23.Ch.Veder Kolloquium

Davorin Kolić , Tomislav Ivšić

Neuron Consult ZT Linz-Pasching , University Zagreb Faculty for Civ.Engineering

Sondermassnahmen beim Light Rail Zagreb Projekt

Graz, 28.04.2008

Sadržaj

1. Einführung / Introduction

Light Rail Projekt Zagreb

4 Linienvarianten wurden entwickelt (2005-2006):

Var.0 : Korridors lt. Stadtplan GUP2003 + Straßenbahn

Var.1 : LRP Führung als „Light-rail“ + Straßenbahn

Var.2 : LRP Führung als Eisenbahn + Eisenbahn

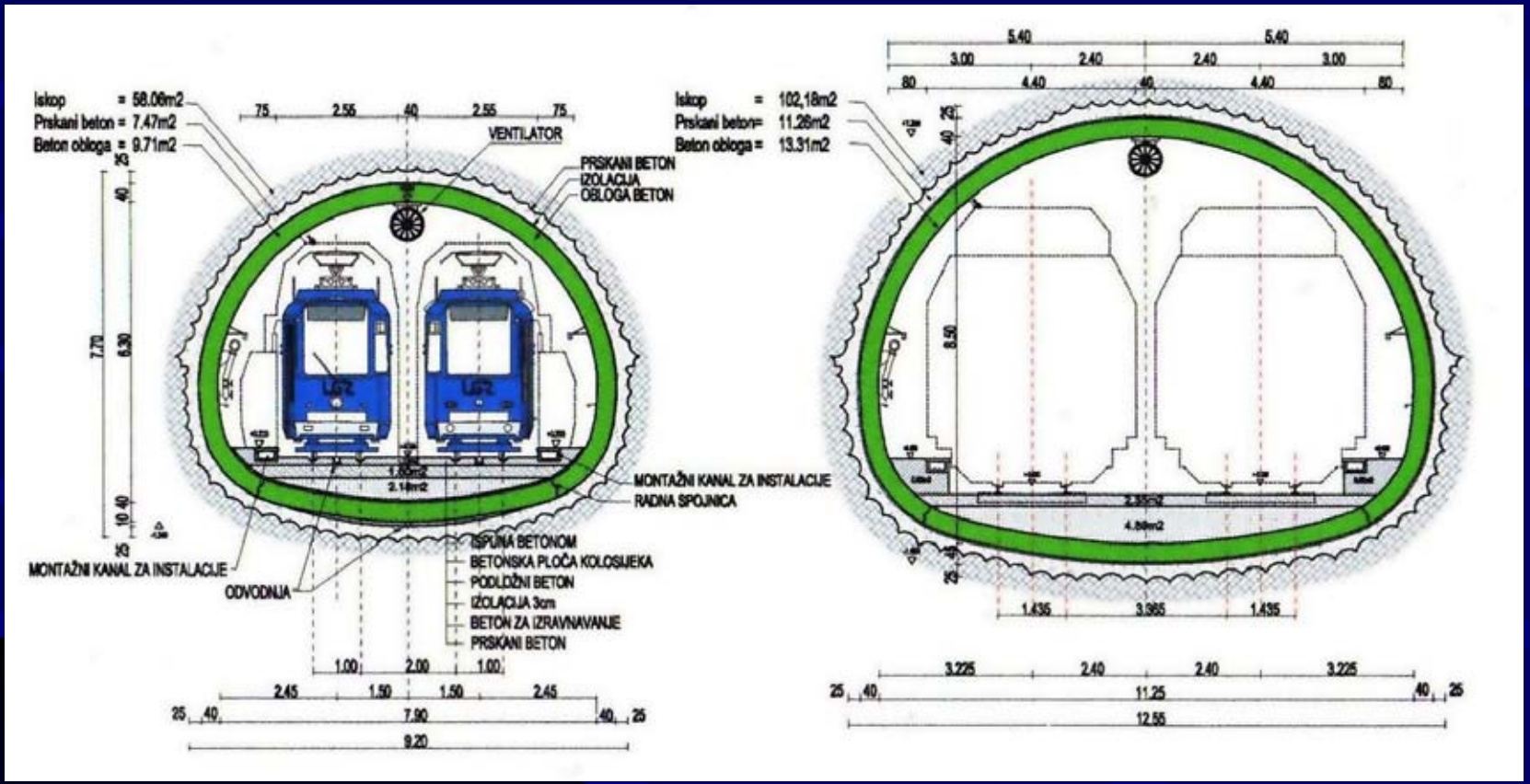
Var.3 : LRP Netz als Straßenbahn

2. Projekt Light Rail Zagreb

Variante 1.1 : LRP + Straßenbahnteile

2. Projekt Light Rail Zagreb

Tunnelvarianten



Zweigleisig , 1000 mm

Ausbruchsfläche = 58 m2

Baukosten = 29.500 € / m

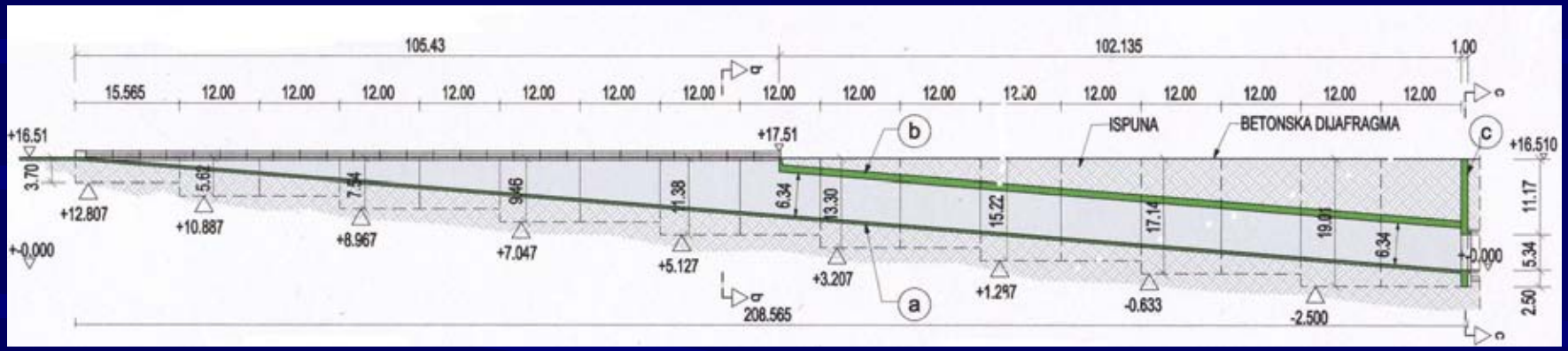
Zweigleisig, 1435 mm

Ausbruchsfläche = 102 m2

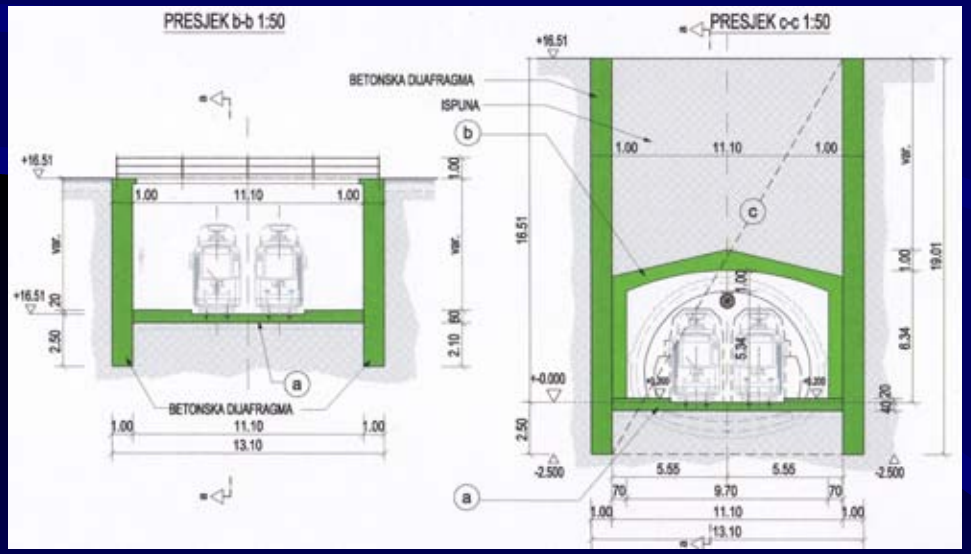
Baukosten = 47.500 € / m

2. Projekt Light Rail Zagreb

Rampe, Offene Bauweise



Längsschnitt



Querschnitte

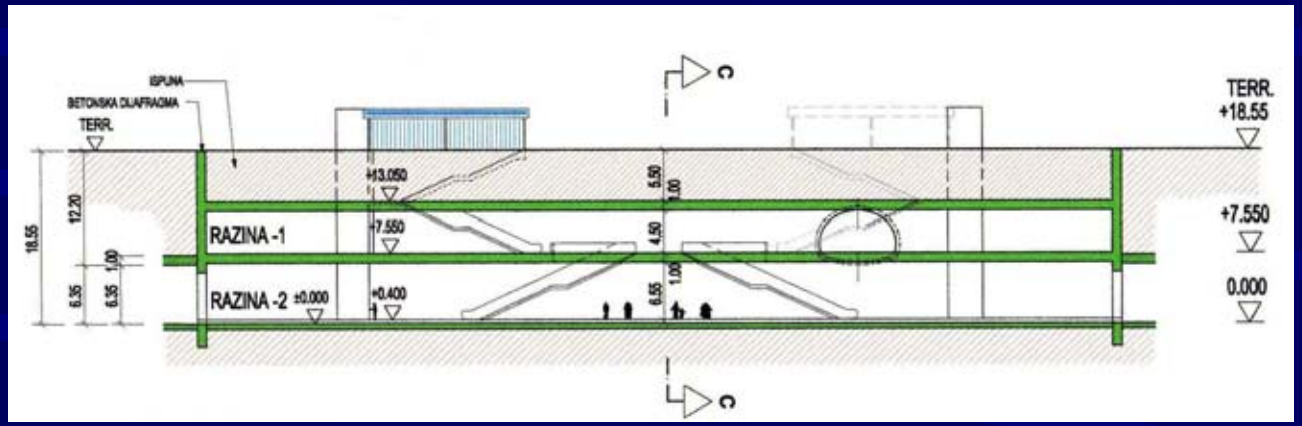
Baukosten :

