friedrich Wilhelm Fördergerüst mit Aggregaten aus unterschiedlichen Zeiten und Ländern.*

SITUATION AROUND SHAFT 1, BENEFICIATION OF THE ORE

VIEW FROM PLATFORM: DISTRICT OF FORMER BENEFICIATION OF THE ORE; OPEN PIT IN BACKGROUND

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Preliminary Research HTW 2018 – May

Voruntersuchungen 2018 -Mai

Getting familiar with the frame: survey, mapping, sampling and report of different conditions and parts.

Testing transparent conservation methods: Which test areas would offer the most reliable results?

Corners of the frame mid of the Shaft chosen for long term exopsure: test area cleaned and coated with microCrystalline waxes.

Activities and achievements - 16 days, 5 persons, financed by htw:

Communication, Cooperation, Documentation, Sampling Steel Qualities + Corrosion products, planning Conservation :

- Multiple Discussions on **cultural values** for local, national + international people of **authenticity**; concept/idea of conservation.
- Memorandum of Understanding with **Dundee precious metals;** Cooperation with **Tsumeb Museum**; Promotion by **Heritage Council** of Namibia.
- **Conservation Planning**: Prof. Ruth Keller (**concept**), Dipl.-Rest. D. Linke, MA (conservation **methods**), R. Jassmann, MA candidate + 2 students: **Condition** Reports (photography, measuring, drawings, sampling steels) + **Calculation** (Expanse of steel degraded, local prices).
- Jens Frautschy, Director Tsumeb Museum: 1. Regional Communication, 2. monitoring the results up to September 2019 (by visual comparison).

2018 FINDING POSITIONS TO TEST TRANSPARENT COATINGS IN ARID CHANGING WITH HUMID CLIMATE; OVERVIEWS (UPPER), DETAILS (LOWER) PICTURE SERIES.

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PRELIMINARY RESEARCH BAM-HTW 2019 AUG.– OCT. (BAM - FEDERAL INSTITUTE FOR MATERIALS TESTING AND RESEARCH)

IMPORTANT FOR SUSTAINABILIY AND SUCCESS OF THE PROJECT: COOPERATION WITH BAM, BERLIN:

- **TESTING** ORIGINAL AND CONSERVATION MATERIALS ON HIGH SCIENTIFIC LEVEL, **AHEAD + AFTER** REALIZATION OF THE CONSERVATION WORK.
- **SUPERVISION** OF MEASURES IMPROVING STABILITY OF THE FRAME BY **DISTANT COMMUNICATION** AND **TRANSFER OF DETAILED PICTURES**; FOR SAFE OF SECURITY AND LASTING STABILITY **DISTANT CONTROL** WILL HAVE TO CONTINUE FOR MANY YEARS: **DOCUMENTATION UNIT** IN TSUMEB NEEDED.

Current Considerations for a Cultural Heritage Corrosion Protection Project

METALLURGY AND CORROSION PROTECTION
SHAFT #1 HEADFRAME AND ADJACENT COMPONENTS

Thomas Boellinghaus

I. Introduction
II. Key questions
III. **Preliminary Working program**
IV. Working Program
V. MSc & PhD theses
VI. Conclusions
VII. Perspectives

Copy out of presentation of
Prof. Dr. Thomas Böllinghaus,
Lecture at HTW Berlin, 21st Jan. 2020

RINGVORLESUNG HTW 21. JANUAR 2020
TSUMEB INDUSTRIAL HERITAGE PROJECT

Prof. Dr.-Ing. Thomas Böllinghaus
Bundesanstalt für Materialforschung und –prüfung
Abteilung 9 – Komponentensicherheit

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Preliminary research BAM-HTW 2019 Aug.– Oct.

Testing Owatrol oil combined with UV-absorber Tinvuin® 900 1% and scavenger (Radikalfänger) Tinvuin® 292 0,5% . **Result:**

→ **No use of this combination of Tinuvin!** Even though recommended by the manufacturer the mixture can not be used.

Studies with other combinations are essential for the long-term conservation of industrial heritage.

