Local seismic networks WEBNET and REYKJANET the tools for understanding the nature of the W-Bohemian and SW-Icelandic earthquake swarms

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W-Bohemia/Vogtland (Lat: ≈ 49.8°N to 50.7°N, Long: ≈12°E to 13°E) -

an intraplate geodynamically active area

<u>earthquake swarms</u> – specific type of seismicity, sequences of seismic events closely clustered in space and time, without a single outstanding earthquake

The origin of earthquake swarms still unclear.





time

W-Bohemia/Vogtland region and local earthquake swarms



Basic characteristics:

- Western part of the Bohemian Massif
- •Intersection of Eger rift and Mariánské Lázně fault
- Quaternary volcanism , crustal-fluid activity
- Frequent occurrence of $M_L < 4.0$ i<u>ntraplate</u> earthquake swarms
- Swarm-like seismicity scattered in the area ≈ 40 x 60 km but mainly concentrated in a few epicentral areas
- About 95 % of the total seismic-moment released in the <u>NK zone</u> ⇒ focal belt 10 x 7 km



Characterization of significant West Bohemia seismicity

	Duration [days]	Total number of events	Characteristics	ML _{max}
1985/86	70	8000 ML>0.5	swarm	4.6
1997	14	500	swarm	3.0
2000	71	3840	swarm	3.2
2008	28	4400	swarm	3.8
2011	12	5740	swarm	3.7
2013	33	270	mini-swarm	2.5
2014	12	2800	3 mainshock- aftershocks sequences	3.5 4.4 3.6
2017	16	2500	swarm	3.1
2018	15	≈ 5000	swarm	3.8

Duration of each activity indicates number of days during which 90% of events occurred.

WEBNET network in 2018



12 BB networked stations
 10 SP autonomous stations

• **BB** networked stations Sensors: Güralp CMG3-ESP, $T_0 = 30s$, $f_{LP} = 80$ Hz DAS: Centaur by Nanometrics

• SP autonomous stations Sensors: Lennartz LE3-D, $T_0 = 1$ s, $f_{LP} = 80$ Hz, DAS: Gaia II, by Vistec Recording media: SD cards data downloaded once in two months or if needed



24 BB networked stations
WEBNET I - 16 stations
WEBNET II - 8 stations
Sensors: Güralp CMG3-ESP,
Digitizers: Centaur by Nanometrics

WEBNET network – current state



Area covered by stations $\approx 900 \text{ km}^2$

WEBNET: instrumentation and data – current state

24 BB stations:

Sensors: Güralp CMG3-ESP, $T_0 = 30s$, $f_{LP} = 100$ Hz Data acquisition systems: Centaur by Nanometrics Sampling rate: 250 Hz All the stations operated in continuous mode

WEBNET I:

Sensors mostly installed in ≈ 4m deep vaults Technical conveniences Stations connected to the electricity net Continuous data tranfer by WaveLan, Satellite, GSM LTE, local provider

WEBNET II:

Sensors mostly installed in ≈ 2 m deep container Power supply: batteries recharged by solar panels Data transmission: using GSM LTE

Data format: miniSEED Data stored on data server SILO Date access: catalogs available on Internet, seismograms on request.

Stations of WEBNET I and WEBNET II and typical seismogram





A dense subnetwork HORC (Horka dam) a part of WEBNET

Supported by AV21 and in cooperation with the Vodní díla - TBD a.s. comp.

HORC instrumentation and data

Sensors:

seismomerer Güralp CMG3-ESP,

on the bottom of the dam

- 3 accelerometers Titan by Nanometric,
- 1 on the bottom

3 on the top of the dam

DAS:

Centaur by Nanometrics Sampling rate: 250 Hz

Data transmission: GSM LTE



SW Iceland

Reykjanes Peninsula and Hengill volcanic complex:

(Lat: ≈ 63.8°N to 64.1°N, Long: ≈21.5°W to 22.3°W)