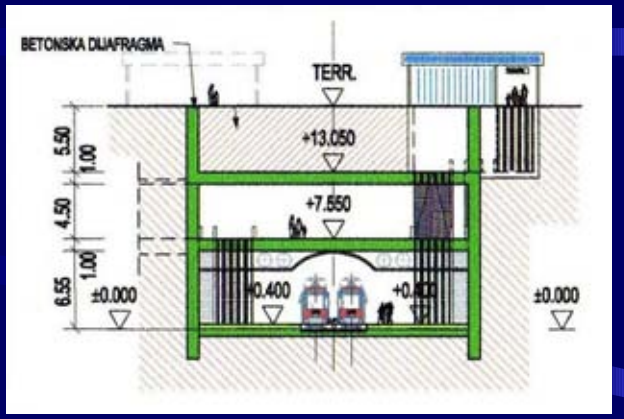
1 Rampe = 4.500.000 €

= 32 000 000 KN

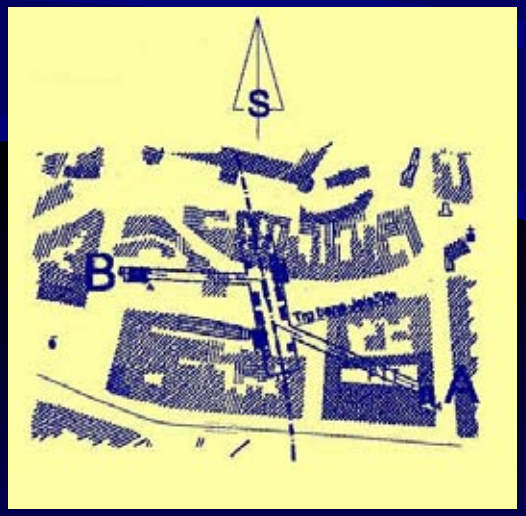
2. Projekt Light Rail Zagreb

Station , Offene Bauweise

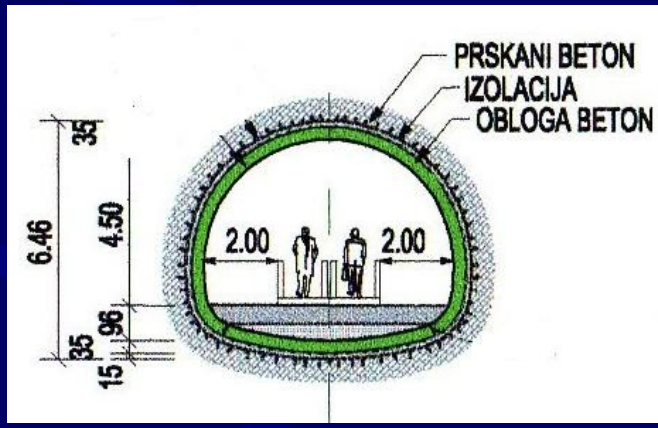




Schnitte



Fußgängertunnel



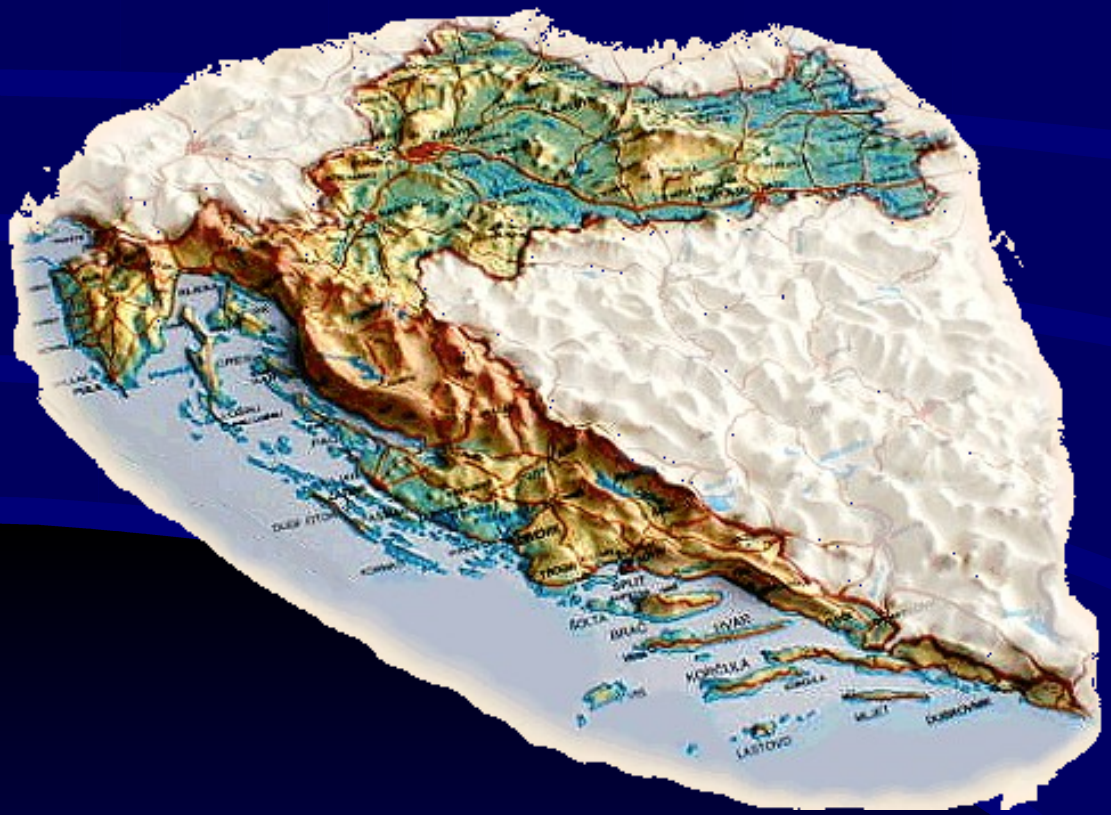
Lokation :

nähe Hauptplatz

Baukosten = 5.500.000 €

= 41.000.000 KN

1. Croatia – major natural regions

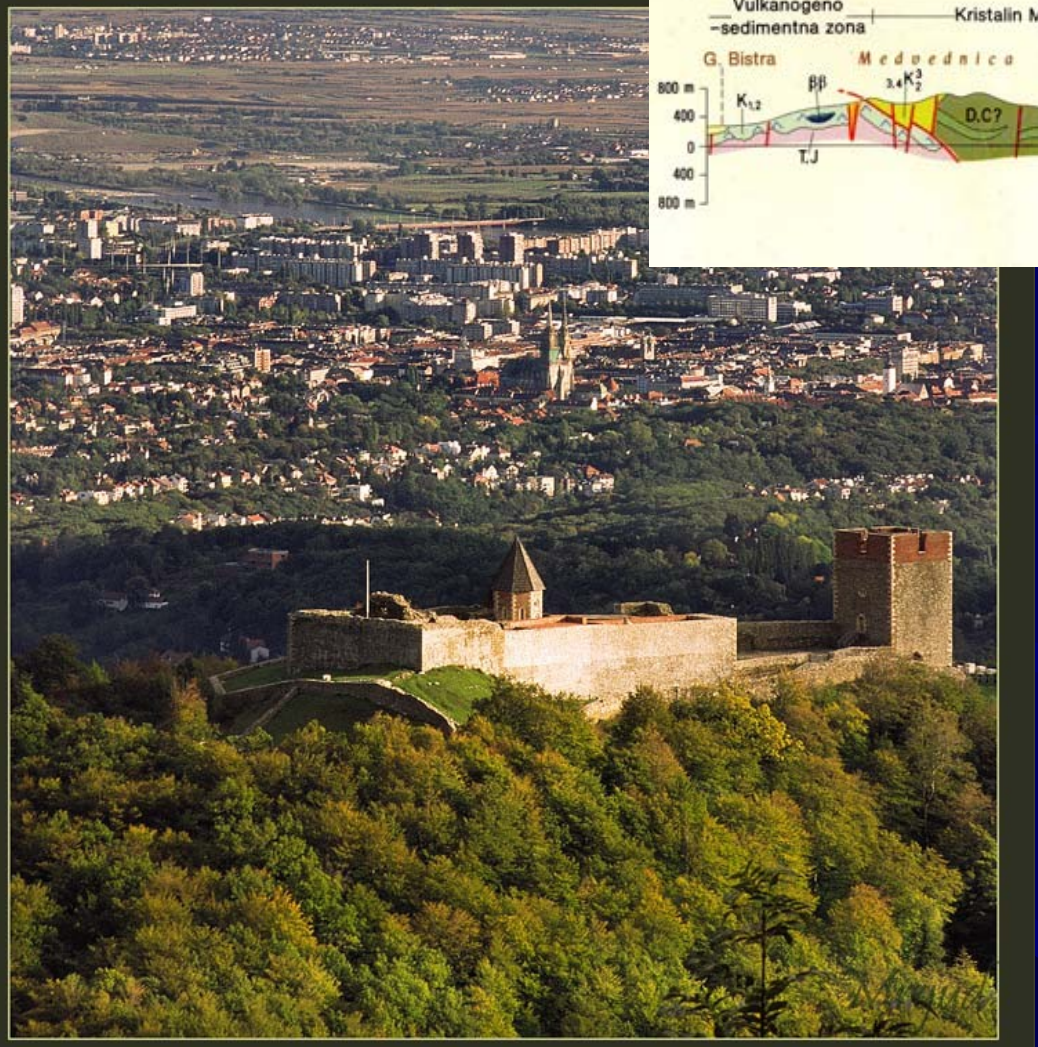


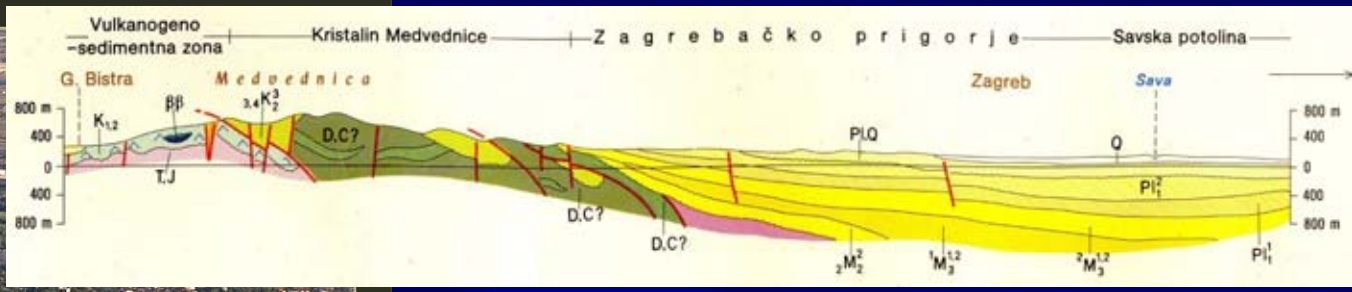
N – NE : Panonian and Peri-Panonian area; lowland and hills; rivers

MIDDLE: hilly and mountainous area; Dinara mountains belt; karst region

S-SW : Adriatic Area – narrow coastal belt and islands; highly karstified

2. Zagreb – relief

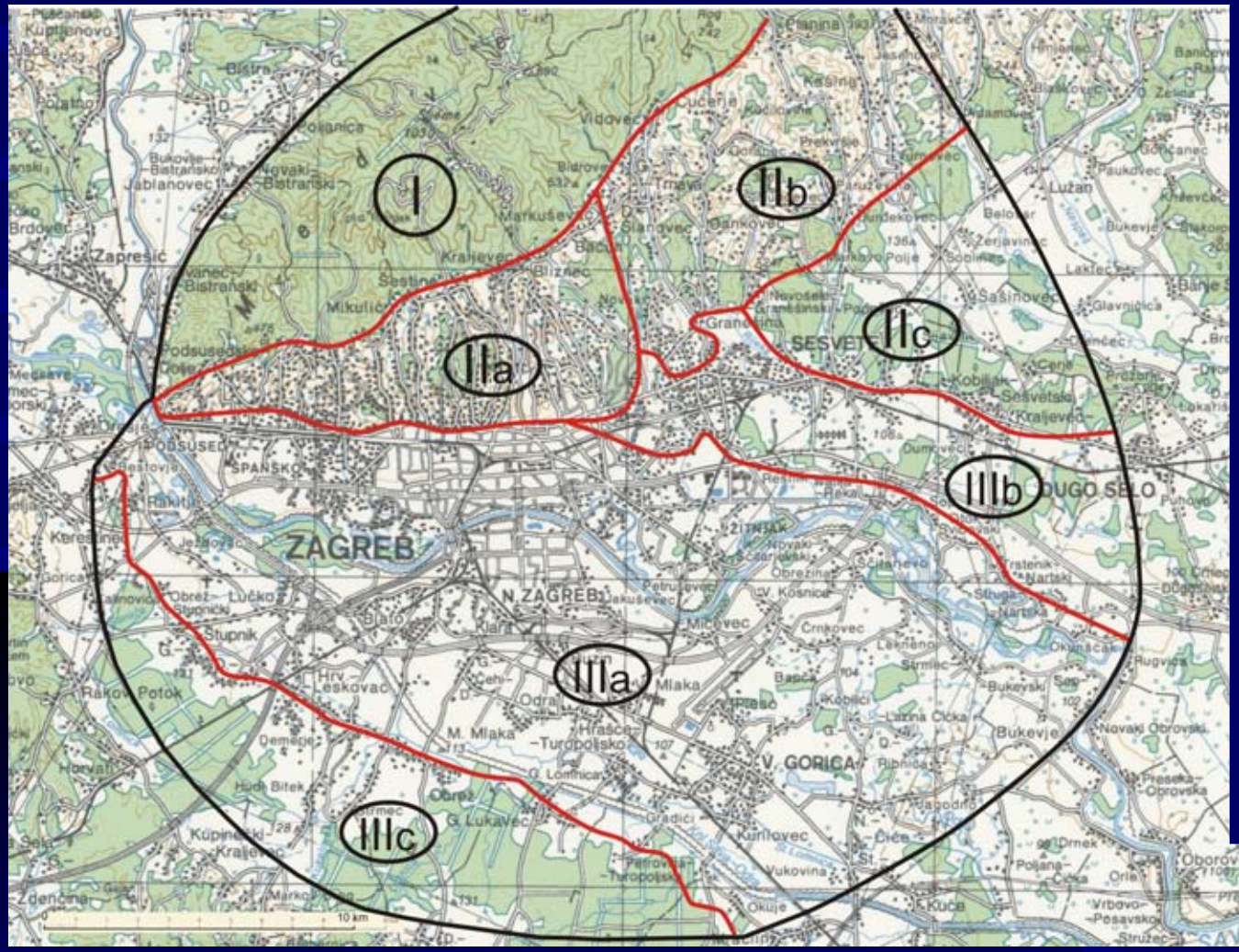




View from the mountain Medvednica:

- **mountain core**
- **Zagreb foothills**
- **River Sava valley**

3. Zagreb – major geologic-topographic regions



Macrozones:

I – Mountain core

II – Foothills

a) young deposits (neogen, older Q)

b) Faulting in neogen

c) Raise of older Q and creek deposits

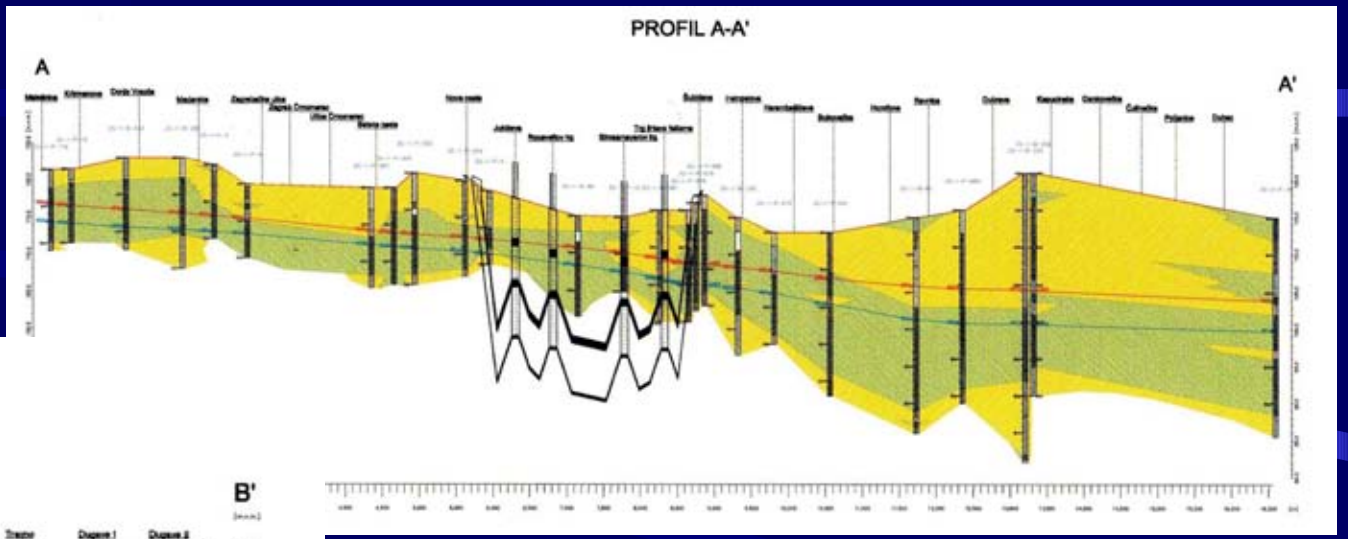
III – river Sava aluvion

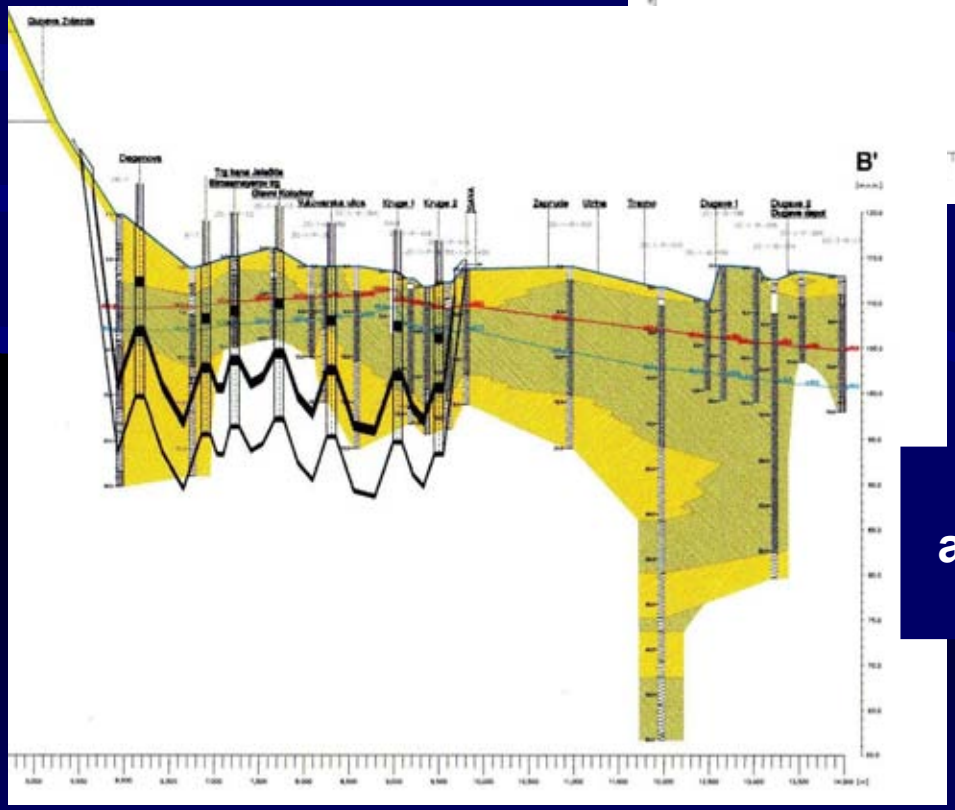
a) River deposits

b) and c) Terraces

4. Hydro-geological longitudinal sections LR

East - West section

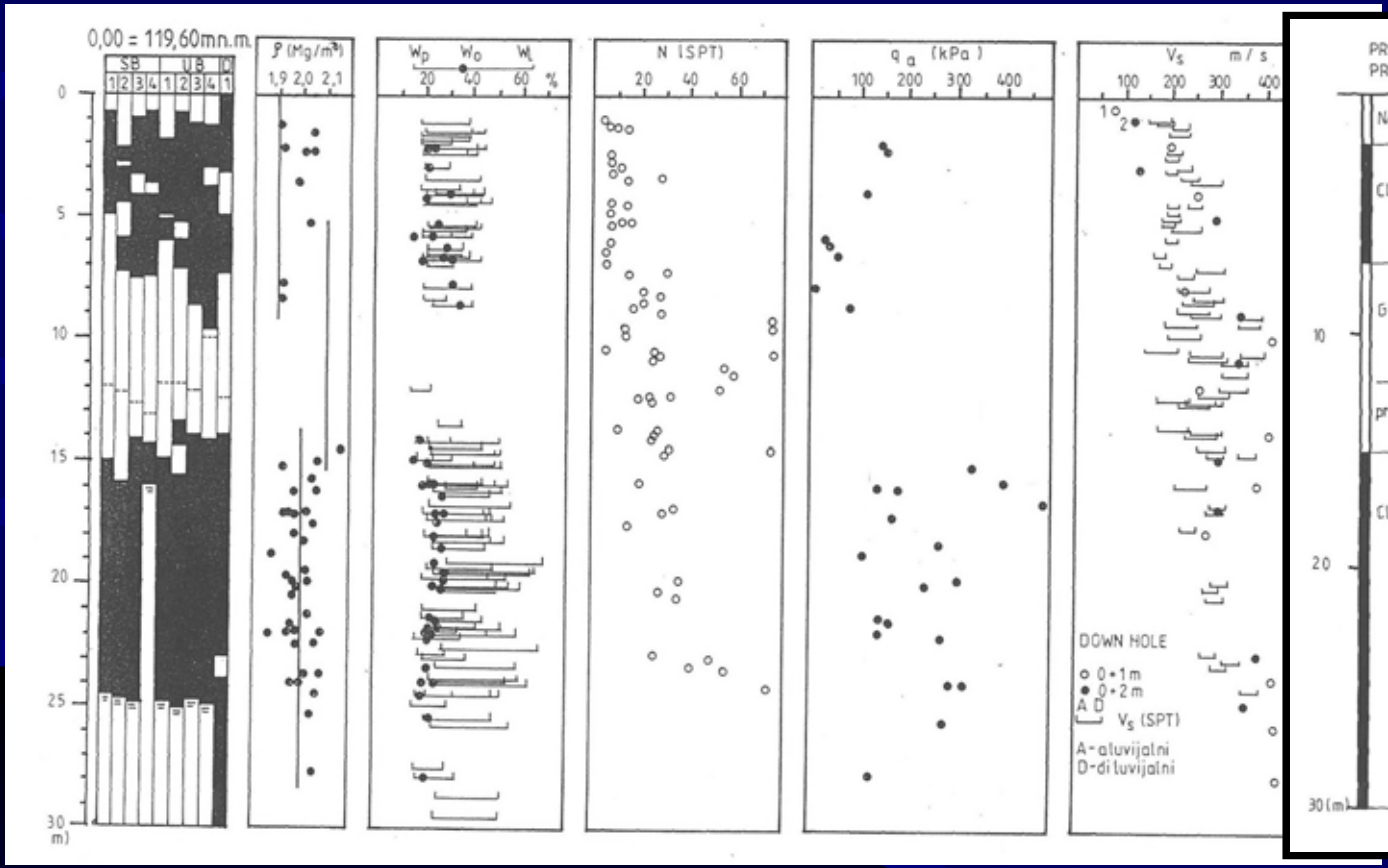


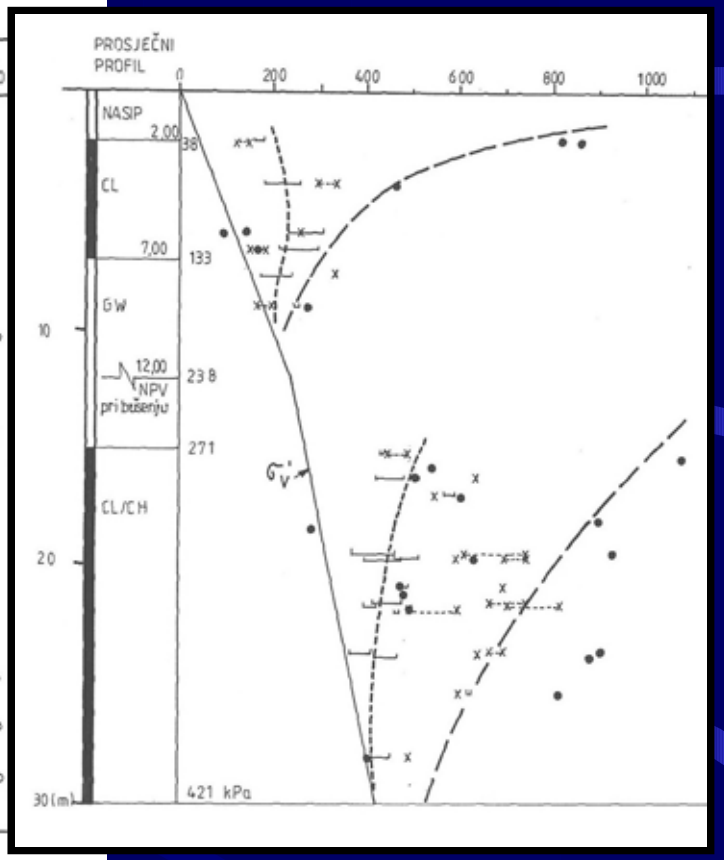


North – South section

Required additional investigation works and deep boreholes on underground parts of the alignment.

