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Field trips 7, 14, 15

Brenner Base Tunnel

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1 Topics and highlights of Exkursion

The Brenner Base Tunnel is a railway tunnel that runs from Innsbruck (Austria) to Fortezza (Italy) through the Alps. It is the main element of the new Brenner railway from Munich to Verona. With a length of 64 km, it is the longest underground railway connection in the world.

The construction lot at Tulfes-Pfons includes 38 km of tunnel excavation work and consists of several structures. Nine excavations are currently in construction, and most of them are excavated by blasting. The construction lot also includes the construction of the exploratory tunnel with an open gripper tunnel boring machine. The construction lot at Wolf includes not only the work on the four-kilometre access tunnel Wolf with a cross-section of 120 m^2, excavated by blasting, but also a series of logistics and safety works (e.g. bulk tunnel, caverns, hydraulic structures) and the construction of the disposal site in the Padaster valley: The Padaster valley, a side valley of the Wipp valley, will be filled in with nearly 8 million m^3 excavation material and with a maximum filling height of about 78 meters. To deposit excavated material over the whole valley a number of measures were necessary. Therefore a 1,500-meter-long diversion tunnel was built for the Padaster brook and during the main disposal phase the brook will flow through this diversion tunnel.

South of the Wolf construction lot, in the area of the Natura 2000 region in the Vals valley, the Brenner Base Tunnel has to cross the Hochstegen marble which is known from hydrogeological testing in deep boreholes to be permeable even in large depths. Different studies have been carried out to identify the potential impact area affected by the construction of a drained tunnel. A main question is the hydrogeological behaviour of a regional fault zone which divides the Hochstegen marble in two compartments. The hydrogeological connection between the two sections is of major interest.

2 Brenner Base Tunnel – The Project

2.1 Corridor SCAN-MED – from Finland to Malta

In the early Nineties, the European Commission established the concept of the Trans-European Networks (TEN) for transport, energy and telecommunications. Up until now, the Brenner Base Corridor had been the central part of the high-velocity railway axis between Berlin and Palermo. In December of 2013, the European Union updated the Trans-European Transport Networks and defined nine priority corridors. Among these corridors, the Brenner Base Tunnel (BBT), being a cross-border project, is especially important and is therefore 40% financed by the European Union. The North-South axis with the BBT has been assigned to the SCAN-MED Corridor (Scandinavia – Mediterranean Corridor, see Fig. 1). This corridor is extremely important for the European economy, as it links urban centers in Germany and Italy with port cities in Scandinavia and along the Mediterranean. It is also the longest corridor in the new TEN.

