

MILAN TO GENOA HIGH SPEED/CAPACITY RAILWAY: THE ITALIAN SECTION OF THE RHINE-ALPINE CORRIDOR



ACCESS through CRAVASCO adit

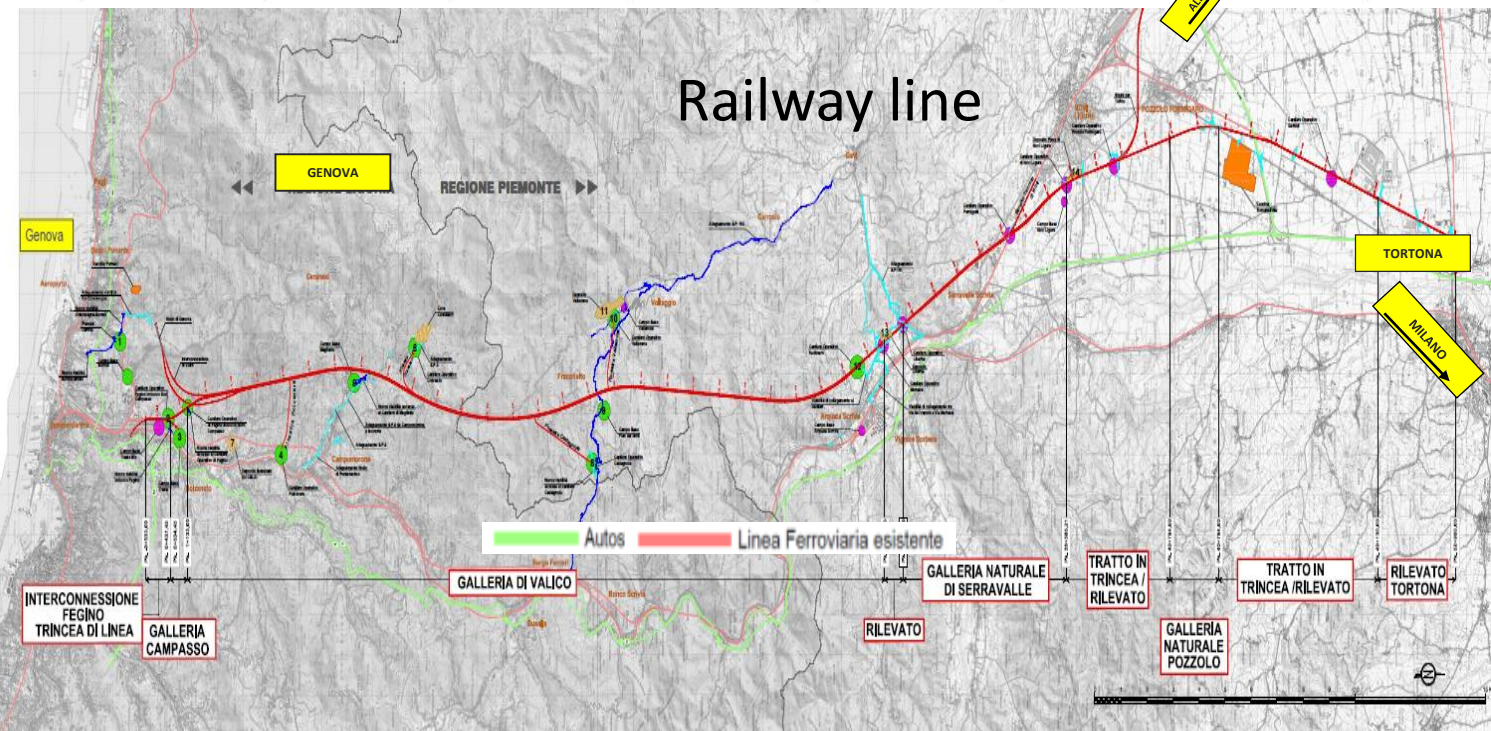
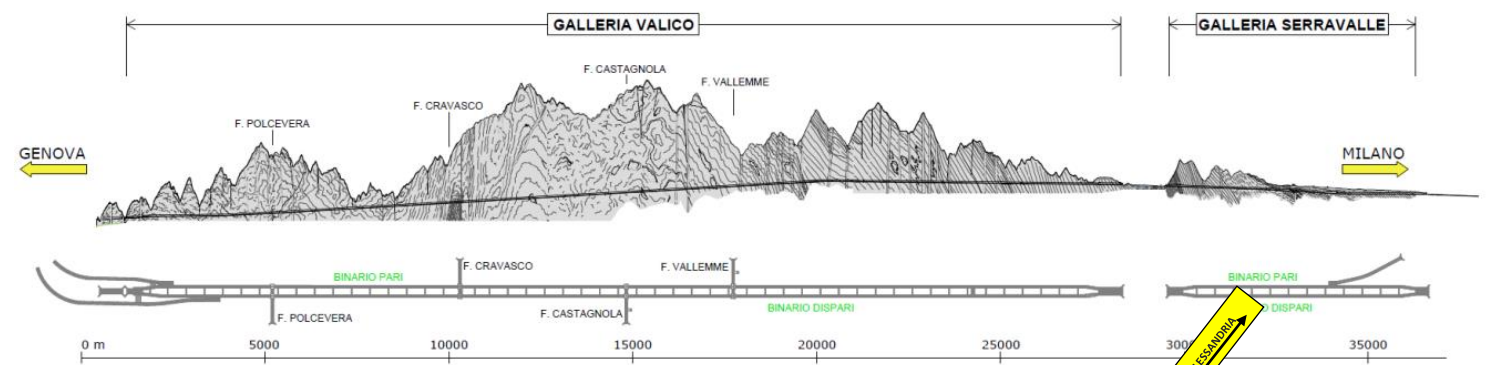


Tunnel Design, Technical
Assistance and Monitoring

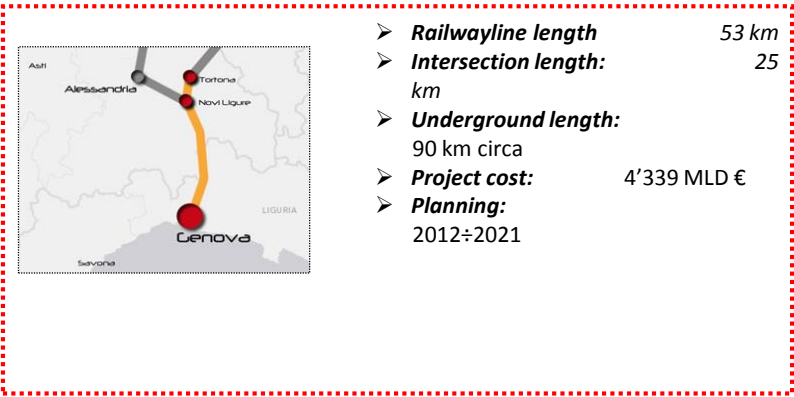


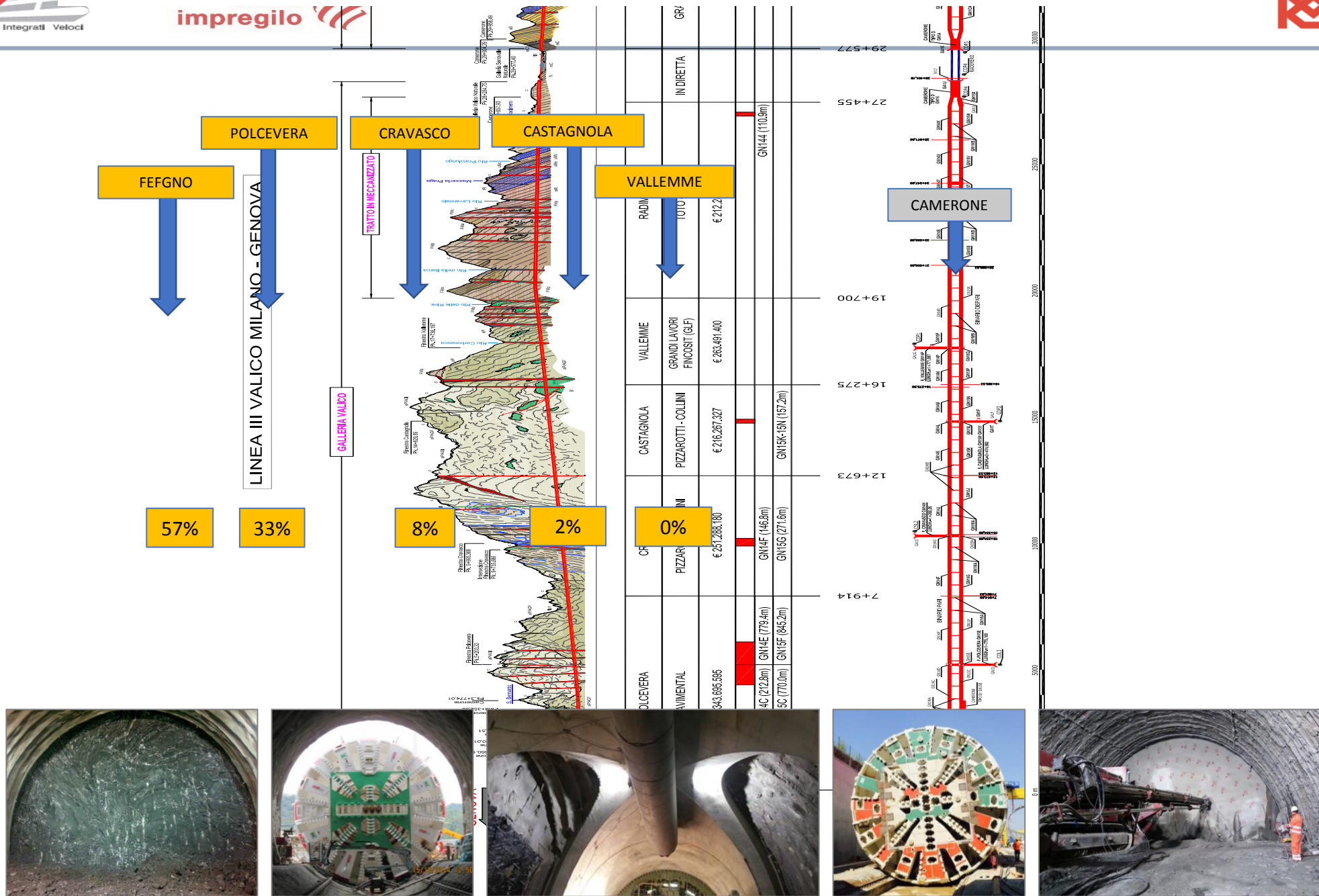
PROJECT OVERVIEW

Railway line - GENERAL DATA



MATERIAL	VOLUME	
Ground excavated	15 million	mc
Concrete	3.5 million	mc
Spritz beton	1.2 million	mc
Concrete aggregate	9.6 million	ton
Steel for concrete reinforcement	160'000	ton
Steel for arches	136'000	ton
Precast segmental lining for TBM	330'000	mc
Asphalt concrete	220'000	mc
VTR for ground Improvement	6'000	km

