

**Boost safety and profitability of  
your subsurface operation with**

# **SEISMIC MONITORING**

for MINING, SALT CAVERNS, GEOTHERMAL, OIL  
& GAS, THERMAL ENERGY STORAGE and CCS

[www.k-utec.com](http://www.k-utec.com)

***K-UTEC***  
MINING SOLUTIONS





## The Subsurface Challenge

Working in the subsurface comes with risks that we all know too well from own experience and media reports:

- Miners buried under falling unstable rock resulting in injuries or even fatalities
- Collapse of a salt cavern leading to damages on surface and revocation of the storage or solution mining license
- Cracks in houses due to earthquakes induced by geothermal energy production, oil & gas extraction, energy storage or carbon-capture-and-storage (CCS). Protests of residents threaten the continuity of the operation

Such risks can be significantly reduced by setting up an effective seismological monitoring system. For this purpose, seismometers and hydrophones are strategically placed across your asset to “listen” continuously into the underground. The system is designed to detect and precisely locate even the most subtle subsurface movements.



## Get Peace of Mind – K-UTE Never Sleeps

Don't worry. You don't need to hire additional staff working in shifts to start with seismic monitoring. K-UTE takes care of this service for you. You focus on your core business, we monitor your seismic events, 24/7. Our highly qualified team of geophysicists keeps an eye on the geomechanical stability of your asset, around the clock. We monitor a large number of operations worldwide through data transfer to a secured cloud server. We inform you immediately in case hazardous subsurface stability issues occur.



## Taking Action

This allows you to take swift action, to address geomechanical and geotechnical instabilities, and to protect your operation and the surrounding neighbourhood:

Evacuate mining staff, strengthen tunnels, and reduce injection and extraction rates for geothermal plants, salt caverns, oil & gas and CCS. This helps to save lives, avoid damages, increase operational uptime, maintain continuity of your operation and protect your public image.

## Learning from the Past

Reviewing data from past microseismic events reveals how the subsurface rocks respond to your mining and geotechnical operations. This allows you to predict and plan for subsurface challenges during future operations.

## Essential Part of Every HSE Concept

Seismic monitoring is an integral part of a robust Health, Safety and Environment (HSE) culture of organisations that operate in the deep subsurface. In some countries, the implementation of seismic monitoring is even required by law. The monitoring data will also help you to document to the public and authorities that your operation runs safely without noteworthy seismic incidents. Furthermore, the data help you to defend against unjustified damage claims.



Seismometer in a mine



Seismometer at surface

## Strong Business Case

Seismic monitoring makes for a convincing and strong business case. Keeping your subsurface stress and strain under permanent observation will save a lot of money, because damages and production outages can be costly. With a small investment in a functional seismic monitoring system, such large losses could be prevented.