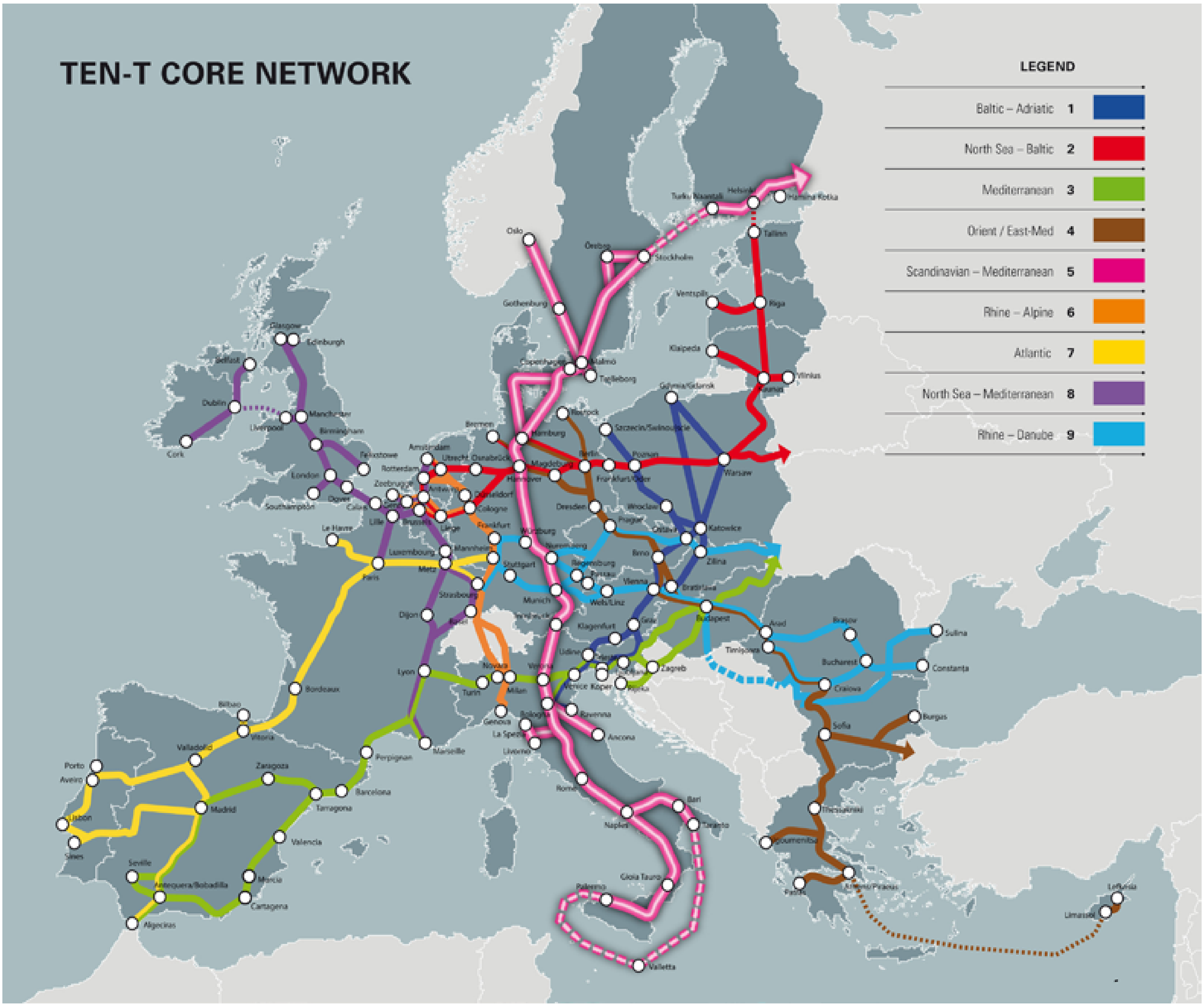

Fig. 1: European Union TEN Core Corridors. They link the most important seaports in Europe with railway infrastructure. The North-South axis with the BBT has been assigned to the SCAN-MED Corridor.

2.2 The tunnel system – Basic data

The BBT runs for 64 km between Tulfes/Innsbruck (Austria) and Fortezza (Italy), making it the longest underground railway stretch in the world (see Table 1 and Fig. 2). The BBT ends in Innsbruck in the existing railway bypass tunnel, which ends in Tulfes near Innsbruck. A new rescue tunnel is being built running parallel to the bypass. The two-tube tunnel system between Innsbruck and Fortezza is 55 km long. The BBT consists of an exploratory tunnel, two main tunnel tubes and four lateral access tunnels, located in Ampass, in Ahrental and in Wolf near Steinach am Brenner in Austria, and in Mules in Italy. The four lateral access tunnels connect the tunnel tubes to the surface. During the construction phase, they are used for logistics and to move the spoil via the access tunnels to the disposal sites. At the same time, all material deliveries for the construction of the tunnel (concrete, iron, tubbing) come in through the access tunnels.

Key data

length of the Brenner Base Tunnel mouth at Tulfes to the mouth at Fortezza	64 km	**emergency stops** (Innsbruck, St. Jodok, Trens)	3
length of the Brenner Base Tunnel mouth at Innsbruck to the mouth at Fortezza	55 km	**excavation material**	17 million m³
maximum overburden	1800 m	**excavation methods**	30 % by blasting 70 % by TBM
inner diameter of the main tunnel	8.1 m	**railway traction power supply**	25 kV 50 Hz
longitudinal gradient	4.0 ‰ - 6.7 ‰	**train control system**	ETCS Level 2
design speed for freight	120 - 160 km/h	**planned date of completion**	2025
design speed for passenger transport	250 km/h	**planned opening**	2026

Table 1: Basic data of the BBT.

