First results of conical borehole strain gauge probes application for induced rock mass stress changes measurement

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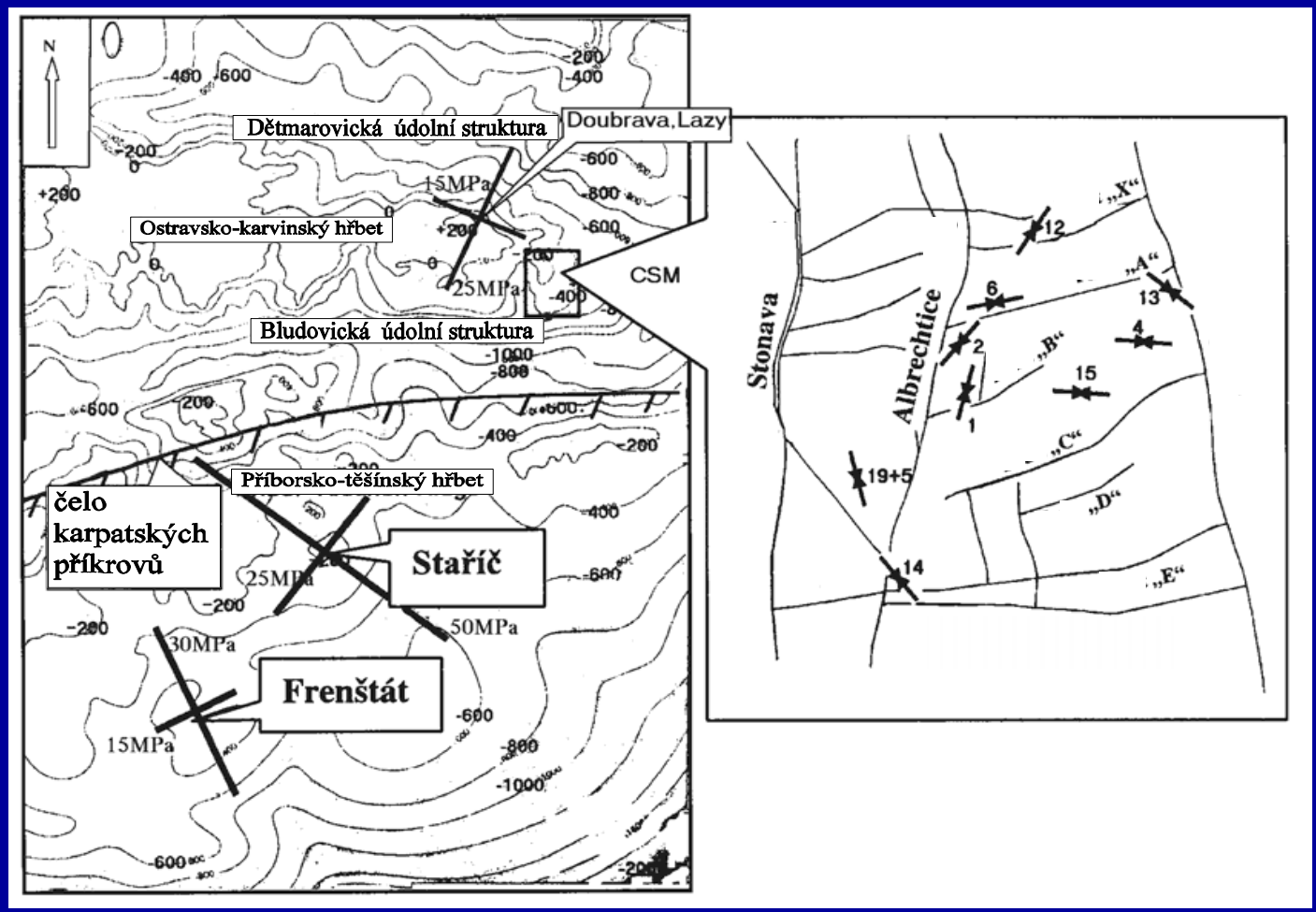
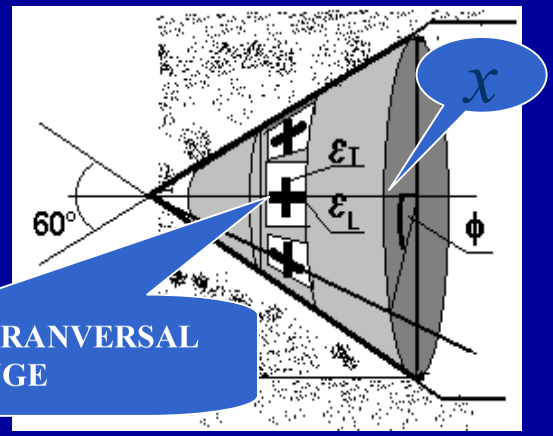
Stress measurement by HF method



Measurement principle



According (Kang 2000)*:

$$\begin{vmatrix} \varepsilon_{T\Phi} \\ \varepsilon_{L\Phi} \\ \vdots \end{vmatrix} = \begin{vmatrix} A_{11}+A_{12}\cos 2\Phi, & A_{11}-A_{12}\cos 2\Phi, & C_{11}, & D_{11}\sin\Phi, & D_{11}\cos\Phi, & 2A_{12}\sin 2\Phi \\ A_{21}+A_{22}\cos 2\Phi, & A_{21}-A_{22}\cos 2\Phi, & C_{21}, & D_{21}\sin\Phi, & D_{21}\cos\Phi, & 2A_{22}\sin 2\Phi \\ \vdots & & \vdots & & \vdots & \end{vmatrix} .\{\sigma\}/E$$

