Albania – Kosovo Highway

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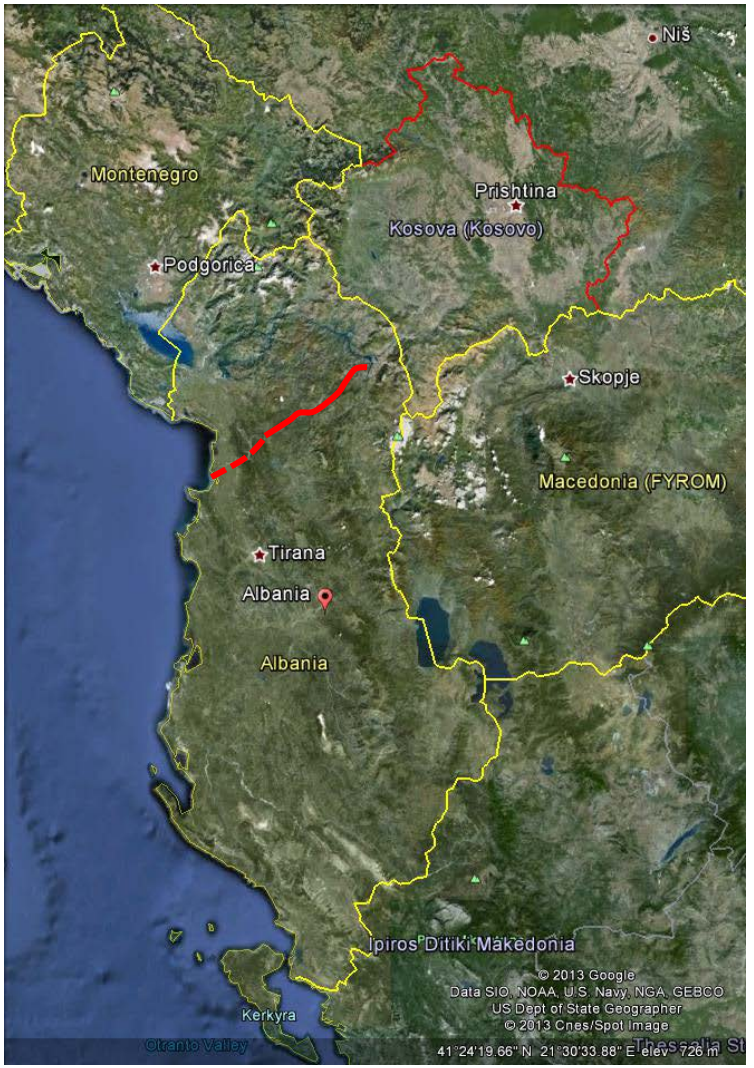
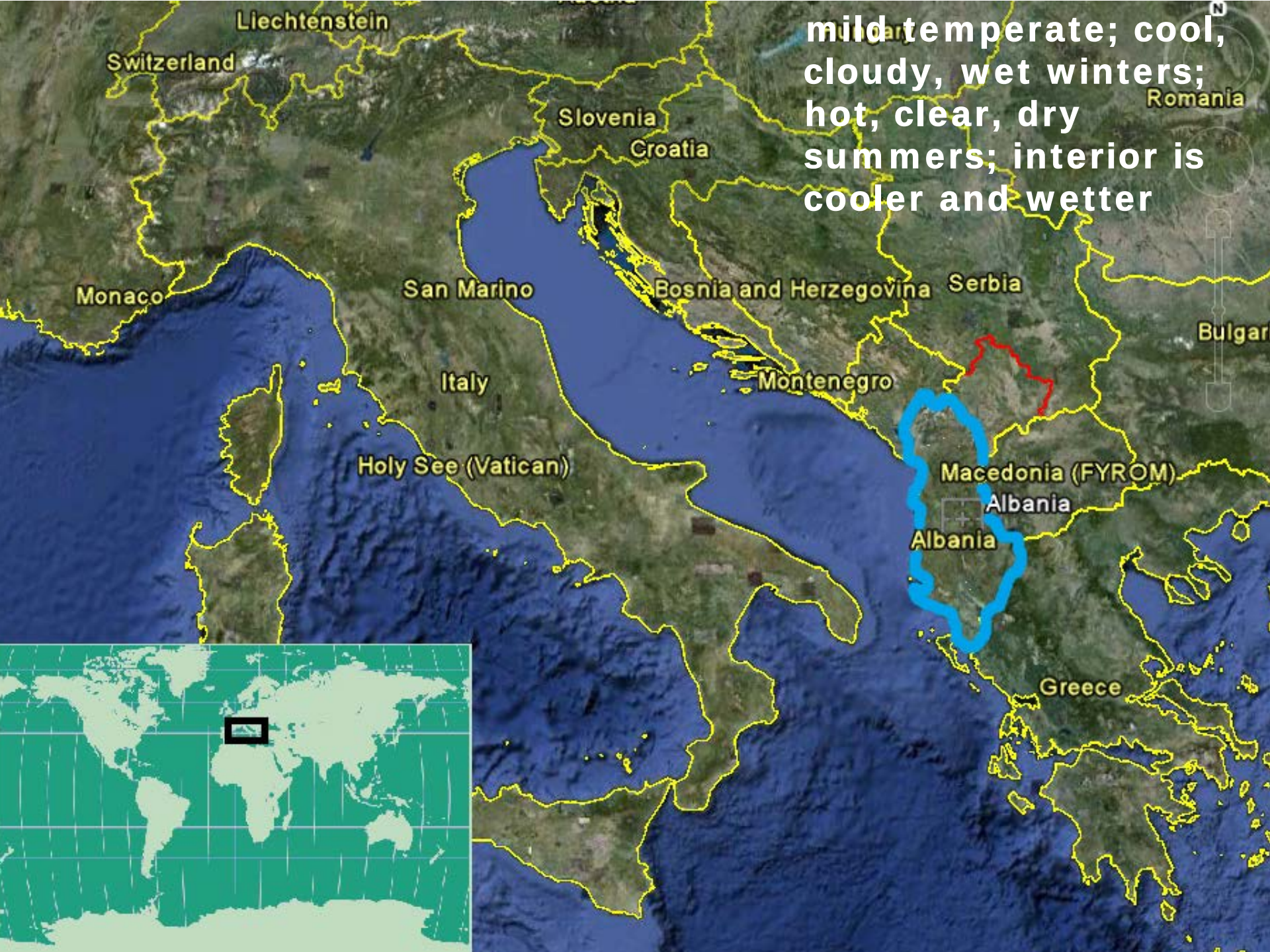
University of Portsmouth

Geological Society – IOM^3
8th April 2013

Pan-European Corridor X




mild temperate; cool, cloudy, wet winters; hot, clear, dry summers; interior is cooler and wetter
Liechtenstein
Switzerland
Slovenia
Croatia
Romania
Monaco
San Marino
Bosnia and Herzegovina
Serbia
Italy
Montenegro
Holy See (Vatican)
Macedonia (FYROM)
Albania
Albania
Greece


Section 2
Section 1
Thirrë, Alban
3
2
1
Mirditë
Rrëshen
Macukull
Image © 2011 GeoEye
Image © 2011 DigitalGlobe
© 2011 Google
© 2011 Europa Technologies
©2010 Google
Imagery Date: Jun 2, 2007
41°51'38.13" N
20°01'54.92" E
elev 402 m
Eye alt 45.63 km

- Links Durres (Adriatic coast) with Kosovo
- 61 km four-lane highway
- One tunnel and 27 bridges
- Steep and mountainous terrain
- Started in 2007
- American-Turkish consortium Bechtel-ENKA
- Albanian section Opened 2010-11
- World Bank funded
- Original cost - €600m – final cost over €1bn

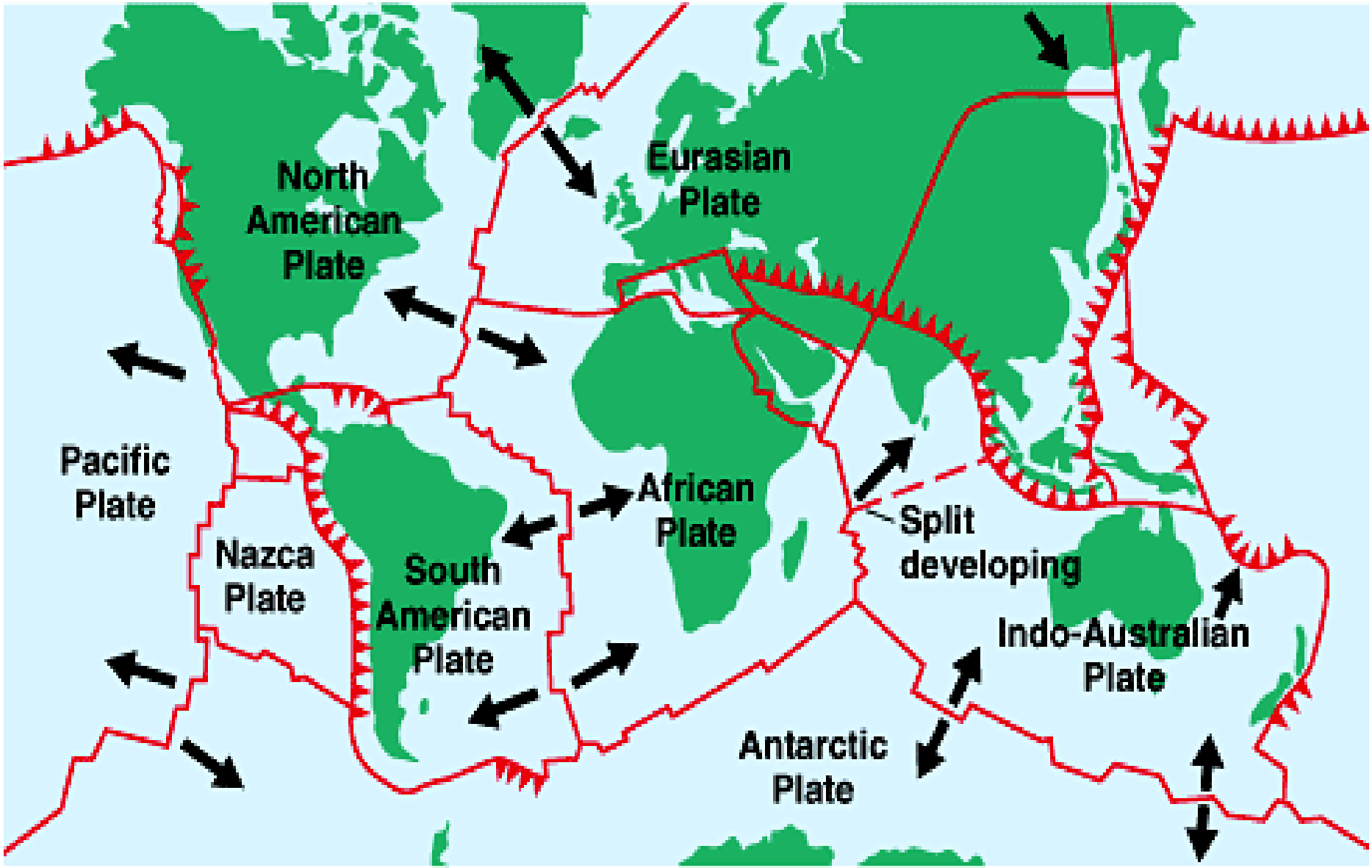
Client – loss adjuster – five failures during construction

