Supplement to Hinterwirth et al. (2025) Data and Methods (Section 3.)

Seismic methodology detailed description

The seismic data were available from various institutions (TU Munich, GFZ Potsdam, Montanuniversität Leoben) and merged into one dataset. The supplied data were originally recorded in two different acquisition campaigns in 1998 and 1999 respectively. The data reprocessing was done on the server and processing platform ProMAX by Geo5 GmbH in Leoben, Austria. Generally, the reprocessing followed a conventional common-midpoint stacking workflow. All coordinates (UTM 32N) of sources and receivers were checked for plausibility and completeness and were then imported into the processing system. The common-midpoint (CMP) numbers, also called common-depth point (CDP) numbers and their corresponding coordinates in meters serve as reference for tying seismic events to geological surface structures. Due to scattering of the calculated midpoints, caused by the geometry of the receiver line, the processing geometry was defined as "crooked-line geometry". The CMP numbers were obtained by binning the crooked line midpoints between sources and receivers in an interval of 25 m. Strongly crooked geometry and varying recording conditions required iterative improvement of processing parameters, in particular with respect to amplitude scaling (geometrical spreading correction and, optionally, automatic gain control (AGC) and trace equalisation), static correction and velocity model building. A combination of elevation statics and velocity statics based on a tomographic inversion of the first breaks and subsequent residual statics, proved to be very efficient for stacking enhancement. The Seismic Reference Datum (SRD) was defined at 700 m above mean sea level with a replacement velocity of 4500 m/s.

Initial breaks were semi-automatically picked on a subset of the raw field records, with manual adjustments made at specific trace intervals on the maximum of the amplitude (zero-phase data) and then snapped automatically on all traces. The traveltime pickset was employed for the Turning-Ray Tomography of ProMAX (Zhu et al., 1992; Stefani, 1993). The creation of a one-dimensional start model based on the pickset was performed, based on Hagedorn's principles (Hagedorn, 1967). Synthetic traveltimes were calculated for the start model for each source point and receiver, respectively. Residual times were then created by comparing observed and synthetic traveltimes. These residuals were utilized as input into the tomographic inversion. Several iterations were performed by varying parameters, such as robustness and smoothing. The horizontal cell size was set to 50 m, and the vertical cell size was set to 25 m. The optimum result was also used for depth migration.

