JORC REPORT

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstädter Strasse 28
99096 Erfurt
Germany

Phone: +49 361 3810 500
Fax: +49 361 3810 505
E-Mail: mining@ercosplan.com
Web: www.ercosplan.com
Managing Director: Dr Henry Rauche

JORC compliant Report for the Gräfentonna Exploration Licence Area, Federal State of Thuringia, Federal Republic of Germany

This JORC REPORT contains

78 Pages
13 Appendices

Client:	**East Exploration GmbH** Burgstraße 12 80331 München Germany
Consultant:	**ERCOSPLAN Ingenieurgesellschaft** **Geotechnik und Bergbau mbH** Arnstädter Straße 28 99096 Erfurt Germany
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Dr Henry Rauche	Andreas Jockel
Managing Director & C.E.O. European Geologist	European Geologist

Compliance Statement

The information in this report that relates to Exploration Targets, Exploration Results, Mineral Resources or Ore Reserves is based on information compiled by Andreas Jockel, a Competent Person who is a Member of a 'Recognised Professional Organisation' (RPO), the European Federation of Geologists, and a registered "European Geologist" (Registration Number 1018) and Dr Henry Rauche, a Competent Person who is a Member of a 'Recognised Professional Organisation' (RPO), the European Federation of Geologists, and a registered "European Geologist" (Registration Number 729).

Andreas Jockel and Dr Henry Rauche are full-term employees of ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH (ERCOSPLAN).

ERCOSPLAN, Andreas Jockel and Dr Henry Rauche are not associates or affiliates of East Exploration GmbH, or of any associated company. ERCOSPLAN will receive a fee for the preparation of this Report in accordance with normal professional consulting practices. This fee is not contingent on the conclusions of this Report and ERCOSPLAN, Andreas Jockel and Dr Henry Rauche will receive no other benefit for the preparation of this Report. ERCOSPLAN, Andreas Jockel and Dr Henry Rauche do not have any pecuniary or other interests that could reasonably be regarded as capable of affecting their ability to provide an unbiased opinion in relation to the Gräfentonna Exploration Licence area.

ERCOSPLAN does not have, at the date of this Report, and has not had within the previous years, any shareholding in or other relationship with East Exploration GmbH or the Gräfentonna Exploration Licence area and consequently considers itself to be independent of East Exploration GmbH.

Andreas Jockel and Dr Henry Rauche have sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity being undertaken to qualify as a Competent Person as defined in the 2012 Edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. Andreas Jockel and Dr Henry Rauche consent to the inclusion in the report of the matters based on their information in the form and context in which it appears.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

EXECUTIVE SUMMARY

Introduction

East Exploration Pty Ltd (Melbourne, Australia) initiated its application for a potash project in the central part of the Federal State of Thuringia, Germany back in early 2014. A local subsidiary company, East Exploration GmbH (East Exploration) was founded and registered in Munich, Germany in late 2014 in order to hold and operate the exploration licence under application. Two Exploration Licence areas, Küllstedt ($241.72 km^2$) and Gräfentonna ($216.52 km^2$), were granted on the 12 January 2015 in compliance with section 6 and 7 BBergG[1] by the Thüringer Landesbergamt[2]. These licences are valid until the 12 January 2020 and restricted to the exploration of mineral resources in compliance with section 3, Paragraph 3 BBergG, which are rock salt[3], potassium salts, magnesia and boron salts together with accompanying salts within the deposit. East Exploration is now owned 100% by Davenport Resources Pty Ltd, which was listed on the Australian Securities Exchange (ASX) in January 2017 under the ticker ASX:DAV.

For the Küllstedt Exploration Licence area the review of historical exploration data and preparation of a Competent Person's Report (CPR) according to the JORC Code has been completed on 31 January 2015. For the Gräfentonna Exploration Licence area a similar review of historical exploration data and CPR in accordance with the JORC Code has been prepared with this CPR, for which ERCOSPLAN was commissioned by East Exploration on 12 January 2017.

Property Location, Local Resources and Infrastructure

The Gräfentonna Exploration Licence area is located in the central-N part of the Federal State of Thuringia, NW of the state's capital Erfurt. The infrastructure is well-developed with several federal and state roads connecting to federal motorways, and a regional railway network connecting to the trans-regional railway network. Power supply is available for households, established commerce and industry via a well-developed network.

Geology of the Deposit and Mineralisation

The Gräfentonna Exploration Licence area is located at the S border of the South Harz Potash District[4], which covers the central and NW part of the Thuringian Basin[5]. The South Harz Potash District reflects the extent of the potash deposit, which is subject of this Report.

The potash deposit is tectonically divided into three tectonic levels consisting of the basement, the saliferous strata and the overburden. Within the saliferous strata the potash mineralisation of the potash deposit is located, hosted by the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt).

The tectonic influence on the potash deposit resulted in brittle deformation in the basement and overburden, and folding of the saliferous strata to various degrees.

Subrosion is a common feature and delimits the extent of the potash deposit towards the N and NW. Within the extent of the deposit subrosion is locally restricted to tectonic structures. However, over most of its extent the potash deposit is still intact.

[1] BBergG is the abbreviation for Bundesberggesetz, the Federal Mining Law of Germany.
[2] Thüringer Landesbergamt is a Federal State Authority.
[3] Rock salt is a salt rock consisting mainly of Halite and Anhydrite (cf. chapter 6.4).
[4] South Harz Potash District is a potash mining district in the NW of the Federal State of Thuringia.
[5] Thuringian Basin is a geological structure in the central and N part of the Federal State of Thuringia.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

The historical drilling results show that the potash seam[6] is distributed almost across the entire Gräfentonna Exploration Licence area. The top varies between -600 and -950 m above sea level (asl) with increasing depth generally from NW to SE. The thickness is uneven ranging between about 2.5 and 23 m with a trend to increase towards the SW, and with a trend to decrease towards the N.

Main minerals of the potash deposit are Halite[7], Carnallite[8], Sylvite[9] and Kieserite[10] with additional amounts of Polyhalite[11] and Langbeinite[12] and accompanying clay minerals. Within the Gräfentonna Exploration Licence area it is assumed that the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) occur predominantly as carnallitite[13] and/or sylvinite[14] as well as locally barren zones.

Below the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) hydrocarbon-bearing dolomite exists.

Historical Resource/ Reserve Estimates

The only historical resource estimate for the Gräfentonna Exploration Licence area is in fact a reserve estimate according to today's reporting standards, and was prepared in 1964 for an area covering about 79% of the licence area's extent. The estimate resulted in 83.7 Mt K_2O of Delta-1 prognostic hartsalz[15] reserves[16].

Exploration History, Status of Exploration and Mining Activities

Historical exploration in the Gräfentonna Exploration Licence area was conducted intermittently between 1911 and 1983 and comprised of exploration drilling, which targeted mainly hydrocarbons, geophysical well-logging of the hydrocarbon exploration holes, chemical assaying of core material of two of these holes, and a 2D seismic survey.

Currently, no exploration activities are being conducted in the Gräfentonna Exploration Licence area.

No mining activities have been conducted in the Gräfentonna Exploration Licence area to date. In the South Harz Potash District, however, potash was conventional mined for almost 100 years, and is mined today by one solution mining operation.

Data Verification

Neither core material nor samples from historical exploration drilling are available for independent verification of the historical assays. Planning, supervision as well as documentation and evaluation of the historical exploration were done according to standards defined by the state reserve commission or reported internal company guidelines at that time. The interpretation of the historical drill hole data is, therefore, accepted as a reliable database for this Report.

Exploration Target Estimates

The results of the Exploration Target estimate for the Gräfentonna Exploration Licence area are:

- **Total volume is 1.464 km³ of mineralised rock**.

[6] Potash seam is defined in chapter 6.2.2.
[7] Halite is an evaporite mineral with the chemical formula NaCl.
[8] Carnallite is an evaporite mineral with the chemical formula $KCl \cdot MgCl_2 \cdot 6H_2O$
[9] Sylvite is an evaporite mineral with the chemical formula KCl.
[10] Kieserite is an evaporite mineral with the chemical formula $MgSO_4 \cdot H_2O$.
[11] Polyhalite is an evaporite mineral with the chemical formula $K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot H_2O$.
[12] Langbeinite is an evaporite mineral with the chemical formula $K_2SO_4 \cdot 2MgSO_4$.
[13] Carnallitite is a potassium-bearing salt rock consisting mainly of the evaporite minerals Carnallite, Halite, Kieserite and Anhydrite.
[14] Sylvinite is a potassium-bearing salt rock consisting mainly of the evaporite minerals Sylvite and Halite. Subordinately, Polyhalite, Langbeinite, Kieserite, Kainite and Anhydrite may occur.
[15] Hartsalz is a salt rock and assigned in this Report to sylvinite.
[16] Prognostic reserves are a classified reserve category according to Stammberger (1963, /25/). Delta-1 prognostic reserves are a classified sub-category of prognostic reserves.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
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- **Average density varies between a minimum of 1.83 t/m^3 and a maximum of 2.32 t/m^3**. These values are based on the varying salt rock densities and depend on the information of the drill holes sunk in the Küllstedt Exploration Licence area.
- **Tonnage range varies between a minimum of 2,678 and a maximum of 3,396 million metric tonnes of mineralised rock**.
- **K_2O grade varies between a minimum of 4.3% and a maximum of 25% of K_2O.** These values depend on the information of the drill holes sunk in the Küllstedt Exploration Licence area.
- **K_2O tonnage varies between a minimum of 115 and a maximum of 849 million metric tonnes of K_2O**.

No geological or technical cut-off values for thickness or grades have been applied.

Adjacent Areas

Adjacent to the northern boundary of the Gräfentonna Exploration Licence area is the Ebeleben Mining Property, managed by the owner BVVG Bodenverwertungs- und -verwaltungs GmbH (BVVG)[17]. It covers a total area of 37.08 km². Further to the NW the Volkenroda Mining Property is located, managed by the owner Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft GmbH (LMBV)[18]. It covers a total area of 68.70 km². Other mining properties in the vicinity of the Gräfentonna Exploration Licence area, held by various owners, are Bischofferode, Bleicherode, Sollstedt and Kehmstedt approximately 30 to 40 km towards the N and NE.

Mining fields for natural gas and crude oil are located approximately 20 km WNW of the Gräfentonna Exploration Licence area.

Interpretation and Conclusions

Modelling results based on historical exploration data show that the potash seam is distributed almost across the entire Gräfentonna Exploration Licence area. The top varies between 700 and 900 m bgl with increasing depth generally from NW to SE. The thickness is uneven ranging between about 2.5 and 23 m. Carnallitite occurs mainly in the E, NE and N of the Gräfentonna Exploration Licence area with some uncertainties due to the existing drill hole density, while the SE, S, SW, W and NW is dominated by sylvinite.

Potash mining in the Gräfentonna Exploration Licence is assumed to be economically feasible based on existing exploration, mining and processing concepts for various potassium salts, further supported by a well-developed infrastructure in the licence area and adjacent region. However, information from confirmation drilling is required for data verification and to decide on an adequate mining and processing concept.

Recommendations

The following recommendation is made for further project development:

In a first phase the data from the historical drill holes completed in the Gräfentonna Exploration Licence area, should be checked via confirmation drilling. This would allow for collection of core material from the potash deposit for detailed description and chemical and mineralogical analysis. Additionally, the confirmation holes will need to be logged geophysically to cross-check the historical data and to correlate the results with those of the chemical analyses.

In a second phase a more detailed exploration program with closer spaced exploration drilling should be established based on the results of the first phase. Also the execution of 2D/3D seismic would be subject to this second phase.

[17] BVVG Bodenverwertungs- und -verwaltungs GmbH is a private company.
[18] Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft GmbH is a state-owned company.

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

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ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

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ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

1 Introduction

East Exploration Pty Ltd (Melbourne, Australia) initiated its application for a potash project in the central part of the Federal State of Thuringia, Germany back in early 2014. A local subsidiary company, East Exploration GmbH (East Exploration) was founded and registered in Munich, Germany in late 2014 in order to hold and operate the exploration licence under application. East Exploration GmbH holds and operates the exploration licences for two areas in the southern part of the South Harz Potash District[19], the Küllstedt Exploration Licence area and the Gräfentonna Exploration Licence area. East Exploration is now owned 100% by Davenport Resources Pty Ltd, which was listed on the Australian Securities Exchange (ASX) in January 2017 under the ticker ASX:DAV.

For the Küllstedt Exploration Licence area a review of the historical exploration data and the preparation of a Competent Person's[20] Report (CPR) according to the JORC Code[21] (2012, /14/, cf. ERCOSPLAN, 2015a, /9/) was completed on 31 January 2015 by ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH (ERCOSPLAN). For the Gräfentonna Exploration Licence area a similar review of the historical exploration data and CPR in accordance with the JORC Code was required. ERCOSPLAN was commissioned by East Exploration on 12 January 2017 for preparation of such CPR, which is subject of this Report.

ERCOSPLAN, based in Thuringia (Germany), has been involved in the mining activities in the South Harz Potash District for more than 60 years. During this period, numerous exploration and underground mining projects were realized under the supervision of ERCOSPLAN. Therefore, ERCOSPLAN has an extensive knowledge about the geological conditions within the South Harz Potash District. For the preparation of this Report, EurGeol Andreas Jockel and EurGeol Dr Henry A M Rauche served as Competent Persons as defined by the JORC Code (2012, /14/). Both Competent Persons have undertaken several site visits of the Gräfentonna Exploration Licence area. The last site visit was conducted in June 2016.

The term potash seam/potash-bearing horizon, used in this Report, is defined in chapter 6.2.2.

In this Report, the names of state authorities and cities/country towns are given in their original language. Settlements with a population equal to or greater 100,000 inhabitants are called "city", settlements with less inhabitants are called "country towns". Topographic, geographic and geologic features, however, are translated according to their meaning wherever possible. Further information regarding terms used in this Report can be found in the glossary.

The terms "Gräfentonna Exploration Licence area and close to it" and "close to the Gräfentonna Exploration Licence area", respectively, used in this Report refer to the Gräfentonna Exploration Licence area with its extent defined in this Report and the area within the outline of the modelling area as shown in APPENDIX 3.

Names and abbreviations of lithostratigraphic terminologies used in the Report are as defined by the Landesamt für Bergbau, Energie und Geologie Niedersachsen[22] (LBEG, 2015, /19/). Geologic timescales refer to STD 2016 (2016, /26/).

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[19] The South Harz Potash District is a potash mining district in the NW of the Federal State of Thuringia.

[20] A 'Competent Person' is a mineral industry professional, who is a Member or Fellow of The Australasian Institute of Mining and Metallurgy, or of the Australian Institute of Geoscientists, or of a 'Recognised Professional Organisation' (RPO), as included in a list available on the JORC and ASX websites. These organisations have enforceable disciplinary processes including the powers to suspend or expel a member. A Competent Person must have a minimum of five years relevant experience in the style of mineralisation or type of deposit under consideration and in the activity, which that person is undertaking.

[21] JORC (2012): Australasian Code for Reporting of Mineral Resources and Ore Reserves – The JORC Code 2012 Edition.- The Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy and the Australian Institute of Geoscientists and the Minerals Council of Australia. 20 December 2012.

[22] Landesamt für Bergbau, Energie und Geologie Niedersachsen is a specialist authority of Lower Saxony.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Coordinate system for all coordinates used in this report is DHDN 3 Degree Gauss Krueger Zone 4 (EPSG-Code 31,468).

1.1 Scope of Work

The scope of work comprised the assessment and evaluation of historical data as presented in chapter 1.2 as well as the estimation of an Exploration Target, based on the available data in compliance with the JORC Code (2012, /14/).

1.2 Terms of Reference

For the preparation of this Report, the following historical data records were used:

- Drill logs of holes located within the Gräfentonna Exploration Licence area and close to it.
- Geophysical well logs of holes located within the Gräfentonna Exploration Licence area and close to it.
- Technical reports of exploration holes located within the Gräfentonna Exploration Licence area and close to it.
- Reports on historical resource estimates together with potash instruction guidelines of the former Germany Democratic Republic (GDR).
- Historical reports on geological, structural and hydrogeological investigations in the Thuringian Basin[23].
- Historical distribution maps of salt rocks (cf. chapter 6.4) of the potash deposit in the South Harz Potash District.

The above mentioned data was partly available in ERCOSPLAN's archive. Drill logs and geophysical well logs have been provided by ENGIE E&P Deutschland GmbH, the German branch of ENGIE SA[24] (until 2015: Gaz de France Suez (GdF Suez)) upon request of ERCOSPLAN on behalf of East Exploration. A list of documents provided by ENGIE E&P Deutschland GmbH is shown in APPENDIX 12.

Furthermore, official licence documents provided by East Exploration were used (cf. APPENDIX 2.

2 Reliance on Other Experts

For the preparation of this Report, the authors have relied on historical reports, opinions, data and statements not prepared under their supervision. These items will be hereinafter identified as being either "third-party reports" or "historical information". Specific citations are listed under

[23] Thuringian Basin is a geological structure in the central and N part of the Federal State of Thuringia.
[24] ENGIE SA is the successor of the private natural gas Group Gaz de France Suez.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

REFERENCES. Analytical procedures, personnel and facilities used by the previous evaluators were independent. It is known that the authors of those reports were not "Competent Persons" as defined by the JORC Code (2012, /14/). However, it is known to the authors of this Report, partly by personal acquaintance, that the authors of those reports have sufficient experience in the exploration of and resource estimation for potash deposits as required by the JORC Code (2012, /14/). They are, therefore, considered trustworthy and their work reliable.

As no samples and no core material from the historical exploration campaigns is preserved, the results of chemical analyses and drill hole logging could not be evaluated by the authors of this Report. However, due to the abovementioned statements and the sample cross-checking by external laboratories, the results of the mentioned investigations are considered reliable.

3 Property Description, Location and Legal Status

This chapter provides an overview about the location of the Gräfentonna Exploration Licence area (chapter 3.1) and the land tenures held by East Exploration (chapter 3.2).

3.1 Property Location

The Gräfentonna Exploration Licence area is located in the state of Thuringia, Germany, NW of the state capital Erfurt, and at the southern boundary of the South Harz Potash District (Figure 1), where potassium salts have been successfully mined for the production of potash-magnesium fertilisers as well as for other products since 1896.

3.2 Property Title

East Exploration Pty Ltd. filed a written application for the granting of the commercial exploration of potassium salts and rock salt[25] for the Gräfentonna Exploration Licence area in compliance with section 7, Paragraph 1 of the Bundesberggesetz[26] (BBergG) on 04 July 2014. East Exploration Pty Ltd. applied to transfer its application to East Exploration GmbH in November 2014 (APPENDIX 2).

The Gräfentonna Exploration Licence was granted to East Exploration GmbH in compliance with section 6 & 7 BBergG by the Thüringer Landesbergamt[27] on 12 January 2015 and is valid for the Gräfentonna Exploration Licence area. The exploration licence is valid until 12 January 2020 and restricted to the exploration of mineral resources in compliance with section 3, Paragraph 3 BBergG, which are rock salt, potassium salts, magnesia and boron salts together with accompanying salts within the deposit. Results of the exploration activities have to be reported to the Thüringer Landesbergamt annually and submitted to the authority at the latest by the expiry of the exploration licence.

[25] Rock salt is a salt rock consisting mainly of Halite and Anhydrite (cf. chapter 6.4).
[26] Bundesberggesetz is the Federal Mining Law of Germany.
[27] Thüringer Landesbergamt is a Federal State Authority.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Figure 1 Location of potash districts in Germany and the Gräfentonna Exploration Licence area within the South Harz Potash District.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
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4 Accessibility, Climate, Local Resources, Infrastructure and Physiography

The accessibility of the Gräfentonna Exploration Licence area (chapter 4.1), the climate (chapter 4.2), the physiography (chapter 4.3) and the local resources as well as the infrastructure (chapter 4.4) of the Gräfentonna Exploration Licence area will be covered in the following chapters.

4.1 Accessibility

The principal town located within the Gräfentonna Exploration Licence area is the country town of Bad Tennstedt. It is accessible

- via the federal motorway BAB 71 (Schweinfurt – Sangerhausen), further via the federal road B 4 and state roads L2165 and L3176.
- via the federal motorway BAB 38 (Göttingen – Leipzig) from the N, then further via the federal roads B 4, B 249 and B 84 and state road L1027.

Different parts of the Gräfentonna Exploration Licence area can be accessed via state or country roads from the roads mentioned above. Beyond these roads, four-wheel drive vehicles can be used to access farm or country tracks.

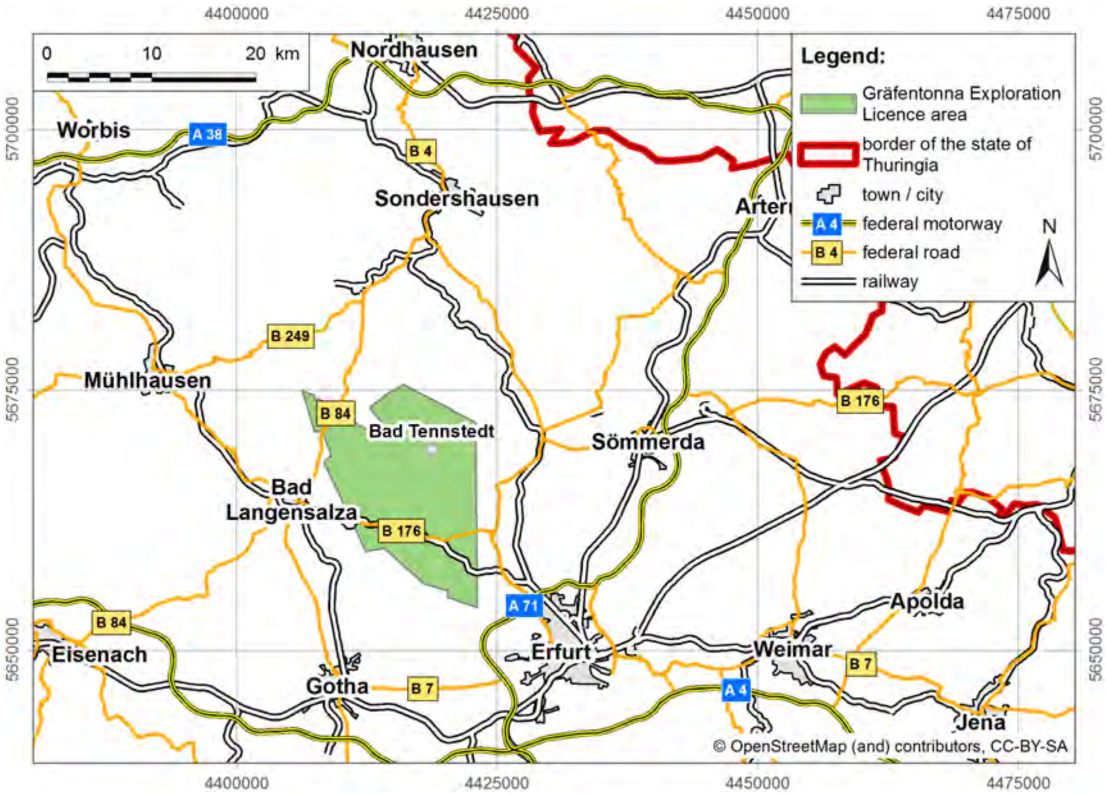

Figure 2 Main roads and railway system in the Gräfentonna Exploration Licence area. Since the airport Erfurt is located within the extent of city of Erfurt, it is not shown separately.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
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Another access possibility is via the railway network of the Deutsche Bahn AG between the city of Erfurt and the country town of Bad Langensalza. The closest civil airport is located in the city of Erfurt, located about 22 km SSE of Bad Tennstedt. Further airfields for small planes are located about 5 km E of the country town of Mühlhausen, about 3 km NW of the country town of Bad Langensalza and about 2 km NW of the country town of Schlotheim. The connection of the Gräfentonna Exploration Licence area to the main roads, the railway network and the airport Erfurt is shown in Figure 2.

4.2 Climate, Vegetation and Fauna

The Gräfentonna Exploration Licence area is located in the temperate climate zone of Central Europe with prevailing westerly winds. The climate is more continental, and especially drier than in the western and northern parts of Germany. Accordingly, the Gräfentonna Exploration Licence area is located in one of the driest regions of the country with comparably low total annual precipitation, accompanied by long dry periods and cold winters (Table 1).

Table 1 Average monthly temperatures and precipitation for Bad Tennstedt (196 m above sea level (asl)), based on data recorded between 01/2016 and 12/2016 (AccuWeather.com, 2017, /1/)

	Avg. Max. Temperature [°C]	**Avg. Min. Temperature [°C]**	**Precipitation [mm]**	**Rainy Days [d]**
January	2.6	-2.6	59	20
February	5.6	0.2	101	20
March	6.9	0.9	33	12
April	12.2	2.5	33	9
May	18.2	8.5	51	6
June	22.0	12.3	49	10
July	24.2	13.6	59	10
August	23.8	12.5	17	5
September	22.6	12.2	35	5
October	10.8	5.6	57	18
November	6.1	0.5	37	10
December	4.2	-1.7	8	7

The average annual temperature for the reported period of the area (AccuWeather.com, 2017, /1/) is 9.3°C. July is the warmest month with an average temperature of 18.9°C and a highest measured temperature value of 31.0°C. January and December are the coldest months with an average temperature of 0.6°C and a lowest measured temperature value in February of -16.0°C.

The total annual precipitation is 539 mm with the highest reported precipitation in February (101 mm), January and July (59 mm) and October (57 mm).

Most of the Gräfentonna Exploration Licence area is covered by agricultural land. Broad-leaved woodland is restricted to the banks of the Unstrut river and the Muschelkalk[28] escarpment of the Fahner Höhe bordering the Gräfentonna Exploration Licence area to the S.

4.3 Physiography

The Gräfentonna Exploration Licence area is located in the S of the Thuringian Basin. The Unstrut river flows roughly from W to E through this area. Smaller streams include the Schambach and the Kleiner Schambach, which flows into the retention reservoir Straußfurt, and the Fernebach stream with its spring at the country town of Bruchstedt and which flows into the Schambach stream at the country town of Bad Tennstedt.

Apart from the reservoir Straußfurt, two additional freshwater reservoirs Dachwig and Döllstedt are located directly E of the Gräfentonna Exploration Licence area.

Topographically, the Gräfentonna Exploration Licence area is dominated by a slightly hilly landscape with the Muschelkalk escarpment of the Fahner Höhe bordering the Gräfentonna Exploration Licence area to the S, and reaching up to 413 m asl on top of the Abtsberg mountain. Generally, the topographic elevation decreases towards the Unstrut river and towards the eastern border of the Gräfentonna Exploration Licence area. However, along the southern border of the Gräfentonna Exploration Licence area, towards the Muschelkalk escarpment of the Fahner Höhe and S of the country town of Witterda, the landscape exhibits a fairly steep rise in its topographic elevation (cf. APPENDIX 1).

Within the Gräfentonna Exploration Licence area smaller mountains are located like the Högk mountain (278 m asl) S of the country town of Haussömmern, the Großurlebener Berg mountain (218 m asl) WNW of the country town of Bad Tennstedt, the Rangenhügelsberg mountain (275 m asl) SW of the country town of Sundhausen, the Wartberg mountain (278 m asl) N of the country town of Nägelstedt, the Riedberg mountain (224 m asl) SW of the country town of Großvargula, the Vargulaer Hügel mountain (252 m asl) SE of the country town of Großvargula, the Hessenberg mountain (185 m asl) E of the country town of Gebesee and the Hoher Berg mountain (205 m asl) E of the country town of Großfahner. The area directly at the bank of the Unstrut river is located at elevations between 171 m asl immediately S of the country town of Nägelstedt and 152 m asl at the eastern border of the Gräfentonna Exploration Licence area. The market of the country town Bad Tennstedt is located at an elevation of 174 m asl.

4.4 Local Resources and Infrastructure

The country town of Bad Tennstedt, the administrative headquarter of the municipalities Bad Tennstedt, Ballhausen, Blankenburg, Bruchstedt, Haussömmern, Hornsömmern, Kirchheilingen, Klettstedt, Kutzleben, Mittelsömmern, Sundhausen, Tottleben and Urleben is located about 27 km ESE of the country town of Mühlhausen, covers an area of approx. 27 km² and is home to more than 2,400 inhabitants (140 km² and over 6,800 inhabitants for all municipali-

[28] Muschelkalk in this context means bivalve-bearing limestones.

ties). On the next higher administrative level (Landkreis[29]) the Gräfentonna Exploration Licence area belongs to the administrative districts Unstrut-Hainich-Kreis with the district office in the country town of Mühlhausen (with over 34,500 inhabitants and an area of about 87 km² for the district), Sömmerda with the district office in the country town of Sömmerda (with about 19,000 inhabitants and an area of about 81 km² for the district) and Gotha with the district office in the country town of Gotha (with over 45,400 inhabitants and an area of about 70 km² for the district). The data are as of 31 December 2015 (Thüringer Landesamt für Statistik, 2016, /29/).

Larger cities in the vicinity are Erfurt (23 km to the SE with about 210,100 inhabitants (Thüringer Landesamt für Statistik, 2016, /29/)), Göttingen (77 km to the NW with about 119,000 inhabitants (Landesamt für Statistik Niedersachsen, 2016, /18/)) and Kassel (97 km to the W with about 198,000 inhabitants (Hessisches Statistisches Landesamt, 2016, /13/)). The data provided is accurate as of 31 December 2015.

Power and water supply is available for households, established commerce and industry via a well-developed network in the region.

5 History

In the following chapters the historical mining activities in the South Harz Potash District (chapter 5.1) and the exploration activities within the Gräfentonna Exploration Licence area and close to it (chapter 5.2) are summarised. The findings, according to the present understanding of the deposit from these available data, will be used as the basis of later discussions.

A description of the lithostratigraphic units used in this and the following chapters is given in chapter 6.

5.1 The History of Potash Exploration and Production in the South Harz Potash District

Potash mining in the South Harz Potash District began with the sinking of the first exploration hole in 1888 near the country town of Kehmstedt in the N of the Federal State of Thuringia. This drill hole proved that potash-bearing salt rocks occurred subsurface. In the following years, extensive exploration for potash was carried out within the northern administrative district of Erfurt. This exploration work was initiated by the ministry Preussisches Ministerium für Öffentliche Arbeit[30].

This early exploration effort resulted in the successful foundation of multiple small and medium sized potash mines. The most important sites of mining and processing in the South Harz Potash District are listed in Table 2 (see also Figure 3).

[29] Landkreis means district.
[30] Preussisches Ministerium für Öffentliche Arbeit was a ministry of the former Kingdom of Prussia.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Table 2 Most important historical sites of potash mining and processing in the South Harz Potash District (Bartl, 2003, /2/; Trautvetter, 2009, /30/; ERCOSPLAN, 2015b, /10/; GSES. 2017, /11/)

Mine and potash plant	**Crude salt extraction**	**Final decommissioning**	**Total crude salt mined until final decommissioning**	**Today's owner**
Sondershausen[31]	1896 - 1991	31 December 1991	110 million tons	GSES[32]
Bischofferode	1911 - 1993	31 December 1993	114 million tons	LMBV[33]
Sollstedt	1905 - 1991	31 December 1991	85 million tonnes	NDH-E[34]
Bleicherode	1902 - 1990	31 December 1991	86 million tons	NDH-E
Volkenroda[35]	1909 - 1991	31 December 1991	55 million tons	LMBV

In the 1920s a period of decommissioning of potash plants in Germany took place. This included the decommissioning of shafts and surface infrastructure, which lead to the final decommissioning of numerous potash plants including the Felsenfest Mine and the Beberstedt-Hüpstedt Mine located in the Küllstedt Exploration Licence area. In the South Harz Potash District and the neighbouring Unstrut Potash District[36] only 10 potash plants remained in production (ERCOSPLAN, 2015b, /10/) following this period of early decommissioning.

Between 1920 and 1950 several of the existing potash operations had stated to show signs of flooding, effecting mainly the mine shafts. Under state resolution decommissioned mines and operations that had flooded mine shafts were put under ownership of the remaining operating potash plants in the South Harz Potash District (Hartung, 2003, /12/). Further consolidation of potash-producing sites in the South Harz Potash District saw the remaining potash operations combined in to the VEB Kaliwerke Südharz[37] which now controlled six separate production units operated at Sondershausen, Bischofferode, Sollstedt, Bleicherode, Volkenroda and Roßleben, with Roßleben located in the Unstrut Potash District. Contemporaneously to the consolidation process the authorisations under mining law were re-organised and the resulting subfields[38] summarised as BWE Thüringen Nord[39]. Today's organisation of the mine property fields (German abbreviation: BWE) in the South Harz Potash District is based on this earlier re-organisation. The mine property fields, as they are defined today, were created by subdividing the former subfields.

With German reunification in 1990 the complete potash industry in the South Harz Potash District was transferred into private ownership and managed by the newly founded Mitteldeutsche Kali AG[40]. By resolution of the board of directors of the Mitteldeutsche Kali AG the last active mines and potash processing plants, as presented in Table 2, were finally decommissioned in

[31] Since 2004 production of rock salt (currently 200,000 tpa) for de-icing salt.
[32] GSES is the abbreviation for Glückauf Sondershausen Entwicklungs- und Sicherungsgesellschaft mbH, a private company.
[33] LMBV is the abbreviation for Lausitzer und Mitteldeutscher Bergbau- und Verwaltungsgesellschaft mbH, a state-owned company.
[34] NDH-E is the abbreviation for NDH Entsorgungsbetreibergesellschaft mbH, a private company.
[35] Since 2007 utilization of mine gas for generation of electricity.
[36] Unstrut Potash District is a potash mining district E of the South Harz Potash District, located in the N of the Federal State of Thuringia covering partly the SW of Saxony-Anhalt.
[37] VEB Kaliwerke Südharz was an organisational structure of the VEB Kombinat Kali.
[38] Subfield in this context means a spatial defined area with a reasonable prospect for mining.
[39] BWE Thüringen Nord is the name, under which the subfields, as described under footnote 38, in the South Harz Potash District were summarised.
[40] Mitteldeutsche KALI AG was the successor of the VEB Kombinat Kali (see glossary).

1991 and 1993 (ERCOSPLAN, 2015b, /10/). Most of the geological documentation was incomplete at the end of the mining activities and was handed over to the trust company "Gesellschaft zur Verwahrung und Verwertung von stillgelegten Bergwerksbetrieben GmbH"[41].

The GDR was always within the top 3 global potash-producing countries globally, with a steady increase in produced K_2O[42] tonnage from 1,336 kt K_2O in 1950 to 3,510 kt K_2O in 1988 (Beinhorn, 2003, /3/). The potash mines in the South Harz Potash District contributed a major share in this production output. In 1985 the combined K_2O tonnage produced by the five potash mines detailed in Table 2 together with the Roßleben mine in the Unstrut Potash District, contributed to 43% of the total produced K_2O tonnage in the GDR. This translates into 1,500 kt K_2O produced by these six mines alone in 1985. The Roßleben mine is mentioned as it was part of the VEB Kaliwerke Südharz. The extraction of the potash ore was mainly carried out by conventional mining.

Today potash is produced in the South Harz Potash District only by solution mining in the Kehmstedt Operation in the BWEs Kehmstedt and Kehmstedt-NW (cf. Figure 3). The Operation is nowadays owned by DEUSA International GmbH[43], and was established in the 1980s.

Procedures for mining and processing of potassium salts were created and developed further and have been state of the art at any given time. A major contributor to this is the Kaliforschungsanstalt GmbH[44], which until the end of Second World War had developed several patents regarding potash processing. After the foundation of the GDR research in the field of potash mining and processing was resumed in 1955 at the Sondershausen mine site by the research institute Zentrale Forschungsstelle für die Kaliindustrie. From this the research institute Kaliforschungsinstitut originated in 1964 later becoming a part of the VEB Kombinat Kali. The VEB Kombinat Kali, founded in 1970, was as the successor of the 1958 founded VVB Kali[45], and was based in the country town of Sondershausen, which established itself as and the central administration of the whole East German potash industry (K-UTEC AG Salt Technologies, 2017, /17/).

In the 1950s and 1960s, an internal company standard for processing of historical and recent exploration data was established in the mines of the South Harz Potash District. This internal standard was set up to evaluate several parameters of the deposit, such as its thickness distribution and structure, which was missing from previous records. Until then, the geological documentation in the mines was prepared in different degrees of detail, depending on which group of companies the individual mine was affiliated with. In 1964 a framework was set for the geological documentation, from which the necessary steps for the information processing could be derived. The documentation was collected and processed according to this newly established framework throughout the following years.

After German reunification the Kali-Umwelttechnik GmbH[46] was established in 1992 as a successor of the Kaliforschungsinstitut. Their role was to continue the research in the field of potash mining and processing. Since 2008 the Kali-Umwelttechnik GmbH is known as K-UTEC AG Salt Technologies[47].

Concepts for decommissioning of mining shaft were developed in the past, and resulted in the establishment of guideline for mine shaft decommissioning, called the "Richtlinie für die Ver-

[41] Gesellschaft zur Verwahrung und Verwertung von stillgelegten Bergwerkbetrieben GmbH is a company responsible for the decommissioning and closure of mines.
[42] K_2O - The grade of potassium products is traditionally expressed in K_2O (potassium oxide; the conversion factor for KCl to K_2O is 0.6317).
[43] DEUSA International GmbH is a private company active in potash mining.
[44] Kaliforschungsanstalt GmbH was a private research institute.
[45] VVB Kali was the central administration, responsible for the supervision of all potash-producing mines of the former GDR.
[46] Kali-Umwelttechnik GmbH was a private company active in potash research.
[47] K-UTEC AG Salt Technologies is a private company active in several mining-related fields.

wahrung von Tagesschächten. These guidelines were released in 1977 by the Institut für Bergbausicherheit Leipzig, a state-owned institution responsible for developing concepts for mine safety. Potash mining shaft decommissioning was carried out in accordance with these guidelines following its release. In 1992, a revision of these guidelines was released, which was adapted to the South Harz Potash District. As a result of this work, carried out by a national research group, a new guideline for mining shaft decommissioning was created and permitted for the Federal State of Thuringia by the Thüringer Landesbergamt in August 2008 (ERCOSPLAN, 2015b, /10/). This guideline is the normative base for the development of mining shaft decommissioning concepts nowadays.

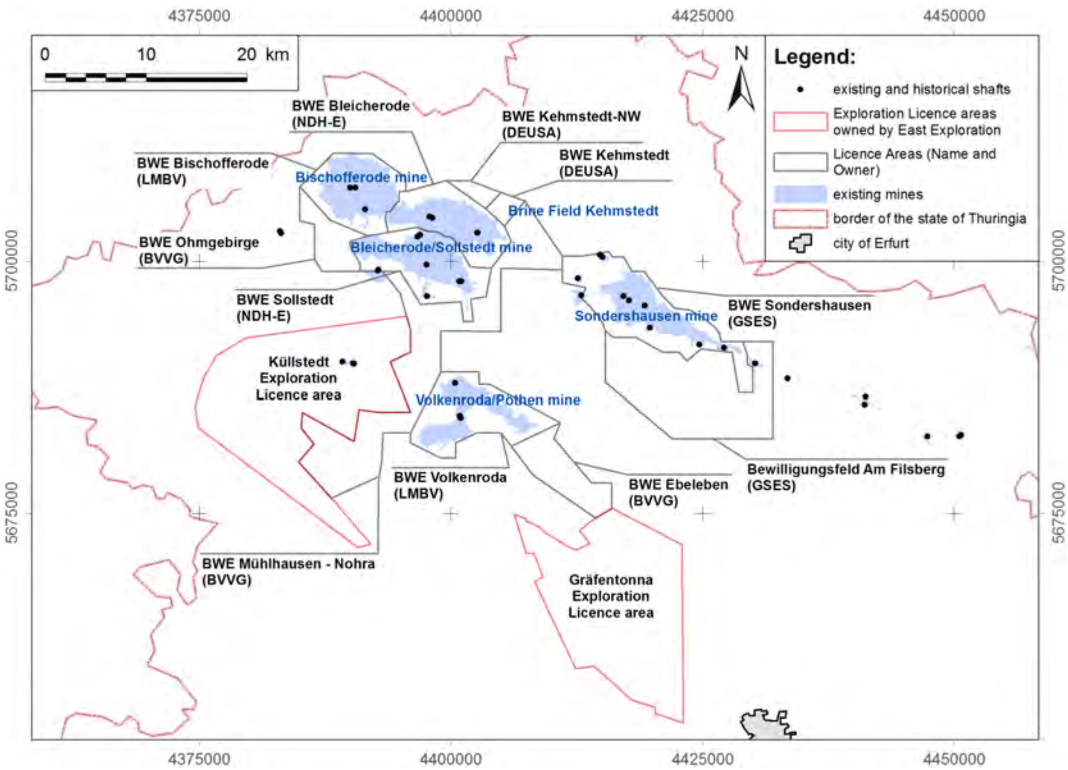

Figure 3 Existing potash related licence areas in the South Harz Potash District.

5.2 The History of Exploration in the Gräfentonna Exploration Licence Area

Exploration activities in the Gräfentonna Exploration Licence area took place intermittently between 1911 and 1983 and targeted three commodities:

1. potash, hosted by the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt),
2. natural gas and crude oil, hosted by the carbonate rocks of the lithostratigraphic unit Staßfurt-Karbonat (z2CA)

and

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

3. the sandstone of the lithostratigraphic unit Chirotheriensandstein (smSTC).

Holes drilled during that time were mainly focussed on both, natural gas and crude oil. The exploration work was realized by drilling accompanied with drill hole geophysics and reflection seismic. To the authors of this Report it is known that within the Gräfentonna Exploration Licence area and close to it in total

- 1 drill hole was sunk for potash exploration,
- 42 drill holes were sunk for hydrocarbon (natural gas and crude oil) exploration
  - with 22 of these holes having reached or penetrated the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt),
  - with 6 of these holes being cored in the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt),
    - with 2 of these holes being assayed over a part or the entire thickness of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt),
  - with evaluated geophysical well logs of 7 of these holes,
- nearly all of the Gräfentonna Exploration Licence area is covered by reflection seismic (cf. chapter 5.2.2.8).