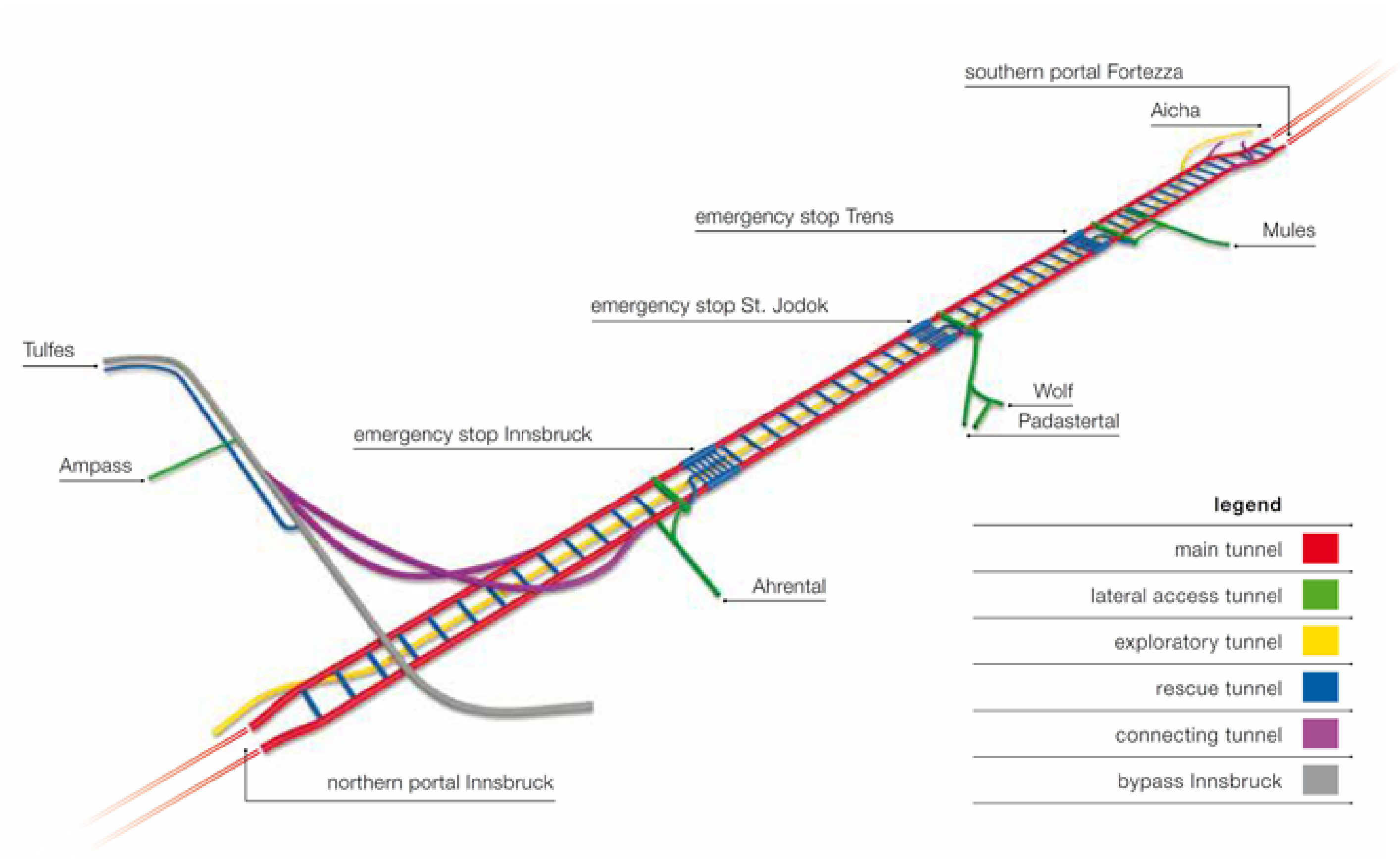

Fig. 2: The tunnel system and the lateral access tunnels in Ampass, Ahrental, Wolf and Mules.

Between Innsbruck and Fortezza two single-track main tunnels are planned at a distance of 40 to 70 meters from each other (see Fig. 3). Smaller tunnels connecting the two main tubes are located every 333 m. They are used for logistics but also for emergency rescue. One special feature is the continuous exploratory tunnel, which is located centrally twelve metres below the two main tunnels. The exploratory tunnel is meant for geological prospection, as a service and logistics tunnel during the construction phase and as a maintenance and drainage tunnel during the operational phase. Overall, the proposed tunnel system of the BBT is comprised of approximately 230 kilometres of tunnels.