$\{\sigma\}$ stress tensor (as $\{\sigma_x,\sigma_y,,\sigma_z,\tau_{yz},\tau_{zx},\tau_{xy}\}^T$)

E –Yang's modulus

ε_T , ε_L – deformations on the conical head surface

Φ – angle of corresponding tensometric gauge

$A_{nm}..D_{kl}$ – numerical coefficients

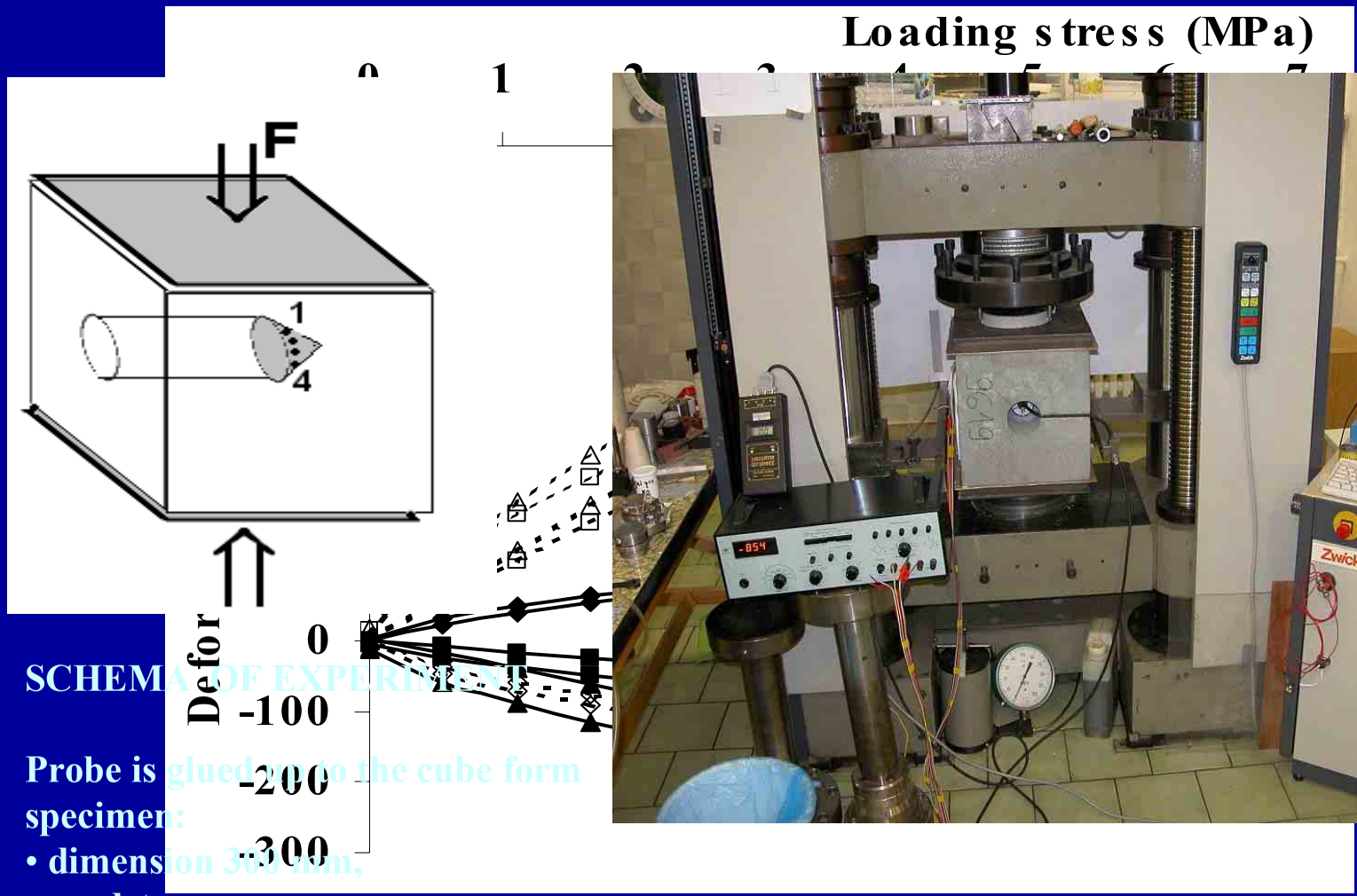
The calculation of stress tensor itself is performed by optimizing of its form by minimal square method of differences of the measured and calculated deformations. (It is necessary to have at least 6 measured values in independend directions).

For calculation of σ it is necessary to know the E and μ values, too.

DESIGN:

- Diameter of borehole 76 mm,
- Water-proof design,
- Probe is unbalanced 12-channel electronically multiplexed linearized strain gauge quarter bridge connected to the analog-digital converter with high linearity and resolution.
- Balancing and temperature compensation of individual strain gauges are executed numerically within data processing.

