



Photo: Agencia Andina, Peru

Project

- Chavimochic Special Project, Stage III
- Water transfer for irrigation, hydro-power and drinking purposes
- Five tunnels: Restitution (2,600 m), road (590 m), aduction (440 m) discharge (350 m) and shaft (65 m), among other major structures
- Excavation with drill & blast method
- Contractor: Concesionaria Chavimochic S.A.C.

Duration

- 2015 - 2017 (90%)

Task

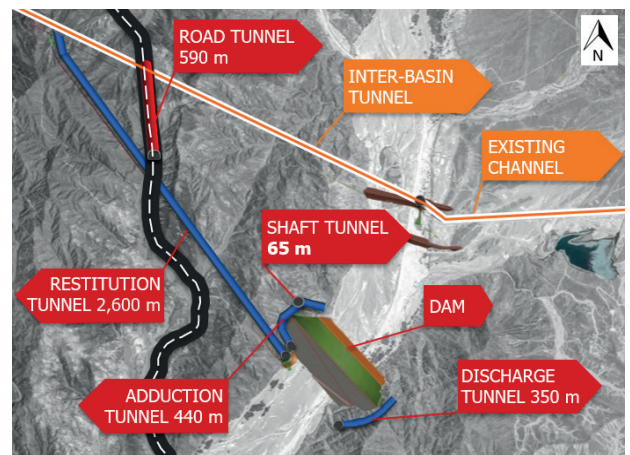
- Geological prediction of 130 m ahead of the tunnel face
- Comparison with mechanical probing

280 km water conveying at the Peruvian Coast

The 3. Stage of the Chavimochic Special Project is based in La Libertad Dept., northern Peru. Its 1. Phase comprises tunnelling works and construction of infrastructures including the Palo Redondo dam. Along with the construction of 130 km channel (2. Phase), it will allow irrigation of more than 160,000 ha of agriculture land.

Stage III aims at providing water for irrigation, power generation and drinking purposes. For this reason, a dam and related structures – including a channel of about 280 km towards the arid valleys near the coast – are being used for diverting water from the River Santa.

Local geology comprises volcano-sedimentary rocks including sandstones, shales and siltstones intruded by andesitic material, and volcanic rocks, mainly represented by andesites. Along the Restitution tunnel, intercalations of slightly altered and fractured andesite and sedimentary rock of moderate quality were found.





«For the planned tunnelling works, the conditions to be faced during excavation were essential for us. They would allow to prepare materials and solutions

needed for possible difficulties timely. Hence, work schedule could be fulfilled and realisation costs controlled. The TSP allowed us to recognise the quality of the rock mass 150 m ahead of the face. By doing about one campaign per month, the excavation cycle was not delayed keeping on time the expected execution schedule. In addition, TSP results were analysed together with other mechanical and geotechnical data to size up explosives charge necessary for each heading blast. The latter aiming at preserving the quality of the natural ground and following the foreseen rock support.»

Helman R. Maldonado Cruzatty
Engineering Manager /
1st Phase Site Engineer
Consorcio Constructor Chavimochic
S.A.C

Challenges

- Limited geological information from surface and uncertainty geological conditions in the Andes region
- Horizontal to sub-horizontal layering at volcano-sedimentary sequences