3. Untersuchungen – Korrosionverhalten

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University of Applied Sciences

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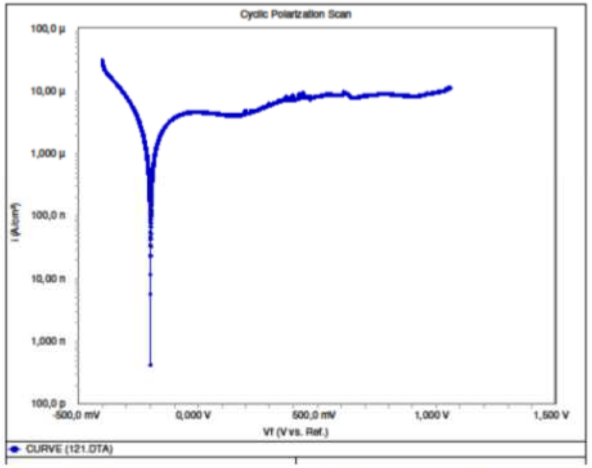
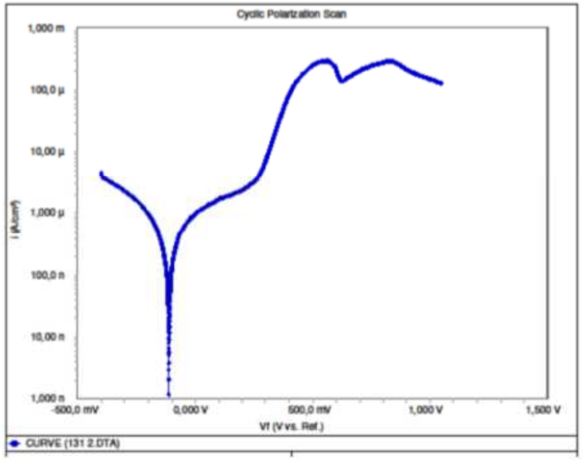
Potentiodynamische Polarisierungskurven

Originalzustand, Owatrol-beschichtet
8.4g $NaHCO_3$, 2,5ml 40% $NaHSO_3$ sol., 160mg NaCl / 1l H_2O dem.



Gleiches Ruhepotential: E =- 250 mV(Ag/AgCl)
Keine Aktivierung erkennbar,
ausgeprägter >passiver< Bereich

Originalzustand, Owatrol+Tinuvin-beschichtet
8.4g $NaHCO_3$, 2,5ml 40% $NaHSO_3$ sol., 160mg NaCl / 1l H_2O dem.



Erhöhtes Ruhepotential: E ca. 0 mV(Ag/AgCl)
Deutlich ausgeprägte Aktivierung,
Darunter >leicht passiver< Bereich

Tinu significantly decreases corrosion resistance

Source: Böllinghaus, invited lecture HTW, Jan. 2020

PRELIMINARY RESEARCH BAM 2006 - 2019

Changing condition of headframe shaft 1 in Tsumeb – documented by Böllinghaus

3. Untersuchungen – Allgemeiner Zustand

>Large Scale<

2006 – November | 2010 – November | 2013 – November | 2019 – Februar

Source: Böllinghaus, invited lecture HTW, Jan. 2020

Fotos Böllinghaus 2006-2019

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3. Untersuchungen – Allgemeiner Zustand

Korrosion – Rampe / Erste Ebene

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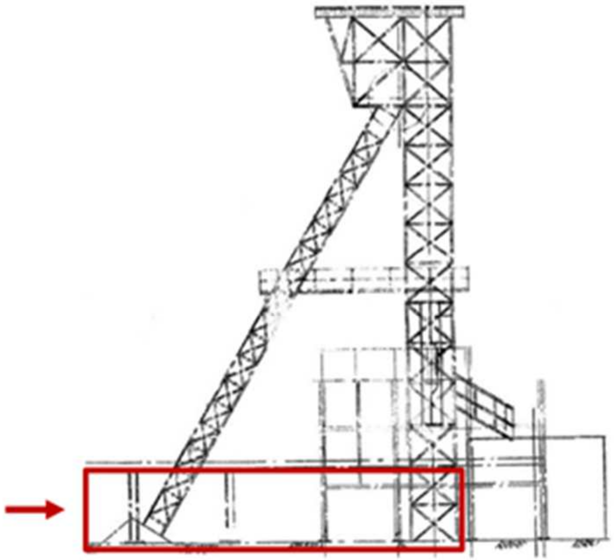

Teilweise erhebliche Korrosionsschäden an Stützen, Trägern und Bodenplatten

ALONG THE RAMP NOT ALL CORROSION PROBLEMS HAVE BEEN ACCESSIBLE AND SOLVED; FURTHER RESEARCH IS INTENDED IN COOPERATION HTW-BAM.