- onshore continuation of the Reykjanes Ridge which is a part of the mid-Atlantic Ridge
- swarm-like seismicity at a contact of lithospheric plates
- Earthquake swarms typical of the Reykjanes Peninsula and Hengill volcanic complex; up to magnitude $M_L = 5+$



Distribution an parameters of the REYKJANET stations



Built up: September 2013

Area covered by the REYKJANET stations: ≈ 60 km x 20 km

- 15 BB autonomous stations
- continuous mode
- frequency band: 0.03-80 Hz for the BB stations
- sampling rate: 250 Hz

Expert and technical support by: Iceland GeoSurvey - ÍSOR

Icelandic Meteorological Office - IMO

REYKJANET: instrumentation and data - current state

14 BB autonomous stations:

Upgraded in June 2019 - granted by the Czech Acad. Sci.

Sensors: Güralp CMG3-ESP, $T_0 = 30s$, $f_{LP} = 100$ Hz Data acquisition systems: Centaur by Nanometrics Sampling rate: 250 Hz All the stations operated in continuous mode

Recording media: SD cards, data downloaded once in 3 months

Power supply: solar panels – wind generator Data format: miniSEED Data stored on data server SILO Date access: seismograms on request

Near-future plans:

Connection to Internet using GSM LTE (unpeopled area \Rightarrow problems of accessibility)

Typical relief of the Reykjanes Peninsula









Space distribution of the swarm-like seismicity on the Reykjanes Peninsula



Diffused ",swarm-like" seismicity along the rift, $M_{Lmax} = 3.6$



Are the W-Bohemian and SW-Icelandic earthquake swarms of similar or completely different nature?

SW-Icelandic swarms

ML_{max} Activity Total number of events 3.0 1997 500 3.2 2000 3840 3.8 2008 4400 3.7 2011 5740 2013 2.5 270 2014 **4.4** 2800 3.1 2017 2500

W-Bohemian swarms



		Num. of		
Activity	Durat.	ev.	M_{Lmax}	M_{Lw}
	[days]	$(M_L \ge 0)$		
Hen 1997	54	4850	4.4	4.7
Ölf 1998	28	5130	4.9	5.1
Krí 2003	6	1160	4.5	5.0
Krí 2017	6	1660	3.9	4.1

Magnitude-time course of the W-Bohemia and SW-Iceland earthquake activities



2017

10/Jul/17

10/Sep/17

10/Aug/17

10/Oct/17

dominated by one or a few strong events of a size of more than 0.5 magnitude higher than the other events). So these swarms resemble mainshock-aftershock (MA) sequences.

Seismic moment released and frequency-magnitude distribution



The stepwise seismic moment release (a few swam phases) is typical for the W-Bohemian swarms, whereas SW Icelandic swarms are characterised by one dominant phase during which most of seismic moment released (similar to MA sequences).

FMDs of the W-Bohemia and SW-Iceland swarms as well as MA-activity (2014 in WB) show similar *b*-values ≈1.0 (typical of maishock-aftershock sequense).











Southwest Iceland: space-time distribution of events in the 1997 Hengill swarm



Conclusions

- W-Bohemian and SW-Icelandic swarms are similar in:
- occurrence of a quasi-dominant event (in all SW-Icelandic and in some W-Bohemian swarms)
- *b-values* of FMDs, i.e. the ratio of small to large events
- inter-event-time distribution, i.e. event rate
- cut-off of the GR law at the highest magnitude level and apparent deflection of the strongest events from the GR curve ⇒ it suggests that earthquake swarms are series of overlapped MA sequences: stronger events are mainshocks (stepwise propagating rupture), weak events are aftershocks

they differ in:

 rate of the seismic-moment release (much higher rate in SW-Icelandic swarms); W-Bohemia swarms are characterised by stepwise seismic moment release, while SW-Icelandic swarms largely by one dominant short-term phase

W-Bohemia and SW-Iceland focal zones are characterized by:

- (largely complex) system of short, differently oriented faults /fault segments
- coexistence of faults predisposed to eq. swarms and differently oriented faults susceptible to mainshocks.

REYKJANET station KLV

Thank you for your attention!