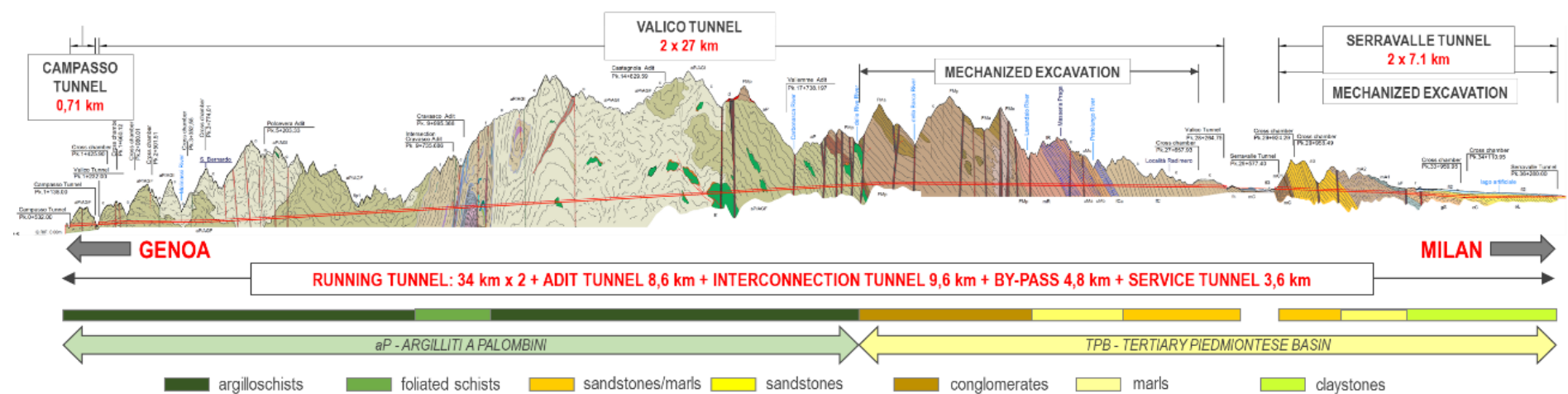




GEOLOGICAL OVERVIEW

- Sestri – Voltaggio Zone (ZVS) is characterized by the “Argille a Palombini” Formation (aP), a sequence of argilloschists, claystones and limestone lenses; between chainage 8+500 and 12+500, rockmass is highly tectonized and squeezing because of tectonic Alpine evolution.
- from chainage 19+500, tunnel stretch crosses Tertiary Piedmontese Basin Units (TPB), a sedimentary sequence constituted by conglomerates, sandstones, marls, claystones.

Terzo Valico dei Giovi – The Geological Condition METAMORPHIC and SEDIMENTARY FORMATION



Argille a Palombini – aP – PK 0+000-19+500

aP - AGI – Claystone schists with limestone lenses («palombini»)
aP- AGF – Claystone schists without limestone lenses («palombini»)

Tertiary Piedmont Basin - TPB

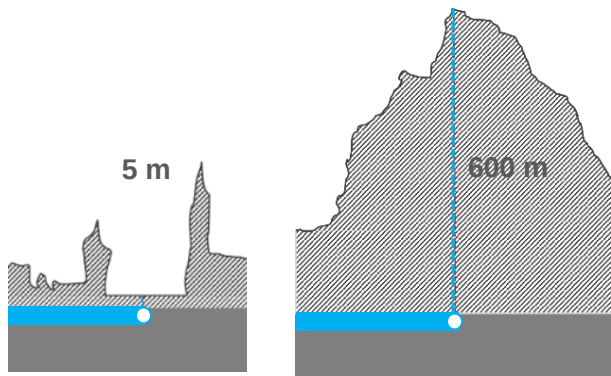
FMA - conglomerates, sandstones, marls
mR – silty marls
fC – marls/sandstoned
mC – Cessole’s marls
aS – Serravalle’s sandstone
aL – Lugagnano’s clay



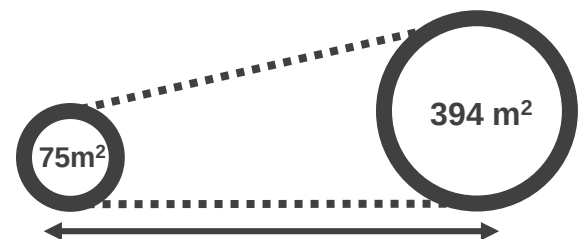
PROJECT OVERVIEW



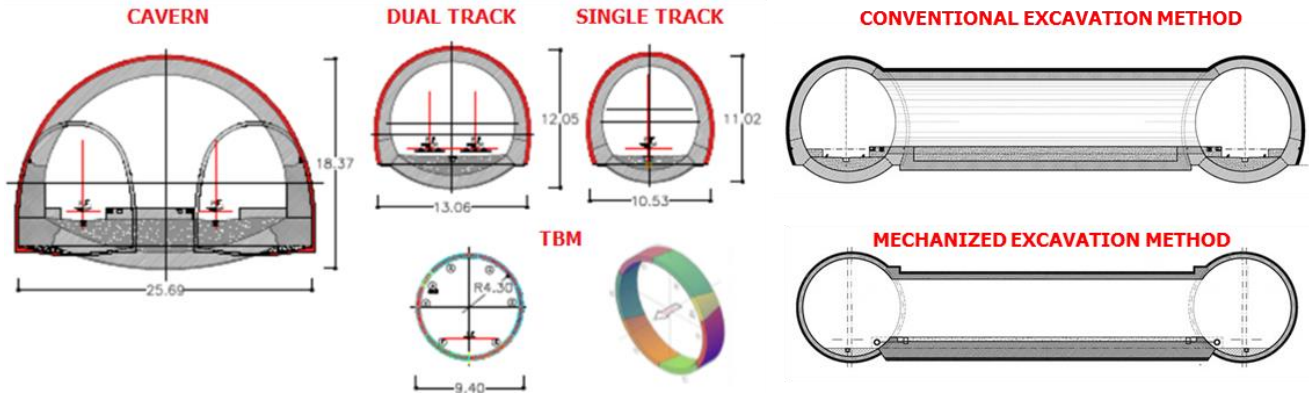
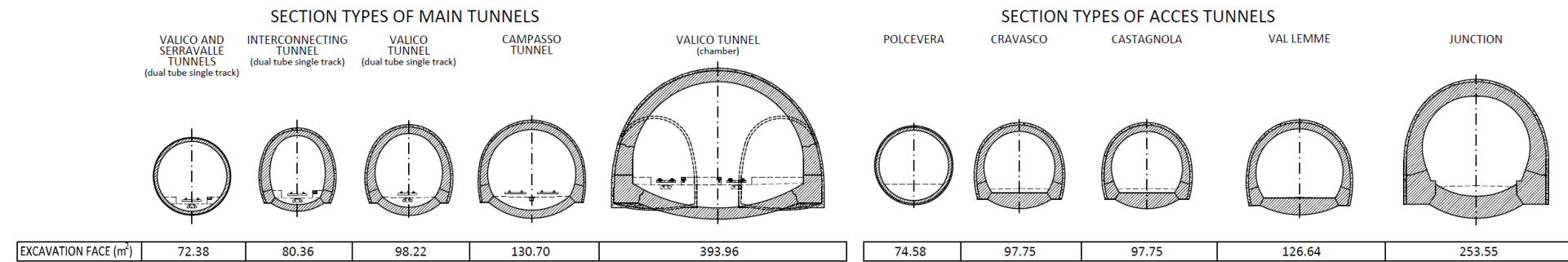
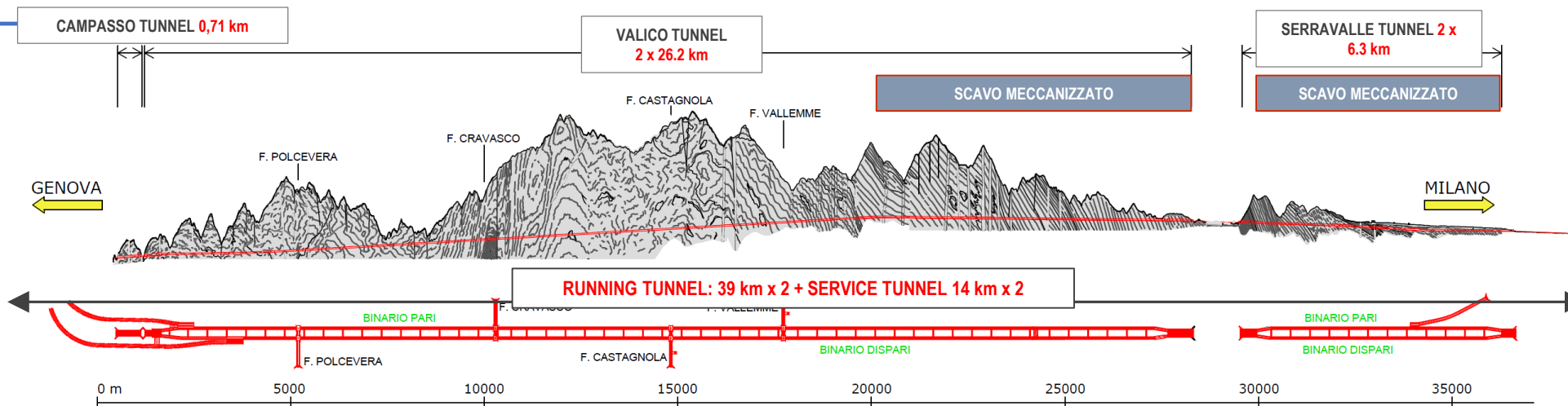
Overburden Range