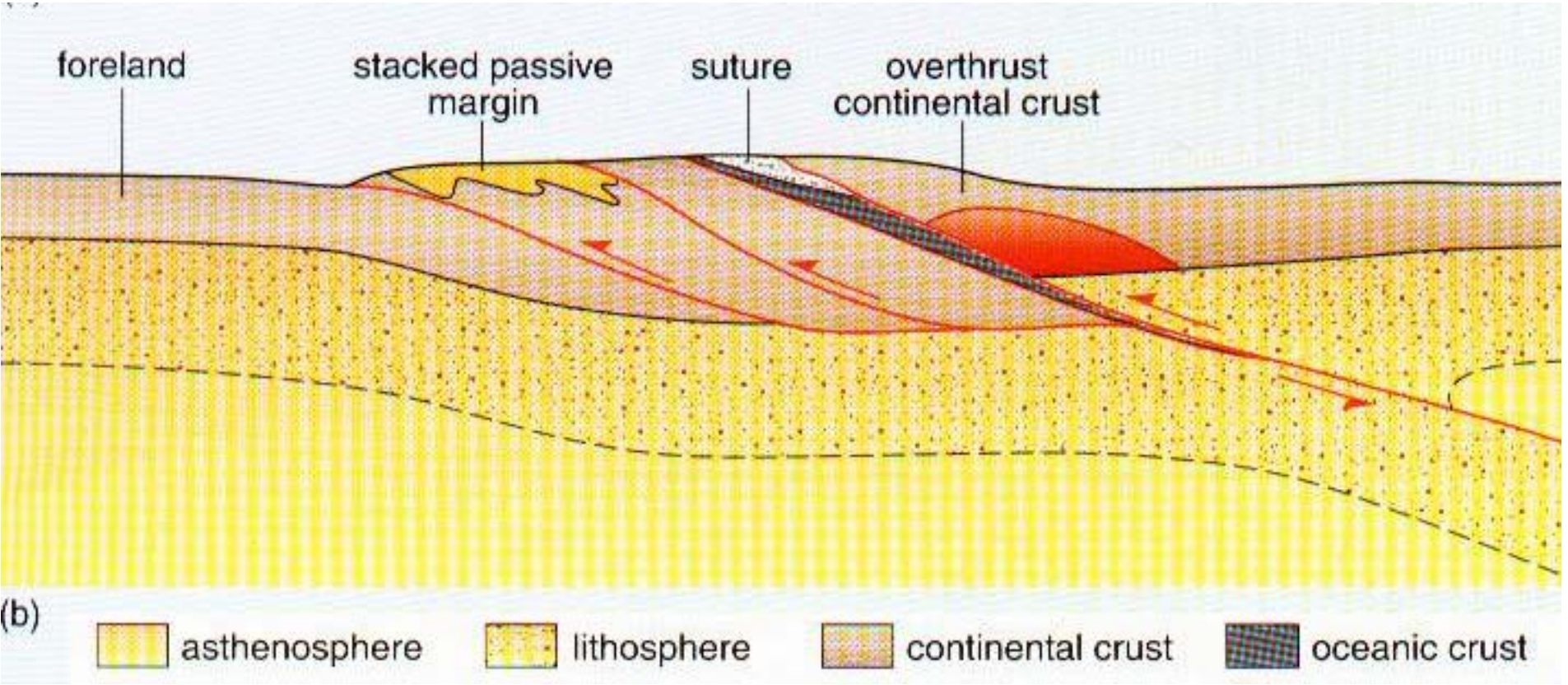
- Adequacy of SI
- Causes of failures
- Remedial proposals
- Future problems

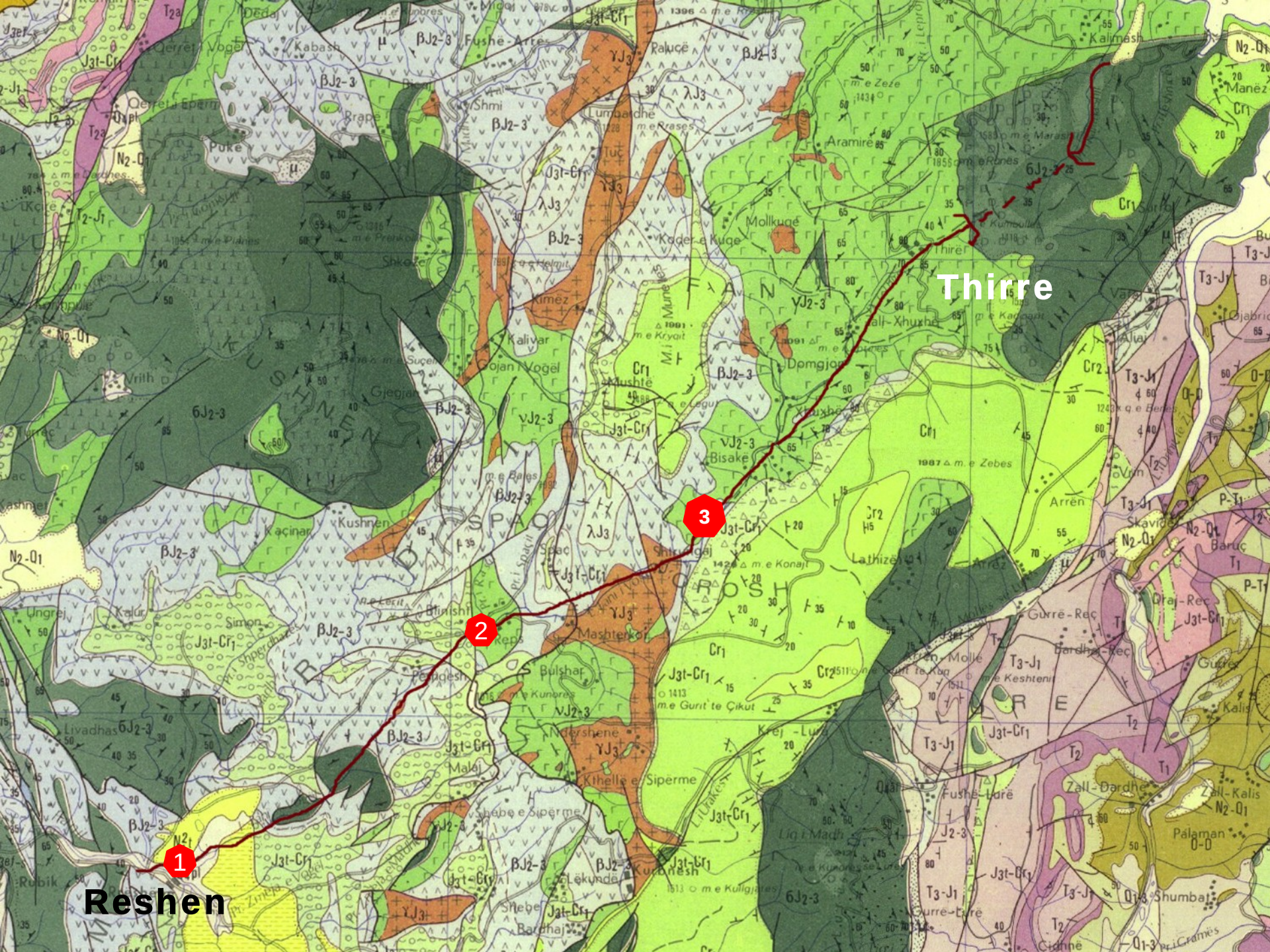
STAGES OF WORK

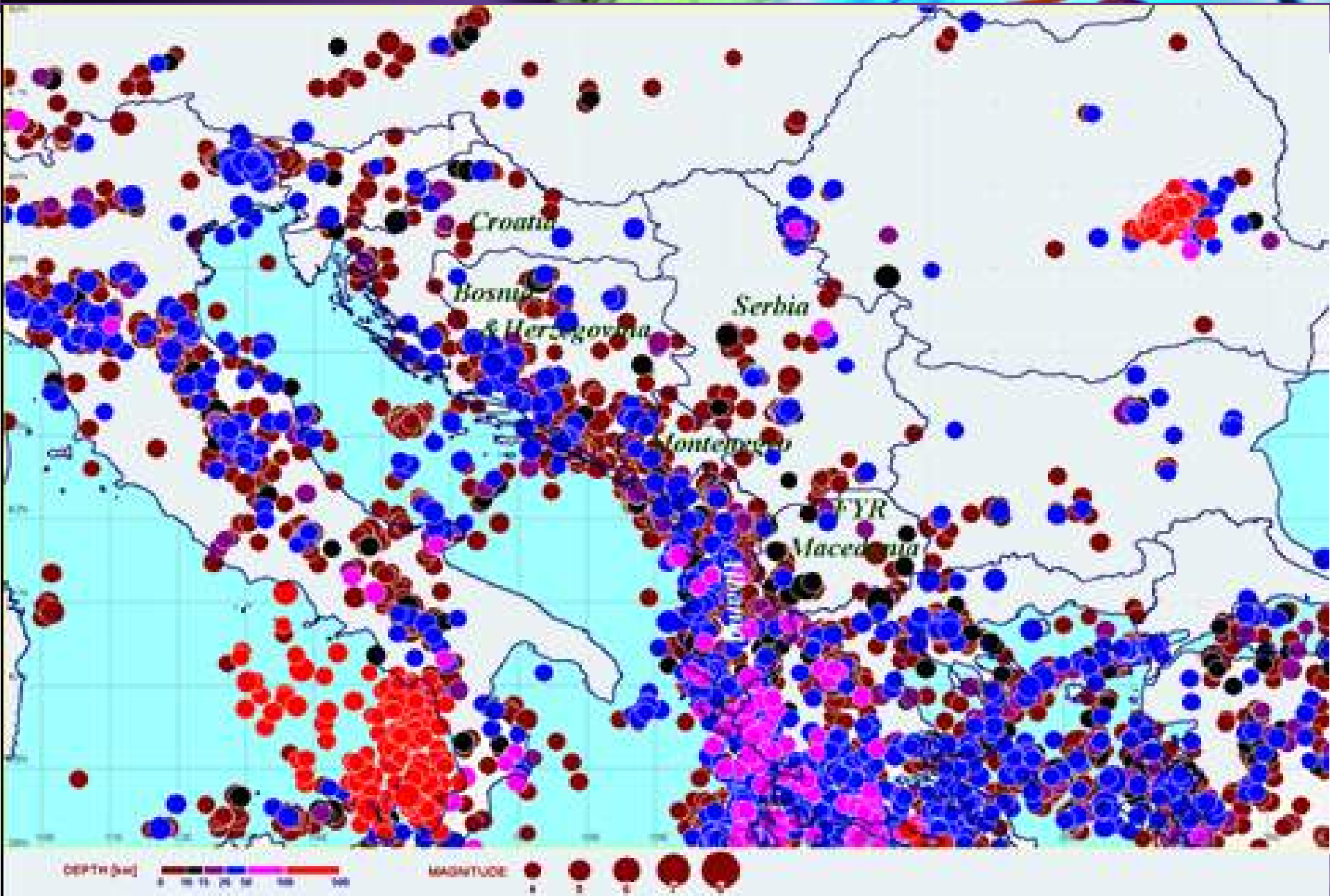
- Review
- Site visit
- Independent Geotechnical Report

