A network of high resolution tilt meters in the Mur-Mürz tectonic zone

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Based on the cooperative work of Austrian, Hungarian and Finnish researchers the Conrad Observatory (COBS), where the continuous tilt observations started in 2016 using both a Lippmann-type 2D and an FGI-type (Finnish Geospatial Research Institute) interferometric water tube tilt sensor became a core station of a local tilt network in 2022. It consists of six sites located in and between COBS and the Sopronbánfalva Geodynamic Observatory (SOPGO), Hungary. Three stations are also equipped with seismometers. The network is devoted to monitor slow tectonic deformations of the area and also provides tilt time series connected to seismic events of the fault zone.

From a financial support of the Eötvös Loránd Research Network, Hungary, four new Lippmann-type 2D tilt sensors were purchased by the Institute of Earth Physics and Space Science, Sopron, Hungary in 2021. By that time two sensors have already been operated continuously at COBS and at SOPGO at 1 Hz sampling rate. Due to two M4+ earthquakes that occurred near Wiener Neustadt (30.03.2021 and 20.04.2021), it was decided to install these sensors at suitable locations between these two sites to form a profile crossing the fault line (Fig. 1).

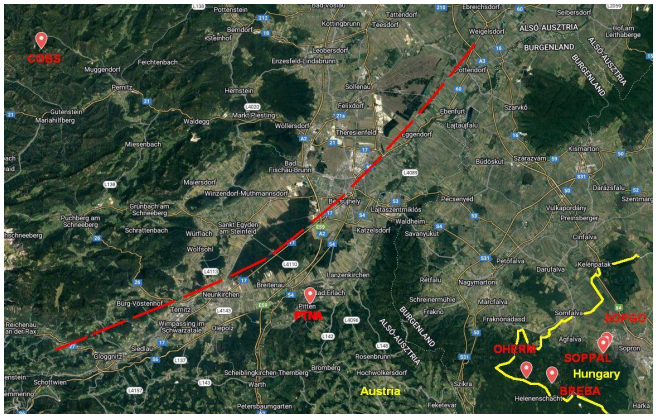

Figure 1: The stations of the tilt meter network at Mur-Mürz tectonic line (red dashed line). Yellow line: the state border (google.com).

The requirements of the tilt measurements at nrad-resolution are very high, especially in terms of the thermal stability of the sites (daily variation should be less than 0.01 °C/day), so only underground sites (e.g. abandoned mines) can be considered as candidates. Eventually three sites seemed to be appropriate and were available near to Sopron, Hungary (SOPPAL, BREBA, OHERM) and one site in Pitten, Austria (PTNA) where an STS2.5 seismometer was also installed by GeoSphere Austria. So at COBS, PTNA and SOPGO tilt measurements co-located with seismic observations run continuously which hopefully will support the determination of rotational movements during seismic events. The data acquisition runs at 5 Hz sampling rate using Raspberry Pi technology. The big advantages of these linux microcomputers are the low cost, low energy consumption, modularity and programming flexibility. With careful modular design, using the RPiZero versions, 1 month long continuous operation of the data logger can be guaranteed by a 100 Ah battery. This time can even be extended by adding a solar panel. The time synchronization can be solved by a GPS module whereas the system, if needed, can be remotely supervised by a GSM SMS tool. On the 06.01.2023 the three operational tilt sensors at COBS, SOPGO and SOPPAL simultaneously recorded an M2.8 earthquake that occurred at Ebreichsdorf. First, the 1.6 sec time delay observed between SOPGO and COBS stations was converted to distances (Fig. 2, dashed cirlcles) using $v_p = (5.0, 8.0)$ km/s. Then an attempt was made to determine the possible azimuths of the epicentre by a simple graphical interpretation. In Fig. 2 the narrow angle domains filled by faded blue color show these ranges of azimuths in both possible directions. The domain pointing north-east just covers the location of the epicentre determined by the seismological network. Due to the closeness of SOPPAL and SOPGO stations ($\sim$ 500 m) a point wise localization of the epicentre was impossible.

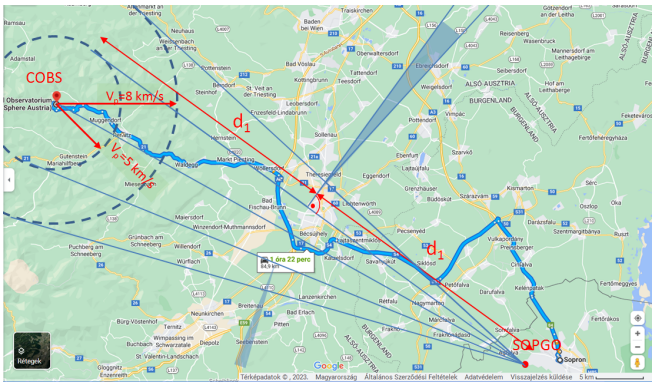

Figure 2: Graphical determination of the domains of possible epicenters based on the interpretation of the time delay observed at COBS.

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