Excavation Section Range



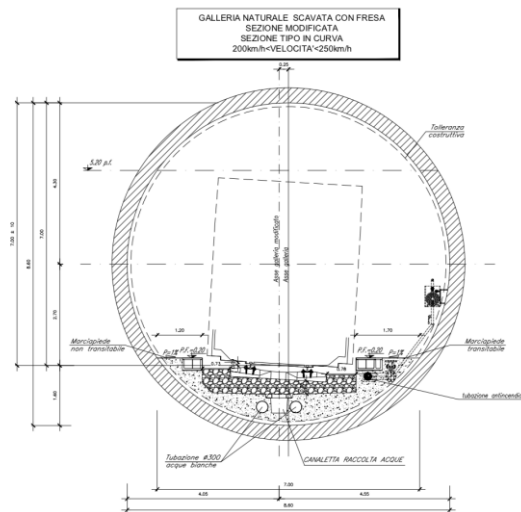
UNDERGROUND WORKS – SECTION TYPES



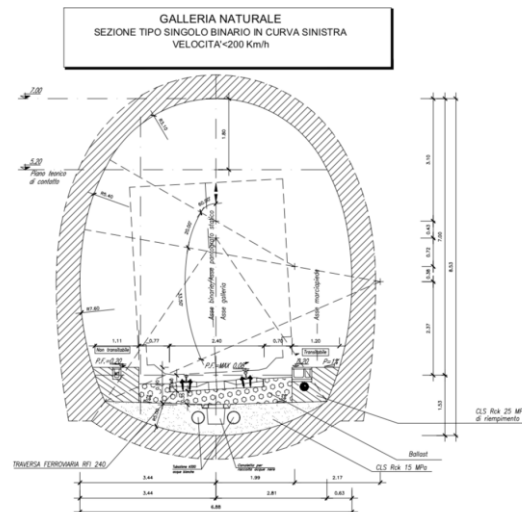
PROJECT OVERVIEW

Sagome interne

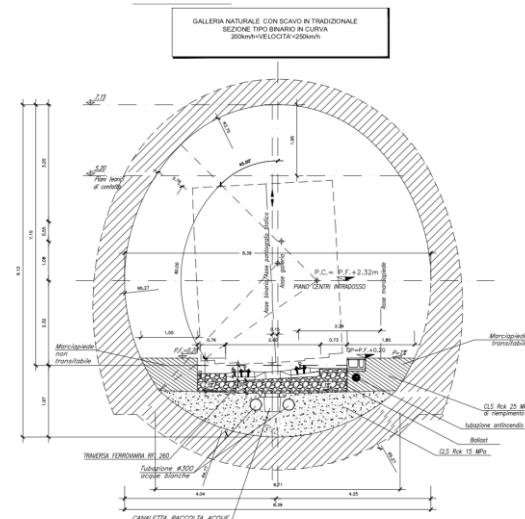
Meccanizzato R_i:4.4m



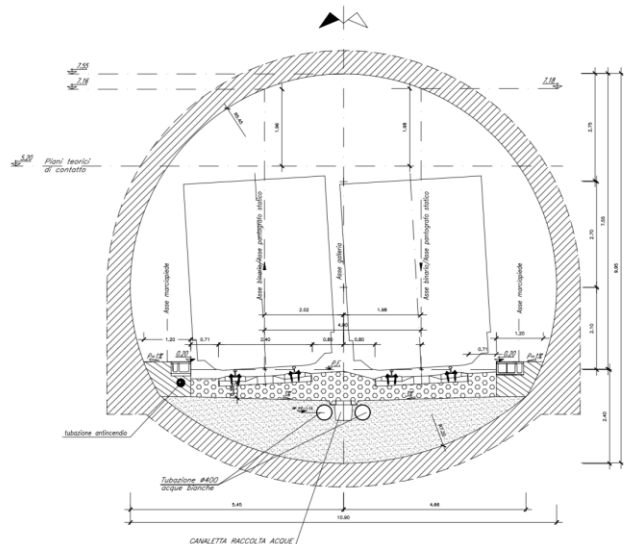
Interconnessioni R_i:3.10m



Galleria di linea monobinario R_i:3.75m



GALLERIA NATURALE
SEZIONE TIPO DOPPIO BINARIO IN CURVA SINISTRA
VELOCITA' < 200 Km/h

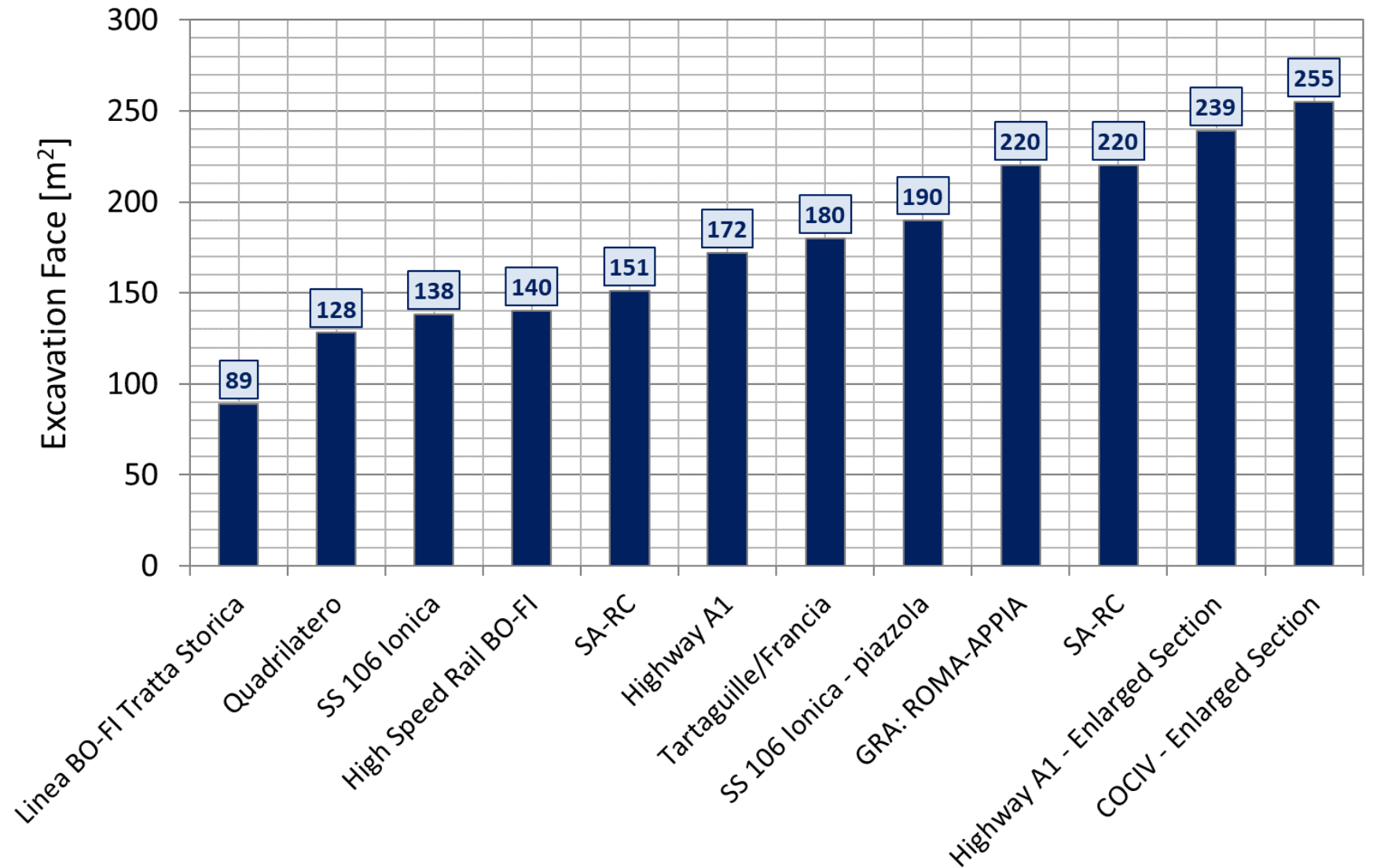


Galleria di Linea doppio binario R_i:5.45m

TUNNEL DESIGN

VALICO TUNNEL New Record Full Face Excavation
255 m²

Conventional Excavation Method



June 2016 Typical Italian Sections Tunnel

*COCIV
VALICO TUNNEL*

*New Record
Full Face
Excavation
255 sqm*



Finestra Cravasco

GENOVA

GALLERIA VALICO

TRATTO IN MECCANIZZATO

MILANO

Sala 15

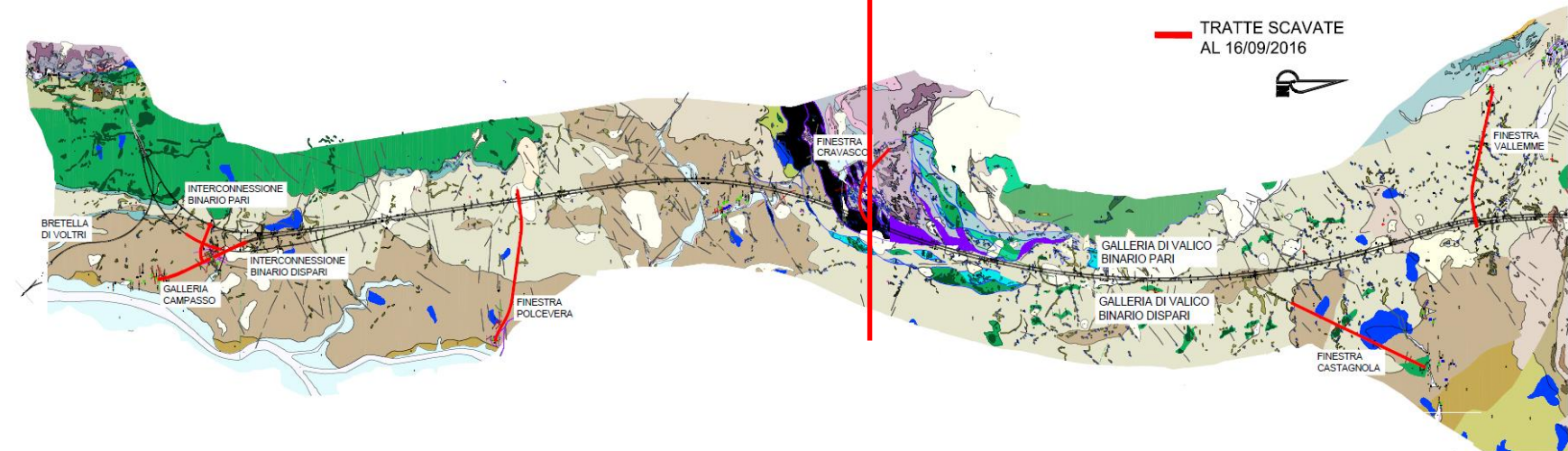
0 REF. 0.00m

ARGILLITI

A PALOMBINI

1+232

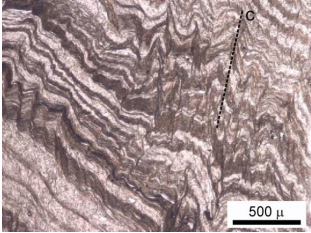
19+700



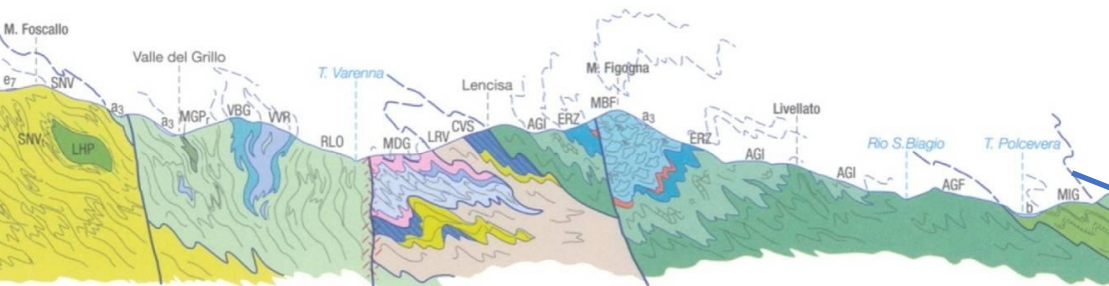
**Geological Layout
Liguria Side**

GEOLOGICAL OVERVIEW

-Ap-
Claystone schists with limestone
lenses («palombini»)



Microscale and Macroscale fold



Geological profile B-B' along the direction WNW-ESE, trough Polcevera Valley and the ridge of M. Figogna (cfr. Capponi et al. 2007).

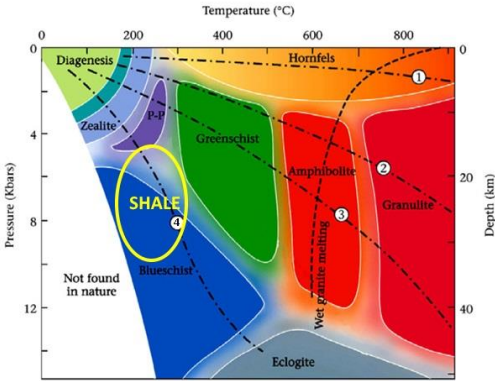
More than 60% of tunnel excavated in aP