5. Geotechnical features of deep soil profiles



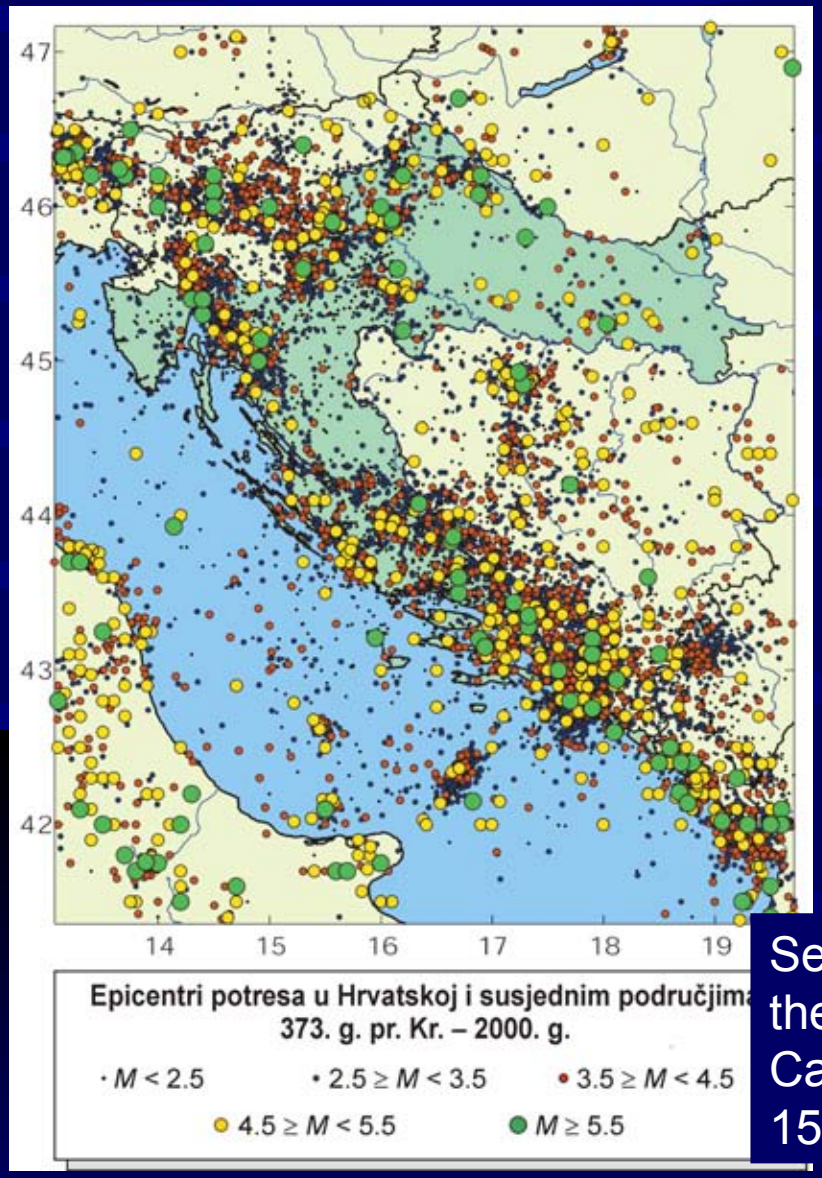


Overconsolidated (deep) clay - CH, possible surface of paleorelief

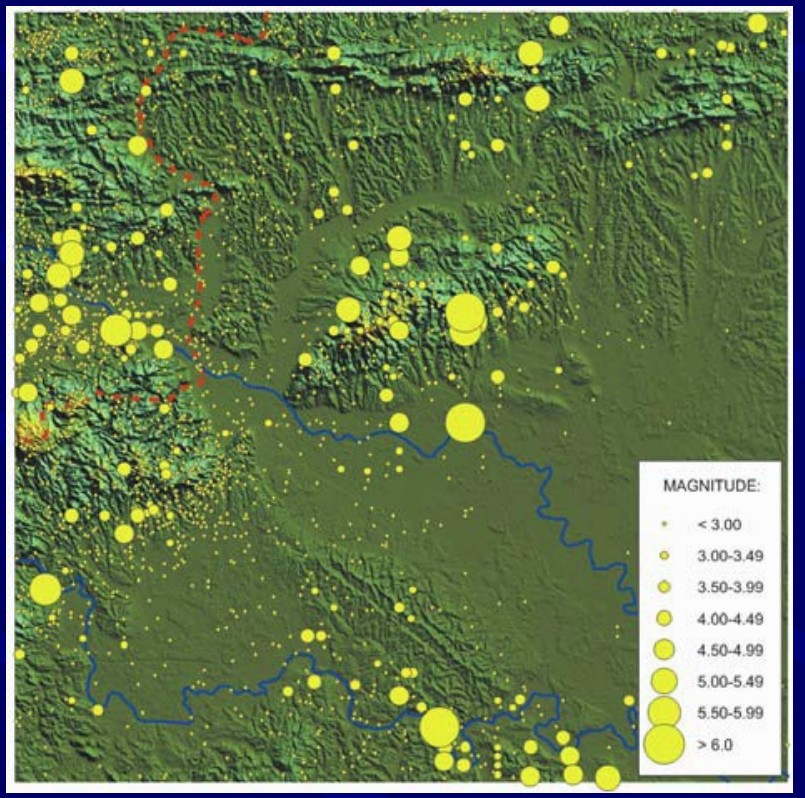
6. Major geohazards in Zagreb

- Earthquakes: max. expected magnitude-over M = 6.5
  - Seismic forces on structures - design PGA 0.25-0.30 g
  - Soil instabilities: sand liquefaction, induced landslides
- Landslides
- Flood and torrents

7. Earthquakes – historical seismicity

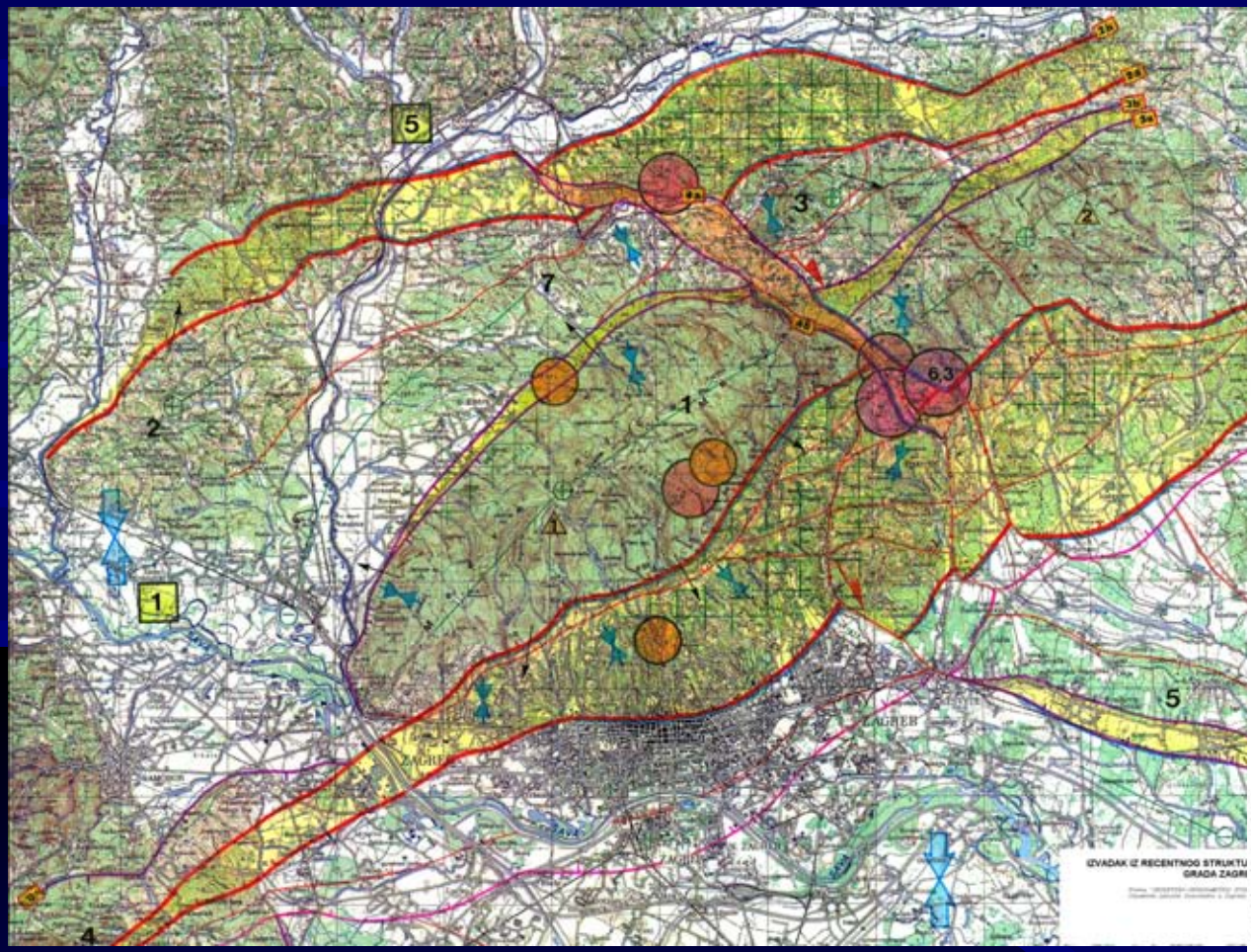


Zagreb and surroundings

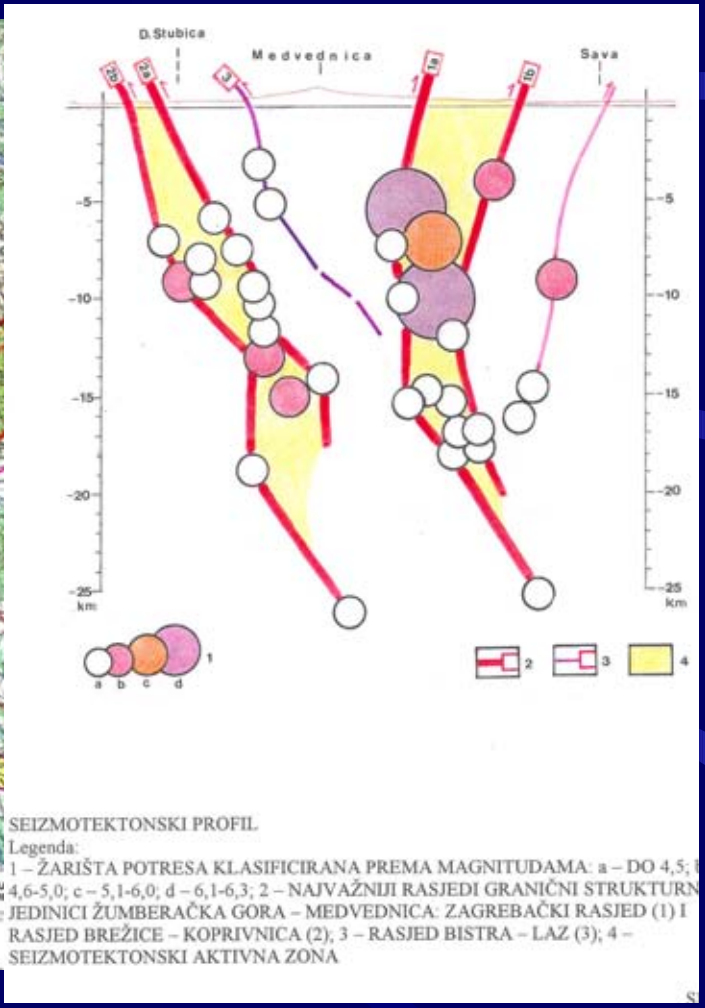


Seismicity of Croatia after the Croatian Earthquake Catalogue that lists over 15.000 events

8. Zagreb - Tectonics and seismicity



Major fault zones



SEIZMOTEKTONSKI PROFIL

Legenda:

1 – ŽARIŠTA POTRESA KLASIFICIRANA PREMA MAGNITUDAMA: a – DO 4,5; b – 4,6-5,0; c – 5,1-6,0; d – 6,1-6,3; 2 – NAJVAŽNIJI RASJEDI GRANIČNI STRUKTURNIM JEDINICI ŽUMBERAČKA GORA – MEDVEDNICA: ZAGREBAČKI RASJED (1) I RASJED BREŽICE – KOPRIVNICA (2); 3 – RASJED BISTRA – LAZ (3); 4 – SEIZMOTEKTONSKI AKTIVNA ZONA

Depth profile

9. Historical events – Zagreb, 1880. M ~ 6.3


Beschreibung des großen
„Erdbebens“
in Agram, der Hauptstadt Kroatiens,
welches sich in der ersten Hälfte des Monates November 1880 ereignete.
(Auszug.)