3 The Wolf construction lot (Field trips 7 and 14; Ulrich Burger, Georg Orsi)

3.1 The construction site at Wolf

The four-kilometre access tunnel Wolf (Fig. 4) with a cross-section of 120 m², excavated by blasting, will end south of St. Jodok (Vals valley). From there the two main tunnels will excavated in northern and in southern direction. The approximately 1 km long Saxener tunnel was built for the construction site in Wolf, which is located near Steinach am Brenner. All site traffic exits the A13 Brenner motorway at the road maintenance depot and passes through the Saxener tunnel directly

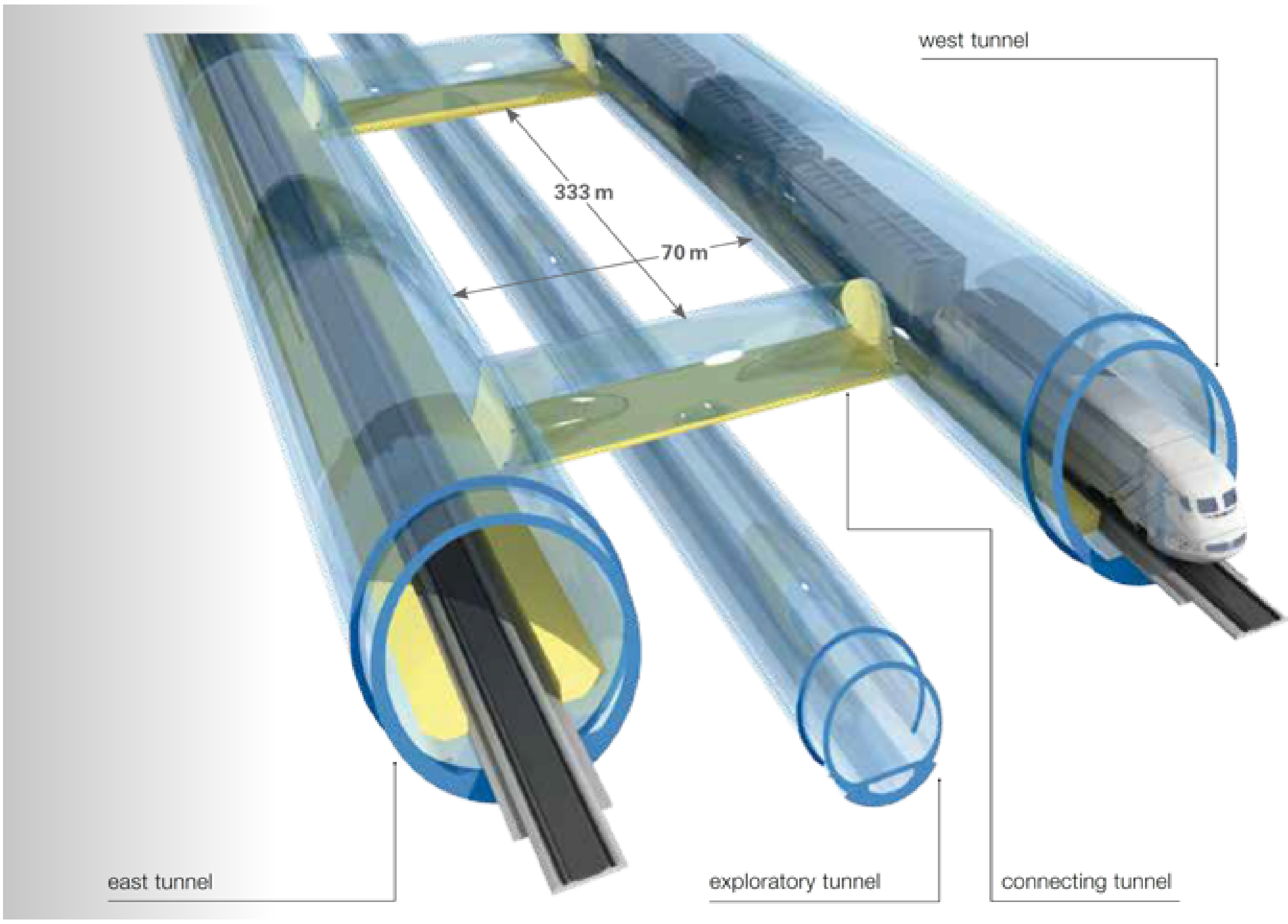

Fig. 3: The tunnel system with the exploratory tunnel , the two single-track main tunnels and the smaller tunnels connecting the two main tubes every 333 m.