SESTRI VOLTAGGIO ZONE



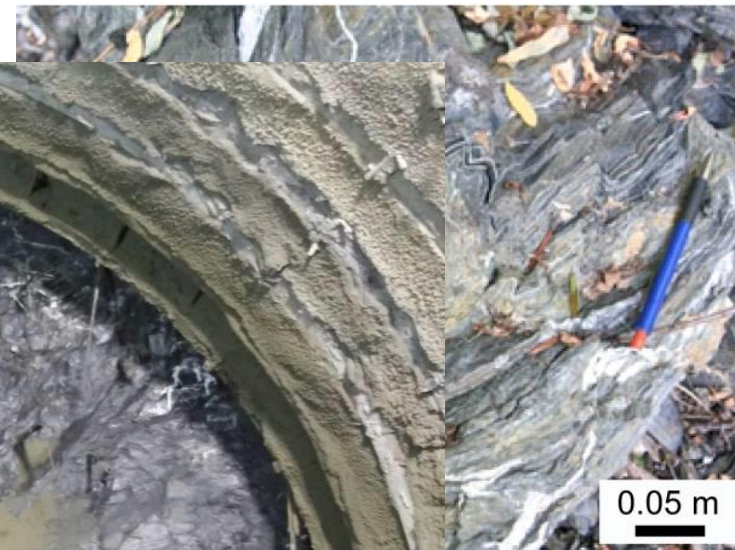
METAMORPHISM DIAGRAM



LE ARGILLITI A PALOMBINI: DALLA MACRO ALLA MICRO SCALA



FRONTE DI SCAVO



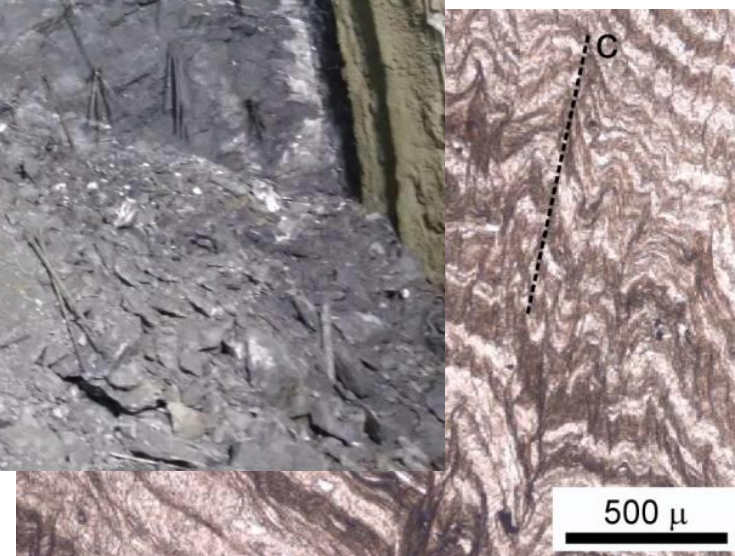
0.05 m

MENTO



PROVINO

FRONTE DI SCAVO



500 μ

VISTA AL MICROSCOPIO

LE ARGILLE A PALOMBINI: LITOFACIES DI COSTAGIUTTA (aP-AGI)

aP – AGI: alternanze di argiloscisti e di calcari cristallini («palombini» di colore grigio in strati di potenza variabile da pochi cm a 1.5 ÷ 2.0 m)
Gli argiloscisti sono di colore grigio scuro con diffuse vene di quarzo e calcite di colore bianco



LA VARIABILITÀ DELLE CONDIZIONI GEOMECCANICHE: SCALA DELL'AMMASSO

Individuazione dei GRUPPI GEOMECCANICI ed elaborazione statistica

- criteri litologici
- criteri strutturali
- criteri lito-meccanici



GRUPPO 1

RQD: >60%
Foliazione: Regolare
Struttura: Non piegata alla microscala
Giunti: Non alterati e asciutti
Palombini > 50%



GRUPPO 2

RQD: 20% - 50%
Foliazione: Regolare e fittamente spaziata
Struttura: Piegata anche alla microscala
Giunti: Da poco a moderatamente alterati
Palombini < 50% fratturati e localmente alterata

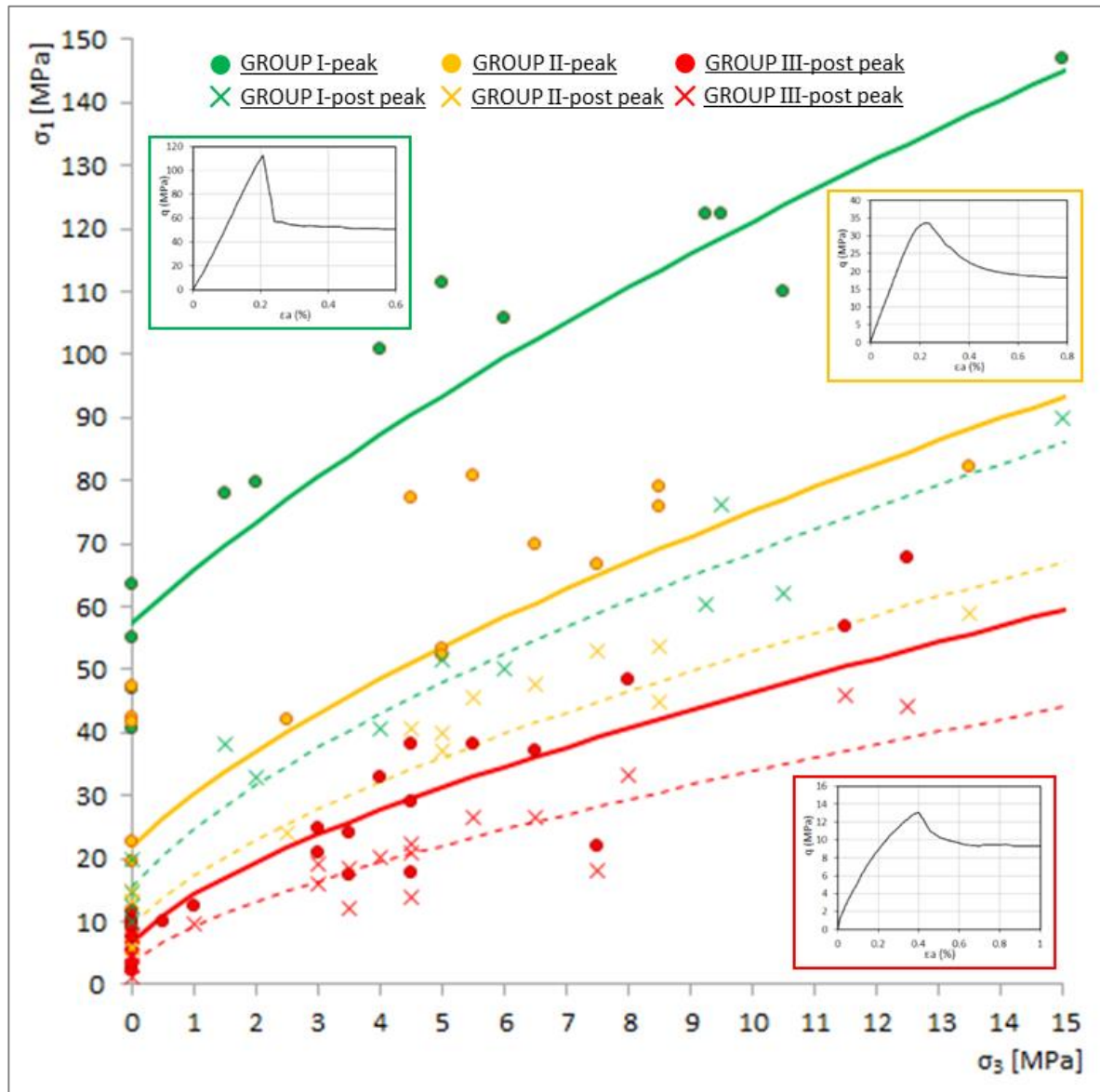


GRUPPO 3

RQD: < 20%
Foliazione: Non riconoscibile o irregolare
Struttura: Intensamente piegata alla microscala
Giunti: Alterati con circolazione idrica
Palombini < 30% fratturati e alterati