PRELIMINARY RESEARCH BAM-HTW AUG.– OCT. 2019

WORKING PROGRAM – USED STEEL PROFILES: REACTIONS TO CONSTRUCTIVE DETAILS + INFLUENCE OF WEATHER CAN BE IDENTIFIED.

Samples prepared from a 1m and 60x60 mm angular mild steel bar

- ca. 200 mm for metallurgical investigations, including SEM + EDS for corrosion product analyses on the as-delivered surface
- ca. 800 mm for about 30 50 x 50 mm specimens for weathering an corrosion tests
- Specimen variance I: 10 uncoated, 10 Owatrol coated, 10 Owatrol + Tinuvin (292+600) coated
- Specimen variance II: 1 Impedance (Nyquist) measurements, 2 non-weathered 20 and 60 °C, 2 weathered

	Conditions	Parameters	Expected Output
Metallurgy of used steel profile	As-delivered	Microstructure Hardness measurement and correlation to strength Grain size and type Chemical composition Steel type Corrosion layer types (magnetite?) and thickness	**→ Publishable and documented high quality metallography** **→ Identification of the steel type and basic mechanical properties** Origin of the steel types (?) Comparison/Extension of the HTW database Type of corrosion products Type of coating
Potentiodynamic and potentiostatic measurements with and without coatings (Flat specimens 5x5 cm, perhaps 2x2 cm)	Condensed rain water (simulated) Sweep rate 2 $mV \cdot s^{-1}$	Rest potentials Electrochemical impedance (=corrosion resistance) Coorsion/pitting potentials threshold potentials (?) for the pure material, for the Owatrol-coated material for the Owatrol+Tinuvin-coated material	**→ Corrosion resistance of the uncoated versus the coated material before weathering** **→ Compatibility of Owatrol and Tinuvin under corrosion conditions**
Weathering 2000 h (Flat specimens 5x5 cm, Perhaps 2x2 cm)	Simulating as close as possible the real environmental conditions (UV+Humidity)	Visual inspection of the surface for - Degradation of corrosion layer types - Degradation of coatings with respect to scratches, defoilation, etc.	Stability of Owatrol under realistic climatic conditions Compatibility of Tinuvin with Owatrol Effect of Tinuvin to enhance the UV stability of Owatrol Comparison to the pure material
Potentiodynamic and potentiostatic measurements of the weathered specimens with and without coatings (Flat specimens 5x5 cm)	Condensed rain water (simulated) Sweep rate 2 $mV \cdot s^{-1}$	Rest potentials Electrochemical impedance (=corrosion resistance) Coorsion/pitting potentials threshold potentials (?) for the pure material, for the Owatrol-coated material for the Owatrol+Tinuvin-coated material	**→ Corrosion resistance of the uncoated versus the coated material after weathering** **→ Stability of the Tinuvin-Owatrol coating vs. pure Owatrol and the uncoated material** **→ Compatibility of Tinuvin with Owatrol in slightly corrosive environments** **→ Temperature resistance of the uncoated and coated material in slightly corrosive environments**

Source: Böllinghaus, invited lecture HTW, Jan. 2020

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WORKING PROGRAM – **USED STEEL PROFILE:** IDENTIFICATION OF ELECTROCHEMICAL CHANGES

200 mm: **Metallurgy, hardness measurements, chemical composition and preliminary tensile testing**

200 mm: **Uncoated = 8 samples**: (1 Electrochemical impedance, 1 Potentiodynamic, 2 Rest potential) á 2 Temperatures

200 mm: **Owatrol = 8 samples**: (1 Electrochemical impedance, 1 Potentiodynamic, 2 Rest potential) á 2 Temperatures

200 mm: **Owatrol+Tinuvin** = 8 samples: (1 Electrochemical impedance, 1 Potentiodynamic, 2 Rest potential) á 2 Temperatures

200 mm: Reserve

NOTE: If the **specimen size is limited to about 20 x 20 mm**, the **number of corrosion test specimens could be doubled** !