## OUR SERVICE IN A NUTSHELL

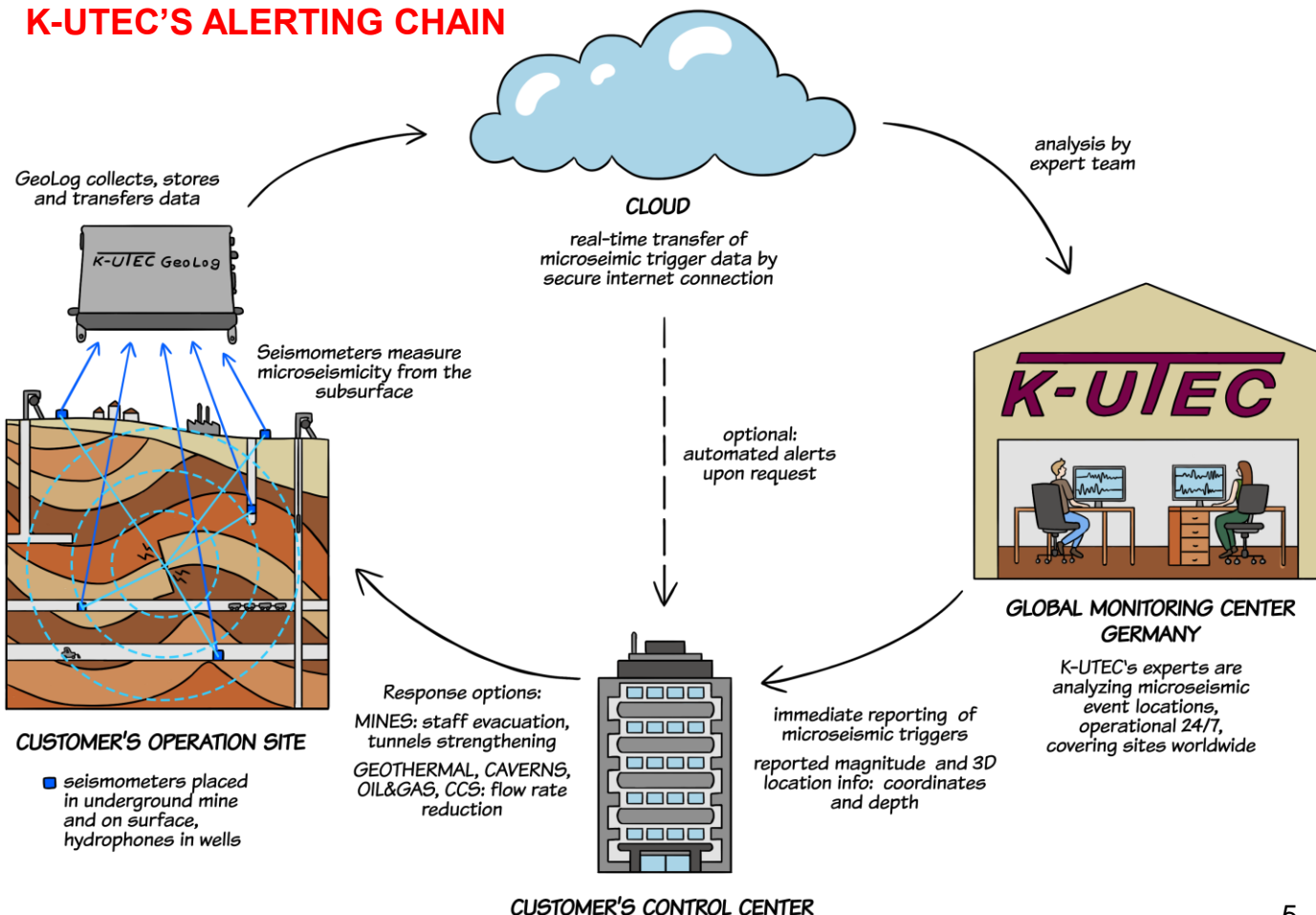
### Thorough Analysis First

We start off with a thorough analysis of your operation and your needs. We then propose a custom-made solution in which we detail the type, number and location of seismometers. We also plan the data transmission infrastructure that transports the data to a Cloud Server and further on to K-UTEC's Global Monitoring Center. Once approved by the client, we procure, build, and install the system that we then put into operation. Several of the components have been specifically developed and designed by K-UTEC to fulfill highest quality standards.

### Strong Partnership

K-UTEC offers monitoring service contracts of one or more years during which we will carry out the entire data analysis, 24/7 alerting and reporting, besides being responsible for the maintenance of the hardware and software. The incoming data from the various seismometer stations are accessible for client and K-UTEC on a secure web-based dashboard. This also includes health data of the stations detailing their individual functional availability as well as a station diary. The data are then sent to SeismoSuite, a software in which the exact location and magnitude of the seismic events are calculated.

## K-UTEC'S ALERTING CHAIN





### **When Every Minute Counts**

Seismic incidents that exceed a pre-defined threshold will trigger an automatic alert for the client and K-UTEC's 24/7 Watch Team. For these events, location and magnitude are immediately calculated and passed on to the client to allow swift action. Clients have the option to book a service in which K-UTEC informs authorities as well, e.g. if speedy reporting within a given time frame is required by law. K-UTEC routinely summarizes all seismological activities occurring on client's assets in regular reports, e.g. monthly, quarterly or yearly.

### **The Choice is Yours**

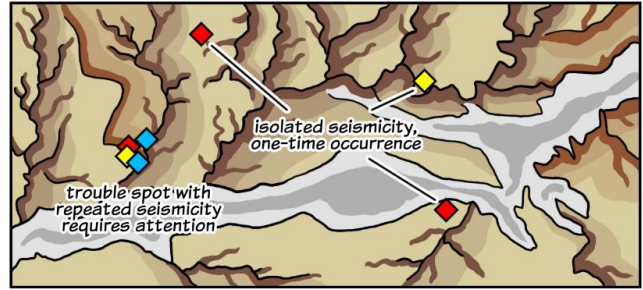
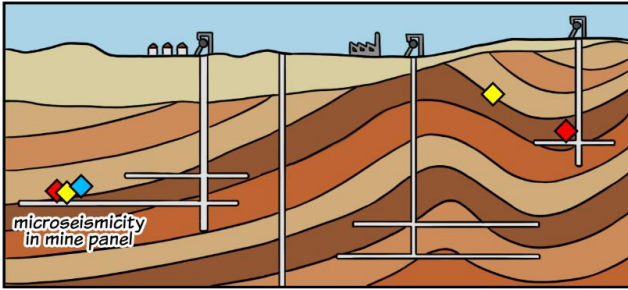
Customers have the choice between a carefree turnkey package, in which we take care of all aspects of seismic monitoring activity, and partial services, in case Customers prefer to supply part of the seismic monitoring tasks themselves. Needless to say that K-UTEC delivers on-time, within budget, and HSE and Sustainability compliant. Some of our Customers have worked with us for several decades now, proving their great level of satisfaction. We work worldwide supported by an international network of regional service partners.

# FIELDS OF APPLICATIONS OF SEISMIC MONITORING

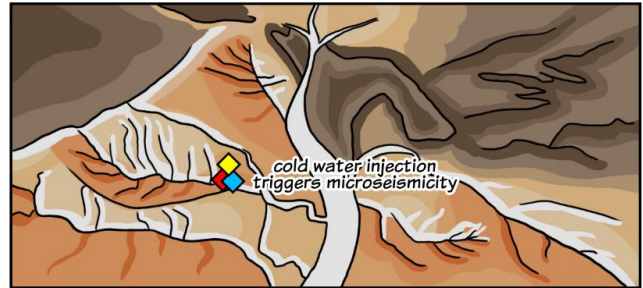
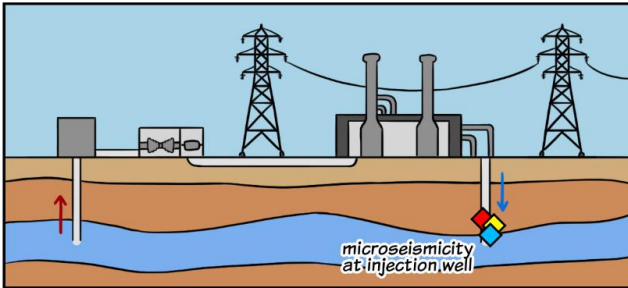
Section view

