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HiTech AlkCarb

New geomodels to explore deeper for High-Technology critical raw materials in Alkaline rocks and Carbonatites

Deliverable D6.3
CHALLENGES IN GEOLOGICAL SCIENTIFIC FIELDWORK AT THE KAISERSTUHL CARBONATITE, GERMANY

Due date of deliverable: 01/11/2018
Actual submission date:

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Summary

This report describes the challenges experienced during the geological scientific fieldwork at the Kaiserstuhl, Germany. Although the general perception of the public regarding the project is positive, the Municipality of Vogtsburg would have allowed the proposed ca. 400 m deep core drilling only if the HiTech AlkCarb project had taken an insurance policy for any potential environmental and social damage for the longest possible period after the drilling. This caution was the result of damage to buildings in the local town of Staufen im Breisgau and induced seismicity near Basel during geothermal energy projects. As it was not possible to obtain such an insurance, the drilling programme had to be abandoned. A company with an official exploration

licence would have had the right to drill, although the lack of social licence for drilling may make an exploration licence hard to obtain in the region at the moment. Moreover, if the drilling programme had been contracted by a German governmental institution, such as a university or the geological survey, the drilling could have been carried out, as governmental institutions in Germany are automatically insured through the state. However, the local university HiTech AlkCarb project partner declined to take over running the drilling contract, and this probably reflects the perceived reputational risk of taking part in any drilling in the region at the moment. It is a good lesson in how damage to social licence can affect permitting. The recommendations to the European Commission arising from this experience are:

- To assign any drilling in research and innovation projects, in Germany, and probably elsewhere in Europe, to a Government organisation where possible.
- To publicise good practice examples and subsurface research projects (such as UK GEOS and similar) that can help to regain public confidence.

Keywords: Environment, drilling, public perception, community

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº. 689909.

Start date of project: 01 February 2016 Duration: 48 months

Document Information

Lead participant:	UNEXE	University of Exeter
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Tasks:	6.1	Start-up meeting & Expert Council workshop 1
	6.4	Environmental & social activities to obtain relevant permits

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0.2	Alex Speiser	22/08/2018	

0.3	Frances Wall, Kathryn Moore	15/10/2018	Review of the manuscript
0.4	Kate Smith	21/11/2018	Addition of sections of risk perception. Additions to sections on Staufen im Breisgau and Basel. Edits to sections on concerns.
0.5	Kate Smith	22/11/2018	Proof reading and minor edits
1.0	Frances Wall	22/11/2018	Proof reading and minor edits
1.1	Kate Smith	23/11/2018	Minor edits
1.2	Alex Speiser	23/11/2018	Minor edits
1.3	Kate Smith	25/11/2018	Final minor edits and upload to participant portal

Dissemination

Date	Issue	Participants
01/11/2018	1	HiTech AlkCarb project team

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Abbreviations

ASEC	A. Speiser Environmental Consultants
UOE	University of Exeter
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
DCA	Designated Conservation Areas
HiTech AlkCarb	High-Technology critical raw materials in Alkaline Rocks and Carbonatites
LGBR	Landesamt für Geologie, Rohstoffe und Bergbau
Terratec	terratec Geophysical Services GmbH & Co. KG

1. Introduction

The HiTech AlkCarb project is funded by the European Union's Horizon 2020 research and innovation programme under the grant agreement number 689909. The project aims to make a step-change in exploration models for alkaline and carbonatite provinces, establishing methodologies by which mineralogy, petrology, geochemistry and geophysics, including state-of-the-art interpretation of high resolution geophysics and downhole measurement tools, can be used to make robust predictions about mineral prospectivity at depth. This will be achieved through studies at seven key natural laboratories (Germany, Italy, Greenland, Malawi, Mongolia, Namibia, South Africa), combined with Expert Council workshops and fieldtrips to 'funnel in' recent research and exploration results. The outcomes will be incorporated into new geomodels on multiple scales from a world catalogue to deposit models. The project includes 12 partners from industry, such as geological, geophysical and environmental companies, as well as universities and geological surveys.

A key natural laboratory for HiTech AlkCarb is the Kaiserstuhl area in southwest Germany. The most intense fieldwork of the HiTech AlkCarb project, involving field geology, ground-based and aerial geophysics and down-hole testing, has been, and is being, carried out at Kaiserstuhl.

This report presents the challenges encountered during geological scientific fieldwork at the natural laboratory at Kaiserstuhl in Germany and documents the steps taken to ensure environmental and socioeconomic best practice in our field research there. In particular this article addresses reasons why it was decided not to carry out research drilling in the area, as had originally been proposed during project planning. To provide appropriate context for this discussion the report includes background information and chronological details about the HiTech AlkCarb project work and consultations with the community stakeholders at Kaiserstuhl which were also presented in Deliverable 6.1. Following this context the report will then go on to discuss the decision not to drill in Kaiserstuhl and the reasons for this.

Kaiserstuhl has historical quarries, a nature reserve and vineyards and serves as a good example of multiple land uses within Europe. Our experiences seeking permission to carry out research drilling mean that it serves as a case study for potential conflicts of interest, likely to offer up lessons of relevance to future field research in Europe and for exploration in the wider context.

2. Natural Laboratory – Kaiserstuhl

The Kaiserstuhl (**Figure 1**) is located in the southwest of Germany, in the districts Emmendingen and Breisgau-Hochschwarzwald of the state of Baden-Württemberg. The area in total is about 2,000 hectares. Kaiserstuhl is located in the Rhine Graben, with the Rhine River forming a natural border with France to the west. Switzerland is only 60 km to the south, to the east is the Black Forest and to the west the Vosges Mountains. The Kaiserstuhl, meaning "Emperor's Chair", is a low mountain range (max height 557 m above sea level) that rises above the Upper Rhine plane. The isolated nature of the hill is because of its volcanic origin[1]. At its core is an alkali-carbonatite volcano that erupted during the Miocene, approximately 15.5 million years ago. There is a working quarry in the area, and previous small quarries for pyrochlore (niobium) but no active metals exploration. The locality is an excellent natural laboratory for geology, geophysics and geochemistry studies in this

[1] http://www.freiburg-home.com/nearby/8-the-kaiserstuhl-region

project because of the exposure of both volcanic and intrusive rocks, easy access for project partners, and good earlier mapping.

***Figure 1:** Location of the Kaiserstuhl.*

The climate of the Kaiserstuhl is determined by the special location of the Kaiserstuhl between the Vogesen and the Rhine Graben mountains. This makes the area one of the sunniest and warmest within Germany, with a landscape characterized by woodland, terraced vineyards, fruit trees, and other unique flora and fauna. During the spring (March – May) many unique flowers are in bloom. Due to the good weather and the scenic views, the Kaiserstuhl is one of the leading tourist and wine producing areas of Germany. It is also well known for its interesting geology. The volcanic rocks provide a perfect K- and P-rich soil for vineyards and the volcanic soils have an enormous capacity to retain and hold heat.

The towns and municipalities (**Figure 2**) in and around the Kaiserstuhl are (in alphabetical order):

- Bahlingen
- Bötzingen
- Breisach
- Eichstetten
- Endingen with Amoltern, Kiechlinsbergen and Königschaffhausen
- Ihringen with Wasenweiler
- Riegel am Kaiserstuhl
- Sasbach with Jechtingen and Leiselheim
- Vogtsburg with Achkarren, Bickensohl, Bischoffingen, Burkheim, Oberbergen, Oberrotweil and Schelingen
- Wyhl

As most of the geological and geophysical surveys for this project are being conducted in the municipality of Vogtsburg, economic statistics of the wine producers and tourism have been sourced from this municipality. Vogtsburg alone has six “Winzergenossenschaften” (wine grower’s associations) and 30 “Winzer” (wine growers and producers).

__Figure 2:__ Towns and villages of the Kaiserstuhl (https://www.naturgarten-kaiserstuhl.de). The red circle marks the main research area.

2.1 Designated Conservation Areas

The Kaiserstuhl contains numerous Designated Conservation Areas (DCA), including Eichstetten, Badberg, and Haselschacher, some up to 60 – 70 hectares and numerous other smaller DCAs (**Figure 3**). Part of the centre also belongs to a Fauna Flora Habitat area (FFH no. 7911-341).
The fertile loess soil and warm climate fosters a mature meadow ecosystem, rich in wild flowers, insects, amphibians and unique bird species such as the hoopoe and bee-eater. Planted forest buffers protect sensitive vineyards from frost and wind erosion, and consist of pine, Douglas fir, oak and beech[2].

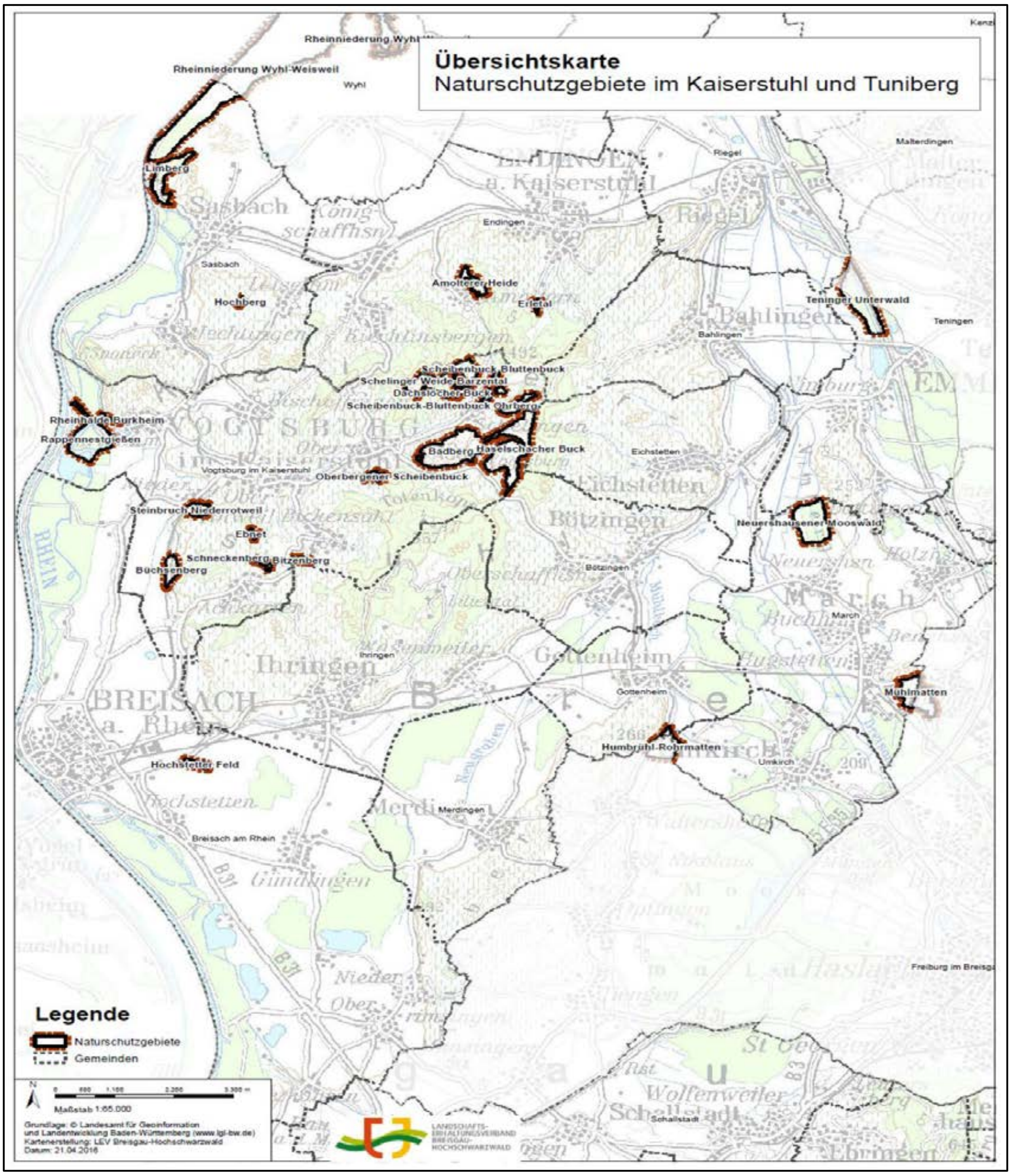

Figure 3: *Designated Conservation Areas (DCA) of the Kaiserstuhl.*

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[2] http://www.coford.ie/media/coford/content/funding/networkingandknowledgetransfer/UCD%20Forestry%20Excursion%20to%20the%20Black%20Forest.pdf

2.2 Current and historical quarries

Active quarrying currently takes place for crushed phonolite stone at the Fohberg quarry near Bötzingen operated by Hans Hauri. Historically, there were numerous quarries both for industrial minerals and for niobium in the form of pyrochlore (**Table 1, Figure 4**)).