Steel type	Metallurgy and mechanical properties, including hardness	Electrochemical impedance, potentio-dynamic a´ 3 conditions - Without coating - With Owatrol - With Owatrol + Tinuvin a´ 2 temperatures (RT and 60 °C) (Flat specimens 5x5 cm)	Weathering 2000 h and subsequent electrochemical impedance, potentio-dynamic a´ 3 conditions - Without coating - With Owatrol - With Owatrol + Tinuvin a´ 2 temperatures (RT and 60 °C) (Flat specimens 5x5 cm)	Remarks
Steel 1 (Structure – angular profile = cross bars?)	ca. 200 mm	1 for each impedance measurement x 3 conditions x 2 temperatures = 6 1 for each potentio-dynamic measurement x 3 conditions x 2 temperatures = 6 -- Total 12 specimens	1 for each impedance measurement x 3 conditions x 2 temperatures = 6 1 for each potentio-dynamic measurement x 3 conditions x 2 temperatures = 6 -- Total 12 specimens	Reserve of about 8 specimens for reproducibility, perhaps required test repetitions and slight cathodic protection

Source: Böllinghaus, invited lecture HTW, Jan. 2020

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WORKING PROGRAM – **USED STEEL PROFILE: DETAILS OF WELL KNOWN + UNKNOWN HISTORIC STEELS** ARE SHOWN.

3. Untersuchungen – Metallurgie

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Stahlproben – Chemische Zusammensetzung und Zuordnung

	C	Si	Mn	P	S	N	Al	Cr	Ni	Mo	Cu	Co	Ti	V	W	B	Sn	As	Bi	O
ACIEBIS DE LONGWY	0,0341	0,0020	0,5635	0,044	0,0434	0,0195	0,0027	0,021	0,0426	0,0031	0,008	0,0148	0,001	0,0003	0,0059	0,0003	0,0003	0,05937	0,0025	0,0044
KÖNIGS-HÜTTE NP20	0,1429	0,0262	0,5446	0,0481	0,0544	0,0041	0,0052	0,015	0,0579	0,0028	0,125	0,0172	0,0011	0,00061	0,0069	0,0004	0,0164	0,03551	0,0027	0,0167
Flach-stahl	0,0281	0,0022	0,3604	0,0573	0,0772	0,0167	0,0026	0,006	0,0400	0,0030	0,024	0,0077	0,001	0,0003	0,0051	0,0005	0,0018	0,05422	0,0027	0,0316
U20 östlich HOEBDE 45	0,0659	0,0037	0,4672	0,0592	0,019	0,0151	0,0014	0,008	0,0369	0,0031	0,019	0,0081	0,001	0,00046	0,0024	0,0002	0,0015	0,03536	0,0009	0,0448
KRUPP NP30	0,0532	0,0032	0,505	0,0414	0,0521	0,012	0,0011	0,01	0,0357	0,0018	0,058	0,0185	0,001	0,00153	0,0010	0,0006	0,0047	0,02505	0,0005	0,0578
Dia-gonale	0,2272	0,0090	0,4938	0,0338	0,0574	0,0045	0,0086	0,017	0,0534	0,0031	0,127	0,0103	0,001	0,00103	0,0033	0,0005	0,0483	0,05009	0,0006	0,0696

→ Mn und P Gehalt: Alle Stähle weisen typische Zusammensetzungen für Flussstähle auf

→ Anmerkung: Krupp NP 30 stammt nicht vom Fördergerüst, sondern von einem Bürogebäude nebenan

→ C Gehalt: Einige sind so niedrig, dass es sich um Puddel-Stähle handeln könnte, aber der Überblick von Helmerich et al. hat ergeben, dass der C-Gehalt im Flussstahl stark variieren kann, zwischen 0,026 to 0,20 %

→ Alle bisher untersuchten Stähle sind Flussstähle

→ N Gehalt < 0,008 %: Zwei Stähle könnten Siemens-Martin-Stähle sein, der C-Gehalt passt ebenfalls dazu

→ Si Gehalt < 0,08 %: Alle Stähle könnten Thomas-Stähle sein

Source: Böllinghaus, invited lecture HTW, Jan. 2020

WORKING PROGRAM – **USED STEEL PROFILE,** CORROSION PRODUCTS: **HIDDEN DANGERS** OR **PROTECTION** AGAINST FURTHER CORROSION?