Laboratory loading test of strain gauge probe



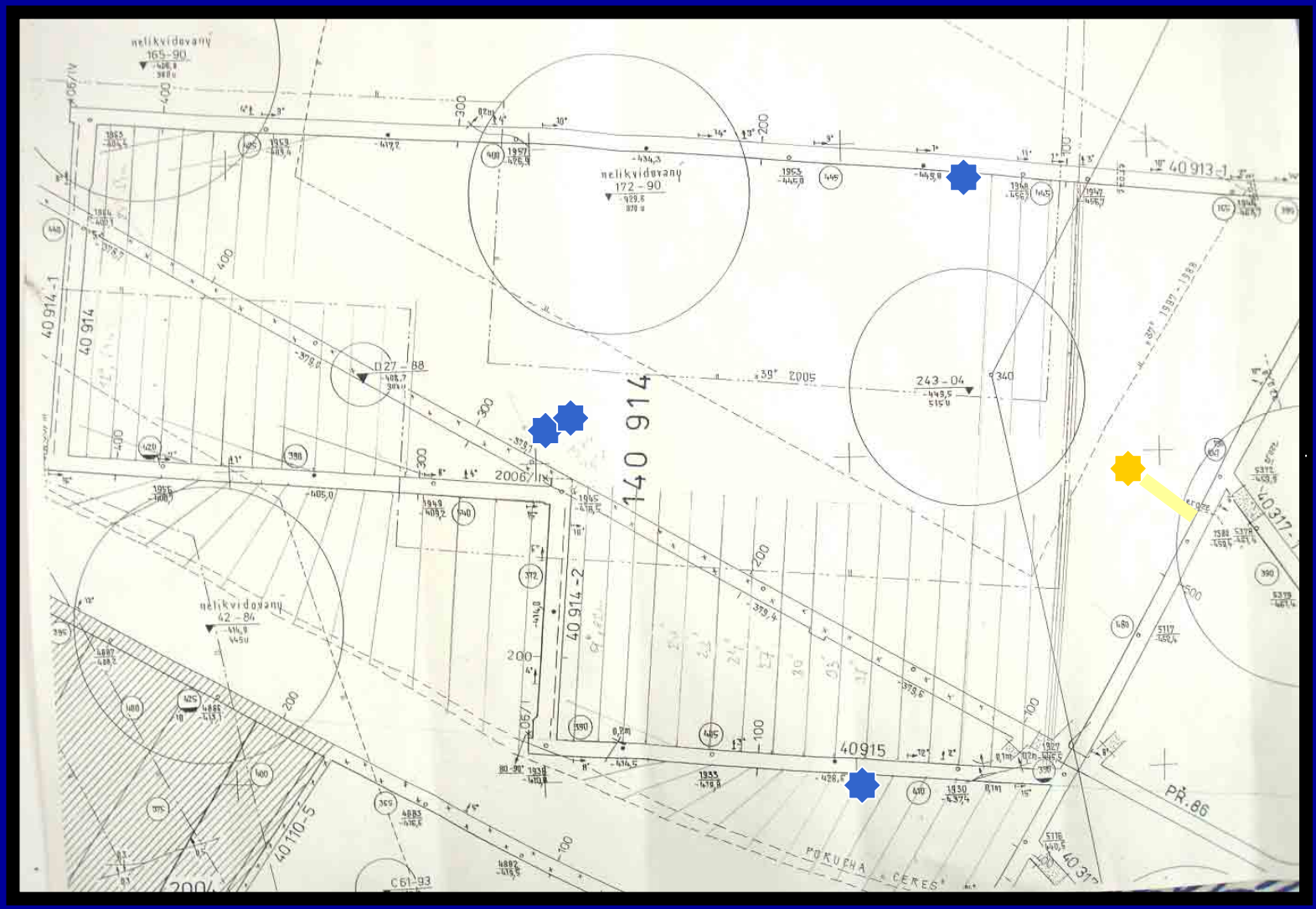
SCHEMA OF EXPERIMENT

Probe is glued up to the cube form specimen:

- dimension 300 mm,
- sandstone.