The drill holes for exploration of natural gas and crude oil targeted the tectonic structure of the Forstberg mountain NE of the country town of Mühlhausen, tectonic structures close to the country towns of Kirchheilingen and Bad Langensalza, and the Muschelkalk escarpment of the Fahner Höhe (VVB FM, 1964, /33/).

The following chapters provide a detailed overview about the historical exploration activities conducted in the Gräfentonna Exploration Licence area.

5.2.1 Description of Historical Potash Exploration

Exploration for potash in the Gräfentonna Exploration Licence was only conducted with the drill hole *Gräfentonna 1/1911 (Burbach[48])*, drilled in 1911. Though this hole remains the only hole to date focussing on potash, holes drilled later for hydrocarbon exploration within the Gräfentonna Exploration Licence area and close to it extended the knowledge about the potash deposit in this area of the South Harz Potash District. The present knowledge about the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), which host the potash mineralisation, originated mainly from the aforementioned exploration work for hydrocarbons conducted in the late 1950s, early 1960s and early 1970s (cf. chapter 5.2.2).

Apart from the lithological description of the potash-bearing salt rocks, given by the corresponding logs of the hydrocarbon exploration holes, additional information about these rocks was derived from geophysical well logs, which were run in these holes.

Since six of the hydrocarbon exploration holes have been cored in the potash-bearing salt rocks, structural information about the deposit, the distribution of minerals and the mineralisation (cf. chapter 6.4.2) can be determined. To the authors of this Report it is known that for one hole the entire thickness of the potash-bearing salt rocks was sampled and analysed. From

[48] Burbach refers to the former potash trade union "Burbach", a part of the company group Kaliwerke Krügershall AG (see glossary). The potash trade union "Burbach" was responsible for drilling the hole and the hole was named accordingly. The name "Gräfentonna 1/1911" is the drill hole reference for today's state authorities.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

another of these five holes one sample covering a part the thickness of these rocks was collected and analysed (cf. chapter 6.4.2).

The surface seismics (cf. chapter 5.2.2.8), which focused on the hydrocarbon-bearing rocks, provided further information about the structure of the potash deposit.

Sampling and documentation followed methodologies used at that time. Interpretation of individual drill holes was mainly achieved through inspection and sampling of drill cuttings and from the correlation with corresponding geophysical well logs. For the single drill hole targeting potash, no other data than location, final depth and a short lithological log could be obtained by the authors of this Report.

Technical details about seismic exploration as well as the analytical procedure used for samples from the drill holes will be provided in the following chapters.

To date no mining activities for potash have been undertaken in the Gräfentonna Exploration Licence area. Therefore, no underground drill holes have been sunk.

5.2.1.1 Available Drill Holes

The only potash exploration hole completed in the Gräfentonna Exploration Licence area to date was sunk in 1911 (*Gräfentonna 1/1911 (Burbach)*) and is located E of the country town of Nägelstedt close to the Unstrut river (cf. APPENDIX 3). Historical information recorded from this hole show that it penetrated 21 m of potash-bearing salt rocks, though no other information was given for this interval. It reached the Anhydrite[49] rocks of the lithostratigraphic unit Unterer Staßfurt-Anhydrit ("Basalanhydrit[50]", z2ANa). The relevant information of the drill hole is given in Table 3.

Table 3 Master data of the potash exploration hole located within the Gräfentonna Exploration Licence area

Drill Hole	Easting	Northing	Elevation [m asl]	Total Depth [m bgl]	Deepest reached lithostratigraphic Unit
Gräfentonna 1/1911 (Burbach)	4411610	5664770	256	993.6	z2ANa

5.2.1.2 Drilling Technology

The potash exploration hole was sunk using state-of-the-art drilling techniques at the time of its construction. Further details are not known to the authors of this Report.

[49] Anhydrite is an evaporite mineral with the chemical formula $CaSO_4$.
[50] "Basalanhydrit" is an older lithostratigraphic term for the lithostratigraphic unit Unterer Staßfurt-Anhydrit (z2ANa).

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

5.2.1.3 Drill Hole Logging, Sampling and Chemical Assaying

At the time the potash exploration hole was drilled, sampling and analytical procedures were already established, allowing precise determination of the mineralisation of potash-bearing salt rocks. Lithological description of these rocks was recorded at least to the extent of stating the top and bottom of these rocks and mentioning the encountered salt rocks (cf. chapter 6.4).

To the authors of this Report the coordinates, final depth and the information stated in the short lithological log of drill hole *Gräfentonna 1/1911 (Burbach)* are available (cf. Table 3).

A geophysical well survey was not run, as the technique was only invented by the Schlumberger brothers in the 1920s.

5.2.1.4 Sampling and Assay Procedure

Sampling and assay procedures performed on samples of potash-bearing salt rocks from potash deposits within the German state territory followed the state-of-the-art technology and state of scientific knowledge at the time the potash exploration hole was sunk. Details are not known to the authors of this Report.

Sampling and assay procedures performed on samples taken from the potash-bearing salt rocks in holes targeting hydrocarbons in the Gräfentonna Exploration Licence area and close to it are described in chapter 5.2.2.4.

5.2.1.5 Reporting of Results and Data Storage

The lithological log of the potash exploration hole is available in the archives of the Thüringer Landesanstalt für Umwelt und Geologie (TLUG)[51]. Apart from this information it is neither known to the authors of this Report, if other documents about this drill hole exist, nor if they have ever been prepared (e.g. cutting samples, assays). Existing information could, therefore, not be verified.

The drill hole *Gräfentonna 1/1911 (Burbach)* was considered for the historical resource estimate presented in the report of VVB FM (1964, /33/; cf. chapter 5.3), and it was also considered for the Exploration Target estimate in this Report.

5.2.2 Description of Oil & Gas Exploration

The hydrocarbon exploration within the Gräfentonna Exploration Licence area and close to it was executed based on the knowledge that liquid and gaseous hydrocarbons had seeped from the footwall into the mine workings of the Volkenroda mine in 1930, and that the amount of liquid hydrocarbons was sufficient to start crude oil production on regular basis in the shaft Volkenroda (“Carl-Eduard-Schacht”) in the same year (Hartung, 2003, /12/). In 1911, the first hydrocarbon exploration hole with the corresponding name was drilled by the potash trade union Burbach close to the country town of Döllstedt. This trade union belonged since the end

[51] Thüringer Landesanstalt für Umwelt und Geologie is a state authority.

of the 1920s partly to the private company Wintershall AG[52] that was active in mining the crude oil in the Volkenroda mine. In 1983 the last hydrocarbon exploration hole was drilled within the Gräfentonna Exploration Licence area. Extensive exploration phases for hydrocarbons took place between 1955 and 1962 with 29 holes, as well as between 1969 and 1971 with 9 holes within the Gräfentonna Exploration Licence area, including deviated holes. Close to the Gräfentonna Exploration Licence area 6 holes, including deviated holes were drilled for the same purpose during both phases.

The exploration activities from the 1950s onwards were conducted to evaluate the resource potential of the GDR in the Thuringian Basin (VEB, 1963, /31/; VVB FM, 1964, /33/). Along with information about the hydrocarbon-bearing rocks, information about the potash-bearing salt rocks were collected as mentioned in chapter 5.2.1.

Exploration drilling targeting hydrocarbons within the Gräfentonna Exploration Licence area was focussed mainly on the W and S areas, with additional three holes drilled around the country town of Bad Tennstedt. The work resulted in the discovery of the natural gas field “Fahner Höhe” in 1960 S of the Gräfentonna Exploration Licence area, and the natural gas fields “Langensalza” in 1935 and “Kirchheiligen-Süd” in 1958, all located W, NE and SW, respectively, of the Gräfentonna Exploration Licence area (cf. Table 10, chapter 14). The target horizons, which are known to be hydrocarbon-bearing, is the dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA) and the sandstone of the lithostratigraphic unit Chirotheriensandstein (smSTC).

As outlined in the previous chapters, detailed geological information about the Gräfentonna Exploration Licence area is known from drill holes completed for exploration of natural gas and crude oil. For this reason the drill holes were selected for the purpose of defining a Potash Exploration Target for the Gräfentonna Exploration Licence area (see chapter 13). Drill holes used comprise of holes having reached or penetrated the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). For the remaining drill holes, targeting both commodities, coordinates, final depths and the final lithostratigraphic unit penetrated are known to the authors of this Report. Information about all exploration holes for natural gas and crude oil drilled within the Gräfentonna Exploration Licence area are listed in Table 4 (chapter 5.2.2.1). Information for holes used for the Exploration Target estimate, though located outside the Gräfentonna Exploration Licence area, but within the modelling area (cf. APPENDIX 7), are listed in Table 5 (chapter 5.2.2.1).

5.2.2.1 Available Drill Holes

Within the Gräfentonna Exploration Licence area 42 drill holes including deviated holes, listed in Table 4 and shown in APPENDIX 3, were drilled for oil and gas exploration in the W, SW and E part with three holes being located W and NE of the country town of Bad Tennstedt.

Out of the 42 drill holes 22 holes are known to have fully or partly penetrated the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). Most of these 22 holes have their final depths in the Anhydrite rocks of the lithostratigraphic unit Oberer Werra-Anhydrit (z1ANc, 15 holes) or dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA, 3 holes). The Anhydrite rocks of the lithostratigraphic unit Oberer Werra-Anhydrit (z1ANc) were partly penetrated in some holes to identify the entire thickness of the dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA). Out of the 42 holes 2 holes have fully penetrated the

[52] Wintershall AG was the predecessor of the today known Wintershall Holding GmbH.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

whole thickness of the Zechstein[53] rocks (cf. chapter 6) reaching into the basement below (cf. chapter 6.3.2).

At two locations deviated holes were drilled for different reasons. At the location of hole *E Langensalza 6/1955* two deviated holes were drilled, *E Langensalza 6h/1955* and *E Langensalza 6h2/1955*. The first deviated hole, *E Langensalza 6h/1955*, was set at 445.6 m bgl, the second deviated hole, *E Langensalza 6h2/1955*, was set at 439.0 m bgl. It is understood, from the technical reports, that the two deviated holes were necessary due to problems encountered after installation of the 10¾” casing. The thread on the last metres of the casing broke during reaming and the detached casing string could not be fished out, and was left blocking the hole. Whether or not this happened two times, in the original hole and first deviated hole, is unclear as no further details were given in the technical report.

At the location of hole *E Dachwig 1/1970* one deviated hole, *E Dachwig 1h/1970*, was completed. The technical report states as reason that the original drill hole trace deviated too much to comply with the requirements for deviation of azimuth and inclination. The original hole was grouted until 189.5 m bgl, and the deviated hole set at 219.5 m bgl.

For more detailed records of drill holes for oil and gas exploration within the Gräfentonna Exploration Licence area and close to it see APPENDIX 4 and APPENDIX 5.

The abbreviations for the lithostratigraphic units used in Table 4 are stated in APPENDIX 6 and the List of Abbreviations at the end of this Report, respectively.

Table 4 Master data for the hydrocarbon exploration holes located within the Gräfentonna Exploration Licence area

Drill Hole	Easting	Northing	Elevation [m asl]	Total Depth [m bgl]	Deepest reached lithostratigraphic Unit
E Bienstädt 2/1961	4420645.5	5655497.6	350.0	1,067.0	z2CA
E Dachwig 1/1970	4420294.3	5659138.8	183.8	467.2	smH
E Dachwig 1h/1970	4420294.3	5659138.8	183.8	1,085.7	z2CA
E Dachwig 2/1971	4419412.4	5659936.1	185.7	1,091.8	z2CA
E Döllstädt (Burbach) 1911/1912	4416750.0	5661050.0	195.0	1,100.2	z2KSt
E Döllstädt 1/1970	4417827.1	5663070.1	237.1	1,143.6	z1ANc
E Fahner Höhe 3/1959	4417723.2	5656780.2	259.5	1,311.5	z1ANc
E Fahner Höhe 103/1958	4414871.2	5662844.8	231.5	111.1	mmWO
E Fahner Höhe 104Ea/1958	4417281.4	5658448.3	220.0	195.5	ku
E Haussömmern 1/1970	4419570.6	5670916.6	219.9	1,162.7	z1ANc

[53] Zechstein is a lithostratigraphic group.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Drill Hole	Easting	Northing	Elevation [m asl]	Total Depth [m bgl]	Deepest reached lithostratigraphic Unit
E Kirchheilingen 1/1934 (Arnold 1 / E Kircheilingen 1)	4410155.0	5672560.0	255.0	1,154.2	z1ANc
E Kirchheilingen 35/1961	4413674.7	5672559.8	285.6	1,157.0	z1NA
E Langensalza 1/1933	4410294.8	5664511.9	190.4	1078.4	z1ANc
E Langensalza 6/1955	4409240.0	5667706.6	270.6	910.8	su
E Langensalza 6h/1955	4409240.0	5667706.6	270.6	508.8	sm
E Langensalza 6h2/1955	4409240.0	5667706.6	270.6	1,158.7	z1ANc
E Langensalza 7/1956	4410747.3	5665700.7	253.6	1,347.0	cs
E Langensalza 7E/1983	4410748.5	5665748.5	not given	435.0	sm
E Langensalza 8/1956	4409311.5	5670173.8	256.0	1,140.7	z1ANc
E Langensalza 17/1957	4412099.0	5665466.1	232.4	1,088.0	z1ANc
E Langensalza 20/1959	4409810.4	5666961.8	244.6	453.2	sm
E Langensalza 20E/1959	4409825.2	5666963.4	244.6	1,089.6	z1ANc
E Langensalza 21/1960	4411494.2	5666006.5	255.3	1,208.5	z1ANc
E Langensalza 25/1962	4412547.4	5663834.0	220.0	1,347.0	cs
E Langensalza 26/1962	4416153.5	5664158.1	206.1	1,118.0	z1ANc
E Langensalza 27/1962	4417383.7	5662810.3	240.0	1,165.9	z1ANc
E Langensalza 30/1957 (=La3)	4408661.4	5671726.6	not given	not given	mu
E Langensalza 31/1957 (=La 4)	4411440.6	5667401.6	not given	212.9	mu
E Langensalza 32E3/1957 (=La 5E3)	4411994.5	5664424.9	not given	402.6	so
E Langensalza 35/1970	4410553.0	5665310.8	236.2	1,090.0	z1ANc
E Langensalza 36/1970	4411469.5	5665143.5	233.3	1,064.6	z2Tb-z3Ta
E Langensalza 101/1958	4410600.4	5664610.1	not given	425.0	sm
E Langensalza 102/1958	4411423.6	5665242.6	not given	417.9	sm
E Langensalza 103/1958	4411357.4	5666179.1	not given	455.9	sm
E Langensalza 104/1958	4410092.2	5665349.1	not given	440.0	sm

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Drill Hole	Easting	Northing	Elevation [m asl]	Total Depth [m bgl]	Deepest reached lithostratigraphic Unit
E Langensalza 105/1958	4410617.8	5665941.5	not given	431.4	sm
E Langensalza 109/1959	4411504.3	5665712.8	not given	419.4	sm
E Langensalza 110/1961	4409819.4	5666110.9	not given	425.1	smSTC
E Langensalza 112/1961	4409749.4	5667207.5	not given	432.0	sm
E Langensalza 114/1961	4410459.6	5666804.5	not given	438.4	sm
E Tennstedt 1/1969	4417218.9	5669625.1	176.8	1,069.0	z1ANc
E Tennstedt 2/1970	4417308.2	5669285.7	186.8	1,159.4	z1ANc

For the estimation of a Potash Exploration Target for the Gräfentonna Exploration Licence area, data from another 6 holes was also used. These holes were also also completed as exploration holes for natural gas and crude oil. An overview of these holes is given in Table 5 and APPENDIX 3. These holes are located outside the Gräfentonna Exploration Licence area, but inside the modelling area (cf. APPENDIX 3).

In the case of hole *E Fahner Höhe 10/1961* two deviated holes were drilled, *E Fahner Höhe 10a/1961* and *E Fahner Höhe 10b/1961*. The original hole was planned to explore the tectonic context of the dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA) in the foreland. This goal was not achieved as the drill hole trace deviated too far to the S. The first deviated hole, *E Fahner Höhe 10a/1961*, was set at 519.9 m bgl, but was terminated as the azimuth of the drill hole trace deviated 180° from its intended direction. With the second deviated hole, *E Fahner Höhe 10b/1961*, set at 498.6 m bgl, the goal was finally achieved.

The sandstones of the lithostratigraphic sub-group Oberes Rotliegend (ro), intercepted in the drill hole *E Fahner Höhe 8/1960*, is stated to be the deepest lithostratigraphic unit reached. Uncertainty regarding the lithostratigraphic classification is noted.

The abbreviations for the lithostratigraphic units used in Table 5 are stated in APPENDIX 6 and the List of Abbreviations at the end of this Report, respectively.

Table 5 Master Data for the hydrocarbon exploration holes located outside the Gräfentonna Exploration Licence area, but inside the modelling area (cf. APPENDIX 3), and used for estimation of an Exploration Target

Drill Hole	Easting	Northing	Elevation [m asl]	Total Depth [m bgl]	Deepest reached lithostratigraphic Unit
E Allmenhausen 10/1961	4415490.0	5675848.4	335.4	1,148.5	z1ANc
E Fahner Höhe 8/1960	4414678.8	5658342.3	402.2	1,257.7	ro(?)
E Fahner Höhe 10/1961	4413468.3	5659571.9	296.8	1,354.5	cs

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

E Fahner Höhe 10a/1961	4413468.3	5659571.9	296.8	571.6	sm
E Fahner Höhe 10b/1961	4413468.3	5659571.9	296.8	1,255.3	z1ANa
E Kirchheilingen 84/1969	4411570.9	5672059.8	251.4	1,133.8	z1ANc

For 25 of the holes presented in Table 4 and Table 5 detailed lithological logs, geophysical well logs and technical reports are available. Analytical results for core sections of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) also partly exist. This detailed information is presented in chapter 6.4.2 and APPENDIX 5. For the remaining holes only short lithological logs could be found.

5.2.2.2 Drilling Technology

Drilling was executed using state-of-the-art technology at the time of completion. For holes *E Döllstädt (Burbach) 1911/1912*, drilled in 1911, and *E Kirchheilingen 1/1934*, drilled in 1934, however, no such information is available to the authors of this Report as for the remaining hydrocarbon exploration holes drilled within the Gräfentonna Exploration Licence area and close to it.

During the hydrocarbon exploration campaigns between 1955 and 1962 and between 1969 and 1971 different drilling rigs (T-50, BU-40 or BU-75) were used. Usually rotary head drilling method was applied but some sections were drilled using a downhole turbine drive. According to the final drilling reports and final technical reports (see APPENDIX 4 and APPENDIX 5) the drill holes usually were started from the surface with tricone bits through the overburden and upper part of the rocks of the Zechstein Group[54] into the top of the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA). The exception is six drill holes, where destructive drilling was stopped within the evaporite and clastic rocks of the lithostratigraphic formation Leine-Formation. Afterwards, the holes were continued using coring methods through the remaining salt section to the final depth. In addition, the sandstone of the lithostratigraphic unit Chirotheriensandstein (smSTC) was cored to gain detailed structural understanding for possible extraction of hydrocarbons. Subsequently, geophysical logs were run in the open holes (cf. chapter 5.2.2.6). Core drilling was conducted with drill hole diameters of 114 mm, 118 mm, 143 mm or 193 mm. The last cemented casing (size: 6 ⅝" or 5 ¾") was mainly installed in the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA), in the Anhydrite rocks of the lithostratigraphic unit Unterer Staßfurt-Anhydrit ("Basalanhydrit", z2ANa) or in the upper part of the dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA). For seven of the drill holes deviation data are available, showing a deviation from the vertical between 7.5 m (inclination: 0.4°) and 101.5 m (inclination: 5.3°).

Clay mud was used as drilling fluid for the overburden section. Within the saliferous strata NaCl-saturated mud was used. Furthermore, CMC (Carboxymethyl cellulose) was added to build filter cake and reduce fluid losses. Additionally, mud pressure and rotation speed of the drilling head were reduced to countermeasure caving and achieve good core quality (VEB GEW, 1963, /31/). The mud was undersaturated regarding KCl and $MgCl_2$, so dissolution of potash-bearing salt rocks has to be expected.

[54] Zechstein Group is a lithostratigraphic group.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

5.2.2.3 Drill Hole Logging

According to the available information, drill hole logging comprised of lithological as well as geophysical well logging (see APPENDIX 4 and APPENDIX 5). While the lithological description of the dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA), being the main hydrocarbon-bearing rock is provided in detail, that of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), however, is mainly restricted to mentioning their thickness and the encountered salt rocks, without distinguishing single layers or providing information about the internal structure. Gamma logging data for the entire thickness of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) is available for 14 holes. Neutron gamma data and gamma-gamma data is available over the same thickness for 13 holes. Caliper data and resistivity data is available over the entire thickness of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) for 12 holes and 14 holes.

For some drill holes the lithological logs state that only traces of potassium salts were found within the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). The reason can be either that the drill hole penetrated a barren or depleted potash seam (cf. chapter 6.2.2), or that an undersaturated mud was used. Some lithological logs do indicate the use of undersaturated mud. This is reflected by the core recovery data collected from within the potash section which varies highly between 18% and 95% recovery.

Dissolution of core material has a huge impact on the validity of assays and leads to inaccurate assumptions in terms of resource estimation. Another point is the impact on geophysical well logging, which is described in chapter 5.2.2.6.

Specifications for logging rock samples from exploration holes are given in the document 1. Kali-Instruktion[55] (Stammberger, 1956, /24/). It furthermore states requirements on the core recovery of potash-bearing salt rocks to allow for representative sampling, and necessary hydrogeological investigations.

5.2.2.4 Sampling and Assay Procedure

Sampling and assay procedures performed on samples of potash-bearing salt rocks from potash deposits within the German state territory followed the state-of-the-art technology and state of scientific knowledge at the time the hydrocarbon exploration holes were sunk. Though no details are known to the authors of this Report about these procedures used prior to 1919, it is known that since its foundation in 1919 the Kaliforschungsanstalt GmbH was in charge for representative sampling and analytical work of potash-bearing salt rock samples following the corresponding procedures.

For the former GDR the document 1. Kali-Instruktion (Stammberger, 1956, /24/), released in 1957, contains detailed information about the sampling and analytical procedure of potash-bearing salt rocks:

- Sampling:
    - The total sampled length has to correspond to the entire thickness of the mineral deposit.

[55] Kali-Instruktion is a document specifying requirements for rock salt and potash exploration, and specifying reserve categories.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

  - In case of inhomogeneous composition of the potash deposit, subdivision into homogeneous sections has to be made to allow for separate analysis of similar salt rocks. The shortest sample length in such a case is 0.5 m, the longest sample length is 5.0 m.
  - If a separation into homogeneous sections is not possible by the naked eye in case of an inhomogeneous composition of the potash deposit, the separation has to be made by grain samples or thin or polished section analysis.
  - In case interlayers of clay, Anhydrite, carbonates or other undesirable substances are contained in potash-bearing salt rocks of the potash deposit, interlayers with a thickness of up to 50 mm are incorporated into the sample being analysed. Interlayers thicker than 50 mm are analysed separately to determine, if separation of the raw ore material is appropriate.
- Additional investigations:
  - Investigations on the material of the potash deposit have to be supported by sufficient crystal-optical and thin as well as polished section analyses.
- Sample processing:
  - Representative reduction of the amount of sampling material is done in such way that segregation by grain size is prevented.
  - Up to a grain size of 0.25 mm the final sample weight, obtained by sample material quartering, is determined according to the grain size distribution of the sample.
- Sample analytics:
  - Samples consisting mainly of Carnallite and/or other hygroscopic evaporite minerals have to be sealed airtight after retrieval of the sample. Storage and transport for analytical work have to be conducted without destroying the seal, if the analysis of the sample is not conducted immediately under mine conditions.
  - Complete and partial sample analyses are distinguished. The latter one is mainly restricted to determining the K_2O content of a sample.
  - Contents of potassium, magnesium, calcium. sulphate, chloride, water and insolubles are analytically determined. The sodium content is determined by calculation.
  - If required, the contents of bromine, boron, iodine, and other valuable components are determined.
  - Partial analyses are only permitted for investigated potash deposits and cannot generally be the base for reserve estimations in newly explored potash deposits.
  - Results of analyses have to be cross-checked by analysing check samples.

The sample preparation and analysis of samples obtained from the potash-bearing salt rocks was carried out in the laboratory of VEB Kombinat Kali's research department according to standard procedures (Table 6), developed by the state authority, and as detailed in Döhner (1986, /6/). These standard procedures were developed during the 1950's, but were mandatory since 1975.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Table 6 Standard procedures applied for sample analysis according to VEB GFEF (1980, /32/)

Sample Preparation/Type of Analysis	Applied Standard	Remarks
Chemical analysis	KALI 97-003/01	Analysis of potassium by flame photometry
Crystallographic investigations	KALI 97-020/1 and KALI 97-020/02	Applied, if K_2SO_4 was analysed.
Bromine analysis	KALI 97-5	—
Iron analysis	TGL 12.126	—
Gas analysis	"Analysenvorschrift zur Bestimmung mineralgebundener und freier Gase mittels Schwingmahlung (Trockendegasierung) und gaschromatographischer Analyse" (standard for the determination of mineral-bound and free gases by oscillating milling (dry de-gasing) and gas-chromatographic analysis).	
Determination of degree of deposit development for Sylvite[56] and Glaserite[57]	KALI 97-021	—
Clay mineralogical investigation	Dilution of sample with tap water and shaking for 96 hours with NaCl (15%) solution to remove Gypsum[58] and Anhydrite. Subsequently, X-ray analysis of the $CaSO_4$-reduced solution residue followed. For comparison, clay samples were elutriated, dried and analysed in the same way. All analyses were conducted by means of X-ray counter-tube goniometers, the evaluation was done semi-quantitatively.	
Thin section analysis	Only transmitted light investigation in bright field was conducted	Nomenclature according to Stolle & Döhner (1970, /27/)

To the authors of this Report it is known that core from the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) was obtained from six drill holes (holes *E Kirchheilingen 1/1934*, *E Langensalza 7/1956, E Langensalza 17/1957, E Fahner Höhe 3/1959, E Langensalza 21/1960, E Fahner Höhe 10/1961*). Analytical results are available for core samples from two out of these six holes (11 samples from hole *E Langensalza 21/1960* covering the entire thickness of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) and 1 sample from hole *E Langensalza 7/1956* covering a part of this thickness).

The individual sampling intervals vary between 0.2 m and 3.9 m. The selection criteria are unknown. The analytical results are given as weight percent of the following salts: $CaSO_4$, $MgSO_4$, K_2SO_4, KCl, $MgCl_2$ and NaCl. Furthermore, values of acid insoluble, R_2O_3, H_2O and total K_2O are given (cf. chapter 6.4.2).

[56] Sylvite is an evaporite mineral with the chemical formula KCl.
[57] Glaserite is an evaporite mineral with the chemical formula $K_3Na(SO_4)_2$.
[58] Gypsum is an evaporite mineral with the chemical formula $CaSO4 \cdot 2H_2O$.

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

5.2.2.5 Quality Control Procedure

The procedures conducted followed strict rules on the execution and checking as well as the evaluation of the results. Quality control was ensured by independent state institutions. According to the knowledge of the authors of this Report all exploration work conducted later than 1950 was completed with detailed reports, which were quality-checked by professionals of the VEB Kombinat Kali.

5.2.2.6 Geophysical Well Logging

The geophysical well logging data currently available to the authors of this Report are limited to 10 of the 25 hydrocarbon exploration holes, for which detailed information is available (see APPENDIX 5 and APPENDIX 12). They comprise of calliper, natural gamma, gamma-gamma, neutron-gamma and resistivity logs in different scales, but not every log is available for each drill hole (cf. chapter 9). For six drill holes, natural gamma and gamma-gamma data at 1:200 scale, covering the entire potash seam, were available. For two drill holes only natural gamma logs were available and in two other holes the logs do not cover the entire thickness of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), because the exploration campaigns were primarily targeting crude oil and natural gas in the dolomite underlying these rocks. All measurements have been completed using different types of probes, therefore it is not possible to compare the values quantitatively or calculate K_2O grades. Furthermore, the data provided is given in different units (counts per minute or micro-roentgen per hour), and the technical specifications of the probes are unknown. Also, information about the background radiation is not given, nor how the background radiation was considered when evaluating the measurements.

The geophysical well logging data is available as scanned graphs. No information was located about the data processing methodologies used.

It is documented that interpretations and correlations were additionally cross-checked by geologists comparing the logging results with results from other drill holes.

5.2.2.7 Reporting of Results and Data Storage

All summarised results from geological descriptions, chemical assaying and geophysical logging are listed in the exploration report, which covers also the Gräfentonna Exploration Licence area (VVB FM, 1964, /33/).

The detailed documentation, such as drilling reports, geophysical logging data, technical drilling records, interim and final reports, were stored in the core archive of the VEB GFE Freiberg[59] (VEB GFEF, 1980, /32/), and are presently part of the archives of ENGIE E&P Deutschland GmbH. Corresponding documents for the holes used in this Report are listed in APPENDIX 12.

[59] VEB GFE Freiberg was a publicy owned company of the former GDR.

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

5.2.2.8 Surface Seismics

Surface seismics in the form of 2D reflection seismic surveys were mainly conducted along with the exploration activities for natural gas and crude oil in the late 1950s and early 1960s. The aim was to identify tectonic structures acting as traps for the hydrocarbons under investigation. Seismic survey work concentrated on the W and central part of the Thuringian Basin (VVB FM, 1964, /33/). The reflection seismic surveys cover the whole area of the Gräfentonna Exploration Licence area (cf. Figure 4). Other than location information of the seismic survey lines no further data is available to the authors of this Report.

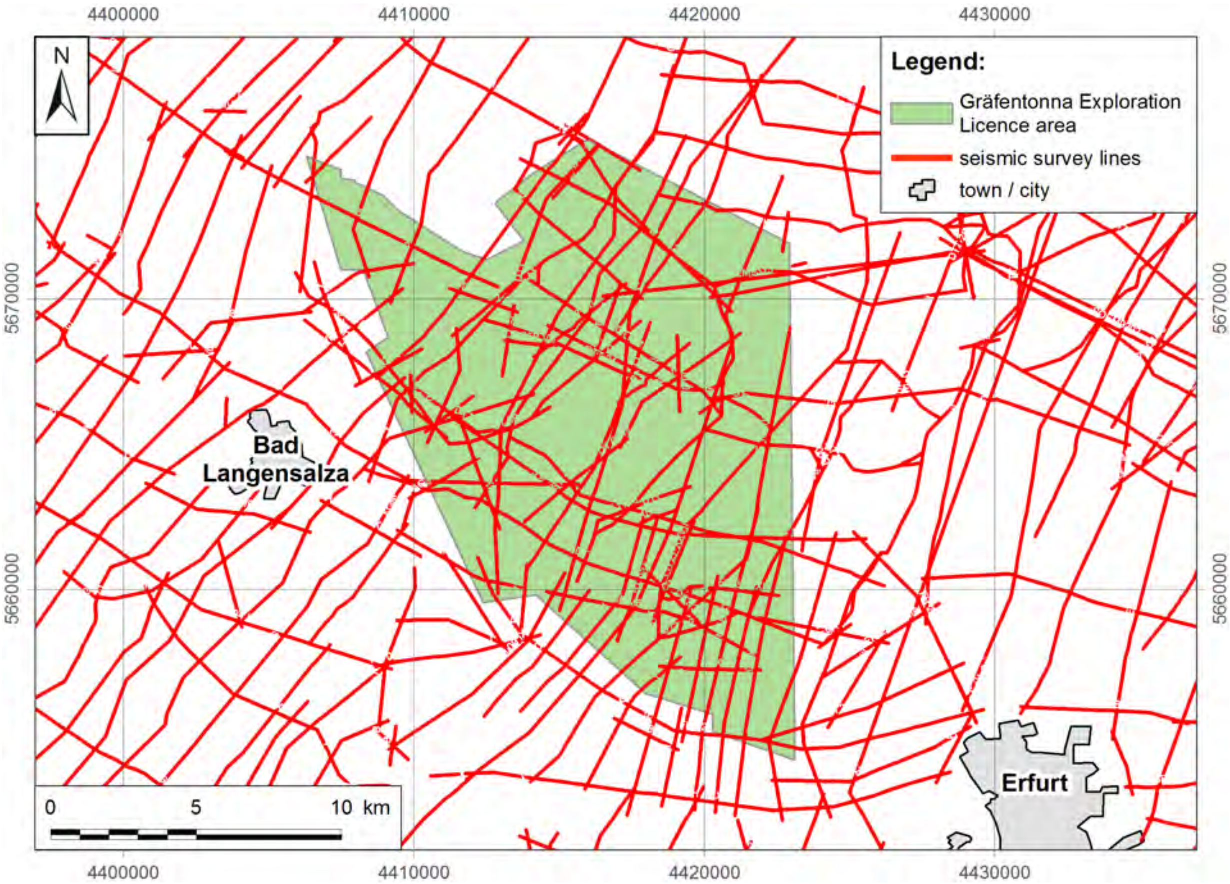

Figure 4 Seismic survey lines covering the Gräfentonna Exploration Licence area and surrounding areas (TLUG, 2016, /28/)

5.3 Historical Resource Estimates

The only historical resource estimate which pertains to the Gräfentonna Exploration Licence area and which is known to the authors of this Report, is in fact a reserve estimate, according to today's reporting standards and was based on calculations of prognostic reserves[60] according to the document 3. Kali-Instruktion (Stammberger, 1963, /25/) with values given in VVB FM

[60] Prognostic reserves are reserve category according to Stammberger (1963, /25/).

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

(1964, /33/) and presented in this chapter. The calculations are based on seven historically defined subfields[61] in the former Küllstedt-Gräfentonna prognostic reserve area. The subfield 7 does not coincide entirely with the extent of the Gräfentonna Exploration Licence area, but covers 79% of it (cf. Figure 5).

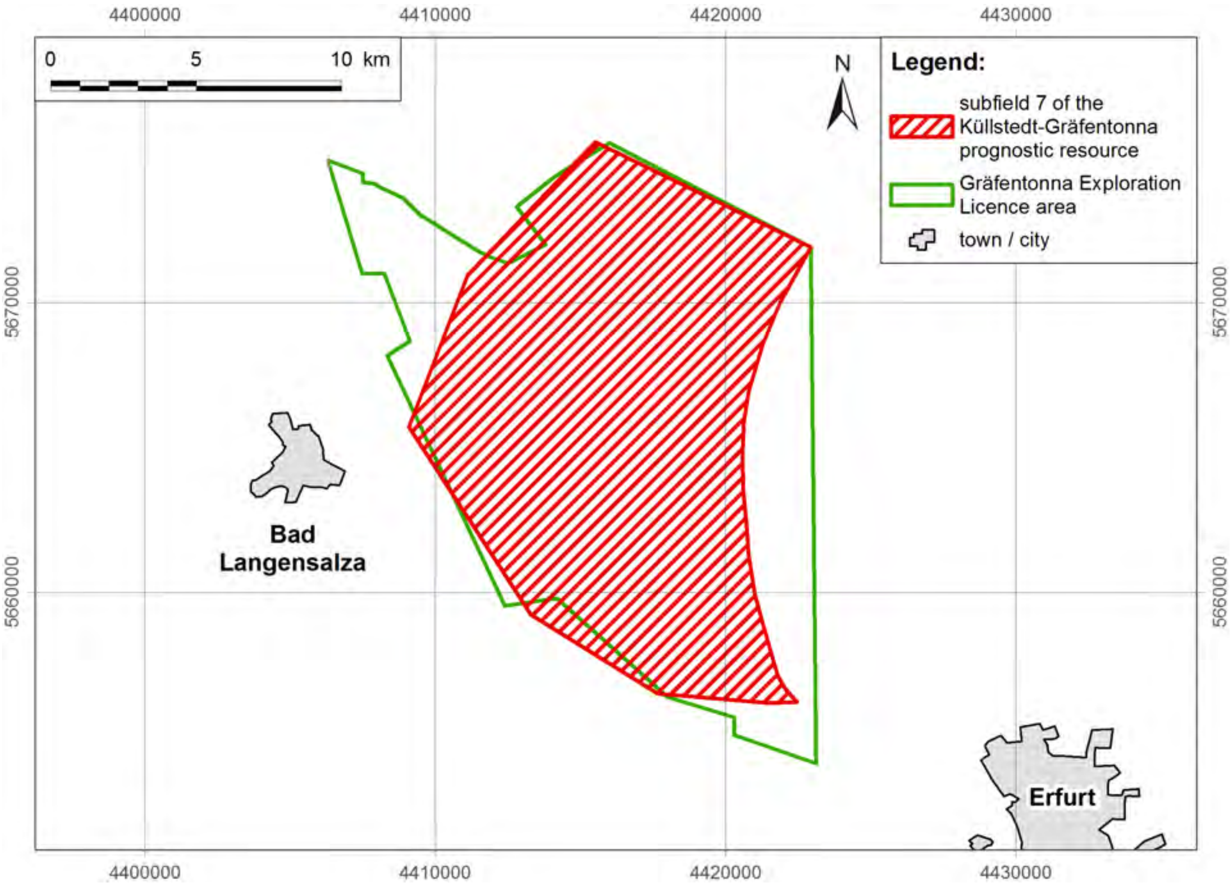

Figure 5 Location and extent of subfield 7 of the historical reserve estimate related to the location and extent of the Gräfentonna Exploration Licence area

For the reserve estimate industrial minimal contents were applied (descriptions of the salt rocks are given in chapter 6.4):

- for carnallitite[62]: 8.0% K_2O
- for hartsalz[63]: 12.0% K_2O
- for mixed salt[64]: 10.0% K_2O
- for sylvinite[65]: 14.0% K_2O

[61] Subfield refers in this context to the original German term "Teilfeld" as stated in VVB FM (1964, /33/). For the purpose of reserve estimation, of which the results are presented in the mentioned document, the South Harz Potash District was divided into resource fields by region. In case of the Küllstedt-Gräfentonna field a subdivision into seven subfields was made according to the level of potash exploration. For these subfields reserves were estimated separately.
[62] Carnallitite is a potassium-bearing salt rock consisting mainly of the evaporite minerals Carnallite, Halite, Kieserite and Anhydrite.
[63] Hartsalz is a salt rock and assigned in this Report to sylvinite.
[64] Mixed salt is a mixture of the salt rocks sylvinite and carnallitite.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

The calculation for prognostic reserves was conducted

- for carnallitite until 900 m bgl
- for hartsalz until 1,200 m bgl.

For salt rocks densities following values were taken:

- carnallitite: 1.8 t/m³
- hartsalz: 2.2 t/m³
- sylvinite: 2.1 t/m³
- mixed salt: 2.0 t/m³.

The following parameters were assumed for subfield 7, based on information available from the adjacent subfield 6 and from the Volkenroda-Pöthen mine claim:

- distribution: 40% barren, 30% hartsalz and 30% carnallitite
- average thickness of the potash seam (cf. chapter 6.2.2): 5 m for hartsalz and 10 m for carnallitite according to lithological logs of three drill holes (*E Döllstedt (Burbach) 1911/1912*, *E Fahner Höhe 3/1959*, *E Langensalza 21/1960*) and data from the neighbouring subfields
- average K_2O content of the potash seam: 15% for hartsalz and 9% for carnallitite.

The results of the reserve estimate for subfield 7 are as follows (VVB FM, 1964, /33/). The reserve is understood as hartsalz reserves:

Reserve category	Delta-1 (hartsalz)
Area	169.6 Mio m^2
Thickness	5.0 m
Volume of mineralised rock	848.0 Mio m^3
Density	2.2 t/m³
Potash-bearing area	30 %
Crude salt (as hartsalz)	558.8 Mio t
K_2O grade	15.0 %
K_2O tonnage	83.7 Mt

For the purposes of calculating the reserve, surfaces were planimetrically determined and the potash-bearing area segment calculated using the method of conclusion by analogy, taking the estimated factor for barren salt rock into consideration. The volume of mineralised rock is the product of the area segment and the average arithmetic thickness of the potash seam (cf. chapter 6.2.2). The rock density was determined using the mineral fractions present in the rocks and their densities. Multiplying the salt rock density, the volume of mineralised rock and the fraction of the potash-bearing area gives the crude salt tonnage. The K_2O percentage, de-

[65] Sylvinite is a potassium-bearing salt rock consisting mainly of the evaporite minerals Sylvite and Halite. Subordinately, Polyhalite, Langbeinite, Kieserite, Kainite and Anhydrite may occur.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

termined as arithmetic average and multiplied with the crude salt tonnage, gives the K_2O tonnage present in the determined volume.

The reserve estimate was prepared and checked by geologists, who had worked for several years in potash mining (VVB FM, 1964, /33/). It is therefore assumed that the estimate is accurate.

6 Geological Setting and Mineralisation

In the following chapters a summary of the regional geology of the South Harz Potash District and the local geology as well as the hydrogeology of the Gräfentonna Exploration Licence area will be covered. The distribution of salt rocks within the Gräfentonna Exploration Licence area (cf. chapter 15), their composition based on available chemical assays (cf. chapter 6.4.2), and the thickness and depth distributions of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), as documented by historical exploration information (cf. chapter 15), is given in the corresponding chapters.

6.1 Regional Geology

The South Harz Potash District developed in the NW part of the Thuringian Basin, which is separated by the uplift of the Harz Mountains[66] to the N from the remaining parts of the South Permian Basin[67]. The South Permian Basin comprises an area from England to E Poland with flanking areas within Denmark and the S Baltic Sea in the N and the upland areas of Belgium and Germany to the S (Ziegler, 1990, /35/).

The South Harz Potash District is divided into several units based on its lithostratigraphic development:

- pre-Variscan basement (Upper Carboniferous and older rocks)
- transition unit (Upper Carboniferous to Lower Permian (Rotliegend Group[68]))
- platform cover (Upper Permian to Upper Cretaceous).

The rocks of the Upper Cretaceous are covered by Cenozoic sediments (Kästner et al., 2003, /16/).