3. Untersuchungen – Korrosionsprodukte

Winkelprofil– HR-REM

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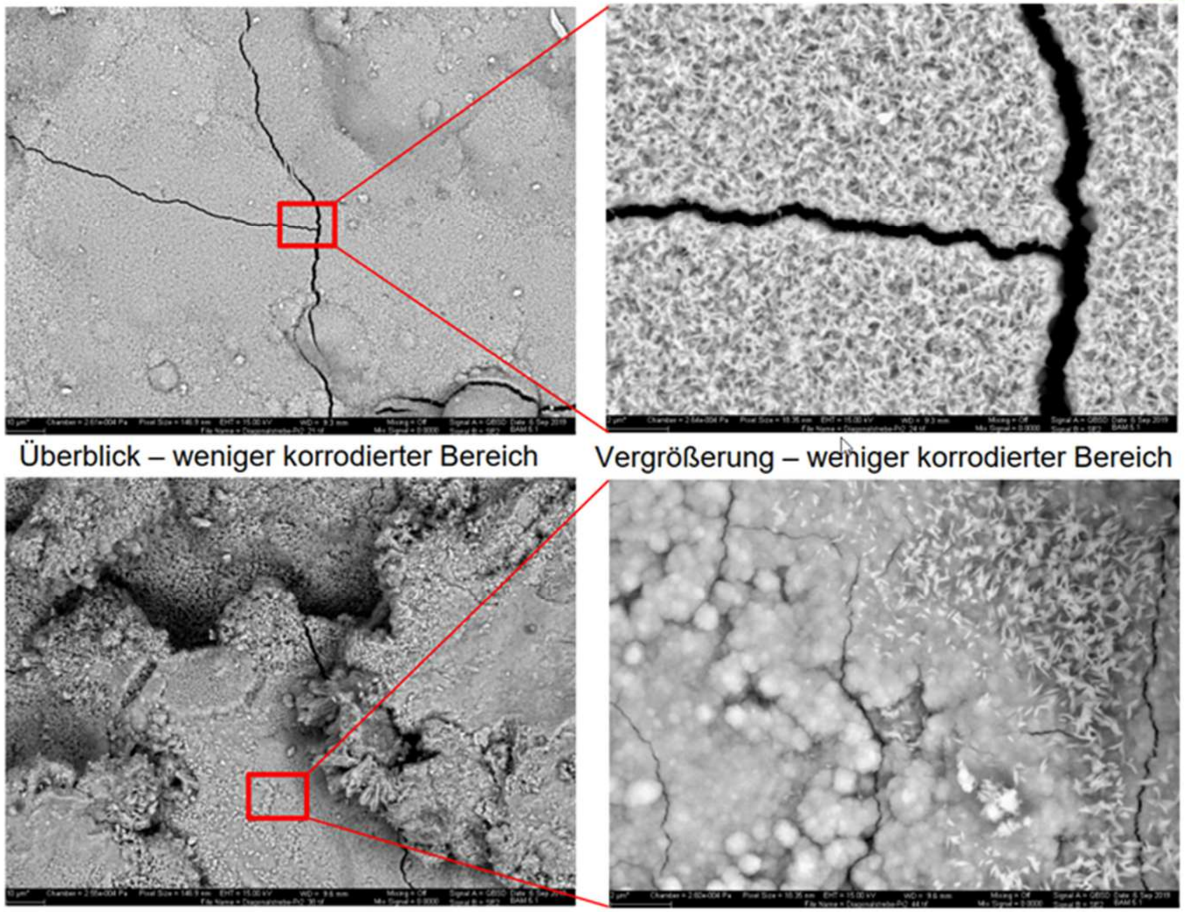


Überblick – weniger korrodierter Bereich

Vergrößerung – weniger korrodierter Bereich

Vergrößerung – korrodierter Bereich

Vergrößerung – korrodierter Bereich

Lepidokrokit:
γ-FeOOH beschleunigt die Korrosion im Anfangsstadium, reduziert aber bei langen Expositionszeiten die Korrosionsrate.