Relative deformations of selected strain gauges

Locality Lazy



Special conical bit for preparing of borehole bottom

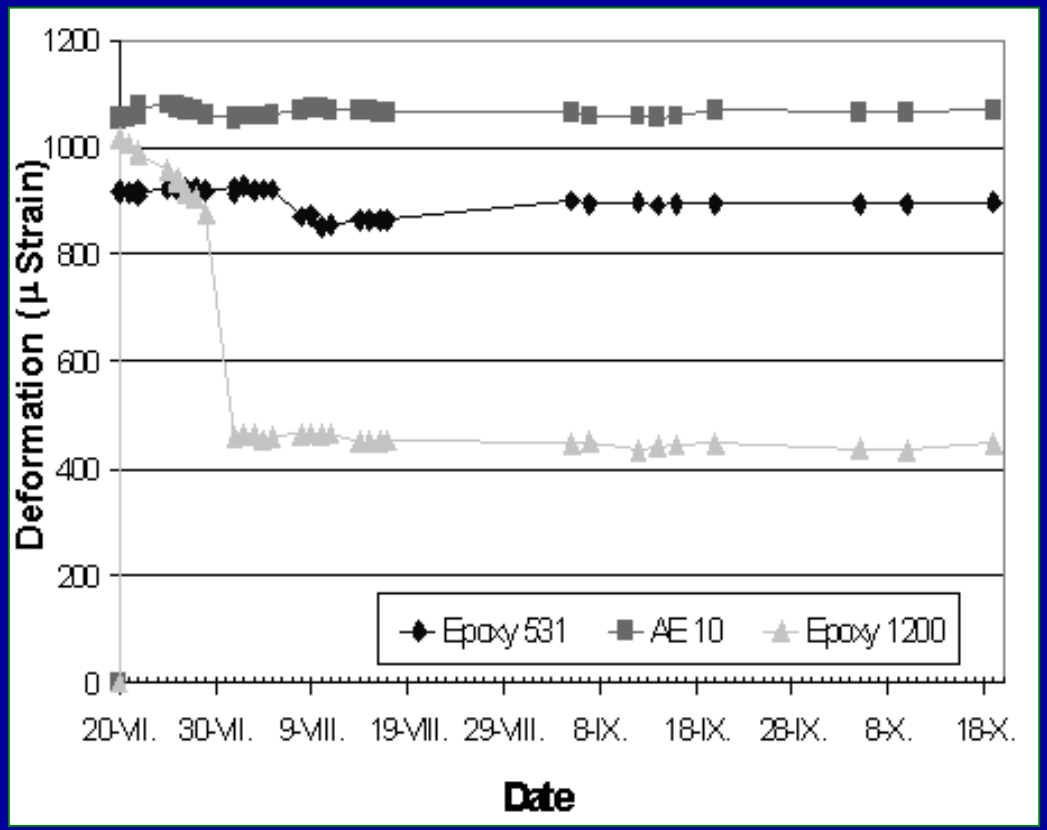
Quality check of borehole bottom

Instalation of probe in-situ

Orientation equipment

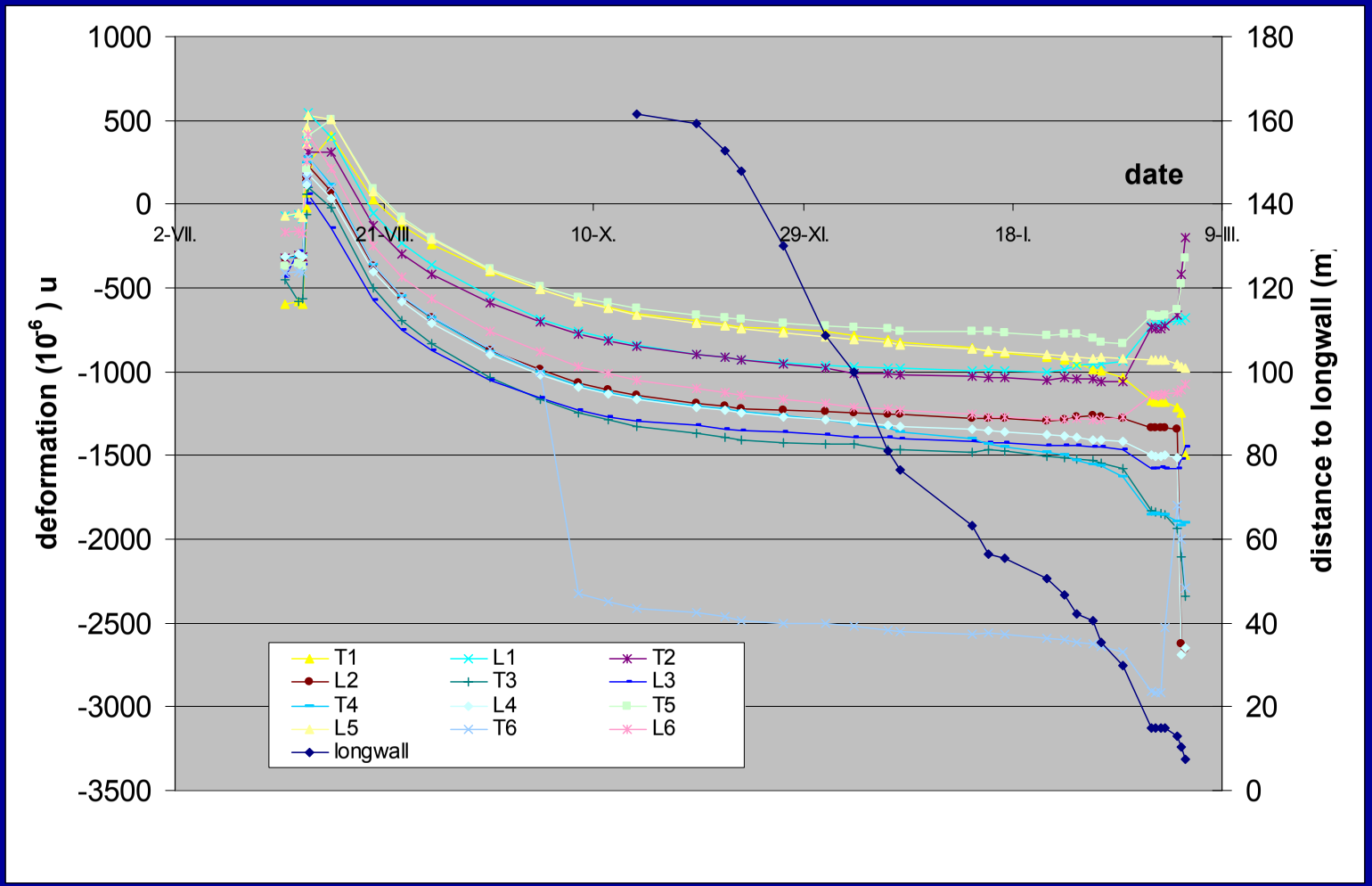
Testing of creep-effect of the potential used glues.

