Induced microseismicity due to mine flooding – Observation, chararterisation and relation to mine water rise in the Eastern Ruhr Area

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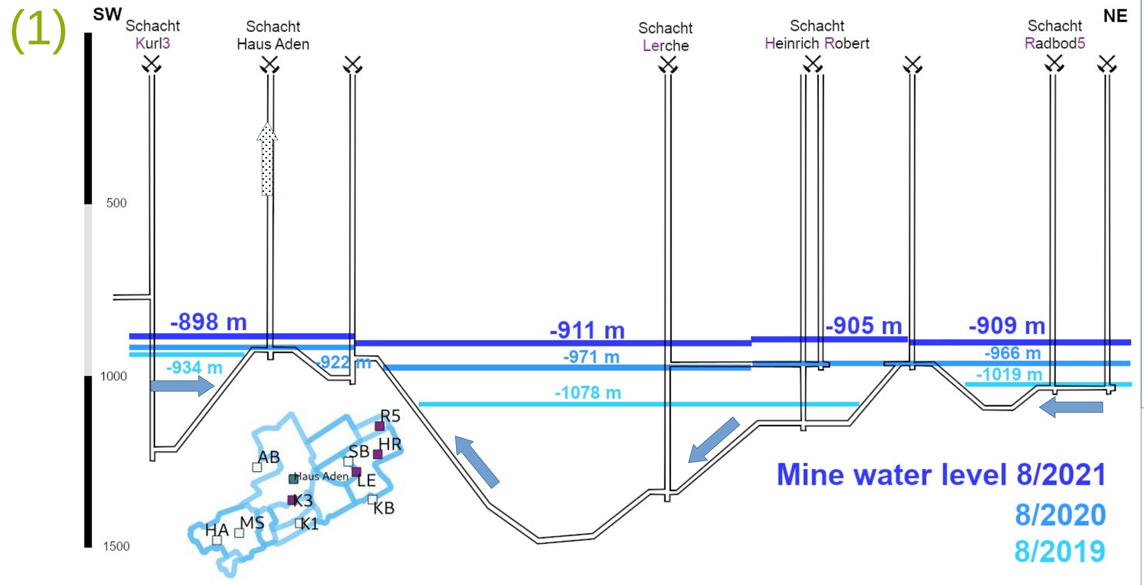
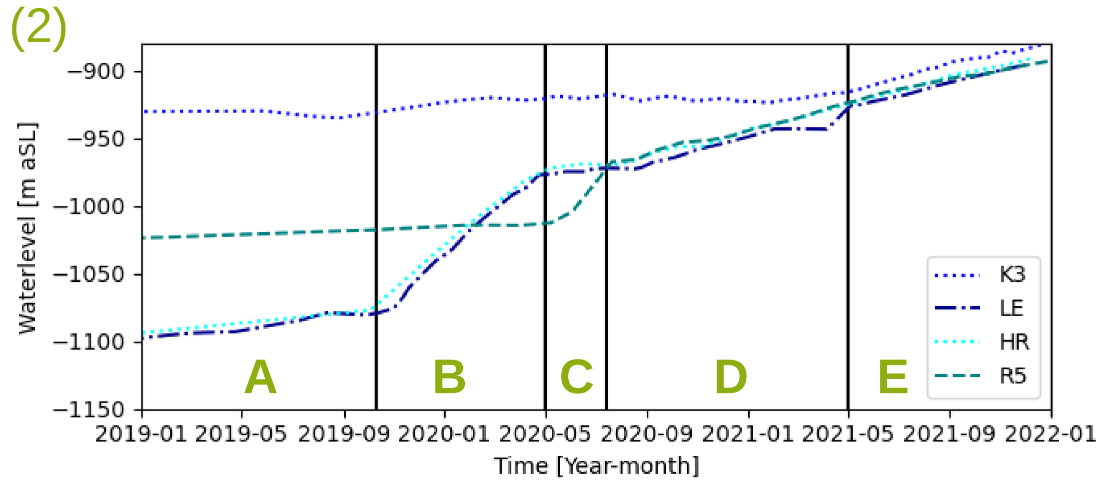
One objective of the FloodRisk project is the simultaneous observation of mine water rise and induced seismicity. For this purpose, a short-period seismological monitoring network (4a) was installed in the study area. The mine water rise is measured in individual cased shafts by RAG. Figure (1) shows a schematic section through the mine workings with shafts and deepest levels. The main water flow takes place via the drifts. In the individual segments of the mine, the level initially rises differently until it reaches an almost uniform level in mid 2021.

