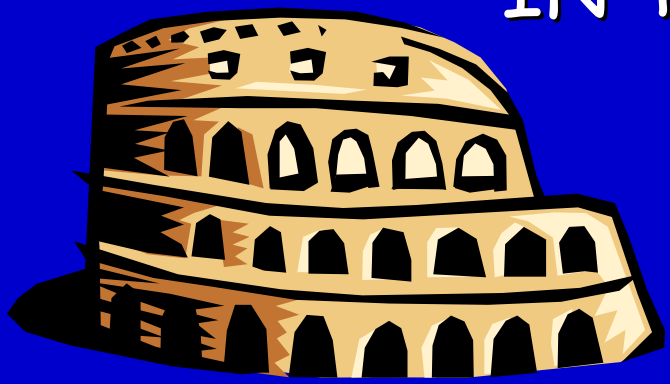
HIGH-DENSITY MACROSEISMIC SURVEY IN THE CITY OF ROME



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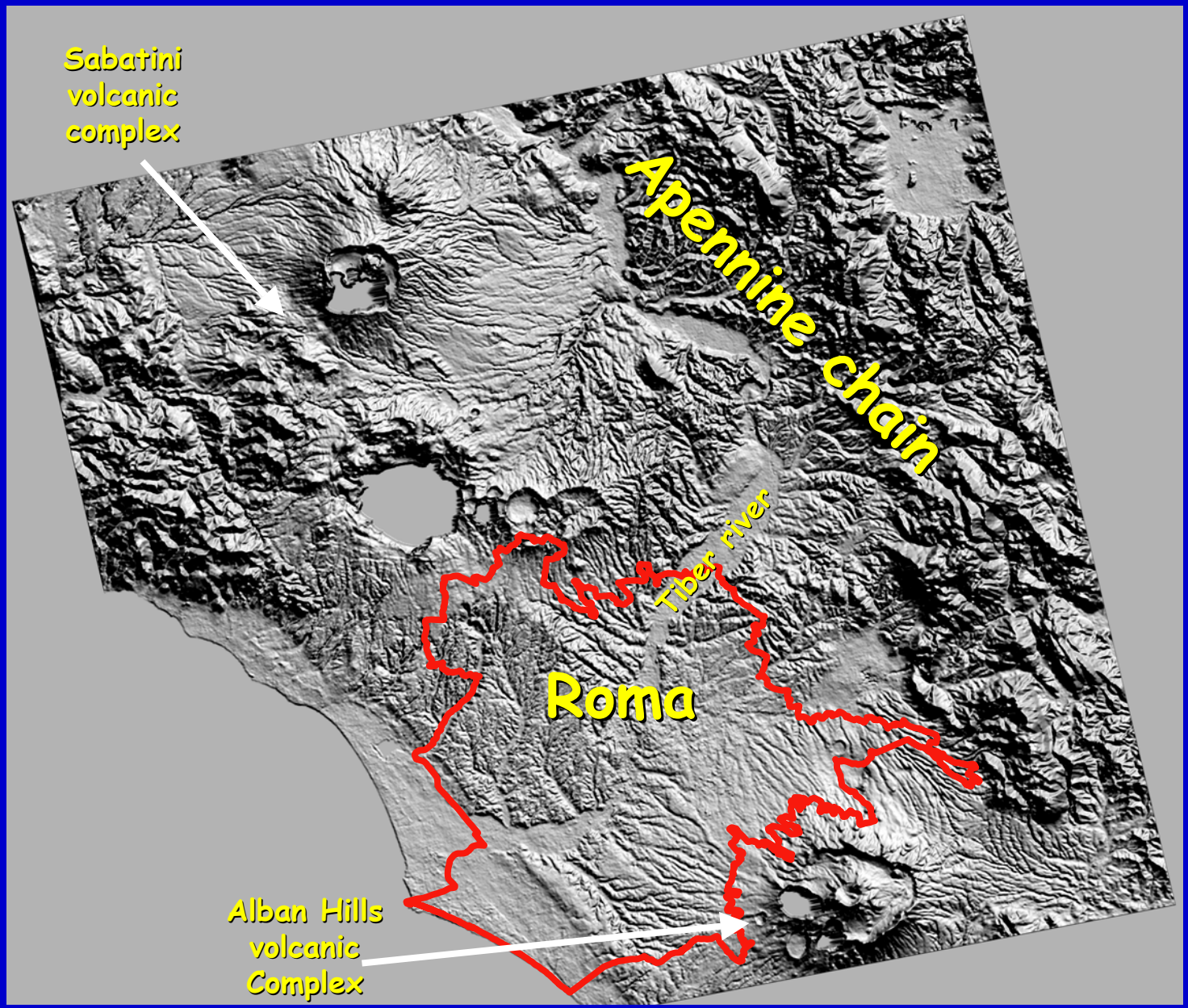
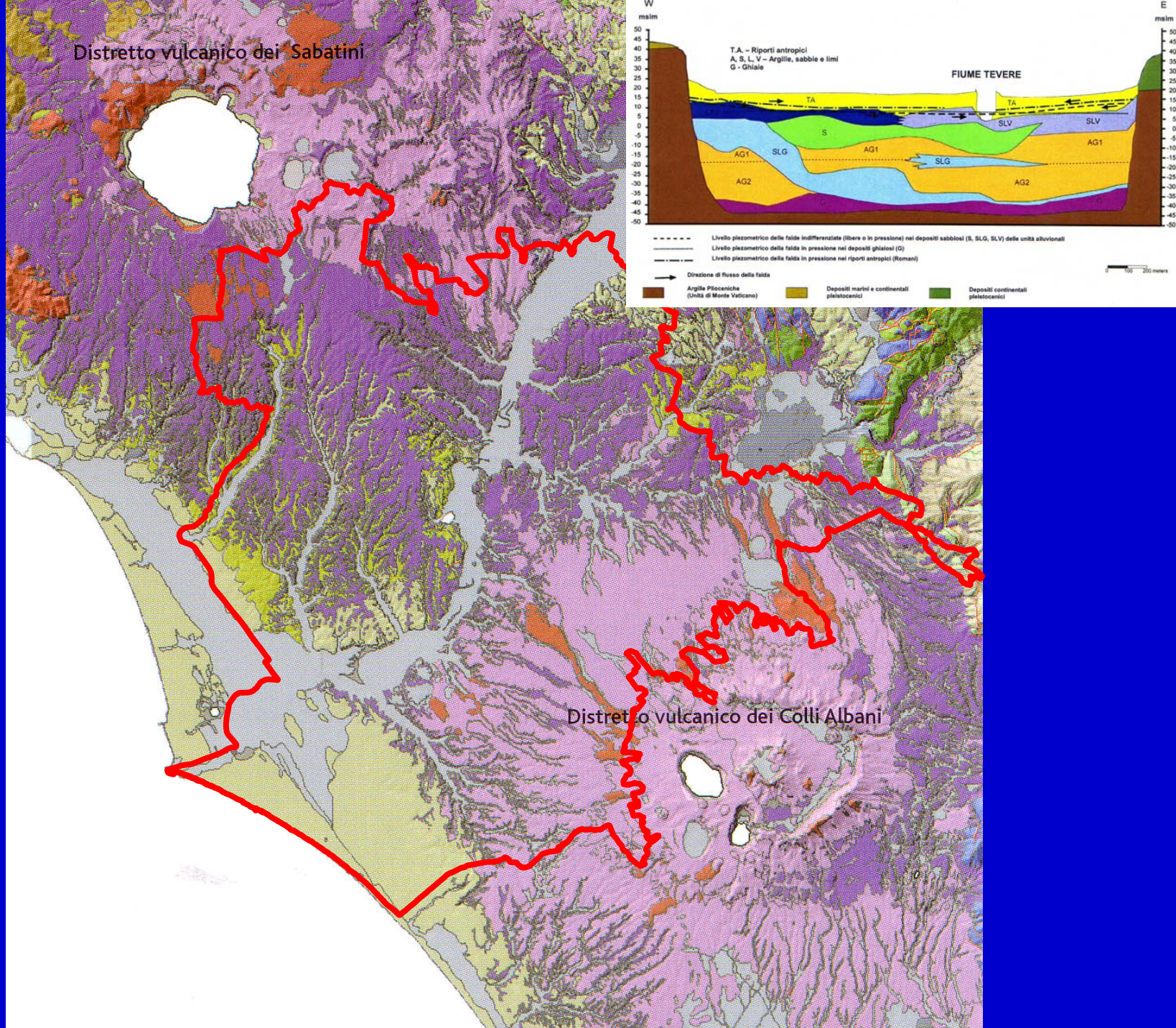
GIFT 2007 Vienna,Austria,16-18April 2007 "GEOSCIENCES IN THE CITY"