We tested three selected glues used for bonding of the metal strain gauges (CHS Epoxy 1200, CHS Epoxy 531, AE10). The strain gauges have been stick on surface of steel cylinder sample by these selected glues. After accomplished hardening of them the cylinder sample was placed in rheological press, loaded by constant power inducing cca 1000 μStrain.



AE 10 and CHS Epoxy 531 manifest good stability for this purpose in contrast to CHS Epoxy 1200. In addition Epoxy 531 is possible to use successfully in wet rock too. On the base of these experiences we will orient our research about long-term behaviour of glues on using of AE 10 and CHS Epoxy 531.

Lazy (probe 2_6)



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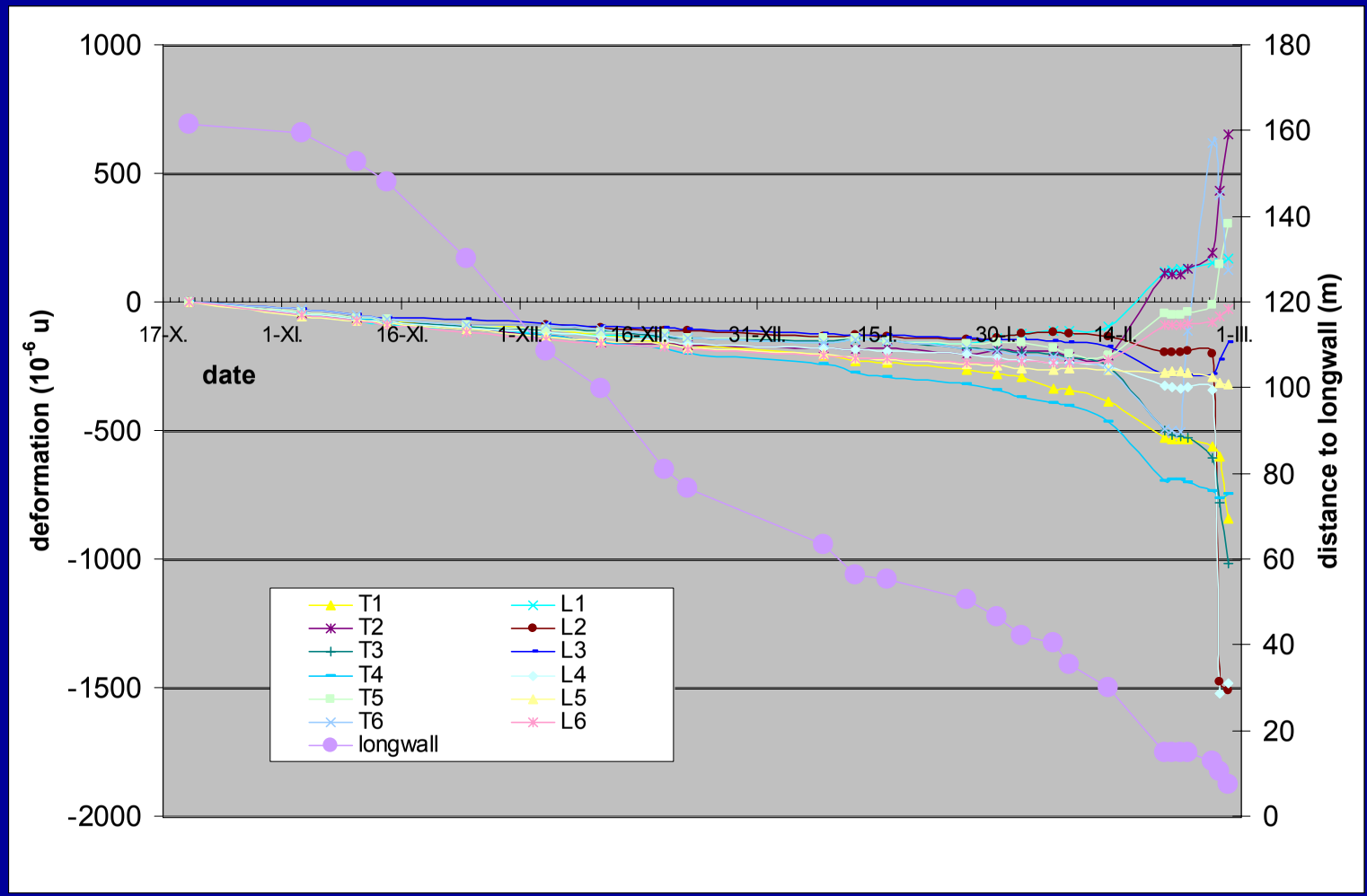