Stage 1 - REVIEW

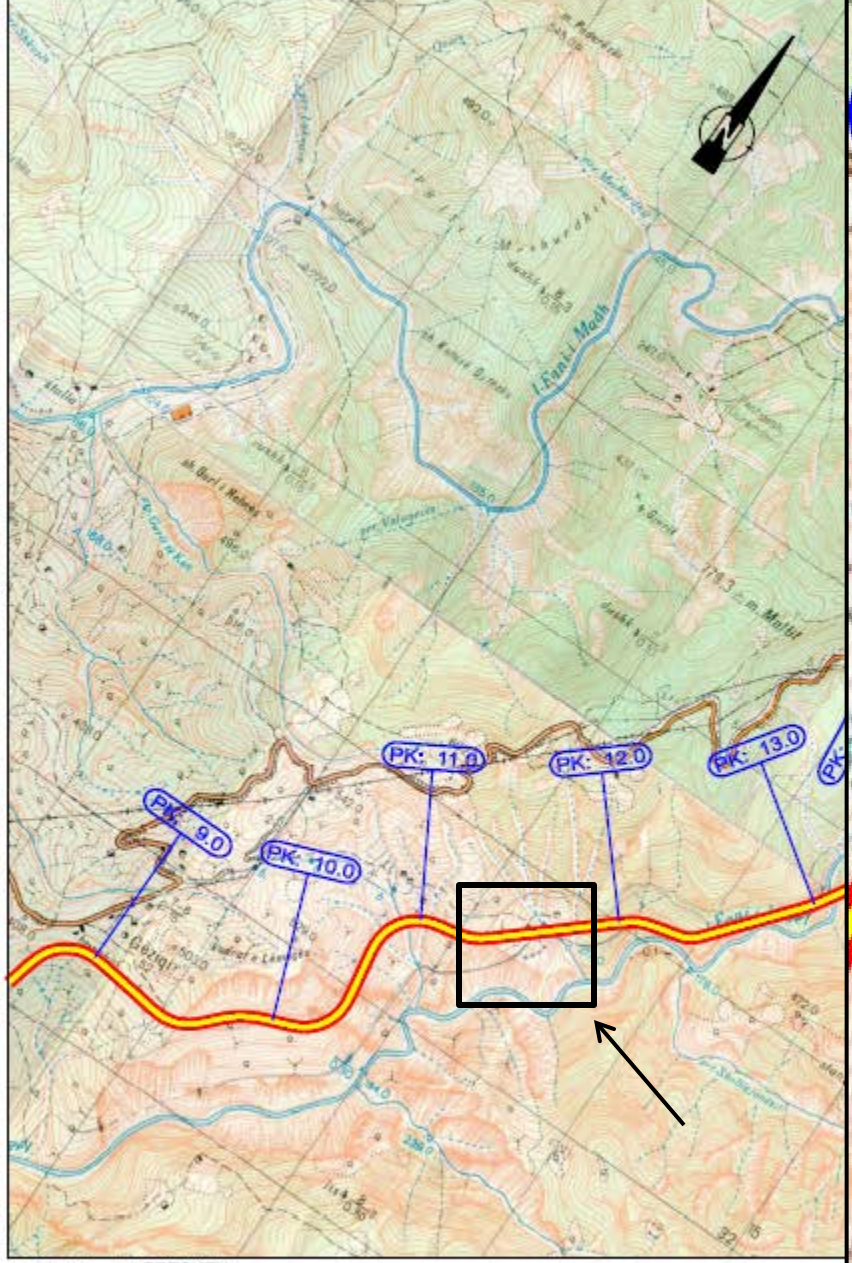

North American Plate
Eurasian Plate
Pacific Plate
Nazca Plate
South American Plate
African Plate
Split developing
Indo-Australian Plate
Antarctic Plate

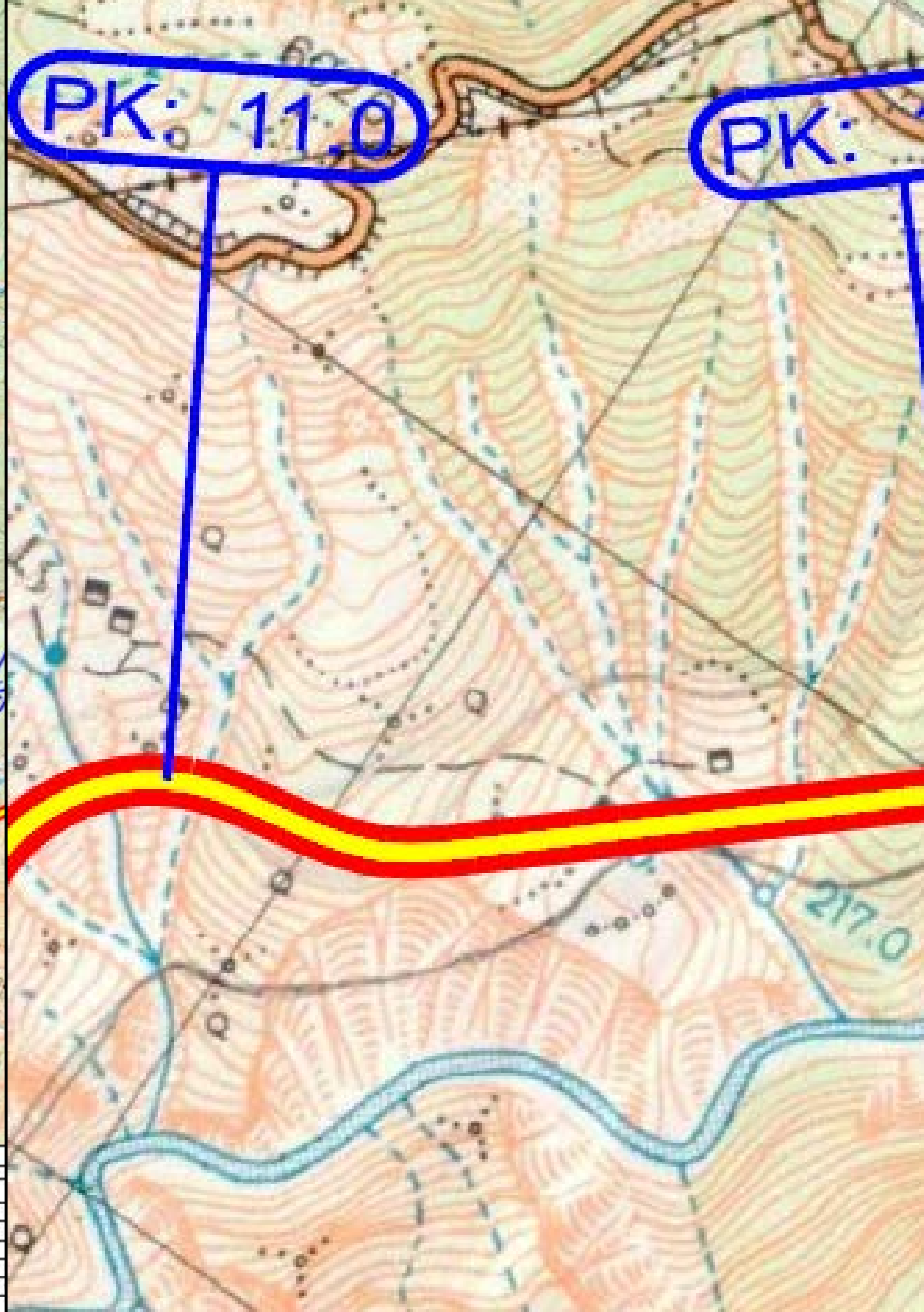

foreland
stacked passive margin
suture
overthrust continental crust
(b)
asthenosphere
lithosphere
continental crust
oceanic crust

