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Challenges and Geology of the Lötschberg Base Tunnel

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Summary of a talk given at the VSP/ASP annual convention, Interlaken, June 2009.

Introduction

The Lötschberg Base Tunnel together with the Gotthard- and the Ceneri-Base Tunnels forms part of the NEAT (New Alpine Rail Traverse) Project. The tunnel is 34.6 km long, crossing the Helvetic Nappes and the Aare-Massif in the Bernese-Valais Alps, connecting Frutigen (Bern) and Raron (Valais) with a high-speed train link. It took 8 years to build and was opened to traffic on the 15th June 2007. At full capacity it allows the daily transit of 46 passenger trains at speeds up to 250 km/hr plus 60 merchandise trains at speeds of 150 km/hr. The option exists for further capacity increase with the eventual building of the postponed double-tunnel.

Challenges

The main challenges of this tunnel project were: decision to build, financing, geological uncertainties and cost management.

Decision to build

The question whether the building of the Lötschberg Base Tunnel in addition to and coincident with that of the Gotthard Base Tunnel was justified was fiercely debated prior to the decisive popular vote of 1992. Opponents criticised the limited efficiency of the Lötschberg transit axis and the high cost of simultaneously realising both projects. The main supporting argument was that of time: the Lötschberg tunnel could be built in considerably less time compared to the Gotthard, thereby allowing a speedy, albeit for the time being only partial realisation of the main objective: to transfer merchandise transit from the road to the rail. With this in mind, the voters in their majority supported the heavy financial consequence of executing both projects in parallel. In hindsight it must be acknowledged, that without the inclusion of the Lötschberg Base tunnel in the first phase of the NEAT project, many voters in western Switzerland would certainly not have given their support. In so far the decision of 1992 includes elements of Swiss federal consensus.
In the face of the ambitious scale of expenditure, the government was anxious to limit the capital expenditure on the Lötschberg axis to the absolutely necessary, without jeopardizing future completion of the full-scale double-tunnel. As a consequence, the presently realised base tunnel is a single-tube system. Eventual completion of the double-tunnel can technically be realised without interfering with continuous train operations.

Financing

The financing of the NEAT base tunnels was another main challenge. Conscious of the fact, that the financing of major construction works over a period of some 20 years had to be dealt with outside the annual expenditure

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budgets, the Government proposed a separate transport infrastructure fund of 30 Million CHF to cover the requirements for the NEAT base tunnels (Gotthard, Ceneri and Lötschberg) and other related projects. This fund was to be alimented by a new countrywide merchandise road tax (LSVA), a share of hydrocarbon import duties and a small fraction of VAT income. The idea of additional financing through public debt was originally considered but soon dropped in recognition of the fact that the project could not qualify as a commercial enterprise. The capital expenditure bulge exceeding the fund income during the construction period was to be dealt with by loans out of government's general finance. The proposal was deemed to secure the financing of the long-term construction projects independent of political shifts and annual budget variances. However, it was formally opposed and therefore submitted to a National referendum. The majority supported the government proposal in 1998, thereby clearing the way for the start of construction work.

Geological uncertainties

The main geological uncertainties as presented in the prognosis (fig. 1) were:

1. Extent of karst development with massive water influx under pressures up to 50 bar in the carbonates of the Helvetic nappes (Wildhorn- and Doldenhorn nappes).
2. Extent of high permeability and consequent massive water influx under high pressure in the Triassic dolomites underlying the Doldenhorn nappe.
3. Potential of high permeability and consequent massive water influx in the carbonate imbrication (Jungfraukeil) within the Aare massif. Potential for communication with the commercially exploited sources of Leukerbad.
4. Potential of heaving shales and formation instability in the Flysch at the base of the Wildhorn nappe and in the autochthonous Triassic both underlying the Doldenhorn nappe and overlying the Aare massif in the Valais.
5. Potential for heaving shales and formation instability in the Carboniferous imbrications within the Aare massif (below Ferden and Dornbach).
6. Potential for spontaneous rock blast in the massive gneisses and granites of the Aare massif.
7. Extent of sulphate concentration in the formation water throughout the tunnel section.
8. Formation boundaries particularly within the strongly folded Helvetic carbonate and Flysch series and within the Central Aare granite.

In hindsight the geological prognosis can be qualified as highly professional and of good quality (fig. 1). The hazards encountered were with notable exception within the quantified range of expectation and the planned measures were adequate and effective. Additionally, it was good fortune that the most significant hazard, the interference of karst cavities with water under high pressure was encountered only at one point at the front of the Doldenhorn Nappe. The injection work went successfully as planned. The only notable geological surprise with consequence was the occurrence of a massive tectonic imbrication of Carboniferous coaly shales and sandstones together with a repetition of the typical Triassic series within the Aare massif under the Doldenhorn nappe.