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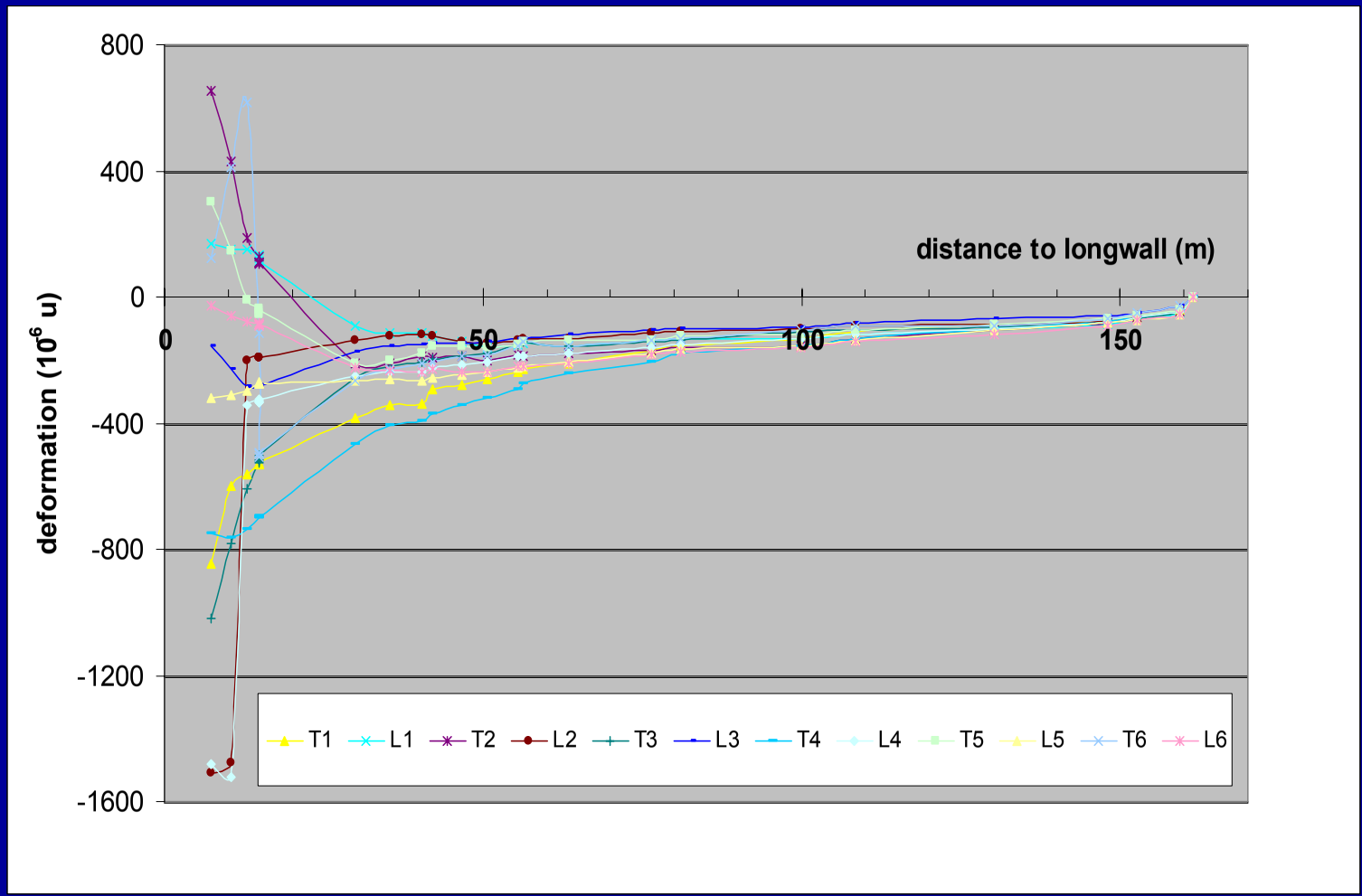
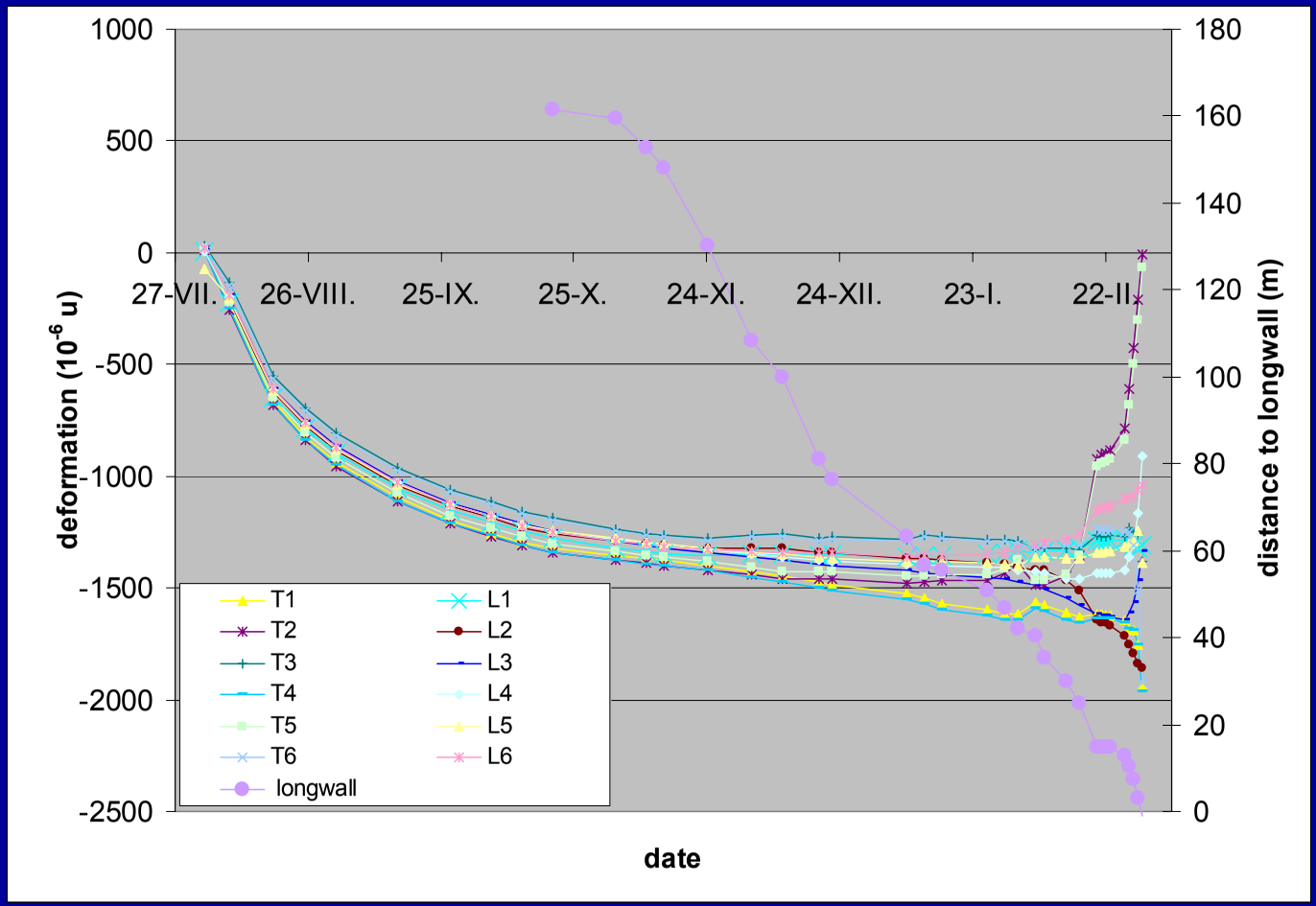