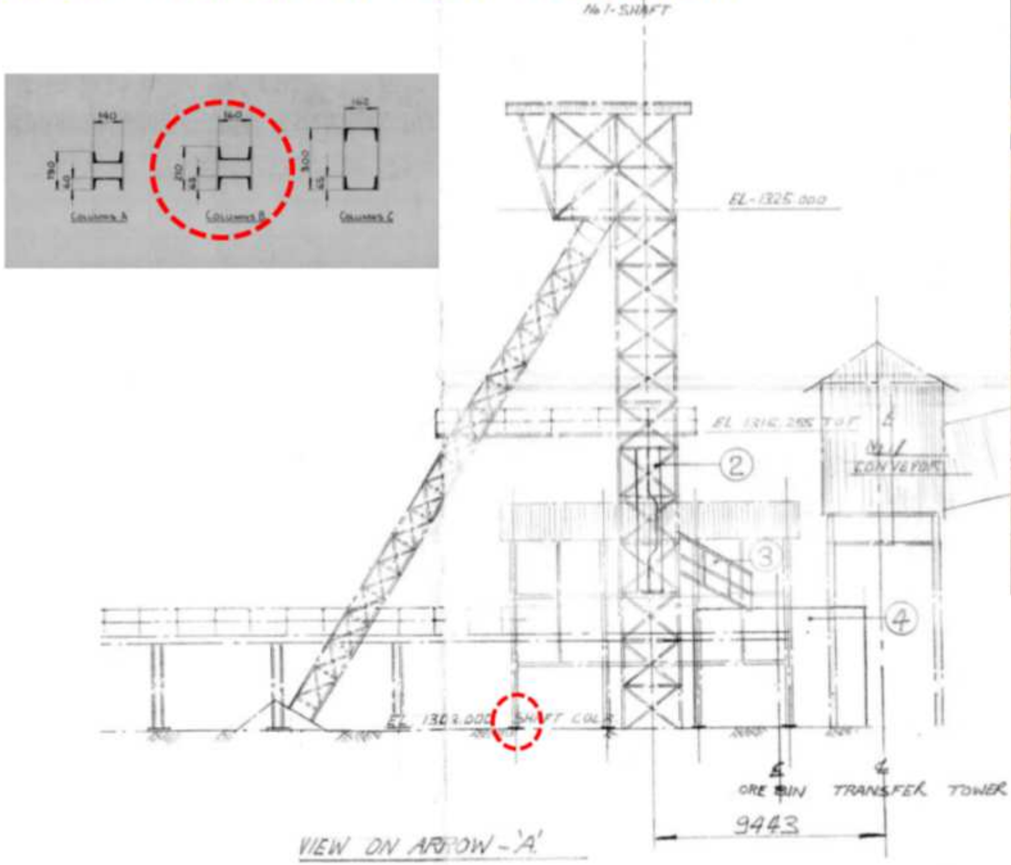
Goethit:
α-FeOOH hat bereits in dünnen Korrosionsschicht en aufgrund seiner Stabilität eine schützende Wirkung.

Source: Böllinghaus, invited lecture HTW, Jan. 2020

HIDDEN DANGERS OF LONG TERM STABILITY – HOW CAN THEY BE DETECTED?
VERBORGENE GEFAHREN FÜR DIE LANGZEITSTABILITÄT; WIE KÖNNEN SIE AUFGESPÜRT WERDEN?

4. Konservierungsarbeiten – Reparaturschweißungen

Unterer Bereich von Stützen



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Stütze B

Hidden dangers: How do they arise and appear?
Verborgene Gefahren: Wie entstehen sie und zeigen sie sich?