Reports in European newspapers

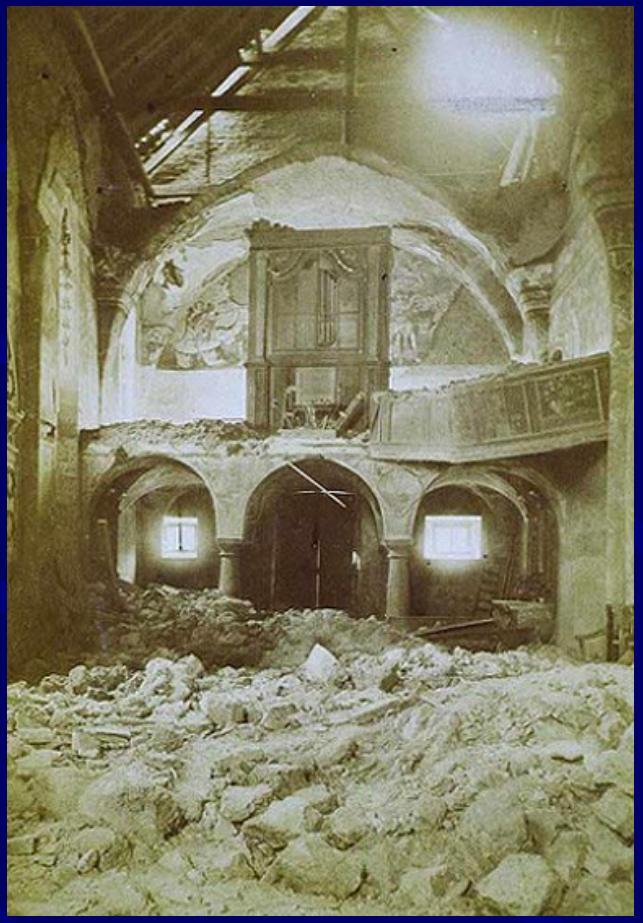
9. Historical events – Zagreb, 1880.

Zagreb. Katedrala s Kaptolom prije potresa god. 1880.
Die Domkirche mit Kaptol vor dem Erdbeben im Jahre 1880.

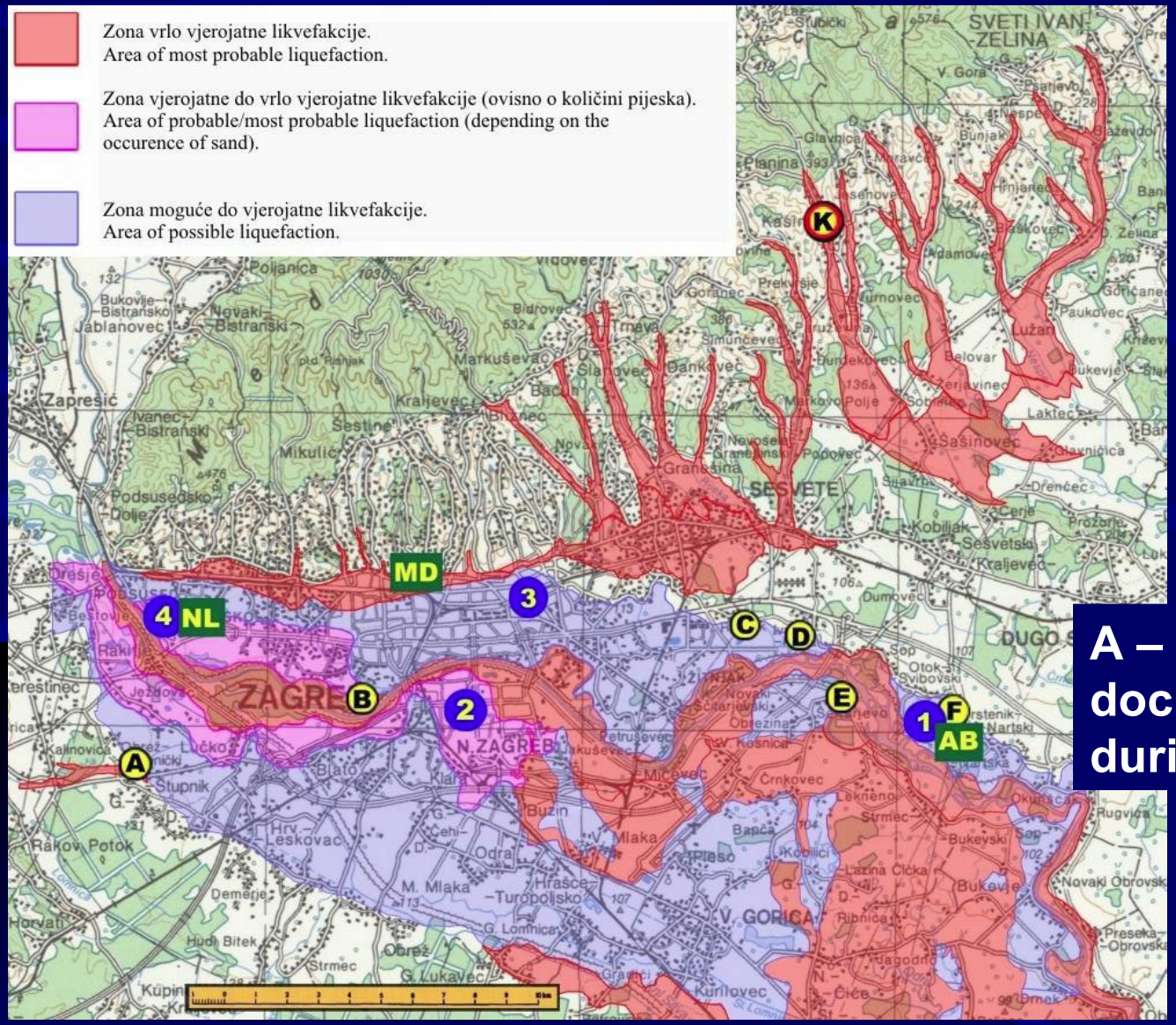
The Cathedral and the bell-tower were heavily damaged

9. Historical events – Zagreb, 1880.

Over 90% of buildings had damages (of various degree)



10. Potentially liquefiable soils

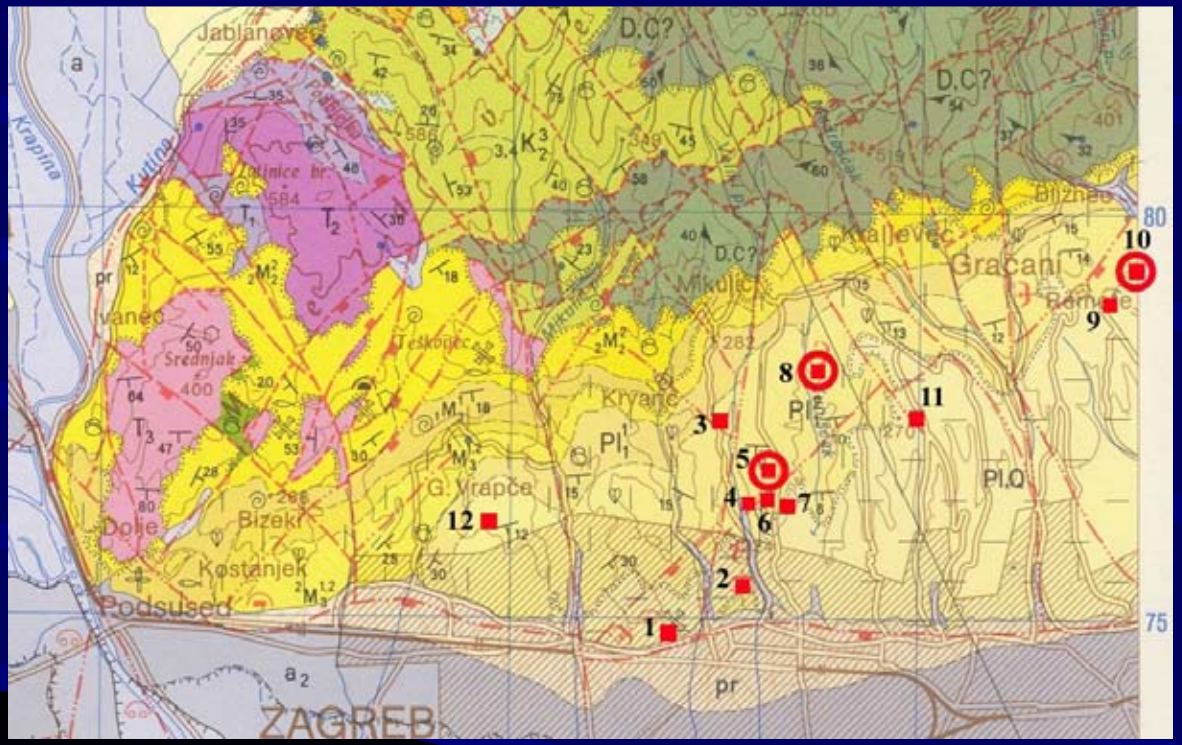


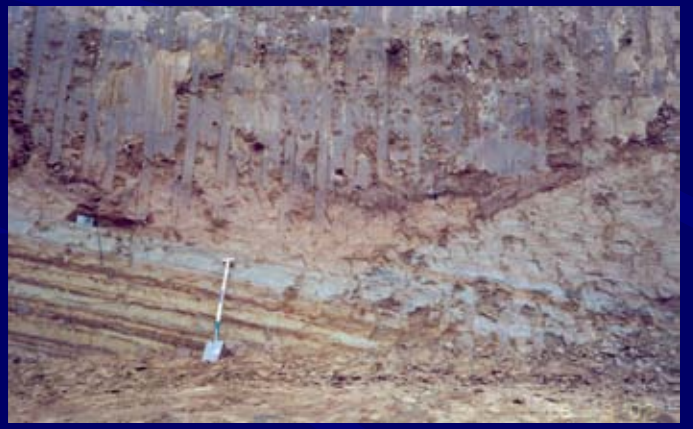
Most vulnerable soils – water saturated loose uniform sands

A – E locations with documented liquefaction during 1880. earthquake

11. Landslides

Large landslides along the secondary fault





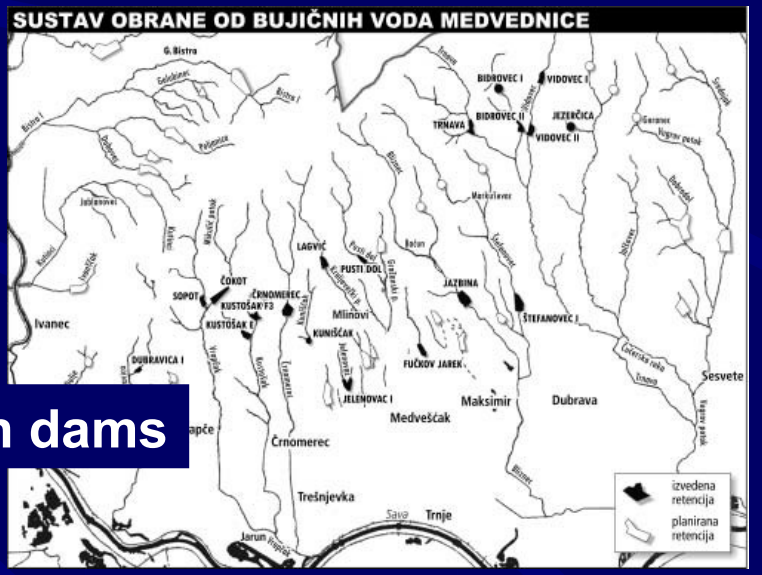
Basic landslide causes: tectonics, layers of high plasticity (blue/grey) clay, high underground water levels, human activities

