

**Seismic Monitoring
for Geothermal plants**

Why seismic monitoring:

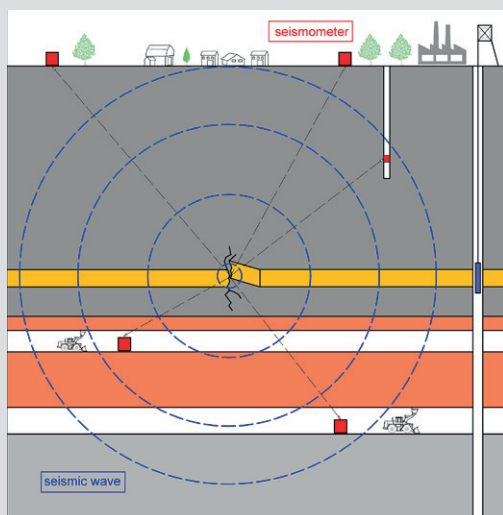
Seismic events, whether they are caused by local tectonics, fracturing of the overburden or induced by local mining or fracturing in the underground, are only sporadically occurring events, thus the assessment of the general seismicity within an area can only be realised over a longer period of time. These events can occur spontaneously or artificially induced (i.e. fracking of lithological layers for geothermal plants).

K-UTEC has a long lasting experience within this subject and offers extensive support both in planning and installing seismic monitoring systems but we also offer extensive assistance for the operation of the monitoring system,

the interpretation of the single events as well as the general assessment of the seismicity in the target area. K-UTEC is able to design always the best fit and individual solution for each customer.

With help of these information it is possible to react to the seismic events. Geothermal plant companies can use these information for detecting areas with higher permeabilities and fractures in the ground. It is also possible to react if the local seismicity increases in a certain area. Furthermore if seismic vibrations occur the measurements can show if the critical values of the authorities were exceeded.

Localization of events and estimation of the event parameters



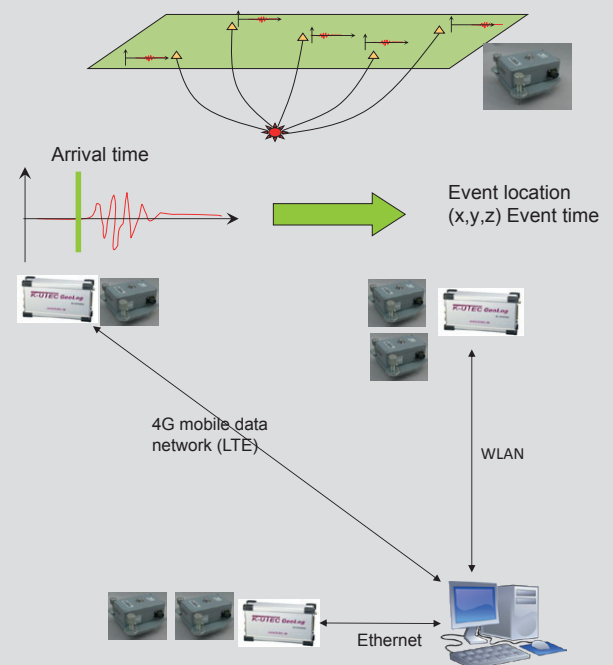
Seismic Monitoring Geophysics

establish seismic monitoring systems	operate seismic monitoring systems	locate seismic events and evaluate the seismic data
<ul style="list-style-type: none"> design the best solution for the customer compute the accuracy of the system in the observed area build up the system in the field 	<ul style="list-style-type: none"> daily control of the monitoring system maintenance of the system updating of the system, in case of changing local conditions 	<ul style="list-style-type: none"> automatic location and alerting manual control of the localization calculation of the event and seismological parameters status report in time intervals as desired by the client

Seismic Monitoring System

Design of the monitoring system:

Measurement of the vibration



The seismic monitoring system or vibration measurement system can be build up on the surface or in mines. The seismometers can be installed on the surface, in boreholes or in the mine.