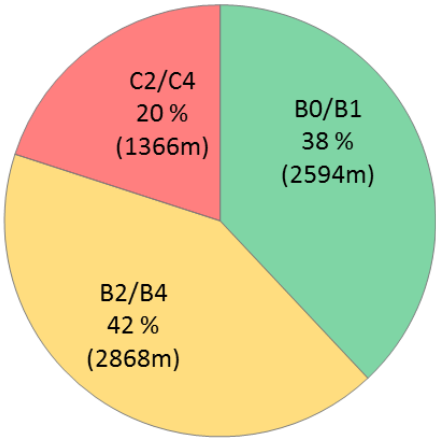
LA VARIABILITÀ DELLE CONDIZIONI GEOMECCANICHE: SCALA DEL PROVINO



LA VARIABILITÀ DELLE CONDIZIONI GEOMECCANICHE: SEZIONI TIPO PREVISTE IN PROGETTO

SECTION TYPE	LONGITUDINAL PROFIL	PRELIMINARY	DEFINITIVE
TYPE B0-1			
TYPE B1			
TYPE B2			
TYPE B4			

Sezioni tipo previste



TYPE C2			
TYPE C4			

Conventional Excavation Method

Guidelines

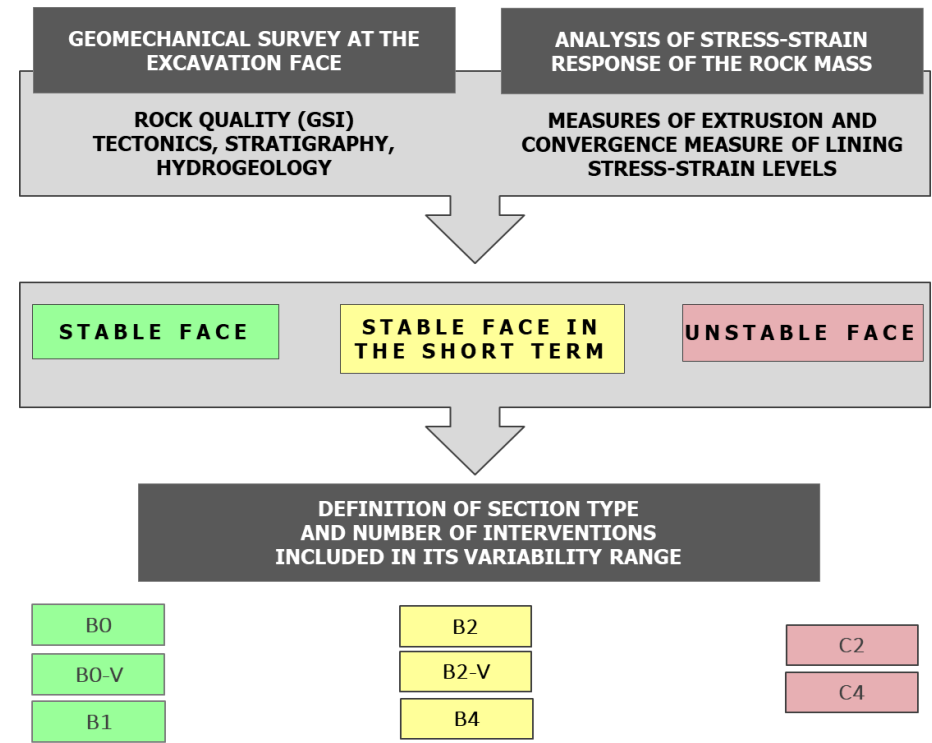
confirm the most applicable section type, selecting it from among those already assigned to a particular tunnel stretch;

define the section type most suitable for the actual geomechanical context, according to the designed variability;

identify a different section type from those assigned to each particular stretch or anyway envisaged in the design for the same formation, in case actual conditions encountered during the excavation differ from those predicted.

TUNNEL DESIGN – GUIDELINES

For each section type, a specific range of application was defined together with a variety of stabilization interventions assigned to it. In this way each section type, without changing the final structural characteristics of the tunnel, can fit to actual geomechanical conditions, the rock mass hydrogeological properties, tunnel face extrusion pattern and cavity deformation type.



SEZIONE TIPO	PROFILO LONGITUDINALE	RIVESTIMENTO DI PRIMA FASE	RIVESTIMENTO DEFINITIVO
B0-1			
B1			
B2			
B4			
C2			
C4			

Legenda

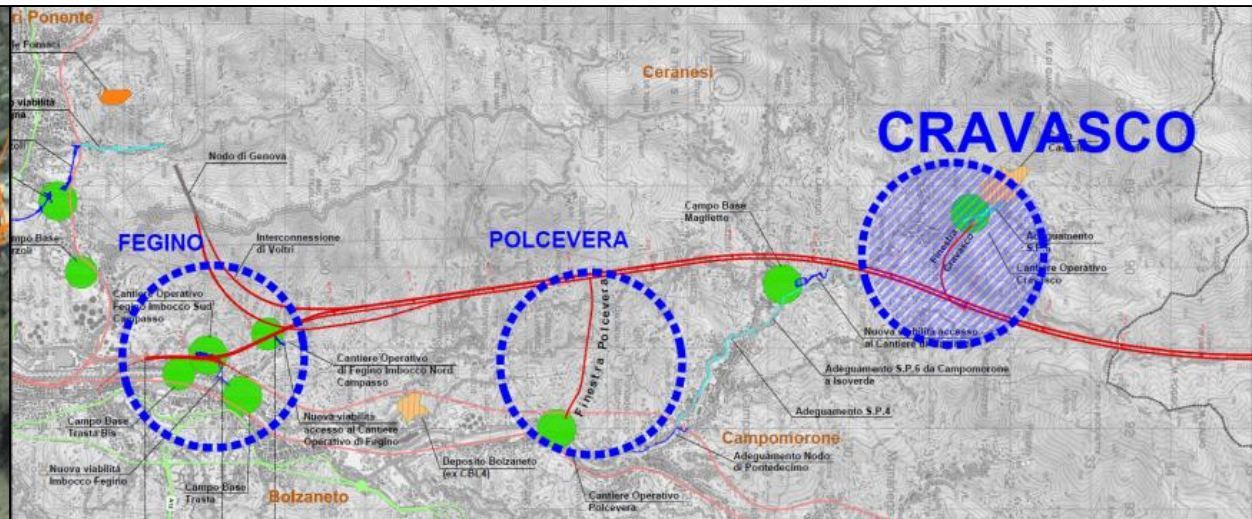
- Linea AV Terzo Valico
- Viabilità di accesso ai Cantieri
- Cantieri
- Opere