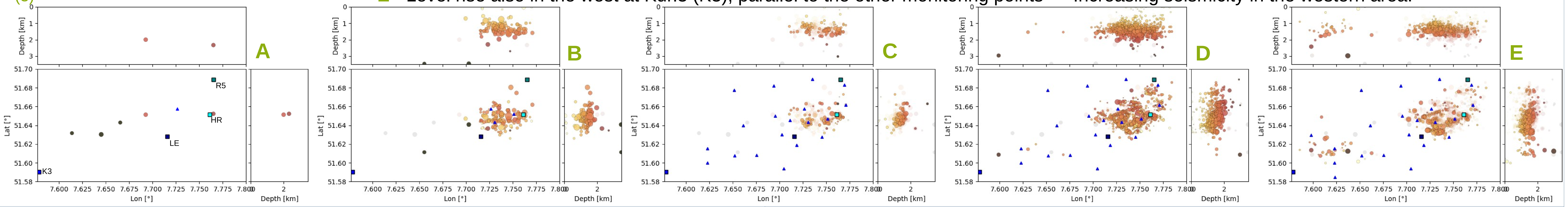
(1)



(2)



(3)



The course of the mine water rise after the shutdown of the pumps in the eastern section in mid 2019 can be divided into five phases. Figure (2) shows the mine water levels, Figure (3) A-E the seismicity measured in the individual phases in map representation and depth sections. Also shown on the map are the mine water monitoring shafts (squares) and the seismic monitoring stations (triangles).

A - The level at Heinrich Robert (HR) and Lerche rises slightly → Low seismicity.