Table 1: *Historical and current quarries.*

Quarry name	Location	No	Rocks/minerals quarried or exposed (and other minerals from mindat.org)
Fohberg (active)	Bötzingen	1	Phonolite (wollastonite, zeolite)
Orberg	Badberg, Schelingen	2	Carbonatite for pyrochlore (magnesioferrite)
Badloch/ Badberg	Orberg-Badberg, Schelingen	2	Carbonatite for pyrochlore (perovskite, barite, galena)
Kirchberg	Oberrtoweil	3, 5	Phonolite (melanite, zeolite, titanite, opal)
	Henkenberg/Niederrotweil	4	extrusive carbonatite
Humburg	Burkheim-Sponeck	6	Tephrite, essexite (opal, phillipsite)
	Büchsenberg/Achkarren	7	Tephrite
	Lützelberg/Sasbach	8	Olivine-nephelinite
Limberg (7 quarries)	Sasbach	9	Limbergite (phillipsite, faujasite, offretite)

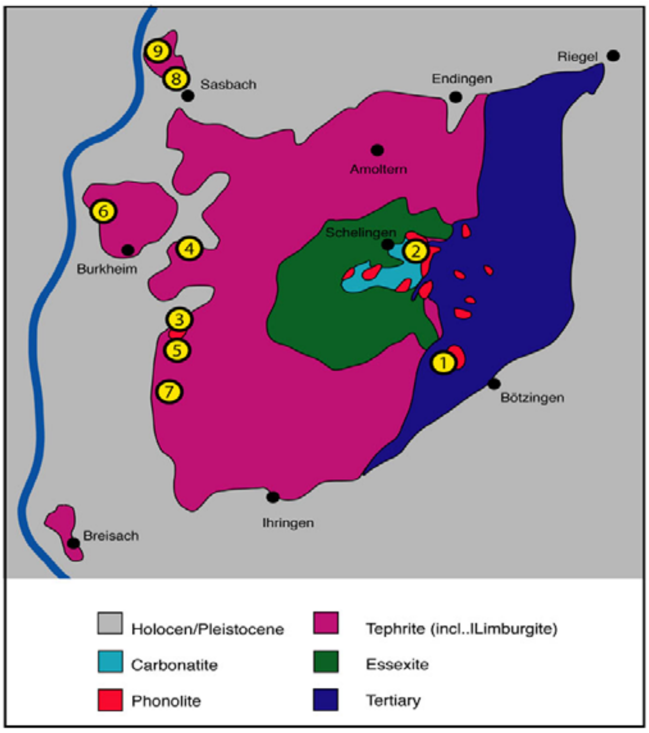

Figure 4: *Map of significant local quarries (http://tobias-weisenberger.de/7Kaiserstuhl-Excursion.html)*

2.3 Historical scientific drill holes

A number of historical drill holes exist at the Kaiserstuhl. The drill holes of interest for the project are briefly described below and their locations are shown in **Figure 5**.

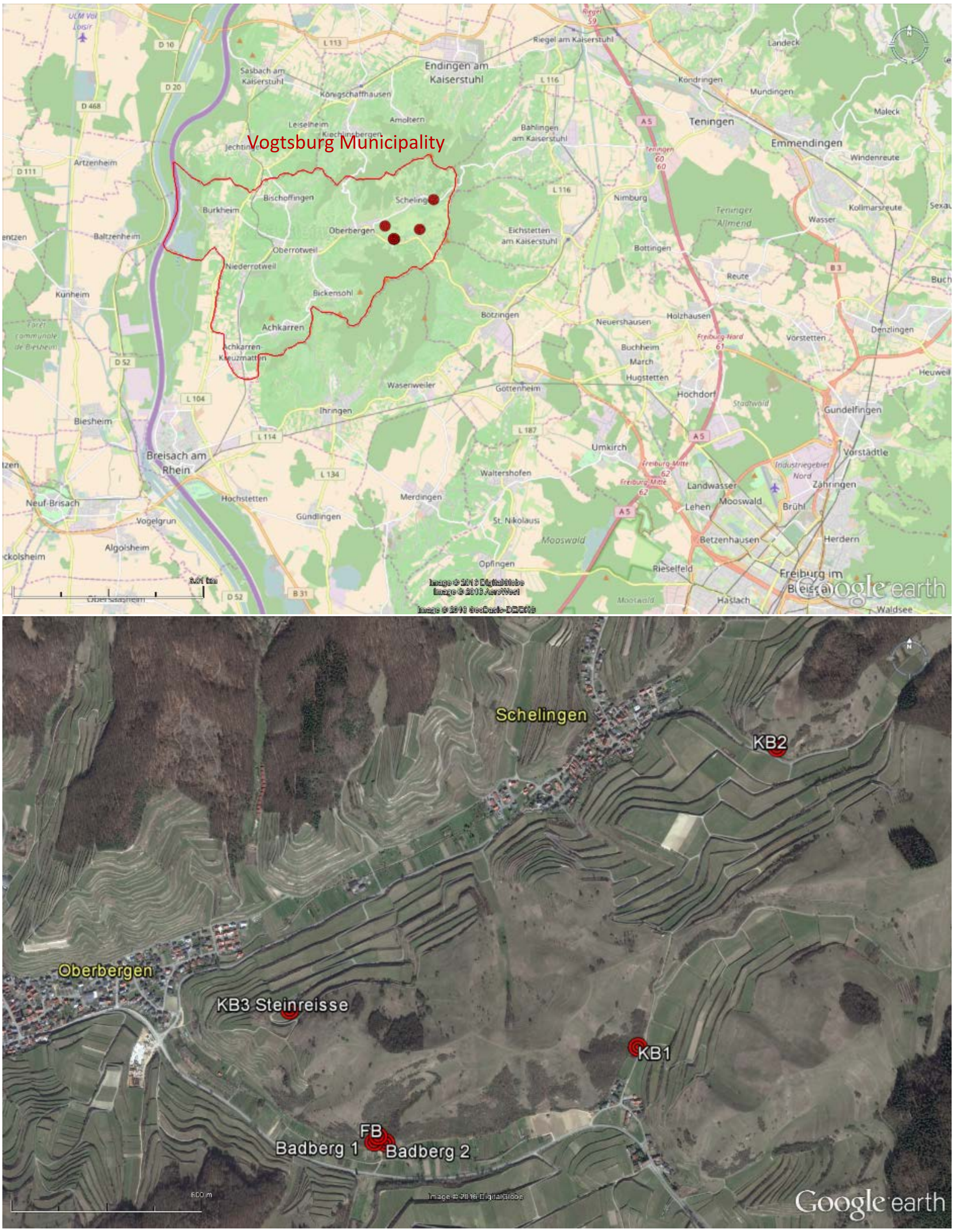

__Figure 5:__ Location of old historical drill holes (red) at the Badberg (Badberg I and II, FB), Eistettertal (KB1), Orberg (KB2) and Steinreisse (KB3).

2.3.1 Badberg I & II and 'Forschungsbohrung Kaiserstuhl' (FB)

In 1967 and 1969 the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) situated in Hannover drilled two holes at the Badberg quarry:

Badberg I - 50.1m total depth

Badberg II - 100m total depth

In 1970 the 'Forschungsbohrung Kaiserstuhl' was drilled, which reached a depth of 500.25 m. The main rock types encountered in the holes are: carbonatite, tinguaite, ledmorite and hauynporphyry. Tinguaite occurs as intrusive dykes and sills.

The cores from these drill holes do not exist anymore, as they were lost during a fire in the core shed of the Landesamt für Geologie, Rohstoffe und Bergbau (LGBR) (State Office for Geology, Raw Materials and Mining).

2.3.2 Drill holes KB1 to KB3

Between June and August 1991 the Geologische Landesamt Freiburg (Freiburg Geological Survey) drilled three more scientific drill holes (KB1 in the Eichstaetter Tal (Altvogtsburg), KB2 at the Orberg quarry (Schelingen) and KB3 at the Steinreisse quarry). The information below was compiled from H. Maus (1996).

KB1 - Eichstaetter Tal near Altvogtsburg

The drill hole KB1 was unfortunately sited on a fracture zone and core loss was very high. The hole was drilled to a depth of 103.9 m. KB1 was filled in after completion. Mainly very brittle carbonatite was encountered.

KB2 - Orberg quarry near Schelingen

The drill hole KB2 was drilled to a depth of 195 m and was filled in after completion. Mainly diatreme breccia intruded by carbonatite was encountered. The diatreme breccia is composed of different fragments of older volcanic and basement rocks. Characteristic is the occurrence of xenoliths from the upper mantle.

KB3 - Steinreisse quarry

Drill hole KB3 was drilled to 400m depth and was left open. The main rock types encountered were carbonatite with Hauynporphyry dykes from 50 to 100 m and then to 300m carbonatite-silicate hybrid rocks. From 300 m until the end of the hole carbonatite was encountered, and in the deepest 50 m mondhaldite dykes were observed.

Following initiation of the HiTech AlkCarb project the field research team was lucky able to locate this Steinreisse historic drillhole and Terratec has conducted downhole surveys there. Four water samples at different depths were taken during January 2017.

As part of this project the University of Tübingen has undertaken an exhaustive geological study of this historic drillhole, carrying out core-logging as well as further field-mapping, sampling and mineralogical analysis.

Out of all the observed drill holes, no adverse environmental impacts have been reported or observed. There has been no surface or ground water pollution, no seismicity, and no accidents or injuries.

3. Fieldwork and interaction with the local authorities

The geological fieldwork, the different meetings held with local authorities at the Kaiserstuhl and all permit applications for fieldwork are presented in **Table 2**, below.

Permit applications to conduct the initial geological fieldwork and geophysical surveys were submitted to the Landesbergdirektion on 20th April 2016 and the go-ahead was given on 27th April 2016.

Dr. Ben Walter (University of Tübingen) started the geological sampling and review of historical data in June 2016. He also sampled the historical drill cores at the storage facility of the Landesamt für Geologie, Rohstoffe und Bergbau (LGBR) (State Office for Geology, Raw Materials and Mining) in Freiburg.

The geophysical ground survey was conducted by project partner, terratec, starting in the beginning of July 2016 and finalised by August 2016.

Terratec's airborne geophysical survey commenced in October 2016 and was intended to be completed by mid-November 2016. However, due to problems with altitude alignment, the survey was halted in beginning of November 2016 and resumed in December 2016. The airborne geophysical survey was finalised in the first quarter of 2017.