PRELIMINARY RESEARCH BAM-HTW AUG.– OCT. 2019

FUTURE WORKING PROGRAM – **USED STEEL PROFILE, REPAIR BY WELDING: FURTHER RESEARCH IS NEEDED FOR THE CONSERVATION OF TECHNICAL/INDUSTRIAL CULTURAL HERITAGE IN AUTHENTIC CONDITION.**

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5. Konservierungsarbeiten – Reparaturschweißungen

Forschungsbedarf

- → Verhalten alter Flussstähle gegenüber neuen hoch- und ultrahochfesten Varianten hinsichtlich Eigenspannungsentwicklung
- → Eigenspannungen bei Laschen gegenüber dem Einschweißen von Sektionen
- → Einfluss und Reduktion der Schrumpfbehinderung in Bezug auf die Eigenspannungen
- → Einfluss des Grundwerkstoffes auf den Aufbau von Eigenspannungen
- → Einfluss von Schweißfolgen, Stützblechen, Naht- und Stoßgeometrien
- → Eigenspannungsentwicklung in Abhängigkeit des Schweißverfahrens
- → Reduktion von Eigenspannungen mittels (Wärme-?) Nachbehandlungen
- → Einfluss der Zusatzwerkstoffe: Basische Elektroden bzw. Fülldrähte, LTT-Zusatzwerkstoffe
- → Prüfung der Schweißverbindungen unter statischen und dynamischen Beanspruchungen
- → Anwendbarkeit und Aussagekraft von Rissprüfungen bzw. Eigenspannungsmessungen
- → Best-Practices zur Reparaturschweißung an alten Industrieanlagen und zum Ersatz von Nieten- und Knotenblechen durch Schweißverbindungen

A research program is about to be applied in this year;
Observation of the headframe will have to continue for long time.

Source: Böllinghaus, invited lecture HTW, Jan. 2020

HISTORIC OVERVIEW: AROUND THE SHAFT HEADFRAME

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2. Fördergerüst Schacht #1 (Shaft #1 Headframe)

Minenareal

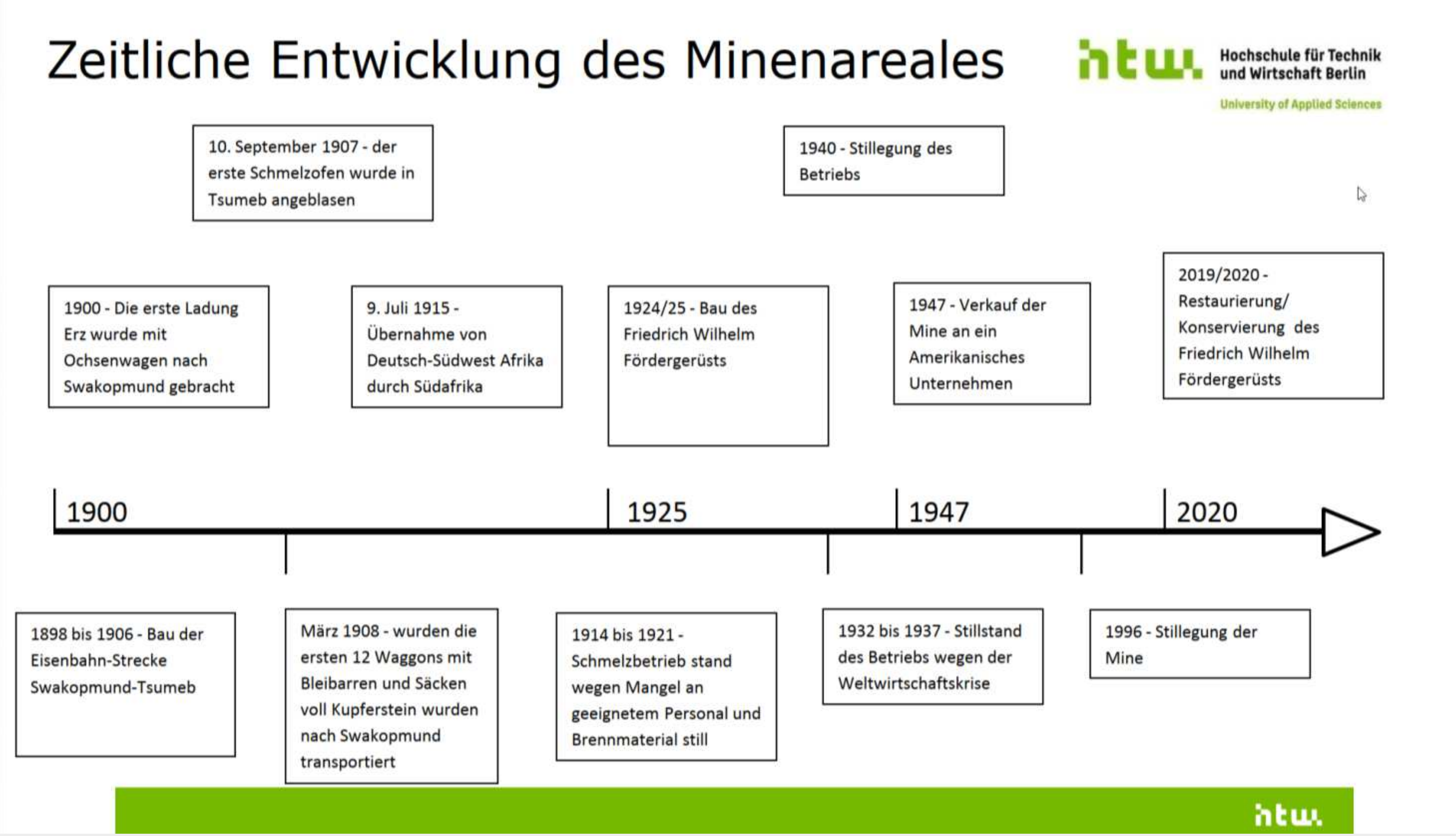
1 – Shaft#1 Fördergerüst
2 – DeWet Shaft Fördergerüst
3 – Förderband
4 – Generatorhalle
5 – Mineralogie