The oldest rocks of the pre-Variscan basement are mainly of metamorphic or magmatic origin (Cambrian and Ordovician phyllites, amphibolites and gneisses in general as well as gabbros) as indicated by drilling results. Younger rocks encountered comprise of Devonian phyllitic shists and Lower Carboniferous graywackes and slates.

Upper Carboniferous rocks of the transition unit were encountered as clays, sandstones and chlorite shists. The rocks of the Lower Permian occur as sandstones and conglomerates of the lithostratigraphic sub-group Unteres Rotliegend[69], and as an interlayering of conglomerates and sandstones with siltstones and claystones of the lithostratigraphic sub-group Upper

[66] Harz Mountains are WNW-ESE highlands in the N of the Federal State of Thuringia.
[67] South Permian Basin is a tectonic basin.
[68] Rotliegend Group is a lithostratigraphic group.
[69] Lower Rotliegend is a lithostratigraphic sub-group of the Rotliegend.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Rotliegend[70]. These rocks are known as molasse and represent sediments resulting from the erosion of the Variscan highlands.

The rocks of the platform cover comprise of the Upper Permian succession of evaporite rocks, which are assigned to the Zechstein Group, and host the potash mineralisation of the potash deposit of the South Harz Potash District. In the hanging wall of the evaporite rocks of Upper Permian age the rocks of the German Trias Supergroup follow with the Buntsandstein Group, as oldest lithostratigraphic group, consisting mainly of sandstone and subordinate siltstone and claystone. The Muschelkalk Group follows chronostratigraphically mainly consisting of carbonate rocks and subordinate evaporite rocks. The Keuper Group is the youngest lithostratigraphic group of this Supergroup and consists mainly of sandstone, siltstones and claystones and subordinately of carbonate and evaporite rocks. Cretaceous sediments are restricted to the Ohmgebirge graben zone[71] with sandstone and marls encountered in drill holes (ERCOSPLAN, 2015b, /10/). Jurassic sediments are not known in the South Harz Potash District.

Cenozoic rocks consist mainly of glacial and fluviatile sediments.

6.2 Local Geology of the Evaporites

This chapter discusses the local geology of the evaporites, which are assigned to the lithostratigraphic group Zechstein Group, subsequently named Zechstein evaporites. These rocks were and still are of interest for potash mining in the South Harz Potash District.

The geological development of the Zechstein evaporites of the South Harz Potash District began with the transgression of the Zechstein Ocean[72] onto the plains of the former foreland and subsided parts of the Variscan highlands during the Late Permian. The basin, which developed from these plains, is known as the South Permian Basin. The primary evaporites were deposited in a shallow marine environment with a distinctive morphological structuring of the basin's floor due to late Variscan structures in the underlaying basement rocks.

The Zechstein Group is developed with seven cycles (cf. APPENDIX 6). The cycles are numbered beginning with 1 for the lithostratigraphic oldest cycle, and 7 for the lithostratigraphic youngest cycle. The cycles were assigned to the corresponding lithostratigraphic formations, which are named according to their type region. The four oldest of these formations, named Werra-Formation, Staßfurt-Formation, Leine-Formation and Aller-Formation beginning with the stratigraphic oldest formation, are represented by evaporite rocks.

The three youngest of these lithostratigraphic formations, named Ohre-Formation, Friesland-Formation and Fulda-Formation beginning with the stratigraphic oldest formation, are represented mainly by clastic sediments (clay, fine sand) with only subordinate occurring Anhydrite and carbonates. The sediments of these three formations reflect the position of the South Harz Potash District, which was in the peripheral zone of the South Permian Basin at the time of deposition (Döhner et al., 2003, /8/; Ziegler, 1990, /35/).

The following chapters discuss the lithostratigraphic units of the seven lithostratigraphic formations of the Zechstein Group. The discussion starts with the stratigraphically oldest and ends with the stratigraphically youngest lithostratigraphic unit. The minimum and maximum thicknesses of these units within the Gräfentonna Exploration Licence area are listed in APPENDIX 6. By the described lithology of the rocks the dynamic interplay between the marine

[70] Upper Rotliegend is a lithostratigraphic sub-group of the Rotliegend.
[71] Ohmgebirge graben zone is a NNE-SSW trending graben structure in the NW of the Federal State of Thuringia.
[72] Zechstein Ocean was an upper Permian-aged ocean corresponding to the extent of the South Permian Basin (see glossary).

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

(sedimentation of carbonate, Anhydrite and saliferous rocks) and terrestrial (sedimentation of clay and sand) influence in the South Harz Potash District can be seen. With deposition of the sediments of the Ohre-Formation the terrestrial influence takes increasingly over, which led finally to the deposition of the mainly terrestrial sediments of the overlying Buntsandstein Group.

6.2.1 Werra-Formation

The sedimentation of the Werra-Formation begins with grey carbonate-cemented conglomeratic sandstones of the lithostratigraphic unit **Zechsteinkonglomerat (z1C)**, which are overlain by the dark grey heavy metal-bearing clay of the lithostratigraphic unit **Unterer Werra-Ton ("Kupferschiefer"[73], z1T)**. This heavy metal-bearing clay was mined in Germany in areas, where it occurred in sufficient thickness to allow for economic extraction.

The lithostratigraphic unit **Werra-Karbonat (z1CA)** consists mainly of limestone, while the overlying lithostratigraphic units **Unterer Werra-Anhydrit (z1ANa)** and **Oberer Werra-Anhydrit (z1ANc)** consist mainly of Anhydrite rocks. Both are separated by salt rocks of the lithostratigraphic unit **Werra-Steinsalz (z1NA)**.

6.2.2 Staßfurt-Formation

The light grey-brown dolomite of the lithostratigraphic unit **Staßfurt-Karbonat (z2CA)** is the basis of the Staßfurt-Formation. Subordinate, layers of Anhydrite occur. The structure of the dolomite varies throughout the South Harz Potash District due to the local variations in the facies conditions of deposition. The dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA) is known to be hydrocarbon-bearing.

The lithostratigraphic unit **Unterer Staßfurt-Anhydrit ("Basalanhydrit"[74], z2AN)** consists of blue-grey to dark grey Anhydrite rocks with a low percentage of carbonate and inclusions of Halite in its upper part indicating transition to the salt rocks of the overlying lithostratigraphic unit **Staßfurt-Steinsalz (z2NA)**. The lithostratigraphic unit Staßfurt-Steinsalz (z2NA) is divided according to lithostratigraphic properties, in case of a fully developed succession, into the following lithostratigraphic sub-units (stratigraphic top to bottom):

- Oberes Südharzsteinsalz,
- Unteres Südharzsteinsalz,
- Anhydritisches Steinsalz.

The lithostratigraphic sub-unit Anhydritisches Steinsalz consists mainly of rock salt, but in the Sondershausen and Bleicherode area it is known to contain a potash-bearing kieseritic horizon of 1 m (Sondershausen area) and 0.2 m (Bleicherode area) thickness (ERCOSPLAN, 2015b, /10/). The lithostratigraphic sub-units Oberes and Unteres Südharzsteinsalz consist mainly of grey or yellow-red Halite[75] and Anhydrite and include in some areas of the South Harz Potash District Polyhalite[76], Kieserite[77], Sylvite and Carnallite[78] in the form of nests or as fissures fillings.

[73] "Kupferschiefer" is an old lithostratigraphic term used by miners.
[74] "Basalanhydrit" is an old lithostratigraphic term.
[75] Halite is an evaporite mineral with the chemical formula NaCl.
[76] Polyhalite is an evaporite mineral with the chemical formula $K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot H_2O$.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

The rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) form a protective layer for the overlying rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) against the hydrocarbons and brines contained in the underlying carbonate and sulphate rocks.

The lithostratigraphic unit Staßfurt-Steinsalz (z2NA) is overlain by the lithostratigraphic unit **Kaliflöz Staßfurt (z2KSt)**, which consists of the potash-bearing salt rocks that host the potash mineralisation of the potash deposit of the South Harz Potash District. These rocks were and still are the target for potash mining in the South Harz Potash District.

Stratigraphically, the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) comprises the rocks between the hanging wall boundary of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) and the footwall boundary of the lithostratigraphic unit "Grauer Salzton" (z2Tb-z3Ta). The lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) was stratigraphically divided into 19 marker horizons, which are assigned to:

- the hanging wall group in the upper part (marker horizon 11 to 19) with fine layering (millimetres to centimetres) and a high percentage of exploitable potassium salts,
- the footwall group in the lower part (marker horizon 1 to 10) with coarser layering (decimetres) and decimetre thick Halite layers.

The salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) were subject to mineral conversion processes by ascending and descending brines. The mineral content of these rocks is described in detail in chapter 6.3.

Important for potash mining is the occurrence of clay layers, which are known under the term Tonlöser. These layers reduce the overall rock strength, and were therefore also the main reason for roof falls that threaten conventional mining.

Both, the lithostratigraphic unit **Decksteinsalz (z2NAr)** and the **Deckanhydrit (z2ANb)** unit, belong lithostratigraphically to the Kaliflöz Staßfurt (z2KSt) and represent no independent lithostratigraphic units as historically anticipated. The rocks of both lithostratigraphic units are interpreted as altered and residual rocks, caused by the leaching processes of the previously described brines during the Upper Permian (ERCOSPLAN, 2015b, /10/). Proof is given by relictic occurring minerals and structures of formerly present potash minerals and the often distinctive layering, which represents the former layering of the potash-bearing salt rocks. The mineral conversions in the lithostratigraphic unit Deckanhydrit (z2ANb) were more intensive than in the lithostratigraphic unit Decksteinsalz (z2NAr). Rocks of the lithostratigraphic unit Decksteinsalz (z2NAr) consist mainly of Halite and Anhydrite, those of the lithostratigraphic unit Deckanhydrit (z2ANb) consist mainly of Anhydrite.

The extent of the salt rocks of the lithostratigraphic units Staßfurt-Steinsalz (z2NA) and Kaliflöz Staßfurt (z2KSt) in the South Harz Potash District is well known in the N and W by the subrosional boundary as described in chapter 6.3.4. Towards the S, the extent of the salt rocks is less well known due to the comparable lower degree of exploration. Here the occurrence of the depleted potash-bearing salt rocks (barren zones, cf. chapter 6.4) of the lithostratigraphic unit Kaliflöz Staßfurt is anticipated to demark the boundary, which runs along the line marked by the country towns/city Lengenfeld - Bad Langensalza - Erfurt - Weimar - Eckartsberga - Bad Bibra - Nebra according to VEB FM (1964, /33/). According to information from drill holes (cf. chapters 5.2.1.1 and 5.2.2.1) the S part of the Gräfentonna Exploration Licence area is located close to this southern boundary.

The term ***potash seam / potash-bearing horizon***, used in this Report, refers to potash mineralisation within certain layers of the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA), which are locally restricted in their occurrence, and within the entire potash-bearing

[77] Kieserite is an evaporite mineral with the chemical formula $MgSO_4{\cdot}H_2O$.
[78] Carnallite is an evaporite mineral with the chemical formula $KCl{\cdot}MgCl_2{\cdot}6H_2O$.

salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) including the lithostratigraphic units Decksteinsalz (z2NAr) and Deckanhydrit (z2ANb).

Above the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) sediments are increasingly dominated by clay. In the lower part of these sediments salt inclusions indicate the gradual cessation of evaporite deposition, which designates this part to the lithostratigraphic unit **Oberer Staßfurt-Ton (z2Tb)**, which belongs to the Staßfurt-Formation, whereas the upper part is designated to the lithostratigraphic unit **Unterer Leine-Ton (z3Ta)**, which belongs already to the Leine-Formation. In the former active potash mines in Germany both lithostratigraphic units were grouped together due to their comparable geomechanical and hydrogeological behaviour and were named **"Grauer Salzton" (z2Tb-z3Ta)** according to prevailing grey colour of these sediments. This lithostratigraphic term is stated in APPENDIX 6.

6.2.3 Leine-Formation

Above the lithostratigraphic unit "Grauer Salzton (z2Tb-z3Ta) the dolomite of the lithostratigraphic unit **Leine-Karbonat ("Plattendolomit[79]", z3CA)** and blue-grey Anhydrite rocks with subordinate limestone and clay inclusions of the lithostratigraphic unit **Leine-Anhydrit ("Hauptanhydrit"[80], z3AN)** occur. The rocks of the above lying lithostratigraphic unit **Leine-Steinsalz (z3NA)** consists mainly of Halite, Anhydrite and subordinate clay. This lithostratigraphic unit forms a protective layer for the underlying rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) against downwards migration of brine and groundwater located in the hanging wall block.

The uppermost lithostratigraphic unit of the Leine-Formation is the **Oberer Leine-Ton (z3Tb)**, which was grouped together with the lithostratigraphic unit **Unterer Aller-Ton (z4Ta)**, already belonging to the Aller-Formation, due to their comparable geomechanical and hydrogeological behaviour. As stated in APPENDIX 6, both are named together **"Roter Salzton" (z3Tb-z4Ta)** according to the prevailing red colour of these sediments.

6.2.4 Aller-Formation

Above the lithostratigraphic unit "Roter Salzton" (z3Tb-z4Ta) the rocks of the lithostratigraphic unit **Unterer Aller-Anhydrit ("Pegmatitanhydrit"[81], z4ANa)** occur, which consist of light grey Anhydrite with Halite intergrowth in subrosion-free areas, and of light grey to white Anhydrite in areas influenced by subrosion. In latter mentioned areas the crystal size of the Anhydrite is generally larger.

The rocks of the overlying lithostratigraphic unit **Aller-Steinsalz (z4NA)** consist of colourless to milky Halite with subordinately occurring Anyhdrite. Like the rocks of the lithostratigraphic unit Leine-Steinsalz (z3NA) the rocks of this lithostratigraphic unit form another protective layer for the underlying rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) against solutions located in the hanging wall block.

The topmost lithostratigraphic unit of the Aller-Formation is the **Oberer Aller-Anhydrit ("Grenzanhydrit"[82], z4ANb)**. The rocks of this lithostratigraphic unit consist of white to flesh-red, partly gypsified Anhydrite. Based on the rock texture these rocks are interpreted as resid-

[79] "Plattendolomit" is an old lithostratigraphic term referring to the structure of the dolomite rocks.
[80] "Hauptanhydrit" is an old lithostratigraphic term.
[81] "Pegmatitanhydrit" is an old lithostratigraphic term.
[82] „Grenzanhydrit"is an old lithostratigraphic term.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

ual rocks of the rocks of the lithostratigraphic unit Aller-Steinsalz (z4NA), left behind by leaching processes during the Upper Permian (ERCOSPLAN, 2015b, /10/).

6.2.5 Ohre-, Fulda- and Friesland-Formation

The rocks of these three lithostratigraphic formations are summarised as the lithostratigraphic unit **"Obere Zechsteinletten" (z4Tb-z7)** in APPENDIX 6. They consist mainly of siltstones and claystones with subordinately occurring Anhydrite and carbonates. Towards the top, the percentage of fine sand increases, indicating the transition to the Triassic Buntsandstein Group.

6.3 Geological Development of the Potash Deposit in the South Harz Potash District

The following chapters present the geological development of the potash deposit due to mineral conversions of the salt rocks of the Zechstein Group and tectonical events.

6.3.1 Origin of the Potash Mineralisation

The potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) were relatively evenly deposited as kieseritic carnallitite (cf. chapter 6.4) with an original mineralisation consisting of Carnallite (between 55% and 60%), Halite (between 25% and 30%) and Kieserite (between 10% and 14%). The lower part of the footwall group is almost Kieserite-free. Shortly after the deposition of the carnallitite (cf. chapter 6.4) mineral conversion processes began due to the high solubility and reactivity of the salt minerals that existed as the units underwent diagenesis in different chemical environments. Brines, usually undersaturated with regards to potassium salts, could flow through the still relatively porous and uncompacted evaporites and remove their components in the order of decreasing solubility, accompanied by the generation of new minerals in the affected areas. Carnallite was converted to Sylvite through the removal of magnesium chloride ($MgCl_2$) brine according to

$KCl{\cdot}MgCl_2{\cdot}6H_2O$ +	H_2O	$\rightarrow$	KCl +	$MgCl_{2(aq)}$
Carnallite	water		Sylvite	magnesium chloride brine

The Sylvite is the main potassium salt in sylvinite (cf. chapter 6.4), whose dissolution led to barren rocks. Kieserite, as a mineral of relative low solubility, was converted to Mg-, Ca-, K- and Na-bearing sulphates, commonly occurring in the sylvinite (cf. chapter 6.4) (Döhner et al., 2003, /8/).

Mineral conversions led to loss of substance in the original evaporites, on one hand due to the dissolution and removal of components of the original minerals, if not recrystallized in other places of the deposit, and on the other hand due to the removal of crystal lattice water from the original minerals like Carnallite, which contains 39% water. Accordingly, different thicknesses of the differently developed potash profiles were the result.

Based on recent knowledge two different directions of Upper Permian-aged brines are known to have had an influence on the deposit. The first was ascending NaCl-saturated (Kästner, 2003, /15/) brines probably having originated from volcanic sources below the rocks of the Zechstein Group or from the compacting of the rocks of the Rotliegend Group below the rocks of the Zechstein Group or the compacting of the rocks of the Zechstein Group. The second were descending brines probably having their origin in the decreasing concentration of the mother liquor at the end of the deposition of rocks of the lithostratigraphic formation Staßfurt-Formation (Döhner et al., 2003, /8/).

Ascending brines affected the original deposit along their pathways creating spatially restricted zones of sylvinite and barren rocks (cf. chapter 6.4), which are very variable in terms of their extension and vertical as well as horizontal in arrangement. The barren rock zones are the final stage of the conversion processes as the inflowing fluids were already saturated with sodium chloride (NaCl). In the South Harz Potash District, extensive barren rock zones are known, which might have been the result of ascending brines converting the original deposit due to the small thickness of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) (cf. chapter 6.2.2). The Kieserite of the original carnallitite (cf. chapter 6.4) with its relatively low solubility was also affected and completely converted to fine crystalline Anhydrite, which occurs as the main sulphate-bearing mineral in the District. Since this mineral is even less soluble, it was not further affected by the ascending brines.

The influence of descending brines on the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) is expressed by the extensive occurrence of the rocks of the lithostratigraphic units Deckanhydrit (z2ANb) and Decksteinsalz (z2NAr), which underwent intensive conversion processes, caused by NaCl-undersaturated solutions (Kästner, 2003, /15/). According to chapter 6.2.2 rocks of the lithostratigraphic unit Deckanhydrit (z2ANb) were affected most intensely by the removal of the chloride minerals, whereas rocks of the lithostratigraphic unit Decksteinsalz (z2NAr) represent a partial development of a barren zone in the upper part of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). Underlying carnallitite (cf. chapter 6.4) is converted to sylvinite (cf. chapter 6.4), if the influence of descending brines is low. As the thickness of affected profiles of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) is determined by the depth of the former sedimentation basin, such profiles of marginal areas have a much larger thickness than profiles located more centrally and in deeper parts of the former South Permain Basin. Accordingly, a stratigraphic reduction of the remaining potash-bearing salt rock profile occurs, whereby the rocks of the lithostratigraphic unit Deckanhydrit (z2ANb) have the largest thickness in profiles of the marginal areas.

Geologically, the influence of both types of brines can be attributed to cycle 2 of the Zechstein Group (cf. chapter 6.2) with the generation of rocks of the lithostratigraphic formation Staßfurt-Formation. However, the ascending brines influenced the deposit at first, whereas the descending brines encountered the results of this prior influence before the sedimentation of the rocks of the lithostratigraphic unit Unterer Leineton (z3Ta) (Döhner et al., 2003, /8/).

Locally, potash mineralisation occurs already in rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) (e. g. in holes *E Bienstädt 2/1961* and *E Haussömmern 1/1970*). Potash mineralisation in rocks of the lithostratigraphic unit Decksteinsalz (z2NAr) of hole *E Fahner Höhe 3/1959* proves the influence of descending brines on the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). Areas with potash mineralisation already present in the Staßfurt-Steinsalz (z2NA) are assumed to have been depressions in ancient times, where brines evaporated and potash mineralisation occurred, while areas around were already dried out. A comparable situation is known from the area N of Mühlhausen (Döhner, 2001, /7/).

The distribution of K_2O within the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) generally shows decrease towards the border of the South Harz Potash District, due to the influences on the potash seam as described above. Small scale variations in salt rock mineralisation of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) cause an inhomogeneous K_2O distribution within the extent of South Harz Potash District as observed in the Bischofferode, Bleicherode, Sollstedt and Volkenroda mines. According to available drill hole information in the Gräfentonna Exploration Licence area a decrease in K_2O content towards the W and S, towards the Muschelkalk escarpment of the Fahner Höhe, can be expected.

6.3.2 Tectonics of the Potash Deposit

The tectonic development of the potash deposit of the South Harz Potash District and its basement and overburden is linked to the different mechanical behaviour of the rocks, which led to a corresponding division into the following tectonic units (Kästner et al., 2003, /16/):

- post-saliferous overburden, in the following text referred to as overburden (here: consisting of rocks of the lithostratigraphic unit Oberer Aller-Anhydrit (z4ANb) to Upper Cretaceous rocks),
- saliferous strata (here: consisting of rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) to rocks of the lithostratigraphic unit Aller-Steinsalz (z4NA)),
- pre-saliferous basement, in the following text referred to as basement (here: consisting of rocks of the lithostratigraphic unit Staßfurt-Anhydrit (z2ANa) and older rocks).

Rocks of the basement and overburden exhibit mainly incompetent mechanical behaviour when put under differential strain, while rocks of the saliferous strata exhibit mainly a competent mechanical behaviour under such conditions. The incompetent behaviour results in brittle deformation, which is expressed by fault structures. The competent behaviour instead allows for ductile reaction, which is expressed by folding and flowing movement of the corresponding rocks.

The division into tectonic units presented in this chapter is not equal to the division presented in chapter 6.1, as the previous definition is based on the lithostratigraphic development of the South Harz Potash District, not on the mechanical behaviour of rocks and the resulting tectonic influence. The description of tectonics in this chapter focuses on the saliferous strata and the overburden due to the higher degree of information obtained from exploration in these units compared to the basement.

Tectonic events affecting the rocks of the basement, saliferous strata and overburden took place during the Mesozoic and Tertiary, and led to the exhumation and uplift of the Harz Mountains and the Thüringer Wald[83] as well as the development of the Thuringian Basin. In the course of these events smaller tectonic structures developed in the form of fault blocks in the basement and overburden, which underwent vertical and tilting movements against each other. Conversely, rocks of the saliferous strata performed characteristic folding and flowing movements, which also led to a different structural formation in the basement and overburden (Kästner et al., 2003, /16/). The degree of the internal structural deformation of the saliferous strata and its influence on the basement and overburden depended on the thickness of the saliferous strata.

As a result of tectonic influences, the rocks of the overburden in the South Harz Potash District show a general dip of less than 10° towards the SE, accompanied by fault and graben structures, and gently undulating flexures. The fault structures developed during the Mesozoic mainly as normal faults with offsets in the range of up to one hundred metres. During the Late Cretaceous these structures where overprinted compressively.

[83] Thüringer Wald is an uplift S of the Thuringian Basin.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

The general trend of tectonic features in the South Harz Potash District is NW-SE. The most important of these features are the Finne fault[84], which extends as Wippertal fault zone[85] towards the NW as a zone of intensively faulted saliferous strata, and the Schlotheim graben[86] which defines the SW border of the former potash mining area. The Ohmgebirge graben[87] as another important tectonic features, located at the NW border of the South Harz District, consists of the Holunger graben in the NE and the Worbiser graben in the SW as its main tectonic structures, and trends in general NNE-SSW. The Ohmgebirge graben zone is the only area in the South Harz Potash District, where Cretaceous sediments occur (cf. Figure 6).

While the overburden is dominated by brittle deformation structures, the saliferous strata, especially the level of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), is dominated by folding structures of different dimensions (several metres to several hundreds of metres). Vergence in tectonically affected areas is, expressed as overturned folds, thrusts, layer thickening and thinning, is punctured by more competent rocks (mainly consisting of Anhydrite), and injection of incompetent rocks (especially carnallitite). The more extensive anticlinal and synclinal structures in the more competent Anhydrite rocks underlying and overlying the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), those of the lithostratigraphic units Unterer Staßfurt-Anhydrit ("Basalanhydrit", z2ANa) and Leine-Anhydrit ("Hauptanhydrit", z3AN), influenced the tectonic deformation of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). Especially the Anydrite rocks of the lithostratigraphic unit Leine-Anhydrit ("Hauptanhydrit", z3AN), embedded in the salt rocks (cf. chapter 6.2), induced compensation movements within these rocks, particularly in the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt), where the carnallitite (cf. chapter 6.4) as a very mobile (incompetent) rock was the preferred material for this compensation. Continuous tectonic strain on rocks of the lithostratigraphic units Unterer Leineton (z3Ta) and Leine-Anhydrit ("Hauptanhydrit", z3AN), especially in hinge and top areas of folds, led to the ripping apart of these rocks, which caused the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) to be directly overlain by the salt rocks of the lithostratigraphic unit Leine-Steinsalz (z3NA). In the E part of the Bischofferode mine, the largest thickness of carnallitite within such structures was measured at >160 m (Döhner et al., 2003, /8/).

The folding structures in the saliferous strata show mainly a NW-SE trend similar to the structural features of the overburden. Small local variations do occur (Zänker, 1972, /34/).

The intensity of tectonic influence on the saliferous strata differs remarkably by region. While almost uninfluenced areas with horizontal to slightly dipping, even to slightly undulating layers of potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) are known from parts of the Bischofferode mine, heavily influenced saliferous strata is known from the Bleicherode mine and Volkenroda mine due to the influence of the Wippertal fault zone and Schlotheim graben, respectively. This is also reflected by the depth and thickness distribution of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt).

The Gräfentonna Exploration Licence area, located in the centre of the Thuringian Basin is influence by the tectonic structures Langensalza upwarp[88] to the W, Erfurt fault zone[89] with the Muschelkalk escarpment of the Fahner Höhe in the central part, the S and SE, and the Schlotheim graben to the N. Together with its graben flanks, referred to as Allmenhausen structure to the NE and the Kirchheilingen structure to the SW, the Schlotheim graben forms the Schlo-

[84] Finne fault is a fault structure in the N of the Thuringian Basin.
[85] Wippertal fault zone is a fault zone in the NW of the Thuringian Basin, emphasized by the Wipper river.
[86] Schlotheim graben is a graben structure near the country town of Schlotheim.
[87] NNE-SSW trending graben structure in the NW of the Federal State of Thuringia.
[88] Langensalza upwarp is an upwarped flexure of the overburden, named by the country town of Bad Langensalza due to its close vicinity.
[89] Erfurt fault zone is a fault zone named by the city of Erfurt due to its close vicinity.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

theim-Tennstedt arch[90]. All mentioned tectonic features generally trend NW-SE (cf. Figure 6). The Muschelkalk escarpment of the Fahner Höhe deviates a little bit trending more WNW-WSE.

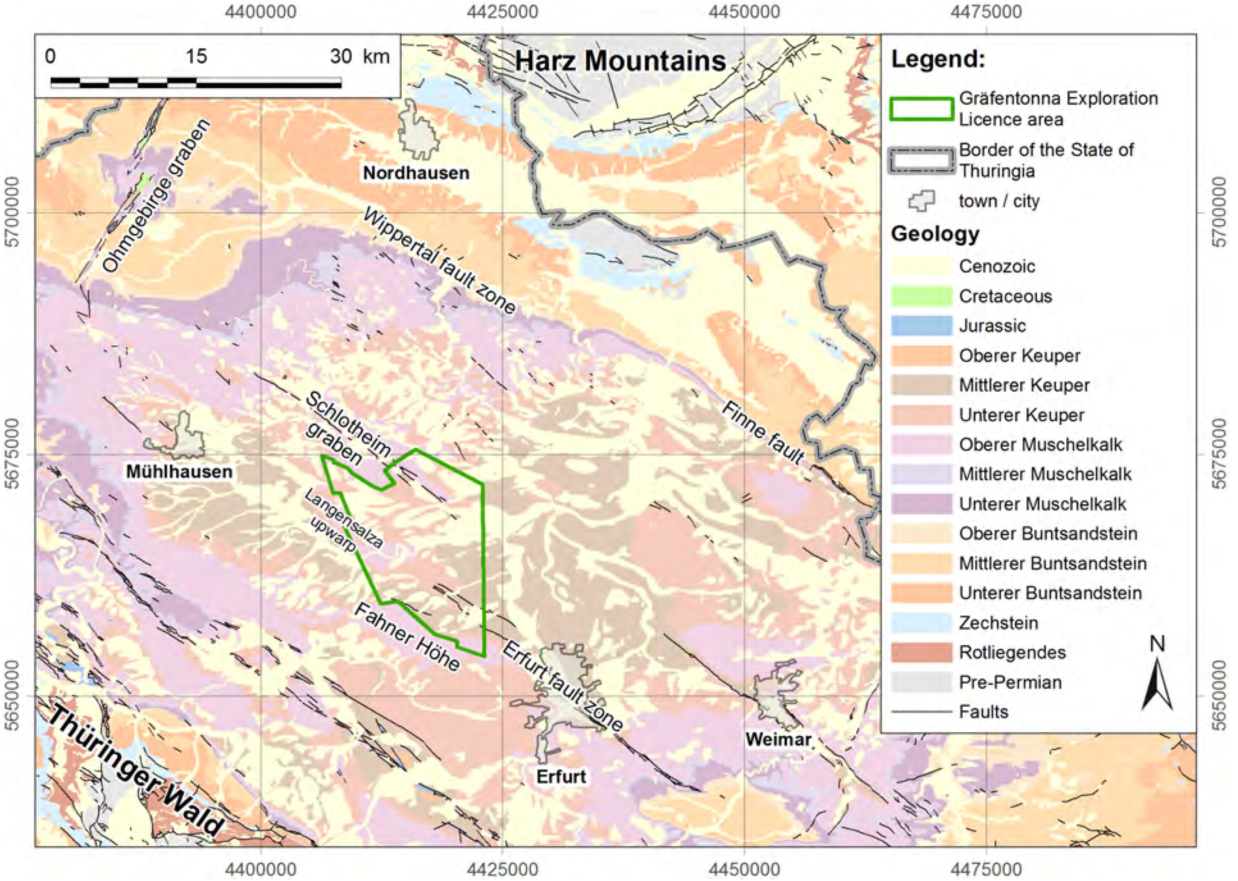

Figure 6 Geological map (BGR, 2007, /4/) of the Gräfentonna Exploration Licence area

The Schlotheim graben has subsided by about 100 m compared to its flanks (Malz, 2014, /21/), which is reflected by the offset of the graben margin faults within the Gräfentonna Exploration Licence area, and which also affects the dolomite of the lithostratigraphic unit Staßfurt-Karbonat (z2CA). From the Volkenroda mine NW of the Schlotheim graben small-scale disharmonic faulting within the more competent rocks of the saliferous strata is known, though the graben shows only extensional structures at the surface. This faulting is partly bound to overthrusting and reflects a multiple stage development by extension and compression.

The Erfurt fault zone runs through the S part the Gräfentonna Exploration Licence area. It is developed as a half graben with a hanging wall block to the SW. Within the Gräfentonna Exploration Licence area the structure consists of two NW-SE trending faults according to BGR (2007, /4/). The trace of both faults is mapped until the country town of Döllstedt (Figure 6). Both faults dip S with the NE fault developed as a normal fault showing an offset of about 50 m, and the SW fault, developed as an overthrust fault, showing an offset of about 40 m (Malz, 2014, /21/).

[90] Schlotheim-Tennstedt arch is an arch structure, named by country towns of Schlotheim and Bad Tennstedt due to the close vicinity.

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Along the northern flank of the Muschelkalk escarpment of the Fahner Höhe, about 3 km S of the Erfurt fault zone, a SW dipping overthrust fault is developed with a detachment in the rocks of the Werra-Formation. The presence of the overthrust is proven by the lithological log of hole *E Fahner Höhe 3/1959* intersecting a repetition of the evaporite rocks of the lithostratigraphic units Röt-Steinsalz (so1NA) and Röt-Sulfat 1 (soAN1), and of the sandstone of the lithostratigraphic unit Chirotheriensandstein (smSTC). According to the lithological log the vertical offset is 67.5 m. The remaining few drill holes sunk in the area of the Muschelkalk escarpment of the Fahner Höhe show a reduced thickness of the lithologies of the Zechstein Group by about 100 m within this structure's core, and an elevated base of those lithologies. This suggests that the basement below the Muschelkalk escarpment of the Fahner Höhe is elevated by at least 500 m compared to the surrounding area (Malz, 2014, /21/).

As a consequence of the tectonic influence, a part of the saliferous strata was exposed to groundwater located in the overburden due to exhumation of extensive parts of the crust (e. g. Harz Mountains). The influence by groundwater on the saliferous strata is described in chapter 6.3.4.

6.3.3 Hydrogeology

Within the following chapters the hydrogeological conditions of the Gräfentonna Exploration Licence area are presented, first with a description of surface waters (chapter 6.3.3.1), followed by a description of the underground hydrogeological conditions (chapter 6.3.3.2).

6.3.3.1 Surface Waters

The Unstrut river with its upper reaches at the W-NW margin of the Thuringian Basin and its source at the country town of Kefferhausen is the largest waterway in the area, flowing through it from W to E. The Schambach and Kleiner Schambach as smaller streams flow into the retention reservoir Straußfurt. The Fernebach stream with its spring at the country town of Bruchstedt flows into the Schambach stream at the country town of Bad Tennstedt. These smaller streams follow roughly the flow direction of the Unstrut river (cf. APPENDIX 1).

Apart from the reservoir Straußfurt other freshwater reservoirs are located S of the country towns of Dachwig and Döllstedt (cf. APPENDIX 1).

6.3.3.2 Groundwater

Hydrogeologically, two different main groundwater levels can be distinguished according to the volume and composition of the circulating water (Figure 7), which are linked to the rocks of the Zechstein Group and Buntsandstein Group (lower main groundwater level) and to the rocks of the Muschelkalk Group, Keuper Group and Quaternary (upper main groundwater level). The individual layers of the lower main groundwater level allow the passage of highly mineralised waters along jointed areas in fracture zones (formations waters), but usually their volumes are small and their movement minimal. The higher main groundwater level comprises of layers with good conductivity, like the highly karstified carbonate rocks of the lithostratigraphic subgroup Mittlerer Muschelkalk (lithostratigraphic formation Anhydrit-Folge: lithostratigraphic unit Oberer Dolomit, mmDO, to lithostratigraphic unit Unterer Dolomit, mmDU) and the overlying

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

lower part of the rocks of the lithostratigraphic formation Hauptmuschelkalk-Folge (lithostratigraphic unit Trochiten-Schichten, moT). The groundwater movement follows the dip of the individual horizons, especially along fault zones. The groundwater can escape at some sources with high flow rates. Since water from these sources is used as potable water, the groundwater-bearing Muschelkalk Group is well investigated and understood (VEB GFEF, 1980, /32/).

According to Brasser et al. (2001, /5/) almost all mineral waters encountered at depths greater than 200 m bgl are classified as brines. Low mineralisation and the sulphate and hydrogencarbonate concentrations indicate their mixing with meteoric waters. The origin of these brines is assumed to lie in the saliferous strata of the Zechstein Group as well as in the rocks of the lithostratigraphic sub-groups Oberer Buntsandstein and Mittlerer Muschelkalk and partly in the rocks of the lithostratigraphic unit Gipskeuper (kmG).

Sulphate waters originate from leaching of Gypsum and Anhydrite belonging to the lithostratigraphic sub-group Mittlerer Muschelkalk and the lithostratigraphic unit Gipskeuper (kmG). Typically, they are encountered between several decametres below ground and 100 m bgl. Sulphur waters are rare and occurrences in the area of the country towns of Bad Langensalza, Merxleben und Bad Tennstedt can be traced to reduction of Mesozoic sulphates by Quaternary peat.

Radioactive waters are known from the potash mine Volkenroda (deep groundwater from the mine) and close to the country town of Saalfeld (iron-, arsenic- and sulphate-rich mine drift drainage from mining of the Ordovician alum shale) in the S of the Federal State of Thuringia.

Quaternary			clay, sand, mudstone, pebble	aquitard
Unterer Keuper	Lettenkeuper		clay, sandstone, limestone, dolomite	aquitard
Oberer Muschelkalk	Hauptmuschel-kalk-Folge	Ceratitenschichten	claystone, limestone, marlstone	aquitard
		Trochitenkalk	claystone	aquifer
Mittlerer Muschelkalk	Anhydrit-Folge	Oberer Dolomit	interbedding of dolomite, anhydrite and marlstone; rock salt, anhydrite	aquifer/ aquitard
		Obere Wechsellagerung		
		Mittlerer Dolomit		
		Mittlere Wechsellagerung		
		Oberes Sulfat	partially depleted sulphates	
		Muschelkalk-Steinsalz	partially depleted sulphates and rock salt	
		Unteres Sulfat	interbedding of dolomite, anhydrite and marlstone; rock salt, anhydrite	
		Untere Wechsellagerung		
		Unterer Dolomit		
Unterer Muschelkalk	Wellenkalk-Folge	Schaumkalkzone	claystone	aquifer
		Oberer Wellenkalk	claystone, marlstone	aquifer
		Terebratulazone	claystone	aquifer
		Mittlerer Wellenkalk	claystone, marlstone	aquifer
		Oolithbank	claystone	aquifer
		Unterer Wellenkalk	claystone, mudstone	aquifer
		Gelbe Grenzbank	dolomite	aquifer
Oberer Buntsandstein	Myophorien-schichten	Strohgelbe Kalke	claystone	aquifer
		Myophorien-Ton	limestone, claystone	aquitard
	Pelitröt	Obere Bunte Schichten	clay, marlstone, sandstone with intercalations of dolomite, fine sandstone and gypsum	aquitard
		Obere Rote Schichten		aquitard
		Doppelquarzit		aquitard/ aquifer
		Untere Rote Schichten		
		Untere Bunte Schichten		aquitard
	Salinarröt	Oberes Sulfat	interbedding of claystone, gypsum, anhydrite and rock salt	aquitard
		Rötsteinsalz		aquitard
		Unteres Sulfat		aquitard
Mittlerer Buntsandstein	Solling-Folge	Oberer Solling-Sandstein	sandstone, claystone	aquifer
		Soling-Zwischenmittel	siltstone, claystone	aquifer
		Unterer Solling-Sandstein	sandstone, claystone	aquifer
	Hardegsen-Folge	Hardegsen-Abfolge 4	sandstone, claystone	aquifer
		Hardegsen-Abfolge 3	sandstone, claystone	aquifer
		Hardegsen-Abfolge 2	sandstone, claystone	aquifer
		Hardegsen-Abfolge 1	interbedding of sandstone and claystone	aquifer/ aquitard
	Detfurth-Folge	Detfurth-Wechsellagerung	sandstone with intercalations of clay	
		Detfurth-Sandstein	sandstone	
	Volpriehausen-Folge	Avicula-Schichten	sandstone, claystone	
		Rotweiße Wechselfolge	interbedding of sandstone and claystone	aquifer/ aquitard
		Basissandstein	sandstone	
Unterer Buntsandstein	Bernburg-Folge	Obere Sandstein-Tonstein-Wechsellagerung	interbedding of sandstone and claystone	aquifer/ aquitard
		Oolithischer Sandstein	sandstone	aquifer
		Untere Sandstein-Tonstein-Wechsellagerung	interbedding of sandstone and claystone	aquitard
	Calvörde-Folge	Sandige Tonsteinschichten	claystone	aquitard
		Tonige Sandsteinschichten	sandstone	aquifer/ aquitard
Zechstein				aquitard

Figure 7 Lithostratigraphy overview of the overburden and classification into aquifers and aquitards

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

6.3.4 Subrosion

The tectonic influence on the rocks in the South Harz Potash District, as described in chapter 6.3.2, allowed the access of groundwater to the soluble rocks of the saliferous strata. The process of dissolving soluble rocks in the underground by undersaturated solutions, removal of the dissolved material and the leaving behind of the insoluble parts of these rocks is called subrosion. In the South Harz Potash District (and other potash mining districts in the Federal State of Thuringia) two types of subrosion are distinguished:

- Regular subrosion, which resulted in the formation of the so called salt table with an inner boundary marking the beginning subrosion of the soluble rocks, and an outer boundary, where these rocks have been completely dissolved. The salt table's outer boundary is equal to the distribution boundary of the salt rocks of the Staßfurt-Formation in the South Harz Potash District (Döhner et al., 2003, /8/). The main reason for the regular subrosion was the exhumation of the Harz Mountains, which brought the saliferous strata at the W and N border of the South Harz Potash District into contact with the groundwater in the overburden, where the described boundary is well known.
- Irregular subrosion occurs within the distribution area of the salt rocks of the Staßfurt-Formation along faults and in the upper areas of salt anticlines. Influent solutions in mine workings due to contact with groundwater-bearing rocks in the overburden are another reason for this type of subrosion, e. g. as reported from the Bischofferode mine.

However, subrosion in the South Harz Potash District is not restricted to the salt rocks of the Staßfurt-Formation, but also known from rocks e. g. of the Aller-Formation as described in chapter 6.2.4.

Based on drill hole information from within the Gräfentonna Exploration Licence area or close to it no subrosion of the saliferous strata is known. Subrosion is only known in the evaporite rocks of the lithostratigraphic sub-group Mittlerer Keuper (lithostratigraphic unit Gipskeuper, kmG), expressed on the surface by the existence of sinkholes from the area immediately NW of the city of Erfurt between the country towns Kühnhausen and Elxleben along the federal road B 4.