Map view

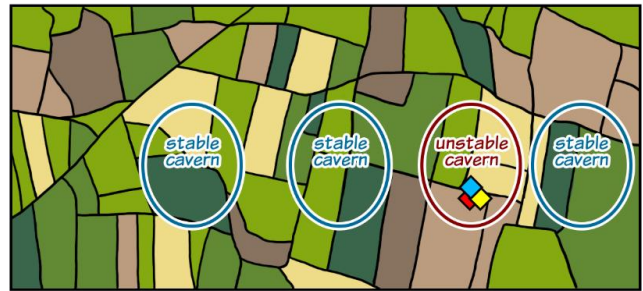
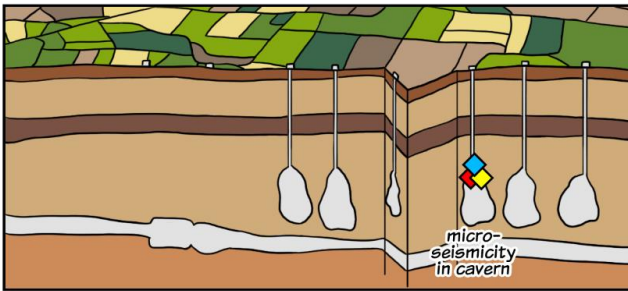
MINING



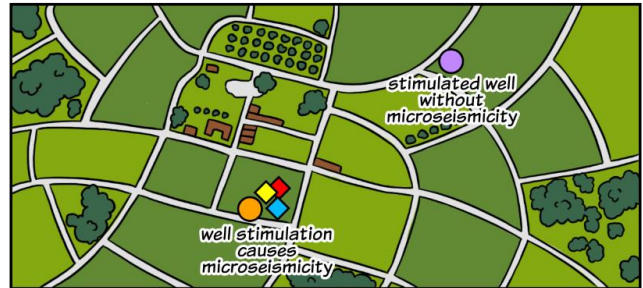
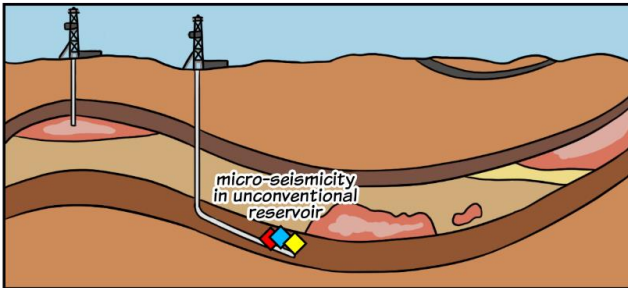
GEOTHERMAL



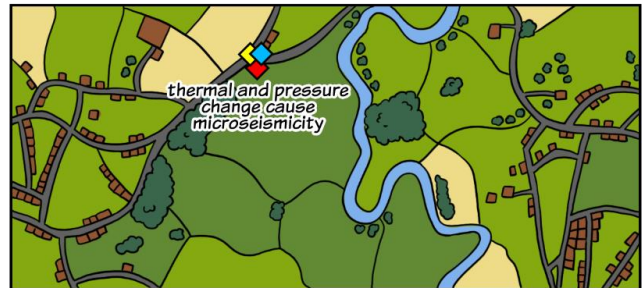
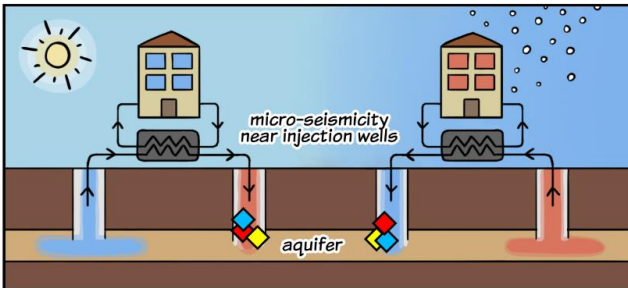
CAVERNS



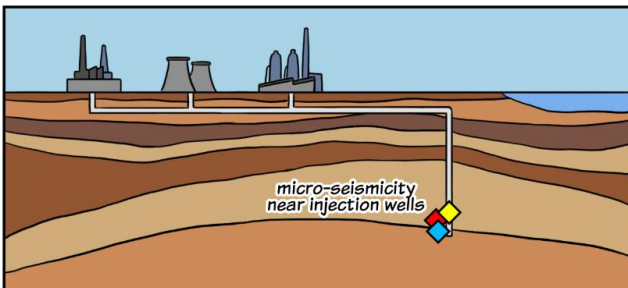
OIL & GAS



ENERGY STORAGE



CCS



Legend: Microseismic incidents occurring in

January

February

March

## EQUIPMENT

### High Quality Hardware

Our flagship seismometers are KU-3D and KU-1D which measure in 3D and 1D, respectively. The ATEX seismometer L-10B/Ex is used for potentially explosive settings, e.g. coal mines. All seismometers are assembled by K-UTEC to ensure full quality control.

## 1D / 3D Seismometer



The KU-3D and KU-1D both fulfill DIN 45669-1 requirements. Their high sensitivity allows applications in mining, geothermal plants, salt caverns, oil & gas, deep thermal energy storage, CCS, as well as construction according to DIN 4150. These seismometers contain SM-6 coils which are used in well-established seismic sensors all over the world.