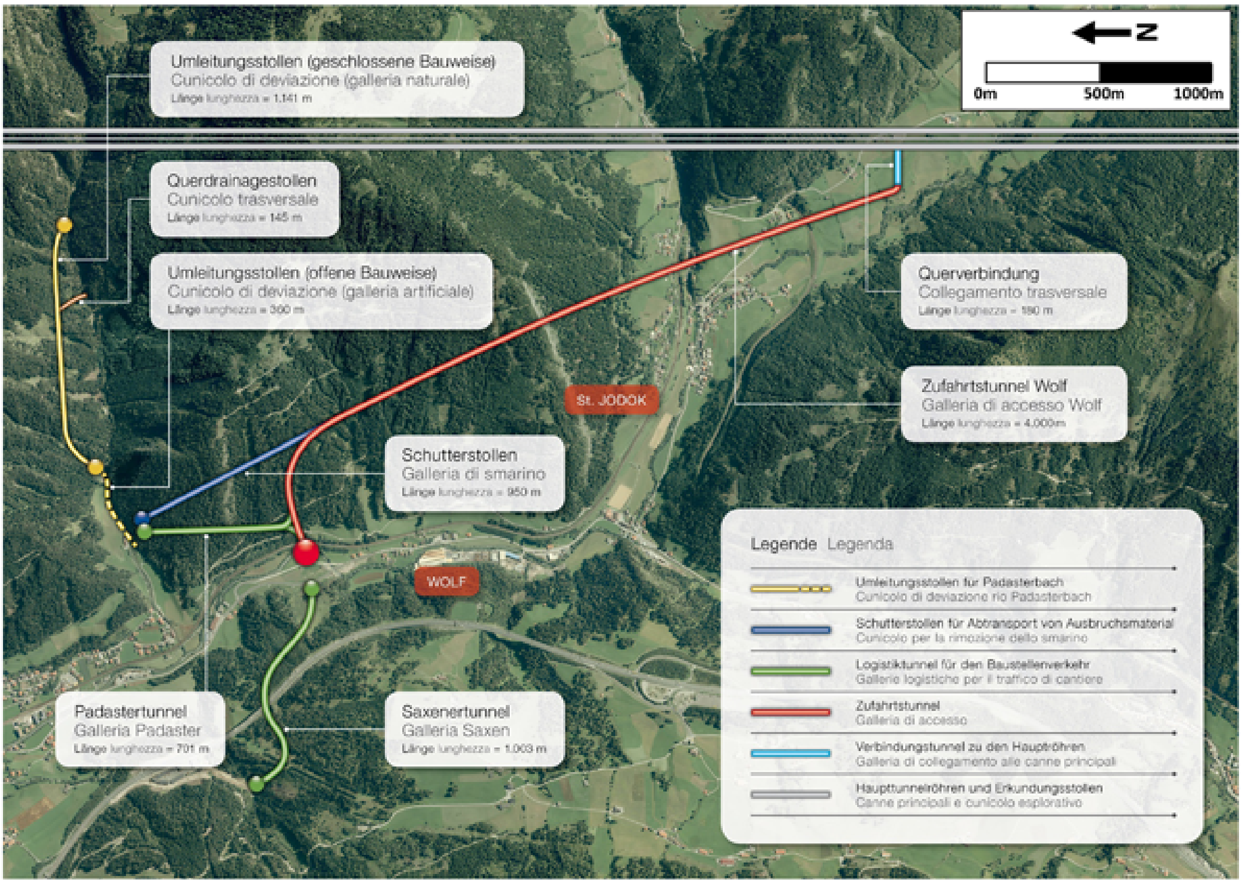

Fig. 4: The construction site at Wolf: Brenner base tunnel (white), access tunnel Wolf (red), Padaster tunnel and Saxener tunnel (green), bulk tunnel (blue) diversion tunnel -closed construction (yellow), diversion tunnel -open construction (yellow dotted), main tunnels (grey).

to the construction lot Wolf. The 700-meter-long Padaster tunnel, was built to reach the disposal site without having to pass through inhabited areas. To enable direct removal of excavated material to the disposal site during the main phases of construction, an additional 950-meter-long bulk tunnel was excavated. Conveyors bring material directly from the excavation to the disposal site through this bulk tunnel.