6.4 Mineralisation

Within the potash seam different evaporite minerals occur changing in their occurrence horizontally as well as vertically in the range of centimetres, with the fine Halite and clay layers usually being unaffected. Distinctive salt rocks are not bound to certain lithostratigraphic units. Within the potash seam the following salt rocks occur (Döhner et al., /8/; Seidel, 2004, /23/):

- carnallitite: The main mineral and also the main potassium-bearing mineral is Carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$), accompanied by Halite ($NaCl$) and Kieserite ($MgSO_4 \cdot H_2O$), subordinately also by Anhydrite ($CaSO_4$), and rarely by clay and Boracite ($Mg_3B_7O_{13}Cl$). Iron-bearing minerals (Hematite (Fe_2O_3) and rarely Goethite ($Fe^{3+}O(OH)$) appear finely dispersed as red colour pigments. Carnallitite occurs most often in terms of area, compared to other salt rocks in the potash seam, with the comparably lowest mineralogical variability of all salt rocks. Carnallitite has a lower percentage of K_2O compared to sylvinite. Furthermore, the original layering of the sediments is rarely preserved. More often, cataclastic structures are present, giving the corresponding salt rock the name cataclastic carnallitite, a variety of carnallitite. The cataclastic material consists mainly of Halite embedded in a Carnallite matrix.

- sylvinite: The main mineral is Halite (NaCl), with Sylvite (KCl) commonly the main potassium-bearing mineral. Additionally, Polyhalite ($K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot H_2O$), Langbeinite ($K_2SO_4 \cdot 2MgSO_4$), Kieserite ($MgSO_4 \cdot H_2O$), Kainite ($KCl \cdot MgSO_4 \cdot 2.75H_2O$), Anhydrite ($CaSO_4$) and, to a lesser degree but more often than in the carnallitite, clay occurs. Admixtures of Boracite ($Mg_3B_7O_{13}Cl$) and Pyrite (FeS_2) in small concentrations are also present. Noteworthy is the zoning of sulphate minerals in the transition zone with carnallitite or barren zones. In the South Harz Potash District polysulphatic sylvinite is mainly restricted to the Volkenroda and Bischofferode mines, but was also identified in samples from hole *E Langensalza 21/1960* in the Gräfentonna Exploration Licence area (cf. chapter 6.4.2). Otherwise, almost only monosulphatic, so-called anhydritic sylvinite occurs, which surrounds the large barren zones of the Potash District. Deposits of sylvinite are usually spatially linked to barren zones, arranged between these zones and carnallitite zones. Generally, there is a high to very high variability in terms of mineralogy of sylvinite. Like in the carnallitite, cataclastic structures are also known to exist in the sylvinite.
    - For the purpose showing the salt facies distribution within the Gräfentonna Exploration Licence area (see APPENDIX 7) in this Report the salt rock hartsalz assigned to the salt rock sylvinite.
- barren (zones): The main mineral is Halite (NaCl), often only accompanied by Anhydrite ($CaSO_4$) as well as locally (Bischofferode mine) Polyhalite ($K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot H_2O$) and Kieserite ($MgSO_4 \cdot H_2O$). These zones comprise partly the complete profile of the potash seam, but can also only affect parts of it, either below, within or above the sylvinite in varying combinations. Barren zones above the sylvinite are a common feature of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). Barren zones are also referred to as rock salt.

The term mixed salt stands for crude salt, of which Sylvite of the sylvinite and Carnallite of the carnallitite are the main valuable potassium-bearing material components. Generally, this crude salt also contains a valuable sulphatic material component like Kieserite (Rauche, 2015, /22/). The term mixed salt is rather a mining term as carnallitite was mined together with sylvinite in case of depletion of sylvinite reserves. Mixed salt was mined in the South Harz Potash District in the Bleicherode mine, Sollstedt mine and Sondershausen mine.

Due to the low dill hole density and the uncertain distribution of carnallitite and sylvinite, derived from information of exploration within the Gräfentonna Exploration Licence area and close to it, the Exploration Target estimate, provided in this Report, is stated as mineralised rock.

The mineralisation within the potash seam is continuous, layer-bound and has its onset already in the upper part of the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) (cf. chapter 6.2.2).

6.4.1 Depth, Thickness and Grade Distribution of the Potash Seam

The stratigraphic succession of the rocks of the lithostratigraphic unit Oberer Staßfurt-Ton to Unterer Leine-Ton (“Grauer Salzton”, z2Tb-z3Ta) was designated in all available drill holes. Therefore, its base was used as a marker horizon that shows the depth distribution of the top of the underlying potash seam (cf. chapter 6.2.2). The depth of the base of the lithostratigraphic unit “Grauer Salzton” (z2Tb-z3Ta) is equal to the depth of the top of the potash seam and varies between about -600 m and -950 m asl as shown in APPENDIX 8. The thickness of the potash seam varies between 2.5 m and 23 m. The thickness is shown together with the distribution of the salt rocks in APPENDIX 7.

The K_2O grade distribution cannot be determined at present within the Gräfentonna Exploration Licence area and close to it as only in one hole from the complete potash seam was sampled and analysed. A second hole was sampled, though only one sample could be located from the samples collected from within the potash seam (cf. chapter 6.4.2).

6.4.2 Composition of the Potash Seam

From two of the drill holes, presented in chapter 5.2, core samples have been taken:

- *E Langensalza 21/1960*: 11 samples covering the entire thickness of the potash seam.
- *E Langensalza 7/1956*: 1 sample covering a part of the entire thickness of the potash seam.

The analytical results are given in Table 7 and were derived from the corresponding documents about both holes.

Table 7 Analytical results of core samples from drill holes *E Langensalza 7/1956* and *E Langensalza 21/1960*

Top [m bgl]	Base [m bgl]	$CaSO_4$ [m.%]	$MgSO_4$ [m.%]	K_2SO_4 [m.%]	KCl [m.%]	$MgCl_2$ [m.%]	NaCl [m.%]	Ins. [m.%]	R_2O_3 [m.%]	H_2O [m.%]	K_2O [m.%]
E Langensalza 7/1956											
1020.40	1022.50	2.10	-	46.47	-	0.10	-	41.60	2.73	0.35	8.24
E Langensalza 21/1960											
1079.60	1080.25	84.10	1.30	-	1.60	0.30	1.60	6.80	2.40	1.70	1.00
1080.25	1080.45	15.60	0.80	-	1.10	0.10	79.10	2.00	0.90	0.60	0.70
1080.45	1081.95	7.20	2.60	0.40	30.20	0.10	55.70	1.80	0.60	0.90	19.30
1081.95	1083.75	3.20	4.20	3.70	35.10	-	51.50	0.90	0.40	0.70	24.10
1083.75	1084.60	2.80	8.30	6.70	26.30	0.10	53.90	0.80	0.40	0.60	20.20
1084.60	1086.50	1.90	1.70	1.00	29.30	0.10	64.30	1.00	0.30	0.40	19.30
1086.50	1088.35	1.70	15.70	11.10	11.00	0.10	58.80	0.90	0.30	0.60	13.20
1088.35	1089.75	4.00	9.80	6.30	9.30	0.10	66.80	1.90	0.60	1.20	9.60
1089.75	1092.10	7.80	3.20	4.90	0.70	0.10	81.30	0.50	0.20	1.30	3.10

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Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

1093.30	1096.80	16.10	5.80	7.40	2.00	0.10	64.60	1.40	0.50	2.00	5.10
1096.80	1100.70	6.00	3.90	1.90	2.30	0.20	81.60	2.10	0.70	1.30	2.50

Based on the analytical results of the samples the composition of each sample was calculated (Table 8).

Table 8 Calculated composition of core samples from drill holes *E Langensalza 7/1956* and *E Langensalza 21/1960*

Top [m bgl]	**Base** [m bgl]	**Car** [m.%]	**Hal** [m.%]	**Poh** [m.%]	**Anh** [m.%]	**Kai** [m.%]	**Lgb** [m.%]	**Kie** [m.%]	**Syl** [m.%]	**H_2O** [m.%]
E Langensalza 7/1956										
1020.40	1022.50	0.00	41.60	0.00	0.00	0.33	0.00	53.42	0.00	7.03
E Langensalza 21/1960										
1079.60	1080.25	0.88	1.60	0.00	84.10	2.69	0.00	1.49	0.56	1.12
1080.25	1080.45	0.29	79.10	0.00	15.60	1.65	0.00	0.92	0.53	0.59
1080.45	1081.95	0.29	55.70	1.38	6.58	4.81	0.00	2.67	28.68	1.59
1081.95	1083.75	0.00	51.50	7.09	0.00	1.04	3.93	0.58	34.79	0.72
1083.75	1084.60	0.29	53.90	6.20	0.00	0.58	11.69	0.32	26.05	0.65
1084.60	1086.50	0.29	64.30	3.46	0.34	2.09	0.00	1.16	28.60	0.92
1086.50	1088.35	0.29	58.80	3.76	0.00	2.31	23.84	1.28	10.23	1.01
1088.35	1089.75	0.29	66.80	8.86	0.00	5.93	8.91	3.29	7.45	2.36
1089.75	1092.10	0.29	81.30	16.03	0.56	0.00	0.00	0.00	0.62	1.07
1093.30	1096.80	0.29	64.60	25.60	4.54	1.42	0.00	0.79	1.50	2.06
1096.80	1100.70	0.58	81.60	6.57	3.03	5.35	0.00	2.97	0.54	2.17

(The abbreviations of mineral names stand for: Car - Carnallite, Hal - Halite, Poh - Polyhalite, Anh - Anhydrite, Kai - Kainite, Lgb - Langbeinite[91], Kie - Kieserite, Syl - Sylvite.)

The calculated composition of the one sample from hole *E Langensalza 7/1956* shows that the main components are Kieserite (about 53 m. %) and Halite (about 42 m. %).

[91] Langbeinite is an evaporite mineral with the chemical formula $K_2SO_4 \cdot 2MgSO_4$.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Certain layers of different salt rock composition can be distinguished by sampled sections from core of drill hole *E Langensalza 21/1960*. While the main component is Halite (between about 52 m.% and 82 m.%), one 6.05 m thick section with elevated Sylvite content (between about 26 m.% and 35 m.%) occurs, accompanied by a 0.85 m thick section of elevated Langbeinite content (about 12 m.%). The 1.85 m thick section below this Sylvite-rich layer shows a lower Sylvite content (about 10 m.%), but a considerable elevated Langbeinite content (about 29 m.%). Within these sections the Polyhalite content is low (between about 1 m.% and 7 m.%) and increases in a 7.05 m thick section below to between about 16 m.% and 26 m.%.

The calculated composition of core samples from hole *E Langensalza 21/1960* shows that the penetrated salt rocks are mainly sylvinite (cf. chapter 6.4) consisting in addition to Halite and Sylvite of polysulphatic potassium salts. Since from only one drill hole such detailed analytical results were obtained, it cannot be stated with the present state of exploration, that these results reflect the typical composition of the potash seam within the entire Gräfentonna Exploration Licence area.

7 Deposit Type

Based on available geological information from previous exploration activities the potash deposit within the Gräfentonna Exploration Licence area can be characterized as follows:

- The occurrence of potassium salts is mainly related to the presence of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). Locally, potash mineralisation also occurs within the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA). Remnants of potassium salts are also present in the salt rocks of the lithostratigraphic unit Decksteinsalz (z2NAr) (e. g. in hole *E Fahner Höhe 3/1959*). Nevertheless, no commercially mineable concentration within the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA) has been identified yet.
- The main potash minerals present in the deposit are Carnallite and Sylvite, as derived from geophysical well logs and lithological logs. The lithological log of hole *E Langensalza 21/1960* also states Polyhalite[92] and Langbeinite[93] is present, which is confirmed by chemical analyses performed on samples from this hole (cf. chapter 6.4.2).
- The Sylvite is of secondary origin, which leads to the assumption that the primary carnallitite was influenced by brines (cf. chapter 6.3.1).
- For Carnallite and Polyhalite a primary origin is assumed.

Generally, the bedding of the deposit is assumed to be slightly wavy with an even dip over large distances (cf. chapter 15). Local differences may occur in areas influenced by tectonic structures.

[92] Polyhalite is an evaporite mineral with the chemical formula $K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot H_2O$.
[93] Langbeinite is an evaporite mineral with the chemical formula $K_2SO_4 \cdot 2MgSO_4$.

8 Recent Exploration

Currently, no exploration activities for potash are ongoing within the Gräfentonna Exploration Licence area or in adjacent properties with exception of the Kehmstedt mining property.

9 Data Verification

Neither core material nor samples from the historical drilling exploration are available for independent verification of the historical assays. Verification of geophysical logs would be possible in two holes as they are either left open (hole *E Allmenhausen 10/1961*) or still used for mining hydrocarbons (*E Fahner Höhe 8/1960*). Hole *E Fahner Höhe 8/1960* is currently equipped with a mining probe and can only be surveyed after completion of mining. The remaining holes presented in Table 4 and Table 5 are grouted. However, as mentioned in chapter 2, the geologists in charge for the exploration work are considered trustworthy and their work is reliable.

Planning, supervision as well as documentation and evaluation of the historical exploration were done according to standards defined by the state reserve commission or reported internal company guidelines. The same applies for categorisation of deposit types, resources and reserves. The interpretation of the historical drill hole data is, therefore, accepted as a reliable database for this Report.

To determine the mineralisation of the potash seam, the available geophysical logs were used. For a single drill hole it was possible to compare relative values (shape and peaks) of the logs and cross-check them with the documented lithology. The correlation, as historically established between lithology (from cuttings) and geophysical logging graphs (Figure 8, natural gamma as well as gamma-gamma readings) could be confirmed.

A geophysical well log is affected by several factors. One factor is the surface of a drill hole wall, especially affecting readings of gamma and porosity logs. Cavities due to dissolution will lead to misreadings. The porosity log is very susceptible here as it requires good connection to the drill hole wall. Also the mud cake clinging to a drill hole wall affects the porosity log as with the short spacing detector reading the near count rate the porosity of the mud cake is measured. It is assumed that corrections were undertaken as part of the data processing during the time the logs were recorded, but this cannot be confirmed by the available documents. The logging speed is another factor to take into consideration. Where available the geophysical logs state a speed between 3 m/min and 6 m/min to 7 m/min.

Natural Gamma

It was described that clay mud and only NaCl-saturated brine were used as drilling fluid. Hence, dissolution of salt rocks and the accompanying reduction in mineral content has to be expected, which would in turn influence the gamma logging results. In general, the relative gamma ray reading (GR) can be ordered as follows:

$GR_{Anhydrite} \approx GR_{rock\ salt} << GR_{carnallitite} < GR_{sylvinite}$

Clays and claystone can generate a wide range of gamma ray readings, but they are always higher than those of rock salt or Anhydrite.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Gamma-Gamma

In general, the relative densities of the different rock types can be ordered as follows:

$\rho_{carnallitite} < \rho_{rock\ salt} < \rho_{sylvinite} < \rho_{claystone} < \rho_{Dolomite} < \rho_{Anhydrite}$

The different mineralisation of the potash seam shows typical values for different geophysical log combinations as derived from similar data sets available for drill holes in the Küllstedt Exploration Licence area (see Figure 8). Rocks of different lithostratigraphic units can also be distinguished: e. g. salt rocks of the Staßfurt-Steinsalz (z2NA) show relatively low natural gamma and medium gamma-gamma readings. On the other hand the Anhydrite rocks of the lithostratigraphic unit Leine-Anhydrit ("Hauptanhydrit", z3AN) show also relatively low natural gamma, but very low gamma-gamma readings (= relative high density). The authors of this Report are of the opinion that characteristics (geophysical logging values and their combination as well as calculated densities for different salt rocks) are comparable between the Küllstedt Exploration Licence area and the Gräfentonna Exploration Licence area and can, therefore, be applied for data evaluation for the Gräfentonna Exploration Licence area.

Table 9 Class of geophysical parameters with the average K_2O content and densities for different salt rocks, derived from the adjacent Küllstedt Exploration Licence area (ERCOSPLAN, 2015a, /9/).

Salt Rock	Relative Natural Gamma Ray Reading	Relative Density	Avg. K_2O Content [%]	Avg. Density [$t \cdot m^{-3}$]
Carnallitite	medium to high	low (< rock salt)	4.3 – 15.0	~ 1.83
Sylvinite	high	medium to high (> rock salt)	6.7 – 25.0	~ 2.32
Rock salt / barren	low	medium	–	~ 2.17

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

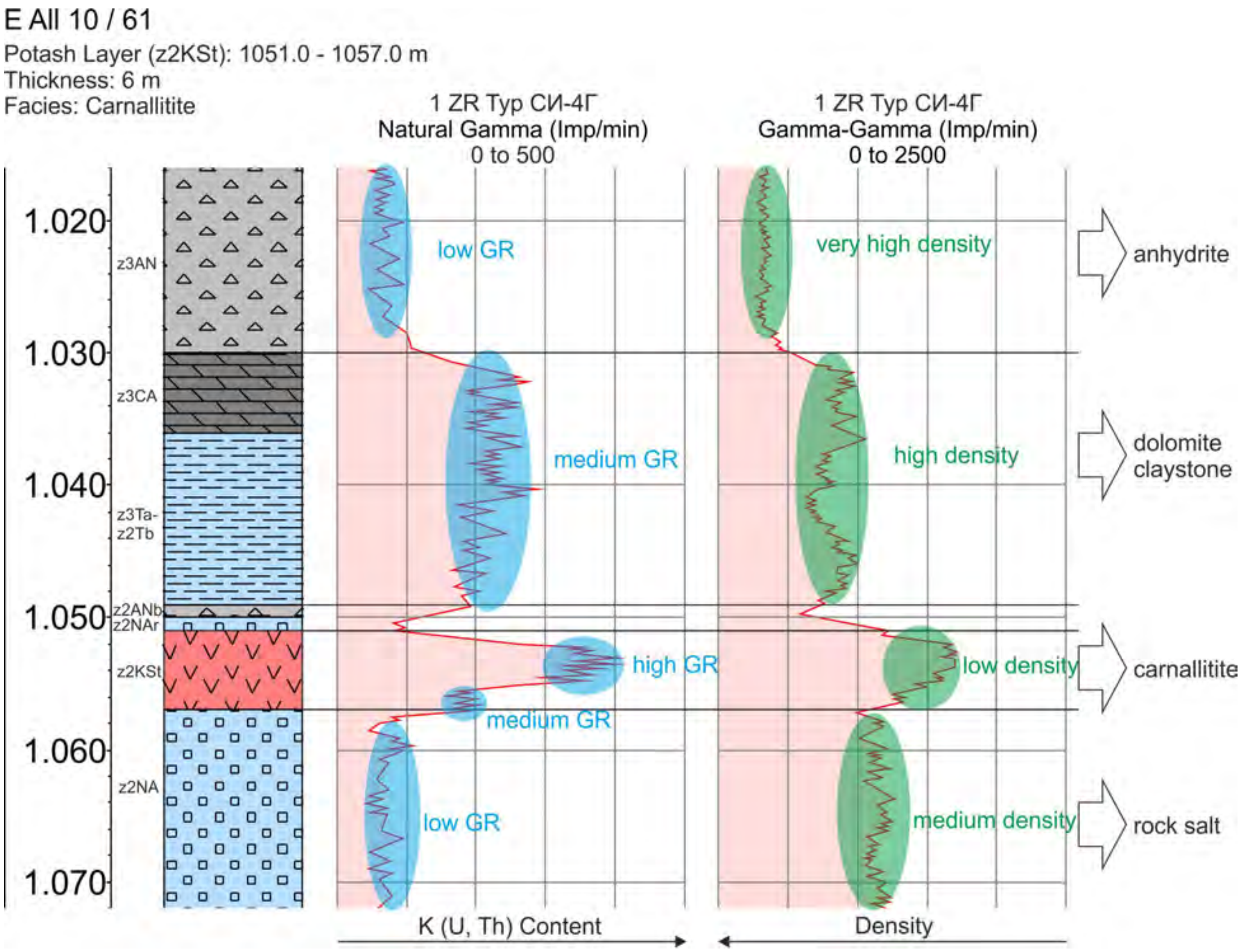

Figure 8 Interpretation of the geophysical logging data using the example of drill hole *E Allmenhausen 10/1961*

Subsequently, a short description of the available geophysical logging data for each drill hole and the interpreted salt rock of the potash seam is given:

E Allmenhausen 10/1961

- Relative GR 1,051.0 – 1,055.5 m: high, even higher than for the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta).
- Relative GR 1,055.5 – 1,057.0 m: medium, in the range of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta).
- Relative density: low, much lower than that of the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA).
- Interpreted salt rock: carnallitite.

E Bienstädt 2/1961

- The natural gamma log covers only the lower part of the potash seam between 990.0 m and 993.0 m, and gamma-gamma data are not available.
- Relative GR: low, in the range of the salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA).
- Interpreted salt rock: barren.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

E Fahner Höhe 8/1960

- Relative GR: medium, higher in the upper part, lower than that of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta).
- Relative Density: low, slightly lower than that of the underlying salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA).
- Interpreted salt rock: carnallitite.

E Fahner Höhe 10/10a/10b/1961

- Relativ GR: medium to high, but lower than that of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta); GR increase towards the top of the potash seam.
- Relative Density: higher than that of the underlying salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA); very high between 988.0 m and 989.5 m and at the base; relative density fluctuates in the upper part of the potash seam.
- Interpreted salt rock: sylvinite.

E Kirchheilingen 35/1961

- Relative GR: medium to high, but lower than that of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta); GR increase towards the top of the potash seam.
- Relative Density: higher than that of the underlying salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA), very high between 1,065.5 m and 1,066.0 m.
- Interpreted salt rock: sylvinite.

E Langensalza 20E/1959

- Relative GR: high, in the middle part higher than that of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta); GR decrease towards the top of the potash seam.
- Relative Density: no data available.
- Interpreted salt rock: sylvinite.

E Langensalza 21/1960

- Relative GR: very high, higher than that of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta); GR increase towards the top of the potash seam.
- Relative Density: slightly lower than that of the underlying salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA); decrease towards the top of the potash seam, possibly caused by a lower sulphate mineral content or cavities.
- The available chemical assay data correlate with the geophysical well logs and show a high K_2O content between 19.3% and 24.1% in the upper part of the layer (1,080.45 – 1,086.50 m).
- Interpreted salt rock: sylvinite.

E Langensalza 25/1962

- Relative GR: high, in the range of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta); GR increase towards the top of the potash seam.
- Relative Density: no data available.
- Interpreted salt rock: sylvinite.

E Langensalza 26/1962

- Relative GR: medium to high, in the range of the rocks of the lithostatrigraphic unit "Grauer Salzton" (z2Tb-z3Ta); GR increase towards the top of the potash seam.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

- Relative Density: low, slightly lower than that of the underlying salt rocks of the lithostratigraphic unit Staßfurt-Steinsalz (z2NA).
- Interpreted salt rock: carnallitite.

E Langensalza 27/1962

- The logs do not cover the entire thickness of the potash seam, but only the upper part between 1,043.0 m and 1,060.0 m.
- Relative GR: low, in the range of the Anhydrite rocks of the lithostratigraphic unit Leine-Anhydrit ("Hauptanhydrit", z3AN).
- Relative Density: medium, in the range of the salt rocks of the lithostratigraphic unit Decksteinsalz (z2NAr).
- Interpreted salt rock: barren.

10 Mineral Processing and Metallurgical Testing

At the present stage no test work programme is planned as no mining or processing concept has been selected yet.

Concepts for processing of different potassium salts are available (cf. chapter 12). Concepts for mineral testing have been developed during the decades of potash mining in the South Harz Potash District as stated in chapter 5, and e. g. in the Werra-Fulda Potash District[94].

11 Mining Concept

For mining of the sylvinite/carnallitite proven mining technologies are available as decades of conventional mining e. g. in the Bischofferode and Volkenroda mine show (cf. chapter 5.1). From the Kehmstedt Operation (cf. chapter 5.1) N of the Bleicherode mine (cf. Figure 3) carnallitite is economically mined by solution mining. Conventional mining of salt rocks containing polysulphatic potassium salts has been carried out for many years in the Hattorf-Wintershall mine in the Werra-Fulda Potash District (mining of Langbeinite) and since 2010 in the Boulby mine in North Yorkshire in Great Britain (mining of Polyhalite). Conventional mining of Kainitite[95] is conducted since 2013 in the Unterbreizbach mine in the Werra-Fulda Potash District.

Since the project is at an early stage, no mining method has been discussed at the moment. However, proven mining methods for different salt rocks exist as shown from mines located in the German Potash districts.

[94] Werra-Fulda Potash District is a potash mining district SW of the Thüringer Wald uplift covering the SW of the Federal State of Thuringia and E and SE of the state of Hesse.
[95] Kainitite is a salt rock mainly consisting of the evaporite mineral Kainite with the chemical formula $KCl \cdot MgSO_4 \cdot 2.75H_2O$.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

12 Processing Concept

As stated in chapter 5 processing concepts for sylvinite and carnallite have been developed during the decades of potash mining in the South Harz Potash District. In the course of mining these salts in other potash mining districts, mentioned in chapter 11, processing concepts for polysulphatic potassium salts were developed as they occur in the Gräfentonna Exploration Licence area, indicated by samples from hole *E Langensalza 21/1960* (cf. chapter 6.4.2).

The development of a processing concept for potassium salts occurring in the Gräfentonna Exploration Licence area will depend on the product requirements. It is therefore recommended that viable processing options are verified during further project development.

13 Exploration Target Estimate

The potash minerals Sylvite and Carnallite, the main valuable potassium-bearing material components in the salt rocks sylvinite and carnallitite, respectively, may potentially form the basis of industrial mining of potash and processing to an MOP product. The experience of the successful potash mining industry in the South Harz Potash District shows that the exploitation of such a deposit is possible. The processing of such type of minerals is technically feasible as well.

It is the opinion of the authors of this Report that the available data from the drilling and geophysical exploration work completed during historical exploration (cf. chapters 5 and 9), are sufficient to confirm that the Gräfentonna Exploration Licence area contains substantial potash mineralisation within the Late Permian lithostratigraphic formation Staßfurt-Formation.

Exploration Targets are estimated in accordance with section 17 of the JORC Code (2012, /14/):

> *An Exploration Target is a statement or estimate of the exploration potential of a mineral deposit in a defined geological setting where the statement or estimate, quoted as a range of tonnes and a range of grade (or quality), relates to mineralisation for which there has been insufficient exploration to estimate a Mineral Resource.*

The potential quantity and grade of the Exploration Targets are conceptual in nature and currently, the available exploration data (only historical data and no original material or independent cross-check analyses available) are considered insufficient for the estimation of a Mineral Resource. Based on the current dataset it is possible but not guaranteed that further exploration will result in the estimation of a Mineral Resource.

The authors of this Report are familiar with the working procedures of the former geologists, which were quality-checked by independent state institutes. The available documents are considered a trustworthy base for the estimation of an Exploration Target for the Gräfentonna Exploration Licence area.

Based on the available documents of the drill holes, mentioned in chapters 5.2.1.1 and 5.2.2.1, four salt rock areas have been determined (see also APPENDIX 7):

- areas dominated by sylvinite,
- areas dominated by carnallitite,
- areas probably dominated by sylvinite,
- areas probably dominated by carnallitite.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

The term “probably“ refers to an assumed occurrence of a certain salt rock without having proof from drill hole information, but indication by information of drill holes in the vicinity.

The estimate of the Exploration Target is based on the method of conclusion by analogy, which was also applied in the former GDR for estimating resources in areas with insufficient exploration, but belonging to the same deposit and exhibiting comparable deposit parameters as areas within the same deposit with a sufficient degree of exploration. For the Gräfentonna Exploration Licence area conclusions of analogy were drawn based on exploration results (rock densities and K_2O grades per hole), obtained within the Küllstedt Exploration Licence area (ERCOSPLAN, 2015a, /9/) taking exploration results obtained within the Gräfentonna Exploration Licence area or close to it into consideration.

In estimating the Exploration Target tonnages, the following procedures were carried out (Exploration Target is given as mineralisation in place):

- Based on the available information a geological model of the deposit was generated. The thickness distribution of the potash seam, derived from drill hole information, was determined by interpolation using an Inverse Distance algorithm with consideration of mapped faults, provided by the software Surfer (version 11.6.1159) by Golden Software. This interpolation was performed on a grid with a cell size of 200 × 200 m. The grid covers all areas within the Gräfentonna Exploration Licence area and close to it (APPENDIX 3). To each cell an average thickness value for the area, covered by it, was assigned, derived from the thickness interpolation. Afterwards the volume of each cell was calculated giving a **total volume of 1.464 km³** for the Exploration Target of the Gräfentonna Exploration Licence area. The total volume of the potash seam within the Gräfentonna Exploration Licence area is equal to the total volume of the Exploration Target.
- The total volume of the potash seam was multiplied with a tonnage factor depending on mineralisation (density). This **average density of the Exploration Target varies between a minimum of 1.83 t/m^3 and a maximum of 2.32 t/m^3**, derived from the Exploration Target estimate for the Küllstedt Exploration Licence area (ERCOSPLAN, 2015a, /9/). This amounts to a **tonnage range of the Exploration Target between a minimum of 2,679 and a maximum of 3,396 million metric tonnes of mineralised rock** for the Gräfentonna Exploration Licence area. The average density range and the tonnage range of the potash seam within the Gräfentonna Exploration Licence area are equal to those of the Exploration Target.
- The related tonnages of K_2O were obtained by multiplying the tonnage of mineralised rock with the corresponding K_2O grade of the potash seam. The **K_2O grade of the Exploration Target ranges from 4.3% to 25%**, derived from the Exploration Target estimate for the Küllstedt Exploration Licence area (ERCOSPLAN, 2015a, /9/). For the Gräfentonna Exploration Licence area **K_2O tonnage of the Exploration Target ranges between a minimum of 115 and a maximum of 849 million metric tonnes of K_2O**. The range of the K_2O grade and the range of the K_2O tonnage of the potash seam within the Gräfentonna Exploration Licence area are equal to those of the Exploration Target.

No geological or technical cut-off values for thickness or grades have been applied.

It is the opinion of the authors of this Report that, taking into account all the factors presented herein, the rocks of the potash seam (cf. chapter 6.2.2) can potentially be extracted by conventional underground or solution mining techniques. The economic and technical viability are subject to further geological, geophysical, rock mechanical and engineering studies.

14 Adjacent Properties

Adjacent to the northern boundary of the Gräfentonna Exploration Licence area is the Ebeleben Mining Property, managed by the owner BVVG Bodenverwertungs- und -verwaltungs GmbH (BVVG)[96]. It covers a total area of 37.08 km². Further to the NW the Volkenroda Mining Property is located, managed by the owner Lausitzer und Mitteldeutsche Bergbau-Verwaltungsgesellschaft GmbH (LMBV)[97]. It covers a total area of 68.70 km². Both mining properties are shown in Figure 3.

Other potash mining properties in the vicinity of the Gräfentonna Exploration Licence area, held by various owners (cf. chapter 5.1), are the BWE Bischofferode, BWE Bleicherode, BWE Ohmgebirge, BWE Sollstedt, BWE Sondershausen and the BWEs Kehmstedt and Kehmstedt-NW approximately 30 to 40 km off to the N and NE.

Furthermore, adjacent to the Gräfentonna Exploration Licence area mining fields for natural gas and crude oil are located – field Fahner Höhe to the S, field Langensalza to the W, field Kirchheilingen-Süd to the NW – all operated by ENGIE E&P Deutschland GmbH (ENGIE)[98]. Additionally, the gas storage fields Allmenhausen, operated by Thüringer Energie AG[99] and Kirchheiligen-Nord, operated by VNG Gasspeicher GmbH[100], are located W of the Gräfentonna Exploration Licence area.

Mining activities are currently conducted for natural gas in the fields Fahner Höhe adjacent S of the Gräfentonna Exploration Licence area, Kirchheilingen, Langensalza-Nord, both adjacent W and NW, and Mühlhausen (cf. APPENDIX 11) about 20 km WNW of Gräfentonna Exploration Licence area (LBEG, 2016, /20/). An overview of the natural gas mining activities is given in Table 10.

Table 10 Overview of mining activities for natural gas within the Federal State of Thuringia (LBEG, 2016, /20/)

Field	Finding year	Operator	Mining probes	Natural gas mining [m³]	
				in 2015	total
Fahner Höhe	1960	ENGIE	4	1,580,575	96,556,209
Kirchheilingen-Süd	1658	ENGIE	4	457,588	301,189,548
Langensalza	1935	ENGIE	6	2,711,109	282,460,886
Mühlhausen	1932	ENGIE	9	15,458,644	2,015,988,972

Since December 2007 natural gas is mined from the flooded Volkenroda mine for the purpose of electricity production.

[96] BVVG Bodenverwertungs- und -verwaltungs GmbH is a private company.
[97] Lausitzer und Mitteldeutscher Bergbau- und Verwaltungsgesellschaft mbH is a state-owned company.
[98] ENGIE E&P Deutschland GmbH is the German branch of the natural gas Group ENGIE SA (see glossary).
[99] Thüringer Energie AG is a German municipal power supply company.
[100] VNG Gasspeicher GmbH is a private owned gas transmission company in the states of the former GDR.

15 Interpretation and Conclusions

The potash seam within the Gräfentonna Exploration Licence area is distributed across almost the entire area with exclusions to the far S, an area between the Rangenhügelsberg mountain, the country towns of Sundhausen, Kirchheilingen and Neunheilingen, an area NE of the country town of Bad Tennstedt, an area N of the country town of Großvargula and an area N of the country town of Döllstädt (APPENDIX 7).

Areas dominated by carnallitite are located in the E, NE and N of the Gräfentonna Exploration Licence area. Especially in the E and NE that statement is subject to uncertainties due to lack of exploration holes here. It is uncertain if the carnallitite distribution extends to the southern border of the Gräfentonna Exploration Licence area because no holes are located within this area. The closest hole located to the S is hole *E Fahner Höhe 8/1960* located close to the Gräfentonna Exploration Licence area, which exhibits the potash seam as carnallitite (cf. chapter 6.4).

Areas dominated by sylvinite are located in the SE, S and towards the SW, W and NW. The occurrence of sylvinite in the SE is uncertain as there are no drill holes located in this area. The same applies for the area between the country towns of Bruchstedt and Klettstedt.

A larger barren area is located in the far NW of the Gräfentonna Exploration Licence area between the Rangenhügelsberg mountain and the country towns of Sundhausen, Kirchheilingen, Kleinwelsbach and Neunheilingen. Smaller barren areas were determined in the far SE, S and SW of the country town of Witterda, N and NE of the country town of Döllstädt, W, NW and N of the country town of Grossvargula, S of the Wartberg mountain, and N and NE of the country town of Bad Tennstedt.

The results indicate that within identified extents of certain salt rocks small-scale variations do occur. This statement is supported by the report of VVB FM (1964, /33/), which states that such variations were observed during underground mining of potassium salts in the South Harz Potash District (Bischofferode mine, Bleicherode mine, Sollstedt mine, Sondershausen mine and Volkenroda mine). Larger continuous patches of sylvinite or carnallitite are known, but within these patches, especially those of sylvinite, extensive mineral differentiations of the corresponding salt rock are known.

Generally, the depth of the potash seam's top increases from the NW to SE with values ranging between about -600 m asl and about -950 m asl (APPENDIX 8). However, since the drill hole density in the E and NE part of the Gräfentonna Exploration Licence area is very low, this statement is subject to uncertainties. Towards the Muschelkalk escarpment of the Fahner Höhe an absolute low of the potash seam's top is located at about -950 m asl, proven by the drill hole *E Fahner Höhe 3/1959*, whereas the adjacent drill holes *E Fahner Höhe 8/1960* and *E Bienstedt 2/1961* show local highs at about -600 m asl.

The interpolated thickness distribution of the potash seam (APPENDIX 7) is uneven, which may be an effect of drill hole density and location. The distribution shows some high thickness zones NE of the country town of Nägelstädt (approx. 23 m), N of the country town of Döllstädt (approx. 19 m) and W of the country town of Burgtonna (approx. 14 m). Some low thickness zones were identified N of the country town of Döllstädt (approx. 2.5 m), S of the country town of Dachwig (approx. 4 m), E of the Abtsberg mountain (approx. 3.5 m), W of the country town of Bad Tennstedt (approx. 4.5 m) and near the country town of Kirchheilingen (approx. 5.2 m) (APPENDIX 7). Generally, no trend of the thickness distribution can be derived (cf. APPENDIX 10).

The K_2O distribution cannot be determined at the present state of exploration as only one hole was sampled and analysed throughout the complete potash seam. As a consequence of the

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

lack of information, values for the range of K_2O grade and density, obtained in the adjacent Küllstedt Exploration Licence area, were used for the Exploration Target estimate.

The W, SW and S part of the Gräfentonna Exploration Licence area underwent intensive hydrocarbon exploration in the past. Along with this exploration information related to potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) were obtained, which host the potash mineralisation of the potash deposit. The available information is sufficient for the definition of an Exploration Target.

Potash can be economically mined in the South Harz Potash District from various depths and with a various thickness distribution of the potash seam as proven by the existence of conventional potash mines and potash plants, which were operational for nearly ten decades in the District (cf. chapter 5.1). Conventional mining of potassium salts from depths comparable to those modelled for the potash seam in the Gräfentonna Exploration Licence area is known from the Volkenroda mine. In the Bleicherode and Sollstedt mine extensive undermining of the Wippertal fault zone, a zone of tectonically intensively influenced saliferous strata, successfully executed showing that conventional potash mining is possible in such areas.

With the establishment of the Kehmstedt Operation it was also proven that solution mining of carnallitite in the area was and still is economical feasible.

Throughout the history of the South Harz Potash District concepts for exploration, mining and processing of different potassium salts have been developed and successfully applied (cf. chapter 5.1). The knowledge gained in the South Harz Potash District is extended by the corresponding knowledge gained over decades of potash mining from potash mining districts in other parts of Germany (e. g. Werra-Fulda Potash District) and in other countries known for their successful potash mining industry like Russia (Solikamsk – Solikamsk 1, 2 and 3 mines, Berezniki – Berezniki 2 and 4 mines), Canada (Moose Jaw – Belle Plain mine, Colonsay – Colonsay mine), Esterhazy – Esterhazy mine), Brazil (Rosario do Catete – Taquari-Vassouras mine), Spain (Súria – Súria mine) and Great Britain (Cleveland – Boulby mine).

Compared to the historical mining activities in the South Harz Potash District modern mining and processing techniques enable an increase in potash yield from the mineralised material. Parts of the deposit that were considered waste in the past can be utilized nowadays. Though polysulfatic potassium salts were not processed in the South Harz Potash District until now, processing concepts for such salts have successfully been developed in other potash districts, as mentioned in chapter 12.

Although the occurrence of hydrocarbon-bearing rocks below the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) is known, and that these hydrocarbons may leak into an underground mine as shown by the Volkenroda mine, they pose no hurdle for conventional potash mining, also shown by the Volkenroda mine, which was operational until 1991, 61 years after the first crude oil had leaked into the mine. Since the Gräfentonna Exploration Licence area is only 20 km away from that mine, natural gas mining fields are located close to the Licence area (cf. chapter 14) and information from the hydrocarbon exploration holes located within the Gräfentonna Exploration Licence area and close to it show evidence of small amounts of hydrocarbons in some of these holes, there is a high probability that hydrocarbons might have an impact on the mining activities in a future conventional potash mine located in the Licence area. From an economic and safety point of view this should be considered as specially designed and hence cost-intensive mining equipment could probably be necessary.

If a confirmation of the historical exploration results is performed, potash mining is assumed to be economically feasible in the Gräfentonna Exploration Licence area, based on the information given in this Report. The well-developed infrastructure in this area can sustain a large potash mining project as is proven by the conventional potash mines and potash plants men-

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

tioned in chapter 5.1, and would allow transport of potash via the well-developed road or railway network to the costumers either in Europe or worldwide.

16 Recommendations

Based on the available data as well as the experience of the authors of this Report with the type of historical exploration carried out and their documentation, it can be justifiably assumed that an analysis of these detailed exploration reports could enable the estimation of Mineral Resources in accordance with the JORC Code (2012, /14/). The following recommendation is therefore made:

Phase 1:

The data from the historical drill holes located within the Gräfentonna Exploration Licence area should be checked via confirmation drilling. This would allow for collection of core from the potash seam for the purpose of detailed description and chemical and mineralogical analyses. All confirmation drill holes will need to be logged geophysically to cross-check against the historical data and to correlate the results with the chemical analyses, in addition to obtain independent and additional data from the new drill holes for assay and drill record confirmation.

Phase 2:

Depending on the results of the initial confirmation drilling, a more detailed exploration programme with closer spaced drilling should be completed. In addition, the use of 2D/3D seismic surveys would be required during this phase.

Upon successful completion of the activities outlined in Phase 1, all historical exploration data can be confidently evaluated. The depth and thickness distribution as well as the composition of the potash seam within the Gräfentonna Exploration Licence area can be determined. This will allow the authors to determine which salt rocks, in which areas within the Gräfentonna Exploration Licence area occur, and where the most promising areas for potash mining could be located for further Targeting. Furthermore, information about the overburden and footwall block as well as about tectonic structures can be obtained, which may have an influence on the mining activities of any future potash mine.

Based on information obtained from Phase 1, in areas, determined as being most promising for potash mining exploration, drill holes can be densified to get a detailed picture about the properties of the potash deposit and the overburden as well as the footwall block in these areas. This would further allow planning of a potash mine and give information, how to get access to the potash deposit.