- Over 700 registered landslides and unstable slopes in Medvednica foothill

12. Floods and torrents

Sava meanders in old Katastar

Regulated river bed

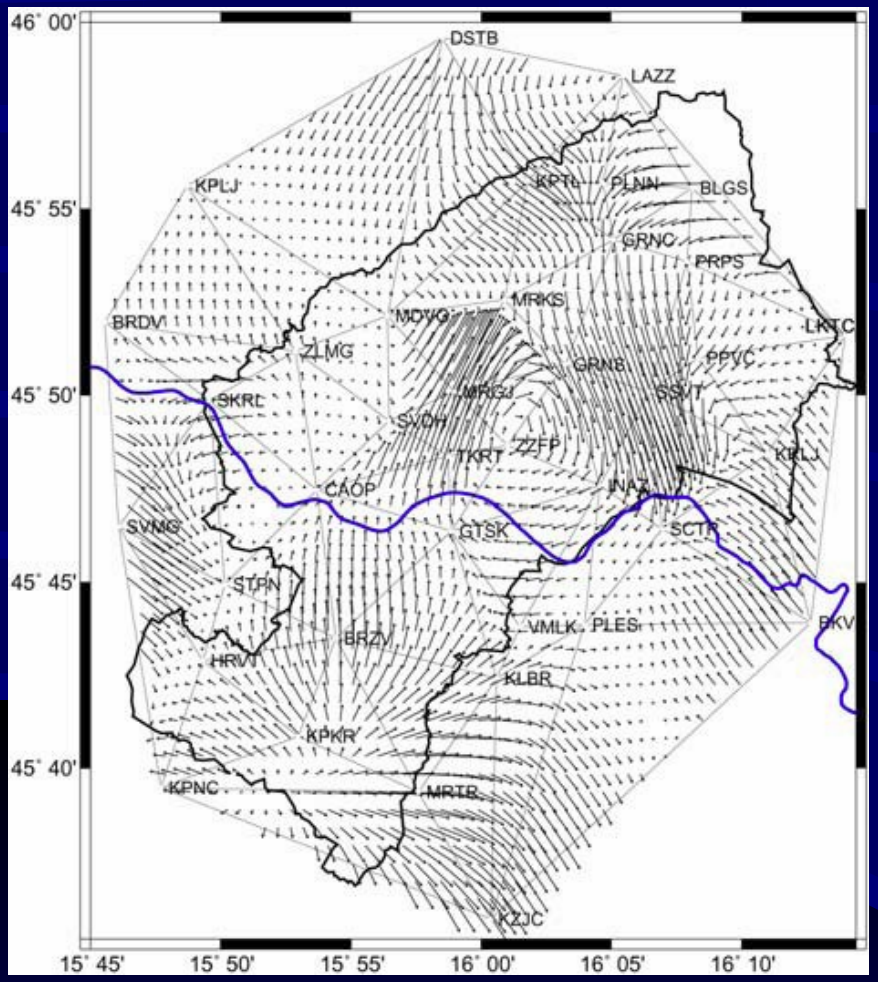


Rapid mountain streams – flood protection dams

13. Current and recent activities

- “Geodynamic” study – long term GPS survey of tectonic movements
- Microtremor (ambient noise) measurements – a method for possible seismic microzonation and estimate of vulnerability of existing buildings
- Comprehensive geological and engineering gelogy mapping for geotechnical categorization and seismic microzonation

