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ENGINEERING GEOLOGY OF THE GOTTHARD BASE TUNNEL AND INTERRELATIONSHIPS WITH ALPINE TECTONICS

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The Swiss AlpTransit System (also called NEAT) is an important element of the new European high speed railway network. This system, which is currently under construction, consists of two railway axes - the Gotthard and Lötschberg Axes - which will pass through the western and eastern parts of Switzerland (Figure 1). Each of these axes consists of 2 to 3 base tunnels, the longest being the two-tube Gotthard base tunnel (57 kms in length), which is currently the world's longest tunnel under construction. Within this system, an existing base tunnel will be used (the Simplon base tunnel), a second is to be located in the pre-alpine foreland (the Zimmerberg tunnel), and the remaining three are to be built within the Alpine region (the Gotthard, Lötschberg and Ceneri base tunnels). These final three tunnels are of notable concern since the rugged topography in this young mountain belt reaches altitudes of up to 3000 m near the tunnel axes, resulting in an overburden of up to 2500 m. Here the new base tunnels will intersect many of the tectonically deep units of the alpine mountain chain: mesozoic to tertiary sediments and the crystalline basement of the helvetic and penninic domain.

The Gotthard (GBT) and Lötschberg (LBT) base tunnels run more or less perpendicular to the main geological structures of the Alps (Figure 2). Crossing from north to south these include 1) The Helvetic autochthonous sediments and nappes, 2) The Aar, Tavetsch and Gotthard basement "massifs", and 3) The Penninic units of the Lepontine area. Together these units form the "core" of the Central Alps, which in turn was primarily shaped during tertiary (Eocene to Miocene) crustal subduction, thrusting, folding and updoming. Even today the Alpine mountain chain is still active. This is reflected, for example, in regional uplift rates derived from selected first order levelling benchmarks and GPS measurements performed along several cross-section through the Swiss Alps. These show maximum values of 1.4 mm/year in the region of the southern LBT and the southern GBT. In addition, neotectonic movements along selected fault zones of steep inclination are postulated based on observed "fault scarps" in young glacial tills and erosion surfaces with glacial polish, and from new geodetic measurements performed across fault zones in the southern Aar Massif (Frei and Löw 2001). These movements would correspond to

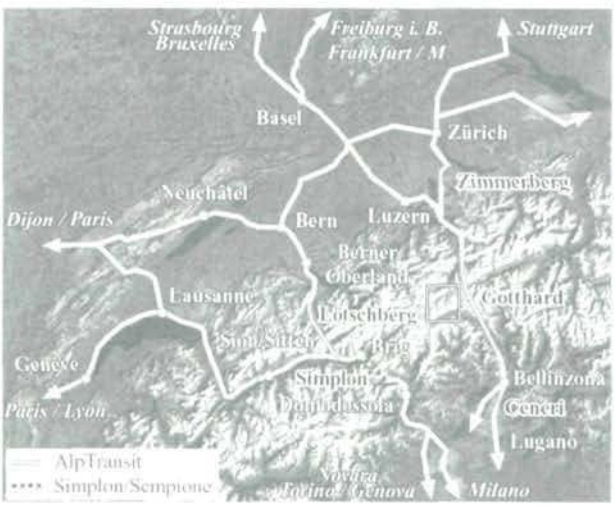

Fig. 1: Geographical and geomorphological situation of the AlpTransit railway system