**Models:** KU-3D and KU-1D  
**Size:** 8 cm x 7.5 cm x 7 cm  
**Base plate:** 16.5 cm x 11 cm  
**Frequency range:** 1 Hz – 80 Hz  
**Sensitivity:** 400 V/m/s  
**Temperature range:** -20°C to +60°C

## ATEX Seismometer



top view

**Size:** 10 cm x 10 cm x 8.5 cm  
**Frequency range:** 4.5-1000 Hz  
**Sensitivity:** 200 V/m/s  
**Temperature range:** -20°C to +60°C

A unique coil system qualifies this seismometer for Ex-proof applications.



## GeoLog - The Data Gateway

The seismometer data is collected, stored and transferred by the K-UTEC GeoLog which is available in normal and toughbox versions.

### K-UTEC GeoLog



- Size 4.5 cm x 8.5 cm x 16.4 cm
- Suitable for various external sensor types measuring acceleration, vibration velocity, pressure and other parameters
- Internal mobile LTE communications modem
- Individual data cloud and server application
- Up to 64 GByte internal storage, with 24 Bit resolution and 5 kHz sampling rate
- 4 to 8 channels with time synchronized sampling, upgradable in modules
- Internal mathematical calculation options
- Remote maintenance and remote software update with watchdog
- Integrated self-sufficient system monitoring with watchdog
- Temperature range -40 °C to +70 °C
- Compact aluminium housing
- Low power input (2.5 W without LTE modem, 6 W with LTE modem)
- Time synchronisation via GPS, NTP or DCF77



side view  
(right)



side view  
(left)

## K-UTEC GeoLog (in tough box)



backside view



side view



**Size:** 27 cm x 22 cm x 17 cm



## All Securely Boxed Up

GeoLog, power supply and other equipment are placed in a control box. This is custom-made depending on the requirements such as indoor or outdoor, energy from grid or battery, voltage 230V or 110V, antenna inside or outside. Solar panels can be installed to achieve energy autonomy. Equipment can be purchased or leased, depending on client's financing preference.



## Thorough Calibration for Precise Results

K-UTEC owns a vibration table which is used for seismometer calibration.



## Calibration Table

Seismic calibration is performed to verify the functionality of the seismometer, by introducing a known calibration signal and adjusting its transfer properties.

## We Adapt to Your Needs

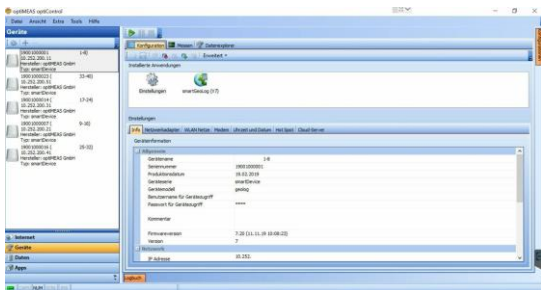
Do you already have an existing seismometer system? In this case, you may still be able to book K-UTEC's monitoring service. We take care of the data analysis, alerts and reporting, whilst you keep responsibility for your existing system operational and maintenance.

## SOFTWARE

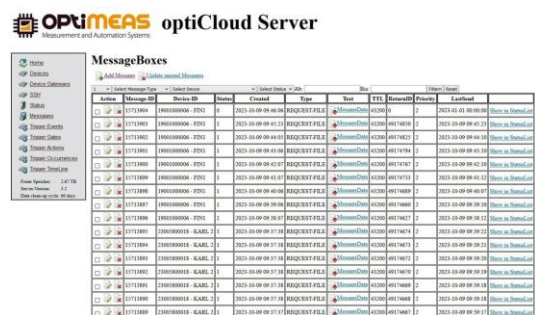
### How the Data is being Transmitted, Processed and Interpreted

Our seismic monitoring solution comes with specialised software. The **GeoLog** is being configured and managed with the **optiControl** application. This includes software updates, log file inspection, definition of threshold values and other options. The **optiCloud Server** acts as an interface between the GeoLog data transfer unit and the seismologists. A **dashboard** contains a map with all seismometer stations and a list of all stations showing their „health data“, i.e. their data transmission status. The colour coding highlights quickly if and where trouble shooting is needed.