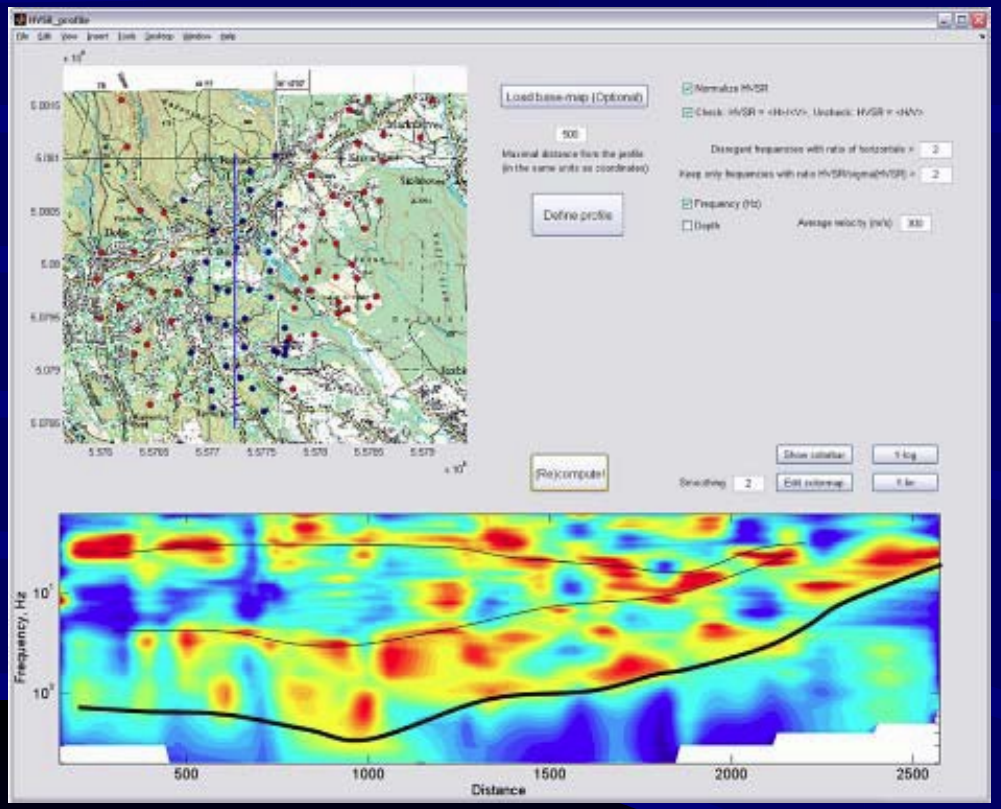
14. Geodynamic study



Vector field – 9 years measurements

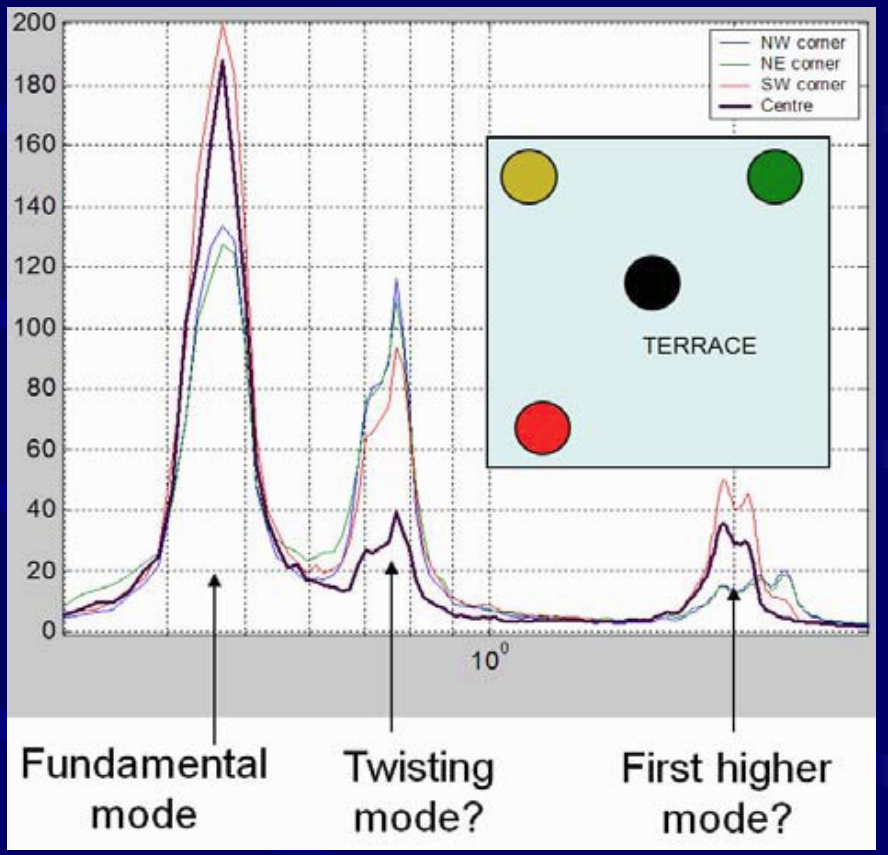
Cracks in buildings on faults

15. Microtremor measurements



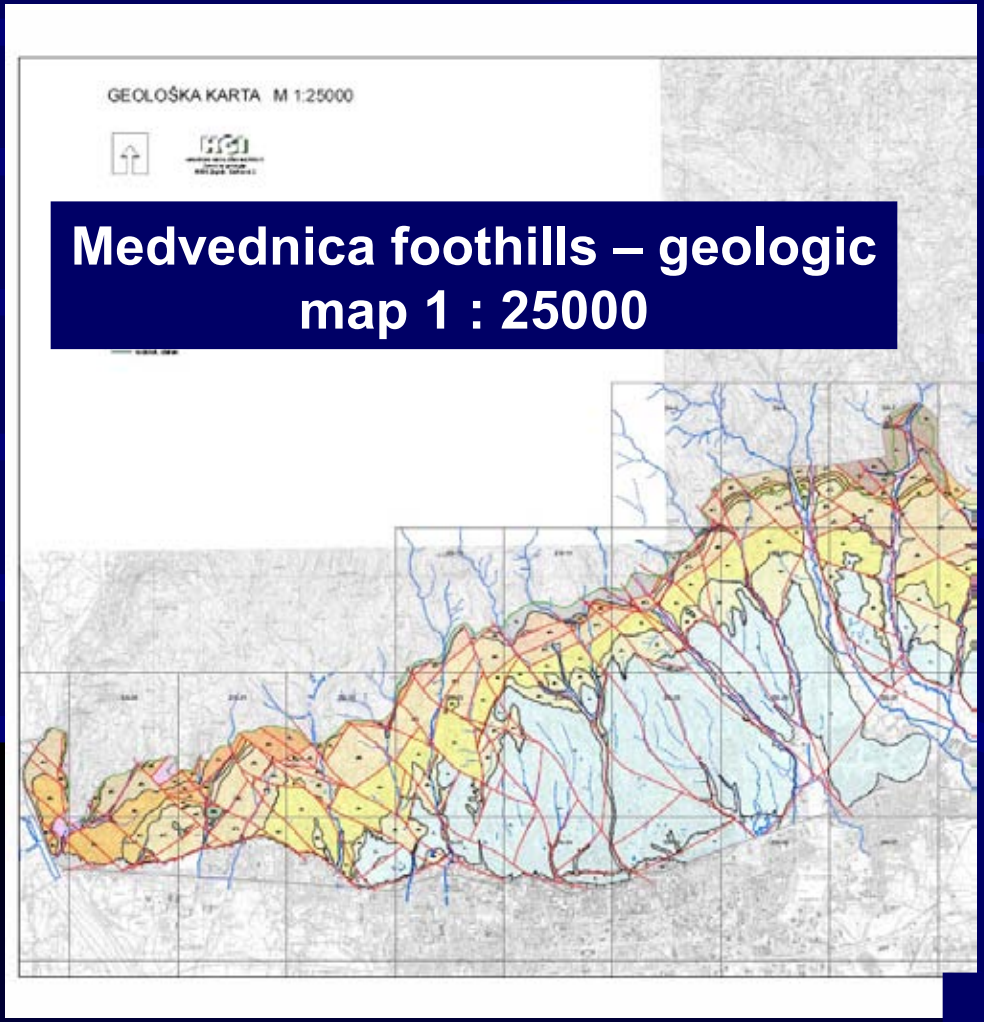
Microtremor profiling

N-S frequency spectrum

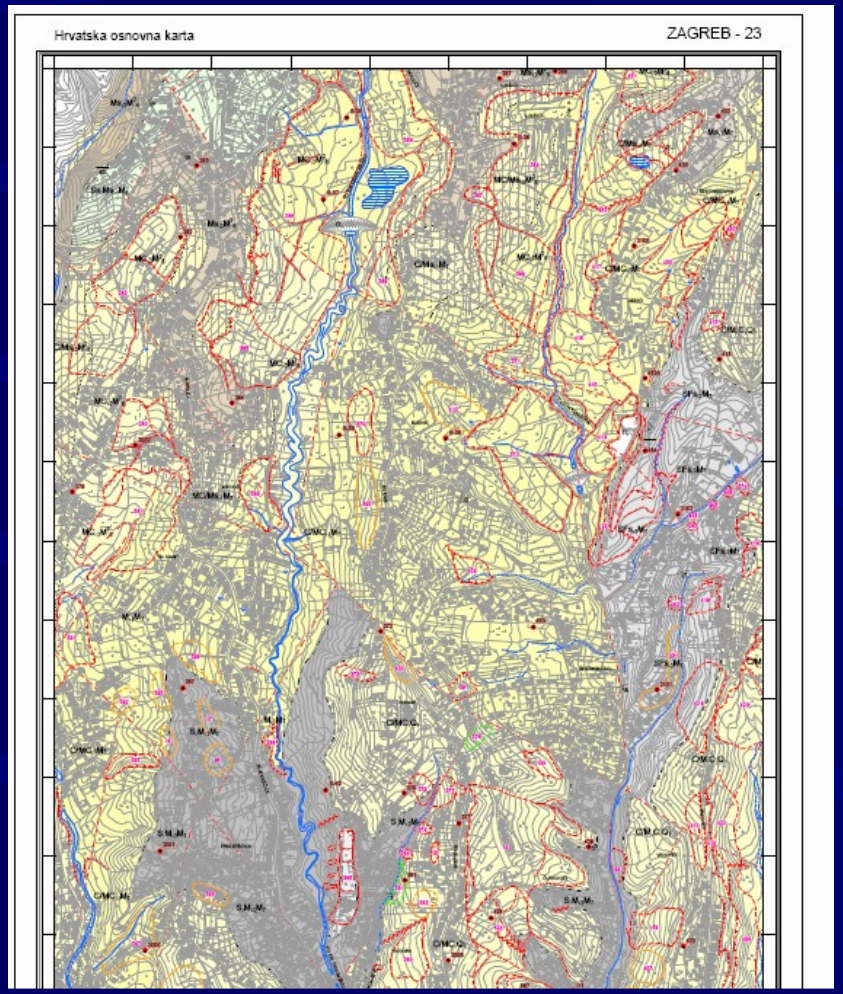


Measured frequencies of high building

16. Mapping for microzonation



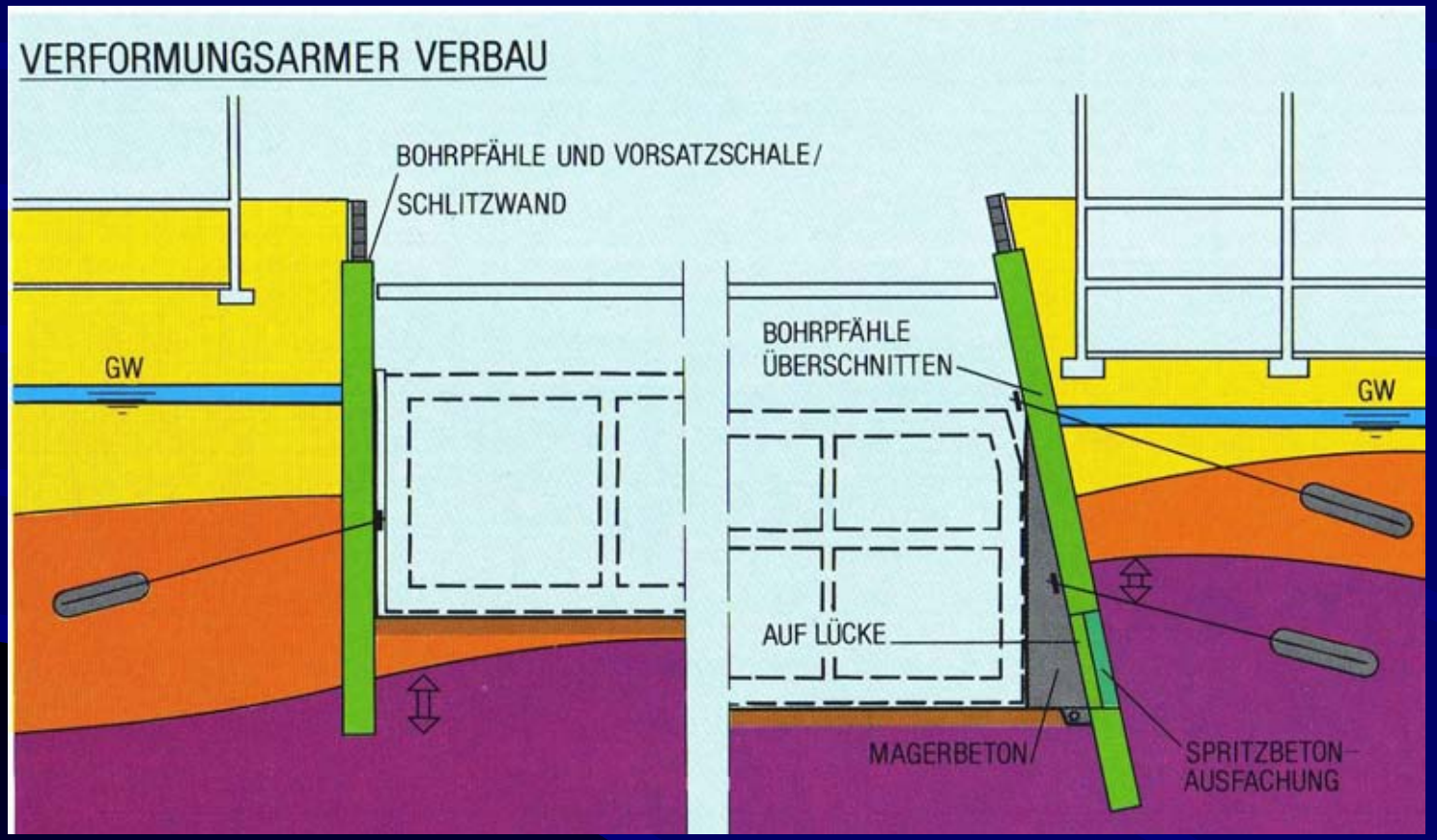
Medvednica foothills – geologic map 1 : 25000



Medvednica foothills – engineering geology map 1 : 5000

4. Vorgeplante Sondermaßnahmen

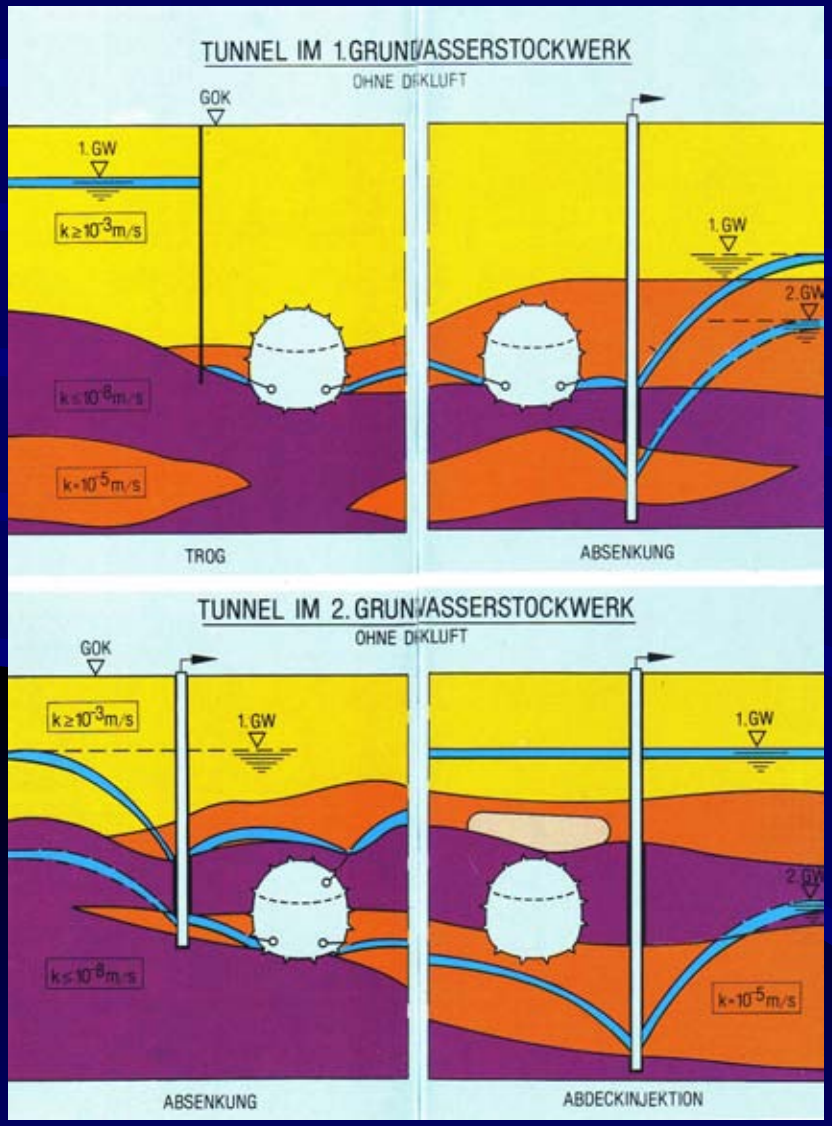
Offene Bauweise



Überschnittene Bohrpfähle oder Schlitzwände :
wasserdicht und / oder mit Spritzbetonausführung

4. Vorgeplante Sondermaßnahmen

Grundwasserabsenkung



Mehrere Grundwasserstockwerke

Wasserabsenkung :