3.2 Padaster valley disposal site

During the construction of the BBT, on the Austrian project side about 12 million m^3 of tunnel excavation material have to be disposed of in landfills, since this material cannot be used as aggregate. Therefore, the Padaster valley, an eastern tributary of the Wipp valley, will be filled with excavated material up to a maximum height of 78 meters above ground level.

In the beginning the excavated material was deposited on the flanks of the valley. As long as the Padaster brook was flowing through the valley, the disposal could not be completely filled, and a number of measures were necessary. Therefore a 1,500-meter-long diversion tunnel (Fig. 4) was built for the Padaster brook and during the main disposal phase the brook will flow through this diversion tunnel (Fig. 5). In addition a large boulder barrier erected upstream of the tunnel and a large debris retention basin erected downstream of the tunnel were build. These structures protect the disposal site and the village of Siegreith from flooding and mudslides. After completion of disposing the excavated material, the newly formed valley floor will be fully rejuvenated (Fig. 6a and Fig. 6b). A new, near-natural river course, pasture management, ecological compensation areas and a woodland path will be created.

Fig. 5: Overview of the Padaster valley (Status 09/2015): the depositing of excavated material in the main disposal phase is in progress.

Fig. 6: Overview of the Padaster valley. a) Current view of the Padaster valley and of the village of Siegreith: The construction (bulk tunnel, diversion tunnel) is completed; the depositing of excavated material is in progress. b) After the deposition of excavated material is completed the Padaster valley will be fully recultivated (reforestation, new stream course, ecological compensation areas, etc.).

4 The hydrogeological risk analysis for the Natura 2000 area in the Vals valley (Field trip 14; Roland Arnold, Ulrich Burger)

4.1 Vals valley

The BBT has to cross the Hochstegen marble, which is known from hydrogeological testing in deep boreholes to be permeable even in large depths. Different studies have been carried out to identify the potential impact area affected by the construction of a drained tunnel. The hydrogeological monitoring network in the Vals valley (Fig. 7) and in the Venn valley includes deep and shallow groundwater wells, monitoring stations in rivers and springs.

A main question is the hydrogeological behaviour of a regional fault zone which divides the Hochstegen marble in two compartments (Fig. 8). The deeper compartment will be crossed by the deep lying tunnel, the shallow is discharging groundwater to the ecological protected area, to rivers and to springs. The hydrogeological connection between the two is of major interest.

Fig. 7: Overview of the Vals valley (View direction: northwest).

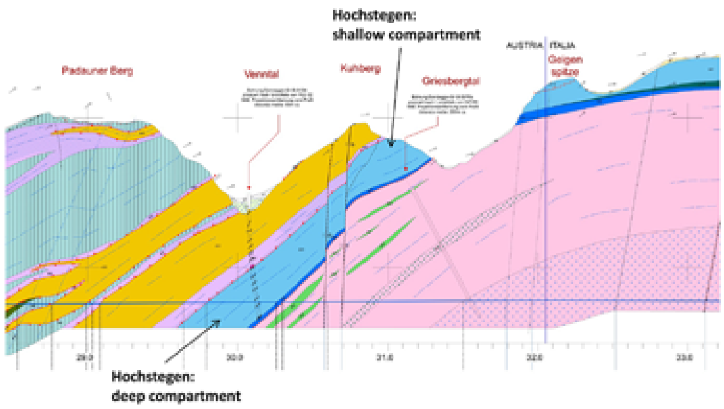

Fig. 8: Geological section showing the Hochstegen marble and its shallow and deep tectonic section.