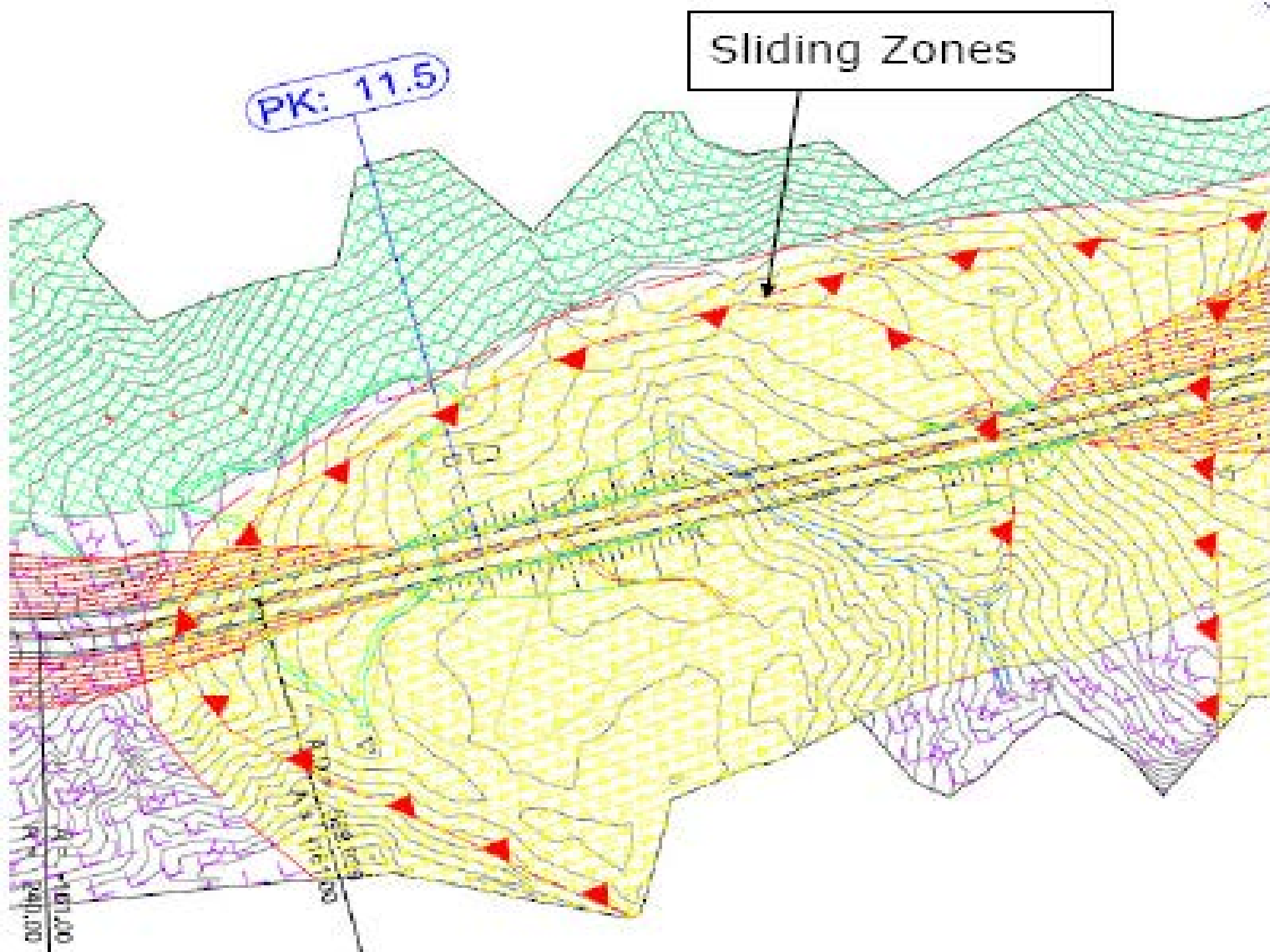

Thirre
Reshen
1
2
3

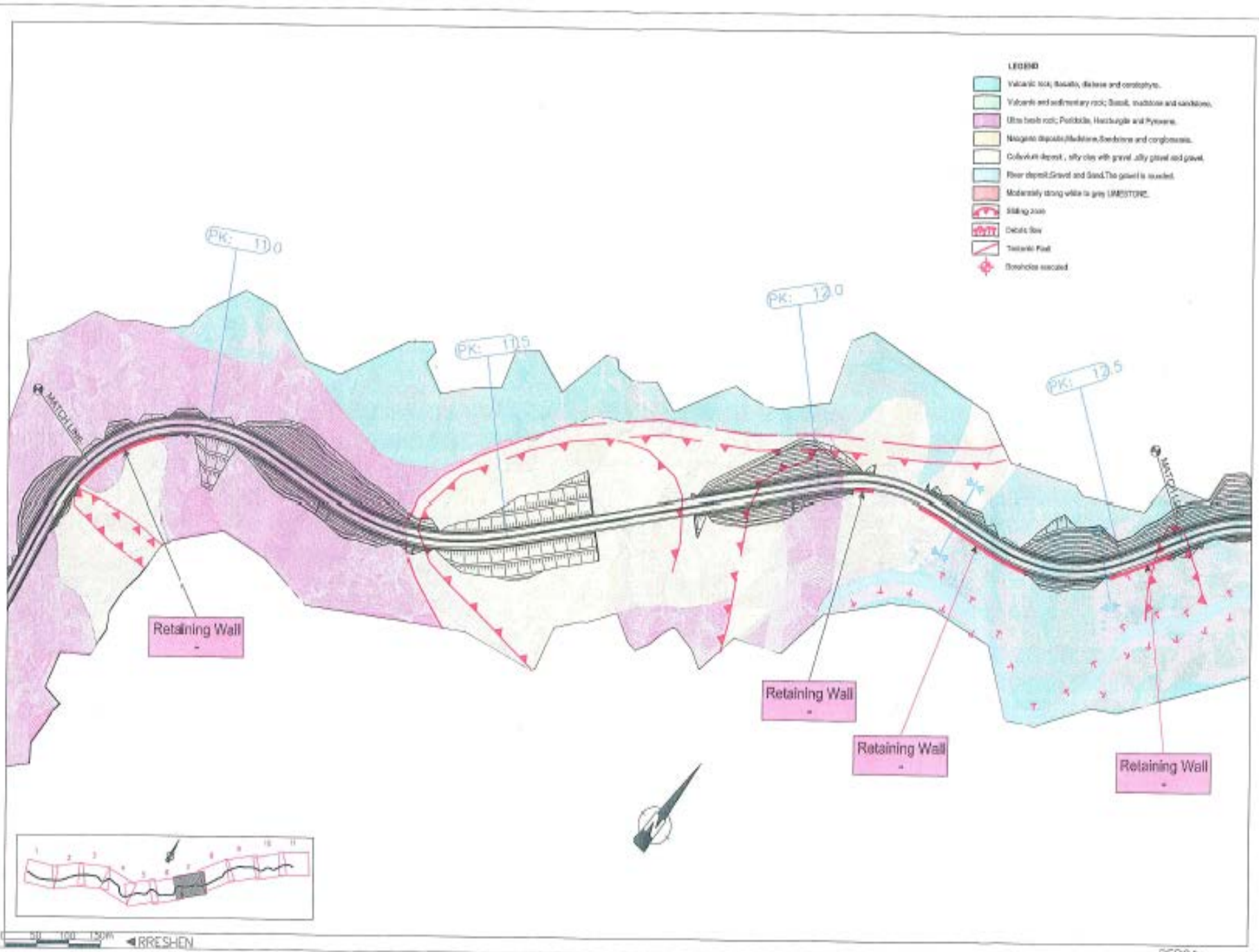

Croatia
Bosnia
& Herzegovina
Serbia
Montenegro
FYR
Macedonia
DEPTH [km]
MAGNITUDE

Geology	Model	Hazard
Ophiolite suite	•Basic and ultra-basic rocks •Shallow burial •Low grade metamorphism	•Hydrothermal alteration – serpentinization •Geological contacts – weak •Deep weathering
Tectonically active	•Thrusts and shears •Seismically active •High K_0 •Geologically complex •Uplift	•Weak zones in rock mass •Instability triggered by seismic events •Stress relief
South of last glacial maxima	•Cryogenic deposits •V-shaped valleys •Periglacial	•Scree slopes - unstable •Over steepened slopes – unstable •Solifluxion


PK: 9.0
PK: 10.0
PK: 11.0
PK: 12.0
PK: 13.0
RRESHEN


PK: 11.0
PK:
217.0


Sliding Zones
PK: 11.5


LEGEND
Volcanic rock; Basalts, dolerite and porphyrite.
Volcanic and sedimentary rock; Basalt, mudstone and sandstone.
Ultra basic rock; Peridotite, Hornblendite and Pyroxenite.
Neogene deposits;Mudstone,Sandstone and conglomerate.
Colluvium deposit ; silty clay with gravel ,silty gravel and gravel.
River deposit;Gravel and Sand.The gravel is rounded.
Moderately strong white to grey LIMESTONE.
Sliding zone
Debris flow
Tectonic Fault
Borehole executed
PK: 11.0
PK: 11.5
PK: 12.0
PK: 12.5
MATCH LINE
MATCH LINE
Retaining Wall
Retaining Wall
Retaining Wall
Retaining Wall
50 100 150m
BRESHEN
REPS

Geological Survey

- Simple walkover
- Focus on geology – very simplistic
- Some areas of instability identified
- Not linked to construction

Site Investigation

- Focussed on structures
- No investigation of instability
- Very poor core recovery/preservation
- Rock-head proved
- No groundwater monitoring

Geomorphology

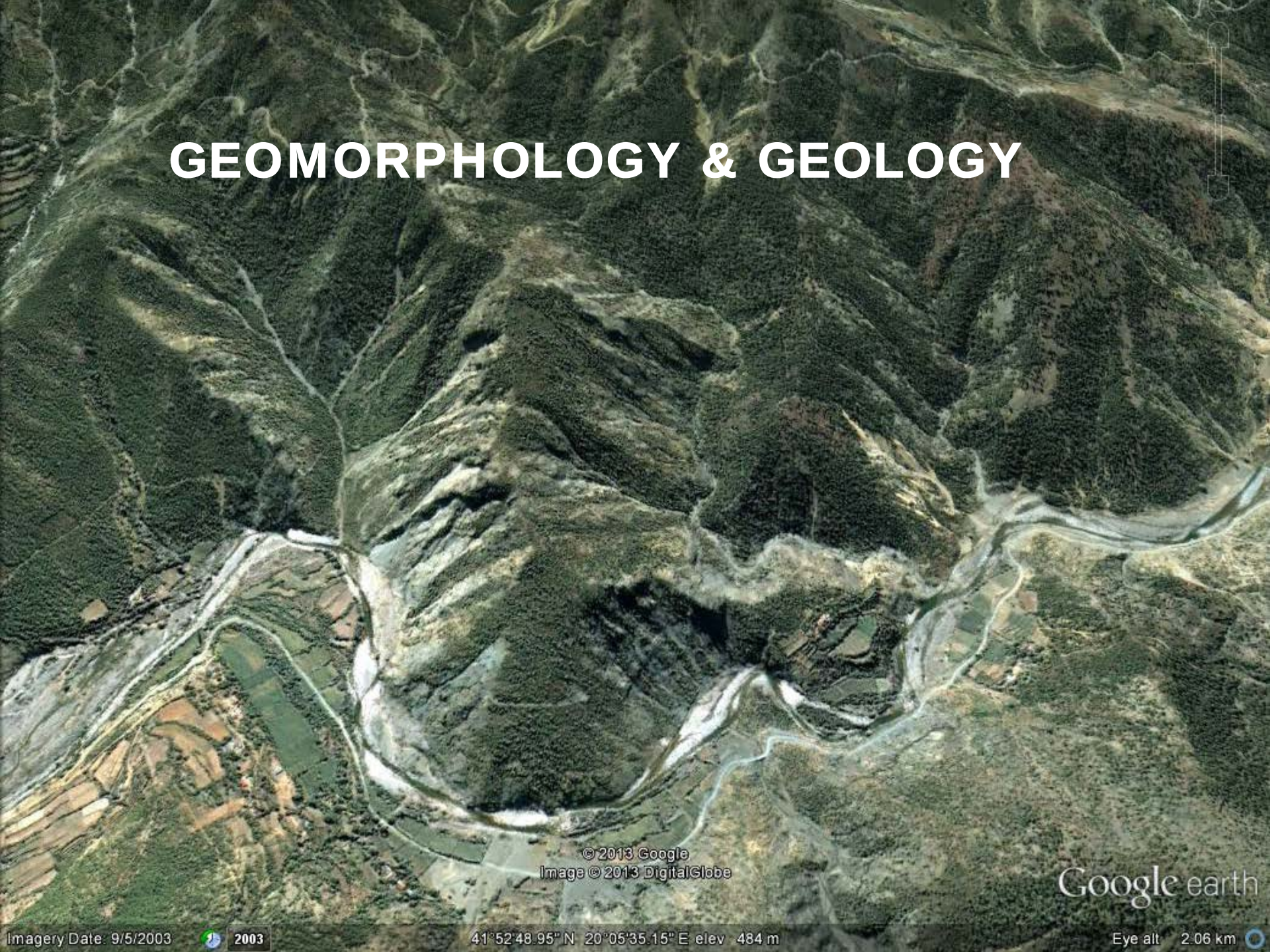
- No systematic geomorphological analysis
- No API
- No attempt to understand ongoing processes