CLS2-Cantiere Operativo
Cravasco

GN14.H-Finestra Cravasco

GENOVA



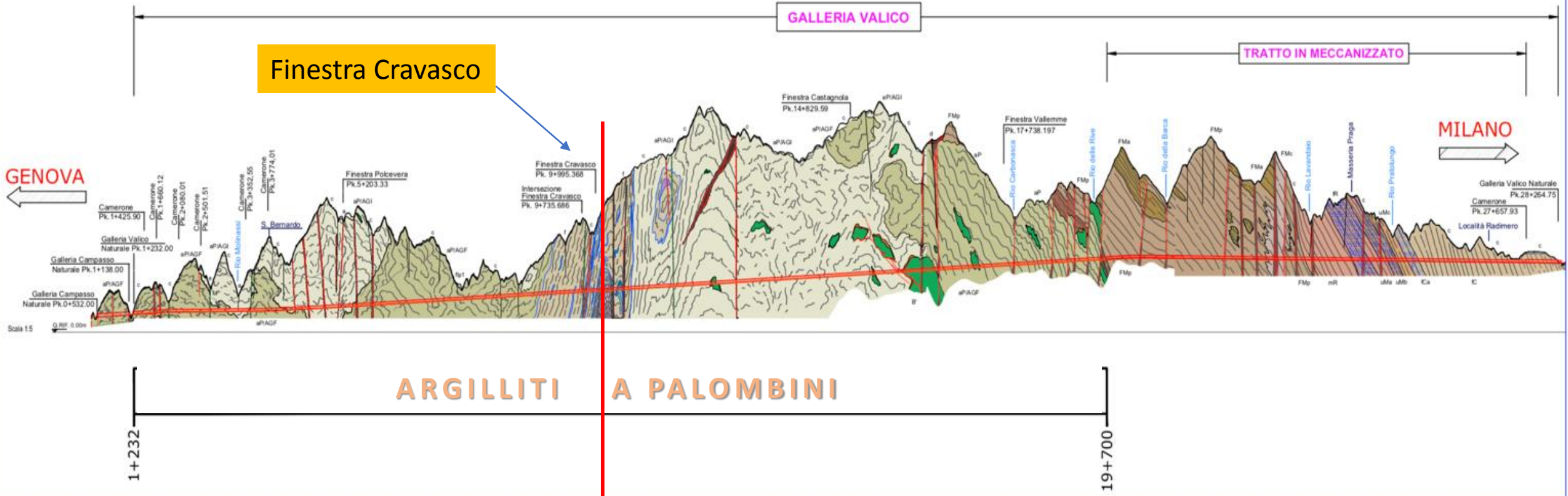
Finestra Cravasco

GENOVA

GALLERIA VALICO

TRATTO IN MECCANIZZATO

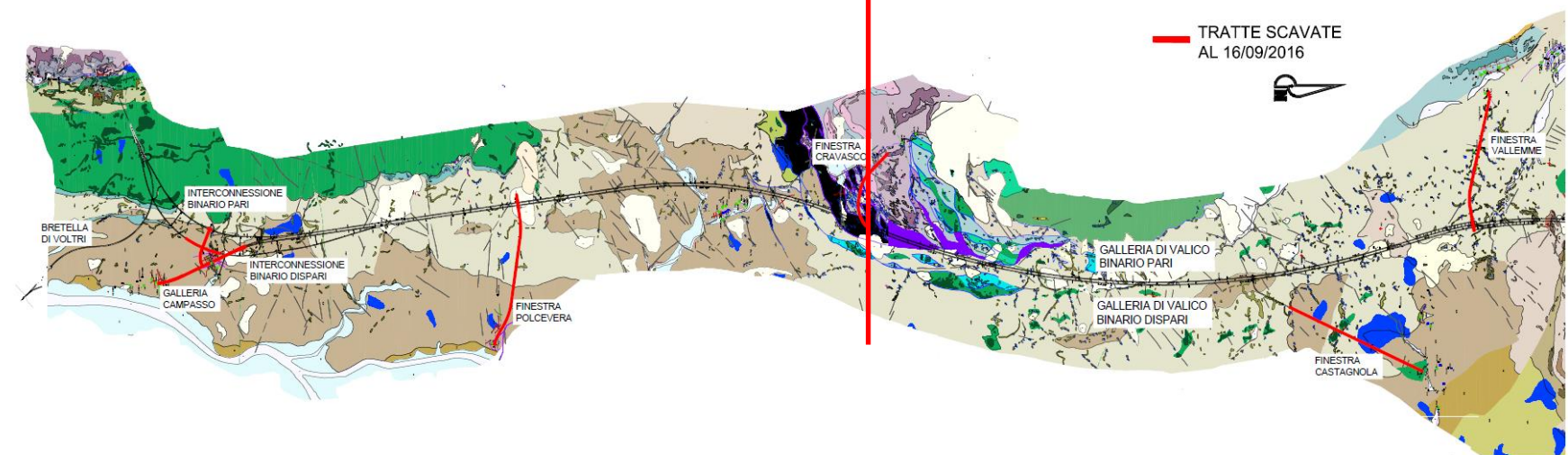
MILANO



ARGILLITI A PALOMBINI

1+232

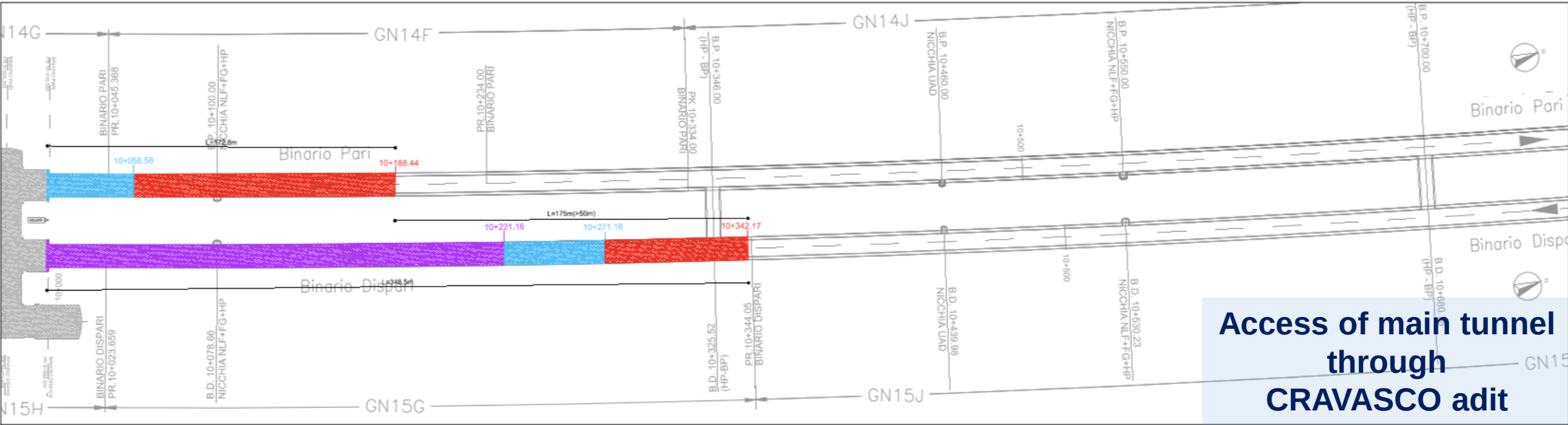
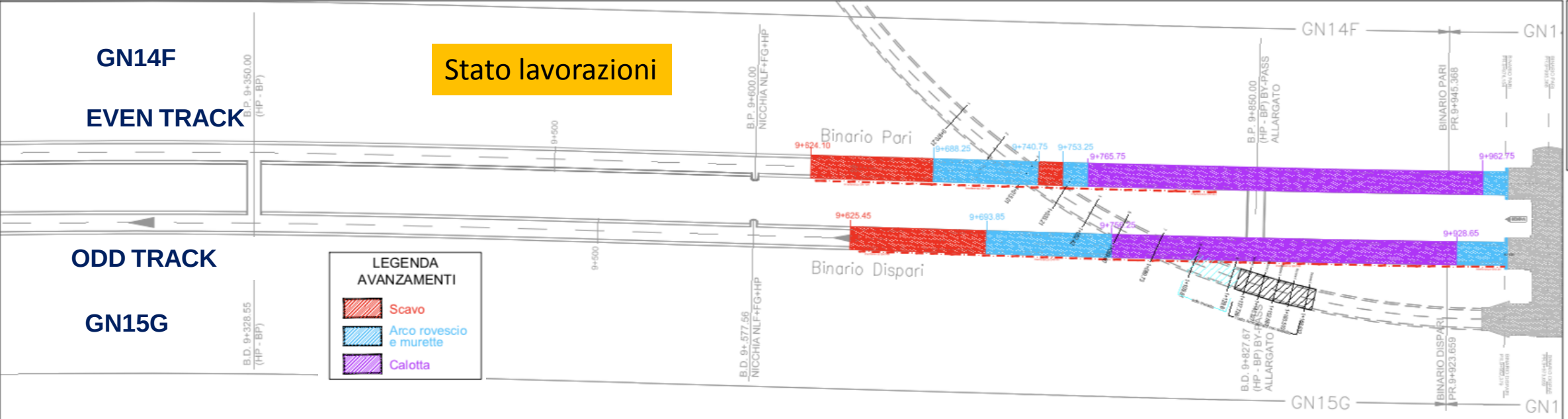
19+700



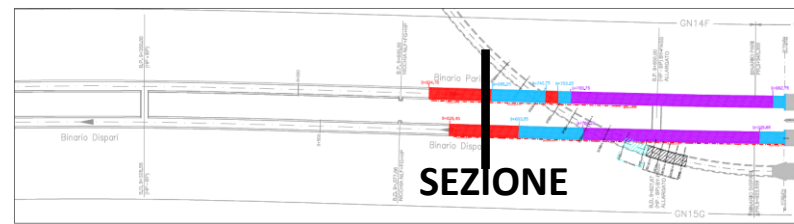
Geological Layout
Liguria Side

VALICO TUNNEL - main tunnel

excavated to Date 2019-07-10



Argilloscisti Filladici, ammasso con scarsa resistenza allo scavo, fratturato e tettonizzato, con piani di fratturazione discordanti dalla scistosità



Argilloscisti Filladici, ammasso prettamente Litoide, avanzamento in volata con sfondi da 3,60 m. Ottima risposta allo scavo

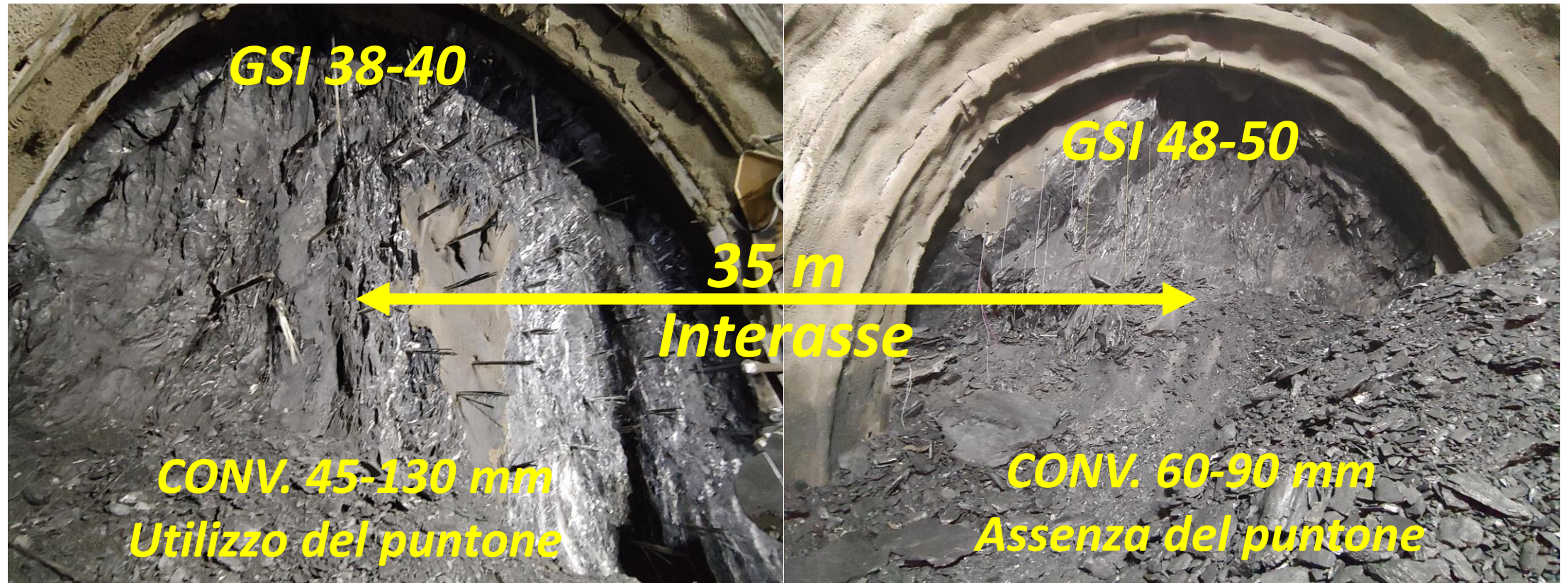
GN15G

Lato Genova

GN14F

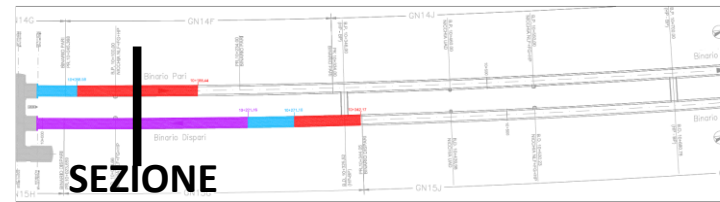
Sez. B2-2 sb con puntone passo 1,00 m – profilato HEB 240