Specialist for the field of seismic monitoring:

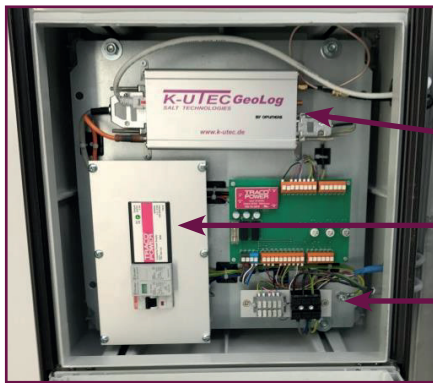
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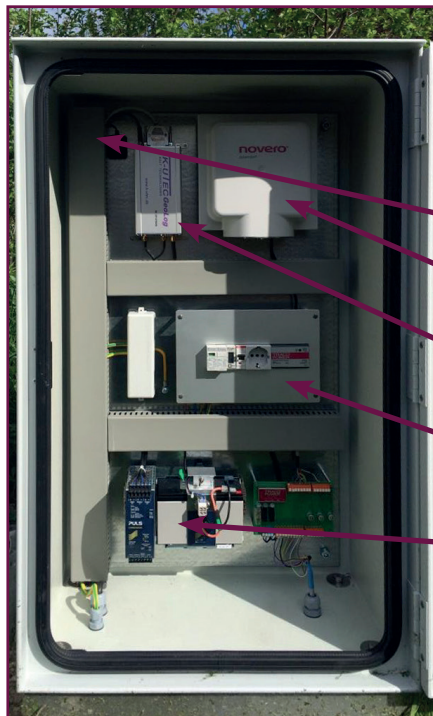
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Design of a single station



indoor

- Transient recorder
- Power supply
- GPS – Antenna-cable



outdoor

with 220 V power supply

- GPS – Antenna
- LTE – Antenna
- Transient recorder
- Power supply
- uninterrupted power supply unit



with Solar power supply

- LTE – Antenna
- GPS – Antenna
- Power supply – Solar panel
- Transient recorder
- power supply – buffer battery

Various types of seismometers

3D Seismometers



1D Seismometers



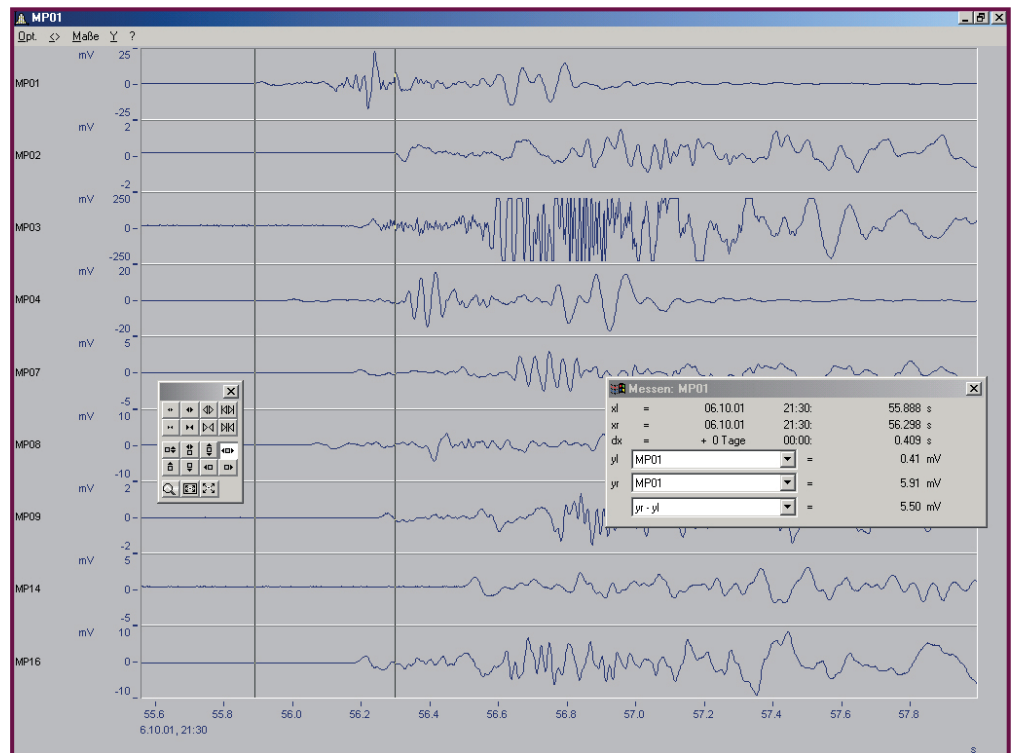
Accelerators Borehole seismometers Hydrophones