5 Tulfes-Pfons construction lot (Field trip 15; Andrea Lussu, Heimo Schierl)

5.1 The construction lot at Tulfes-Pfons

The construction lot at Tulfes-Pfons (Fig. 9) includes 38 km of tunnel excavation work and consists of several structures:
- Tulfes emergency tunnel
- Connection Ahrental access tunnel
- Innsbruck emergency stop with central tunnel and ventilation structures
- Main tunnel tubes
- Connecting tunnels
- Ahrental-Pfons exploratory tunnel

The Tulfes emergency tunnel (Fig. 10) is being driven parallel to the existing Innsbruck railway bypass; it will be 9.7 km long and the excavation cross-section is 35 m^2. The drill-and-blast excavation work on this tunnel is in operation from three points at the same time: from Tulfes westwards, from the Ampass access tunnel eastwards and again westwards. The emergency tunnel will be completed in Summer of 2017. The main tubes are being excavated by blasting. This stretch includes 2.2 km of main tunnels with an excavated cross-section of about 70 m^2. The connecting tunnels (Fig. 11) between the main tubes and the existing Innsbruck bypass will be excavated by blasting, with a cross-section of about 115 m^2.

The construction lot also includes the construction of the 15 km stretch of exploratory tunnel between the Ahrental junction point and the

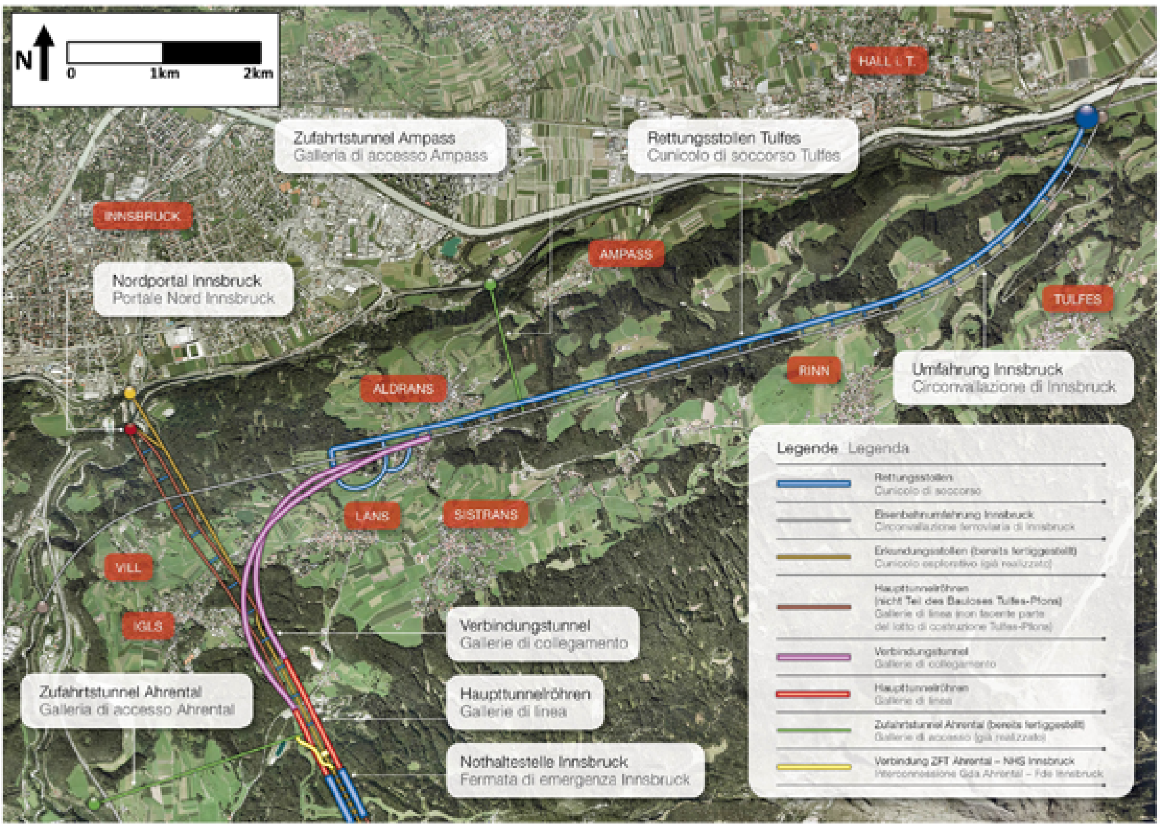

Fig. 9: The construction lot at Tulfes-Pfons: Tulfes emergency tunnel (blue), Connection Ahrental access tunnel (green), Innsbruck emergency stop (blue), Main tunnel tubes (red), Connecting tunnels (violet), Innsbruck bypass (grey), Exploratory Tunnel (outside image area).