Lazy (probe 1_9)



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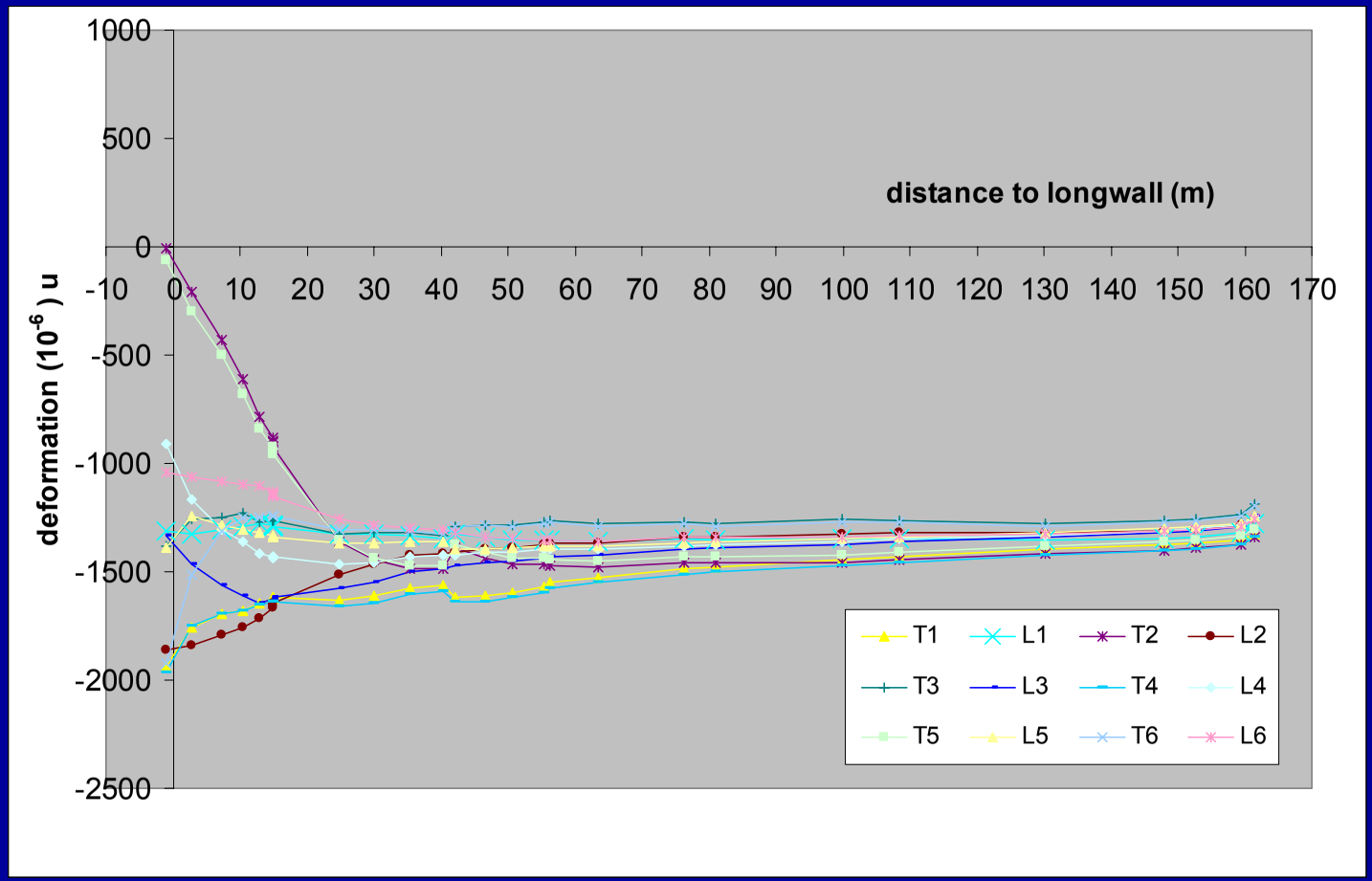
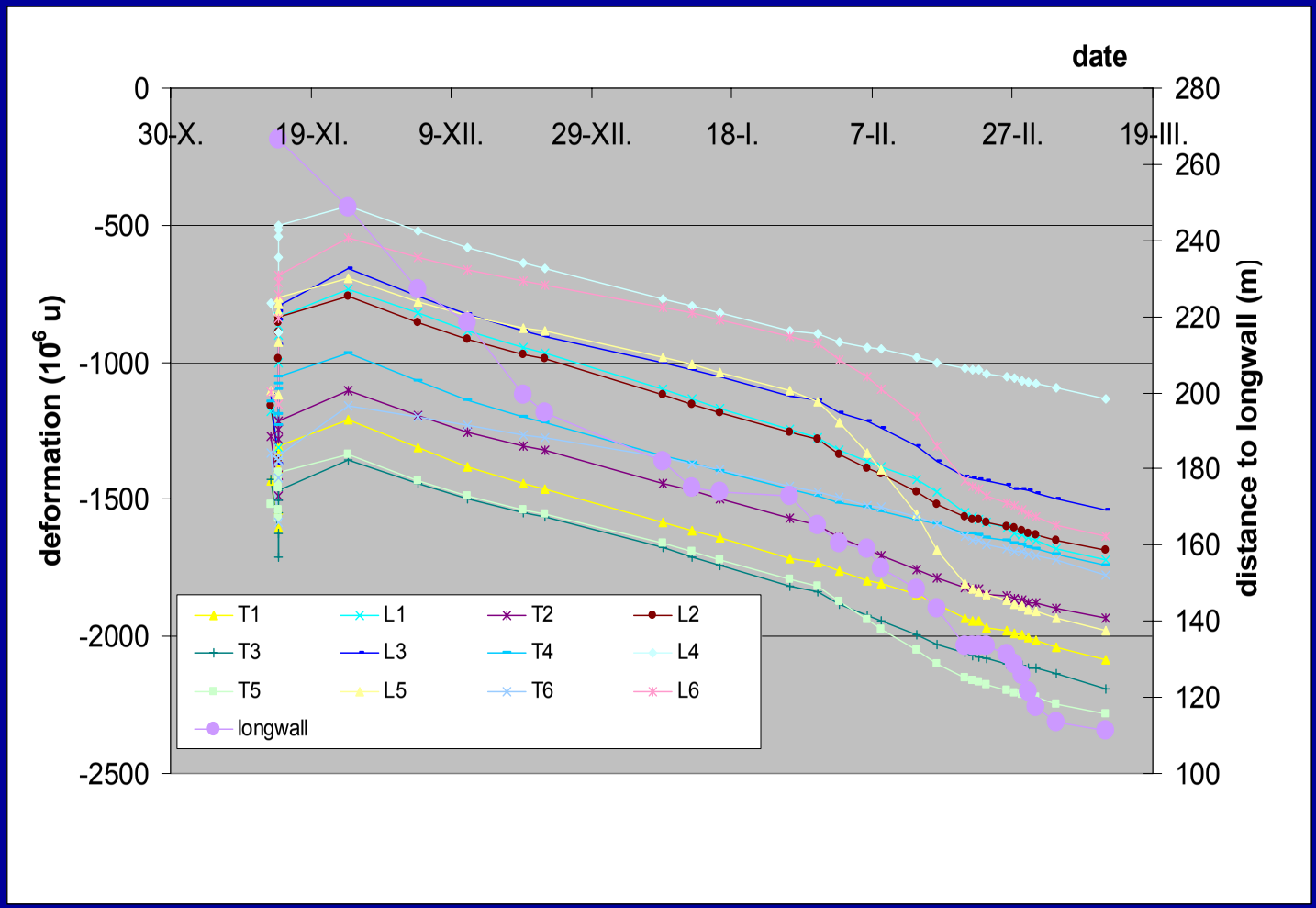


Lazy (probe 3_1)



CONCLUSIONS

On the base of the principles published by Nakamura et al. 1999 and Kang, 2000 was opened research of the stress tensor measurement using conical strain gauge probe in the Institute of Geonics of the AS CR.

Obtained results:

- Way of preparing of borehole and probe instalation were checked up,
- Prototypes of strain gauge conical probes for long term monitoring were designed.
- Laboratory was checked up features of the conical strain gauge probe. Results manifest proper way of design.
- The possibility of use of the probe for long term monitoring in situ was checked at observation of stress changes at long wall advance.

Thank You for your attention

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