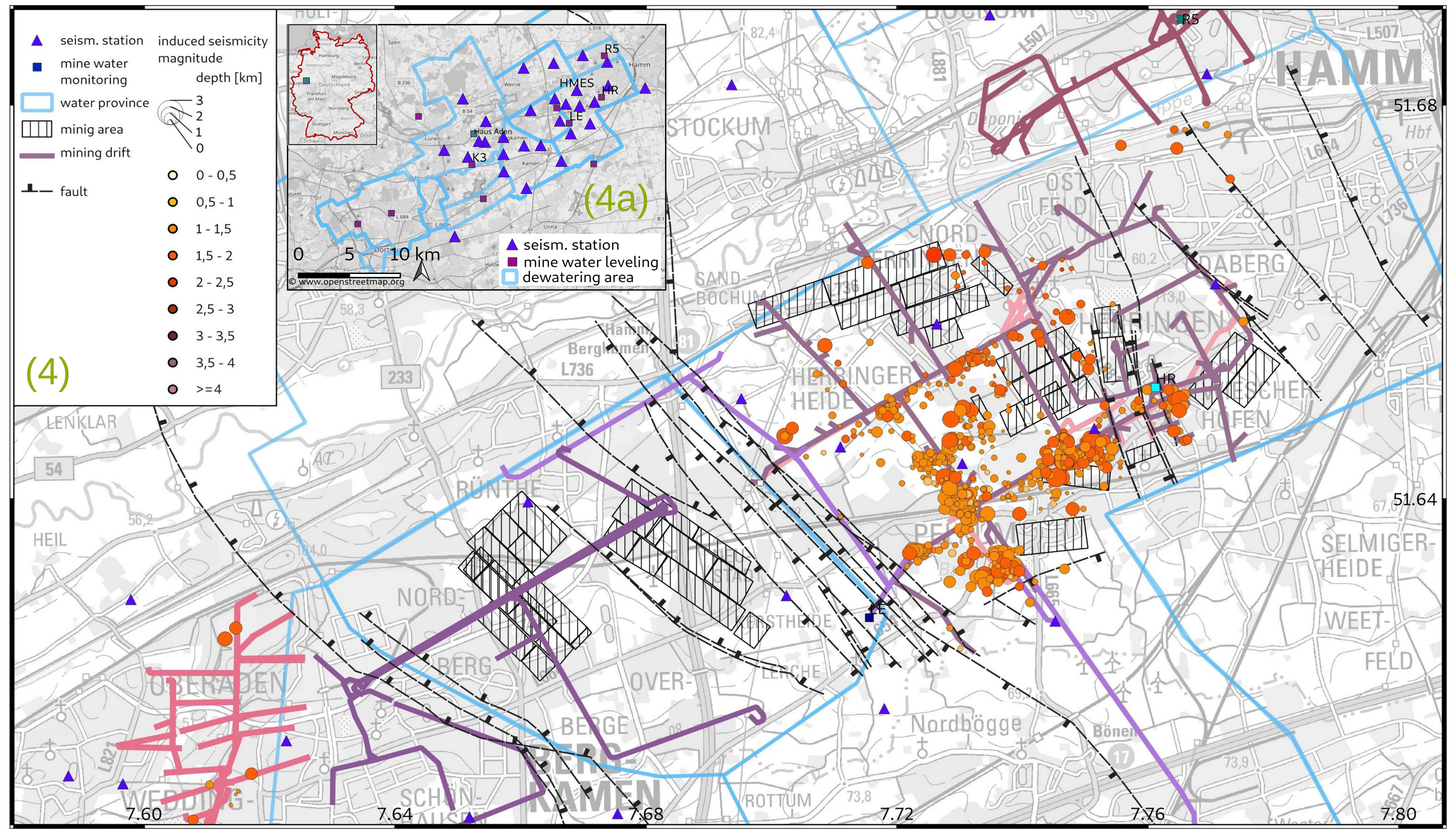
B - Strong rise in mine water at HR and LE → Accumulation of events in the area between these shafts in the depth range 1-2 km. One event with 2.6 M_{LV} in November 2019 (strongest earthquake in the study period)