© Tsumeb Museum, J. Frautschy 2019

What functions of mining are to be found around the shaft head frame?

Source: Böllinghaus, invited lecture HTW, Jan. 2020

HISTORIC OVERVIEW: A CHRONOLOGY



BASED ON DOCUMENTS FROM TSUMEB MUSEUM, ON LITERATURE AND,
AMONGST OTHERS, PUBLICATIONS BY JUDITH FAIT (2019), P.G. SOEHNGE (1967), I. SCHATZ (1997).

HISTORIC OVERVIEW: **HISTORIC AND NEW FOTOS OF SHAFT AND HEADFRAME**

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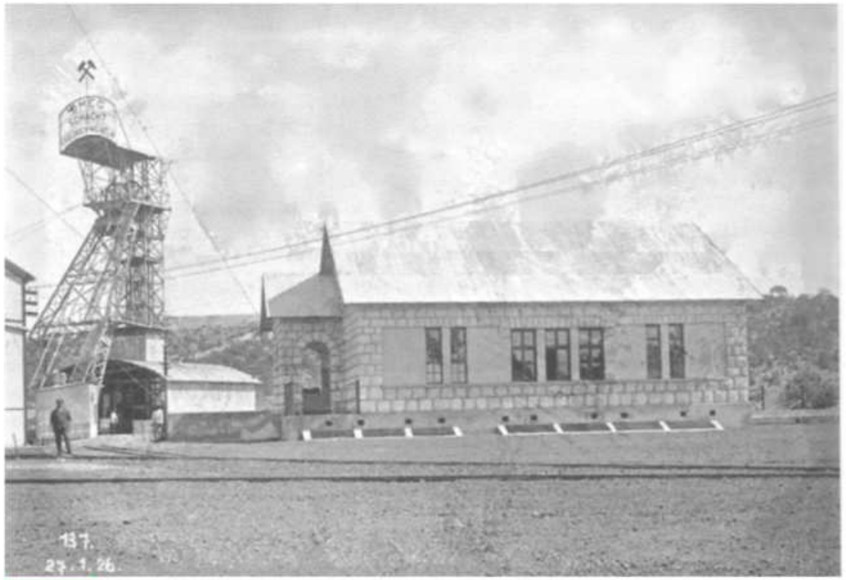
2. Fördergerüst Schacht #1 (Shaft #1 Headframe)

Geschichte des Fördergerüstes

Entwurf ca. 1923, Baujahr 1925



2019

First power plant house at the side the headframe

Source: Böllinghaus, invited lecture HTW, Jan. 2020