Geotechnical Design of Slopes

- Simple circular analysis made
- No link to on going process
- No apparent seismic analysis carried out
- Appeared to have ignored geological report – ongoing instability
- Optimistic parameters
- Poor hydrogeological model

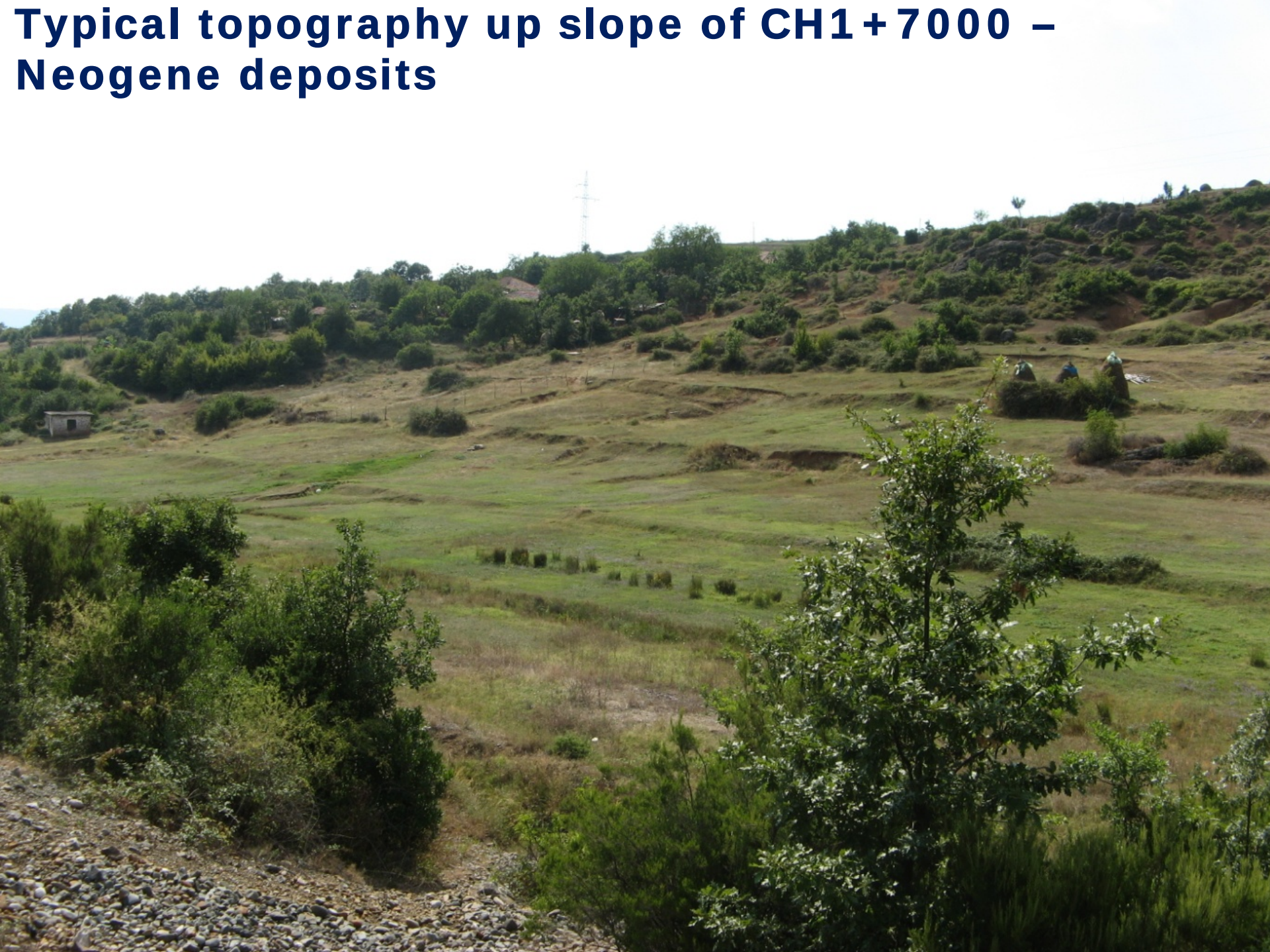
My Involvement - VISIT

GEOMORPHOLOGY & GEOLOGY



Neogene deposits opposite CH1+7000 – Section 1

Typical topography up slope of CH1+7000 – Neogene deposits



View west along Section 1 from old Kosovo Road


View east along Section 1 from old Kosovo road


View east along Section 1 from old Kosovo road

Colluvium wedge opposite camp – Reps junction of Section 1 & 2

Incised Colluvium lobes – Reps junction of Section 1 & 2

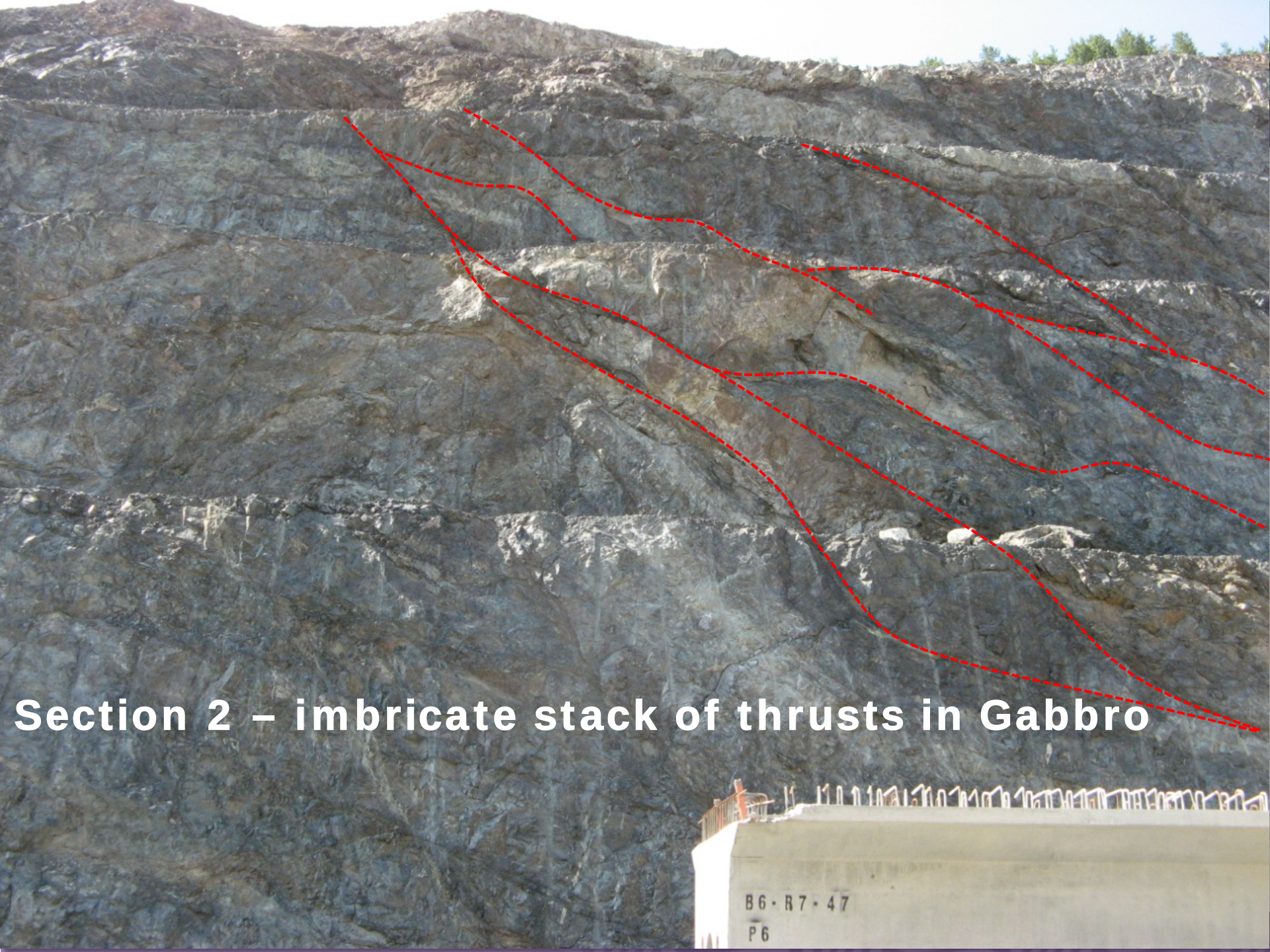

Old mine workings - tailings dam at Reps

Old mine workings – tailings dam - Reps

Old mine workings – tailings dam - Reps

Cut slope approach to tunnel portal

Tunnel portal – start of Section 3


Section 2 – imbricate stack of thrusts in Gabbro
B6 · R7 · 47
P6

Loss 1

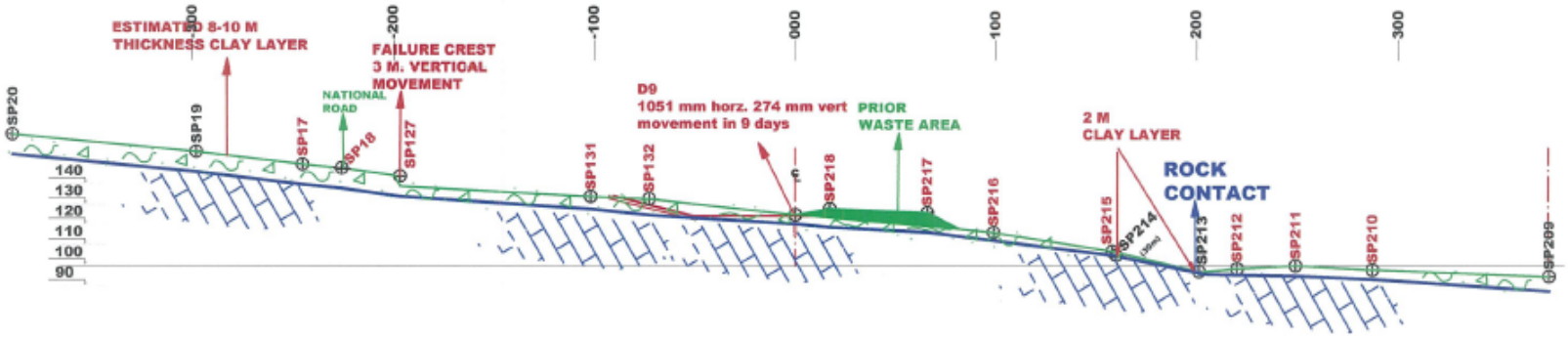
RRESHEN TO KALIMASH MOTORWAY
ALBANIA

SECTION 1

Km 1+820

NATURAL GROUND GRADE : 6.0 DEGREE

ROCK SLOPE GRADE BELOW CLAY : 5.0 DEGREE



Km 1+880

NATURAL GROUND GRADE : 6.2 DEGREE

ROCK SLOPE GRADE BELOW CLAY : 5.6 DEGREE

S.O.