Table 2: *Summary of meetings, fieldwork and community interaction.*

Date / reason	Company	Summary
31st October 2015 / Preliminary Meeting with the Landesamt für Geologie, Rohstoffe und Bergbau, Baden-Württemberg	terratec, GeoAfrica & ASEC	• Introduction of the proposed project • Summary of anticipated work at the Kaiserstuhl • Enquiry regarding permits need to conduct the work
13th April 2016 / First Meetings with the mayors of Vogtsburg Municipality	University of Tübingen, terratec, ASEC	• Introduction of the project • Summary of anticipated work at the Kaiserstuhl • Reassurance to the mayors that the work will only be carried out if the required permits have been obtained • The mayors raised concern regarding the anticipated borehole at the Badberg

Date / reason	Company	Summary
		• Introduction of project to the Kaiserstuhl community in the local municipality newspapers
Summer 2016 / geological mapping	University of Tübingen	• Geological mapping and sampling • Literature review • Sampling of historical cores
July – August 2016 / ground geophysical survey	terratec	• Ground geophysical survey around the Badberg
October 2016 – first quarter 2017 / airborne geophysical survey	terratec	• Airborne geophysical survey to collect magnetic and radiometric data of the Kaiserstuhl
17th November 2016 / water sampling of the springs at the Badberg	ASEC	• Water sampling of springs
18th November 2016 / Second Meeting with the Mayor of Vogtsburg	terratec, ASEC	• To inform the mayor of the progress of the project
December 2016 to July 2018	Terratec	• Downhole survey of KB3 (Steinreisse borehole) • Water samples
November 2016	Terratec	• Request for permission to drill at the Badberg to the Landesamt Breisgau-Hochschwarzwald
July 2017	Terratec	• Changes to the request for permission to drill at the Badberg to the Landesamt Breisgau-Hochschwarzwald
August 2017	Landesamt Breisgau-Hochschwarzwald	• Notification to terratec that drilling is permitted if certain conditions are fulfilled as stipulated by the municipality of Vogtsburg
October 2017	terratec	• Final decision not to drill at the Badberg (decision was taken at a Project Partner Management

Date / reason	Company	Summary
		Meeting on 21st September 2017)

3.1 Preliminary Meeting with the Landesamt für Geologie, Rohstoffe und Bergbau, Baden-Württemberg (31st October 2015)

The first official meeting with regulators was held on 31st October 2015 at the premises of the Landesamt für Geologie, Rohstoffe und Bergbau (LGBR) (State Office for Geology, Raw Materials and Mining) and four representatives, as well as members of terratec, GeoAfrica and A. Speiser Environmental Consultants were present. The meeting was held to introduce the proposed project.

Terratec provided a short overview of the anticipated work expected to be conducted at the Kaiserstuhl, followed with the details of which permits need to be obtained to be able to conduct the work. Below is a summary of the different permits explained by the Landesamt:

- '*Erlaubnis zu wissenschaftlichen Zwecken*' – a concession to conduct scientific work. This includes the application and the start of the public process, e.g. meetings with the mayors of the different villages, Behörden, Kommunen, and nature conservation bodies.

- Provide Landesamt with a '*Betriebsplan*' regarding drilling. This provides information on the detailed steps that would need to take place during the drilling programme including best practice, etc. Once approved, a '*Betriebsplanzulassung*' (drilling permit) would be granted. During this phase further public meetings should be conducted to explain the what, where, who, and when regarding drilling activities. The '*Betriebsplan*' is usually compiled by the drilling company. The HiTech AlkCarb team would be responsible for making sure that all best practice actions are incorporated into the document. This should include a transparent tender bidding application process for determination of the responsible drilling company.

3.2 First Meetings with the mayors of Vogtsburg Municipality (13th April 2016)

On the 13th April 2016 the HiTech AlkCarb project team held a first meeting with the mayor and heads of local councils in Oberrotweil at Kaiserstuhl, Germany. During the meeting, partners of the project (from the University of Tübingen, terratec, and ASEC) introduced the scientific programme and explained the purpose and benefits of the work at the Kaiserstuhl.

The team explained why the Kaiserstuhl is important for the project: The Kaiserstuhl alkaline-carbonatite volcano is an ideal project area in which to gain in-depth knowledge about how rare earth elements and other critical metals have become enriched in some volcanic rocks during the active volcanic phase. Over the past centuries much scientific geological work has already been conducted, but now new and more advanced geophysical methods have been developed that will allow us to acquire more detailed data during the project. This information will be used to meet the overall goal of developing new geo-models for international critical metal exploration programmes.

The team described that initial fieldwork entailed taking rock samples with a hammer from existing rock exposures and old quarries. Additionally, geophysical surveys would be conducted along tracks. The main focus of these activities would be at the centre of the Kaiserstuhl (Badberg and Ohrberg). An airborne survey was planned to follow this during which magnetic and radiometric data would be collected using a helicopter. The area of investigation is approximately 12 x 12 km. These plans are explained further in Deliverable 4.1, the background report for drilling.

Finally, the team explained their proposal that a borehole would be drilled to obtain a continuous core of rock down to a depth of a few hundred metres. The final location could only be decided once the ground geophysical and airborne data had been analysed. The core would have provided samples that we could have analysed to study the enrichment of rare earth elements and other critical metals in the rocks at depth.

3.2.1 Concerns raised

The mayor and heads of councils were interested in this scientific research project. However, work could only commence once all necessary authorisation documents and permits had been obtained from the local government institutions.

The mayor expressed concerns that were arising from negative consequences of previous drilling in the area and hydraulic fracturing. The mayor asked HiTech AlkCarb to provide him with proof of liability insurance from the drilling company as well as a long-term liability policy. These concerns and the responses from HiTech AlkCarb at the time are covered more in Section 5 where we compare different drilling projects, the incidents that caused concern locally and the decision making regarding the research drilling proposal.

3.3 Public Participation

To inform the wider public of the Kaiserstuhl area, the mayor suggested that we write a short notice for the local municipality newspaper in which we explain the project. This was done and was placed in the edition of 22nd April 2016. Further notices of each field activity were supplied to the wider public in the same manner. **Figure 6** shows an example of the notifications.

Achkarren Bickensohl Bischoffingen Burkheim Oberbergen Oberrotweil Schelingen

Nachrichtenblatt

DER STADT VOGTSBURG IM KAISERSTUHL

Freitag, den 22. April 2016
41. Jahrgang
Nummer 16

Herausgeber: Stadt Vogtsburg im Kaiserstuhl, 79235 Vogtsburg-Oberrotweil, Tel. 07662/8120 · **Verantwortlich für den redaktionellen Teil:** der Bürgermeister, **für die Anzeigen:** Anton Stähle, Stockach · **Druck und Verlag:** Primo Verlagsdruck, Anton Stähle, Postfach 1254, 78329 Stockach, Telefon 07771 9317-11, Telefax 07771 931740, E-Mail: info@primo-stockach.de, Internet: www.primo-stockach.de
Redaktionsschluss: Dienstag, 12.00 Uhr · **Anzeigenschluss:** Dienstag 12.00 Uhr in Vogtsburg, am Mittwoch 15.00 Uhr in Stockach

Amtlicher Teil

Geowissenschaftliche Forschung im Kaiserstuhl

In den nächsten Monaten werden Geologen der Universität Tübingen und der Firma terratec Geophysical Services (Heitersheim) geologische und geophysikalische Untersuchungen im Kaiserstuhl durchführen.

Dabei werden die verschiedenen Gesteine an bereits bestehenden Aufschlüssen und Steinbrüchen mit dem Hammer beprobt und es werden geophysikalische Messungen entlang von Wegen durchgeführt. Diese Untersuchungen werden sich auf die Gegend um den Badberg und den Ohrberg konzentrieren.

Im Spätherbst wird dann ein Helikopter der mit verschiedenen Messgeräten ausgestattetet ist das gesamte Kaiserstuhlgebiet überfliegen, um die Messungen aus der Luft mit denen die am Boden durchgeführt wurden zu vergleichen. Die geplanten Untersuchungen stehen im Zusammenhang mit einem internationalen Forschungsprojekt, das von der EU finanziert wird.

In diesem Projekt geht es darum zu verstehen, wie bestimmte Metalle sich im Zusammenhang mit Vulkanismus anreichern und wie man solche Anreicherungen mit Hilfen von geophysikalischen Methoden detektieren kann. Der Kaiserstuhl stellt dabei ein besonders gut geeignetes Anschauungsobjekt dar.

Wenn ein Grundbesitzer prinzipielle Einwände dagegen hat, dass diese Begehungen auf seinem Grundstück stattfinden, so soll er dies dem Bürgermeisteramt Vogtsburg umgehend melden.

Dieses Projekt ist von dem European Union Horizon 2020 Forschungs- und Innovationsprogramm bezahlt unter dem ' grant agreement No 689909'.

Vorankündigung der 1. Energiewerkstatt am 02.05.2016 - Kommunales Klimaschutzkonzept Vogtsburg im Kaiserstuhl

Die Stadt Vogtsburg lädt zur 1. Energiewerkstatt des kommunalen Klimaschutzkonzepts ein. Sie findet statt am Montag, **2. Mai 2016 von 19:00 bis 22:00 Uhr im Atrium der Wilhelm-Hildenbrand-Schule, Eisentalstraße 12, 79235 Vogtsburg-Oberrotweil**.

Die Stadt Vogtsburg lässt derzeit durch den regionalen Energie- und Umweltdienstleister badenova ein Klimaschutzkonzept erstellen. Ziel des Konzepts ist es, Strategien und konkrete Maßnahmen für eine klimafreundliche und effiziente Energieversorgung der Stadt zu erarbeiten. Diese Maßnahmen sollen die drei wichtigsten Felder des Klimaschutzes umfassen: Energieeinsparungen auf der Verbraucherseite, Effizienzsteigerungen in der Energieerzeugung und Substitution fossiler Energieträger durch den Einsatz erneuerbarer Energien. Das Konzept dient als Vorbereitung für eine grundlegende und nachhaltige Modernisierung der kommunalen Energieinfrastruktur. Themen wie die Mobilität werden ebenso berücksichtigt und bewertet. Die Erstellung des kommunalen Klimaschutzkonzepts wird zu 65 % durch Fördermittel des Bundes finanziert.
In diesem Zusammenhang möchten wir Sie bereits heute ganz herzlich zur Mitarbeit am Klimaschutzkonzept einladen

Energiewerkstätten für Bürger und Akteure: „Klimaschutz aktiv mitgestalten"

Zentraler Bestandteil der ca. zehnmonatigen Konzepterarbeitung ist die Beteiligung der Öffentlichkeit. Interessierte Bürger, lokale Akteure und Bürgergruppen sind daher eingeladen, ihre Ideen einzubringen und den Prozess im Rahmen von Workshopveranstaltungen aktiv mitzugestalten. Vorgesehen sind zwei Energiewerkstätten mit folgenden Leitfragen: Welche Themen im Bereich Klimaschutz sind den Bürgern wichtig? Wie und wo wollen sich die Bürger direkt einbringen? Wer sind die maßgeblichen Akteure in der Umsetzung? Die Energiewerkstätten werden durch einen neutralen Moderator und durch die Klimaschutzberater der badenova als fachliche Experten begleitet. Für die Teilnahme sind keine Fachkenntnisse erforderlich. Für einen kleinen Imbiss wird gesorgt.

Zur 1. Energiewerkstatt am **Montag, 2. Mai 2016** ist die gesamte Bevölkerung herzlich eingeladen.

Für die Teilnahme an der Veranstaltung wird um Anmeldung gebeten.
Bitte melden Sie sich dazu bis spätestens Freitag, 29.04.2019 bei der Stadtverwaltung, Herr Hohwieler, Tel.: 07662-812-33, E-Mail: hohwieler@vogtsburg.de.

Figure 6: *Example of notification to the local public through the municipality newspaper.*

3.4 Geological mapping and ground geophysics

The documents for the permit to conduct the initial geological fieldwork and geophysical surveys were submitted to the Landesbergdirektion (relevant authority to grant such permits). On 27th April 2016 the HiTech AlkCarb team received an answer that it could go ahead, as no permission needed to be granted in regard to the existing legislation, because the project was only for scientific work.

Figure 7 shows the ground geophysical lines. See Deliverable 4.1 for more information.