ATEX seismometer

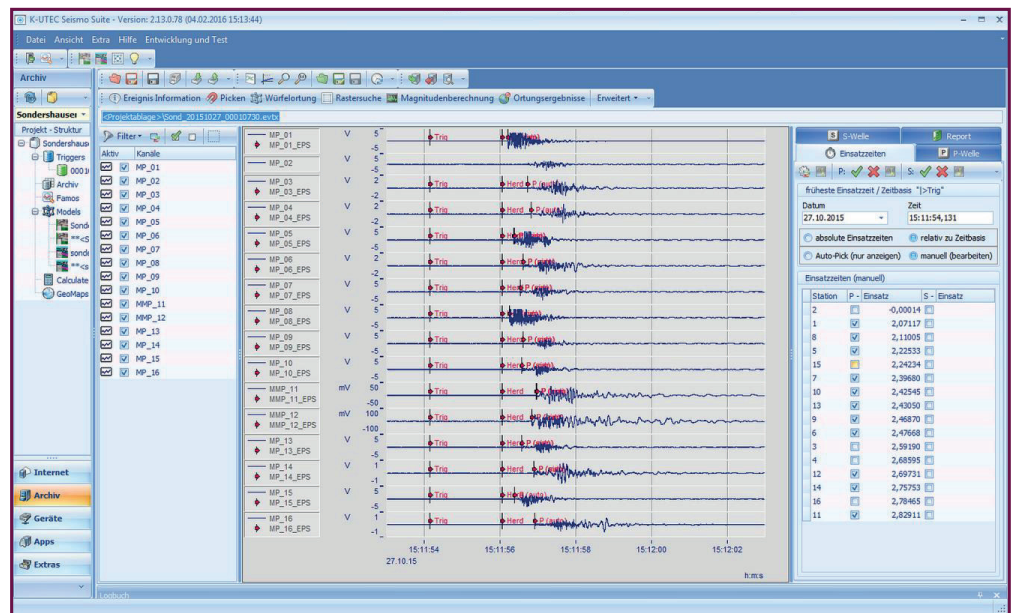


Event Example



Raw data of a seismic event

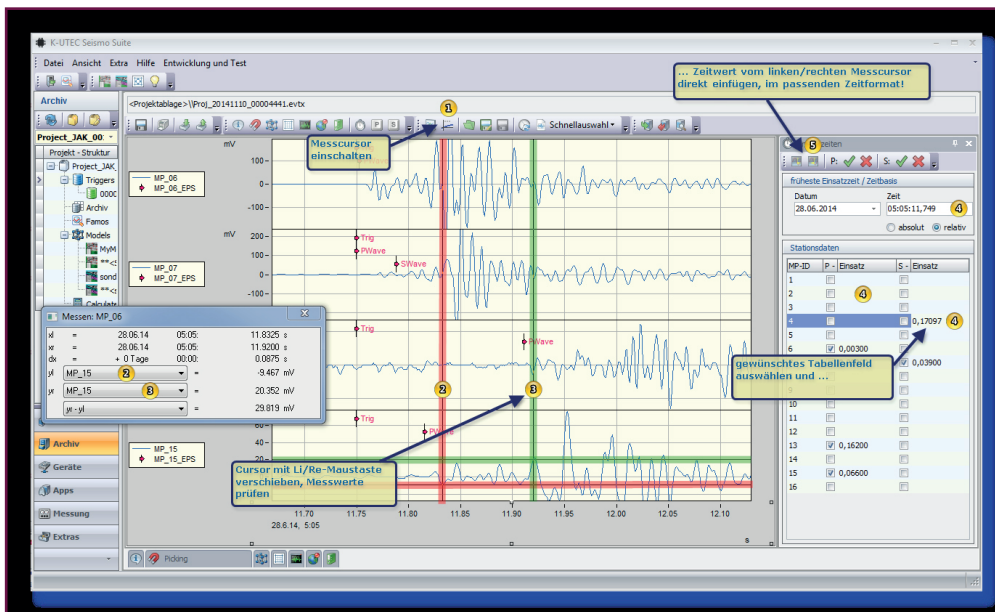
Automatic Localization



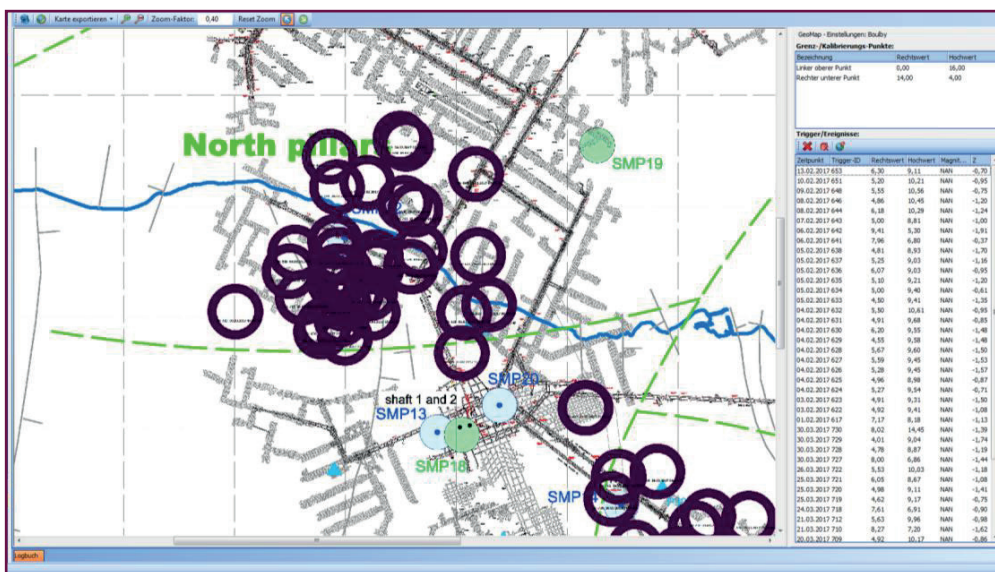
Automatically marked arrival times

Software packages:
SeismoSuite and SeismoLocal

Manual Localization



Marked arrival times

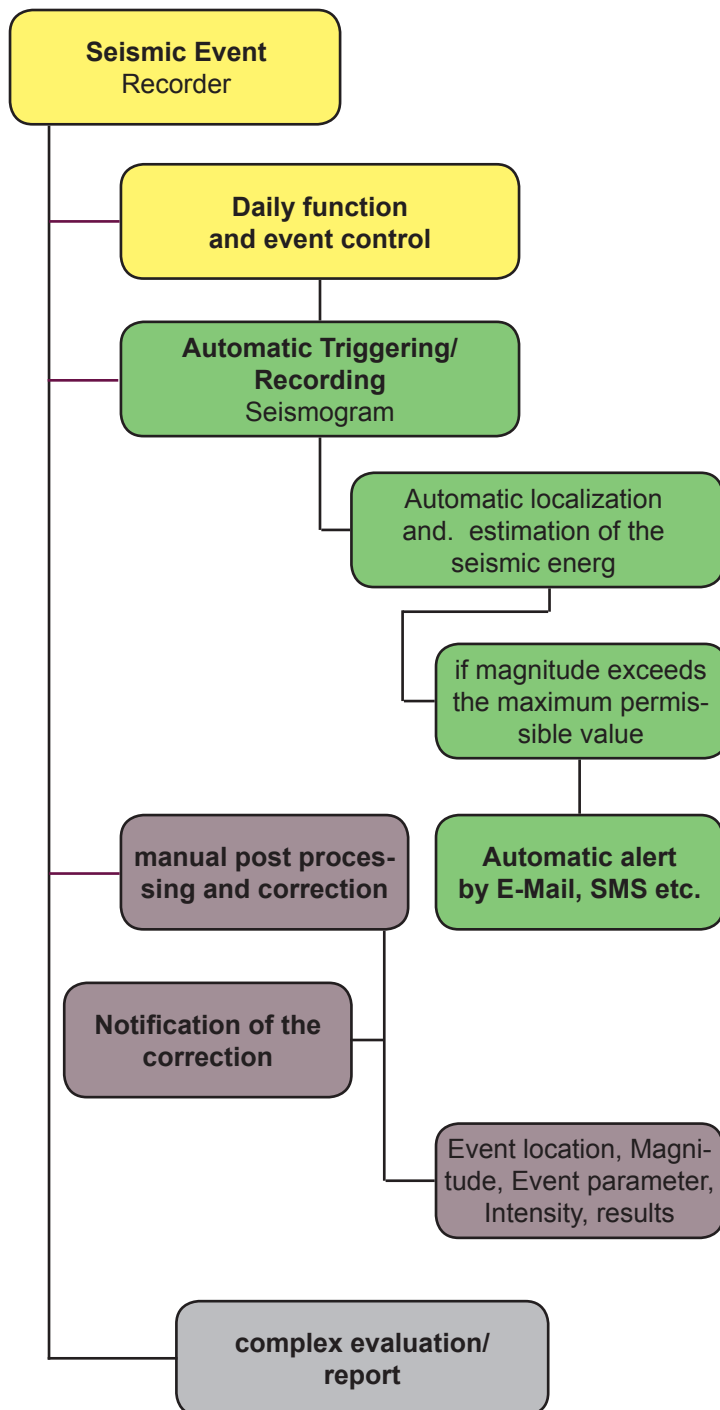


Marked events on the map

Manual Localization ans visualization

Graphical implementation
of site and mine plants

Scheme of the event processing



Technical characteristics of the transient recorder (basic system):