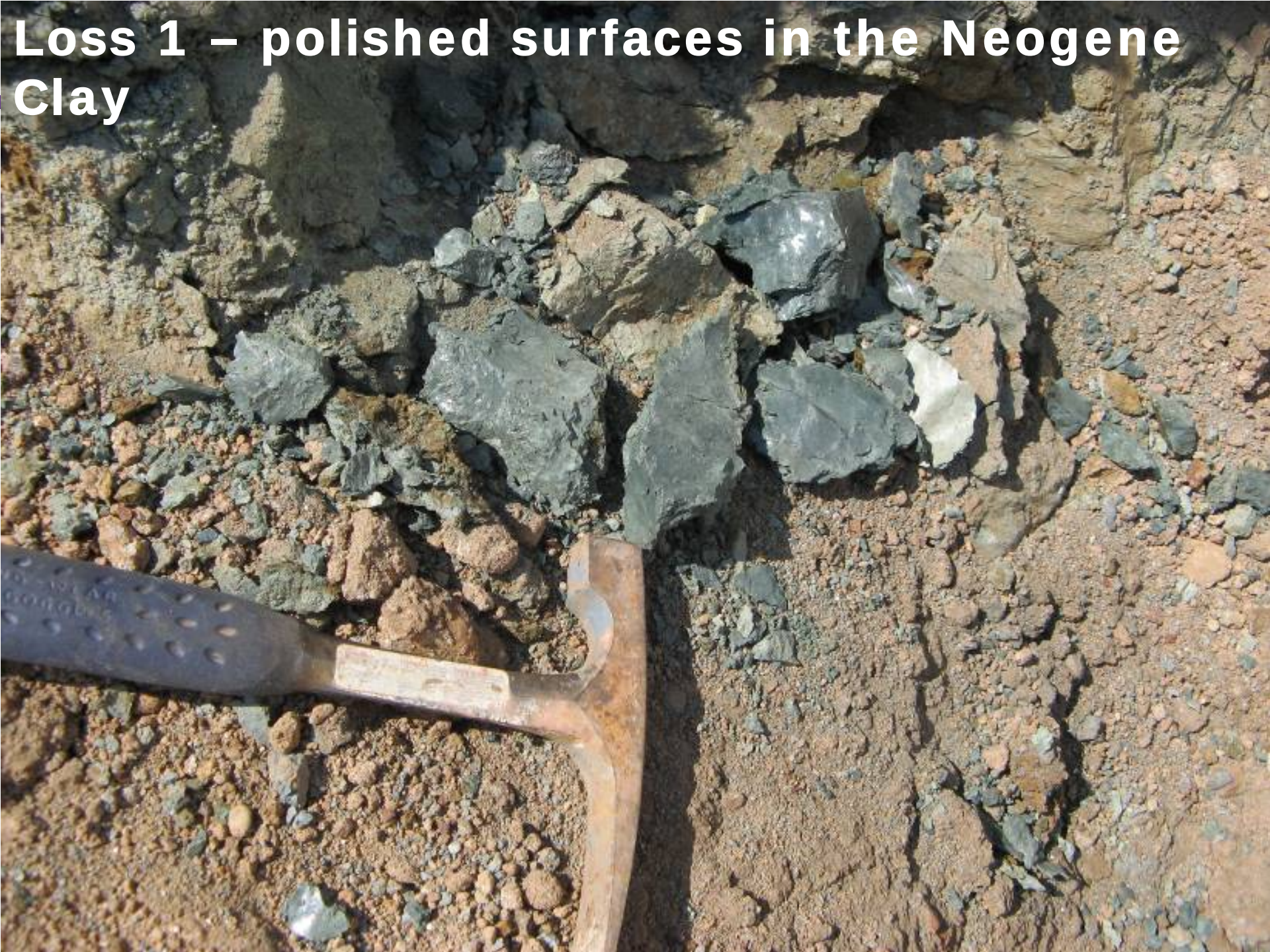
Loss 1 – movement up-slope adjacent to old Kosovo Road