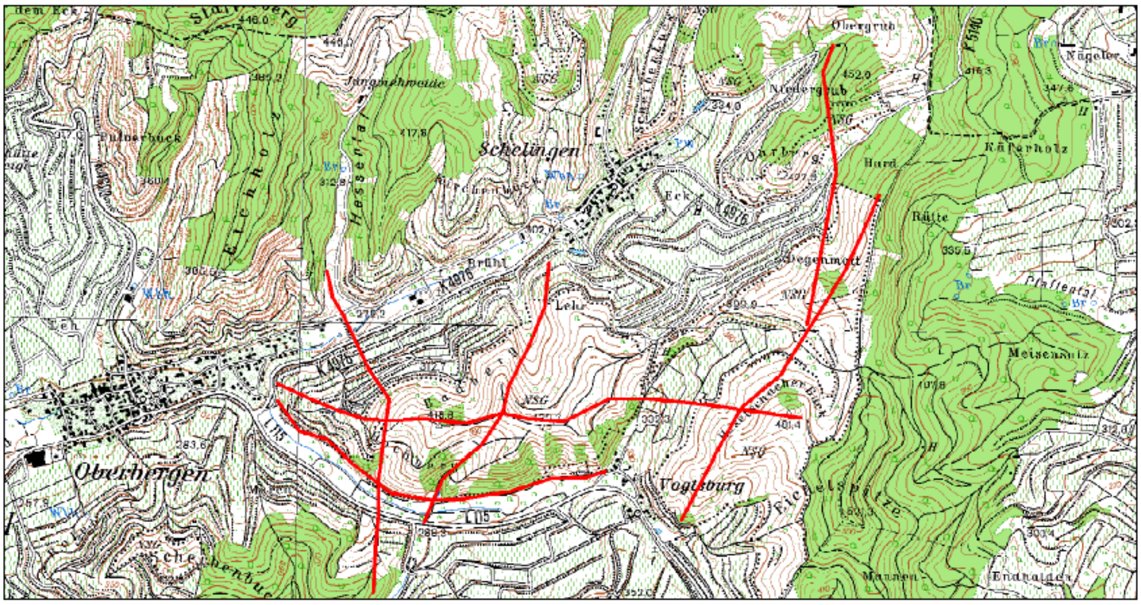

Figure 7: *Location of ground geophysical lines.*

The geological mapping started at the end of May 2016, while the geophysical ground survey started at the beginning of July 2016. As discussed with the mayor of Vogtsburg, a notice was placed in the local municipality newspaper. The ground geophysics were conducted by terratec during July and August 2016, and the results are presently being interpreted.

The utmost precaution was taken when conducting all geological and geophysical fieldwork. This includes avoiding work on weekends or other public holidays, which might interfere with tourism and recreational use of the area. There are several, small nature conservation sites to protect rare species such as the emerald lizard, certain types of snakes, birds, and a rare honey bee. To ensure that all project members who work in the field are aware of potential negative impacts, environmental rules were established and circulated. Potential negative aspects in the area that were mitigated are:

- Harm to protected plants. Due to its special soils and water regime some flora, e.g. orchids can only be found at the Badberg.
- Disturbance of fauna and avifauna. Lots of protected birds and lizards are found within the Kaiserstuhl area due to its climatic conditions.
- Creation of new access tracks. A policy was established to inform landowners before any tracks were created.

3.5 Airborne Geophysical Survey

The airborne geophysical survey was conducted to collect magnetic and radiometric data, commencing in October 2016. It was planned to be finalised by mid-November 2016, however, due to problems with altitude alignment, the survey was halted until the beginning of November 2016 and resumed in December 2016. It was finalised in the first quarter of 2017.

The necessary permit application was submitted to the Regierungspräsidium Freiburg, which granted the permission to conduct the airborne survey.

A small helicopter was used to fly a 12 x 12 m grid over the whole Kaiserstuhl area from the river Rhine in the West to Eichstetten in the East, and from Gündlingen in the South to Wyhl in the North. **Figure 8** shows the grid that was flown in the project.

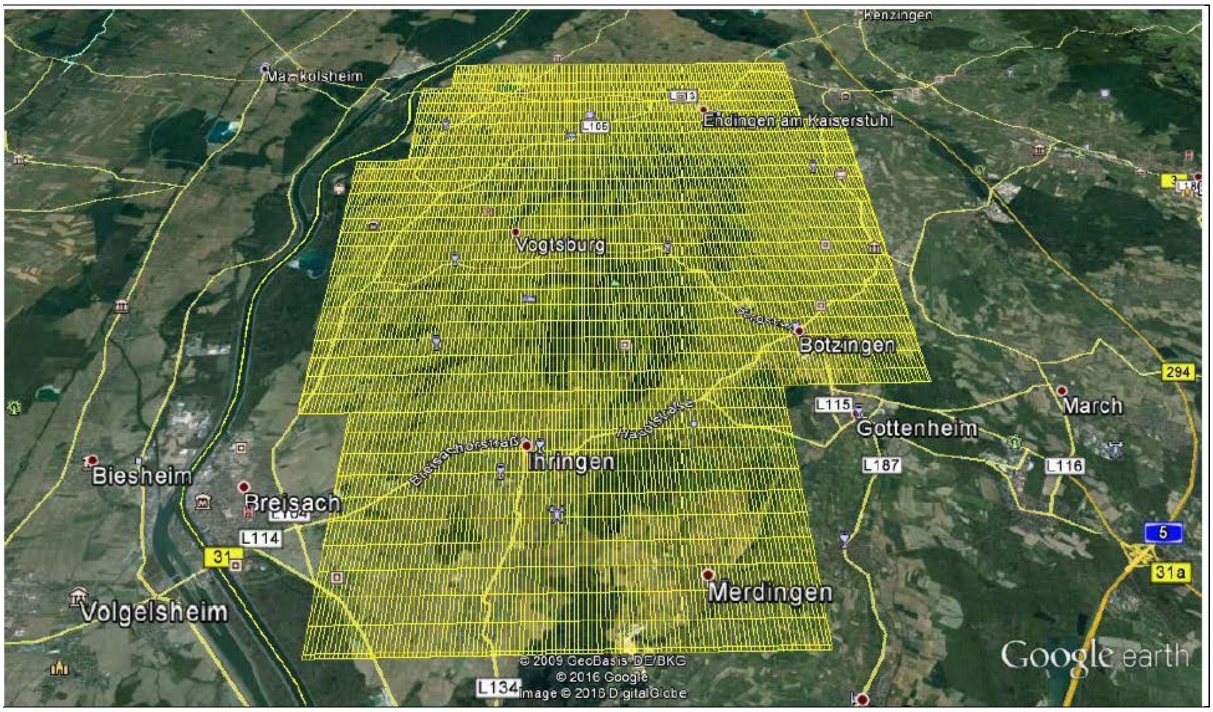

Figure 8: *Flight area of the airborne geophysical survey.*

The potential negative impacts during the airborne survey were:

- Harm to birds - none was reported by the pilot
- Disturbance of animals. We notified all inhabitants at the Kaiserstuhl about the survey and asked to put their livestock into stables if needed - no complaints were received during the survey.
- Potential confusion during a police investigation, while helicopters were in use during the survey period to search for a murder suspect. We notified the communities through the community newspaper about the survey again and added a picture of the helicopter used for the airborne survey.

Notifications were issued to people in numerous newsletter articles and by speaking to municipality officials. All affected municipalities (Whyl, Forchheim, Endingen, Sasbach, Eichstetten, Boetzingen, Ihringen, Merdingen, Gottenheim and Breisach) of the Kaiserstuhl were informed about the activity and the first notification was published in each local municipality newspaper. Additionally a notification of the survey was published in the 'Badische Zeitung'.

The helicopter only flew during working hours, in good weather, and at a minimum height above houses to minimize disturbance. There is very little animal husbandry in the Kaiserstuhl, and the risk of disturbing animals was not deemed significant.

After the second meeting with the mayor of Vogtsburg on 18th November 2016, a second notification regarding the progress of the airborne geophysical survey was mailed to municipalities of the Kaiserstuhl, to inform the public of the delay in the survey. No formal requirement to communicate with members of the public exists under German or local laws. This is contrary to geophysical work conducted in many countries in Africa and North America or Australia. In the United Kingdom, during the TELLUS geophysical survey of the Southwest of England, a prolonged communications program was required using radio, television, newspaper and social media outlets.

3.6 Second Meeting with the Mayor of Vogtsburg (18th November 2016)

On 18th November 2016 the HiTech AlkCarb project team held a second meeting with the mayor of Vogtsburg (Herrn Bohn), the '*Hauptamtsleiter*' and one head of the local council in Oberrotweil at the Kaiserstuhl, Germany. During the meeting, partners of the project (terratec and ASEC) summarised progress to date and further procedures expected.

3.6.1 Concerns and issues raised

During the geological fieldwork, the municipality of Vogtsburg did not received any comments or questions from the public. However, during the ground geophysical survey a number of people contacted the municipality to enquire about what was happening, and they were directed to the public notice in the municipality newspaper. More people enquired about the airborne geophysical survey, and again the municipality was able to refer them to the public notice in the municipality newspaper.

During this meeting the mayor enquired if we could present him with a time plan for further activities of the project which he would like to present to the council members. He liked the idea of starting a webpage associated with the drilling project to commence in the first quarter of 2017.

While discussing the proposed drill hole, the mayor asked what the benefits for the community would be. He also expressed his concern regarding potential temporary and chronic impacts to groundwater resulting from the drill hole. In response to this water quality concerns the HiTech AlkCarb project carried out an analysis of water quality at the Badberg.

3.7 Water Analysis of the Badberg springs

At the Badberg four natural warm springs occur. Water samples of these springs were taken because the mayor of Vogtsburg raised a concern that water quality might be affected by the proposed drill hole. HiTech AlkCarb therefore decided that it would be of value to assess the current water parameter of the springs. Analysis of the water samples taken at the Badberg springs was completed by Hydroisotop.

One of the springs feeds a small water basin, while the other three run into the local environment. **Figure 9** to **Figure 12** show the four springs, while **Figure 13** shows their location.

Figure 9: *KSWS 1*

Figure 10*: KSWS 1 (left) and KSWS 2 (right)*

Figure 11: KSWS 3

Figure 12: KSWS 4

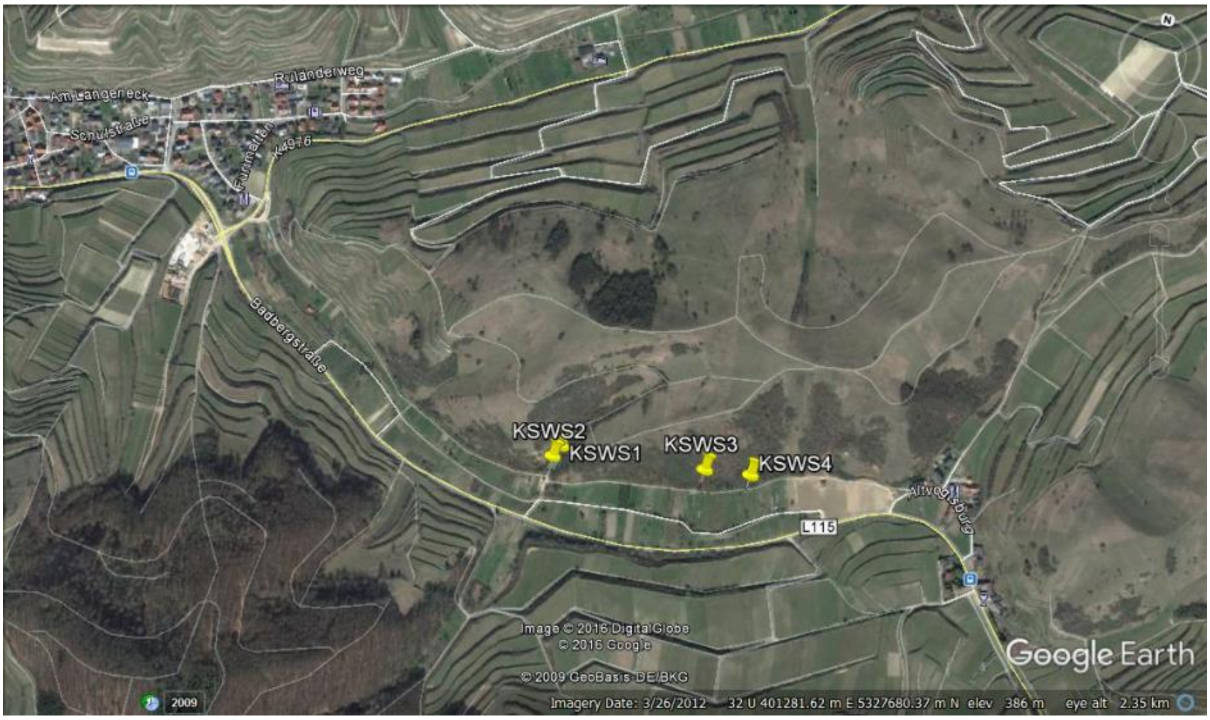

Figure 13: *Location of the Badberg springs.*

Table 3 provides the water quality results of the sampled four springs KSWS 1 – KSWS 4, while **Table 4** provides the chemical parameters to determine potability of a water supply based on EC Directive 80/778/EEC.