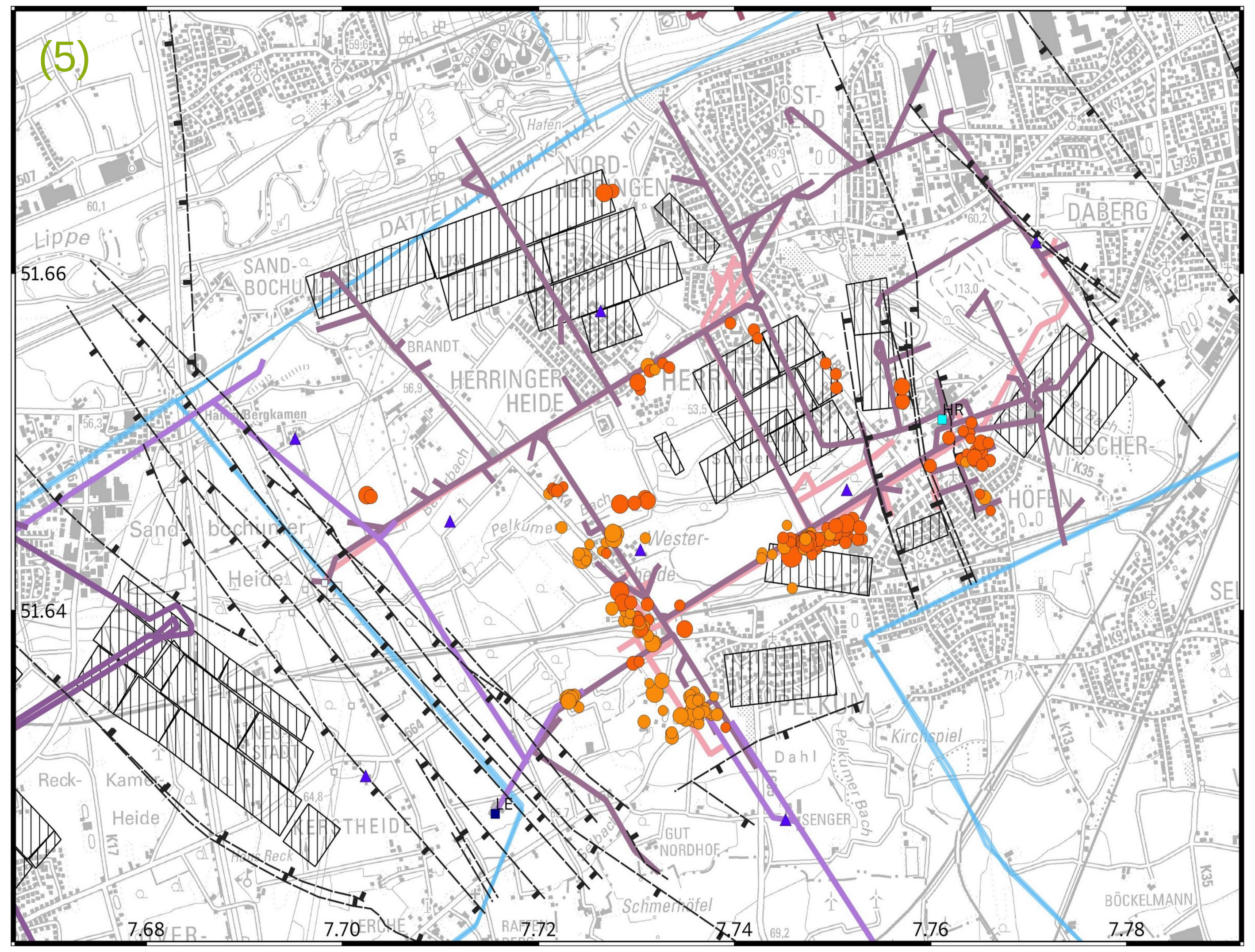
C - The curve of HR and LE flattens, the level at Radbod (R5) rises sharply until it reaches the level of HR and LE → The same area as in phase B is seismically active, but fewer earthquakes with greater magnitude occur, the events cluster spatially.