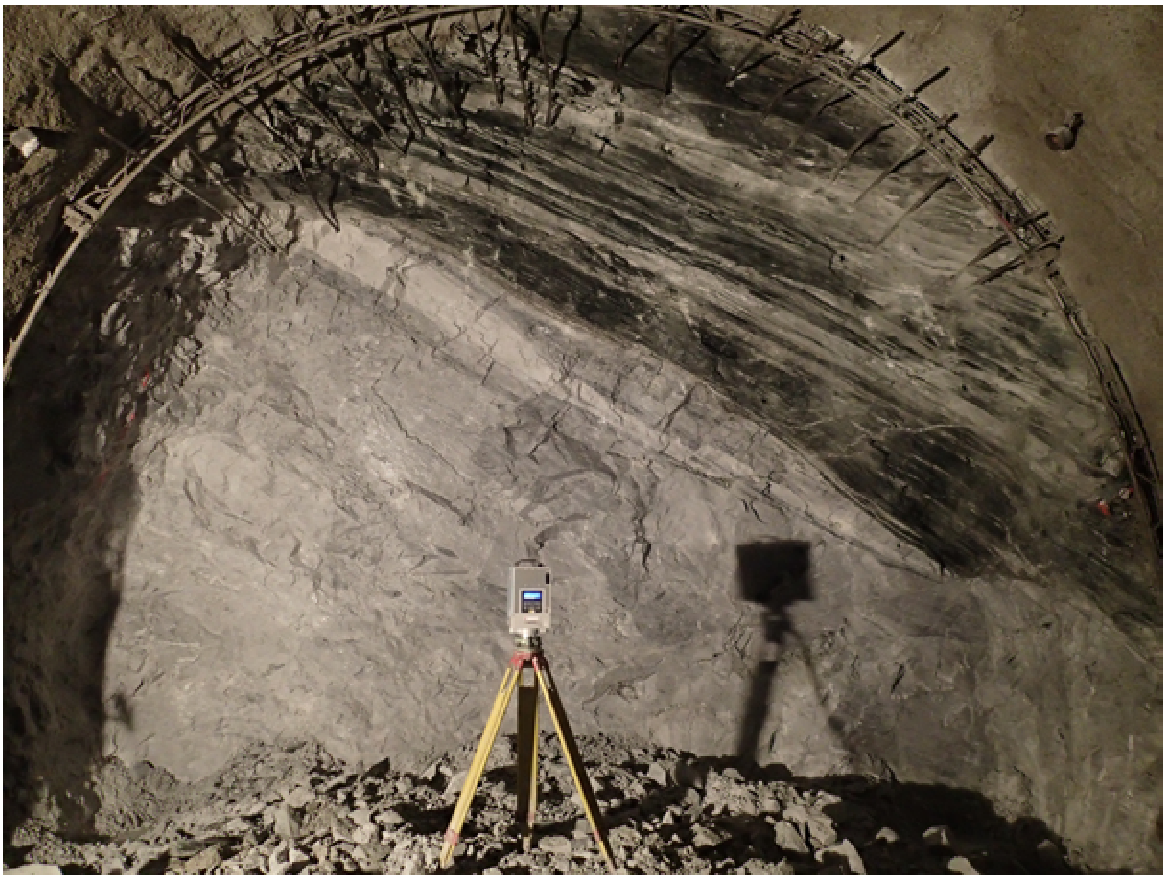

Fig. 10: Tunnel face of the Tulfes emergency tunnel: marble and quartz phyllite.

village of Pfons. The open gripper tunnel boring machine (Fig. 12a and Fig. 12b) with a length of 200 m has started on September 26th, 2015. The machine will excavate 15 km of the exploratory tunnel in south direction.

Fig. 11: Tunnel face of the connecting tunnel: quartz phyllite.

Fig. 12: The tunnel boring machine (TBM). a) The open gripper TBM. Approximately 70 % of the BBT is being built using mechanical excavation. b) The TBM will excavate 15 km of the exploratory tunnel in south direction.