Table 3: *Results of the water sample KSWS 1 - KSWS 4.*

Parameters	Unit	KSWS 1	KSWS 2	KSWS 3	KSWS 4
Physical-chemical parameters					
Colour		no colour	no colour	no colour	no colour
Turbidity visible		clear	clear	clear	clear
Smell		neutral	neutral	neutral	H_2S
Temperature	^oC	20.7	18.6	22.2	26.6
Spec. electr. Conductivity (25 ^oC) at sampling	µS/cm	464	462	510	518
Spec. electr. Conductivity (25 ^oC) at lab (µS/cm)	µS/cm	459	459	503	503
pH value at sampling		7.4	7.7	7.7	7.3
pH value at sampling		7.5	7.6	7.8	7.4
Temperature at lab	^oC	21.2	21.3	21.4	21.2
Dissolved oxygen content	mg/l	4.4	5.1	6	0.2
Redox potential EH (calculated)	mV	402	405	478	165
Base capacity (pH 8.2)	mmol/l	0.74	0.47	0.45	0.95

Alkalinity (pH 4.3) at sampling	mmol/l	4.6	4.25	4.4	4.75
Alkalinity (pH 4.3) at lab	mmol/l	4.12	4.15	4.5	4.45
Parameters	**Unit**	**KSWS 1**	**KSWS 2**	**KSWS 3**	**KSWS 4**

Cations					
Sodium (Na^+)	mg/l	11	11	13	13
Potassium (K^+)	mg/l	4.4	4.4	5.4	5.4
Calcium (Ca^{2+})	mg/l	63	62	66	65
Magnesium (Mg^{2+})	mg/l	17	17	20	20
Ammonium (NH_4^+)	mg/l	0.06	<0.05	<0.05	<0.05

Anions					
Hydrogene carbonate (HCO_3^-)	mg/l	251	253	275	272
Chloride (Cl^-)	mg/l	2.3	2.3	1.5	1.5
Sulphate (SO_4^{2-})	mg/l	37	37	49	49
Nitrate (NO_3^-)	mg/l	1.2	1.2	<0.2	<0.2

Deviation anion to cation sum					
Deviation anion to cation sum	%	1.46	0.65	0.10	0.70

Trace compounds					
Fluoride (F^-)	mg/l	0.50	0.50	0.62	0.60
Phosphorus total	mg/l	0.01	<0.005	<0.005	0.01
Silicon	mg/l	11.8	11.7	13.4	12.7

Metals					
Iron total	mg/l	<0.02	<0.02	0.26	0.25
Thallium	mg/l	<0.001	<0.001	<0.001	<0.001
Thorium	mg/l	<0.00001	0.00003	<0.00001	0.00004
Uranium	mg/l	0.0039	0.0040	0.0011	0.0010

Sum and single parameter					
water hardness calculated	mmol/l	2.25	2.24	2.45	2.45
water hardness calculated	^{o}dH	12.6	12.6	13.8	13.7

Gases					
Nitrogen	Nml/kg	93	54.1	78.9	42.1
Carbon dioxide	Nml/kg	7.59	5.33	4.69	10.6
Argon	Nml/kg	1.400	0.660	0.880	0.600
Oxygen	Nml/kg	25.6	14.6	20.9	6.26

Table 4: *Chemical parameters to determine potability of a water supply (EC Directive 80/778/EEC).*

Parameter	Unit	Guide level	Max. acceptable concentration
Conductivity	µS/cm @ 20°C	400	1500
Chloride	mg/l Cl	25	400
Sulphate	mg/l SO_4	25	250
Nitrate	mg/l NO_3	25	50
Magnesium	mg/l Mg	30	50
Sodium	mg/l Na	20	175
Potassium	mg/l K	10	12
Calcium	mg/l Ca	100	250
Iron	mg/l Fe	50	200

The four water samples are all from hot water springs ranging in temperature from 16 – 19 °C. The results of the water samples indicate they can be grouped into two groups (KWS1 & KWS2; KWS3 & KWS4) almost certainly the result of common aquifers. Although all the springs show elevated TDS (>450 ppm) the chemistry is largely a reflection of the underlying geology of carbonatite and sodic alkali silicate rocks. The samples from all the boreholes show high concentrations of cations of Na, Mg and Ca, the anion HCO_3- and all have very high amounts (>40 ppm) of sulphate. Halogens (Cl, F) are negligible and no concentrations of radio-active elements (Th, U) were noted. In the case of sample KWS4, the high sulphur content is detectable by smell, and the low redox potential suggests a high amount of dissolved sulphide. It is the warmest of all the springs but its chemical similarity with KWS3 suggest both tap the same source aquifer. The water quality is regarded to be potable in limited amounts for KWS1, 2 and 3, but will probably cause gastro-intestinal upset due to high sulphate content. The extremely low oxygen content and low redox potential for KWS4 means it is unsafe and harmful to aquatic life.

4. Open Day at the Naturzentrum Kaiserstuhl – feedback to the community

In October 2017, after nearly 20 months of work conducted at the Kaiserstuhl, the HiTech AlkCarb team decided it would be a good time to provide some feedback to the general public. Hence, on Sunday 8th October the HiTech AlkCarb project invited members of the public to an Open Day at the Naturzentrum Kaiserstuhl in Ihringen [3]. The team introduce the geological and geophysical findings of the work conducted at the Kaiserstuhl and the exhibits additionally included the results of water sampling. The public was introduced to the general uses of rare earth elements (REE) and what importance carbonatites have as hosts for REE deposits, and also to a wider understanding of geological processes. The day offered activities for children such as building your own 'earth' and finding hidden magnets, and opened with a live mini–volcano welcoming the attendees. The Open Day was advertised in the local municipality newspapers and in local newspapers. On the day, some 150 people came to the Naturzentrum Kaiserstuhl to interact with the HiTech AlkCarb team. The day

[3] http://www.naturzentrum-kaiserstuhl.de

ended with a talk by Dr. Ben Walter, giving a detailed overview of the geology of the Kaiserstuhl, in the Rathaus conference hall. Mr. Kai Kircheldorff from the Badische Zeitung interviewed Prof. Frances Wall and Dr. Ben Walter, and a very positive article was published in the newspaper on 10th October 2017 [4].

5. Drilling concerns

The public support and interest of the Mayors in the scientific research has been heartening. However, concerns were raised in meetings with these stakeholders about the proposed drilling. In this section we look at the past history of drilling in the area, compare these and other drilling projects with the HiTech AlkCarb proposals and consider why the risk perception for drilling was so high, in comparison with our internal project assessment of low environmental and social risk.

Past experiences – Staufen and Basel.

Two drilling incidents have led to a generally negative public perception of borehole drilling in the area around the Kaiserstuhl.

1. Geothermal boreholes in Staufen im Breisgau

In September 2007, seven geothermal boreholes were drilled to a depth of 140 m in the town of Staufen im Breisgau (located 25 km from Kaiserstuhl; 7800 inhabitants) to establish borehole heat exchangers (BHE) to heat the town hall. Unfortunately, at one of the boreholes water entered layers of anhydrite ($CaSO_4$) which reacted with water and became gypsum ($CaSO_42H_20$). This reaction results in the rock absorbing water and can lead to an increase in volume of up to 61%, subsequently causing deformation of rock layers.

Within weeks of drilling completion, the ground surface began to experience uplift at rates of up to 10 mm per month and cracks appeared in buildings, including the 16th Century Town Hall. This inflation rate reached a maximum of 2.9 mm per month during the incident [5] and resulted in a total inflation of 26 cm in some places by 2010[6]. The cracks expanded over the months and, as of July 2012 [5], 269 buildings in the historic town centre had been affected, including the Town Hall and adjacent buildings (Figure 14 a and b), and gas and water utility pipes had suffered damage. The damaged buildings have even become a tourist attraction while the town tries to raise the money to repair them (Figure 14 b and c).

[4] http://www.badische-zeitung.de/ihringen/der-kaiserstuhl-ist-eine-beispielregion-fuer-seltene-gesteine--143196319.html
[5] http://www.staufenstiftung.de/risse-chronik.html
[6] Sass, I. and Burbaum, U. 2010 Damage to the historic town of Staufen (Germany) caused by geothermal drillings through anhydrite-bearing formations, Acta Carsologica, 39 (2), 233-245

Figure 14 a

Figure 14 b

Figure 14 c

***Figure 14** Examples of the damage caused in Staufen im Breisgau: a) Cracks in the Town Hall and adjacent buildings, b) an example of the plasters painted over the cracks with the phrase 'Staufen darf nicht zerbrechen!', 'Staufen must not break!', c) Information boards to explain the incident and impacts in central Staufen im Breisgau.*

The reason that the water was able to enter the anhydrite layers was that the upper parts of the borehole were cased, but not the lower parts, and some sections of the borehole likely collapsed [7]. This allowed artesian groundwater to penetrate the anhydrite layer.

In March 2014 the inflation appeared to have stopped[8]. This cease in inflation may either be due to a halt in the volume increase caused by the gypsum formation, or to karstification, because gypsum is soluble and may result in sinkhole generation[9] which could balance out continuing inflation.

Goldscheider and Bechtel (2009)[10] consider the situation in Staufen to have been an avoidable crisis, because it is well known than anhydrite is present in this area. The potential swelling of anhydrite when in contact with water and potential for damage to buildings and infrastructure they consider to be a well-known geotechnical issue and they expressed concerns that this incident had not only

[7] Sass, I. and Burbaum, U. 2010 Damage to the historic town of Staufen (Germany) caused by geothermal drillings through anhydrite-bearing formations, Acta Carsologica, 39 (2), 233-245

[8] http://www.staufenstiftung.de/risse-chronik.html

[9] Sass, I. and Burbaum, U. 2010 Damage to the historic town of Staufen (Germany) caused by geothermal drillings through anhydrite-bearing formations, Acta Carsologica, 39 (2), 233-245

[10] Goldscheider, N. and Bechtel, T.D. 2009 Editors' message: The housing crisis from underground—damage to a historic town by geothermal drillings through anhydrite, Staufen, Germany, Hydrogeology Journal, 17, 491–493

damaged a beautiful old town, but has also potentially damaged public confidence in geothermal technology.

To make matters worse, the company is no longer operating.