If Phase 1 and Phase 2 activities show promising results and the decision is made to start a mining operation, subsequent studies on environmental and social impacts have to be conducted prior to it, accompanied by hydrogeological drilling to obtain information on the groundwater-bearing layers above the deposit and below. Although this is not necessary in the immediate future, it should be taken into account for further planning.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

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ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

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ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany

Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

GLOSSARY

Term	Explanation
Aktiengesellschaft	German for stock company.
Anhydrite	Evaporite mineral with the chemical formula $CaSO_4$.
Bergwerkseigentum(sfeld)	A spatially defined area, for which the right to mine mineral resources is granted according to paragraph 9 of the federal mining law Bundesberggesetz. Abbreviation: BWE.
Bewilligungsfeld	A spatially defined area, for which the right to mine mineral resources is granted according to paragraph 8 of the federal mining act Bundesberggesetz.
Bodenverwertungs- und -verwaltungs GmbH	A private company responsible for recycling and managing of former industrial areas. Abbreviation: BVVG.
Bundesberggesetz	Federal Mining Law of Germany, which covers the prospection and exploration as well as the mining of commodities and, furthermore, the closure of mines. The law was enacted on 13 August 1980 and came into force on 01 January 1982. Abbreviation: BBergG. English translation: Federal Mining Act.
Bundesautobahn	German for federal motorway. Serves only for rapid transit and freight transport and crosses boundaries of federal states in Germany. Continuation into neighbouring countries are also possible.
Bundesstraße	German for federal road. A road that crosses boundaries of federal states in Germany.
Buntsandstein (Group)	Lithostratigraphic group of Indusian (Lower Triassic) to Anisian (Middle Triassic) age. Lower part of the tripartite German Trias Supergroup. “Buntsandstein” is also used to describe the typical lithology of this lithostratigraphic group (cf. chapter 6.1).
Burbach Kaliwerke AG	Predecessor of the Kaliwerke Krügershall AG.
BWE Thüringen Nord	Name, under which the subfields, as described under footnote 38, in the South Harz Potash District were summarised. The summary of the permission fields happened in the course of the consolidation of potash-producing sites in the South Harz Potash District.
Carnallite	Evaporite mineral with the chemical formula $KCl{\cdot}MgCl_2{\cdot}6H_2O$.
Carnallitite	Potassium-bearing salt rock consisting mainly of the evaporite minerals Carnallite, Halite, Kieserite and Anhydrite.
Cataclastic carnallitite	A variety of the salt rock carnallitite. Potassium-bearing salt rock with mainly brecciated Halite and Anhydrite embedded in a carnallitic matrix. In German: Trümmercarnallitit.
DEUSA International GmbH	Private company mining potash via solution mining from the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) in the NW part of the South Harz Potash District.
Deutsches Hauptdreiecksnetz	Geodetic datum for spatial informations in Germany. In Eng-

Term	Explanation
	lish: German Main Triangular Network,
ENGIE E&P Deutschland GmbH	German branch of ENGIE SA.
ENGIE SA	Private natural gas group. Successor of the private natural gas Group Gaz de France Suez.
Erfurt fault zone	Roughly NW-SE trending fault zone running from the country town of Bad Berka SW of the city of Erfurt through the S part of Erfurt to the country town of Döllstedt NW of Erfurt. In German: Erfurter Störungszone.
Fahner Höhe	WNW-ESE trending Muschelkalk escarpment WNW of the city of Erfurt. In English: Fahner high.
Federal State of Thuringia	Cf. Freistaat Thüringen.
Finne fault	NW-SE trending fault structure in the N of the Thuringian Basin. The name “Finne” originates from the highlands in the region bearing the same name. In German: Finne-Störung.
Freistaat Thüringen	One of the 16 states of Germany, located almost in the centre of the country. The total area is approx. 16,172 km², the capital is the city of Erfurt. Approx. 2.2 million people live in the state. English translation: Federal State of Thuringia.
German Democratic Republic	German state also known as East Germany, founded in 1949 and accessed to the Federal Republic of Germany in 1990. Abbreviation: GDR. In German: Deutsche Demokratische Republik.
Gesellschaft zur Verwahrung und Verwertung von stillgelegten Bergwerkbetrieben GmbH	Company responsible for the decommissioning and closure of mines in the Federal States of Saxony and Thuringia and in the State of Saxony-Anhalt, which were closed between 1990 and 1991 due to economic reasons.
Glaserite	Evaporite mineral with the chemical formula $K_3Na(SO_4)_2$.
Glückauf Sondershausen Entwicklungs- und Sicherungsgesellschaft mbH	Private company active in mine safe-keeping, rock salt mining and recycling of dump material at the Sondershausen mine site. Abbreviation: GSES.
Gypsum	Evaporite mineral with the chemical formula $CaSO4{\cdot}2H_2O$.
Halite	Evaporite mineral with the chemical formula NaCl.
Harz Mountains	Uplift covering the intersection point of the states of Lower Saxony, Saxony-Anhalt and Thuringia. In German: Harz.
Kainite	Evaporite mineral with the chemical formula $KCl{\cdot}MgSO_4{\cdot}2.75H_2O$.
Kainitite	Potassium-bearing salt rock consisting mainly of the evaporite minerals Kainite and Halite.
Kaliforschungsanstalt GmbH	Private research institute, founded in 1919 and based in the former country town of Leopoldshall, today a district of the country town of Staßfurt in Saxony-Anhalt. The institute moved to Berlin in 1927. It was responsible for researching the behaviour of salt rocks in contact with solutions, developing processing methods for potash and the collection and evaluation of scientific reports and literature regarding potash.
Kali-Instruktion	Guideline for the classification of solid mineral resources of rock salt and potash deposits in the former German Demo-

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Term	Explanation
	cratic Republic. Furthermore, it defines requirements for exploration of rock salt and potash. It was published with the original document, dated 05 December 1956, and its three revisions, dated 09 January 1960 (2nd revision), 20 June 1963 (3rd revision) and 17 November 1981 (4th and last revision). English translation: Potash Instruction Guideline.
Kali-Umwelttechnik GmbH	Private company, founded in 1992, active in the research of potash mining and processing. Its successor is the K-UTEC AG Salt Technologies.
Kaliwerke Krügershall AG	Company group founded in 1905 in Germany. Active in mining potash, rock salt, evaporated salt and bromine and producing potash fertilizer, table salt, salt for industrial purposes and de-icing salt. Renamed in Burbach Kaliwerke AG in 1928.
Keuper (Group)	Lithostratigraphic group of Ladinian (Middle Triassic) to Rhaetian (Upper Triassic) age. Upper part of the tripartite German Trias Supergroup. “Keuper” is also used to describe the typical lithology of this lithostratigraphic group (cf. chapter 6.1).
Kieserite	Evaporite mineral with the chemical formula $MgSO_4 \cdot H_2O$.
Küllstedt Exploration Licence area	Licence area held by East Exploration. Its extent is defined by the official licence documents.
Kupferschiefer	Marine calcareous claystone of the Middle-European Upper Permian, locally enriched with sulphur-bearing copper, zinc and lead minerals. Also used by miners as a synonym for the rocks of the lithostratigraphic Unterer Werra-Ton (z1Ta). In English: copper slate.
K-UTEC AG Salt Technologies	Private company active in physico-chemical analytics, processing, disposal and backfill technology, geomechanic- and mining-related research and geophysics. Based in the country town of Sondershausen. Since 2008 successor of the Kali-Umwelttechnik GmbH.
Landesamt für Bergbau, Energie und Geologie Niedersachsen	Specialist authority supporting the state government, public administration and economy of Lower Saxony on all questions regarding mining, energy and geology.
Landesstraße	German for state road. A road that cross the boundary of a rural or urban districts in Germany.
Landkreis	German for district, an administrative subdivision. Most districts in Germany are rural districts. Cities (and some country towns) do not belong to districts, but take over district responsibilities themselves.
Langbeinite	Evaporite mineral with the chemical formula $K_2SO_4 \cdot 2MgSO_4$.
Langensalza upwarp	NW-SE trending upwarped flexure of the overburden, named after the country town of Bad Langensalza.due to its close vicinity. In German: Langensalzaer Sattel.
Lausitzer und Mitteldeutscher Bergbau- und Verwaltungsgesellschaft mbH (LMBV)	State-owned company responsible for managing, remediation and structuring of open-cast lignite coal mining regions in Lusatia and Central Germany (region of the city of Leipzig). Abbreviation: LMBV.

Term	Explanation
Mitteldeutsche Kali AG	Successor of the VEB Kombinat Kali since June 1990.
Mühlhausen-Altengottern-Mulde	Synclinal structure between Mühlhausen and Altengottern with a NW-SE trend.
Muschelkalk (Group)	Lithostratigraphic group of Anisian (Middle Triassic) to Ladinian (Middle Triassic) age. Middle part of the tripartite German Trias Supergroup. “Muschelkalk” is also used to describe the typical lithology of this lithostratigraphic group (cf. chapter 6.1) or a limestone consisting mainly of bivalve fossils.
NDH Entsorgungsbetreibergesellschaft mbH	Private company responsible for backfilling of former potash mines in the South Harz Potash District and remediation of potash tailing dumps. Abbreviation: NDH-E.
Oberes Rotliegend	Lithostratigraphic sub-group of the Rotliegend Group defined by its lithology, which consists of red clastic sediments of non-volcanic origin (sandstones, siltstones). Regional differences are possible.
Ohmgebirge graben	NNE-SSW trending graben structure in the NW of the Federal State of Thuringia. In German: Ohmgebirgs-Grabenzone.
Polyhalite	Evaporite mineral with the chemical formula $K_2SO_4 \cdot MgSO_4 \cdot 2CaSO_4 \cdot H_2O$.
Potash-bearing section/horizon, potash seam/section	Defined in chapter 6.2.2.
Potash trade union Burbach	Private company active in mining potash from the potash deposit of the South Harz Potash District. It belonged to the Kaliwerke Krügershall AG. In German: Gewerkschaft Burbach.
Preussisches Ministerium für Öffentliche Arbeit	Ministry in the former Kingdom of Prussia responsible for development of the infrastructure. English translation: Prussian Ministry for Public Works.
Prognostic Reserves	Classified resource category according to Stammberger (1963, /25/), for which resources are calculated for larger geological units or deposit areas, respectively. Delta-1 prognostic reserves comprise resources of areas, which can be compared to already explored areas, based on regional exploration results, and in which the existence of the commodity was verified in at least one point. This means that the prognostic reserve can be calculated by the method of conclusion by analogy.
Rotliegend (Group)	Lithostratigraphic group of Gzhelian (Upper Carboniferous) to Wuchiapingian (Upper Permian) age. The term “Rot” comes from the prevailing colour of the rocks, which is red.
Schillingstedter Mulde	NW-SE trending syncline N of Sömmerda. English translation: Schillingstedt syncline.
Schlotheim graben	Graben structure near the country town of Schlotheim, which affected parts of the rocks of the Zechstein Group in the Volkenroda mine. In German: Schlotheimer Graben.
Schlotheim-Tennstedt arch	NW-SE trending arch structure SE of the country town of Schlotheim, separated by the Schlotheim graben into the

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Term	Explanation
	Allmenhausen structure to the NE and the Kirchheilingen structure to the SW. In German: Schlotheim-Tennstedter Gewölbe.
South Harz Potash District	Area in the N part of the Federal State of Thuringia, which reflects the extent of the potash deposit. Potash is explored intermittently since 1888 and was conventional mined between 1888 and 1993. Since the 1980s potash is additionally solution mined in the district. In German: Südharz-Kalirevier.
South Permian Basin	Tectonic basin comprising an area from England to E Poland with flanking areas within Denmark and the S Baltic Sea in the N and the upland areas of Belgium and Germany to the S.
Südharz-Kalirevier	Cf. South Harz Potash District
Sylvinite	Potassium-bearing salt rock consisting mainly of the evaporite minerals Sylvite and Halite. Subordinately, Polyhalite, Langbeinite, Kieserite, Kainite and Anhydrite may occur.
Sylvite	Evaporite mineral with the chemical formula KCl.
Thüringer Energie AG	German municipal power supply company. Was privately owned until 2013 by E.ON, the holding company of an investor-owned electric utility service provider.
Thuringian Basin	Geological structure in the central and N part of the Federal State of Thuringia. It extends from the upper reaches of the Unstrut river S of the country town of Dingelstädt to the lower reaches of the Ilm River at the country town of Bad Sulza. It trends WNW-ESE over a distance of approx. 90 km. In the NNE to SSW direction it extends from break-through of the Wipper river at the country town of Sachsenburg to the inflow of the Gera River at Arnstadt over a distance of approx. 55 km. The total area is about 2,700 km². In German: Thüringer Becken.
Thüringer Landesanstalt für Umwelt und Geologie	State authority and as a scientific-technical institution active in the field ecology, environmental protection, immission, recycling economy and waste management, water, soil, hazardous sites, geological survey, groundwater, environmental informations, environmental education, spatial analysis, environmental analysis and environmental radioactivity.
Thüringer Landesbergamt	Federal State Authority, which is responsible for the execution of the mining law. In English: State Mining Authority of Thuringia.
Thüringer Wald	Uplift S of the Thuringian Basin. In English: Thuringian Forest.
Tonlöser	Clay-rich intercalations in the potash seam that reduce the overall strength of the rock.
Unstrut Potash District	Potash mining district E of the South Harz Potash District. It is located in the N of the Federal State of Thuringia and covers partly the SW of Saxony-Anhalt. In some publications both district are mentioned as one due to their close vicinity and the mining of the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). However, the depositional factors for the salt rock deposition were somewhat different in both districts.

Term	Explanation
Unterer Buntsandstein	Lithostratigraphic sub-group of the Buntsandstein Group.
Unteres Rotliegend	Lithostratigraphic sub-group of the Rotliegend Group defined by its lithology, which is. Mainly an interlayering of none-volcanic sediments with volcanic sediments (tuffs, basalt lava). Regional differences are possible.
VEB	Abbreviation for Volkseigener Betrieb. In English: publicy owned company.
VEB Geologische Erkundung West	Publicy owned company active in the field of geological investigation (exploration etc.), based in the country town of Jena,Thuringia.
VEB Geologische Forschung und Erkundung Freiberg	Publicy owned company active in the field of geological investigation (exploration etc.), based in the country town of Freiberg, Saxony.
VEB Kaliwerke Südharz	Organisational structure of the VEB Kombinat Kali comprising of the six potash mines and plants Bleicherode, Bischofferode, Roßleben, Sollstedt, Sondershausen and Volkenroda.
VEB Kombinat Kali	Central administration responsible for the supervision of all potash-producing mines of the former GDR. Successor of the VVB Kali, founded 1 January 1970
VNG Gasspeicher GmbH	Private owned gas transmission company in the states of the former GDR (Mecklenburg-Western Pomerania, Brandenburg, Brandburg, Saxony-Anhalt, Saxony, Thuringia).
VVB	Abbreviation for Vereinigung Volkseigener Betriebe. In English: union of publicly owned companies.
VVB Kali	Central administration, responsible for the supervision of all potash-producing mines of the former GDR. Founded on 01 April 1958. Predecessor of the VEB Kombinat Kali.
Werra-Fulda Potash District	Potash mining district SW of the Thüringer Wald uplift covering the SW of the Federal State of Thuringia and E and SE of the State of Hesse. Due to the tectonic development the district is separated into two separate districts, the Werra Potash District, named after the Werra river flowing through the corresponding area, and the Fulda Potash District, named after the Fulda river flowing through the corresponding area. Potash mining here started at about the same time as in the South Harz Potash District, and is still ongoing nowadays.
Wintershall AG	Private company active in potash mining since its foundation in 1894 and active in mining hydrocarbons since 1930. Today known as Wintershall Holding GmbH and only active in production of natural gas and crude oil.
Wippertal fault zone	NW-SE trending fault zone in the NW of the Thuringian Basin. The name “Wippertal” is a composite name consisting of “Wipper” meaning the Wipper river flowing in the corresponding area, and “Tal”, which is German for valley. Hence, the name is a direct description of the morphology created by the Wipper river. This river created its own river bed by incising into the fractured rocks, which are the result of tectonic movement along this fault zone. In German: Wippertal-Störungszone.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

Term	Explanation
Zechstein (Group)	Lithostratigraphic group of latest Wuchiapingian (Upper Permian) to Changhsingian (Upper Permian) age found. The name "Zechstein" originated from the German "zäher Stein", literally translated as tough rock. The second meaning refers to the rocks, which served as base for the copper slate mines in Germany.
Zechstein Ocean	Upper Permian-aged ocean corresponding to the extent of the South Permian Basin.

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
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Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

LIST OF ABBREVIATIONS

Abbreviations of physical units/constants used throughout this study are as follows:

°C	degree Celsius
AG	Aktiengesellschaft
approx.	approximately
asl	above sea level (see also m asl)
avg.	average
B	boron
B	Bundesstraße
BAB	Bundesautobahn
bgl	below ground level (see also *m bgl*)
BGR	Bundesantalt für Geowissenschaften und Rohstoffe
BVVG	BVVG Bodenverwertungs- und -verwaltungs GmbH
BWE	Bergwerkseigentum(sfeld)
Ca	calcium
$CaSO_4$	calcium sulphate
CMC	Carboxylmethylcellulose
cs	Silesium (Carboniferous) *(lithostratigraphic series)*
d	day(s)
DEUSA	DEUSA International GmbH
DHDN	Deutsches Hauptdreiecksnetz
E	east
ESE	east-southeast
Fe	iron
g/cm^3	gram(s) per cubic centimetre
GDR	German Democratic Republic
GR	gamma ray
GSES	Glückauf Sondershausen Entwicklungs- und Sicherungsgesellschaft mbH
H_2O	water
ha	hectare(s)
Ins.	acid insolubles
K	potassium
K_2O	potassium oxide

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

KCl	potassium chloride
km	kilometre(s)
km²	square kilometre(s)
km³	cubic kilometre(s)
kt	kilo ton
L	Landesstraße
LBEG	Landesamt für Bergbau, Energie und Geologie Niedersachsen
LMBV	Lausitzer und Mitteldeutscher Bergbau- und verwaltungsgesellschaft mbH
m.%	mass percent
m	metre(s)
m²	square metre(s)
m³	cubic metre(s)
m asl	metres above sea level
max.	maximal
m bgl	metres below ground level
Mg	magnesium
$MgCl_2$	magnesium chloride
$MgSO_4$	magnesium sulphate
min	minimum
mm	millimetre
mmWO	Obere Wechsellagerung of Mittlerer Muschel-kalk *(lithostratigraphic unit)*
MSL	mean sea-level
Mt	million metric tonnes
NaCl	sodium chloride
NDH-E	NDH Entsorgungsbetreibergesellschaft mbH
NE	northeast
NNE	north-northeast
NNW	north-northwest
NW	northwest
R_2O_3	sesquioxide (the letter “R” stands for a metal or metalloid; ratio within formula between met-al/metalloid and oxygen is 1:1.5, e. g. Al_2O_3)
ro	Oberes Rotliegend *(lithostratigraphic sub-group)*
SE	southeast

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

smSTC	Chirotherien-Sandstein of Mittlerer Buntsand stein *(lithostratigraphic unit)*
SSE	south-southeast
SSW	south-southwest
t	metric tonne
TLBA	Thüringer Landesbergamt
t/m³	metric tonne(s) per cubic metre
TLUG	Thüringer Landesanstalt für Umwelt und Geologie
tpa	tons per year (annum)
VEB	Volkseigener Betrieb
VEB GEW	Volkseigener Betrieb Geologische Erkundung West
VEB GFEF	Volkseigener Betrieb Geologische Forschung und Erkundung Freiberg
VVB	Vereinigung Volkseigener Betriebe
W	west
WNW	west-northwestern
WSW	west-southwest
°C	degree(s) Celsius
%	percent

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstädter Straße 28, 99096 Erfurt, Germany
Phone: + 49 361 3810 500 Fax: +49 361 3810 505 E-mail: mining@ercosplan.com Web: http://www.ercosplan.com

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH

Arnstaedter Strasse 28
99096 Erfurt/Germany

phone: +49 361 3810 500
fax: +49 361 3810 505

e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

Legend:

Gräfentonna Exploration Licence area

JORC Report Gräfentonna Licence Area

Appendix 1
Topographic Map Showing Location and Available Infrastructure of the Gräfentonna Exploration Licence Area

Scale: 1:100,000

0 5 10 km

Coordinate System: ETRS 1989 UTM Zone 32N

ERCOSPLAN
Geotechnik und Bergbau

Date: 2017-05-16
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ERCOSPLAN Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt
Germany

Tel.: +49 361 3810 500
Fax: +49 361 3810 505
E-Mail: mining@ercosplan.com
Web: www.ercosplan.com
Managing Director: Dr Henry Rauche

APPENDIX 2

Copy of Official Licence Document for Gräfentonna Exploration Licence Area

Client:	**EAST EXPLORATION GmbH** Burgstraße 12 80331 München Germany
Bidder:	**ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH** Arnstaedter Strasse 28 99096 Erfurt Germany
Project Reference:	14-069.N02

A[illegible]LAGE

Freistaat Thüringen

Thüringer Landesbergamt

Der Amtsleiter

Thüringer Landesbergamt · Puschkinplatz 7 · 07545 Gera

EAST EXPLORATION GmbH
Burgstraße 12
80331 München

Thür. Landesbergamt
Postausgangs-Nr.: 50213-261/10

14. JAN. 2015

Ihre Ansprechpartnerin:
Larissa Färber

Durchwahl:
Telefon 0365 7337-412
Telefax 0365 7337-105

larissa.faerber@
tlba.thueringen.de

Ihr Zeichen:
EGB 12-043.No1-AJ/SGO

Ihre Nachricht vom:
04.07.2014 (ERCOSPLAN)

Unser Zeichen:
(bitte bei Antwort angeben)
PE 14928/14
R4-76b3403

Gera
12. Januar 2015

Bescheid Nr. 17/2015

Erteilung einer Erlaubnis zur Aufsuchung zu gewerblichen Zwecken

I.

1. Gemäß §§ 6 und 7 Bundesberggesetz (BBergG) wird der

EAST EXPLORATION GmbH
(eingetragen im Handelsregister beim AG München unter HRB 213516)

die Erlaubnis erteilt, im Erlaubnisfeld **„Gräfentonna“**, begrenzt durch die Feldeseckpunkte

Lfd.-Nr.	Rechtswert	Hochwert	Ostwert	Nordwert
1	44 20 300	56 55 102	32 630 614	5 654 317
2	44 20 300	56 55 700	32 630 590	5 654 915
3	44 18 000	56 56 400	32 628 264	5 655 520
4	44 14 200	56 59 800	32 624 330	5 658 762
5	44 12 395	56 59 542	32 622 537	5 658 431
6	44 08 355	56 68 166	32 618 151	5 666 880
7	44 09 125	56 68 675	32 618 899	5 667 420
8	44 08 250	56 71 000	32 617 930	5 669 707
9	44 07 496	56 71 000	32 617 177	5 669 676
10	44 06 313	56 74 907	32 615 836	5 673 530
11	44 07 500	56 74 450	32 617 040	5 673 122
12	44 07 500	56 74 150	32 617 053	5 672 823
13	44 07 950	56 74 100	32 617 504	5 672 791
14	44 08 000	56 74 020	32 617 557	5 672 713
15	44 08 900	56 73 600	32 618 474	5 672 330
16	44 09 100	56 73 400	32 618 681	5 672 139
17	44 09 450	56 73 050	32 619 045	5 671 803

Thüringer
Landesbergamt
Puschkinplatz 7
07545 Gera

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18	44 11 500	56 71 750	32 621 146	5 670 588
19	44 11 800	56 71 600	32 621 452	5 670 451
20	44 12 500	56 71 350	32 622 161	5 670 230
21	44 13 800	56 72 000	32 623 433	5 670 932
22	44 12 800	56 73 300	32 622 381	5 672 190
23	44 14 000	56 74 250	32 623 541	5 673 188
24	44 14 370	56 74 500	32 623 901	5 673 452
25	44 16 000	56 75 500	32 625 488	5 674 518
26	44 22 942	56 71 909	32 632 569	5 671 214
27	44 23 123	56 54 110	32 633 474	5 653 441

Stein-, Kali-, Magnesia- und Borsalze nebst den mit diesen Salzen in der gleichen Lagerstätte auftretenden Salzen

die bergfreie Bodenschätze gemäß § 3 Abs. 3 BBergG sind, aufzusuchen sowie die bei planmäßiger Aufsuchung notwendigerweise zu lösenden oder freizusetzenden Bodenschätze zu gewinnen und das Eigentum daran zu erwerben.

2. Die Erteilung einer Erlaubnis zur Aufsuchung zu gewerblichen Zwecken ist eine Amtshandlung, für die gemäß § 1 Abs. 1 Thüringer Verwaltungskostengesetz von der Antragstellerin, hier der Firma EAST EXPLORATION GmbH, Burgstraße 12 in 80331 München, Kosten zu erheben sind. Die Höhe der Verfahrenskosten (Gebühren und Auslagen) werden mit gesondertem Bescheid festgesetzt.

II.

Diesem Bescheid liegen folgende Antragsunterlagen zu Grunde:

1. Antrag der EAST EXPLORATION PTY LTD mit Sitz in Melbourne, Australien, eingereicht mit Schreiben vom 04.07.2014 der ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau GmbH im Auftrag der Antragstellerin, auf Erteilung einer Erlaubnis gemäß § 7 BBergG zur Aufsuchung von Stein-, Kali-, Magnesia- und Borsalzen nebst den mit diesen Salzen in der gleichen Lagerstätte auftretenden Salzen zu gewerblichen Zwecken im Erlaubnisfeld „Gräfentonna".

2. Vereinbarung vom 10.11.2014 zwischen der EAST EXPLORATION PTY LTD und der EAST EXPLORATION GmbH zur Übertragung des vorgenannten Antrages der EAST EXPLORATION PTY LTD auf Erteilung einer Erlaubnis gemäß § 7 BBergG auf die EAST EXPLORATION GmbH.

3. Schreiben vom 01.12.2014 der ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau GmbH mit Karte des Erlaubnisfeldes „Gräfentonna" vom 27.11.2014.

III.

Nebenbestimmungen gemäß § 5 BBergG i. V. m. § 36 Thüringer Verwaltungsverfahrensgesetz (ThürVwVfG):

1. Die Erlaubnis wird bis zum 12.01.2020 befristet.

2. Die Ergebnisse der Aufsuchung sind gemäß § 11 Nr. 4 BBergG unverzüglich nach Abschluss der Arbeiten, spätestens beim Erlöschen der Erlaubnis dem Thüringer Landesbergamt bekanntzugeben. Zudem ist dem Thüringer Landesbergamt jährlich über den Stand der Aufsuchung zu berichten.

IV.

Hinweise:

1. Diese Erlaubnis allein berechtigt nicht schon zur Durchführung der Aufsuchungsarbeiten. Auf ggf. weitere notwendige Zulassungen, Genehmigungen, Anzeigen insbesondere aufgrund des
   - Bundesberggesetzes (BBergG),
   - Gesetzes zur Ordnung des Wasserhaushalts (WHG),
   - Thüringer Wassergesetzes (ThürWG),
   - Baugesetzbuches (BauGB),
   - Thüringer Bauordnung (ThürBO),
   - Gesetzes über Naturschutz und Landschaftspflege – Bundesnaturschutzgesetz – (BNatSchG),
   - Thüringer Gesetzes für Natur und Landschaft (ThürNatG),
   - Thüringer Waldgesetzes (ThürWaldG),
   - Thüringer Denkmalschutzgesetzes (ThürDSchG)
   - Gesetzes zum Schutz vor schädlichen Bodenveränderungen und zur Sanierung von Altlasten (BBodSchG)
   - Thüringer Bodenschutzgesetzes (ThürBodSchG) sowie
   - Gesetzes über die Durchforschung des Reichsgebietes nach nutzbaren Lagerstätten (Lagerstättengesetz)

   wird hingewiesen.
   Dies gilt im Besonderen im Zusammenhang mit den im Erlaubnisfeld befindlichen
   - Schutzgebieten und Objekten nach BNatSchG i. V. m. ThürNatG und

- Wasserschutzgebieten und einem Überschwemmungsgebiet nach WHG i. V. m. ThürWG.

2. Die Erlaubnis kann gemäß § 18 BBergG und § 49 ThürVwVfG widerrufen werden.

3. Es wird auf die Feldesabgabepflicht gemäß § 30 BBergG hingewiesen. Gemäß § 19 der Thüringer Verordnung über die Feldes- und Förderabgabe sind Abgabepflichtige mit einer Erlaubnis zur Aufsuchung der hier in Rede stehenden Bodenschätze von der Feldesabgabe zumindest bis zum 31.12.2015 befreit.

4. Gemäß den Regionalplänen Mittel- und Nordthüringen befinden sich im Erlaubnisfeld vollständig bzw. teilweise Vorrang- bzw. Vorbehaltsgebiete für Freiraumsicherung, Hochwasserschutz, Landwirtschaftliche Bodennutzung, Rohstoffe, Tourismus und Erholung.

5. Für die Planung der 2. Erkundungsphase wird bereits jetzt darauf hingewiesen, dass
   - bei Inanspruchnahme von Flächen, insbesondere auch bei landwirtschaftlichen Nutzflächen, mit den Eigentümern und Nutzern dieser Flächen privatrechtliche Vereinbarungen zu treffen sind,
   - in den Geltungsbereichen rechtskräftiger Bebauungspläne deren Festsetzungen zu berücksichtigen sind.

6. Das Erlaubnisfeld hat teilweise eine gemeinsame Grenze bzw. überschneidet sich mit Bergwerkseigentumen, die auf andere bergfreie Bodenschätze verliehen sind. Sollten die Aufsuchungsarbeiten in diesen Feldesteilen durchgeführt werden, so sind im Rahmen des Aufsuchungsbetriebsplanes mit deren Rechtsinhabern bzw. Bergbauunternehmern Maßnahmen festzulegen, um eine Beeinträchtigung der dort zurzeit geführten Gewinnungsarbeiten auszuschließen.

V.

Begründung:

1.

Mit Schreiben vom 04.07.2014 der ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau GmbH hat diese für die EAST EXPLORATION PTY LTD mit Sitz in Melbourne, Australien, einen Antrag auf Erteilung einer Erlaubnis zur Aufsuchung von Stein-, Kali-, Magnesia- und Borsalzen nebst den mit diesen Salzen in der gleichen Lagerstätte auftretenden Salzen zu gewerblichen Zwecken im Erlaubnisfeld „Gräfentonna" gestellt.

Mit Vereinbarung vom 10.11.2014 wurde dieser Antrag auf ihr Tochterunternehmen, die EAST EXPLORATION GmbH mit Sitz in München, übertragen.

Im Rahmen der Beteiligung gemäß § 15 BBergG wurde folgenden Trägern öffentlicher Belange Gelegenheit zur Stellungnahme gegeben:
- Thüringer Landesverwaltungsamt (Referate: 350 – Raumordnungsfragen, 410 – Naturschutz, 440 – Wasserwirtschaft und 460 – Ländlicher Raum)
- Thüringer Landesanstalt für Umwelt und Geologie
- Landwirtschaftsämter Sömmerda, Leinefelde-Worbis und Bad Salzungen
- Landesamt für Denkmalpflege und Archäologie
- Amt für Landentwicklung und Flurneuordnung Gotha
- kreisfreie Stadt Erfurt
- Landratsämter der Landkreise Gotha, Sömmerda und des Unstrut-Hainich-Kreises
- Stadtverwaltungen Bad Langensalza und Bad Tennstedt
- Verwaltungsgemeinschaften: Bad Tennstedt, Gera-Aue, Fahner Höhe, Nesseaue und Schlotheim
- Gemeinden: Andisleben, Ballhausen, Bienstädt, Bruchstedt, Dachwig, Döllstädt, Gebesee, Gierstädt, Großfahner, Großvargula, Haussömmern, Herbsleben, Kirchheilingen, Kleinwelsbach, Klettstedt, Kutzleben, Mittelsömmern, Neunheilingen, Sundhausen, Tonna, Tottleben, Urleben, Walschleben und Witterda.

Die Regionale Planungsgemeinschaft Mittelthüringen erhielt ebenso Gelegenheit, eine Stellungnahme zum Antrag abzugeben.

Die Antragstellerin wurde am 11.12.2014 zu den für die Entscheidung erheblichen Tatsachen und Gründen gehört.

2.

2.1 Die Erlaubnis war gemäß §§ 6 und 7 BBergG zu erteilen, da es sich bei Stein-, Kali-, Magnesia- und Borsalzen nebst den mit diesen Salzen in der gleichen Lagerstätte auftretenden Salzen um die bergfreien Bodenschätze gemäß § 3 Abs. 3 BBergG handelt und der Erteilung keine Versagungsgründe entgegenstehen, insbesondere keine überwiegenden öffentlichen Interessen i. S. d. § 11 Nr. 10 BBergG, die eine Aufsuchung im gesamten Erlaubnisfeld „Gräfentonna" ausschließen.

2.2 Eine Erlaubnis gemäß § 7 BBergG ist eine Berechtigung, die das Recht einräumt, im Erlaubnisfeld die in der Erlaubnis bestimmten Bodenschätze zu suchen und die Ausdehnung der Lagerstätten dieser Bodenschätze festzustellen.
Diese Erlaubnis zur Aufsuchung ist bei bergfreien Bodenschätzen gemäß § 6 Satz 1 BBergG zwingend erforderlich. Stein-, Kali-, Magnesia- und Borsalze sind nach § 3 Abs. 3 BBergG solche bergfreien Bodenschätze.

2.3 Mit Vereinbarung vom 10.11.2014 übertrug die EAST EXPLORATION PTY LTD als Antragstellerin alle aus ihrem Erlaubnisantrag resultierenden Rechte und Pflichten auf ihr Tochterunternehmen, die EAST EXPLORATION GmbH, die diese daraufhin übernahm.
Die EAST EXPLORATION PTY LTD erklärte weiterhin, alle nunmehr der EAST EXPLORATION GmbH durch das Erlaubnisverfahren entstehenden Zahlungspflichten zu übernehmen und insbesondere die gemäß § 11 Nr. 7 BBergG erforderlichen Mittel aufzubringen.

2.4 Tragfähige rechtliche Gründe, die entsprechend § 11 Nr. 10 BBergG im öffentlichen Interesse die Aufsuchung im gesamten Erlaubnisfeld ausschließen würden, sind weder in den Stellungnahmen der beteiligten Träger öffentlicher Belange vorgetragen worden noch anderweitig erkennbar.
Die im Erlaubnisfeld befindlichen Schutzgebiete und Objekte nach Naturschutz- bzw. Wasserrecht stellen mehrheitlich keinen Versagungsgrund dar, da sich diese nicht auf das gesamte Erlaubnisfeld erstrecken. Des Weiteren stehen ausweislich der Stellungnahmen der Fachbehörden die naturschutz- bzw. wasserwirtschaftlichen Belange den Aufsuchungsarbeiten auch in den Schutzgebieten nicht im Wege, wenn entsprechende Anforderungen eingehalten bzw. erfüllt werden.
Die Genehmigungsfähigkeit der geplanten Aufsuchungsarbeiten, hier speziell von Bohrungen, kann allerdings nur standortbezogen festgestellt werden und ist dann Gegenstand des nachfolgenden Zulassungsverfahrens für den Betriebsplan des Aufsuchungsbetriebes.

2.5 Den Belangen der im Rahmen des § 15 BBergG beteiligten Behörden wird, soweit sie einen Bezug zu dieser Bergbauberechtigung haben, durch die Hinweise dieses Bescheides Rechnung getragen.

2.6 Eine Erlaubnis gestattet nicht die Durchführung von Aufsuchungsarbeiten. Die konkrete Ausgestaltung der Anforderungen an die Aufsuchungstätigkeiten ist dem späteren Zulassungsverfahren für den Betriebsplan des Aufsuchungsbetriebes gemäß §§ 52, 55 BBergG vorbehalten. In diesem Zulassungsverfahren, das unter Beteiligung der Träger öffentlicher Belange, darunter der Gemeinden und Landkreise, gemäß § 54 Abs. 2 BBergG zu führen ist, wird dann zu prüfen sein, ob Aufsuchungstätigkeiten zulässig, unzulässig oder unter bestimmten Auflagen und Vorgaben zulässig sind.
Falls für Aufsuchungstätigkeiten weitere fachgesetzliche Genehmigungen erforderlich sind, sind diese entsprechend den Zuständigkeitsbestimmungen von den Fachbehörden oder im Einvernehmen mit den Fachbehörden zu entscheiden.

3.

3.1 Im Rahmen der Behördenbeteiligung wurden u. a. Einwände erhoben, dass die Aufsuchung der vorliegenden Bodenschätze in Anbetracht der bereits bekannten Kalilagerstätten bzw. der laufenden Kalibetriebe in Thüringen nicht erforderlich sei. Vielmehr sei es sinnvoll, diese Standorte in Anspruch zu nehmen bzw. weiterhin zu betreiben. Hierzu wird auf den in § 1 formulierten Zweck des Bundesberggesetzes hingewiesen, wonach u. a. das Aufsuchen von bergfreien Bodenschätzen zu ordnen und zu fördern ist.
Die vorliegend beantragte Erlaubnis zur Aufsuchung bezweckt die Erkundung von bestimmten Bodenschätzen, inwieweit diese vorhanden sind und welche Lage und Ausdehnung deren Lagerstätten haben. Es ist nicht erkennbar, inwieweit der in § 1 bestimmte Zweck dem Aufsuchungsziel entgegensteht, da Aufsuchungen gerade dazu dienen, Erkenntnisse zu Bodenschätzen und Lagerstätten zu gewinnen, die es dann ermöglichen, die Zielstellung des § 1 BBergG sachgerecht anzuwenden und umzusetzen. Tragfähige rechtliche Grundlagen, die den vorgetragenen Einwänden entsprechend eine Versagung begründen, sind weder vorgetragen worden noch erkennbar.

Der Bergbehörde obliegt nicht die Planung von Aufsuchungen. Hierzu fehlt der Behörde die gesetzliche Ermächtigung. Die Planung, sowohl in Bezug auf die aufzusuchenden Bodenschätze als auch auf die Lage und Größe der Erlaubnisfelder, ist Sache des Antragstellers. Tragfähige Gründe, entsprechend § 16 Abs. 2 BBergG vom beantragten Erlaubnisfeld abzuweichen, sind nicht gegeben. Auch die Entscheidung über die Wirtschaftlichkeit eines möglichen künftigen Bergbaubetriebes liegt nicht im Entscheidungsbereich einer Bergbehörde. Dies ist für die Entscheidung über einen Erlaubnisantrag gemäß § 11 Nrn. 1 bis 9 BBergG nicht vorgesehen.

3.2 Einige beteiligte Gemeinden lehnten in den Stellungnahmen das Fracking ausdrücklich ab. Ausweislich der in diesem Erlaubnisverfahren vorliegenden Antragsunterlagen ist die Anwendung dieser Technologie nicht Gegenstand des Arbeitsprogramms.

3.3 Im Zusammenhang mit den von einigen Trägern öffentlicher Belange vorgebrachten Bedenken in Bezug auf die Vorlage einer Sicherheitsleistung bzw. die Haftung des Bergbauunternehmers für evtl. Bergschäden aufgrund der Aufsuchungsarbeiten wird auf die entsprechenden Vorschriften der §§ 56 und 114 BBergG hingewiesen. Diese sind allerdings erst später im Rahmen eines Betriebsplanverfahrens anzuwenden.

3.4 Die getroffene Befristung der Erlaubnis erfolgte gemäß § 16 Abs. 4 BBergG unter Berücksichtigung des antragsgemäß vorliegenden, sachlich nachvollziehbaren Zeitplanes zu den vorgesehenen Aufsuchungsmaßnahmen.

Die Behördenentscheidung zu einer Erlaubnis ist eine gebundene Entscheidung, d. h. der zuständigen Bergbehörde steht kein Entscheidungsermessen zu. Diese ist vielmehr zwingend verpflichtet, dem Antragsteller die Erlaubnis zu erteilen, wenn nicht die in § 11 BBergG genannten Versagungsgründe entgegenstehen. Die in § 11 Nrn. 1 bis 9 BBergG genannten Erfordernisse sind von der Antragstellerin ausweislich der eingereichten Antragsunterlagen erbracht worden.

Die beantragte Erlaubnis war daher, wie erfolgt, zu erteilen.

VI.

Rechtsbehelfsbelehrung:

Gegen diesen Verwaltungsakt ist Widerspruch möglich. Der Widerspruch ist innerhalb eines Monats, nachdem der Verwaltungsakt bekannt gegeben worden ist, schriftlich oder zur Niederschrift beim Thüringer Landesbergamt, Puschkinplatz 7, 07545 Gera zu erheben.
Die Frist wird auch durch rechtzeitige Einlegung bei der Außenstelle Bad Salzungen des Thüringer Landesbergamtes, Langenfelder Straße 108, 36433 Bad Salzungen gewahrt.