Sez. B0-2 sb, passo 1,20 m, sfondo 3,60 m – profilato HEB200



Elevata eterogeneità nel comportamento del materiale di scavo, anche a parità di progressiva di avanzamento e di litologia coinvolta, nelle due canne adiacenti. Forti dissimetrie nelle spinte agenti ed elevata tettonizzazione a scala locale

Argilloscisti Neri con incluso basaltico (ofiolite) in destra, ammasso con buona competenza, con bancate massive, mediamente fratturato



Argilloscisti Neri con incluso basaltico (ofiolite) in sinistra, ammasso con scarsa competenza, a elevata tettonizzazione e alterazione

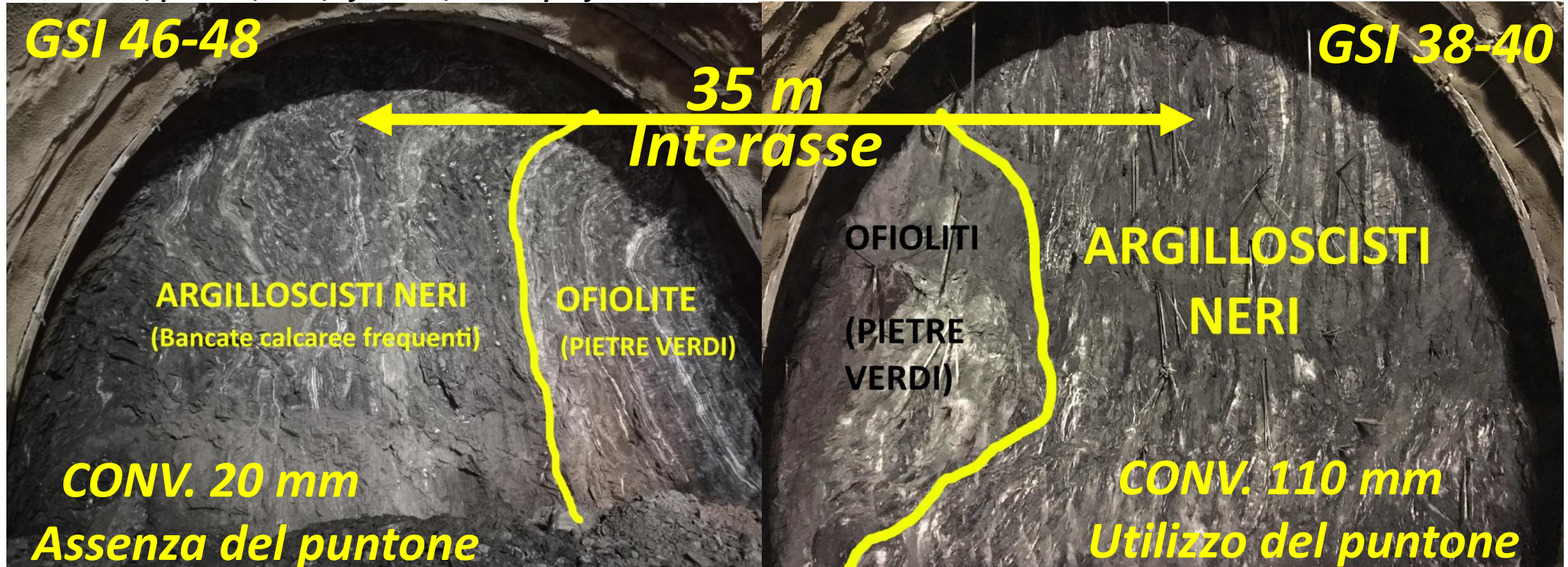
GN14F

Lato Milano

GN15G

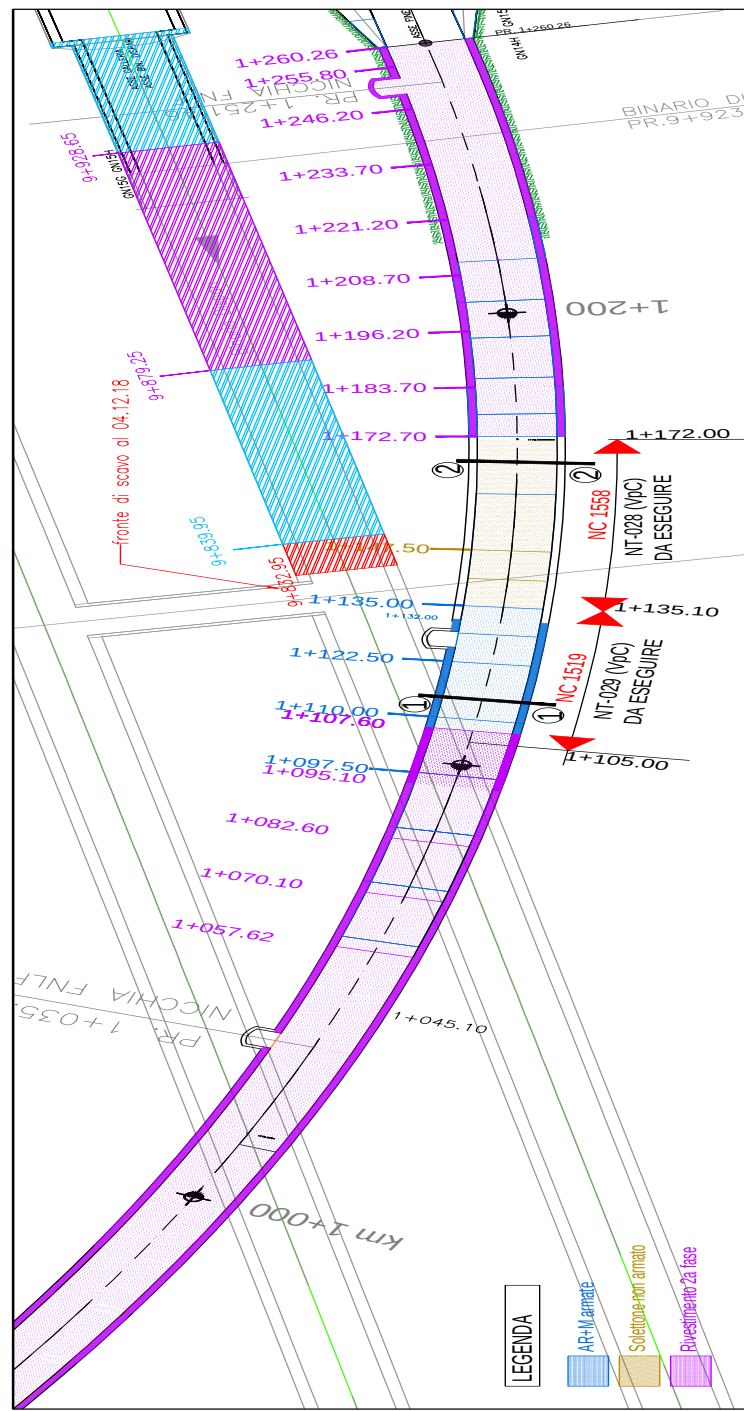
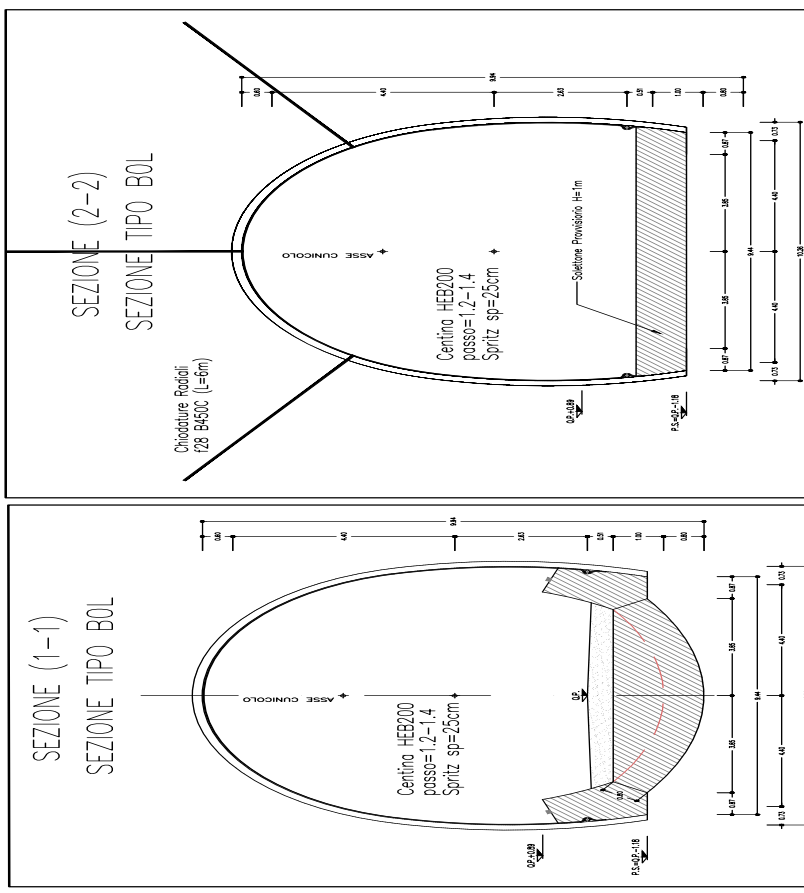
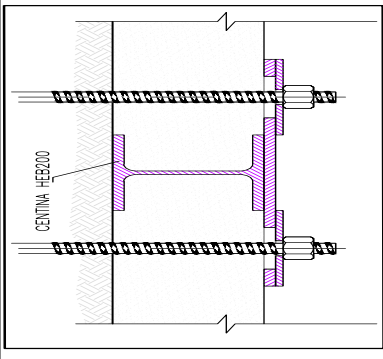
Sez. B0-2 sb, passo 1,20 m, sfondo 1,20 m – profilato HEB200