Products Used

- One TSP 303 Plus system

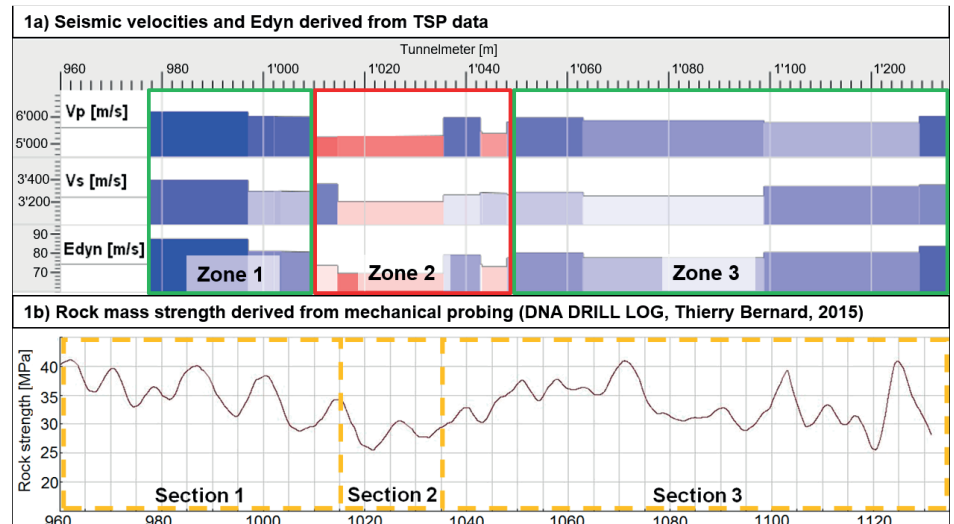
Contact

Amberg Technologies AG
Trodenloostasse 21
8105 Regensdorf-Watt
Switzerland
Phone +41 44 870 92 22
geophysics@amberg.ch
www.amberg.ch/at

TSP results and comparison with mechanical probing

Three seismic zones are identified (Figure 1a): Zone 1, P- & S-wave velocity of $V_p > 6,000$ m/s and $V_s > 3,290$ m/s, respectively, and dynamic Young's Modulus (E_{dyn}) of 87 GPa, indicating high rock stiffness. Zone 2, large decrease in V_p (5,240 m/s), V_s (3,205 m/s) and E_{dyn} (69 GPa) associated to a possible fracture or fault zone. Zone 3, V_p , V_s and E_{dyn} increase to values $> 5,700$ m/s, $> 3,300$ m/s, and ca. 83 GPa, respectively, indicating improving rock conditions.

Rock strength estimated from probe drills show three main sections which are in good agreement with the seismic zones (Figure 1b).

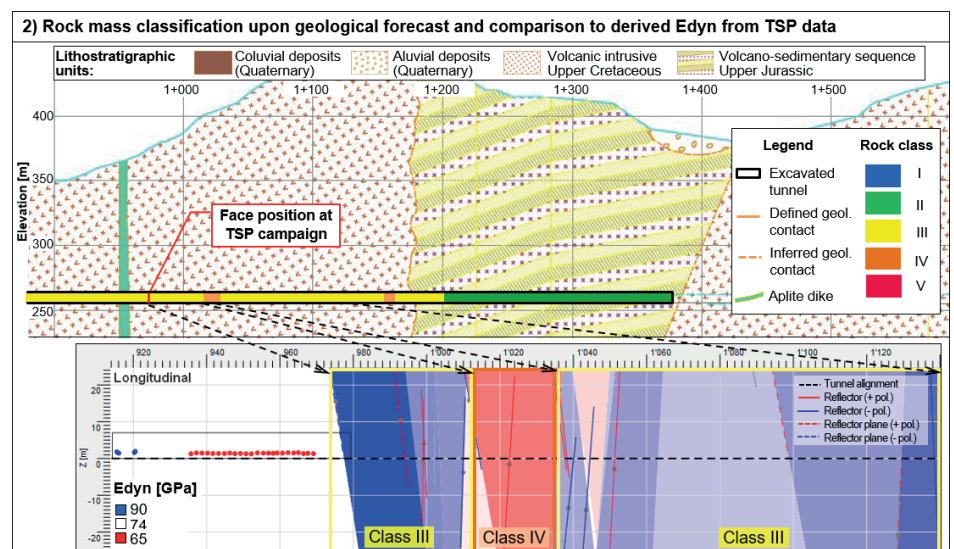


Geological conditions during excavation and results validation

TM 0+960 to 1+015: Alternation of sedimentary and volcanic rock, fractured and moderately altered. Rock strength is moderate. Rock mass Type III.

TM 1+015 to 1+035: Occurrence of unfavourable structures: sedimentary rocks with low angle stratification, unconformable contacts and a subvertical minor fault at the face. High rock weakening at some segments. Rock mass Type IV.

TM 1+035 to 1+135: Alternation of sedimentary and volcanic rocks with moderate alteration and fracturing and moderate rock mass strength. Rock mass Type III. Figure 2 shows the match of defined rock mass classification and seismic zones upon the TSP 2D longitudinal view. Blue/red colouring indicates variation of Edyn for interpreted reflectors.



Conclusion

Seismic results proved TSP 303 as an efficient and reliable prediction tool. Due to the proper identification of unfavourable rock conditions in Zone 2, logistics was prepared in time in order to fulfil special treatment for rock mass stability.