Hartmut Kießling
Amtsleiter

THÜRINGER LANDESBERGAMT 1 – Siegel –

Anlagen - Karte des Erlaubnisfeldes „Gräfentonna" vom 27.11.2014
- Empfangsbestätigung

Fä 11.12.14
Re 11/12
VH 11.12.2014

Verteiler:

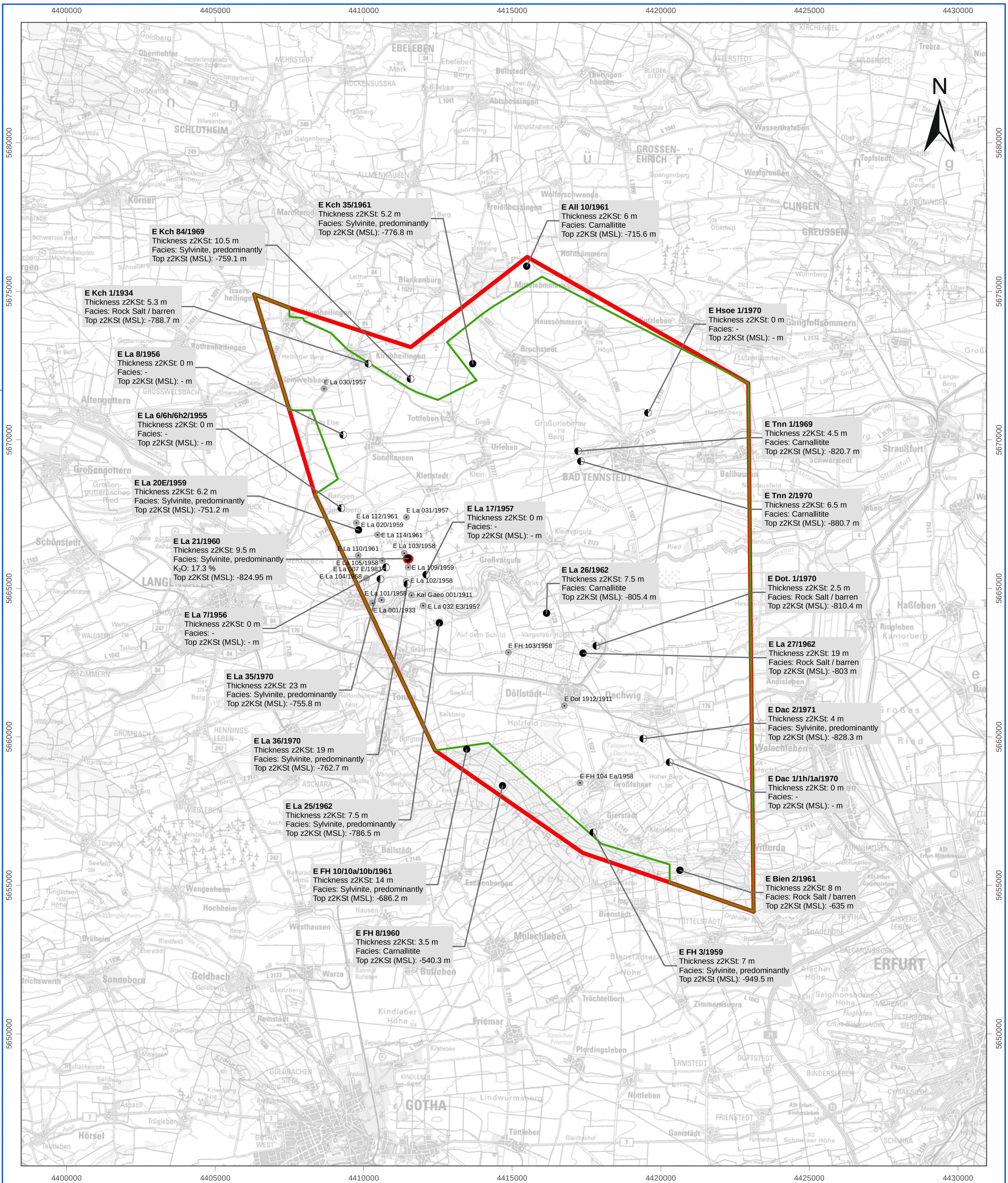
1. Erlaubnisinhaberin (Original des Bescheides, Empfangsbestätigung)
2. Thüringer Landesbergamt, Ref. 4 (Ablageexemplar)

Kopien:

1. Thüringer Landesbergamt, Ref. 2
2. Thüringer Landesverwaltungsamt, Ref. 350 Raumordnungsfragen
3. Thüringer Landesverwaltungsamt, Ref. 410 Naturschutz
4. Thüringer Landesverwaltungsamt, Ref. 440 Wasserwirtschaft
5. Thüringer Landesverwaltungsamt, Ref. 460 Ländlicher Raum
6. Thüringer Landesanstalt für Umwelt und Geologie, Ref. 62
7. Landwirtschaftsamt Bad Salzungen
8. Landwirtschaftsamt Leinefelde-Worbis
9. Landwirtschaftsamt Sömmerda
10. Landesamt für Denkmalpflege und Archäologie
11. Amt für Landentwicklung und Flurneuordnung Gotha
12. Landratsamt Gotha
13. Landratsamt Sömmerda
14. Landratsamt Unstrut-Hainich-Kreis
15. kreisfreie Stadt Erfurt
16. Stadtverwaltung Bad Langensalza
17. Stadtverwaltung Bad Tennstedt
18. Verwaltungsgemeinschaft Bad Tennstedt
19. Verwaltungsgemeinschaft Gera-Aue
20. Verwaltungsgemeinschaft Fahner Höhe
21. Verwaltungsgemeinschaft Nesseaue
22. Verwaltungsgemeinschaft Schlotheim
23. Gemeinde Andisleben
24. Gemeinde Ballhausen
25. Gemeinde Bienstädt
26. Gemeinde Bruchstedt
27. Gemeinde Dachwig
28. Gemeinde Döllstädt
29. Gemeinde Gebesee
30. Gemeinde Gierstädt
31. Gemeinde Großfahner
32. Gemeinde Großvargula
33. Gemeinde Haussömmern
34. Gemeinde Herbsleben
35. Gemeinde Kirchheilingen
36. Gemeinde Kleinwelsbach
37. Gemeinde Klettstedt
38. Gemeinde Kutzleben
39. Gemeinde Mittelsömmern
40. Gemeinde Neunheilingen

41. Gemeinde Sundhausen
42. Gemeinde Tonna
43. Gemeinde Tottleben
44. Gemeinde Urleben
45. Gemeinde Walschleben
46. Gemeinde Witterda
47. Regionale Planungsgemeinschaft Mittelthüringen
48. Verbandwasserwerk Bad Langensalza

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com



JORC Report Gräfentonna Licence Area

Legend:

Drill Holes

- ◐ stratigraphy available
- ● stratigraphy and geophysical logging data (1:200) available
- ● chemical assaying data available
- ⊙ without information

Gräfentonna Exploration Licence area

modelling area

Scale: 1:125,000

0 5 10 km

Coordinate System: DHDN 3 Degree Gauss Zone 4

Appendix 3

Drill Holes from Different Exploration Campaigns and Extend of the Modelling Area

ERCOSPLAN Geotechnik und Bergbau

Date: 2017-05-16

O:\@@@GIS\@@@GIS_Projekte\THUERINGEN\Karten\14-069N02_Graefentonna\14-069N02_App_03_DrillHoles_irev01.mxd

Drill Hole	**E Allmenhausen 10/1961**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4415490.00	5675848.40	335.40	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	65.00	65.00	
mm	65.00	148.00	83.00	
mu	148.00	247.00	99.00	
so	247.00	421.00	174.00	
sm	421.00	606.00	185.00	
su	606.00	936.00	330.00	
z7-z4Tb			0.00	
z4ANb	936.00	937.00	1.00	
z4NA	937.00	947.00	10.00	
z4ANa	947.00	948.00	1.00	
z4Ta-z3Tb	948.00	951.00	3.00	
z3NA	951.00	991.00	40.00	
z3AN	991.00	1030.00	39.00	
z3CA	1030.00	1036.00	6.00	
z3Ta-z2Tb	1036.00	1049.00	13.00	
z2ANb	1049.00	1050.00	1.00	
z2NAr	1050.00	1051.00	1.00	
z2KSt	1051.00	1057.00	6.00	Carnallitite
z2NA	1057.00	1092.00	35.00	
z2ANa	1092.00	1119.00	27.00	
z2CA	1119.00	1143.50	24.50	
z1ANc	1143.50	1148.50	5.00	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Bienstädt 2/1961**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4420645.50	5655497.60	350.00	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	32.00	32.00	
mm	32.00	115.00	83.00	
mu	115.00	217.00	102.00	
so	217.00	387.50	170.50	
sm	387.50	568.50	181.00	
su	568.50	906.00	337.50	
z7-z4Tb			0.00	
z4ANb	906.00	907.00	1.00	
z4NA	907.00	911.50	4.50	
z4ANa	911.50	912.50	1.00	
z4Ta-z3Tb	912.50	915.50	3.00	
z3NA	915.50	937.00	21.50	
z3AN	937.00	968.00	31.00	
z3CA	968.00	972.00	4.00	
z3Ta-z2Tb	972.00	981.00	9.00	
z2ANb	981.00	982.00	1.00	
z2NAr	982.00	985.00	3.00	
z2KSt	985.00	993.00	8.00	barren
z2NA	993.00	1008.50	15.50	
z2ANa	1008.50	1011.50	3.00	
z2CA	1011.50	1067.00	55.50	
z1ANc				
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Dachwig 1/1970**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4420294.30	5659138.80	183.80	
Stratigraphy	From	To	Thickness (m)	
q	0.00	1.50	1.50	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	1.50	21.00	19.50	
mo	21.00	85.00	64.00	
mm	85.00	166.50	81.50	
mu	166.50	266.50	100.00	
so	266.50	415.50	149.00	
sm	415.50	607.00	191.50	
su	607.00	926.00	319.00	
z7-z4Tb	926.00	940.50	14.50	
z4ANb			0.00	
z4NA	940.50	945.50	5.00	
z4ANa	945.50	946.50	1.00	
z4Ta-z3Tb	946.50	948.00	1.50	
z3NA	948.00	968.00	20.00	
z3AN	968.00	997.00	29.00	
z3CA	997.00	1001.00	4.00	
z3Ta-z2Tb	1001.00	1011.50	10.50	
z2ANb	1011.50	1013.00	1.50	
z2NAr			0.00	
z2KSt			0.00	
z2NA	1013.00	1038.00	25.00	
z2ANa	1038.00	1041.55	3.55	
z2CA	1041.55	1084.70	43.15	
z1ANc				
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Dachwig 2/1971**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4419412.40	5659936.10	185.70	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	16.00	16.00	
mo	16.00	85.00	69.00	
mm	85.00	151.00	66.00	
mu	151.00	255.00	104.00	
so	255.00	402.00	147.00	
sm	402.00	599.50	197.50	
su	599.50	913.50	314.00	
z7-z4Tb	913.50	927.50	14.00	
z4ANb	927.50	928.00	0.50	
z4NA	928.00	939.00	11.00	
z4ANa	939.00	940.00	1.00	
z4Ta-z3Tb	940.00	942.00	2.00	
z3NA	942.00	975.00	33.00	
z3AN	975.00	998.50	23.50	
z3CA	998.50	1002.00	3.50	
z3Ta-z2Tb	1002.00	1012.00	10.00	
z2ANb	1012.00	1014.00	2.00	
z2NAr			0.00	
z2KSt	1014.00	1018.00	4.00	Sylvinite
z2NA	1018.00	1047.50	29.50	
z2ANa	1047.50	1053.00	5.50	
z2CA	1053.00	1091.80	38.80	
z1ANc				
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Döllstädt 1/1970**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4417827.10	5663070.10	237.10	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	21.50	21.50	
mo	21.50	85.00	63.50	
mm	85.00	161.00	76.00	
mu	161.00	264.50	103.50	
so	264.50	435.00	170.50	
sm	435.00	622.50	187.50	
su	622.50	936.50	314.00	
z7-z4Tb	936.50	949.00	12.50	
z4ANb	949.00	950.00	1.00	
z4NA	950.00	956.50	6.50	
z4ANa	956.50	958.00	1.50	
z4Ta-z3Tb	958.00	959.50	1.50	
z3NA	959.50	994.00	34.50	
z3AN	994.00	1028.50	34.50	
z3CA	1028.50	1033.00	4.50	
z3Ta-z2Tb	1033.00	1044.00	11.00	
z2ANb	1044.00	1045.00	1.00	
z2NAr			0.00	
z2KSt	1045.00	1047.50	2.50	barren
z2NA	1047.50	1079.00	31.50	
z2ANa	1079.00	1090.80	11.80	
z2CA	1090.80	1138.95	48.15	
z1ANc	1138.95	1141.60	2.65	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Fahner Höhe 3/1959**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4417723.20	5656780.20	259.50	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	42.00	42.00	
mo	42.00	107.50	65.50	
mm	107.50	184.00	76.50	
mu	184.00	290.00	106.00	
so	290.00	552.50	262.50	
sm	552.50	780.00	227.50	
su	780.00	1118.50	338.50	
z7-z4Tb			0.00	
z4ANb	1118.50	1119.50	1.00	
z4NA	1119.50	1121.00	1.50	
z4ANa	1121.00	1122.20	1.20	
z4Ta-z3Tb	1122.20	1123.30	1.10	
z3NA	1123.30	1165.50	42.20	
z3AN	1165.50	1194.00	28.50	
z3CA	1194.00	1197.00	3.00	
z3Ta-z2Tb	1197.00	1206.50	9.50	
z2ANb	1206.50	1207.50	1.00	
z2NAr	1207.50	1209.00	1.50	
z2KSt	1209.00	1216.00	7.00	Sylvinite
z2NA	1216.00	1234.50	18.50	
z2ANa	1234.50	1238.90	4.40	
z2CA	1238.90	1310.90	72.00	
z1ANc	1310.90	1311.50	0.60	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Fahner Höhe 8/1960**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4414678.80	5658342.30	402.20	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	24.00	24.00	
mm	24.00	102.50	78.50	
mu	102.50	209.00	106.50	
so	209.00	372.50	163.50	
sm	372.50	553.00	180.50	
su	553.00	888.00	335.00	
z7-z4Tb			0.00	
z4ANb	888.00	889.00	1.00	
z4NA	889.00	895.50	6.50	
z4ANa	895.50		1.50	Fault
z4Ta-z3Tb		897.00		
z3NA	897.00	914.00	17.00	
z3AN	914.00	932.50	18.50	
z3CA	932.50	935.00	2.50	
z3Ta-z2Tb	935.00	941.00	6.00	
z2ANb	941.00	942.00	1.00	
z2NAr	942.00	942.50	0.50	
z2KSt	942.50	946.00	3.50	Carnallitite
z2NA	946.00	970.00	24.00	
z2ANa	970.00	974.20	4.20	
z2CA	974.20	1044.00	69.80	
z1ANc	1044.00	1049.50	5.50	
z1NA	1049.50	1142.50	93.00	
z1ANa	1142.50	1249.00	106.50	
z1CAa	1249.00	1251.00	2.00	
z1Ta	1251.00	1251.30	0.30	
z1BK	1251.30	1252.25	0.95	
Basement	1252.25	1257.70	5.45	

Drill Hole	**E Fahner Höhe 10/1961**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4413468.30	5659571.90	296.80	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	20.00	20.00	
mm	20.00	103.50	83.50	
mu	103.50	210.00	106.50	
so	210.00	386.50	176.50	
sm	386.50	563.50	177.00	
su	563.50	896.50	333.00	
z7-z4Tb			0.00	
z4ANb	896.50	897.50	1.00	
z4NA	897.50	902.00	4.50	
z4ANa	902.00	903.00	1.00	
z4Ta-z3Tb	903.00	904.50	1.50	
z3NA	904.50	940.00	35.50	
z3AN	940.00	966.00	26.00	
z3CA	966.00	970.50	4.50	
z3Ta-z2Tb	970.50	976.50	6.00	
z2ANb	976.50	977.50	1.00	
z2NAr	977.50	983.00	5.50	
z2KSt	983.00	997.00	14.00	Sylvinite
z2NA	997.00	1013.50	16.50	
z2ANa	1013.50	1017.00	3.50	
z2CA	1017.00	1092.00	75.00	
z1ANc	1092.00	1138.00	46.00	
z1NA	1138.00	1170.00	32.00	
z1ANa	1170.00	1348.50	178.50	
z1CAa	1348.50	1351.00	2.50	
z1Ta	1351.00	1351.40	0.40	
z1BK	1351.40	1352.50	1.10	
Basement	1352.50	1354.50	2.00	

Drill Hole	**E Hausömmern 1/1970**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4419570.60	5670916.60	219.90	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	66.00	66.00	
mm	66.00	145.50	79.50	
mu	145.50	249.00	103.50	
so	249.00	421.50	172.50	
sm	421.50	605.00	183.50	
su	605.00	908.00	303.00	
z7-z4Tb	908.00	921.00	13.00	
z4ANb	921.00	923.00	2.00	
z4NA	923.00	930.00	7.00	
z4ANa	930.00	931.00	1.00	
z4Ta-z3Tb	931.00	933.00	2.00	
z3NA	933.00	970.50	37.50	
z3AN	970.50	1011.00	40.50	
z3CA			0.00	
z3Ta-z2Tb	1011.00	1035.50	24.50	
z2ANb			0.00	
z2NAr			0.00	
z2KSt			0.00	
z2NA	1035.50	1112.20	76.70	
z2ANa	1112.20	1124.00	11.80	
z2CA	1124.00	1157.40	33.40	
z1ANc	1157.40	1160.70	3.30	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Kirchheilingen 1/1934**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4410155.00	5672560.00	255.00	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	55.00	55.00	
mm	55.00	130.00	75.00	
mu	130.00	243.00	113.00	
so	243.00	410.00	167.00	
sm	410.00	650.00	240.00	
su	650.00	918.65	268.65	
z7-z4Tb	918.65	930.35	11.70	
z4ANb	930.35	931.50	1.15	
z4NA	931.50	943.95	12.45	
z4ANa	943.95	945.00	1.05	
z4Ta-z3Tb	945.00	948.85	3.85	
z3NA	948.85	991.60	42.75	
z3AN	991.60	1028.35	36.75	
z3CA	1028.35	1033.35	5.00	
z3Ta-z2Tb	1033.35	1041.90	8.55	
z2ANb	1041.90	1043.70	1.80	
z2NAr			0.00	
z2KSt	1043.70	1049.00	5.30	barren
z2NA	1049.00	1074.95	25.95	
z2ANa	1074.95	1099.20	24.25	
z2CA	1099.20	1149.20	50.00	
z1ANc	1149.20	1154.15	4.95	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Kirchheilingen 35/1961**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4413674.70	5672559.80	285.60	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	5.00	5.00	
mo	5.00	65.00	60.00	
mm	65.00	130.00	65.00	
mu	130.00	241.50	111.50	
so	241.50	422.00	180.50	
sm	422.00	601.00	179.00	
su	601.00	928.00	327.00	
z7-z4Tb			0.00	
z4ANb	928.00	930.30	2.30	
z4NA	930.30	944.60	14.30	
z4ANa			0.00	
z4Ta-z3Tb	944.60	947.00	2.40	
z3NA	947.00	1010.00	63.00	
z3AN	1010.00	1049.00	39.00	
z3CA	1049.00	1051.00	2.00	
z3Ta-z2Tb	1051.00	1059.40	8.40	
z2ANb	1059.40	1061.00	1.60	
z2NAr	1061.00	1062.40	1.40	
z2KSt	1062.40	1067.60	5.20	Sylvinite
z2NA	1067.60	1105.00	37.40	
z2ANa	1105.00	1114.00	9.00	Fault
z2CA	1114.00	1116.00	2.00	
z1ANc	1116.00	1148.00	32.00	
z1NA	1148.00	1157.00	9.00	
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Kirchheilingen 84/1969**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4411570.90	5672059.80	251.40	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	50.00	50.00	
mm	50.00	126.00	76.00	
mu	126.00	228.00	102.00	
so	228.00	391.50	163.50	
sm	391.50	572.00	180.50	
su	572.00	890.00	318.00	
z7-z4Tb	890.00	901.50	11.50	
z4ANb			0.00	
z4NA	901.50	909.80	8.30	
z4ANa	909.80	910.50	0.70	
z4Ta-z3Tb	910.50	912.00	1.50	
z3NA	912.00	954.50	42.50	
z3AN	954.50	987.00	32.50	
z3CA	987.00	992.00	5.00	
z3Ta-z2Tb	992.00	1008.00	16.00	
z2ANb	1008.00	1009.00	1.00	
z2NAr	1009.00	1010.50	1.50	
z2KSt	1010.50	1021.00	10.50	Sylvinite
z2NA	1021.00	1075.00	54.00	
z2ANa	1075.00	1084.00	9.00	
z2CA	1084.00	1130.00	46.00	
z1ANc	1130.00	1133.80	3.80	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 6/1955**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4409240.00	5667706.60	270.60	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	33.00	33.00	
mo	33.00	98.50	65.50	
mm	98.50	182.00	83.50	
mu	182.00	285.00	103.00	
so	285.00	446.00	161.00	
sm	446.00	628.00	182.00	
su	628.00	958.00	330.00	
z7-z4Tb			0.00	
z4ANb	958.00			
z4NA			9.00	
z4ANa				
z4Ta-z3Tb		967.00		
z3NA	967.00			
z3AN			78.00	
z3CA				
z3Ta-z2Tb		1045.00		
z2ANb			0.00	
z2NAr			0.00	
z2KSt			0.00	
z2NA	1045.00	1081.00	36.00	
z2ANa	1081.00	1088.42	7.42	
z2CA	1088.42	1155.90	67.48	
z1ANc	1155.90	1158.70	2.80	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 7/1956**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4410747.27	5665700.68	253.60	
Stratigraphy	From	To	Thickness (m)	
q	0.00	12.00	12.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	12.00	17.00	5.00	
mo	17.00	61.50	44.50	
mm	61.50	143.00	81.50	
mu	143.00	245.00	102.00	
so	245.00	408.50	163.50	
sm	408.50	590.00	181.50	
su	590.00	912.50	322.50	
z7-z4Tb			0.00	
z4ANb	912.50			
z4NA			10.50	
z4ANa				
z4Ta-z3Tb		923.00		
z3NA	923.00			
z3AN			70.00	
z3CA				
z3Ta-z2Tb		993.00		
z2ANb			0.00	
z2NAr	993.00			
z2KSt			31.90	barren
z2NA		1024.90		
z2ANa	1024.90	1034.60	9.70	
z2CA	1034.60	1084.00	49.40	
z1ANc	1084.00	1096.00	12.00	
z1NA	1096.00	1285.00	189.00	
z1ANa	1285.00	1331.50	46.50	
z1CAa	1331.50			
z1Ta			4.50	
z1BK		1336.00		
Basement	1336.00	1346.95	10.95	

Drill Hole	**E Langensalza 8/1956**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4409311.50	5670173.79	256.00	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	42.00	42.00	
mo	42.00	109.00	67.00	
mm	109.00	192.00	83.00	
mu	192.00	297.00	105.00	
so	297.00	457.00	160.00	
sm	457.00	466.50	9.50	
su	466.50	951.50	485.00	
z7-z4Tb			0.00	
z4ANb	951.50	953.50	2.00	
z4NA	953.50	967.00	13.50	
z4ANa	967.00	970.00	3.00	
z4Ta-z3Tb	970.00	972.00	2.00	
z3NA	972.00	1003.00	31.00	
z3AN	1003.00	1032.00	29.00	
z3CA	1032.00	1034.00	2.00	
z3Ta-z2Tb	1034.00	1043.00	9.00	
z2ANb			0.00	
z2NAr			0.00	
z2KSt			0.00	
z2NA	1043.00	1070.00	27.00	
z2ANa	1070.00	1087.00	17.00	
z2CA	1087.00	1139.95	52.95	
z1ANc	1139.95	1140.70	0.75	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 17/1957**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4412098.99	5665466.14	232.40	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	62.00	62.00	
mm	62.00	145.00	83.00	
mu	145.00	246.00	101.00	
so	246.00	403.50	157.50	
sm	403.50	582.00	178.50	
su	582.00	911.50	329.50	
z7-z4Tb			0.00	
z4ANb	911.50			
z4NA			8.00	
z4ANa				
z4Ta-z3Tb		919.50		
z3NA	919.50	939.00	19.50	
z3AN	939.00	971.50	32.50	
z3CA	971.50	973.50	2.00	
z3Ta-z2Tb	973.50	985.00	11.50	
z2ANb			0.00	
z2NAr			0.00	
z2KSt			0.00	
z2NA	985.00	1022.00	37.00	
z2ANa	1022.00	1041.00	19.00	
z2CA	1041.00	1086.00	45.00	
z1ANc	1086.00	1088.00	2.00	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 20E/1959**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4409825.20	5666963.40	244.60	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	64.00	64.00	
mm	64.00	146.00	82.00	
mu	146.00	249.00	103.00	
so	249.00	411.50	162.50	
sm	411.50	588.00	176.50	
su	588.00	916.50	328.50	
z7-z4Tb			0.00	
z4ANb	916.50	917.20	0.70	
z4NA	917.20	922.00	4.80	
z4ANa	922.00	923.00	1.00	
z4Ta-z3Tb	923.00	924.00	1.00	
z3NA	924.00	955.50	31.50	
z3AN	955.50	983.50	28.00	
z3CA	983.50	986.00	2.50	
z3Ta-z2Tb	986.00	994.00	8.00	
z2ANb	994.00	994.80	0.80	
z2NAr	994.80	995.80	1.00	
z2KSt	995.80	1002.00	6.20	Sylvinite
z2NA	1002.00	1028.00	26.00	
z2ANa	1028.00	1037.70	9.70	
z2CA	1037.70	1088.60	50.90	
z1ANc	1088.60	1089.60	1.00	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 21/1960**			Remark	Percentage [K_2O%]
Location	Easting	Northing	Elev. (MSL)		
	4411494.20	5666006.50	255.30		
Stratigraphy	From	To	Thickness (m)		
q			0.00		
t			0.00		
kr			0.00		
j			0.00		
k (ku)	0.00	5.50	5.50		
mo	5.50	71.00	65.50		
mm	71.00	151.00	80.00		
mu	151.00	253.50	102.50		
so	253.50	418.00	164.50		
sm	418.00	596.00	178.00		
su	596.00	925.00	329.00		
z7-z4Tb			0.00		
z4ANb	925.00	926.00	1.00		
z4NA	926.00	938.00	12.00		
z4ANa	938.00	938.70	0.70		
z4Ta-z3Tb	938.70	940.20	1.50		
z3NA	940.20	1020.00	79.80		
z3AN	1020.00	1063.00	43.00		
z3CA	1063.00	1067.00	4.00		
z3Ta-z2Tb	1067.00	1079.15	12.15		
z2ANb	1079.15	1080.25	1.10		
z2NAr			0.00		
z2KSt	1080.25	1089.75	9.50	Sylvinite	
z2NA	1089.75	1145.00	55.25		
z2ANa	1145.00	1164.00	19.00		
z2CA	1164.00	1207.00	43.00		
z1ANc	1207.00	1208.50	1.50		
z1NA					
z1ANa					
z1CAa					
z1Ta					
z1BK					
Basement					
	1079.60	1080.25	0.65		1.00
	1080.25	1080.45	0.20		0.70
	1080.45	1081.95	1.50		19.30
	1081.95	1083.75	1.80		24.10
	1083.75	1084.60	0.85		20.20
	1084.60	1086.50	1.90		19.30
	1086.50	1088.35	1.85		13.20
	1088.35	1089.75	1.40		9.60
	1089.75	1092.10	2.35		3.10
	1093.30	1096.80	3.50		5.10
	1096.80	1100.70	3.90		2.50

Drill Hole	**E Langensalza 25/1962**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4412547.40	5663834.00	220.00	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	62.50	62.50	
mm	62.50	140.00	77.50	
mu	140.00	244.00	104.00	
so	244.00	415.00	171.00	
sm	415.00	593.00	178.00	
su	593.00	920.00	327.00	
z7-z4Tb			0.00	
z4ANb	920.00	921.00	1.00	
z4NA	921.00	924.50	3.50	
z4ANa	924.50	925.00	0.50	
z4Ta-z3Tb	925.00	927.50	2.50	
z3NA	927.50	965.00	37.50	
z3AN	965.00	990.50	25.50	
z3CA	990.50	993.00	2.50	
z3Ta-z2Tb	993.00	1004.00	11.00	
z2ANb	1004.00	1006.00	2.00	
z2NAr	1006.00	1006.50	0.50	
z2KSt	1006.50	1014.00	7.50	Sylvinite
z2NA	1014.00	1043.50	29.50	
z2ANa	1043.50	1053.50	10.00	
z2CA	1053.50	1102.00	48.50	
z1ANc	1102.00	1112.00	10.00	
z1NA	1112.00	1148.00	36.00	
z1ANa	1148.00	1326.50	178.50	
z1CAa	1326.50	1333.00	6.50	
z1Ta	1333.00	1333.40	0.40	
z1BK	1333.40	1334.00	0.60	
Basement	1334.00	1347.00	13.00	

Drill Hole	**E Langensalza 26/1962**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4416153.50	5664158.10	206.10	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	4.00	4.00	
mo	4.00	70.00	66.00	
mm	70.00	146.50	76.50	
mu	146.50	250.00	103.50	
so	250.00	418.40	168.40	
sm	418.40	596.50	178.10	
su	596.50	923.00	326.50	
z7-z4Tb			0.00	
z4ANb	923.00	924.00	1.00	
z4NA	924.00	931.00	7.00	
z4ANa	931.00	931.50	0.50	
z4Ta-z3Tb	931.50	933.00	1.50	
z3NA	933.00	964.50	31.50	
z3AN	964.50	995.00	30.50	
z3CA	995.00	998.50	3.50	
z3Ta-z2Tb	998.50	1009.50	11.00	
z2ANb	1009.50	1011.00	1.50	
z2NAr	1011.00	1011.50	0.50	
z2KSt	1011.50	1019.00	7.50	Carnallitite
z2NA	1019.00	1052.00	33.00	
z2ANa	1052.00	1065.40	13.40	
z2CA	1065.40	1118.90	53.50	
z1ANc	1118.90	1119.90	1.00	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 27/1962**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4417383.70	5662810.30	240.00	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	23.00	23.00	
mo	23.00	88.00	65.00	
mm	88.00	162.00	74.00	
mu	162.00	266.00	104.00	
so	266.00	435.00	169.00	
sm	435.00	619.00	184.00	
su	619.00	944.00	325.00	
z7-z4Tb			0.00	
z4ANb	944.00	945.00	1.00	
z4NA	945.00	949.00	4.00	
z4ANa	949.00	949.50	0.50	
z4Ta-z3Tb	949.50	951.00	1.50	
z3NA	951.00	991.00	40.00	
z3AN	991.00	1024.00	33.00	
z3CA	1024.00	1027.00	3.00	
z3Ta-z2Tb	1027.00	1038.00	11.00	
z2ANb	1038.00	1039.50	1.50	
z2NAr	1039.50	1043.00	3.50	
z2KSt	1043.00	1062.00	19.00	barren
z2NA	1062.00	1102.50	40.50	
z2ANa	1102.50	1115.60	13.10	
z2CA	1115.60	1164.10	48.50	
z1ANc	1164.10	1165.90	1.80	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Langensalza 35/1970**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4410553.00	5665310.80	236.20	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	56.00	56.00	
mm	56.00	139.00	83.00	
mu	139.00	237.00	98.00	
so	237.00	401.00	164.00	
sm	401.00	580.00	179.00	
su	580.00	894.00	314.00	
z7-z4Tb	894.00	906.00	12.00	
z4ANb			0.00	
z4NA	906.00	912.00	6.00	
z4ANa	912.00	913.00	1.00	
z4Ta-z3Tb	913.00	914.50	1.50	
z3NA	914.50	946.00	31.50	
z3AN	946.00	978.50	32.50	
z3CA	978.50	983.00	4.50	
z3Ta-z2Tb	983.00	992.00	9.00	
z2ANb			0.00	
z2NAr			0.00	
z2KSt	992.00	1015.00	23.00	Sylvinite
z2NA	1015.00	1028.00	13.00	
z2ANa	1028.00	1032.35	4.35	
z2CA	1032.35	1088.00	55.65	
z1ANc	1088.00	1090.00	2.00	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

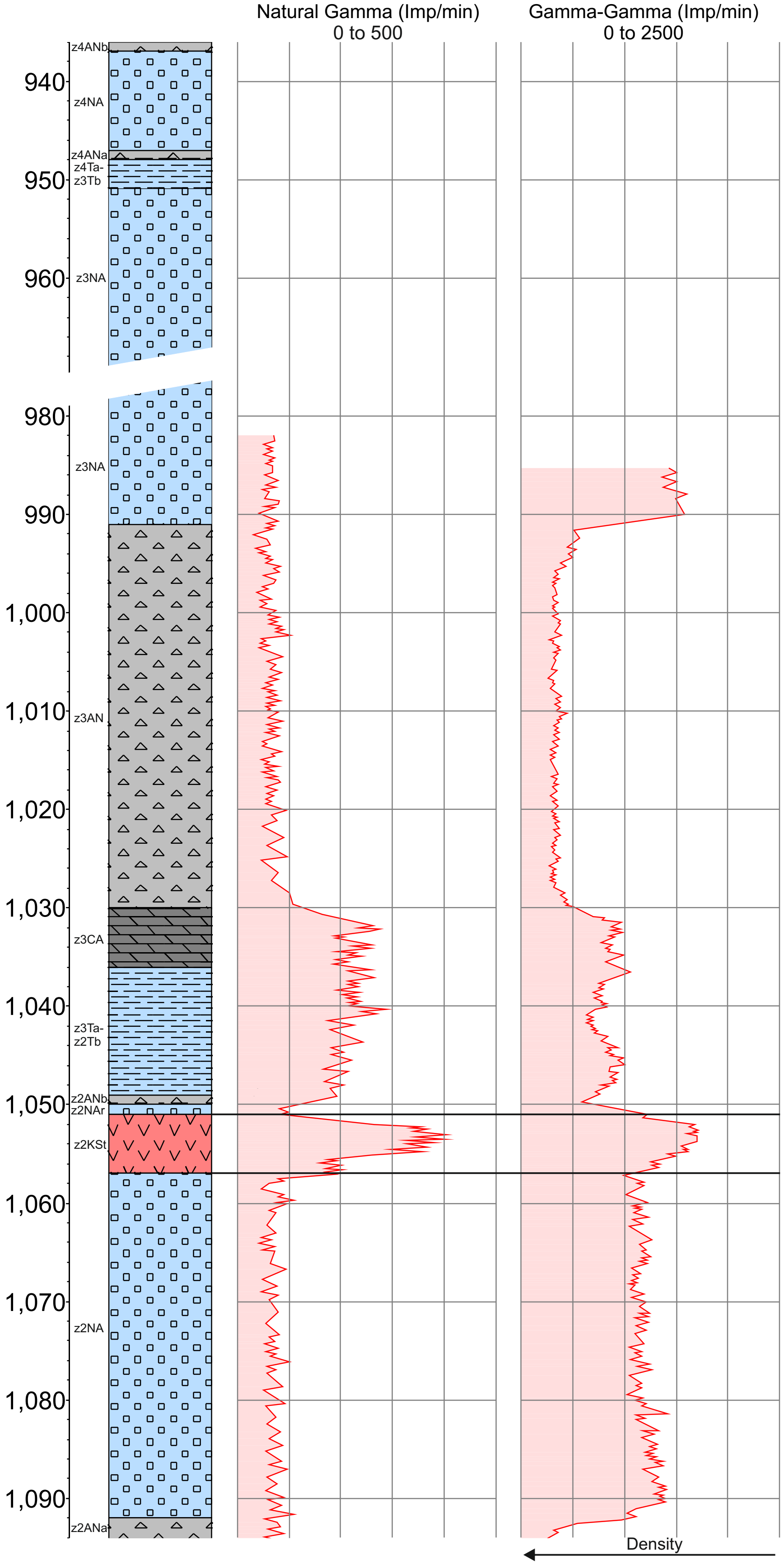
Drill Hole	**E Langensalza 36/1970**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4411469.50	5665143.50	233.30	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)			0.00	
mo	0.00	51.00	51.00	
mm	51.00	127.00	76.00	
mu	127.00	230.00	103.00	
so	230.00	393.00	163.00	
sm	393.00	573.00	180.00	
su	573.00	891.00	318.00	
z7-z4Tb	891.00	902.00	11.00	
z4ANb			0.00	
z4NA	902.00	907.70	5.70	
z4ANa	907.70	908.50	0.80	
z4Ta-z3Tb	908.50	910.00	1.50	
z3NA	910.00	945.00	35.00	
z3AN	945.00	980.00	35.00	
z3CA	980.00	984.50	4.50	
z3Ta-z2Tb	984.50	995.00	10.50	
z2ANb	995.00	996.00	1.00	
z2NAr			0.00	
z2KSt	996.00	1015.00	19.00	Sylvinite
z2NA	1015.00	1030.00	15.00	
z2ANa	1030.00	1045.20	15.20	
z2CA	1045.20	1064.60	19.40	
z1ANc				
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Tennstedt 1/1969**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4417218.9	5669625.1	176.8	
Stratigraphy	From	To	Thickness (m)	
q	0.00	2.00	2.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	2.00	4.00	2.00	
mo	4.00	71.00	67.00	
mm	71.00	144.50	73.50	
mu	144.50	248.00	103.50	
so	248.00	438.00	190.00	
sm	438.00	631.00	193.00	
su	631.00	943.00	312.00	
z7-z4Tb	943.00	955.70	12.70	
z4ANb	955.70	956.00	0.30	
z4NA	956.00	967.00	11.00	
z4ANa			0.00	Fault
z4Ta-z3Tb			0.00	
z3NA			0.00	
z3AN	967.00	986.00	19.00	
z3CA	986.00	990.00	4.00	
z3Ta-z2Tb	990.00	995.00	5.00	
z2ANb	995.00	996.00	1.00	
z2NAr	996.00	997.50	1.50	
z2KSt	997.50	1002.00	4.50	Carnallitite
z2NA	1002.00	1010.00	8.00	
z2ANa	1010.00	1024.50	14.50	
z2CA	1024.50	1065.00	40.50	
z1ANc	1065.00	1069.00	4.00	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

Drill Hole	**E Tennstedt 2/1970**			Remark
Location	Easting	Northing	Elev. (MSL)	
	4417308.20	5669285.70	186.80	
Stratigraphy	From	To	Thickness (m)	
q			0.00	
t			0.00	
kr			0.00	
j			0.00	
k (ku)	0.00	16.00	16.00	
mo	16.00	82.00	66.00	
mm	82.00	163.00	81.00	
mu	163.00	268.00	105.00	
so	268.00	444.00	176.00	
sm	444.00	634.00	190.00	
su	634.00	944.00	310.00	
z7-z4Tb	944.00	958.00	14.00	
z4ANb			0.00	
z4NA	958.00	977.00	19.00	
z4ANa			0.00	Fault
z4Ta-z3Tb			0.00	
z3NA	977.00	1014.00	37.00	
z3AN	1014.00	1047.50	33.50	
z3CA	1047.50	1051.00	3.50	
z3Ta-z2Tb	1051.00	1062.00	11.00	
z2ANb	1062.00	1063.00	1.00	
z2NAr	1063.00	1067.50	4.50	
z2KSt	1067.50	1074.00	6.50	Carnallitite
z2NA	1074.00	1102.00	28.00	
z2ANa	1102.00	1125.70	23.70	
z2CA	1125.70	1156.70	31.00	
z1ANc	1156.70	1159.40	2.70	
z1NA				
z1ANa				
z1CAa				
z1Ta				
z1BK				
Basement				

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Allmenhausen 10/1961	
Depth z2KSt (m below surface)	1051.0 - 1057.0
Top z2KSt (m related to MSL)	-715.6
Thickness z2KSt (m)	6.0
Facies	Carnallitite
Cored	no
Geophysical Logging Probe	1 ZR Typ СИ-4Г



JORC Report Gräfentonna Licence Area

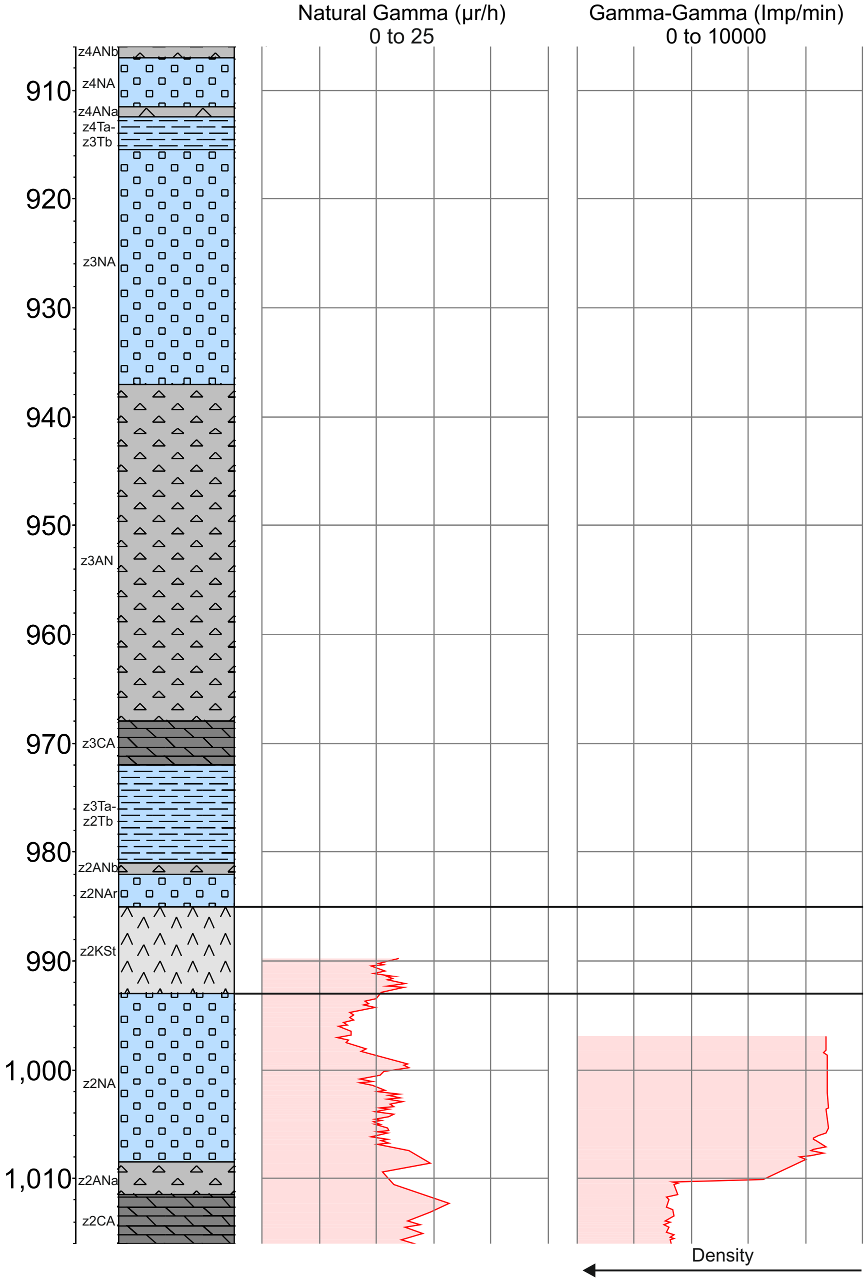
Appendix 5.1
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

ERCOSPLAN Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Bienstädt 2/1961

Depth z2KSt (m below surface)	985.0 - 993.0
Top z2KSt (m related to MSL)	-635.0
Thickness z2KSt (m)	8.0
Facies	Rock Salt / barren
Cored	no
Geophysical Logging Probe	6 ZR Typ BC-9 (NG), 1 ZR Typ СИ-4Г (GG)