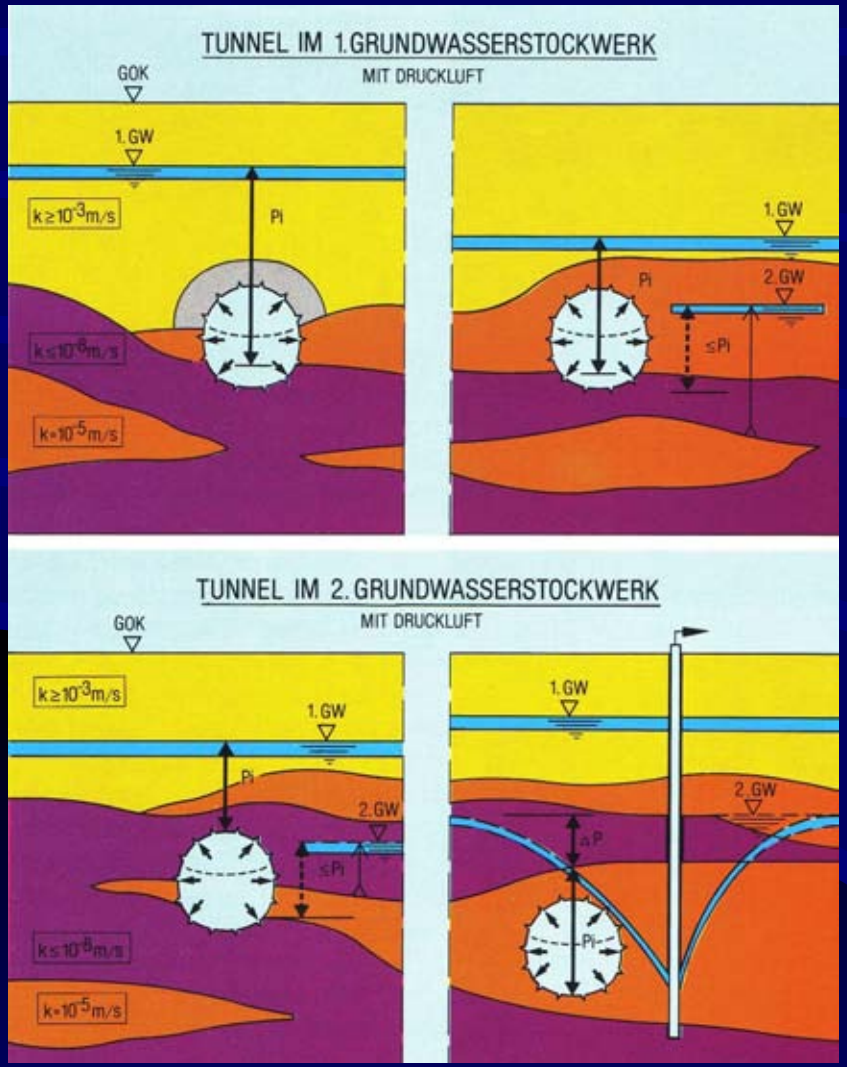
Trog

norm.Absenkung

Abdeckinjektion

4. Vorgeplante Sondermaßnahmen

Tunnelbau mit Druckluft



Tunnelvortriebe

unter Druckluft

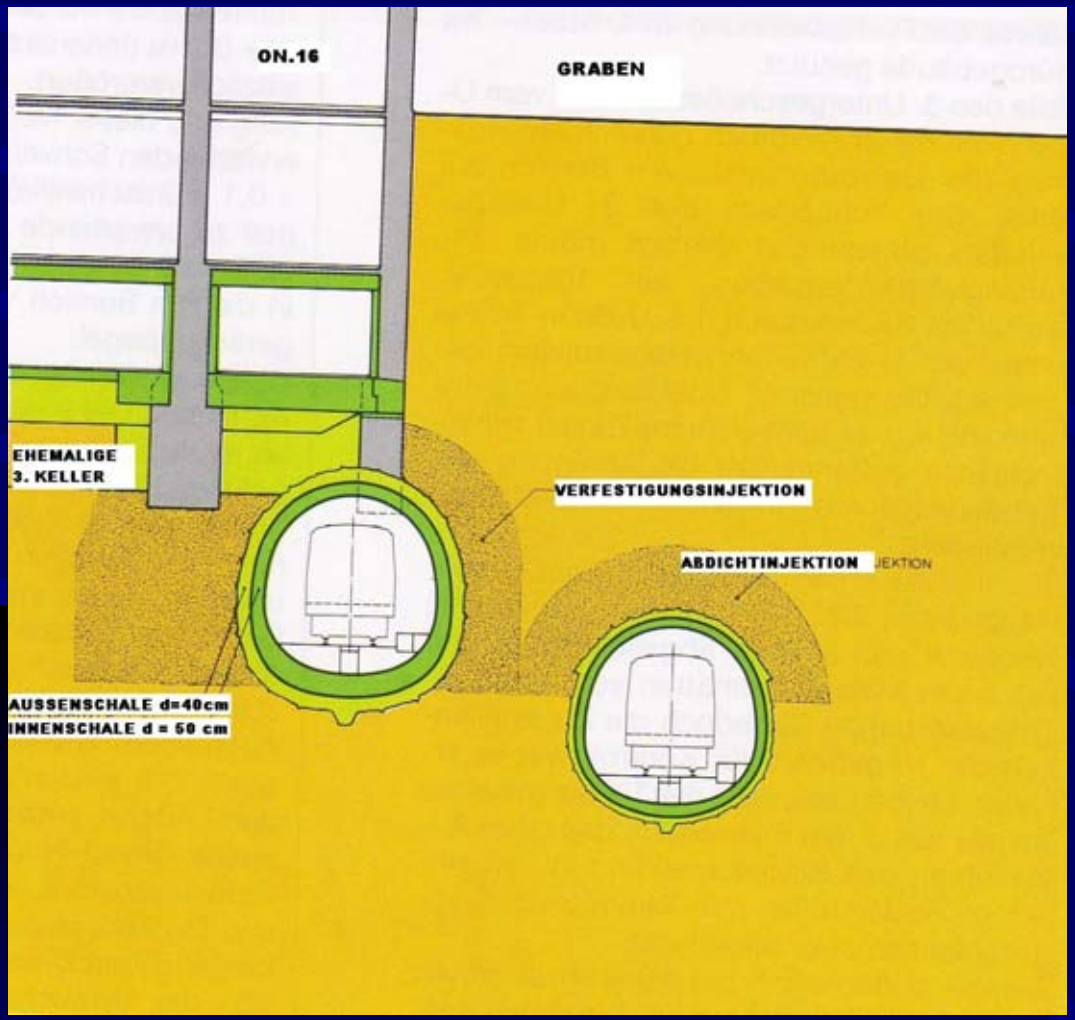
NÖT

und

TVM Vortriebe

4. Vorgeplante Sondermaßnahmen

Injektionen



Tunnelvortriebe

unter Druckluft

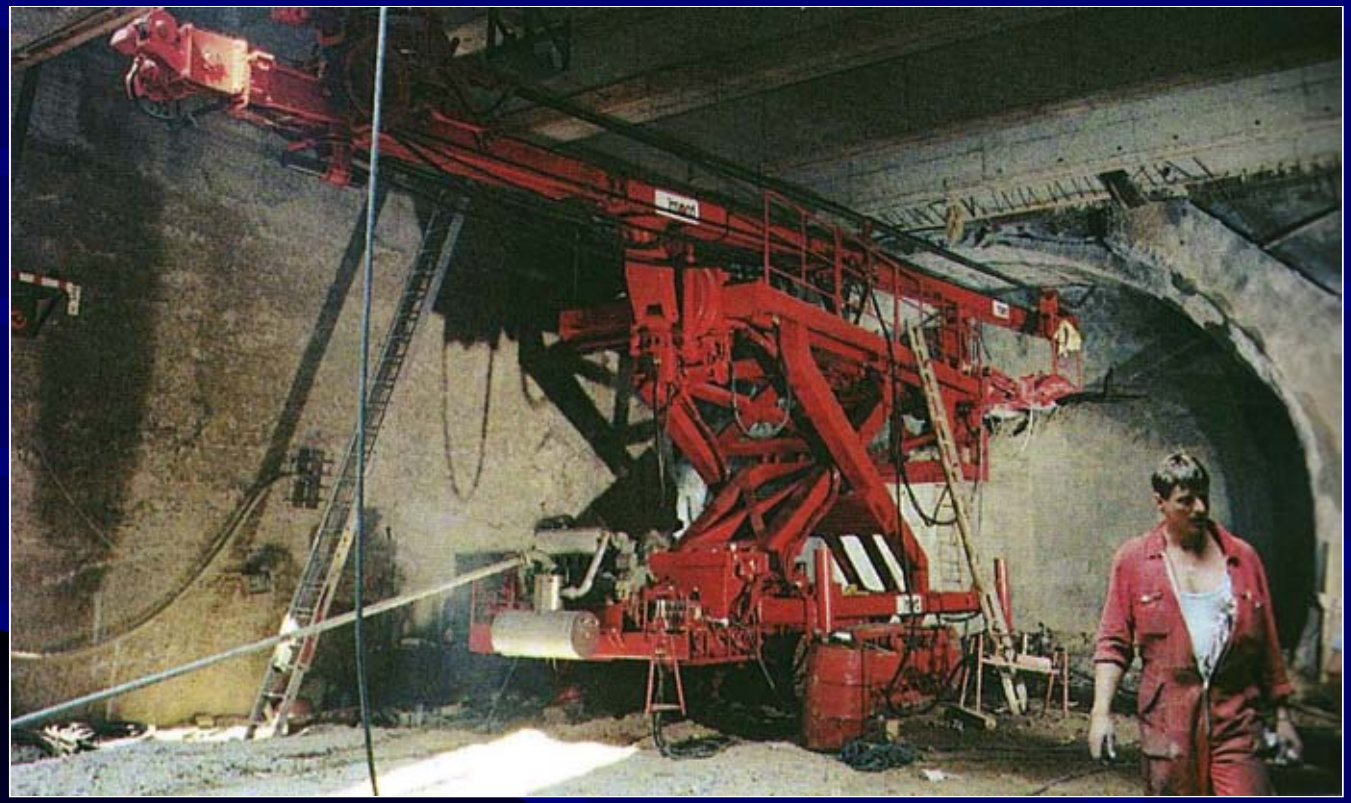
NÖT

und

TVM Vortriebe

4. Vorgeplante Sondermaßnahmen

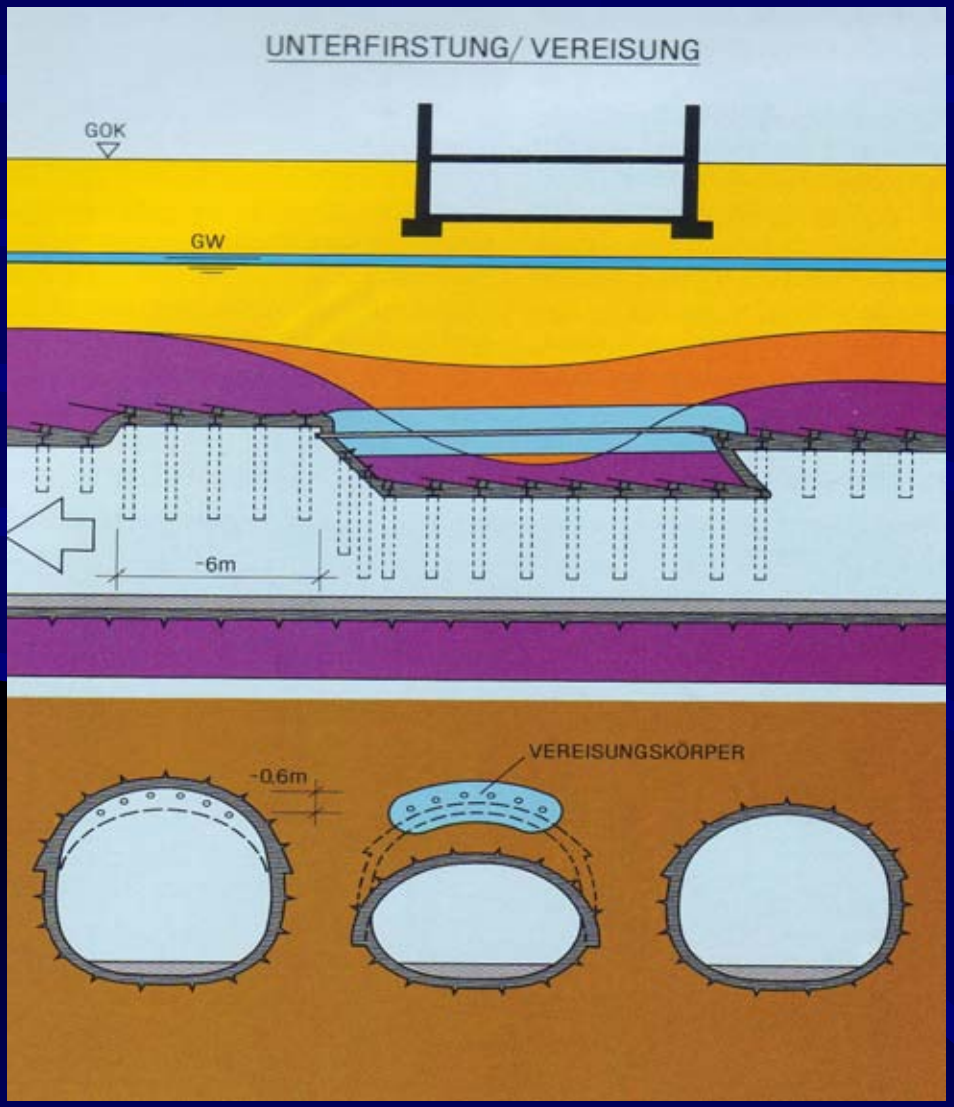
HDBV Pfähle



Großgerät bei der Arbeit.

4. Vorgeplante Sondermaßnahmen

Bodenvereisung



Unterfirstung

und

Vereisung

5. Zusammenfassung

Bauzeitplan : Ost -West

1. Phase : 2.6 km - 116.7 mil.€ - 24 Mo.
2a Phase : 2.7 km - 15.2 mil.€ - 8 Mo.
2b Phase : 2.4 km - 98.9 mil.€ - 24 Mo.

3a Phase : 3.5 km – 22.3 mil.€ - 10 Mo.
Depot Špansko : 20.000.000 €
3b Phase : 2.3 km – 15.5 mil.€ - 7 Mo.

5. Zusammenfassung

Bauzeitplan : Nord - Süd

2. Phase : 3.3 km – 136.4 mil.€ - 30 Mo.

3a Phase : 1.8 km – 41.0 mil.€ - 24 Mo.

3b Phase : 2.1 km – 26.0 mil.€ - 12 Mo.

Depot Dugave : 20.000.000 €

5. Zusammenfassung

- Projekt ist notwendig für weitere Stadtentwicklung.

- Erwartete Privatfinanzierung (Konzession, PPP)
- Baukosten :
  - Var.1. : 600 Mill.€ (Light-Rail + Straßenbahn)
  - Var.2. : 1.300 Mill.€ (Eisenbahn)

- Wird von ¼ Bevölkerung der Republik Kroatiens benützt

- Hauptinfrastrukturprojekt der Stadt Zagreb für die nächste Zeitperiode von 25 Jahren.