2. Geothermal power project in Basel

Around the same time as the uplift problem was beginning in Staufen, induced seismicity associated with a geothermal power project in Basel, 60 km to the south of the Kaiserstuhl area, also caused concern. The boreholes in Basel reached a depth of 4.8 km and injection of water into granite at a depth of more than 4.6 km resulted in several small earthquakes (magnitude 0.7 – 3.4) during 2006 – 2007[11, 12]. Following normal industrial regulation procedures this induced seismicity put a halt on the work, but seismicity continued with four earthquakes over ML 3 in the following 56 days[13]. All work ceased on the project in 2009. Geopower Basel AG, the responsible company paid compensation to affected owners.

Impacts of drilling projects

Incidents like these, though widely publicised and causing justifiable alarm, are not common. Drilling (for unconventional oil and gas, geothermal projects, or research) is not unusual and the great majority of these projects do not have serious negative impacts. The drilling process is rarely the cause of problems, however induced seismicity can be caused by fluid injection into boreholes and resultant, hydraulic fracturing, which is associated with fossil fuel extraction and sometimes geothermal projects. This disputed technology was officially banned in Germany in 2016, as environmental groups protested against possible water pollution and seismicity.

In a small number of cases groundwater pollution has been caused by poor construction or design of boreholes or drill sites, but this is very rare[14] and best practice, backed up with regulation, can reduce the potential for such impacts.

Concerns about other potential impacts of projects which involve drilling include noise pollution impacts on people and wildlife during the day and night, pollution to land, water and air caused by release of oil or chemicals, resultant impacts on human health, pressure on infrastructure, water use, waste management, impact on house prices, and other socioeconomic impacts on nearby communities[15]. The potential for these impacts depends on the scale and purpose of the drilling activities, as well as the decisions of the organisation involved and the regulation in place, and are least likely for small drilling projects. In the case of drilling associated with oil and gas, concerns are also regularly raised about continued fossil fuel use and climate change.

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[11] Häring, M.O., Schanz, U., Ladner, F., and Dyer, B.C. 2008. Characterisation of the Basel 1 enhanced geothermal system. Geothermics, 37, 469-495

[12] http://www.seismo.ethz.ch/en/earthquakes/monitoring/geothermal-energy-basel/Project-Description/

[13] Foulger, G.R., Wilson, M.P., Gluyas, J.G., Julian, B.R., Davies, R.J. 2018 Global review of human-induced earthquakes, Earth-Science Reviews, 178, 438-514.

[14] https://www.parliament.uk/documents/post/postpn374-unconventional-gas.pdf

[15] Clarke, C.E., Hart, P.S., Schuldt, J.P., Evensen, D.T.N., Boudet, H.S., Jacquet, J.B., Stedman, R.C. 2015 Public opinion on energy development: The interplay of issue framing, top-of-mind associations, and political ideology, Energy Policy, 81, 131 – 140.

Differences between these case studies and the HiTech AlkCarb proposed drilling plan at the Kaiserstuhl

Comparing the HiTech AlkCarb drilling proposals with these industrial case studies, particularly the circumstances at Staufen im Breisgau and Basel, it is clear that the scale and purpose of the drilling and the geological circumstances of the drill site are quite different. The purpose of the drilling proposed for HiTech AlkCarb was to collect rock samples and to carry out downhole geophysics measurements. There would be no need for fluid injection or hydraulic fracturing and operations would be much smaller (Figure 15). The HiTech AlkCarb team's evaluation of the risk to the surrounding environment and community from the proposed drilling indicated that risk was very low.

During the first meeting with the mayors of Vogtsburg Municipality (13th April 2016) HiTech AlkCarb partners explained that the geology at Kaiserstuhl is totally different to that in Staufen and Basel. At the Kaiserstuhl, there are no anhydrite layers, and therefore the inflation associated with gypsum formation cannot occur at there. Furthermore, drilling was planned to be completed with a very small core diameter, and operated for a short period of time, after which the hole would be completely sealed off and reclaimed to natural site conditions. To help explain the differences between geothermal drilling, hydraulic 'fracking' methods, and small diameter diamond drilling as used in mineral exploration, some explanatory figures were prepared (Figure 15). The University of Tübingen offered to provide a written statement stating that geologically none of the above raised concerns would happen at the Kaiserstuhl. The only possible impact that could occur during drilling may be encountering artesian ground water. This is a regular occurrence in places with an elevated water table, and easily manageable with small boreholes and small pressures. If artesian conditions occurred, the borehole would be sealed off correctly.

Difference between a fracking drill rig and diamond drilling

	Hydraulic Fracturing	vs.	Diamond Drilling
Drilling method	mud rotary		diamond core
Purpose	Destroy rock for high pressure gas exploitation		Recover small rock "core" for scientific research
Footprint	7,000m2		10m2
Depth	4,000 - 8,500 ft.		200m
Horizontal extent	3,000 - 5,000 ft.		0 ft.
Hole diameter	203.2 mm		63.5 mm
Duration	30 years		10 - 20 days
Perforation blasts?	YES		NO
Fracking Fluid?	YES		NO
High Pressure Gas?	YES		NO
Harmful, toxic chemicals?	YES		NO, Bentonite clay
Bit	Hardened metal tri-cone		Circular, hollow diamond
Bit action	Pulverize rock to powder		Cut rock to extract intact core
Site infrastructure	Drill equipment, pipes, storage, portacabins, etc.		Truck-mounted drill rig
Other infrastructure/industry	Flaring, compressor stations, trucking, tanks, processing plants, LNG terminals, silica mining		Small group of geoscientists
Seismic risk?	YES		NO
Hazardous to human health?	YES		NO
Failure rate	9%		< 0.0001%
Earthquake probability	Highly probable		Never recorded in 100+ years

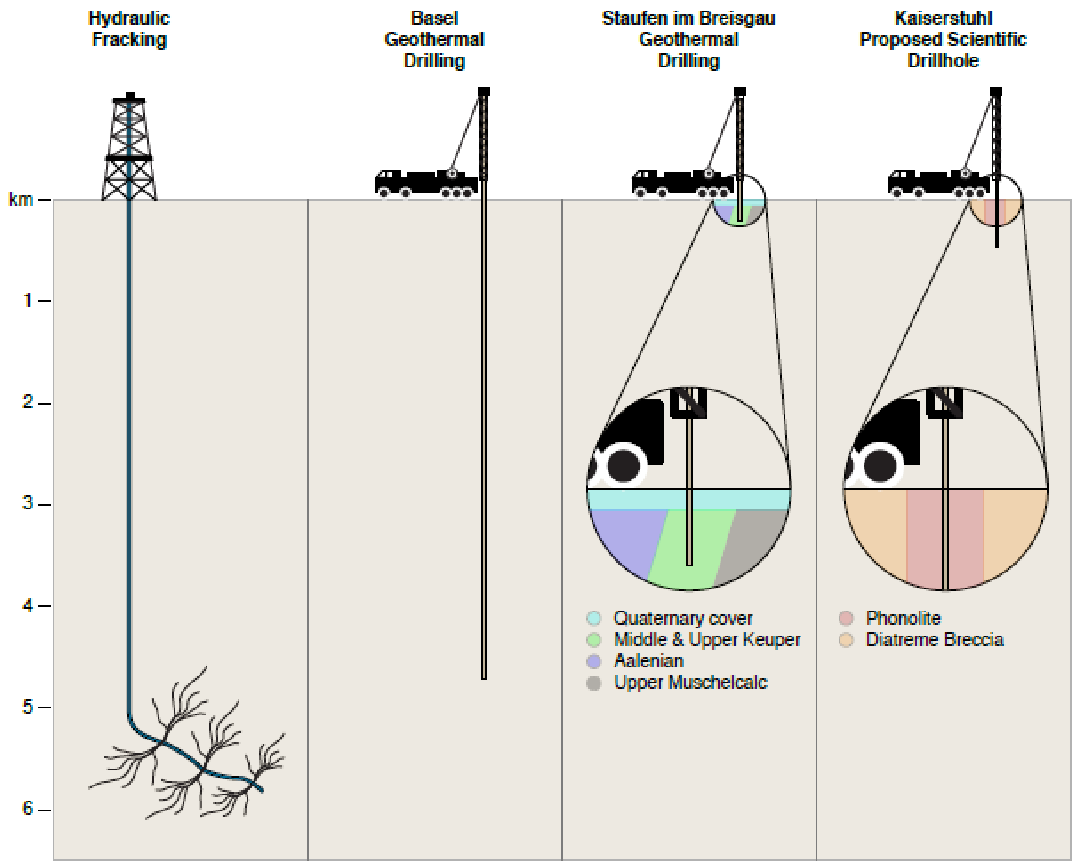

Figure 15 *Explaining the difference between the proposed diamond drilling versus large diameter geothermal drilling.*

During the second meeting with the Mayor of Vogtsburg (18th November 2016) while discussing the proposed drill hole, the mayor expressed concern about potential temporary and chronic impacts to groundwater resulting from the drill hole. Water sampling and analysis was therefore carried out by HiTech AlkCarb and proposed to be repeated during the project to monitor water quality and any impact from drilling. He also asked what the benefits for the community would be. Potential benefits highlighted in the meeting were that local wine growers or other users might be interested in utilizing a cheap nearby water source.

Despite this these consultations, decision makers at Kaiserstuhl were very concerned about potential risks from the HiTech AlkCarb research drilling proposal. We will now go on to outline the decision making process which resulted in a decision not to drill the borehole and discuss why concern about risks was so prohibitive, in contrast to the low risks assessed by project members.

6. Drillhole decision making

Table 5 provides a short summary of steps taken during the proposal to drill at the Badberg and towards the final decision not to conduct the drilling.

Table 5: Correspondence to obtain drilling permission.

Date / reason	Company	Summary
December 2016 to present	terratec	• Downhole survey of KB3 (Steinreisse borehole) • Water samples
November 2016	terratec	• Request for permission to drill at the Badberg to the Landesamt Breisgau-Hochschwarzwald
July 2017	terratec	• Changes to the request for permission to drill at the Badberg to the Landesamt Breisgau-Hochschwarzwald
August 2017	Landesamt Breisgau-Hochschwarzwald	• Notification to terratec that drilling is permitted if certain conditions are fulfilled as stipulated by the municipality of Vogtsburg
October 2017	terratec	• Final decision not to drill at the Badberg (decision was taken at a Project Partner Management Meeting on 21st September 2017)

In the original grant proposal and agreement with the European Commission it was proposed that a new research borehole would be drilled at the Badberg to gain additional knowledge about the Kaiserstuhl carbonatite. All necessary applications were submitted to the Landesamt Breisgau-Hochschwarzwald (Landesamt). The Landesamt granted permission if agreement was also forthcoming from the municipality of Vogtsburg. Attached to the notification from the Landesamt in August 2017 were the requests from the municipality of Vogtsburg, which included the following four aspects which needed to be contractually included in the permission to drill:

1. To use the parking area (at the Badberg) the applicant needs to pay compensation.
2. The original state of the parking area needs to be restored after the drilling.
3. The liability risk of any damage caused by the drilling needs to be insured by the applicant for the longest possible period, with particular reference to any negative impacts to the 'Neunbrunnenquelle' (a spring in the valley South of the Badberg) and inclusion of a sewage pressure line in the insurance.
4. The geological drilling should generate a positive impact to tourism industry in the area. A pavilion and/or an information board should be erected close to the drill site, showing the research results for the local population and tourists.

All of these aspects listed above could have been fulfilled, except number three. Points one and two address impacts to the local area and point four addresses benefit to the community.