Loss 1 – tension cracks in fields below works area

Loss 1 – general view of instability

Loss 1 – shear surface at Alluvium – Neogene Clay interface

Loss 1 – polished surfaces in the Neogene Clay

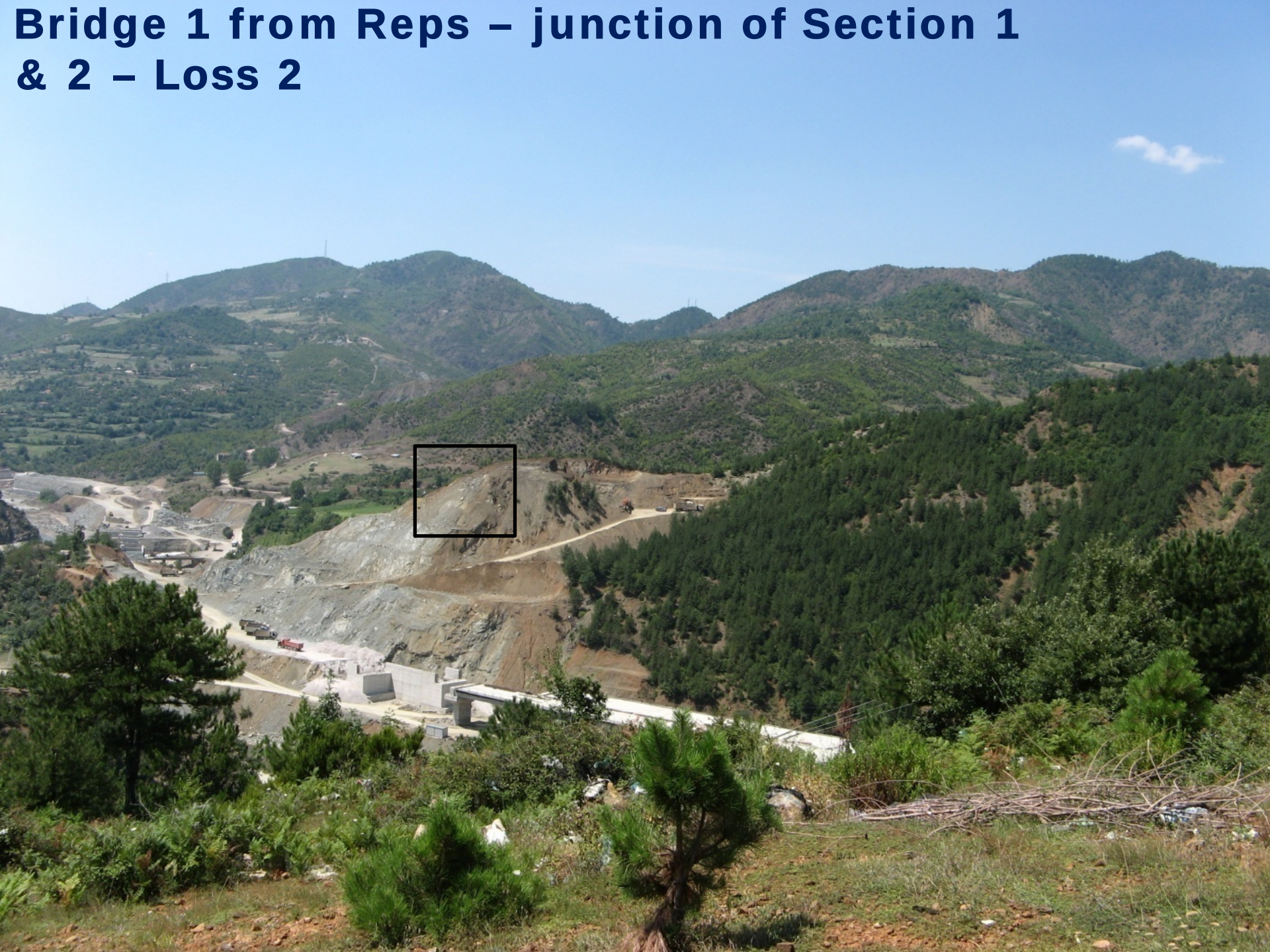



2769
NDERFUSHAZ

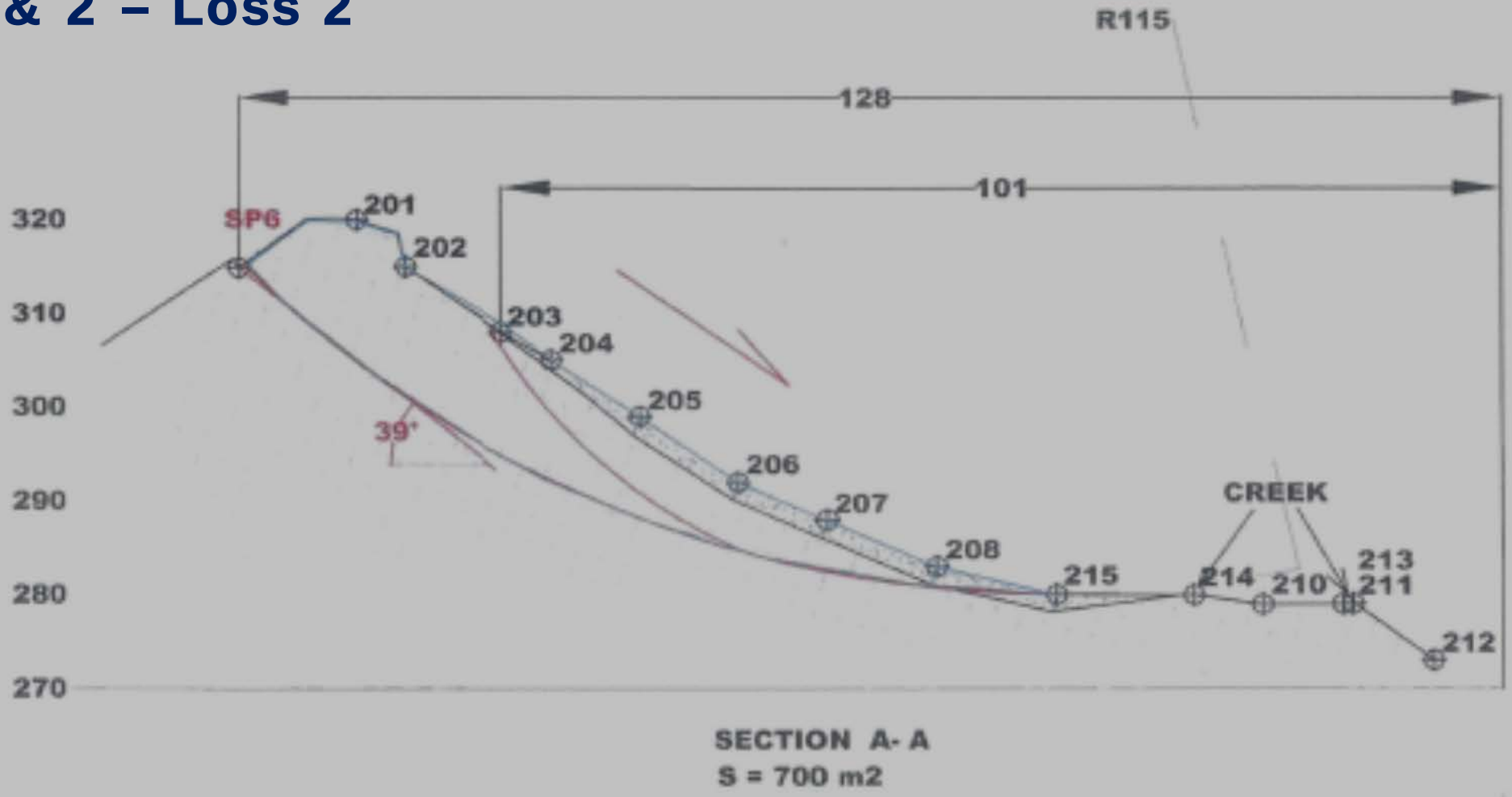
Loss 1 – remedial works in progress

Loss 1 – road works complete

Bridge 1 from Reps – junction of Section 1 & 2 – Loss 2

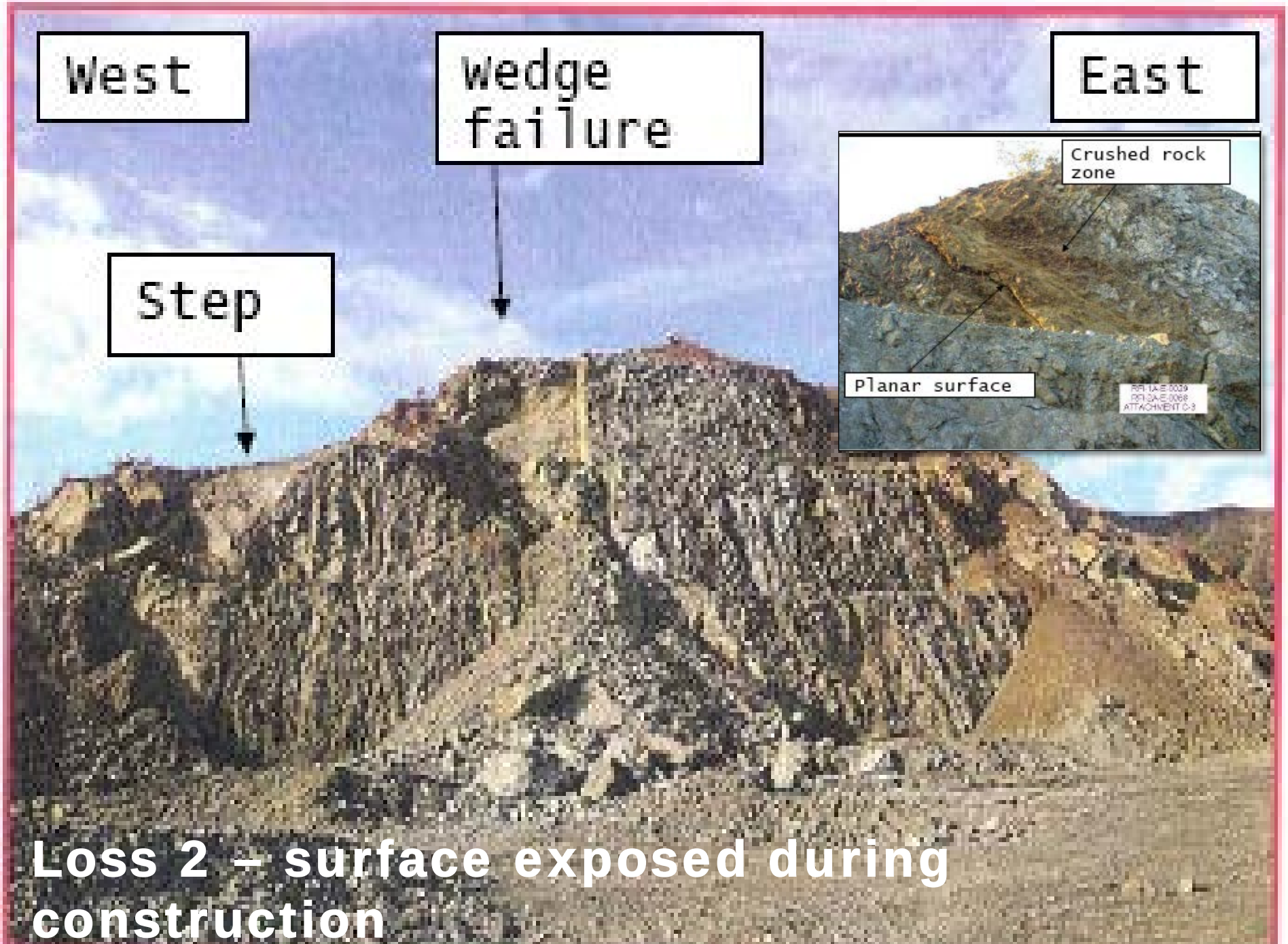


Bridge 1 from Reps – junction of Section 1 & 2 – Loss 2

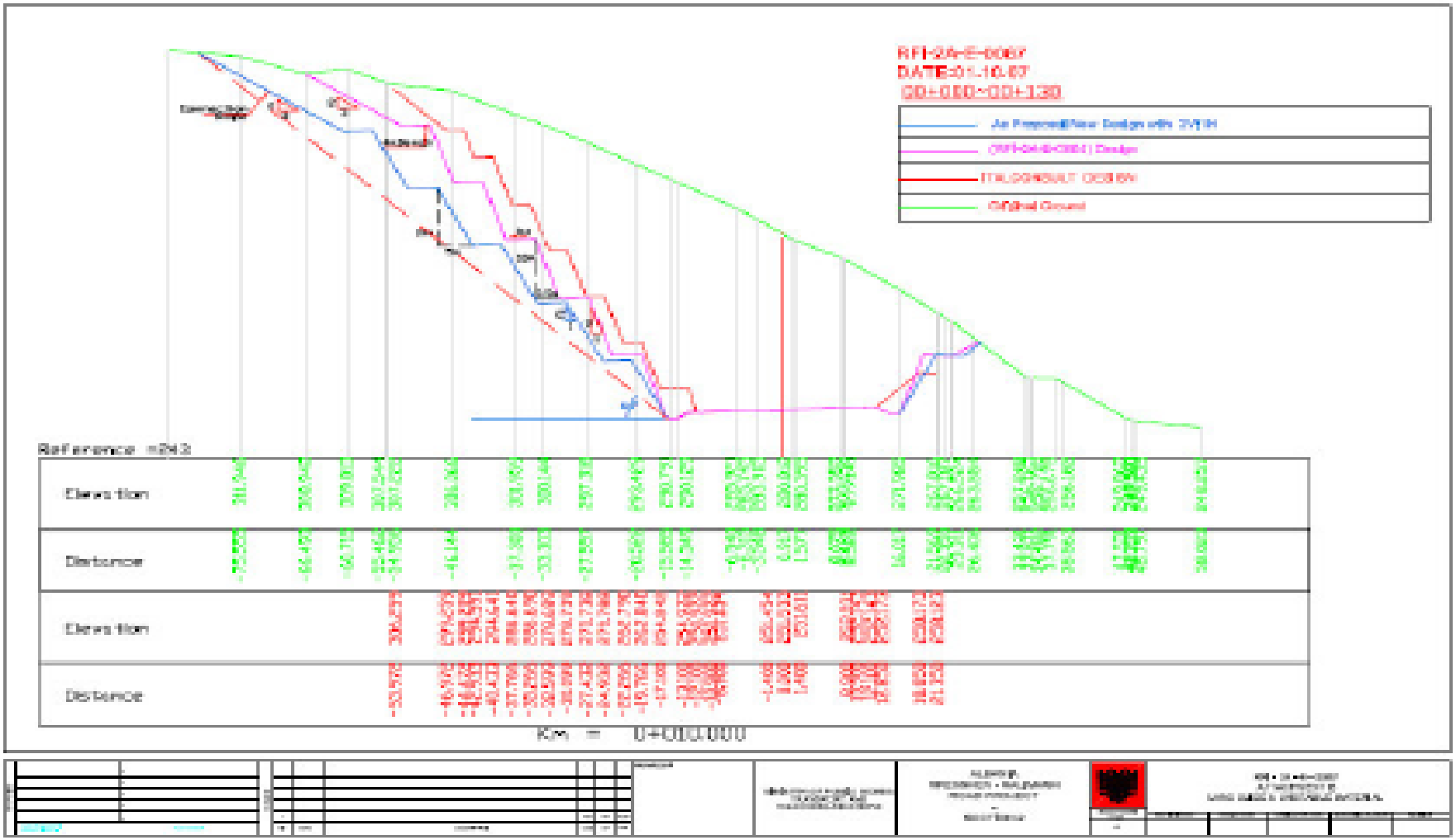


Loss 2 – sinuous shear surface day lighting in rock cut slope


Loss 2 – sinuous shear surface
day lighting in rock cut slope



Loss 2 – surface exposed during construction



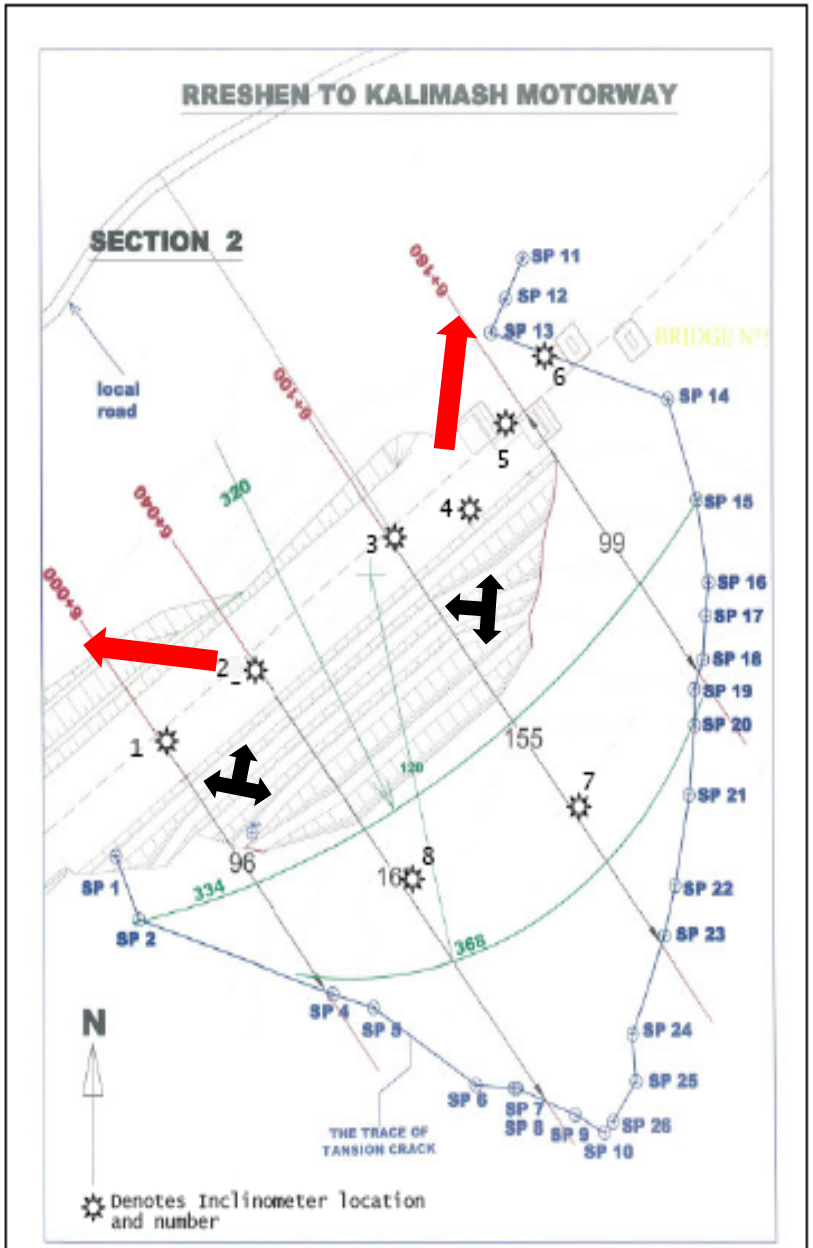
Bridge 1 CH18+800 Section 1. Typical Section through cut slope showing a succession of different design profiles. Figure is part of RFI 2A E 0067 dated 1 October 20008.