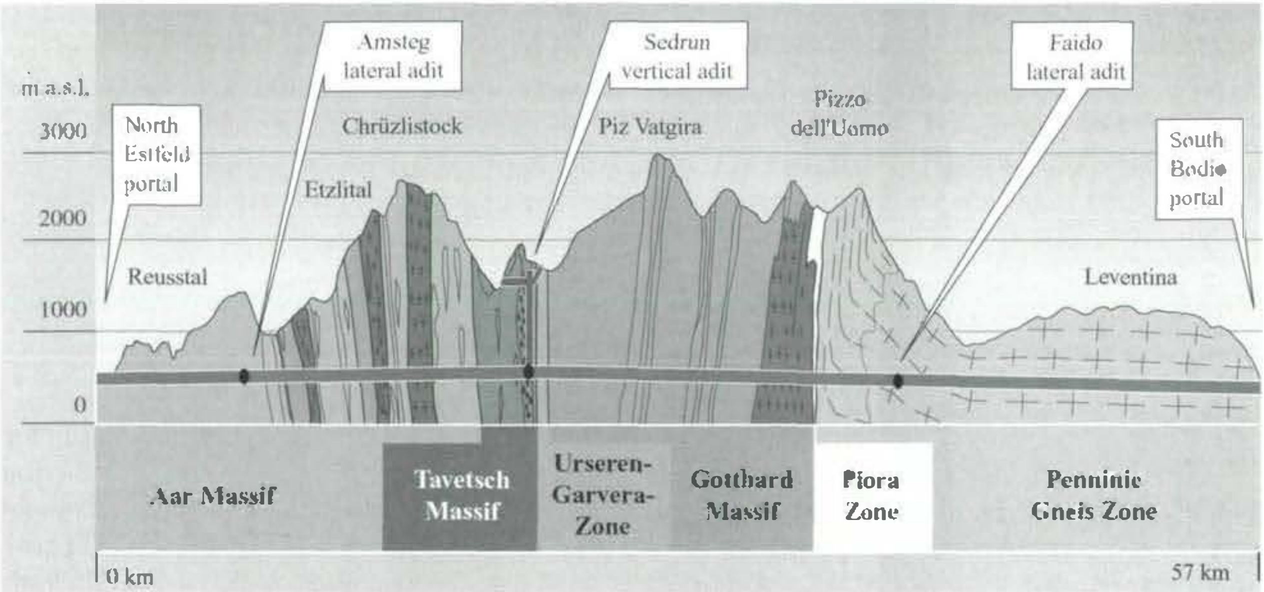

Fig. 2: Simplified longitudinal section of the Gotthard base tunnel

continued reactivations of old shear structures. Unfortunately the active stress field in this aseismic area is not well understood and paleostress analyses give uncertain results.

While the longest sections of the Gotthard base tunnel will be drilled in fairly stable ground, this project will also be confronted with a large variety of geologically controlled hazards, most of them being interrelated with Alpine tectonics. The most important hazards include: high water inflows along faults, inflows of rock debris (e.g. sugar-grained dolomites) under high fluid pressures, strongly squeezing ground in schists and phyllites, stress-controlled instabilities (i.e. rock bursting), and surficial disturbances (settlements) through drainage effects (Loew et al. 2000). Within the framework of the AlpTransit project these hazards have been investigated during the past 10 years by means of a long exploration tunnel (the Polmengo Tunnel in the Penninic Domain, from which 4 intermediate size boreholes have been drilled into the Piora Zone), 5 deep boreholes drilled from surface into the Tavetsch Massif, several geophysical and geodetical surveys, and geological field mapping and data compilation at the scales of 1:10'000 and 1:50'000 (Löw and Wyss 1999). In addition to these works, several Swiss research groups have been working in related fields mainly focussing on the structural, petrological and rock-mechanical aspects of fault zones and sugar-grained dolomites. In the lecture we will present new results from field and laboratory studies related to the dense fault and fracture patterns occurring in the Aar- and Gotthard massifs (Laws 2001, Laws et al. 2001, Zangerl et al. 2001) and demonstrate some important relationships between engineering geological problems and Alpine tectonics. Among these relationships special weight will be given to the impact of late- to post-alpine brittle and fracturing and rock mass stability, deformability and permeability.

References

FREI, B. & LOW, S. (2001): Struktur und Hydraulik der Störzonen im südlichen Aar-Massiv bei Sedrun. – Eclogae geol.Helv. Vol. 94, no. 1.

LAWS, S., LOEW, S. & BURG, J.P. (2001): Structural Properties of Shear Zones in the Eastern Aar Massif, Switzerland. Eclogae geol.Helv. submitted.

LAWS, S. (2001): Structural, Geomechanical and Petrophysical Properties of Shear Zones in the Eastern Aar Massif, Switzerland. – Dissertation ETH Zürich.

LÖW, S. & WYSS, R. (1999): Vorerkundung und Prognose der Basistunnels am Gotthard und am Lötschberg. Rotterdam. – A.A. Balkema. 90 5410 480 5, pp. 405.

LOEW, S., ZIEGLER, H., & KELLER, F. (2000): AlpTransit: Engineering Geology of the World's Longest Tunnel System. – In: GeoEng2000, Proceedings of an International Conference on Geotechnical and Geological Engineering, Vol. 1 . Lancaster: Technomic Publishing Co. 927–937.

ZANGERL, C., EBERHARDT, E., & LOEW, S. (2001): Analysis of ground settlements above tunnels in fractured crystalline rocks. – In: ISRM Regional Symposium EUROCK 2001, Rotterdam, Balkema.

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