Point three was particularly addressed during the first meeting with the mayors of Vogtsburg Municipality (13th April 2016). The mayor asked HiTech AlkCarb to provide him with proof of liability insurance from the drilling company as well as a long-term liability policy. During drilling and up until borehole closure, the drilling contractor assumes liability for all events, and is required to hold appropriate insurance for all risks and eventualities. However, in addition to this, the mayor stipulated that HiTech AlkCarb needed to acquire a 10 year insurance policy guarantee to cover any and all possible impacts. These risks were not specified, and could therefore be interpreted as widely as groundwater disturbance, surface storm water events, human accidents, seismicity, or anything imaginable. The HiTech AlkCarb team has centuries of combined experience in drilling narrow diameter (64mm) boreholes in exploration projects around the world and was able to make several inquiries in the UK, USA and Germany to insurance providers specializing in drilling, long-term liability, and pollution insurance. Advice was also garnered from the International Continental Drilling Programme and British Geological Survey, who were also unaware of any such insurance requirement. After many weeks of inquiry, it was demonstrated that the only available insurance policy would have astronomical premiums (over 10,000 EUROS per month) and could only be purchased on a month-by-month basis.

These four requirements would all have needed to be agreed in a separate contract with the applicant (terratec on behalf of the HiTech AlkCarb project). Terratec would have been responsible for the drilling, and as a private company could not take this risk.

Therefore, the HiTech AlkCarb team decided in a Project Partner Management Team meeting, that no drilling would be conducted at the Badberg. This was conveyed to Landesamt and the municipality in a letter from terratec at the beginning of October 2017.

The decision not to drill and to allocate the project money elsewhere within the HiTech AlkCarb project was made on the basis that terratec could access the historical drill hole KB3 at the Steinreisse quarry. Owing to the unexpected discovery of this historical KB3 borehole, the need for a new research drill hole had also become less urgent. Most of the proposed measurements and data collection were now possible at KB3 and this course of action removed any potential impacts from the proposed drilling at the Badberg.

A survey was conducted in the historical 'Steinreisse' borehole down to 350 m. Optical logging and structural measurements were made using a video camera down the hole, and a full, state-of-the-art suite of down-hole geophysical instruments were utilized to measure magnetic, radiometric, and other properties.

5. Risk perception

The final result of these drilling proposal discussions, thanks to the serendipitous discovery of the historical KB3 borehole, has not had a significantly negative impact on the HiTech AlkCarb project. However, it is still interesting to look at why, in light of the project assessment of low risk and considerable consultation with local stakeholders, political concern about risk was so high.

In the decision-making process regarding whether drilling could be permitted a key criteria was the levels of risk posed to local communities and local infrastructure. Local communities, represented by local politicians, were tasked with the responsibility of deciding upon whether drilling could be permitted and therefore needed to carry out an evaluation of risk. To help inform this process the HiTech AlkCarb team provided information about the proposed drilling project, research context and assessed risks, as well as regular updates and meetings with the community and local politicians, as has been detailed in this report so far.

However, risk communication and decision making is challenging, because response to a risk is not purely based on information about risk levels. Instead, it is influenced by risk perceptions which are often based upon a wider range of criteria, and thus can result in a discrepancy between individual risk evaluations and formal, institutional risk assessments.

The differences in risk perception between different groups are widely recognised from some five decades of research on risk perception, across a broad spectrum of fields including natural hazards, medicine, insurance and industrial development. Slovic and others [16] suggest that the difference between the risk person of laypeople and scientists does not relate to irrational versus rational thought, rather is attributed to the evaluations being carried out by different rules for assessing risk. Looking at this, Fischhoff and others [17] found that risk perception is influenced by factors that include how voluntary the risk-taking is, the knowledge about the risk, associated dread, immediacy, irreversibility and intensity of impacts and whether the risk can be controlled or reduced (Figure 16). These factors vary between individuals, and are in turn influenced by the wider context, including education, social context, personal circumstances, sources of information and world view. Media coverage of risks and impacts can also influence risk perception [18] and can contribute to social amplification of risk[19]. Risk perception is therefore multi-faceted and influenced by many different factors.

[16] Articles by Slovic and others, for example:

- Slovic, P. Fischhoff, B. and Lichtenstein, S., 1981. Facts and Fears: Societal Perception of Risk, in Monroe, K.B. (ed), NA - Advances in Consumer Research Volume 08, Association for Consumer Research, 497-502.
- Slovic, P., Fischhoff, B., Lichtenstein, S. 1982. Why Study Risk Perception?, Risk Analysis, 2 (2), 83–93.
- Slovic, P. 1987. Perception of risk, Science, 236, 280–285.
- Slovic, P. (ed.) 2000. The Perception of Risk. London: Earthscan.

[17] Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, 9, 127–152.

[18] Mackie, B. 2014. Warning fatigue : Insights from the Australian Bushfire Context. Unpublished PhD thesis, University of Canterbury;
Wachinger, G., Renn, O., Begg, C., and Kuhlicke, C. 2012. The Risk Perception Paradox—Implications for Governance and Communication of Natural Hazards, Risk Analysis, 33 (6) 1049-1065.

[19] Kasperson, R.E., Renn, O., Slovic, P., Brown, H., Emel, J., Goble, R., Kasperson, J., and Ratick, S. 1988. The Social Amplification of Risk: A Conceptual Framework, Risk Analysis, 8, (2), 177–187.

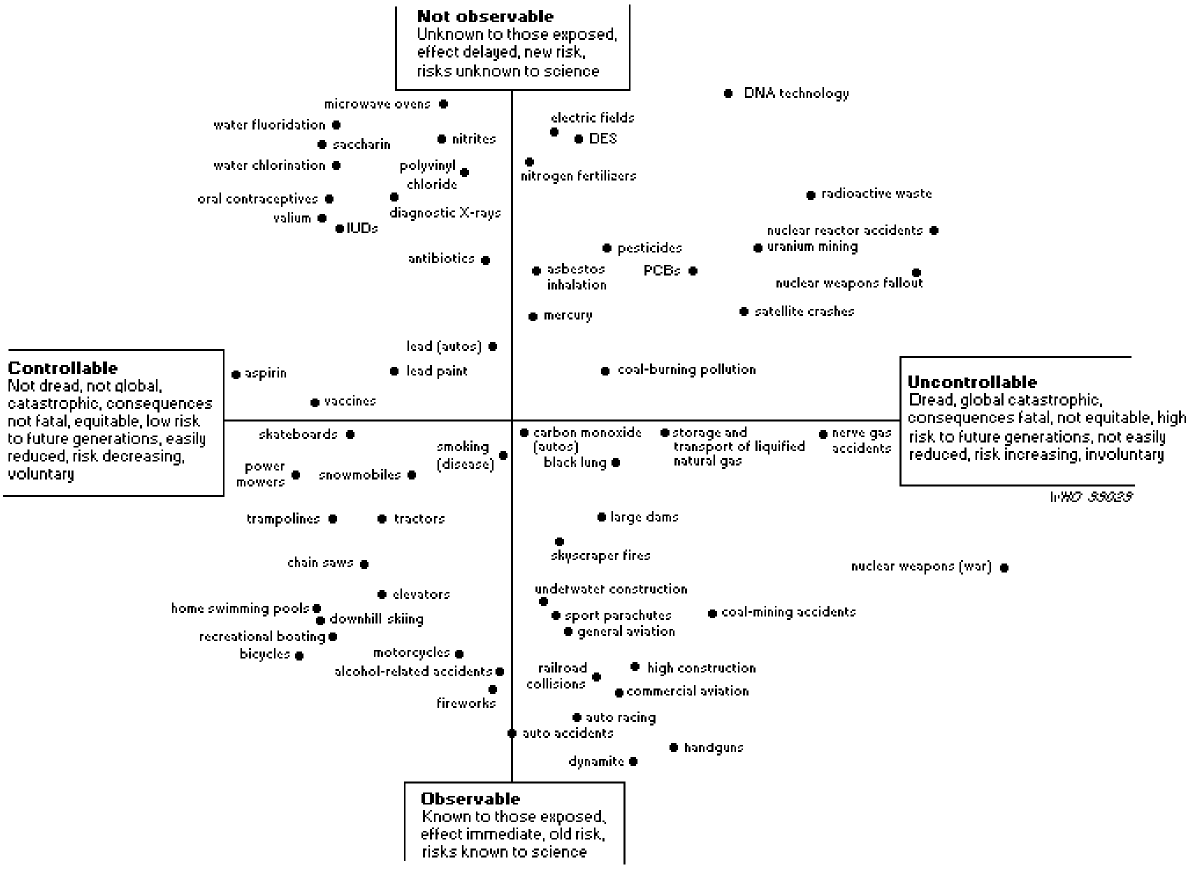

Figure 16 Risk space quadrants for public perceptions of risk (Morgan[20])

Sandman [21] proposed a way of viewing this as the cultural view of risk, or outrage as he termed it

[20] Morgan, M.G. 1993. Risk Analysis and Management, Scientific American, 269 (1) 32-41

[21] Sandman, P. 1993. Responding to Community Outrage: Strategies for Effective Risk Communication, American Industrial Hygiene Association, Fairfax, VA.

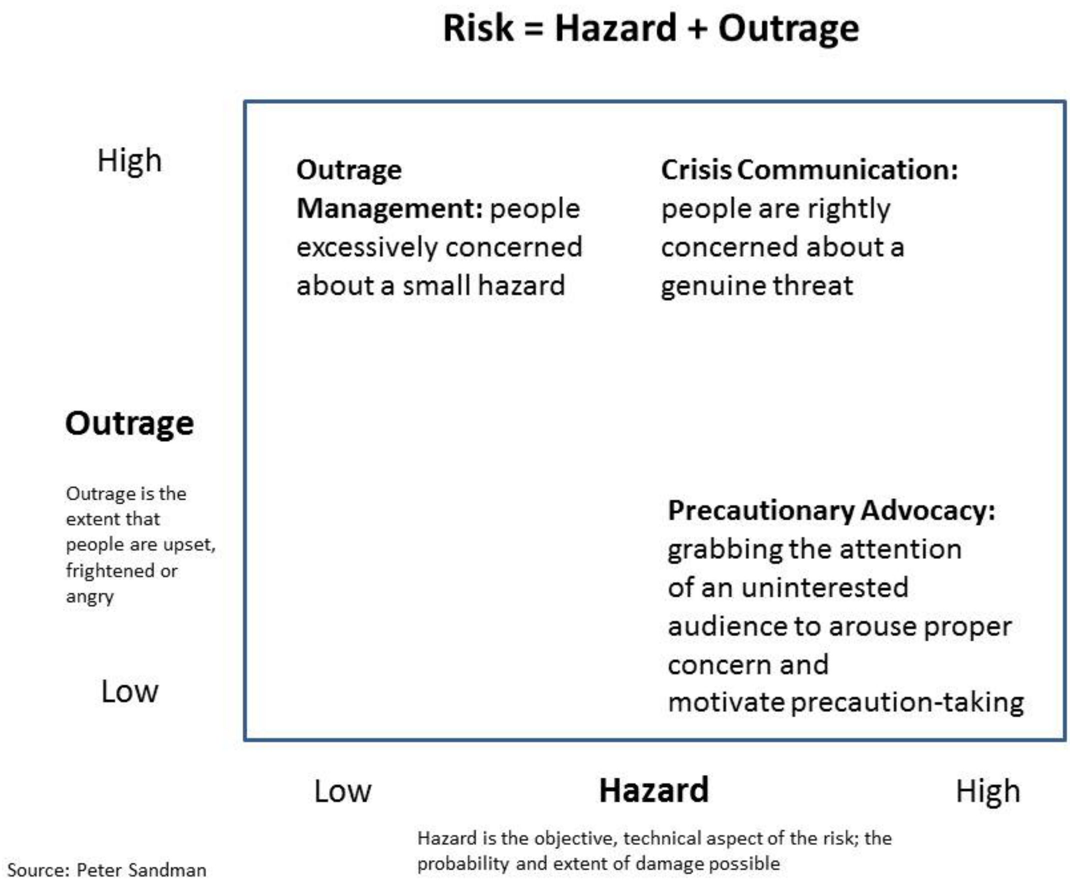

Figure 17 The balance between outrage and hazard and suitable risk communication responses. Adapted by Bruce Miyashita (https://xray-delta.com/tag/dr-peter-sandman/) from Sandman: http://www.psandman.com/index-intro.htmIn each of these zones of Figure 17 it is recognised that communication can be a solution bringing risk perception into line with actual risks. However, the type of communication varies depending on the balance between the quantitatively assessed hazard and the community outrage. In addition, effective communication should not simply cover project facts and quantitative risk assessments but instead needs to involve a dialogue with communities. Potentially, such outrage management could effectively reduce community upset to a level that matches the actual risk, if there is a situation where people are unduly concerned about very small risks. This can help to obtain social license for a project, but it may not remove all opposition if there are real risks posed to local communities or the environment.