Sez. B2-2 sb con puntone passo 1,20 m – profilato HEB 240

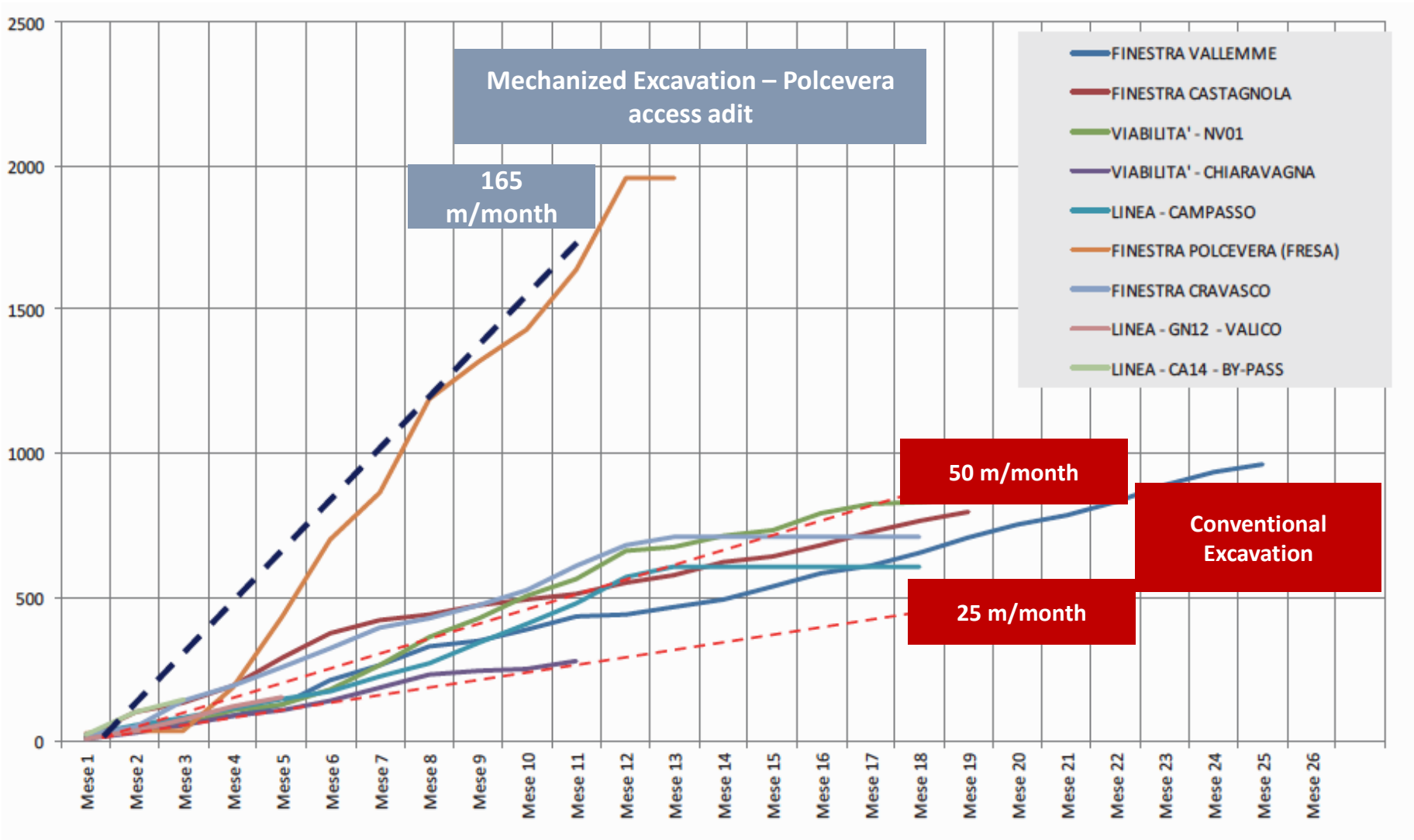


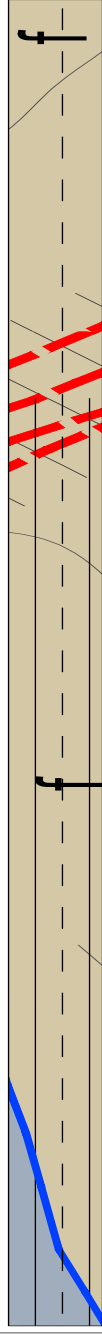
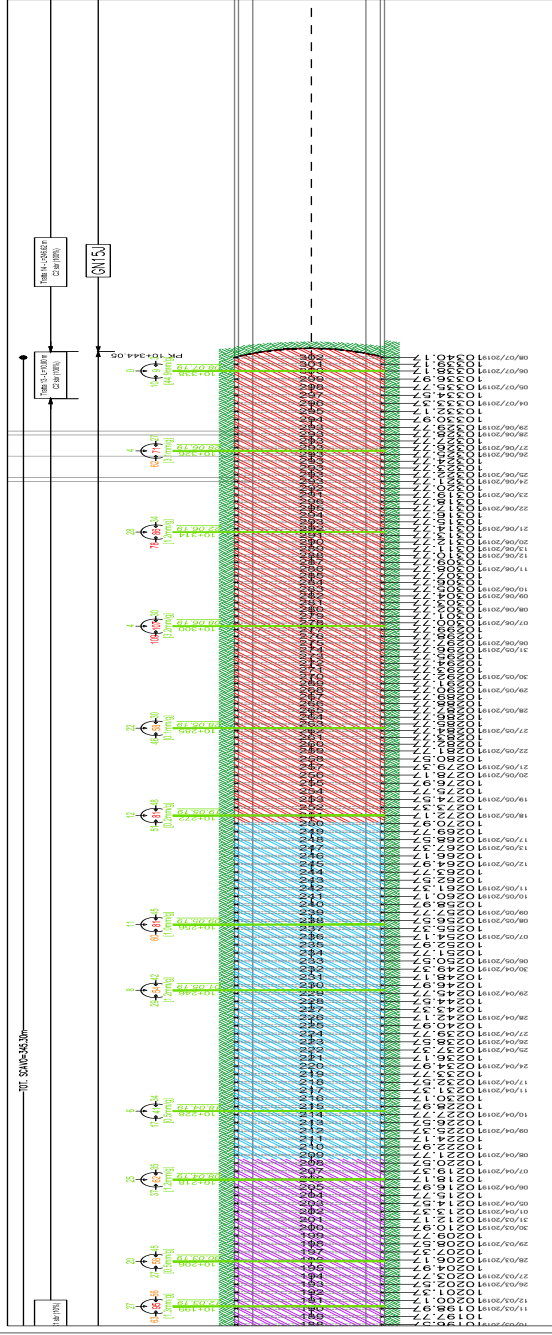
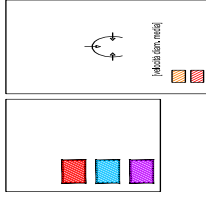
Elevata eterogeneità, sia litologica (fronte misto argilloscisti Neri-ofiolite su entrambi i fronti), sia nel comportamento del materiale di scavo, a parità di progressiva di avanzamento. Elevate dissimetrie nelle spinte in entrambe le gallerie, ma condizioni geomeccaniche molto peggiori nella GN15G

n°3 coppie di bulloni radiali fi 28
L=6m raccordati da piastre di
ripartizione a cavallo del profilato
centina



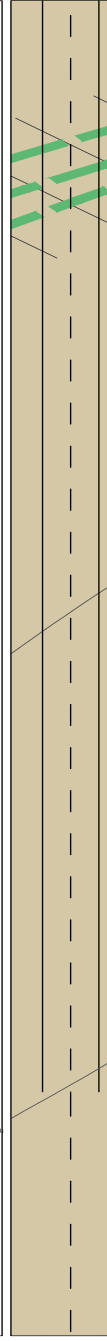
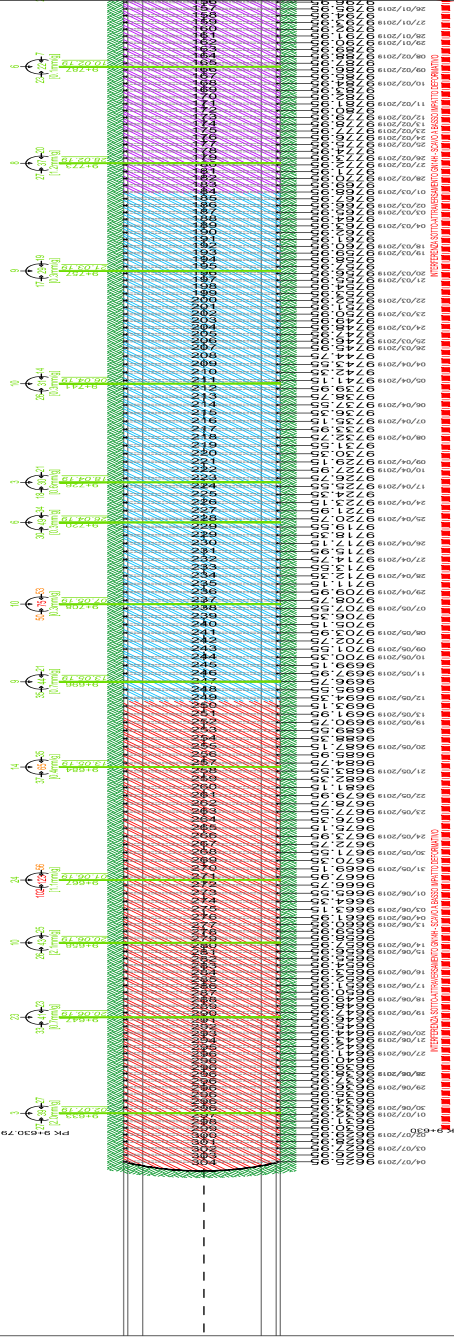
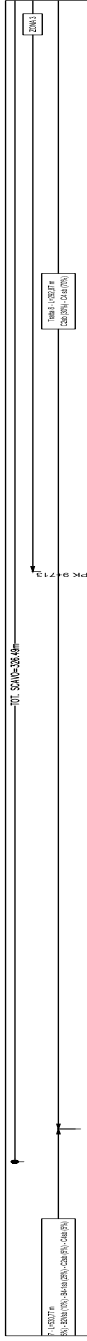
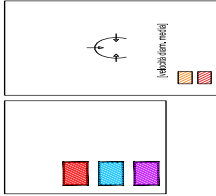
Excavation Speed – AP



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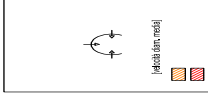
1. consolidamento B2-2 punt n°53/55



264

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