2013 a new concept for aseismologic registration unit was carried out by the K-UTEC AG Salt Technologies. The background of the concept was to develop a device for high resolution data (24 Bit) high sampling rates (5 kHz each channel), time synchronisation (GPS module) and the ability to use modern median for data transfer (internal 4G modem downward compatible, internal LAN port, WLAN hotspot, and more). The power supply is very low with less than 6 W. For this reason it is possible to supply the data recorder by solar power in the field.

The K-UTEC Geolog is able to work together with different sensors like velocity proportional seismometers, accelerators, piezoelectrical pressure transducers and more.

The K-UTEC GeoLog is useable for:

- Qualifying of seismic events
- Alerting by specified parameters
- Long-time monitoring of geoscientific parameters
- Mobile and permanent data logging, monitoring and documentation



Characteristics

- Flexible external sensors with different parameters: accelerations, vibration velocities, pressure and more
- Internal mobile LTE 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
 - modular extendable
- Internal mathematical calculation options
- Remote maintenance and remote-software-update with watchdog

Miscellaneous

- Temperature range -40° to +70° C
- Compact ALU-Housing
45 mm x 85 mm x 164 mm
- Integrated self-sufficient system monitoring (watchdog)
- Low power input (2,5 W without LTE modem, 6 W with LTE modem)