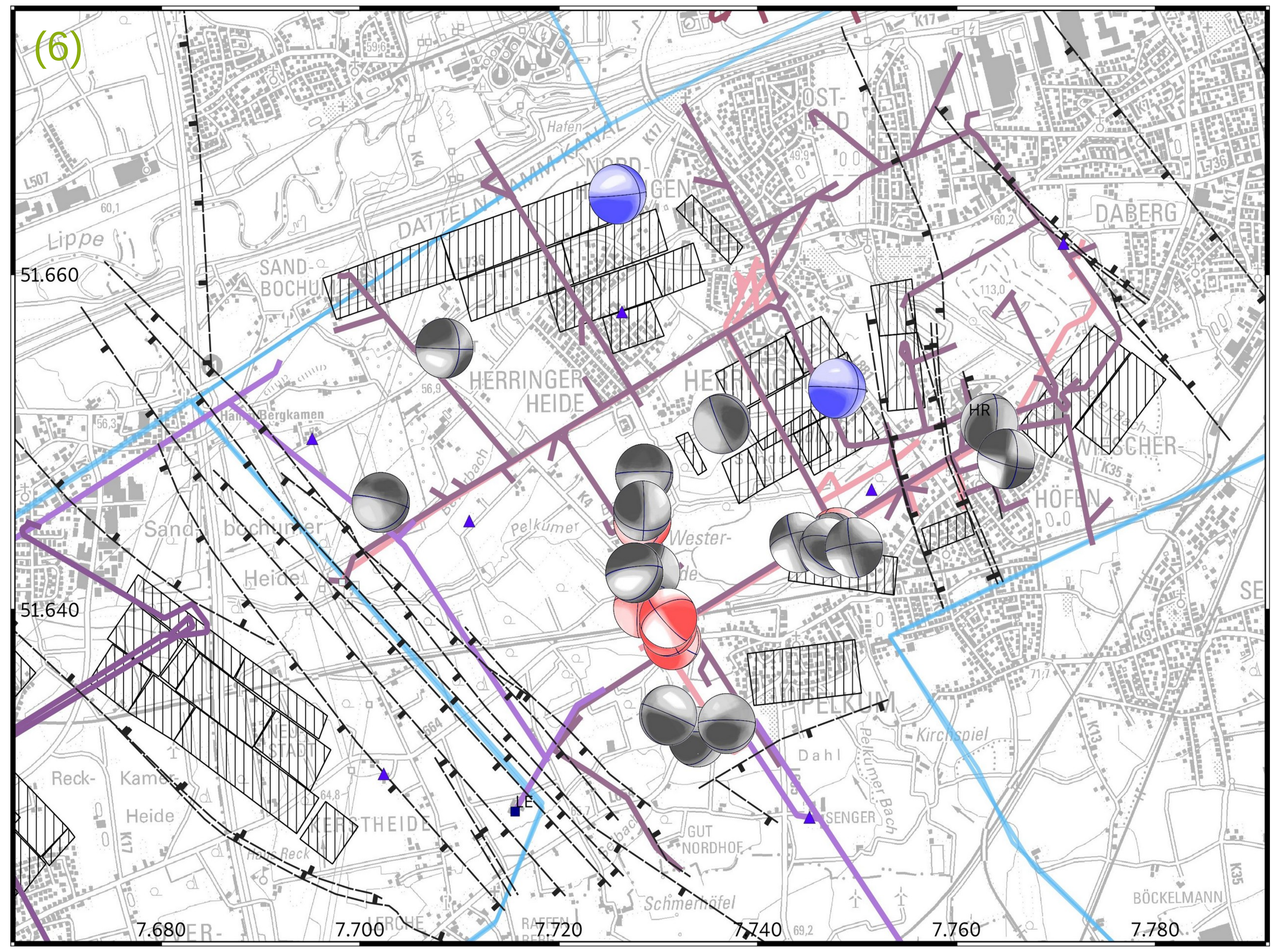
D - Simultaneous moderate increase of levels at HR, LE and R5 → seismicity additionally observed in the northeastern area south of R5.

E - Level rise also in the west at Kurl3 (K3), parallel to the other monitoring points → Increasing seismicity in the western area.

In order to be able to assign the induced seismicity to sources and structures, we only consider localisations with an inaccuracy of less than 600 m for the absolute localisation (NonLinLoc) (4). To further increase the accuracy, a relative localisation was carried out using HYPODD. The predominant structures in the seismicity distribution remain the same (5).
In contrast to tectonically active regions or induced seismicity during active mining, faults as well as mining areas do not show seismicity. The events cluster below the drif system, which serves as the main waterway during flooding. All activity seems to occur within the horst structures and thus the shallower pit area, which is currently flooded, while the trench structure with the deepest area of the mine shows no seismic activity during the observation period.







In order to gain insight into the prevailing stress directions, fault plane solutions can be considered. To account for uncertainties in the localisation and velocity model, the take-off angles are varied in the calculations of the routine HASH and thus a set of solutions is calculated in each case. A total of 64 consistent fault plane solutions could be calculated. The solutions with the two best quality classes are shown here (6) coded by focal depth (red - shallower than 1.5 km ,black - 1.5 - 2 km, blue - deeper 2 km). A preferential mechanism for the entire area is not recognisable.

References:
RAG BID: Mine water monitoring http://www.bid.rag.de/bid/index.htm
F. Maibaum, RAG (2012): Wassertechnisches Feinkonzept zum Abschlussbetriebsplan der ZWH Ost

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