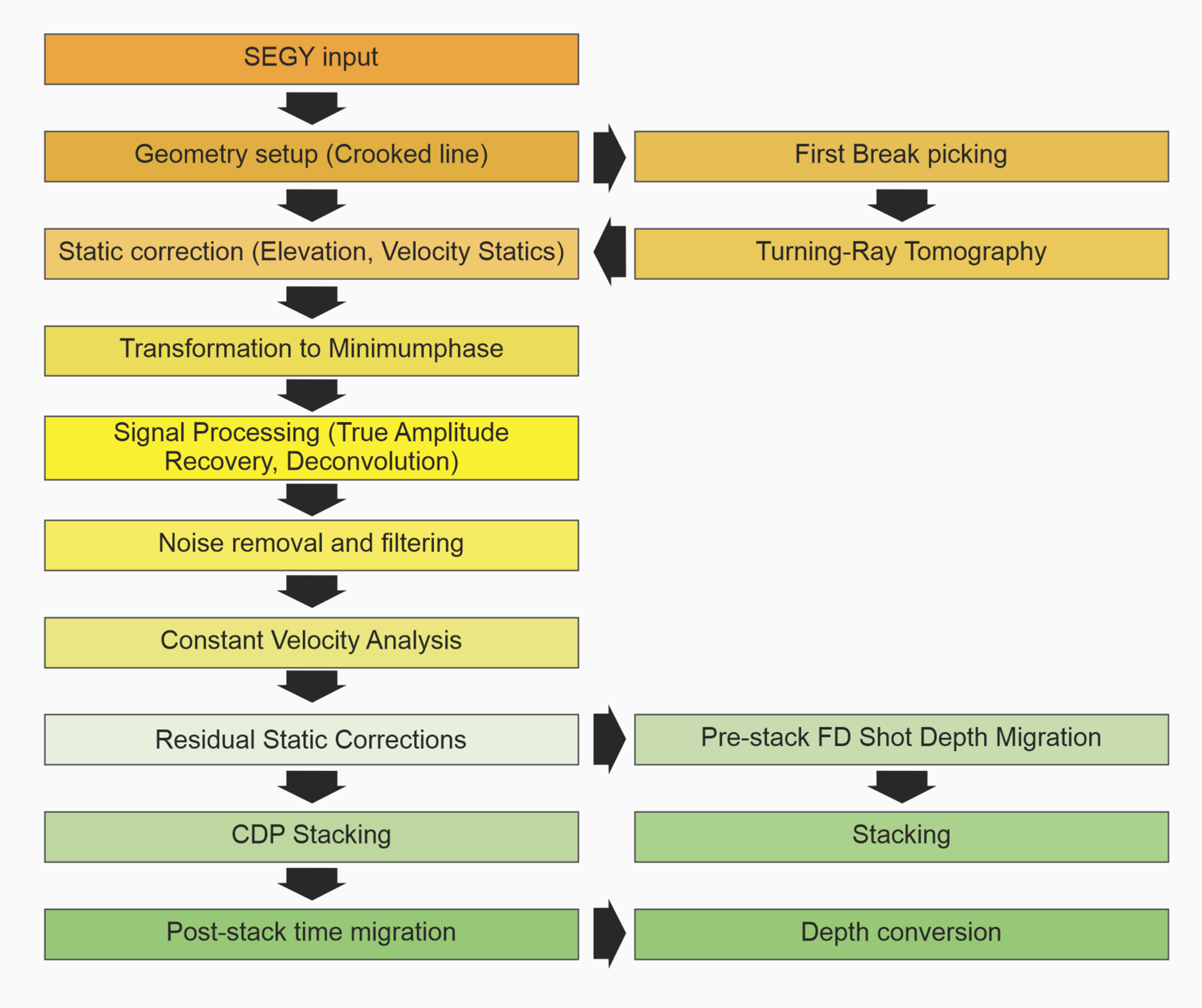

Figure S1: Workflow steps for the reprocessing of the original TRANSALP seismic data set.

For the velocity model, the profile was scanned for optimal stacking velocities by constant velocity stacking analysis (CVA) in dependence on location (CDP) and time. The velocity model required for time migration was obtained by analysis of the stacking velocities. The complete processing flow from geometry setup to time migration (post-stack) is fundamentally based on the workflow shown in Figure S1.

Figure S2 shows a comparison of migrated stacks between the original results (vertical axis in depth) and the corresponding reprocessed section (vertical axis in two-way travel time).

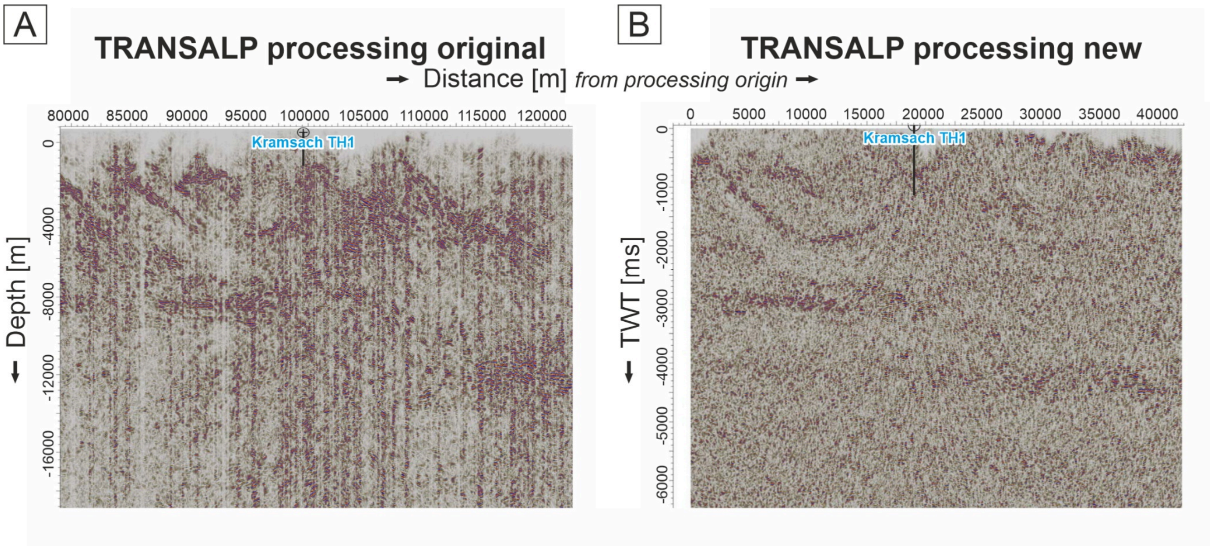

Figure S2: Comparison between the original results and the corresponding reprocessed TRANSALP section A: Original processing of the TRANSALP segment reaching from approximately 20 km north to 20 km south of the Inn valley (see Fig. 3) in depth domain (y-axis in meters). The well Kramsach TH1 (Inn valley) is projected orthogonal from 640m east into the section, also in depth. B: Reprocessed segment in two-way-travel time (milliseconds). The projected well Kramsach TH1 Is also converted to time domain.

Figure S3: Simplified P-wave velocity model of the reprocessed seismic section for depth conversion. Generated on a first conceptional interpretation of time-migrated stack. Modified from Galler et al.

References

Galler R., Villeneuve M., Schreilechner M.G., Jud M., Binder H., Hainisch A., Lüschen E., Eichkitz C.G., Neuhold C., Hasni M., Bottig M., Hoyer S., Schubert G., Rupprecht D., Weginger S., Apoloner M.-T., Hausmann H., Ortner H., Hinterwirth S., 2023. The Potential of Deep Geothermal Energy in Tyrol—Based on a Pre-feasibility Study. BHM Berg- und Hüttenmännische Monatshefte, 168/12, 555–565. https://doi.org/10.1007/s00501-023-01405-9

Hagedorn R., 1967. On the hadronic mass spectrum. Il Nuovo Cimento A Series 10, 52/4, 1336–1340. https://doi.org/10.1007/BF02755235

Stefani J.P., 1993. Possibilities and limitations of turning ray tomography: A synthetics study. In: SEG Technical Program Expanded Abstracts 1993. Society of Exploration Geophysicists, pp 610–612

Zhu X., Sixta D.P., Angstman B.G., 1992. Tomostatics: Turning-ray tomography + static corrections. The Leading Edge, 11/12, 15–23. https://doi.org/10.1190/1.1436864