References actual in seismic monitoring by K-UTEC

Project	Location / Client	Size	Year	Remarks
Installation of a seismic monitoring system	Unterbreizbach-Merkers-Wintershall / K+S, Germany	49 measuring points	Since 1970s renewed according to technical developments	installation of a seismic monitoring system, technical support, consulting
Seismic monitoring of natural and induced seismicity	Teutschenthal, Angersdorf and Salzmünde / GTS mbH, Germany	16 measuring points	Since 1985 renewed according to technical developments	Seismic monitoring of the mine deposit, control of natural and induced seismicity, control and guidance of deposit work
Seismic monitoring of induced and natural seismicity	Bleicherode / NDH-E mbH, Germany	16 measuring points	Since 1994 renewed according to technical developments	Seismic monitoring of the mine deposit, control of induced and natural seismicity, control and guidance of deposit work
Seismic monitoring of natural and induced seismicity	Sondershausen / GSES mbH, Germany	12 measuring points	Since 1994 renewed according to technical developments	Seismic monitoring of the mine deposit, control of natural and induced seismicity, control and guidance of deposit work
Seismic monitoring of induced and natural seismicity	Bischofferode / LMBV KSE (former GVV mbH), Germany	27 measuring points	Since 1995 renewed according to technical developments	Seismic monitoring of induced and natural seismicity, monitoring of non-controlled flooding
Seismic monitoring of induced and natural seismicity	Sollstedt / NDH-E mbH, Germany	11 measuring points	Since 1995 renewed according to technical developments	Seismic monitoring of the mine deposit, control of mining induced seismicity, control and guidance of deposit work
Monitoring of natural seismicity	Zielitz / K+S, Germany	11 measuring points	Since 1997	monitoring of natural seismicity, technical support
Seismic monitoring of natural and induced seismicity during brine process	Staßfurt / LAGB, Germany	16 measuring points	1997 (and before) 2010	Seismic monitoring of natural and induced seismicity during brine process
Seismic monitoring of induced and natural seismicity	Velenje / Premogovnik Velenje, Slovenia	8 measuring points	Since 1998, rebuild 2016	Seismic monitoring, control of induced and natural seismicity for a lignite mine
Seismic monitoring of natural seismicity	Bernburg / esco, Germany	8 measuring points	Since 2000	Seismic monitoring of natural seismicity
Seismic monitoring of seismic activity	Kirchheilingen / VGS, Germany	1 measuring point	Since 2001 renewed according to technical developments	Vibration measurement (monitoring of seismic activity in the area of gas storage caverns)
Seismic monitoring of induced and natural seismicity	Volkenroda / LMBV KSE (former GVV mbH), Germany	11 measuring points	Since 2002	Seismic monitoring of induced and natural seismicity, monitoring of non-controlled flooding
Seismic monitoring of natural seismicity	Salzbergwerk Stetten / Wacker Chemie GmbH, Germany	9 measuring points	since 2002	Seismic monitoring of the mine deposit, control of natural seismicity
Installation of the seismic monitoring system in a radioactive waste mine	Morsleben / DBE	24 measuring points	Since 2005, rebuilt 2016	Seismic monitoring, control of induced and natural seismicity
Seismic monitoring of natural seismicity	Boulby Mine / ICL, UK	20 measuring points	Since 2009	Seismic monitoring, control of induced and natural seismicity
Seismic monitoring of the explosive compaction activities	Lausitz / LMBV, Germany	4 to 15 measuring points	Since 2012	Seismic monitoring of the explosive compaction activities in several areas in the former lignite opencast pit area
Seismic monitoring of the former lignite opencast pits areas	Lausitz / LMBV, Germany	8 measuring points	Since 2013	Seismic monitoring of the former lignite opencast pits area
Seismic monitoring of a former lignite opencast pit	Schlabendorf / LMBV, Germany	20 measuring points	Since 2014	Seismic monitoring of the former lignite opencast pit Schlabendorf-South
Seismic monitoring of the vibroflotation soil compaction activities	Nachterstedt / LMBV, Germany	6 measuring points	Since 2015	Seismic monitoring of the vibroflotation soil compaction activities in a former lignite opencast pit area
Seismic monitoring of a cavern field	Hengelo / Akzo Nobel, The Netherlands	4 measuring points	Since 2015 in extension	Seismic monitoring of a cavern field
Seismic monitoring of a geothermal plant	Poing / Markt Schwabach – Bayernwerke Natur GmbH	2 vibration monitoring stations	Since 2016 in extension	Seismic monitoring of a geothermal plant with an increasing number of wells



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