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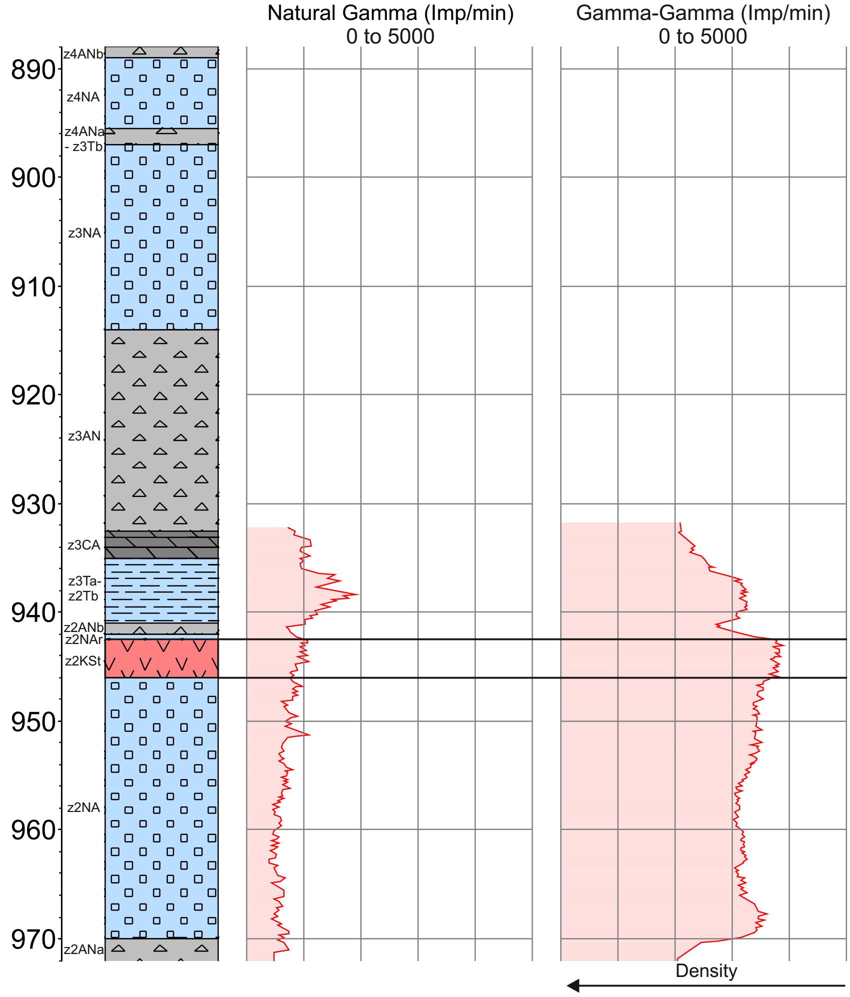
Appendix 5.2
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

ERCOSPLAN Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Fahner Höhe 8/1960	
Depth z2KSt (m below surface)	942.5 - 946.0
Top z2KSt (m related to MSL)	-540.3
Thickness z2KSt (m)	3.5
Facies	Carnallitite
Cored	no
Geophysical Logging Probe	unknown



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Appendix 5.3
Drill Hole Stratigraphy with
Natural Gamma and
Gamma-Gamma Log

ERCOSPLAN
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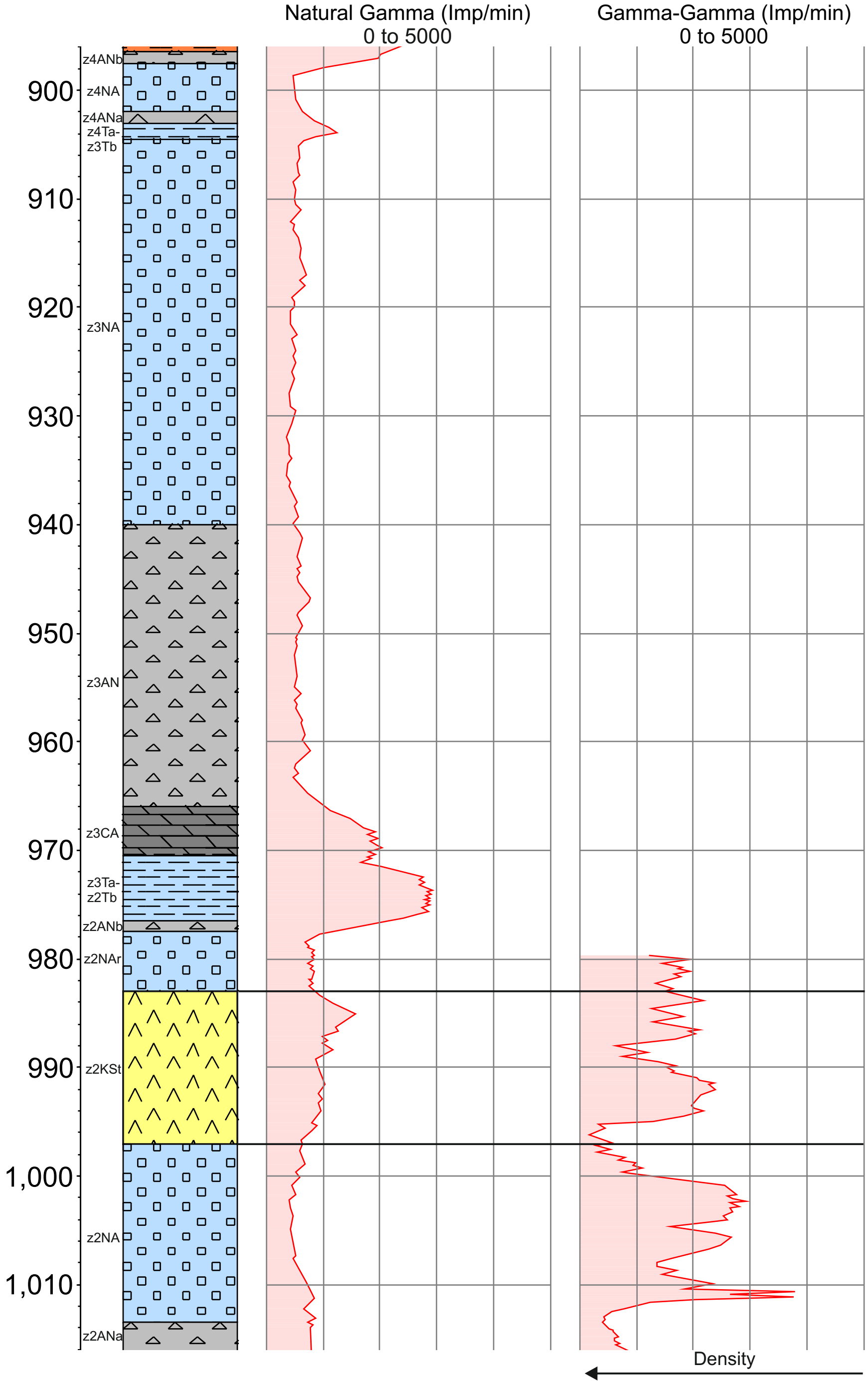
ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Fahner Höhe 10/1961	
Depth z2KSt (m below surface)	983.0 - 997.0
Top z2KSt (m related to MSL)	-686.2
Thickness z2KSt (m)	14.0
Facies	Sylvinite
Cored	yes
Geophysical Logging Probe	6 ZR Typ СИ-4Г (NG), 2 ZR Typ СИ-4Г (GG)



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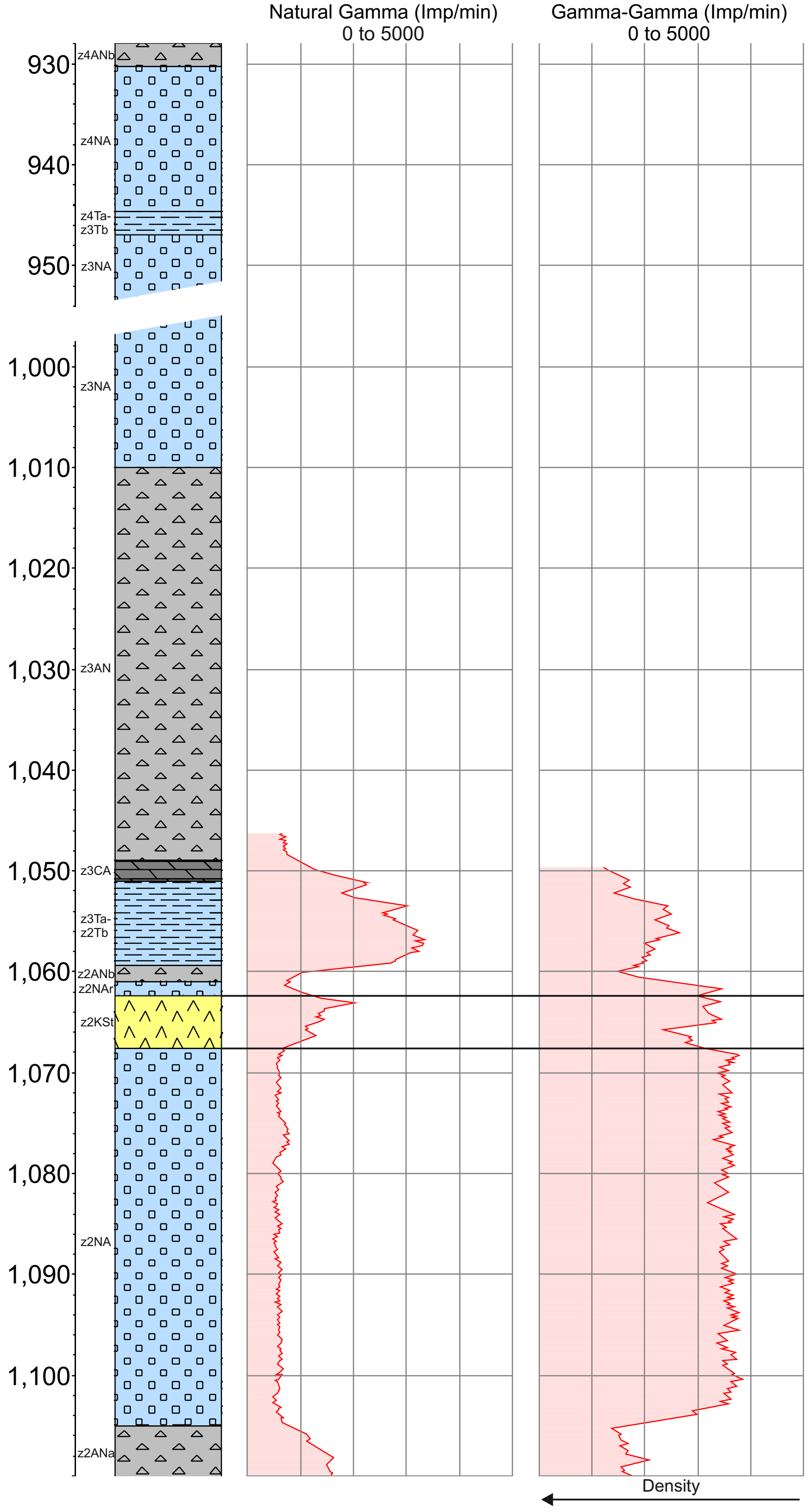
Appendix 5.4
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

ERCOSPLAN
Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Kirchheilingen 35/1961	
Depth z2KSt (m below surface)	1062.4 - 1067.6
Top z2KSt (m related to MSL)	-776.8
Thickness z2KSt (m)	5.2
Facies	Sylvinite
Cored	no
Geophysical Logging Probe	6 ZR Typ BC-9 (NG), 1 ZR Typ СИ-4Г (GG)



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Appendix 5.5
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

ERCOSPLAN Geotechnik und Bergbau

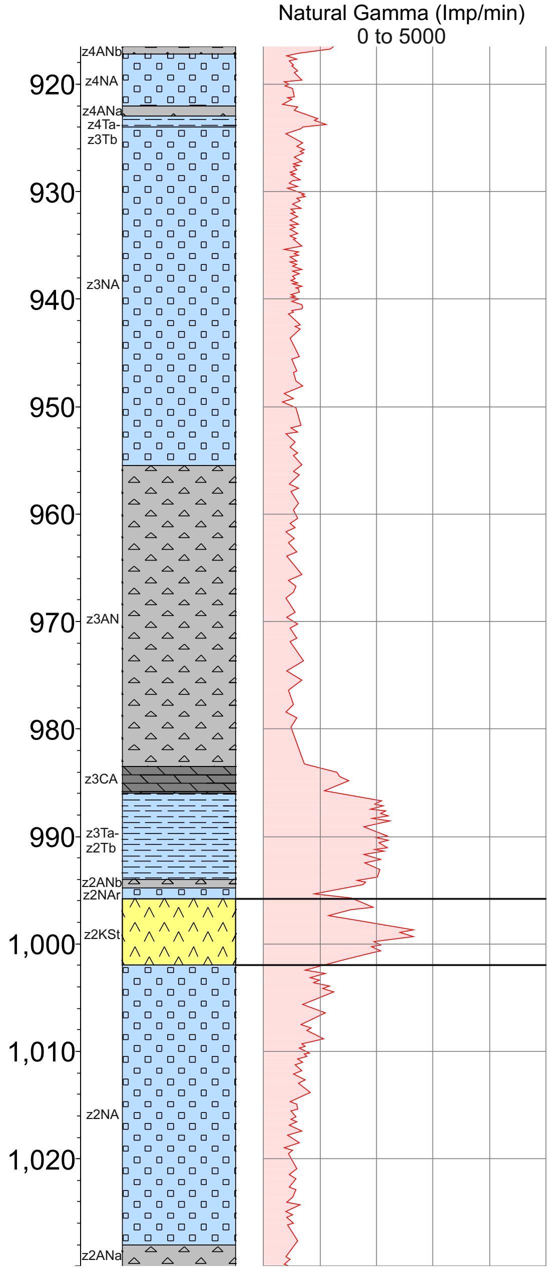
ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH

Arnstaedter Strasse 28
99096 Erfurt/Germany

phone: +49 361 3810 500
fax: +49 361 3810 505

e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Langensalza 20E/1959	
Depth z2KSt (m below surface)	995.8 - 1002.0
Top z2KSt (m related to MSL)	-751.2
Thickness z2KSt (m)	6.2
Facies	Sylvinite
Cored	no
Geophysical Logging Probe	unknown



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Appendix 5.6
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

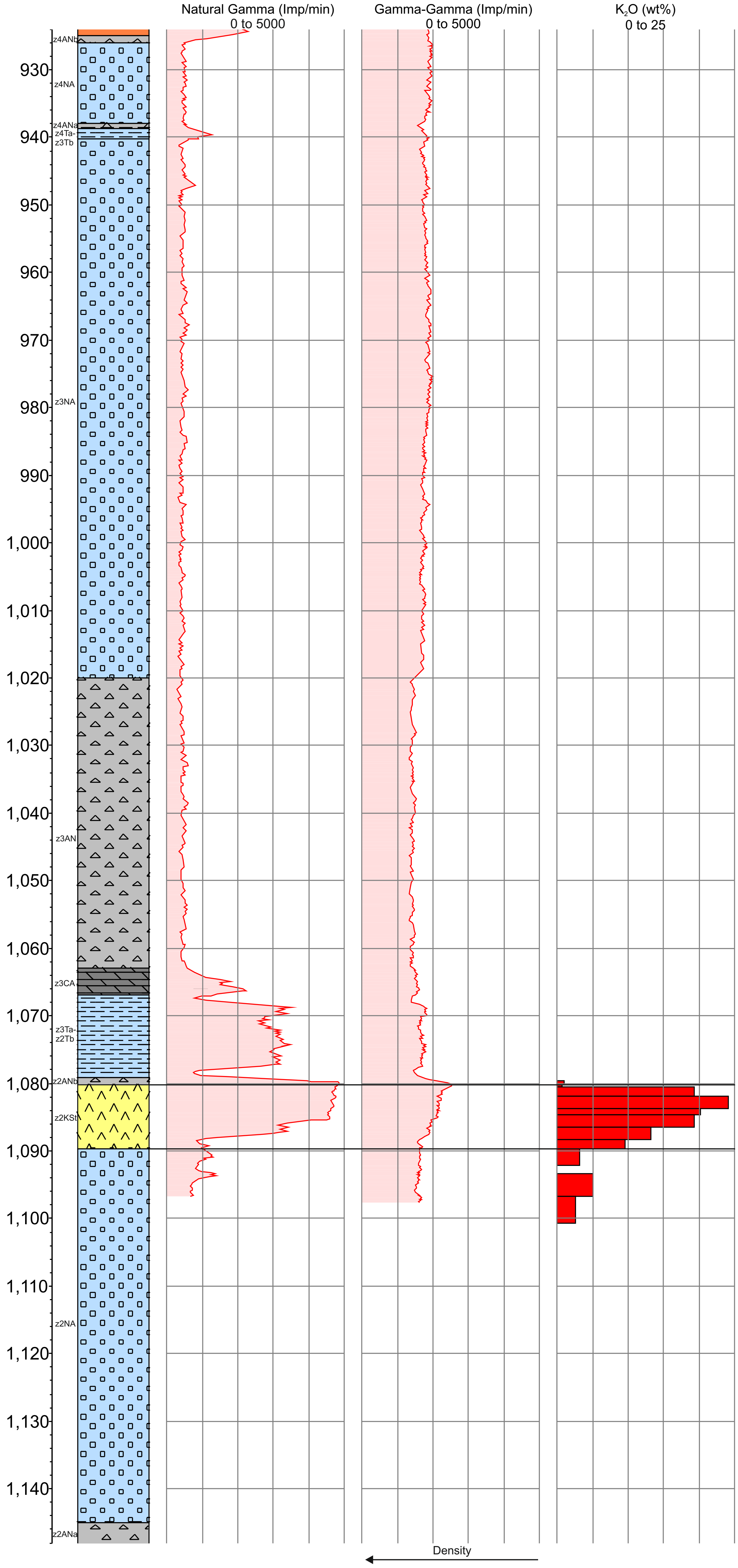
**ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH**

Arnstaedter Strasse 28
99096 Erfurt/Germany

phone: +49 361 3810 500
fax: +49 361 3810 505

e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Langensalza 21/1960	
Depth z2KSt (m below surface)	1080.25 - 1089.75
Top z2KSt (m related to MSL)	-824.95
Thickness z2KSt (m)	9.5
Facies	Sylvinite
Cored	yes
Geophysical Logging Probe	unknown



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Appendix 5.7
Drill Hole Stratigraphy with Natural Gamma, Gamma-Gamma Log and K_2O Grade

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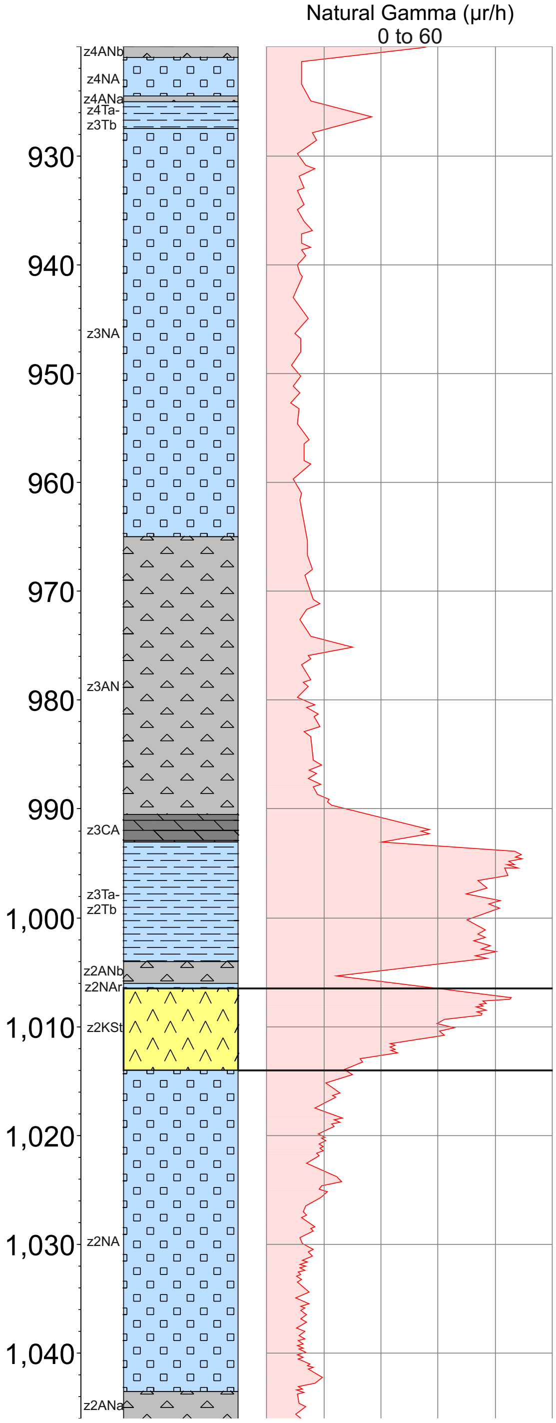
E Langensalza 25/1962	
Depth z2KSt (m below surface)	1006.5 - 1014.0
Top z2KSt (m related to MSL)	-786.5
Thickness z2KSt (m)	7.5
Facies	Sylvinite
Cored	no
Geophysical Logging Probe	6 ZR Typ СИ-4Г



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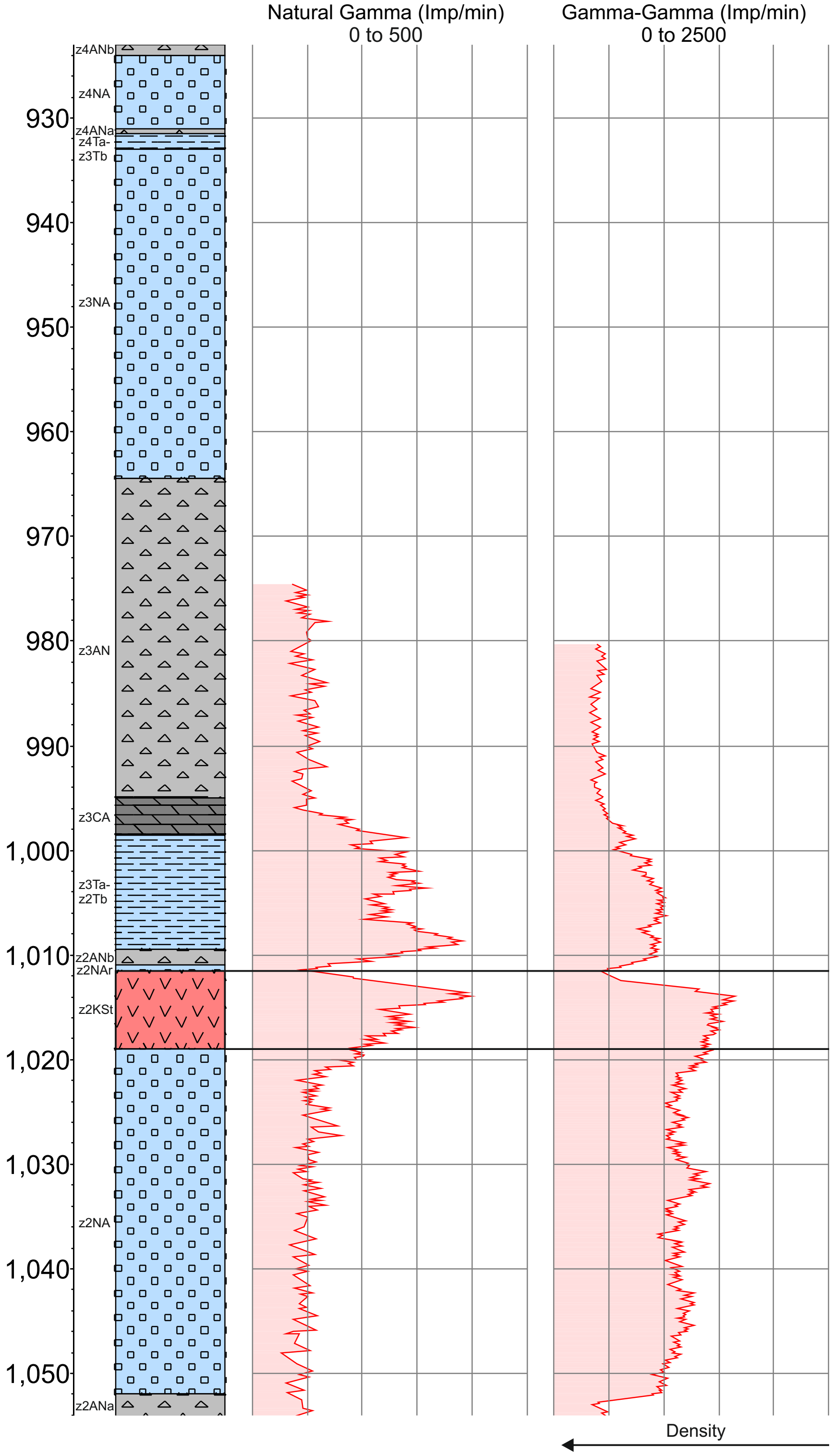
Appendix 5.8
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

E Langensalza 26/1962	
Depth z2KSt (m below surface)	1011.5 - 1019.0
Top z2KSt (m related to MSL)	-805.4
Thickness z2KSt (m)	7.5
Facies	Carnallitite
Cored	no
Geophysical Logging Probe	1 ZR Typ BC-9



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Appendix 5.9
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

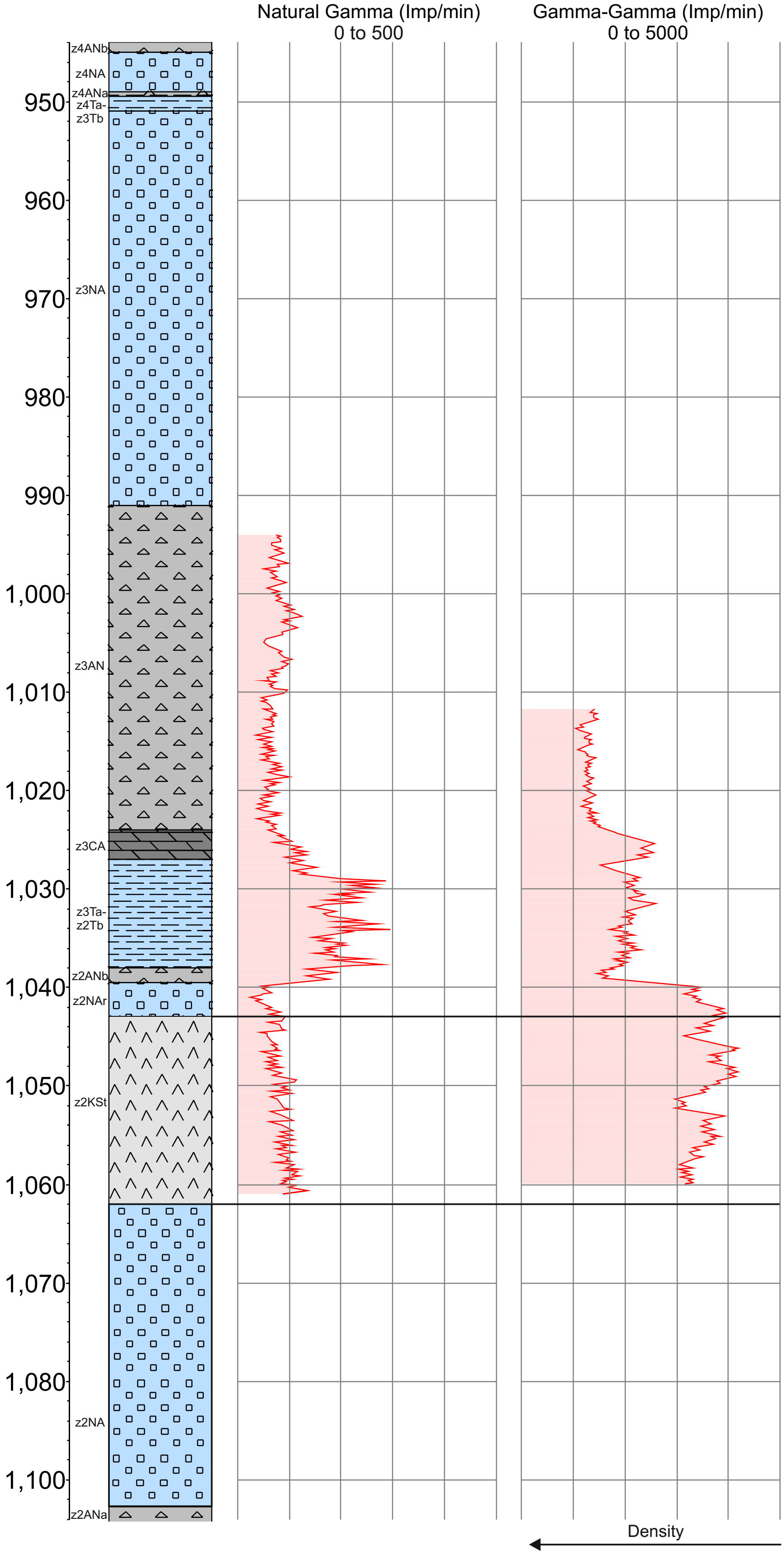
ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH

Arnstaedter Strasse 28
99096 Erfurt/Germany

phone: +49 361 3810 500
fax: +49 361 3810 505

e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

E Langensalza 27/1962	
Depth z2KSt (m below surface)	1043.0 - 1087.0
Top z2KSt (m related to MSL)	-803.0
Thickness z2KSt (m)	19.0
Facies	Rock Salt / barren
Cored	no
Geophysical Logging Probe	1 ZR Typ СИ-4Г



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Appendix 5.10
Drill Hole Stratigraphy with Natural Gamma and Gamma-Gamma Log

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ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com

	Series	(Regional) Group	Formation/Sequence	Horizon (Local Name)	Stratigraphic Symbol		Thickness [m] min	Thickness [m] max
Quaternary					q		1.5	12.0
								Hiatus
Triassic	Keuper	Unterer Keuper			ku		2.0	42.0
	Muschelkalk	Oberer Muschelkalk			mo		20.0	69.0
		Mittlerer Muschelkalk			mm		65.0	83.5
		Unterer Muschelkalk			mu		98.0	113.0
	Buntsandstein	Oberer Buntsandstein	Röt 4		so4	so	39.5	262.5
			Röt 3		so3			
			Röt 2		so2			
			Röt 1		so1			
			Roter Röt		soR			
			Pelit-Röt		soP			
			Grauer Röt		soG			
		Mittlerer Buntsandstein	Solling-Folge		smS	sm	9.5	240.0
			Hardegsen-Folge		smH			
			Detfurth-Folge		smD			
			Volpriehausen-Folge		smV			
		Unterer Buntsandstein	Bernburg-Folge		suBG	su	268.7	485.0
			Calvörde-Folge		suC			
Permian	Zechstein		Ohre- bis Fulda-Formation	"Obere Zechsteinletten"	z4Tb-z7		0.0	14.5
			Aller-Formation	Oberer Aller-Anhydrit (Grenz-anhydrit)	z4ANb		0.0	2.3[1]
				Aller-Steinsalz	z4NA		1.5	19.0[1]
				Unterer Aller-Anhydrit (Pegmatitanhydrit)	z4ANa		0.0	3.0[1 2]
			Leine-Formation	"Roter Salzton"	z3Tb-z4Ta		0.0	3.9[1 2]
				Leine-Steinsalz	z3NA		0.0	79.8[3]
				Leine-Anhydrit (Hauptanhydrit)	z3AN		18.5	43.0[3]
				Leine-Karbonat (Plattendolomit)	z3CA		0.0	6.0[3]
			Staßfurt-Formation	"Grauer Salzton"	z2Tb-z3Ta		5.0	24.5[3]
				Deckanhydrit	z2ANb		0.0	2.0
				Decksteinsalz	z2NAr		0.0	5.5[4]
				Kaliflöz Staßfurt	z2KSt		0.0	23.0
				Staßfurt-Steinsalz	z2NA		8.0	76.7
				Staßfurt-Basalanhydrit	z2ANa		3.0	27.0
				Staßfurt-Karbonat/Hauptdolomit	z2CA/z2D		2.0	75.0
			Werra-Formation	Oberer Werra-Anhydrit	z1ANc		0.6	46.0[5]
				Werra-Steinsalz	z1NA		9.0	189.0
				Unterer Werra-Anhydrit	z1ANa		46.5	178.5
				Werra-Karbonat	z1CA		2.0	6.5[6]
				Werra-Ton (Kupferschiefer)	z1T		0.3	0.4[6]
				Zechsteinkonglomerat (Werra-Basalkonglomerat)	z1C		0.6	1.1[6]
Basement							2.0	13.0

[1] For hole *E Langensalza 17/1957* only the thickness from top z4ANb to bottom z3Tb is given with 8 m. For holes *E Langensalza 6/1955* and *E Langensalza 7/1956* the thickness for the same succession is given with 9.0 m and 10.5 m, respectively.
[2] For hole *E Fahner Höhe 8/1960* only the thickness from top z4ANa to bottom z3Tb is given with 1.5 m.
[3] For hole *E Langensalza 6/1955* only the thickness from top z3NA to bottom z2Tb is given with 78.0 m. For hole *E Langensalza 7/1956* only the thickness from top z3Na to bottom z2Tb is given with 70.0 m.
[4] For hole *E Langensalza 7/1956* only the thickness from top z2NAr to bottom z2NA is given with 31.9 m.
[5] For hole *E Fahner Höhe 10/1961* the bottommost 33.0 m of z1ANc are considered an equivalent of rock salt.
[6] For hole *E Langensalza 7/1956* only the thickness from top z1CA to bottom z1C is given with 4.5 m.

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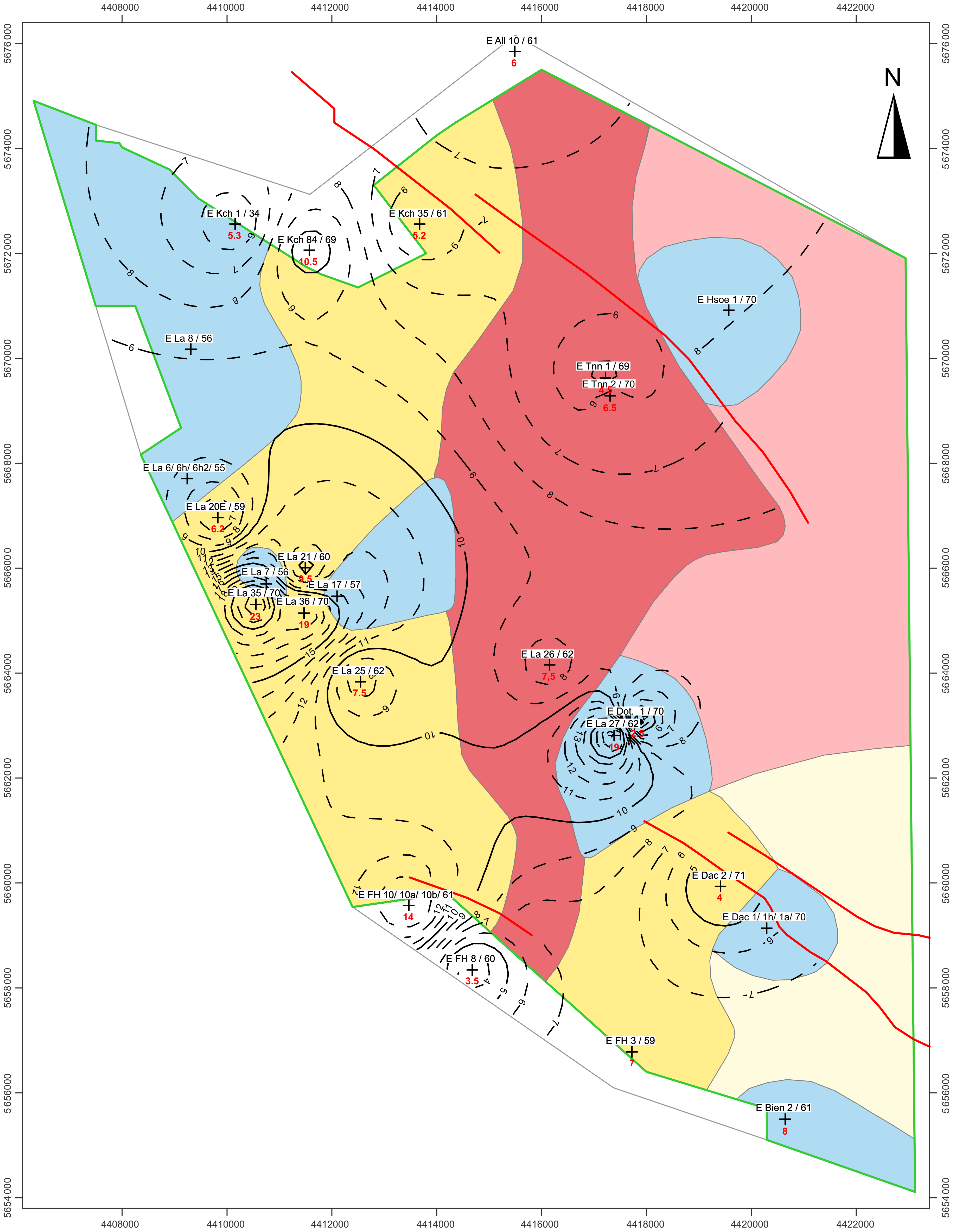
Appendix 6
Stratigraphic Succession in the Gräfentonna Exploration Licence Area derived from Drill Hole Information

ERCOSPLAN Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com



Legend:

- drill holes with z2KSt-thickness [m] (7.5)
- Gräfentonna Exploration Licence area
- modelling area
- faults

Isopach Lines of the Potash Seam:

- major step (5 m)
- minor step (1 m)

Facies of the Potash Seam:

- sylvinite
- carnallitite
- rock salt / barren
- sylvinite, probably
- carnallitite, probably

Scale: 1:75,000

0 2 4 km

Coordinate System: DHDN 3 Degree Gaus Zone 4

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Appendix 7

Isopach Map for the Potash-Bearing Horizon and Facies Distribution in the Gräfentonna Exploration Licence Area

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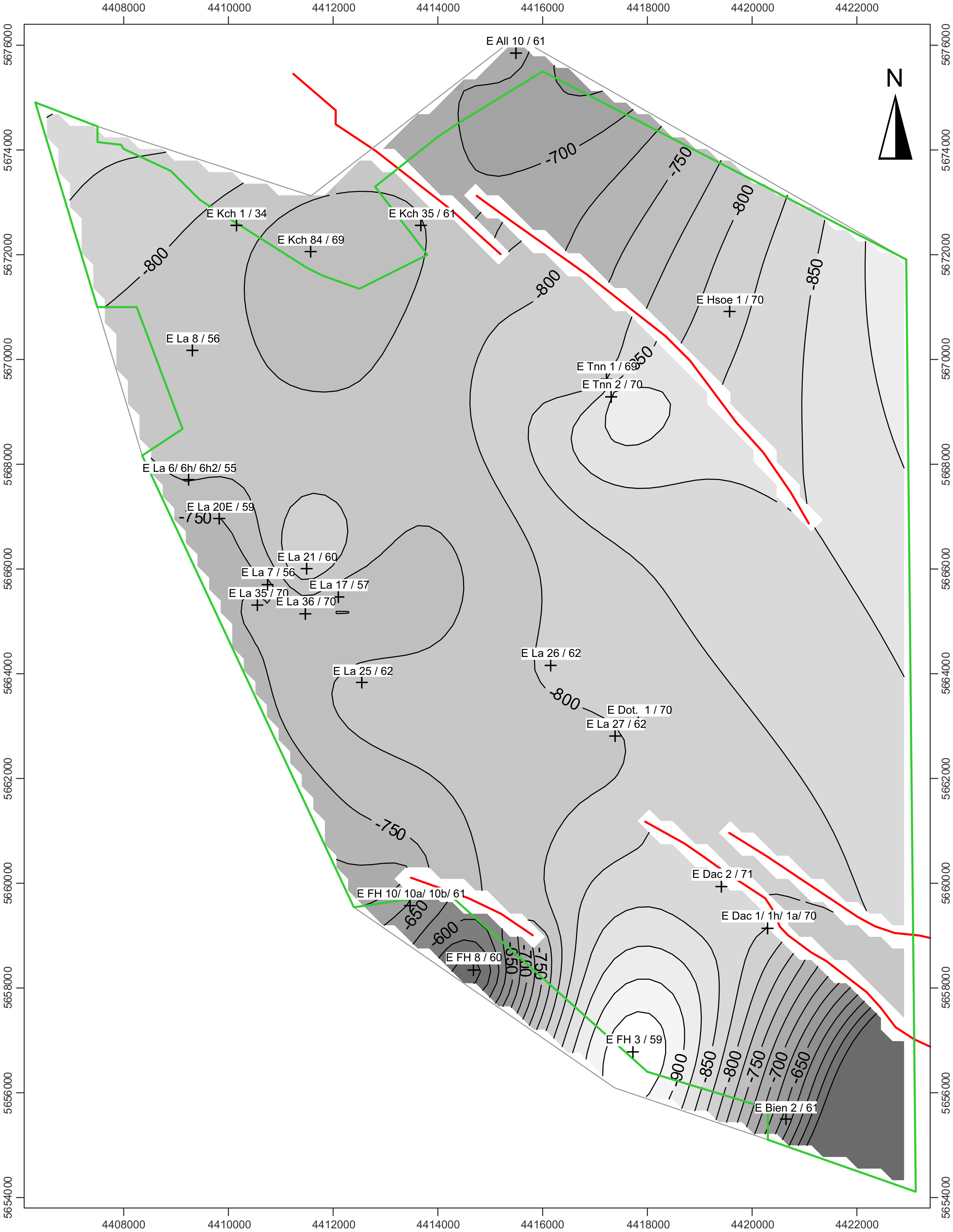
ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com



Legend:

- drill holes
- Gräfentonna Exploration Licence area
- modelling area
- faults
- isobath lines of the base of the lithostratigraphic unit "Grauer Salzton" (z2Tb-z3Ta, [m above see level])

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Appendix 8
Isobath Map of the Base of the Lithostratigraphic Unit Grauer Salzton (z2Tb-z3Ta) in the Gräfentonna Exploration Licence Area