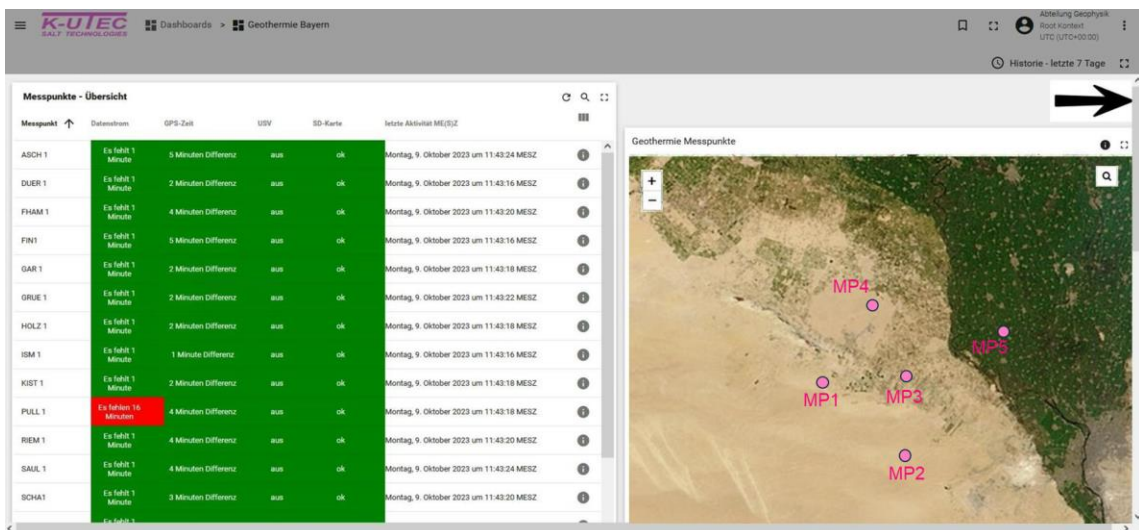
### optiControl



### optiCloud Server



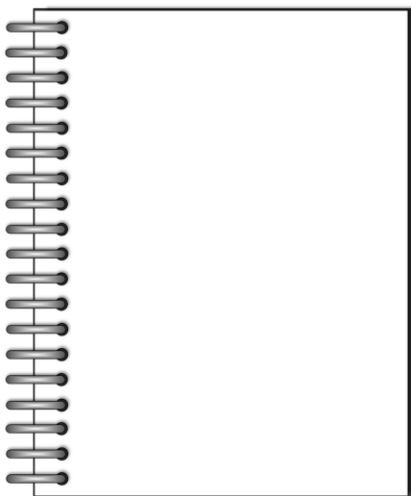
### Dashboard



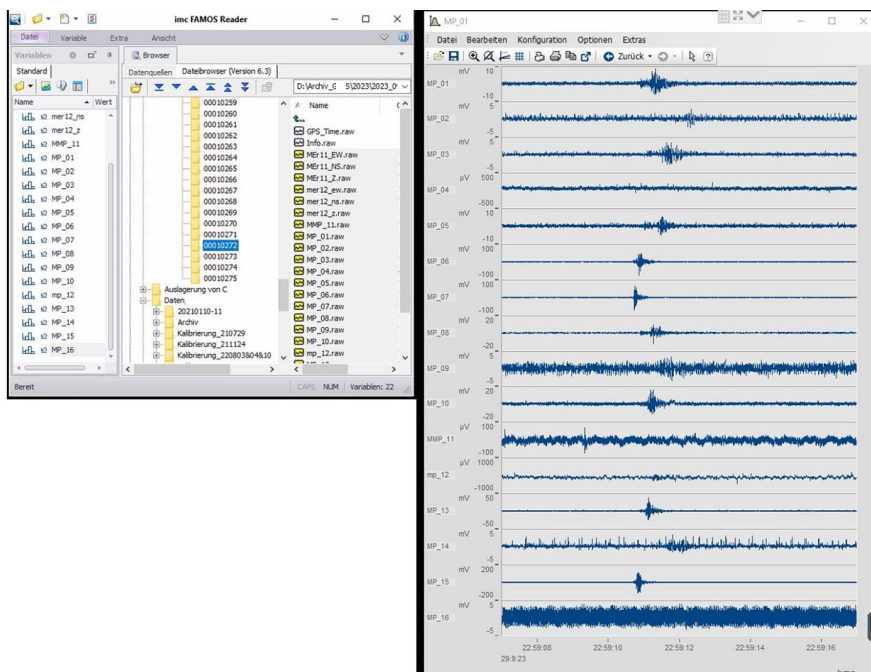
## Managing Seismometer Stations

Data is continuously recorded and can be retrieved on demand. The **station diary** lists the history of everything that occurred in this specific monitoring cluster, e.g. seismic events, changes in system and hardware, outages, and maintenance. The station diary also allows to exchange messages with the client. A so-called „**trigger file**“ is created by the transfer unit when the seismometer measures a movement that is above a pre-defined threshold. The trigger file is then uploaded to the cloud.

## Station Diary



24/05/2023	10:39	5422	5172,5200 seismic event; 5173-82, 84-99, 201-56, 258-422 noise; 5183,257 Imp.	K-UTECAP
25/05/2023	06:40	5458	5423,26-58 noise, 24+25 seismic event	K-UtecSchi
26/05/2023	10:35	5511	5459-60,62-81,83-96,99-5508,10-11 noise, 5461, 97 impulse, 82,98,5509 seismic event	K-UTECAS
27/05/2023	10:50	5628	5512-5623,25-27 noise, 5623 seismic event, 28 test trigger after offset correction MP19	K-UTECAS
28/05/2023	09:09	5695	5629-45,47,49-81,83-93 noise, 46,82,94-95 seism. event, 48 impulse	K-UTECAS
29/05/2023	07:56	5728	5696-702,05-27 noise, 703-04,28 impulse	K-UTECAS
30/05/2023	12:37	5988	5729-33,35-37,39-5941,5943-5988 noise; 5734,5738,5942 seismic event	K-UTECW0
31/05/2023	14:02	6002	5989-97 noise, 5998-6002 seismic event	K-UtecV0
01/06/2023	09:57	6013	6003,12-13 seismic event, 6004-11 noise	K-UTECAP
02/06/2023	13:17	6024	6014,15,19,22,24 seismic event, 23 impulse 16-18,20-21 noise	K-UtecSchi
03/06/2023	13:29	6028	6025 imp. 26-28 noise	K-UtecSchi
04/06/2023	19:14	6038	6029-32, 34-38 noise, 33 seismic event	K-UtecSchi
05/06/2023	13:04	6040	6039-40 seismic events; stop/start all devices	K-UTECAS
06/06/2023	11:30	6046	6041-42;44;46 seismic event, 43,45 noise stop/start all devices.	K-UTECAB
07/07/2023	11:05	6055	6047-51,53-54 seismic event; 52,55 noise	K-UTECTB
08/06/2023	09:49	6059	6056,59 seismic event, 57-58 noise	K-UTECAP



*Content of a trigger file showing a seismic event which can be mining-induced, of tectonic nature, or associated with a long-distance earthquake or thunderstorm.*

*The microseismic event typically lasts only up to a few seconds (x axis shows time, y axis shows amplitude, in each of the stacked stations)*

## Finding the Geomechanical Troublespot

**SeismoSuite** is a software developed to calculate location and magnitude of a seismic event. It contains a list of all seismic events in that specific measuring area. It gives an overview of selected seismic source parameters (e.g. location, timing and magnitude) of both analyzed and still to be analyzed events.