Social license to operate is a term commonly associated with mining projects and it often addresses a relationship between companies and the local communities[22]. An aspect of this, when there is public concern about a development where concern is high but actual risk to social and environmental spheres is low, is a requirement for understanding of risk perception and potentially also outrage management.

[22] Koivurova, T., Buanes, A., Riabova, L., Didyk, V., Eidemo, T., Poelzer, G. Taavo, P and Lesser, P. 2015. 'Social license to operate': a relevant term in Northern European mining? Polar Geography, 38 (3), 194-227.

Risk perception drilling

Gibson and others[23] demonstrated in a study of public understanding of the subsurface that many people, in the UK where the study was carried out, have a limited understanding of the characteristics of rocks and ground water beneath our feet. The difference in understanding of geology between laypeople and geologists might help us to understand where to place actions such as drilling in Figure 16, potentially moving such projects into the non-observable and uncontrollable fields. This may help to indicate why drilling can create considerable concerns about risk. House [24] also addressed this problem of limited public understanding in relation to hydraulic fracturing and highlighted how the speed of technological development was faster than the spread of knowledge about the technology, such that it has created concern and attached a fear of the unknown to unconventional oil and gas projects.

Challenges of risk perception, outrage management and social licence have been significant in the oil and gas industry and there have been several studies looking at risk perception in relation to these fields. Bomberg [25] has looked at the debate about shale gas in the UK and identified that the two opposing viewpoints have from stemmed trust issues with the pro-shale messengers, and strong arguments tapping into local politics of power and democracy, as well as environmental and economic concerns. In particular she highlights that, in the UK, the wider, national and international implications and concerns about shale gas, use of fossil fuels and climate change have a much lower relevance to the opposing groups than local concerns and local issues.

Boudet and others [26], on the other hand, in a study of public attitudes to fracking in the US found that, of those who held opinions of on fracking (the minority since most were uninformed about the topic), those against tended to be concerned about environmental impacts and those in favour valued potential economic advantages of the technology. Their approach particularly looked at affective imagery or 'top of mind' associations, many of which pointed to a general lack of familiarity regarding fracking, but also showed that many of the factors that lead to support or opposition to emerging technologies relate to more fundamental traits, such as world view or political ideology, which are more difficult to alter through information or persuasion campaigns. The important influence of fundamental traits was backed up in a similar study in the UK [27] and fits with risk perception studies across a broad spectrum of fields. Boudet and others[28] and Choma and others[29]

[23] Gibson, H., Stewart, I.S., Paul, S. and Stokes, A., 2016. A "mental models" approach to the communication of subsurface hydrology and hazards. Hydrology and Earth System Sciences, 20, 1737–1749.
[24] House, E.J. 2013. Fractured Fairytales: The Failed Social License for Unconventional Oil and Gas Development, Wyoming Law Review, 13 (1), 5-67.
[25] Bomberg, E. 2017. Shale We Drill? Discourse Dynamics in UK Fracking Debates. Journal of Environmental Policy & Planning, 19 (1), 72-88.
[26] Boudet, H. Clarke, C., Bugden, D., Maibach, E., Roser-Renouf, C., and Leiserowitz, A. 2014. "Fracking" controversy and communication: Using national survey data to understand public perceptions of hydraulic fracturing. Energy Policy, 65, 57–67.
[27] Whitmarsh, L., Nash, N., Upham, P., Lloyd, A., Verdon, J.P., and Kendall, M. 2015. UK public perceptions of shale gas hydraulic fracturing: The role of audience, message and contextual factors on risk perceptions and policy support. Applied Energy, 160, 419–430.
[28] Boudet, H. Clarke, C., Bugden, D., Maibach, E., Roser-Renouf, C., and Leiserowitz, A. 2014. "Fracking" controversy and communication: Using national survey data to understand public perceptions of hydraulic fracturing. Energy Policy, 65, 57–67.
[29] Choma, B.L., Hanoch, Y. and Currie, S. 2016. Attitudes toward hydraulic fracturing: The opposing forces of political conservatism and basic knowledge about fracking. Global Environmental Change, 38, 108–117.

found that in the U.S. democrats tended to be concerned about environmental impacts and republicans interested in economic benefits. The same politics related pattern was found in the UK for left and right politically-leaning individuals[30].

Local, regional and national attitudes to shale gas have also been seen to vary in the United States [31], and different approaches to communication are needed at the different scales, with local impacts and concerns of relevance to only very local areas around a drill site, as opposed to wider environmental and economic concerns being important at a larger scale. This is an important point, since all such activities will need to engage with local communities as well as interact with a wider region for permitting, political support and reputation, and thus may need multiple different communication methods and messages.

So, to summarise, in these cases, local impacts concerned people living in the local area and broader concerns were important at larger scales. Trust in messengers was also highlighted as an important factor, which potentially can be addressed by communication. However, some tendencies to support or object to projects also related to other characterises such as political ideology and world view, as these are less easy to influence.

Risk perception for geothermal projects is rather different than for oil and gas, particularly since the broader climate-change related environmental concerns associated with continued fossil fuel use are not relevant. However, similar fears, especially those regarding the local community still exist in Germany, often including concerns about earthquakes, environmental impact locally and also issues of trust about whether legitimate risks will be well communicated [32].

Koivurova and others[33], using examples from mining projects in northern Europe, discussed the factors that can determine whether a project receives social license to operate or not. They particularly highlighted the need for a belief in the credibility of the project, that a company had the best interests of the area at heart, and that there was strong trust between the community and the project operators. Different behaviours of companies were able to alter the level of support received from the community, but also the history of each area, the political landscape and other local differences in cultural and environment impacted the degree to which social license to operate was achieved.

Miethling [34] states that geothermal energy development will not occur without strong public support throughout all stages of development generally and specifically in Germany where protests have occurred related to concerns about induced seismicity. Kunze and Hertel [35] investigated objection to geothermal projects in Germany and identified the problems in Basel as a trigger for the development of a German-language public and media encouraged risk discourse about geothermal

[30] Bomberg, E. 2017. Shale We Drill? Discourse Dynamics in UK Fracking Debates. Journal of Environmental Policy & Planning, 19 (1), 72-88.
[31] Evensen, D. and Stedman, R. 2016. Scale matters: Variation in perceptions of shale gas development across national, state, and local levels. Energy Research and Social Science, 20, 14–21.
[32] Zaunbrecher, B.S., Kluge, J., and Ziefle, M. 2018. Exploring Mental Models of Geothermal Energy among Laypeople in Germany as Hidden Drivers for Acceptance. Journal of Sustainable Development of Energy, Water and Environment Systems, 6 (3), 446-463.
[33] Koivurova, T., Buanes, A., Riabova, L., Didyk, V., Eidemo, T., Poelzer, G. Taavo, P and Lesser, P. 2015. 'Social license to operate': a relevant term in Northern European mining? Polar Geography, 38 (3), 194-227.
[34] Miethling, B. 2011. Different but Similar: Geothermal Energy and the Role of Politics in Germany, Iceland and the United States. Z Energiewirtsch, 35, 287–296.
[35] Kunze, C. and Hertel, M. 2017. Contested deep geothermal energy in Germany—The emergence of an environmental protest movement. Energy Research and Social Science, 27, 174–180

development, which has led to local protest groups being founded and the promotion of a new environmental protest movement. Their conclusion from this study was that there will be strong conflicts and challenges of acceptance for deep geothermal projects in Germany and this would likely slow down the growth of this new technology.

HiTech AlkCarb and broader implications for research and exploration.

The HiTech AlkCarb team's evaluation of the risk to the surrounding environment and community from the proposed drilling indicated that risk was very low, and that the problems encountered in Staufen and Basel could not occur in the Kaiserstuhl due to different geological conditions and the different purpose and scale of the drilling project. An entire work package of HiTech AlkCarb focusses on environmental and social impacts and considerable effort was put into developing dialogue with local communities and decision makers and also to put in place a programme of monitoring environmental impact and guidelines for responsible and low-impact field research. HiTech AlkCarb therefore approached the challenge of risk communication and community engagement following best practices and with a very open manner.

However, we recognise that the community decision-makers had to include an evaluation of public and political risk perception in their decision making in process. In view of the impacts of projects in Staufen and Basel, the growth of resistance to other drilling projects in Germany and challenges of risk acceptance this led to their requirement for an insurance policy to cover potential drilling impacts far into the future, and unfortunately this was beyond the means of the project team to fulfil. With this broader context it seems that it would have been very difficult for HiTech AlkCarb to have been able to fully reduce the concerns about risk so that this insurance policy was not needed. Interestingly, when meeting with the public on several occasions, including at the local museum open day, the project team felt that there was strong public support for HiTech AlkCarb in the area and this is likely an outcome of the good dialogue with the local community throughout the project.

We note that other geothermal projects involving drilling are continuing in Germany, such as the Dorfen deep geothermal project near Munich[36]. Such projects may provide an opportunity for best practice to be communicated to the south western region of Germany to help to regain public confidence. In the UK, the controversy around fracking for shale gas has been at least in part responsible for a major Natural Environment Council project to set up two new Geoenergy Observation Sites managed by the British Geological Survey[37] for research into the subsurface environment. Results from projects such as this are important in improving both the technical knowledge and public confidence that is needed to be able to make safe and sustainable use of georesources.

7. Conclusion

Doing scientific research or exploration should always start with public consultation and socio-economic research of the area.

[36] http://www.thinkgeoenergy.com/drilling-progressing-well-for-dorfen-geothermal-project-in-icking-bavaria-germany/ accessed 22.11.2018 and http://www.erdwaerme-isar.de/ accessed 22.11.2018
[37] https://www.bgs.ac.uk/ukgeoenergyobs/ accessed 22.11.2018

The community of the Kaiserstuhl area was sensitised by the two incidents related to drilling – Staufen im Breisgau and Basel. Hence the communities around the Kaiserstuhl are very worried about any potential damage caused by drilling. Despite a general very positive response to our project from the local community, the perceived risk from even the small research drill hole meant that local politicians felt it necessary to have additional insurance.

This led to point 3 of the drilling permit, in which the Mayor requested that HiTech AlkCarb acquire a 10 year insurance policy guarantee to cover any and all possible impacts. Worldwide inquiries showed that such an insurance does not exists, the only available insurance policy would have astronomical premiums (over 10,000 EUROS per month) and could only be purchased on a month-by-month basis. Terratec would have been responsible for the drilling, and as a private company could not take the risk.

It seems most likely that the negative impact for future geothermal acceptance of the Staufen and Basel situations identified by other recent studies has also had a broader impact on all drilling projects, including those for small drill holes for scientific research in this area of Germany. There is very limited literature available on the impacts of this knock-on effect on science from concerns about industrial drilling projects and so this situation at Kaiserstuhl is an interesting case study that highlights these challenges for future projects. This area of research into social license for drilling and exploration, and the wider field of risk perception and communication, is still evolving rapidly and further work is needed into how to address risk perception concerns and balance community needs and fears and research drilling requirements.

The recommendations to the European Commission arising from this experience are:

- To assign any drilling in research and innovation projects, in Germany, and probably elsewhere in Europe, to a Government organisation where possible.
- To publicise good practice examples and subsurface research projects (such as UK GEOS and similar) that can help to regain public confidence.