Loss 2 – oblique Google Earth image

Loss 3 – cut slope adjacent to bridge foundations - view looking west

Loss 3 – cut slope adjacent to bridge foundations - view looking east

Loss 3 – cut slope

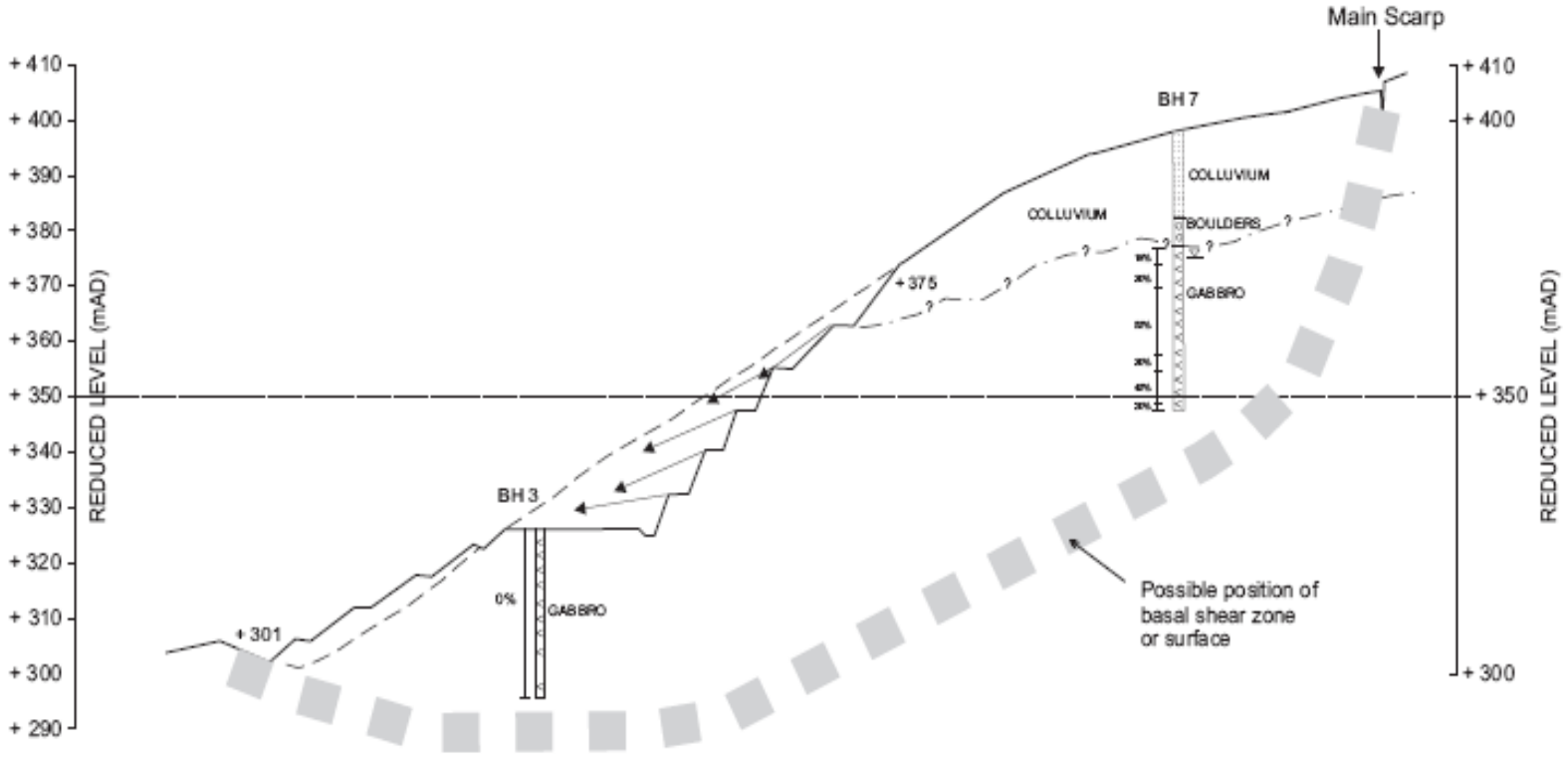


Section 2 Bridge 5. Survey of main scarp (TANSION CRACK on drawing) made by BEJV in March 2008. Inclinometer survey positions also shown.

Loss 3 – cut slope


N
Shtrungaj
Bisak

Ch 6 + 100 Section 2 - Bridge 5



KEY

- 18% — Rock quality designation (RQD) 18%
- – ? – Uncertain geological boundary
- Groundwater level in borehole
- – – – Original ground level
- ——— a.s built ground level
- Movement vector (mm) (1:10 at A3)

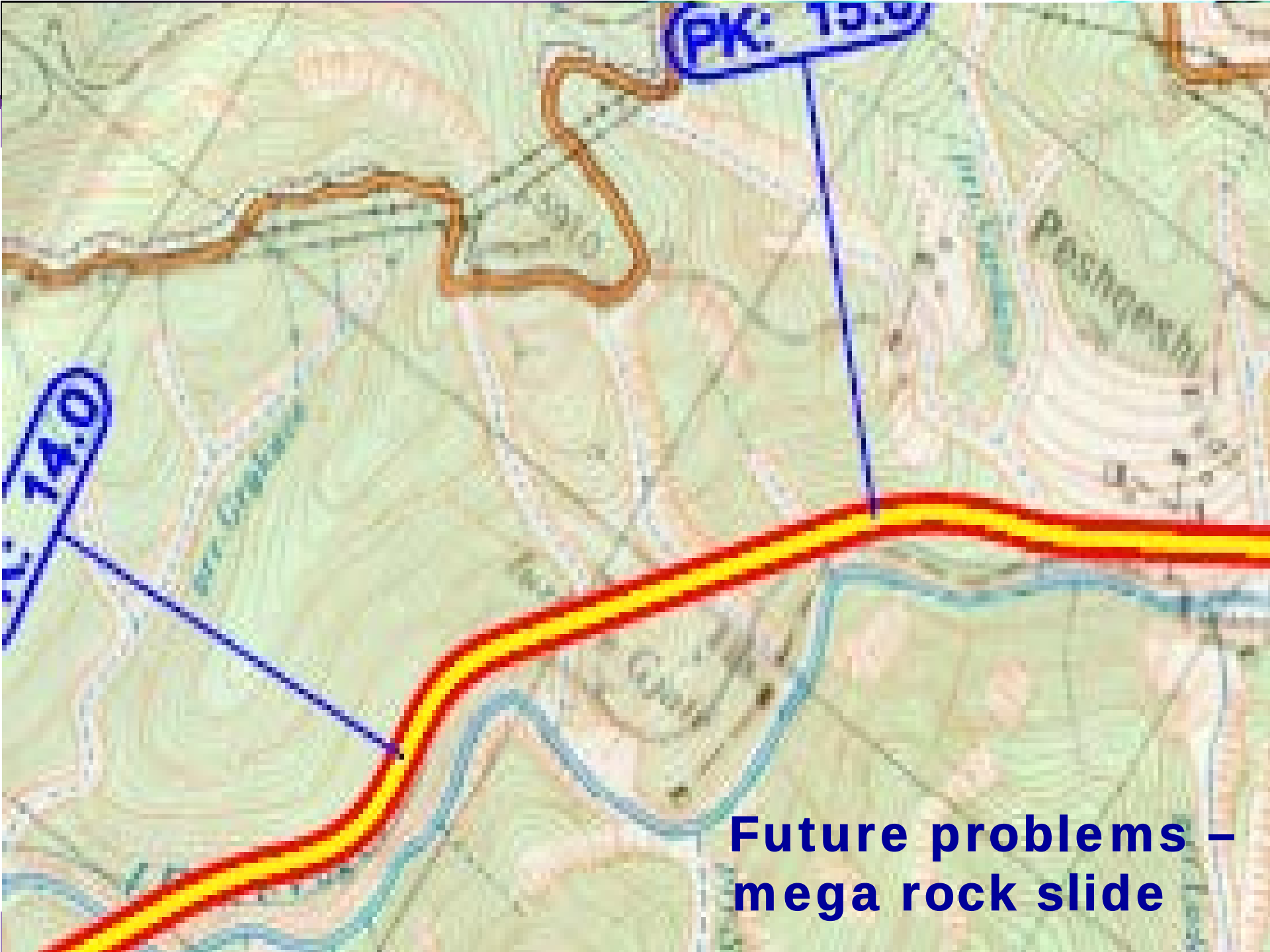
Scale v : 1 - 1000 H : 1 : 1000 at A3

Movement vectors 1:10 at A3

MADE BY NPK 11/6/08

Loss 3 – toe berm to stabilise slope

Future problems – weathered rock – colluvium in cut slopes


PK: 13.9
PK: 14.0
Future problems –
mega rock slide


Future problems –
mega rock slide

Future problems – mega rock slide

Slope degradation observed in Google Earth image

MAIN CONCLUSIONS

Adequacy of SI

- No meaningful desk study – no API
- Geomorphological processes not understood or identified
- Intrusive investigation focussed on structures
- No groundwater monitoring

Causes of failures

- Loss 1 – reactivation of translational slide – possibly periglacial in origin
- Loss 2 – cut through existing active large slope failure
- Loss 3 – cut slope formed in a failed rock mass – wedge failure

Remedial proposals

- Loss 1 – not all weak material removed – possible future movement
- Loss 2 – cut back only a short term solution – ongoing instability of landslide not addressed
- Loss 3 – toe berm solution appears adequate

Future problems

- No geotechnical risk framework
- Re-activation of relict landslides
- Seismically triggered landslides
- Failures in weathered rock slope

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