Cost management

The final cost of the Lötschberg Base Tunnel amounts to 4.247 Billion CHF, roughly 30% above the original reference of 3.214 Billion CHF. By far the most important factors are related to change orders in connection with improvement of safety and environmental/social standards. This must be seen in the context of national and international experience over a period of almost 10 years between project development and execution. The cost increase related to geological aspects amounts to 244 Mio CHF, i.e. 7.5% of the original reference. This also includes cost increases due to «optimistic project planning» related to geological hazards that were found as prognosed. The case history of the Lötschberg Base Tunnel therefore gives an example for good planning in a complex geological environment.

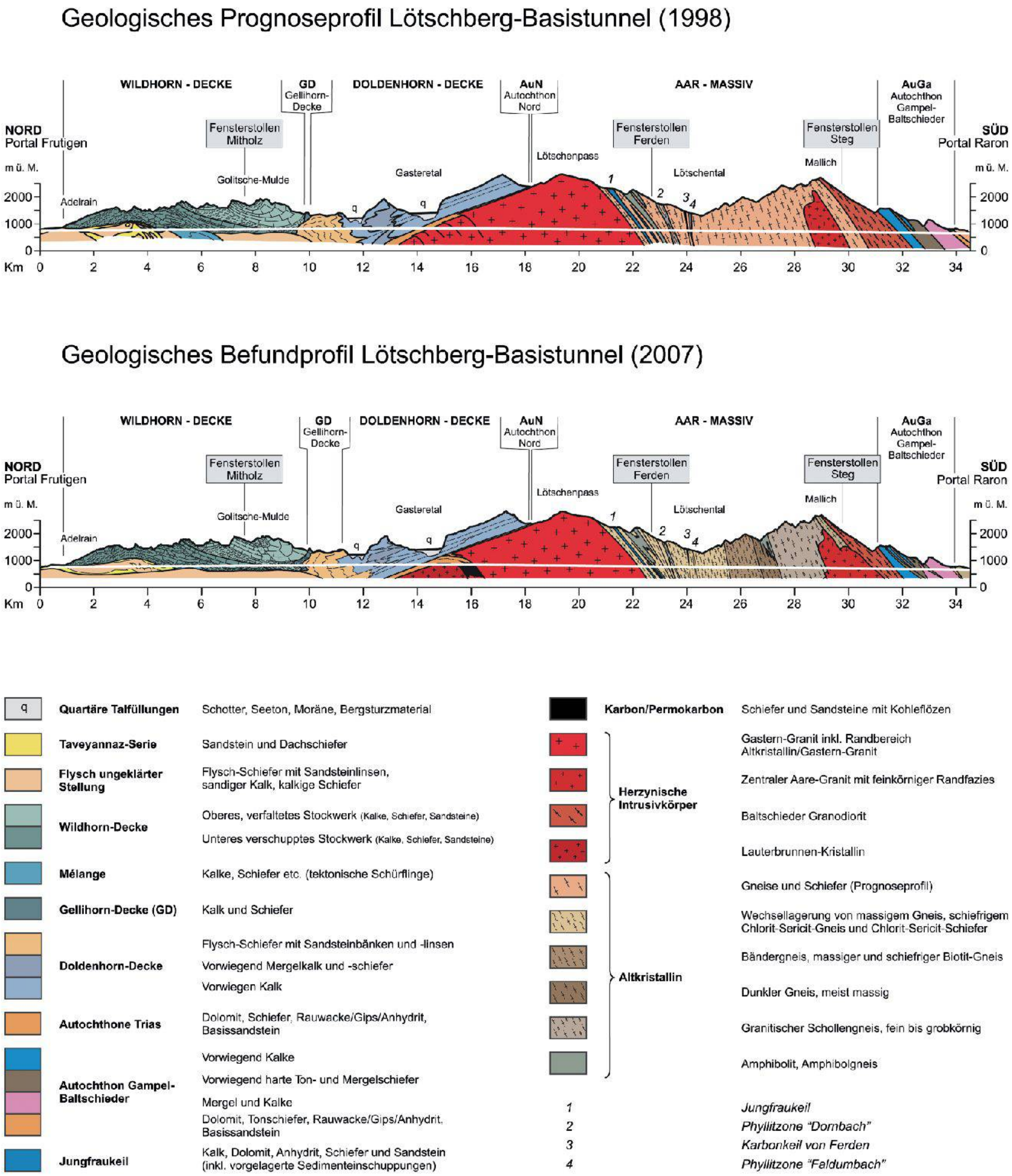

Fig. 1: Simplified longitudinal section of the Lötschberg Base Tunnel, prognosis (1998) vs. finding (2007); kindly provided by Kellerhals + Haefeli AG.

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