### List of seismic events in a seismometer cluster

ID	TriggerID	Trigger time (UTC)	Ersteinsatz-Zeit (UTC)	Data complete	Edited	Number of raw files	Hearth location_X / km	Hearth_Y / km	Hearth_Z / km	T_RMS / ms	GAP / °	ML
00036753	15	06.10.2023 01:21:32	06.10.2023 01:21:31.68f	✓	☐	8	5505,630	137,741	-0,230	3,851		291,8
00036752	15	05.10.2023 22:38:43	05.10.2023 22:38:43.00f	✓	☐	8	5505,779	137,452	0,026	0,177		257,1
00036751	15	04.10.2023 20:34:44	04.10.2023 20:34:43.89f	✓	☐	8	5505,724	137,322	-0,117	61,437		334,5
00036750	15	04.10.2023 17:33:06	04.10.2023 17:33:05.43f	✓	☐	8	5506,185	137,657	-0,097	4,753		248,5
00036749	15	04.10.2023 16:08:04	04.10.2023 16:08:03.81f	✓	☐	8	5505,732	136,479	-0,117	21,335		298,4
00036748	15	04.10.2023 03:46:00	04.10.2023 03:45:59.17f	✓	☐	8	5505,807	136,833	0,053	0,000		221,1
00036747	15	04.10.2023 00:37:11	04.10.2023 00:37:10.58f	✓	☐	8	5506,101	136,724	-0,658	0,000		169,2
00036746	15	03.10.2023 23:33:12	03.10.2023 23:33:12.39f	✓	☑	8	5505,723	137,302	-0,147	7,618		174,1
00036745	15	03.10.2023 17:56:23	03.10.2023 17:56:22.91f	✓	☑	8	5505,846	137,275	-0,106	4,383		211,3
00036744	15	03.10.2023 09:23:25	03.10.2023 09:23:24.73f	✓	☑	8	5505,775	137,299	-0,144	3,826		177,5
00036743	15	02.10.2023 17:38:59	02.10.2023 17:38:58.87f	✓	☑	8	5505,735	137,362	-0,134	4,646		182,4
00036742	15	01.10.2023 12:07:24	01.10.2023 12:07:14.23f	✓	☑	8	5505,682	137,114	-0,145	2,306		248,5
00036741a	15	30.09.2023 03:57:08	30.09.2023 03:57:07.66f	✓	☑	8	5505,758	137,191	-0,139	5,890		169,0
00036741	15	30.09.2023 03:57:08	30.09.2023 03:57:07.66f	✓	☑	8	5505,756	137,203	-0,142	2,931		168,3
00036740	15	30.09.2023 00:19:40	30.09.2023 00:19:39.80f	✓	☑	8	5505,672	137,411	-0,144	6,408		242,1
00036739	15	29.09.2023 20:52:53	29.09.2023 20:52:52.91f	✓	☑	8	5505,812	137,262	-0,117	1,960		194,8
00036738	15	29.09.2023 18:43:30	29.09.2023 18:43:29.28f	✓	☑	8	5505,508	137,461	-0,168	0,895		286,3
00036737	15	29.09.2023 16:40:31	29.09.2023 16:40:24.08f	✓	☑	8	5505,882	137,006	-0,133	3,472		239,2
00036736a	15	29.09.2023 10:53:02	29.09.2023 10:53:01.11f	✓	☑	8	5505,867	137,358	-0,102	6,380		236,1
00036736	15	29.09.2023 10:53:02	29.09.2023 10:53:01.11f	✓	☑	8	5505,825	137,350	-0,071	7,815		211,9
00036735	15	28.09.2023 22:30:51	28.09.2023 22:30:50.82f	✓	☑	8	5505,730	137,203	-0,157	5,382		147,0
00036734	15	28.09.2023 16:41:41	28.09.2023 16:41:29.89f	✓	☑	8	5505,714	137,402	-0,147	6,546		216,8
00036733a	15	28.09.2023 16:27:53	28.09.2023 16:27:52.85f	✓	☑	8	5505,822	137,269	-0,125	4,499		199,6
00036733	15	28.09.2023 16:27:53	28.09.2023 16:27:52.85f	✓	☑	8	5505,774	137,287	-0,141	7,075		177,1
00036732	15	28.09.2023 06:55:15	28.09.2023 06:55:14.50f	✓	☑	8	5505,837	137,354	-0,068	4,171		212,2

SeismoSuite

### Station Window, Seismogram Window, Pick Results Window

The screenshot displays three main windows in the SeismoSuite interface:

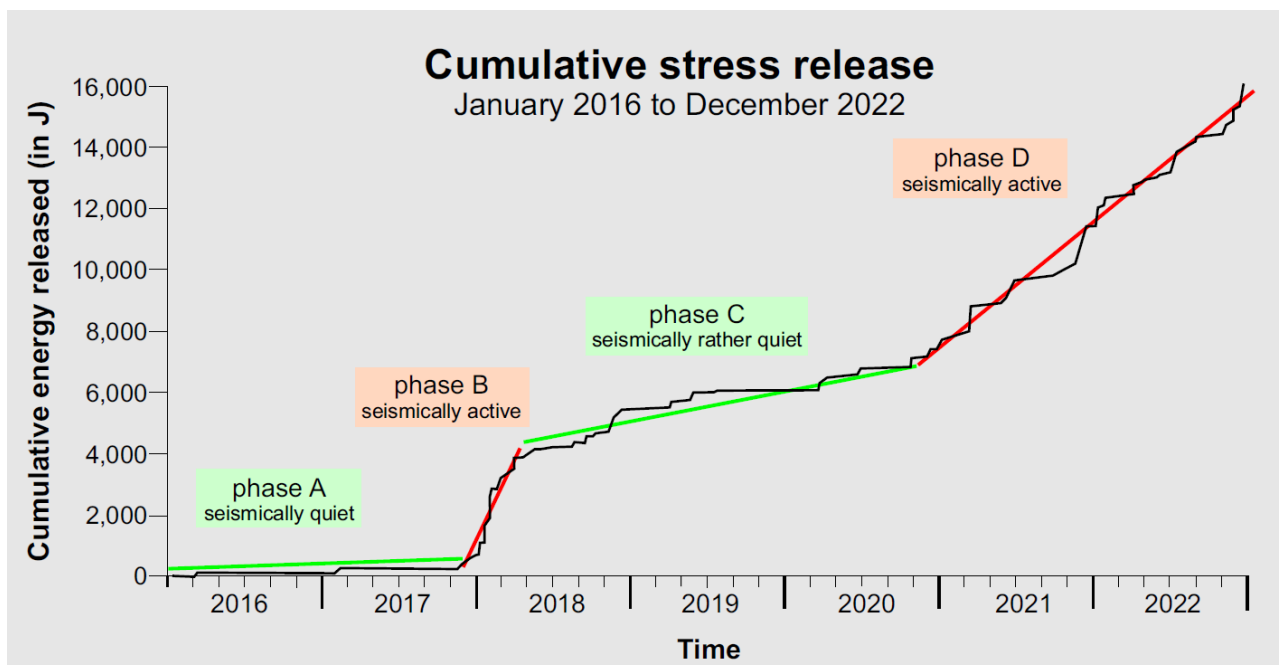
- Station Window (green border):** Shows a list of active stations and channels. The 'Aktiv: Station' column lists stations like MP01a\_cleaned, MP02a\_cleaned, etc., with their corresponding channel names (e.g., MP01a\_EPS).
- Seismogram Window (red border):** Displays multiple seismic traces for different stations. Each trace shows amplitude (e.g., mm/s, μm/s) over time. Red arrows indicate picked P-wave arrivals, labeled with 'P (man)' or 'P (sm)'. The time axis ranges from 2.10.23 to 17.38.
- Pick Result Window (black border):** Shows a table of manually picked results. It includes columns for Station, P-Deployment, and S-Deployment, with checkboxes and numerical values for each.

SeismoSuite

**REPORTING**

**All Data Neatly Summarized**

K-UTEC summarizes all seismological activities occurring on client’s assets in regular reports, e.g. monthly, quarterly or yearly. Reports are typically in English or German, but are also available in many other languages such as French, Spanish, or Russian. With the help of translators, we are in a position to offer most languages, so that they can be used for your national regulator authorities.



*Plots of cumulative stress release (Benioff curves) help to identify seismically quiet (green) and active (red) periods. This allows the planning of mitigation measures and monitoring of subsequent changes (success/failure). For example, a seismically active phase can be stopped in a mine by local backfilling.*

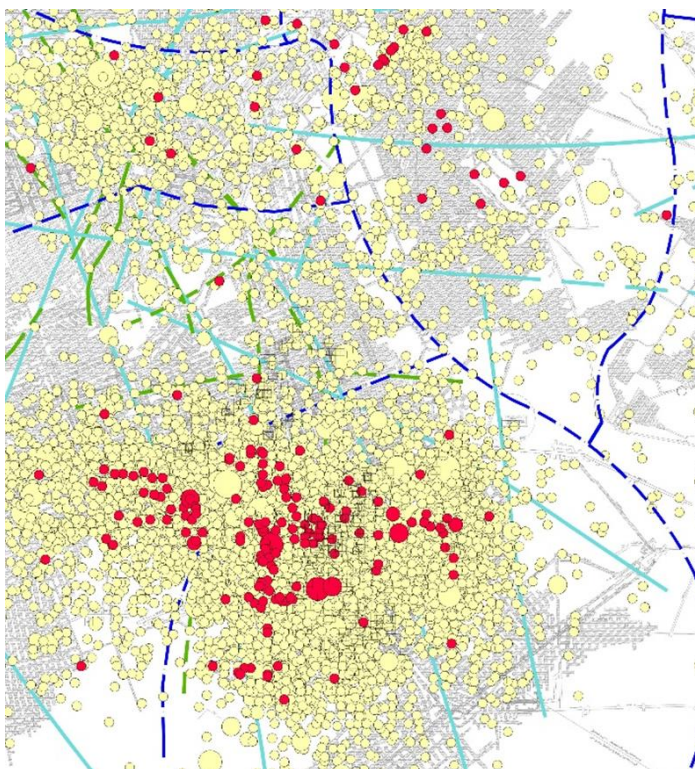
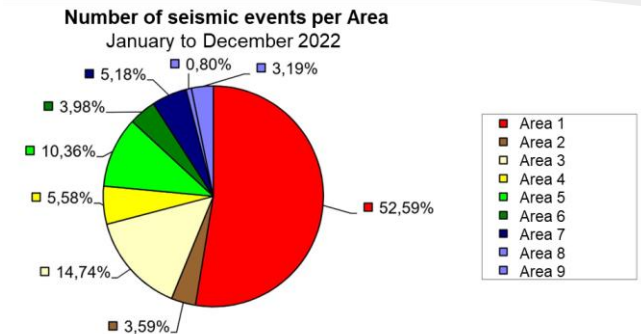