Scale: 1:75,000
0 2 4 km

Coordinate System: DHDN 3 Degree Gaus Zone 4

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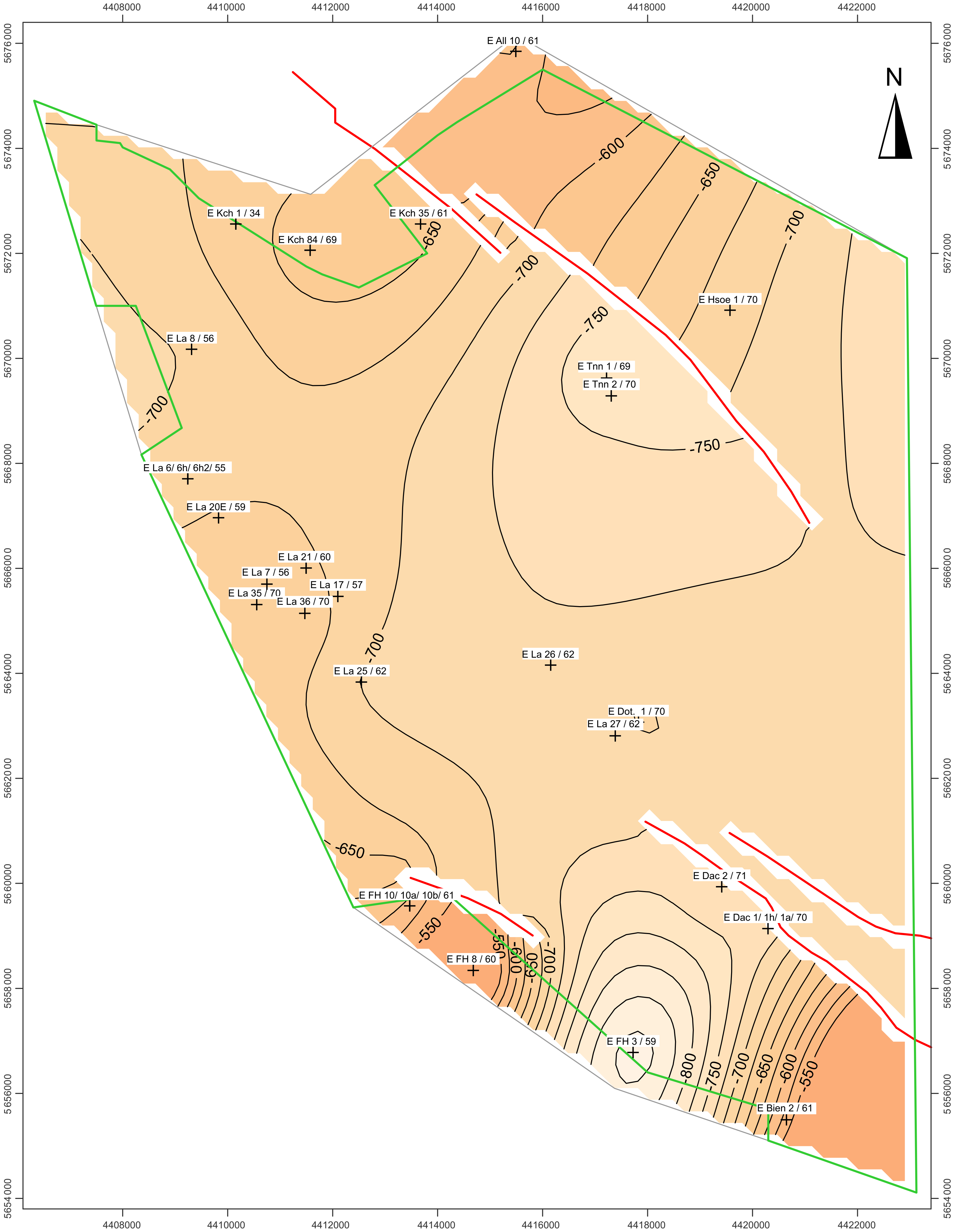
Date: 2017-05-16
Z:\14-069_EastExploration_TechnicalAssistance\05_Geologie\06_Drawings\N02_JORC Gräfentonna\
14-069N02_App_08_Isobath_z2Tb-z3Ta_irev02.cdr

ERCOSPLAN Ingenieurgesellschaft Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com



Legend:

- drill holes
- Gräfentonna Exploration Licence area
- modelling area
- faults
- isobath lines of the base of the lithostratigraphic unit "Unterer Buntsandstein" (su, [m above see level])

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Appendix 9

Isobath Map of the Base of the Lithostratigraphic Unit Unterer Buntsandstein (su) in the Gräfentonna Exploration Licence Area

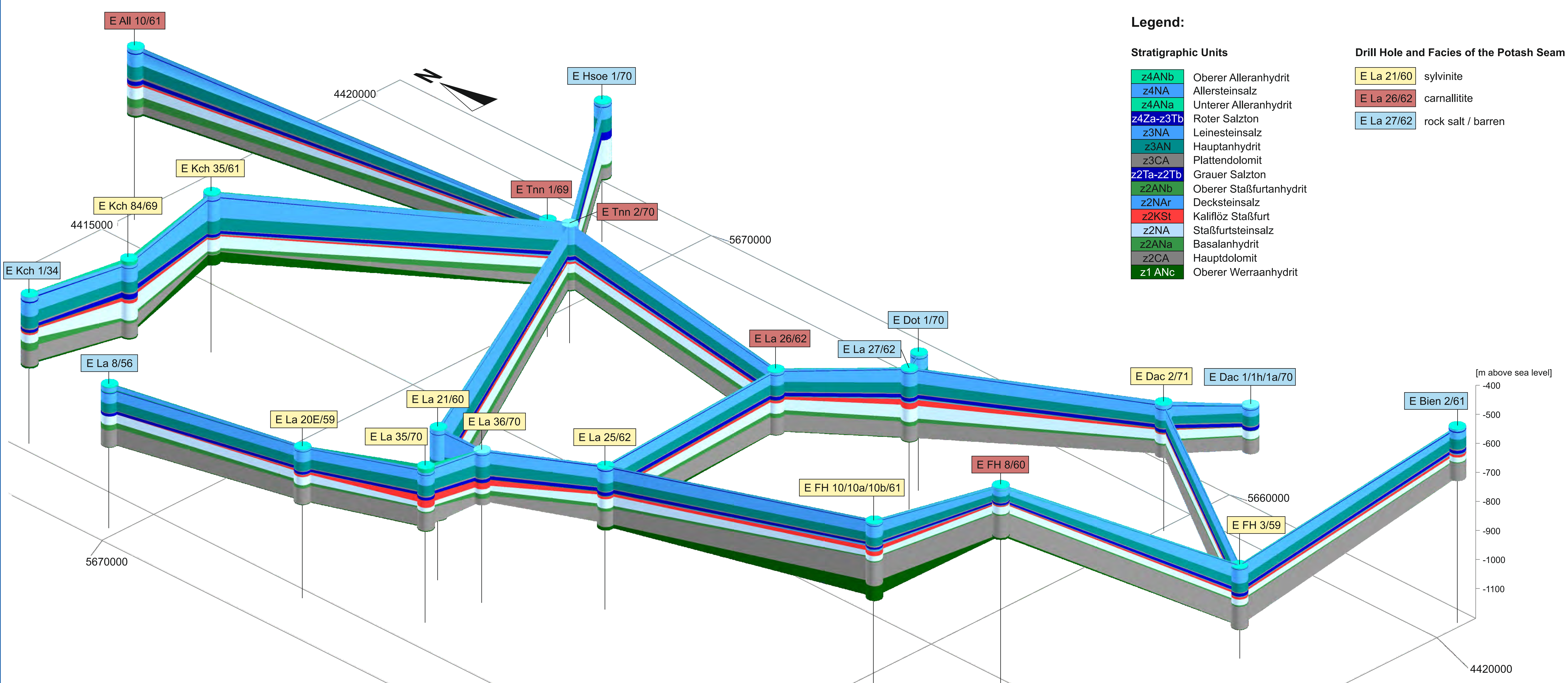
Scale: 1:75,000

0 2 4 km

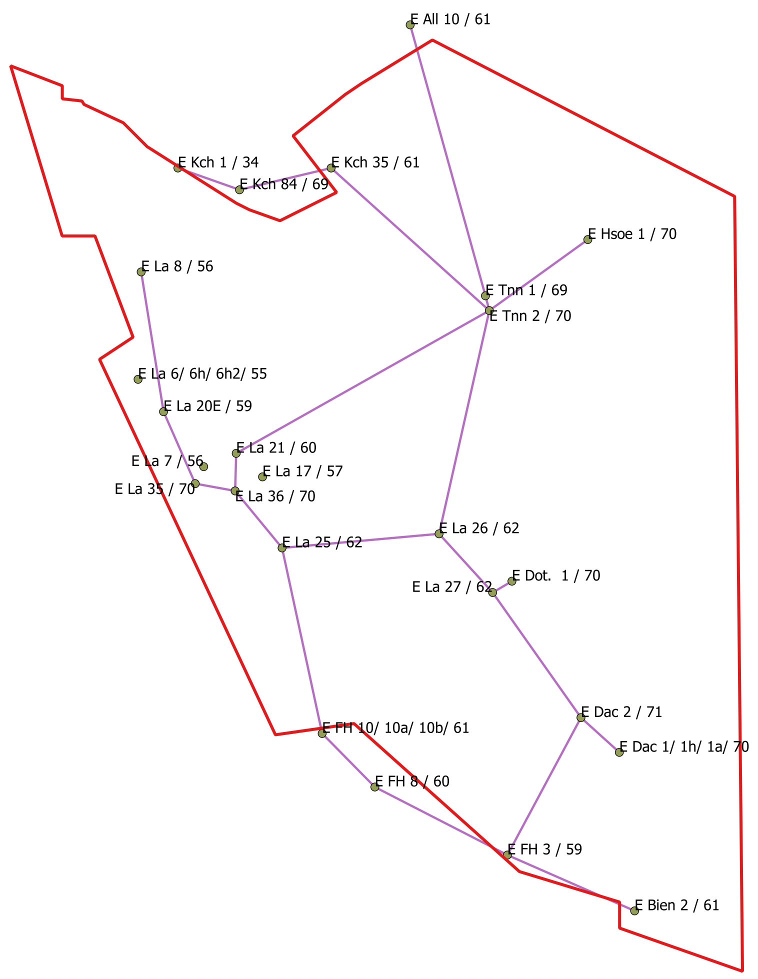
Coordinate System: DHDN 3 Degree Gaus Zone 4

ERCOSPLAN Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH
Arnstaedter Strasse 28
99096 Erfurt/Germany
phone: +49 361 3810 500
fax: +49 361 3810 505
e-mail: mining@ercosplan.com
web: http://www.ercosplan.com



Gräfentonna Exploration Licence Area:



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Appendix 10
Fence Plot of the Gräfentonna Exploration Licence Area

Coordinate System: DHDN 3 Degree Gaus Zone 4
Vertical Exaggeration: 5x

Date: 2017-05-16
Z:\14-069_EastExploration_TechnicalAssistance\05_Geologie\06_Drawings\N02_JORC Gräfentonna\14-069N02_App_10_FencePlot_irev02.cdr

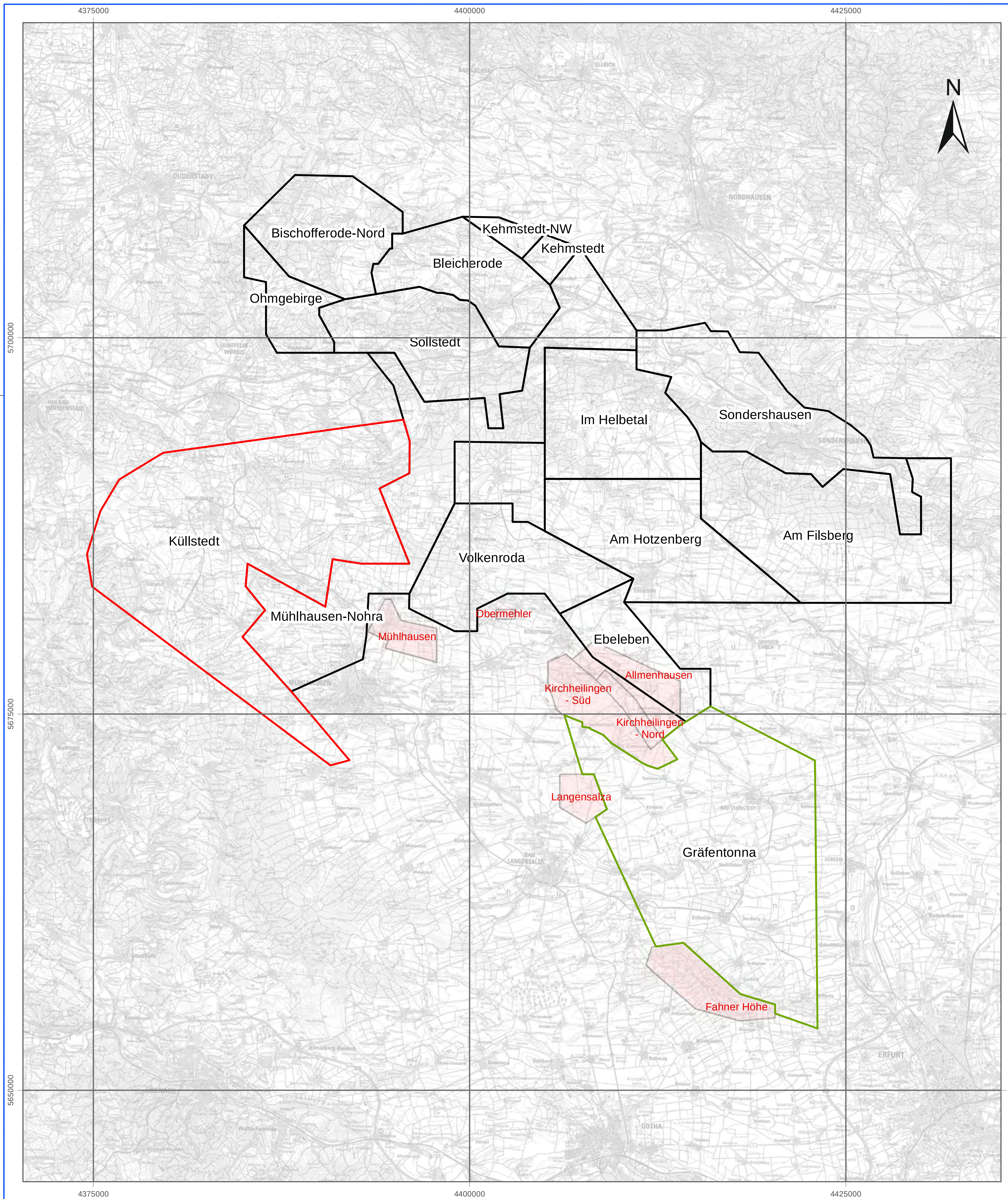
ERCOSPLAN
Geotechnik und Bergbau

ERCOSPLAN Ingenieurgesellschaft
Geotechnik und Bergbau mbH

Arnstaedter Strasse 28
99096 Erfurt/Germany

phone: +49 361 3810 500
fax: +49 361 3810 505

e-mail: mining@ercosplan.com
web: http://www.ercosplan.com



JORC Report Gräfentonna Licence Area

Appendix 11
Licence Areas Adjacent to the Gräfentonna Exploration Licence Area

Legend:

- Gräfentonna Exploration Licence area
- Küllstedt Exploration Licence area
- adjacent potash related licence areas
- other licence areas

Scale: 1:250,000

0 10 20 km

Coordinate System: DHDN 3 Degree Gauss Zone 4

Date: 2017-05-16
O:\@@@GIS\@@@GIS_Projekte\THUERINGEN\Karten\14-069N02_Graefentonna\14-069N02_App_11_Props_irev01.mxd

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Drill Hole	Available Documents
E Allmenhausen 10/1961	final report stratigraphic column geophysical log
E Bienstädt 2/1961	final report final technical report stratigraphic column geophysical log
E Dachwig 1/1970	final report stratigraphic overview stratigraphic column
E Dachwig 2/1971	final report stratigraphic overview stratigraphic column
E Döllstädt 1/1970	final report stratigraphic overview final technical report stratigraphic column
E Fahner Höhe 3/1959	final report final technical report stratigraphic column
E Fahner Höhe 8/1960	final report final technical report stratigraphic column geophysical log
E Fahner Höhe 10/1961	final report final technical report stratigraphic column detailed core description geophysical log
E Hausömmern 1/1970	final report final technical report stratigraphic column
E Kirchheilingen 1/1934	geological report stratigraphic column
E Kirchheilingen 35/1961	final report final technical report stratigraphic column geophysical log
E Kirchheilingen 84/1969	final report final technical report stratigraphic column
E Langensalza 6/1955	drilling data final technical report drill column stratigraphic column

Drill Hole	Available Documents
E Langensalza 7/1956	final report technical data stratigraphic column
E Langensalza 8/1956	drilling data final technical report stratigraphic overview stratigraphic column
E Langensalza 17/1957	final data monthly reports stratigraphic overview stratigraphic column
E Langensalza 20E/1959	final data monthly reports stratigraphic column geophysical log
E Langensalza 21/1960	final report technical data final technical report stratigraphic column analysis of potash bearing horizon z2KSt geophysical log
E Langensalza 25/1962	final report final technical report stratigraphic column geophysical log
E Langensalza 26/1962	final report final technical report stratigraphic column geophysical log
E Langensalza 27/1962	final report final technical report stratigraphic column geophysical log
E Langensalza 35/1970	final report stratigraphic column geophysical log
E Langensalza 36/1970	final report final technical report stratigraphic column
E Tennstedt 1/1969	final report stratigraphic column
E Tennstedt 2/1970	final report final technical details stratigraphic column

Appendix 13
JORC Code, 2012 Edition – Table 1

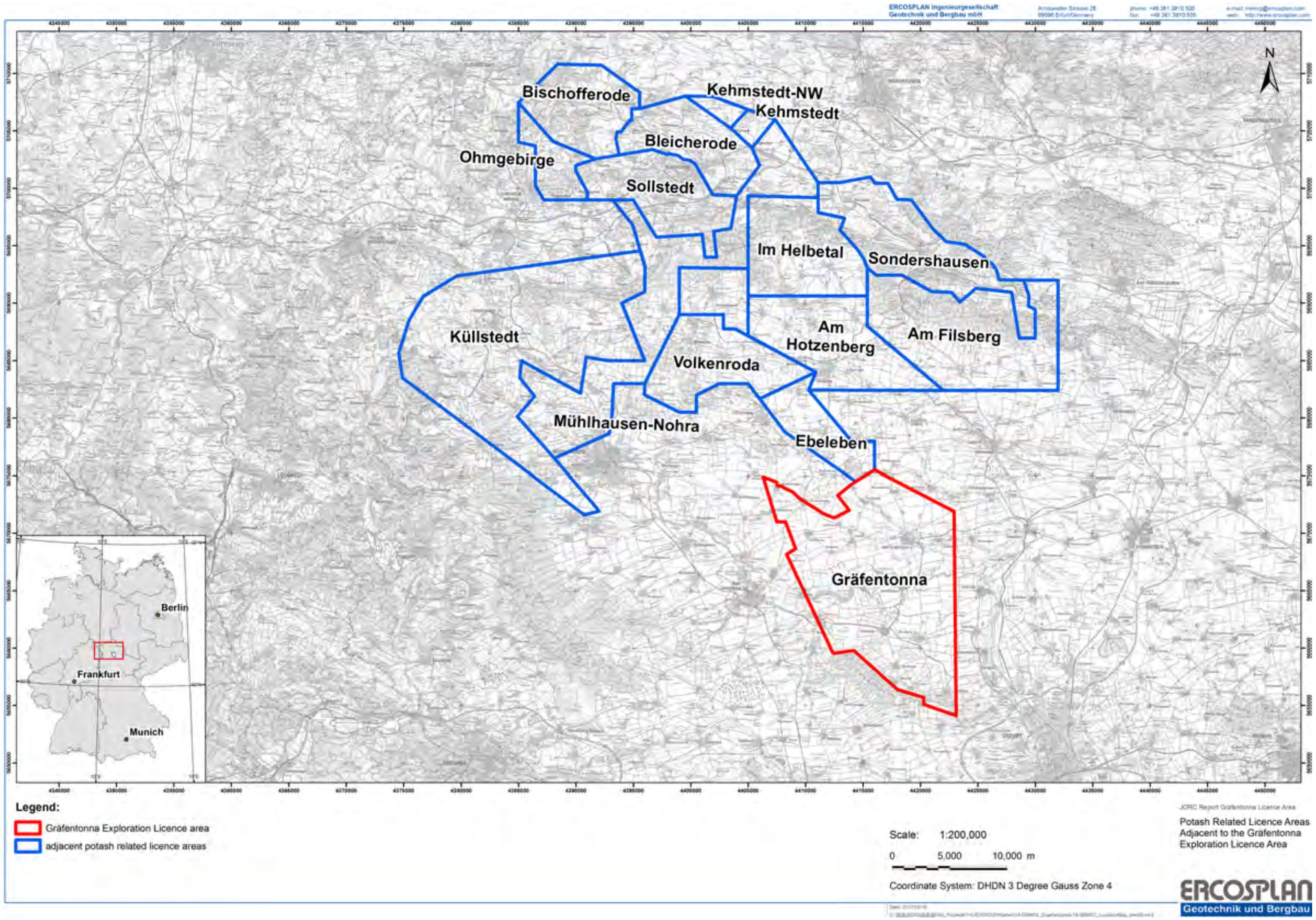

Figure 1 Potash related licence areas adjacent to the Gräfentonna Exploration Licence area

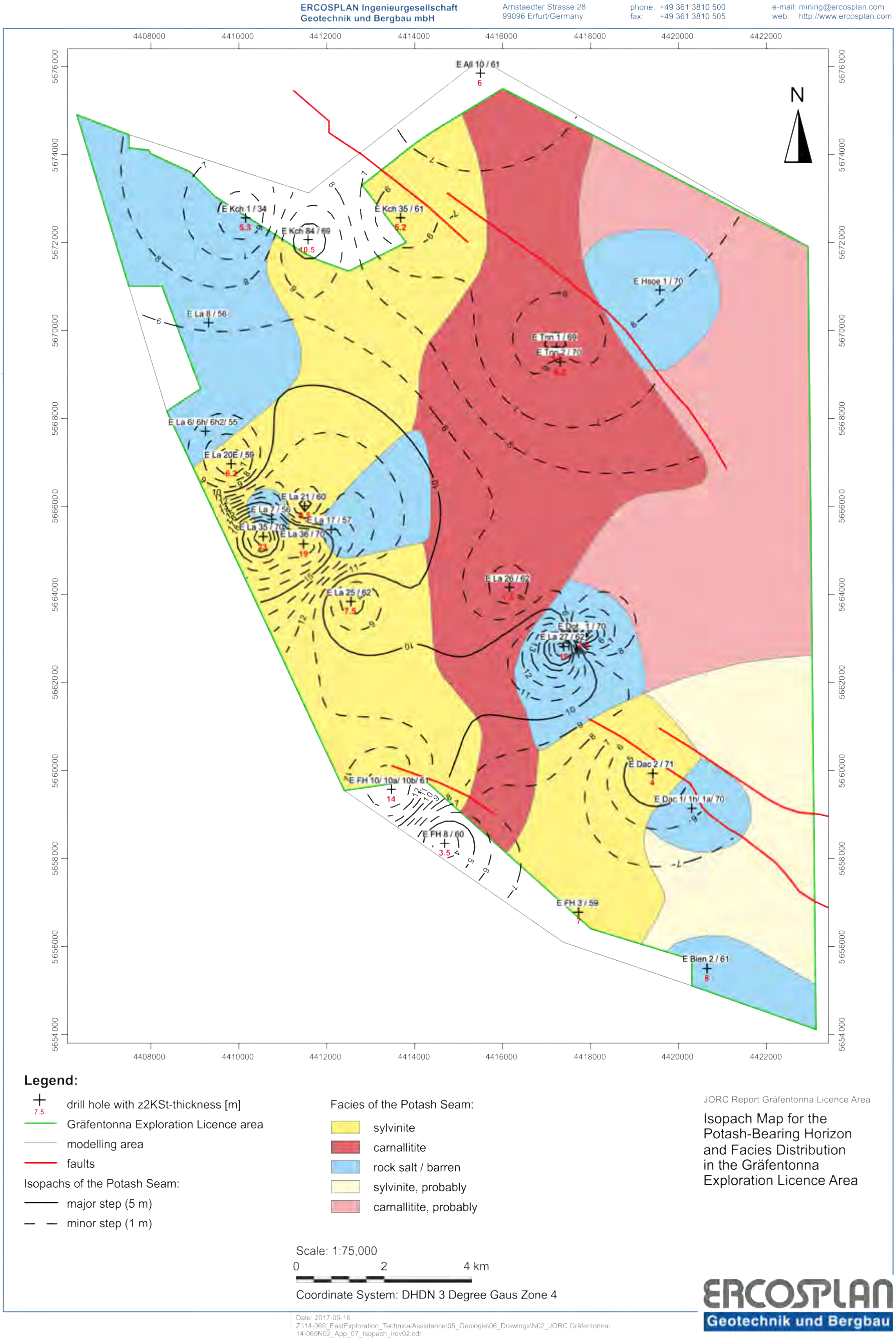

Figure 2 Isopach map of the potash-bearing horizon and facies distribution in the Gräfentonna Exploration Licence area

Section 1 Sampling Techniques and Data

(Criteria in this section apply to all succeeding sections.)

Criteria	Commentary
Sampling techniques	Currently, only historical exploration data are available. For the only potash exploration hole drilled until today, hole *Kal Gräfentonna 1/1911 (Burbach)*, no information is available, if samples have been taken. The same applies to hole *E Kirchheilingen 1/1934*, a hydrocarbon exploration hole. For the hydrocarbon exploration hole *E Langensalza 7/1956* it is known that only 1 core sample was taken to check presence of the potash seam. However, no interval length is mentioned. For the hydrocarbon exploration hole *E Langensalza 21/1960* it is known that 11 core samples have been taken out of 5 core repeats covering the entire potash seam thickness. Interval lengths are varying between 0.20 m and 3.90 m. However, no information is given about the criteria, on which the interval lengths were based. For all other holes mentioned in the Report there is no knowledge about determination of sample intervals. Furthermore, for only 5 out of all holes presented in the Report (cf. sections 5.2.1.1 and 5.2.2.1) it is known that they were cored in the potash seam including holes *E Kirchheilingen 1/1934*, *E Langensalza 7/1956* and *E Langensalza 21/1960*. There is no knowledge, if the other 2 holes have been sampled. For 22 holes, it is known that they were destructively drilled in the potash seam without information if samples were taken. For the remaining holes, there is no knowledge as well if samples were taken from the potash seam. Regarding all holes there is no knowledge about sample packing and sample transport to the laboratory for analysis at present due to the limited access to the corresponding documents. No information is available about the sampling procedure. If core samples for geotechnical investigations were taken, is not known.
Drilling techniques	No information is available about the drilling technique used for drilling hole *Kal Gräfentonna 1/1911 (Burbach).* The same applies to hole *E Kirchheilingen 1/1934*. For holes, sunken during drilling campaigns between 1955 and 1962 and between 1969 and 1971 drilling rigs T-50, BU-40 or BU-75 were used. Usually rotary drilling was applied, but some sections were drilled using a downhole turbine drive. According to the available information, drilling started from the surface with tri-cone bits through the overburden and upper part of the Zechstein section into the top of the Staßfurt-Steinsalz (z2NA), except for six drill holes, where destructive drilling was stopped within the Leine-Formation. That was due to the fact that the exploration campaign was primarily targeting crude oil and natural gas. Afterwards the remaining salt section was cored to the final depth. In addition, the Chirotheriensandstein (smSTC) was cored to gain detailed structural understanding for possible mining of hydrocarbons. Core drilling was conducted with drill hole diameters of 114 mm, 118 mm,

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Criteria	Commentary
	143 mm or 193 mm. For seven drill holes deviation data is available, showing a deviation from the vertical between 7.5 m (inclination: 0.4°) and 101.5 m (inclination: 5.3°). Clay mud was used as drilling fluid for the overburden section; within the salt sections NaCl saturated mud was used. Furthermore CMC (Carboxymethyl cellulose) was added. The mud was undersaturated with regard to KCl and $MgCl_2$, so potash mineral dissolution (especially for Sylvite, Carnallite) has to be expected.
Drill sample recovery	According to available information core recovery within the potash section varied between 18% and 95%. Apart from that there is no further knowledge regarding this subject.
Logging	Lithological logs are available for 25 holes as detailed logs, for the remaining holes as summary logs. However, the potash seam is rarely described in detail. Geophysical well logging data are available for 10 holes. They comprise of calliper, natural gamma, gamma-gamma, neutron-gamma and resistivity logs in different scales, but not every log is available for each of the 10 drill holes. For 6 holes, natural gamma and gamma-gamma data in the scale of 1:200, covering the entire potash section, are available. For two holes only natural gamma logs are available, and in two other holes the logs do not cover the entire potash section. Logging speed is given with between 3 m/min and 6 m/min to 7 m/min. The geophysical well logging data is only available as scanned graphs and nothing is known about the data processing. It has been documented that interpretations and correlations were additionally cross-checked by geologists comparing the logging results with results from other drill holes. The coverage of the available geophysical well logs for the potash seam ranges between 2.5 m and 23.0 m absolute and between 37.5% and 100% relative (calliper, gamma, neutron-gamma, gamma-gamma, resistivity). For 1 hole, no gamma-gamma coverage exists, for another hole no resistivity coverage exists. Out of the 10 holes with available geophysical logs in 8 holes the potash seam is entirely covered by gamma-log. No information is available about the photo documentation of the drilled cores.
Sub-sampling techniques and sample preparation	Cores were brought to the laboratory and analysed according to standard procedures developed by the state authority of the GDR. No information is available about the sample preparation.
Quality of assay data and laboratory tests	The procedures conducted followed strict rules on execution, checking and evaluation of assay data. Quality control was ensured by independent state institutions. The quality of the analyses is considered to be satisfactory.
Verification of sampling and assaying	Cross-check analyses were conducted by independent laboratories to verify the assay results. As no core and sample material is preserved, ERCOSPLAN could not review the results.

Criteria	Commentary
Location of data points	Coordinates of drill holes within the Gräfentonna Exploration Licence area or adjacent to it and used for modelling were obtained partly from state authorities and partly from ENGIE E&P Deutschland GmbH. Locations of drill holes with available detailed logs are given with decimetre accuracy, those of drill holes with available summary logs only to meter accuracy. No detailed information is available for the deviation survey of the 7 drill holes (see section 2). Coordinate system is DHDN 3 Degree Gauss Krueger Zone 4 (EPSG-Code 31,468) Locations of the drill holes are shown in APPENDIX 3, their coordinates given in APPENDIX 4 and Table 2 and Table 3 in the Report.
Data spacing and distribution	The drill holes used as data points for modelling are located mainly in the W and SW with a few holes to the E and NE. Four holes used for modelling are located outside of the Gräfentonna Exploration Licence Area. The data spacing ranges between 200 m and 900 m in the western area of the Gräfentonna Exploration License Area, between 1,500 m and 1,700 m in the NW and between 1,200 m and 3,600 m in the S and SE.
Orientation of data in relation to geological structure	The location of the drill holes follows in general the trend of tectonic structures. Concentration of data points in the W of the Gräfentonna Exploration Licence Area is due to the detailed exploration of hydrocarbons present in the Langensalza upwarp, where natural gas is mined since its finding year 1935.
Sample security	No information is available about the sample storage until shipment to the laboratories in charge. Furthermore, no information is available, if special procedures were executed to preserve sample material.
Audits or reviews	ERCOSPLAN could not review analytical results, since no samples and cores are available from the historical exploration campaigns. Available detailed core logs could be reviewed. However, the editors of the historical reports and the results they present therein are considered to be reliable. Therefore, this information is acceptable for the present project status and the initial estimation of Exploration Targets.

Section 2 Reporting of Exploration Results

(Criteria listed in the preceding section also apply to this section.)

Criteria	Commentary
Mineral tenement and land tenure status	East Exploration GmbH (EAST EXPLORATION), a subsidiary of Davenport Resources Limited, currently holds an exploration license for the Gräfentonna Exploration License area in the Federal State of Thuringia, Federal Republic of Germany, about 23 km northwest of the state capital, Erfurt (cf. Figure 1). The exploration license covers a total area of 216.52 km². The exploration license grants the exploration of rock salt, potash salts, magnesia and boron salts together with other salts within the deposit.
Exploration done by other parties	Exploration in the Gräfentonna Exploration License area started in 1911 with to date only one potash exploration hole. All following exploration campaigns focussed only on hydrocarbons. The first exploration phase on hydrocarbons was conducted in 1933 and 1934 with two drill holes. The second phase was conducted between 1955 and 1962, mainly focussing on exploring the Langensalza upwarp. Additionally, 2D seismic surveys were conducted covering nearly 100% of the license area. The third phase was conducted between 1969 and 1971. Drill holes were sunken to explore the Erfurt fault zone and Schlotheim graben. During the last phase in 1983 one drill hole was sunken, again to explore the Langensalza upwarp.
Geology	The Gräfentonna Exploration Licence area is located at the S border of the South Harz Potash District, which covers the central and NW part of the Thuringian Basin. The South Harz Potash District reflects the extent of the potash deposit. The potash deposit is tectonically divided into three tectonic levels consisting of the basement, the saliferous strata and the overburden. Within the saliferous strata the potash mineralisation is hosted by the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt). The tectonic influence on the potash deposit resulted in brittle deformation in the basement and overburden, and folding of the saliferous strata to various degrees. Subrosion is a common feature and delimits the extent of the potash deposit towards the N and NW. Within the extent of the deposit subrosion is locally restricted to tectonic structures. However, over most of its extent the potash deposit is still intact. The historical drilling results show that the potash seam is distributed almost across the entire Gräfentonna Exploration Licence area. The top varies between -600 and -950 m above sea level (asl) with increasing depth generally from NW to SE. The thickness is uneven ranging between about 2.5 and 23 m with a trend to increase towards the SW, and with a trend to decrease towards the N (cf. Figure 2). Main minerals of the potash deposit are Halite, Carnallite, Sylvite and Kieserite with additional amounts of Polyhalite and Langbeinite and accompanying clay minerals. Within the Gräfentonna Explora-

Criteria	Commentary
	tion Licence area it is assumed that the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) occur predominantly as carnallitite and/or sylvinite as well as locally barren zones (cf. Figure 2). Below the potash-bearing salt rocks of the lithostratigraphic unit Kaliflöz Staßfurt (z2KSt) hydrocarbon-bearing dolomite exists.
Drill hole information	Drill hole records from the historical exploration holes are presently available as detailed logs for 25 holes and summary logs, latter ones presenting a summarised description of the cap rock layers and the layers of the potash deposit. The short logs partly also comprise the layers below the deposit, if encountered. A part of the logs also mentions the encountered salt rock facies (sylvinite, carnallitite). All information about the holes are given in the Report. 23 of the historical holes used for modelling intersected the entire thickness of the potash section. No holes were drilled recently in the licence area.
Data aggregation methods	Neither minimum nor maximum cut-off grades have been used for the present Exploration Target estimation.
Relationship between mineralisation widths and intercept lengths	For seven drill holes deviation data is available, showing a deviation from the vertical between 7.5 m (inclination: 0.4°) and 101.5 m (inclination: 5.3°). However, detailed information about the actual drill hole traces are not available. Hence, no impact on the encountered potash seam thickness can be stated. The same applies for the remaining holes.
Diagrams	Refer to Figure 1 and Figure 2.
Balanced reporting	The values for thickness of the potash seam presented in the Report were derived from modelling, based on available information from drill holes. A values range of approx. 2.5 m and approx. 23 m is given (cf. Figure 2). For K_2O content no values can be stated as mentioned above.
Other substantive exploration data	The information from the historical exploration campaigns could not be reviewed as neither confirmation holes have been sunk nor have seismic surveys been conducted recently. The information found are presented in the Report.
Further work	The data from the historical drill holes located within the Gräfentonna Exploration Licence area should be checked via confirmation drilling. This would allow for collection of core from the potash seam for the purpose of detailed description and chemical and mineralogical analyses. All confirmation drill holes will need to be logged geophysically to cross-check against the historical data and to correlate the results with the chemical analyses, in addition to obtain independent and additional data from the new drill holes for assay and drill record confirmation.

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Section 3 Estimation and Reporting of Mineral Resources

(Criteria listed in section 1, and where relevant in section 2, also apply to this section.)

Criteria	Commentary
Database integrity	Summarised lithological and geophysical drill hole data as well as data from mapped faults in the licence area have been processed using Golden Software Surfer (Version 11.6), Microsoft Excel (Version 2010), RockWare RockWorks (Version 15) and ESRI ArcGIS (Version 10.4). Digitized data were cross-checked by other team members responsible for the Report.
Site visits	A site visit was carried out by ERCOSPLAN and EAST EXPLORATION on 06 June 2016. The objectives of the site visit were an overview of the site situation, an inspection of closed shafts and a general geological introduction.
Geological interpretation	Confidence on the geological interpretation of the potash deposit and its overburden is very high as exploration activities as well as mining activities since more than 100 years in different areas have extended the overall and detailed knowledge tremendously. The data used is historical. Assumptions made are based on methods, which were applied for resource and reserve estimations in former times. Factors affecting the potash deposit are small-scale tectonic structures and variations in mineralisation, which cannot be investigated in detail by exploration drilling or other surficial exploration methods. The existence of these small-scale variations is proven by mining activities conducted in the deposit.
Dimensions	The potash seam spreads across the licence area over a distance of about 26 km in NW-SE direction and over a distance of about 16 km the in NE-SW direction (cf. Figure 2). The top of the potash seam ranges between about 940 m below surface and about 1,220 m below surface. Its base ranges between about 950 m below surface and about 1,230 m below surface.
Estimation and modelling techniques	In estimating the Exploration Target tonnages, the modelling results of the program Golden Software Surfer (Version 11.6.1159) using Inverse Distance algorithm with consideration of mapped faults and with a gridding cell size of 200x200 m was used. The following procedures were carried out (Exploration Target is given as mineralisation in place): (1) All drill holes with information about the thickness were used for modelling its distribution across the whole extent of the potash seam within the license area. The modelling did not extend beyond the boundary of the potash seam within the area. The K_2O grade was obtained by the method of conclusion by analogy, which was also applied in the former GDR for estimating exploration targets in areas with an insufficient degree of exploration, but belonging to the same deposit and exhibiting comparable deposit parameters as areas within the same deposit with a sufficient degree of exploration. For the Gräfentonna Exploration License area

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Criteria	Commentary
	conclusions of analogy were drawn based on exploration results obtained in the Küllstedt Exploration License area taking exploration results obtained in or near the Gräfentonna Exploration License area into consideration. The same applies to the densities. (2) The volume of the potash seam was calculated by summarizing the single cell volumes, derived from the average thickness of each cell of the above mentioned grid and the area of 40.000 m^2 for each of these cells. (3) The calculated volume of the potash seam was multiplied by a tonnage factor depending on the mineralisation (density). (4) The tonnage of K_2O was obtained by multiplying the tonnage of mineralised material with the corresponding K_2O grade of the potash seam.
Moisture	Considered not relevant for the potash mineralisation.
Cut-off parameters	For the current study, no cut-off parameters, which have a direct influence on the mineability and processability, were applied for the thickness and grade of the mineralisation.
Mining factors or assumptions	Neither assumptions for preliminary processing concepts nor mining factors been considered during the current Exploration Target estimation.
Metallurgical factors or assumptions	Neither assumptions for preliminary mining concepts nor metallurgical factors been considered during the current Exploration Target estimation.
Environmental factors or assumptions	No environmental factors, which would have been relevant to the current Exploration Target estimation, have currently been considered.
Bulk density	The bulk density of the potash salt mineralisation has been derived by method of conclusion by analogy as mentioned above. Depending on the mineralisation, the average density varies between 1.83 g/cm³ (for carnallitite) and 2.32 g/cm³ (for sylvinite), obtained from the Küllstedt Exploration Licence area.
Classification	The potash mineralisation present in the potash seam can be correlated between the historical drill holes. The thickness is relatively uneven with local highs and lows due to halotectonic processes. Locally, the potash seam is not developed within the licence area. Information on the K_2O grade is available only by the corresponding report of hole *E Langensalza 21/1960*. The whole extent of the potash seam within the licence area is considered an Exploration Target. For the Exploration Target estimation, the following values have been calculated: • The total volume of the potash seam amounts to 1.464 km³. • The tonnage of the mineralised rock ranges between 2,679 and 3,396 million metric tonnes.

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Criteria	Commentary
	• The K_2O tonnage ranges between 115 and 849 million metric tonnes of K_2O. No Mineral Resources have been defined at present.
Audits or reviews	The results of the "historical prognostic resource estimate" of 1964 could not be reviewed by ERCOSPLAN. However, since it is known that the historical resource estimates were prepared and checked by geologists with several years of experience in potash mining, they are considered to be consistent and satisfactory.
Discussion of relative accuracy/confidence	Will be applied at a later project stage.

Section 4 Estimation and Reporting of Ore Reserves

(Criteria listed in section 1, and where relevant in sections 2 and 3, also apply to this section.)

Criteria	Commentary
Mineral Resource estimate for conversion to Ore Reserves	NOT APPLICABLE FOR THIS REPORT
Site visits	
Study status	
Cut-off parameters	
Mining factors or assumptions	
Metallurgical factors or assumptions	
Environmental	
Infrastructure	
Costs	
Revenue factors	
Market assessment	
Economic	
Social	
Other	
Classification	
Audits or reviews	
Discussion of relative accuracy/ confidence	

Section 5 Estimation and Reporting of Diamonds and Other Gemstones

(Criteria listed in other relevant sections also apply to this section. Additional guidelines are available in the 'Guidelines for the Reporting of Diamond Exploration Results' issued by the Diamond Exploration Best Practices Committee established by the Canadian Institute of Mining, Metallurgy and Petroleum.)

Criteria	Commentary
Indicator minerals	NOT APPLICABLE FOR THIS REPORT
Source of diamonds	
Sample collection	
Sample treatment	
Carat	
Sample grade	
Reporting of Exploration Results	
Grade estimation for reporting Mineral Resources and Ore Reserves	
Value estimation	
Security and integrity	
Classification	