## Understanding the Big Picture

Our reports not only include the raw data, but also contain statistical trends and practical conclusions which can be used for operational planning purposes. We extract the maximum amount of information from the seismic monitoring data. Common visualization products are maps with surface projections of seismic events, differentiated by colour coding and bubble size for time of occurrence and magnitude. Plots of cumulative stress release help to identify seismically quiet and active periods. This allows the planning of mitigation measures and monitoring of subsequent changes (success/failure). For example, a seismically active phase can be stopped in a mine by local backfilling. We help your experts to fully understand the results and use the findings for planning and decision-making.

**Seismic events per Area, measured as number of incidents and energy release**  
January to December 2022

Area	Number of events		Energy Release	
	#	%	in (kJ)	%
Area 1	132	52,59	15893	1,55
Area 2	9	3,59	2	0,00
Area 3	37	14,74	192	0,02
Area 4	14	5,58	2	0,00
Area 5	26	10,36	1002019	97,95
Area 6	10	3,98	375	0,04
Area 7	13	5,18	4198	0,41
Area 8	2	0,80	0	0,00
Area 9	8	3,19	307	0,03
Total	251	100	1022989	100



**Map showing seismic events per time period, differentiated by magnitude**

Year of event

- 1990-2021
- 2022-2023

Magnitude

- $M \leq 0$
- $0 < M \leq 0,5$
- $0,5 < M \leq 1,0$
- $1,0 < M \leq 1,5$
- $M > 1,5$



## WHO WE ARE

### We Build on Many Decades of Experience

K-UTEC is a renowned service provider for the global mining and natural resources industry with several decades of experience since 1951. We are among the world leaders in seismic monitoring, based on a long experience in this field. We serve Customers from various industrial fields including potash mines, salt mines, limestone mines, brown coal open pit mines, geothermal producers, and salt cavern operators. Our clients' salt caverns are used for solution mining, as well as for subsurface storage of natural gas, oil, and hydrogen.

Our seismic monitoring system fits for all industrial applications. We run our own laboratory and workshop to customize all solutions exactly to your needs and to offer full repair and maintenance service of our products. We offer consultancy in seismic monitoring for operations of every size and are confident to find the right solution to your needs.



## SEISMIC MONITORING 101

### Useful to Know

Seismic monitoring is the process of recording and analyzing the ground vibrations or seismic waves that are generated by natural or human-induced events, such as earthquakes, volcanic activity, explosions, or industrial processes. These seismic waves travel through the Earth and can be detected and recorded by instruments known as seismometers or seismographs.

Industrially-induced seismicity is typically weak. These “microseismic events” are small-scale seismic vibrations that are often imperceptible to humans without the aid of sensitive instruments. They typically have magnitudes of less than 2.0 on the Richter scale. Nevertheless, microseismicity helps to detect instabilities in the subsurface early enough to prevent the development of larger seismic events. These “macroseismic events” can be felt at the Earth's surface and can cause damage to structures and people.

### Different Names, Same Thing

Alternative terms in use for “Seismic Monitoring” are “Seismological Monitoring”, “Induced Seismicity Monitoring” and “Microseismic Monitoring”. The latter term is also used for the performance analysis of hydraulic fracture stimulation (“fracking”) which forms not part of K-UTEC’s service.

### Always Know What is Happening Around You

Seismic monitoring is carried out over longer periods of years and decades as a continuous background measurement. It serves as a cumulative memory of the micro- and macroseismic events which occur sporadically. Seismic monitoring provide operators of deep subsurface industries with a three-dimensional record of geomechanical instabilities at depth and their development over time. In that respect it could be compared with a radar of ships and planes that require a full picture of the situation around them at all times. The same is true for the leadership boards of mines, salt caverns, geothermal plants, oil & gas producing companies, operators of deep thermal energy storage and CCS projects.



## FULLY CERTIFIED AND ACCREDITED

### You can rely on us

K-UTEC's geophysics department is a laboratory accredited by the German Accreditation Body (DAkkS) according to DIN EN ISO/IEC 17025. In addition, K-UTEC AG is registered as a measuring body according to § 29b of the Federal Immission Control Act (BlmSchG) in the sense of § 26 BlmSchG for the field of activity "Determination of vibrations". K-UTEC is a Certified Quality Company according to the criteria of the Professional Association of German Geoscientists (BDG). K-UTEC is DIN EN ISO 9001:2015 certified.

## TRAINING

### We Don't Leave You in the Dark

As part of our Customer onboarding program, K-UTEC offers optional training in seismic monitoring for your staff. This may take place in K-UTEC's head office in Germany or at the client's location. We speak several languages and also work with interpreters to cover all regions of the world.

## Protect your Subsurface Operation and contact us today:

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