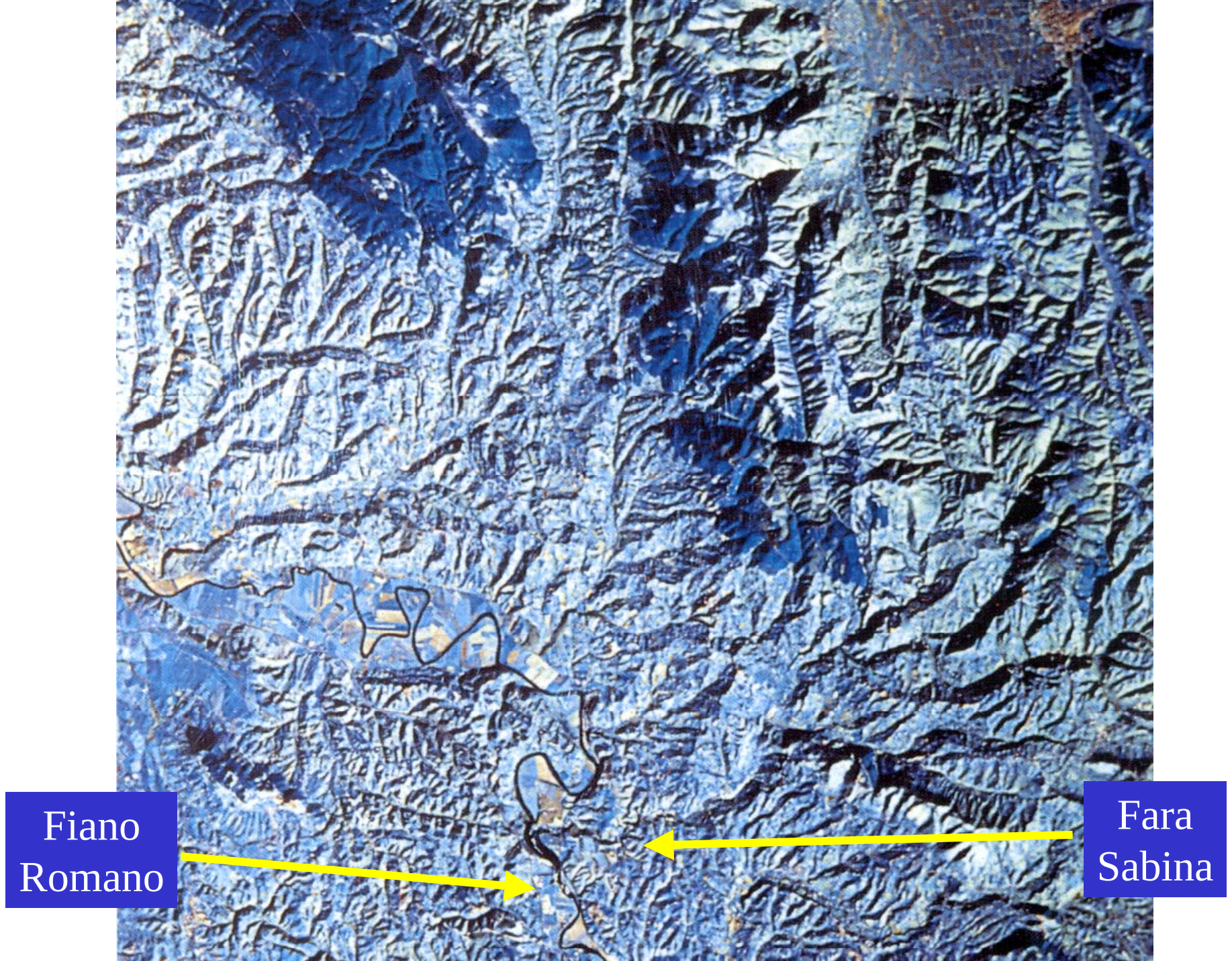
OUTLINES

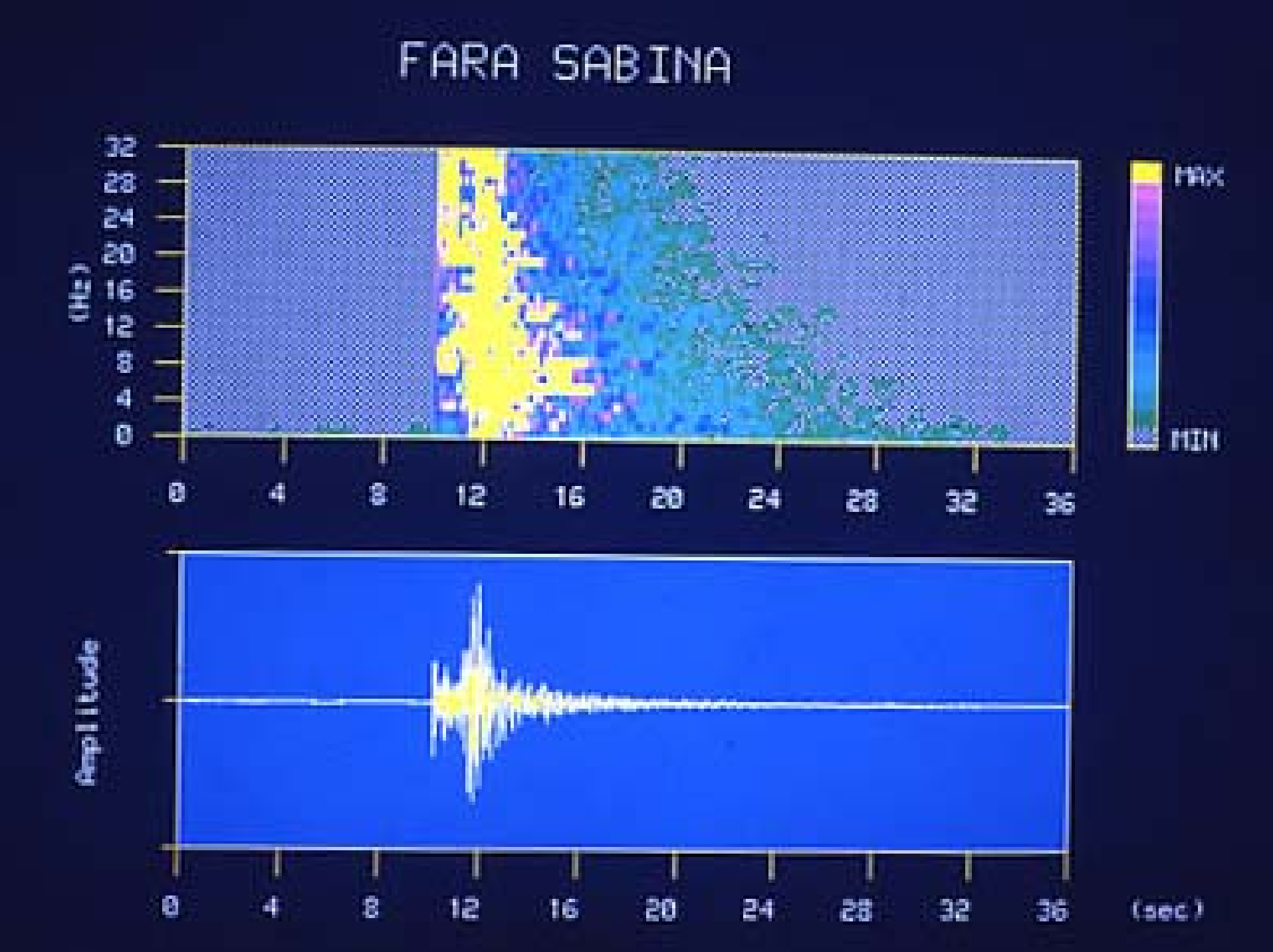
- SCIENTIFIC OBJECTIVES
- METHODOLOGY
- COMPILATION OF MACROSEISMIC QUESTIONNAIRE
- ANALYSIS AND RESULTS
- EXCHANGE BETWEEN UNIVERSITY and SCHOOL

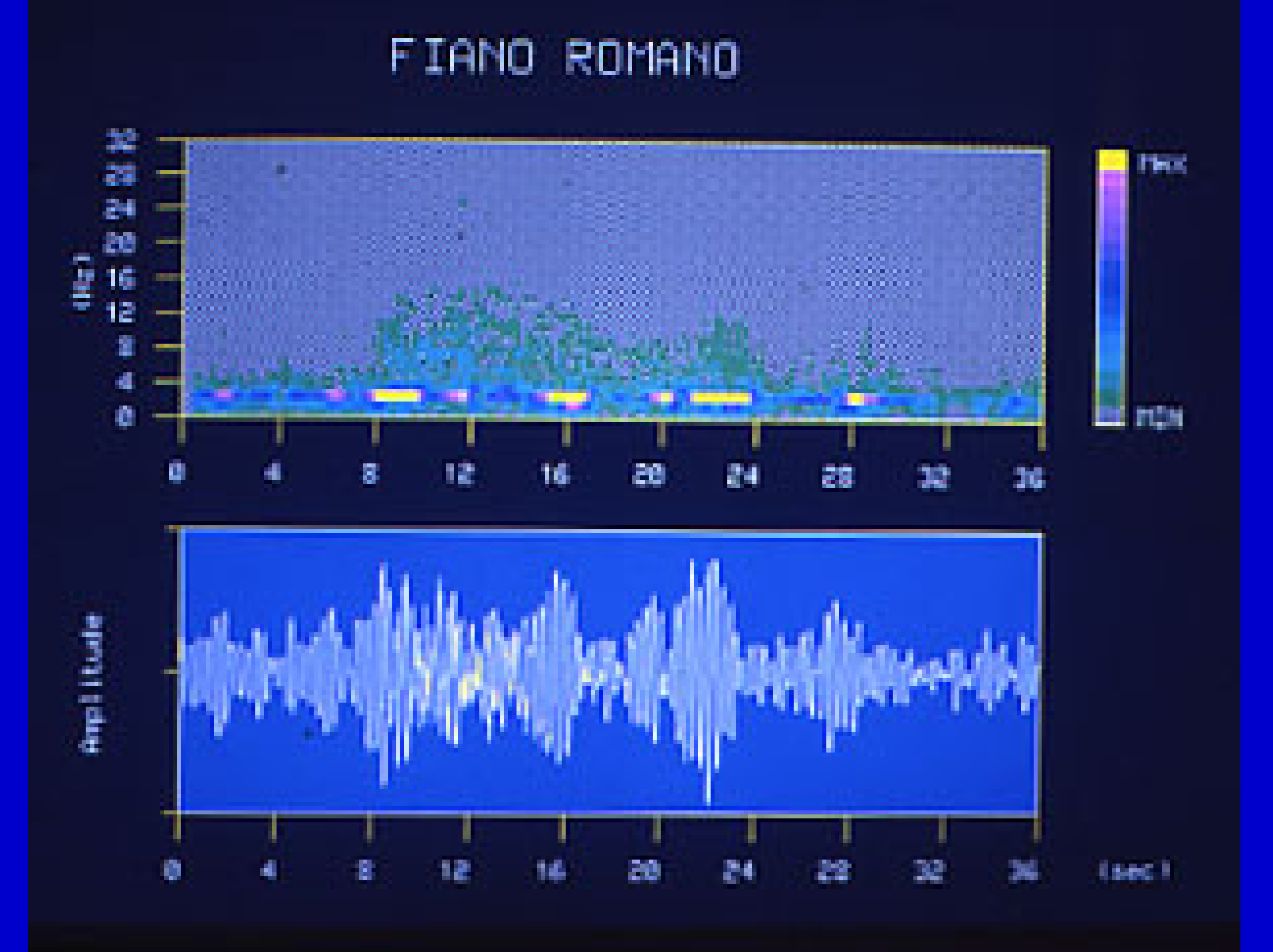
WHY WE DECIDED TO CARRY OUT A MACROSEISMIC SURVEY IN THE CITY OF ROME?




Distretto vulcanico dei Sabatini
Distretto vulcanico dei Colli Albani
W
E
msim
T.A. – Riporti antropici
A, S, L, V – Argille, sabbie e limi
G - Ghiaie
FIUME TEVERE
TA
SLV
S
AG1
SLG
AG2
G
Livello piezometrico delle falde indifferenziate (libere o in pressione) nei depositi sabbiosi (S, SLG, SLV) delle unità alluvionali
Livello piezometrico della falda in pressione nei depositi ghiaiosi (G)
Livello piezometrico della falda in pressione nei riporti antropici (Romani)
Direzione di flusso della falda
Argille Pliceniche (Unità di Monte Vaticano)
Depositi marini e continentali pleistocenici
Depositi continentali pleistocenici


Fiano
Romano
Fara
Sabina


FARA SABINA
(Hz)
32
28
24
20
16
12
8
4
0
0
4
8
12
16
20
24
28
32
36
MAX
MIN
Amplitude
0
4
8
12
16
20
24
28
32
36
(sec)

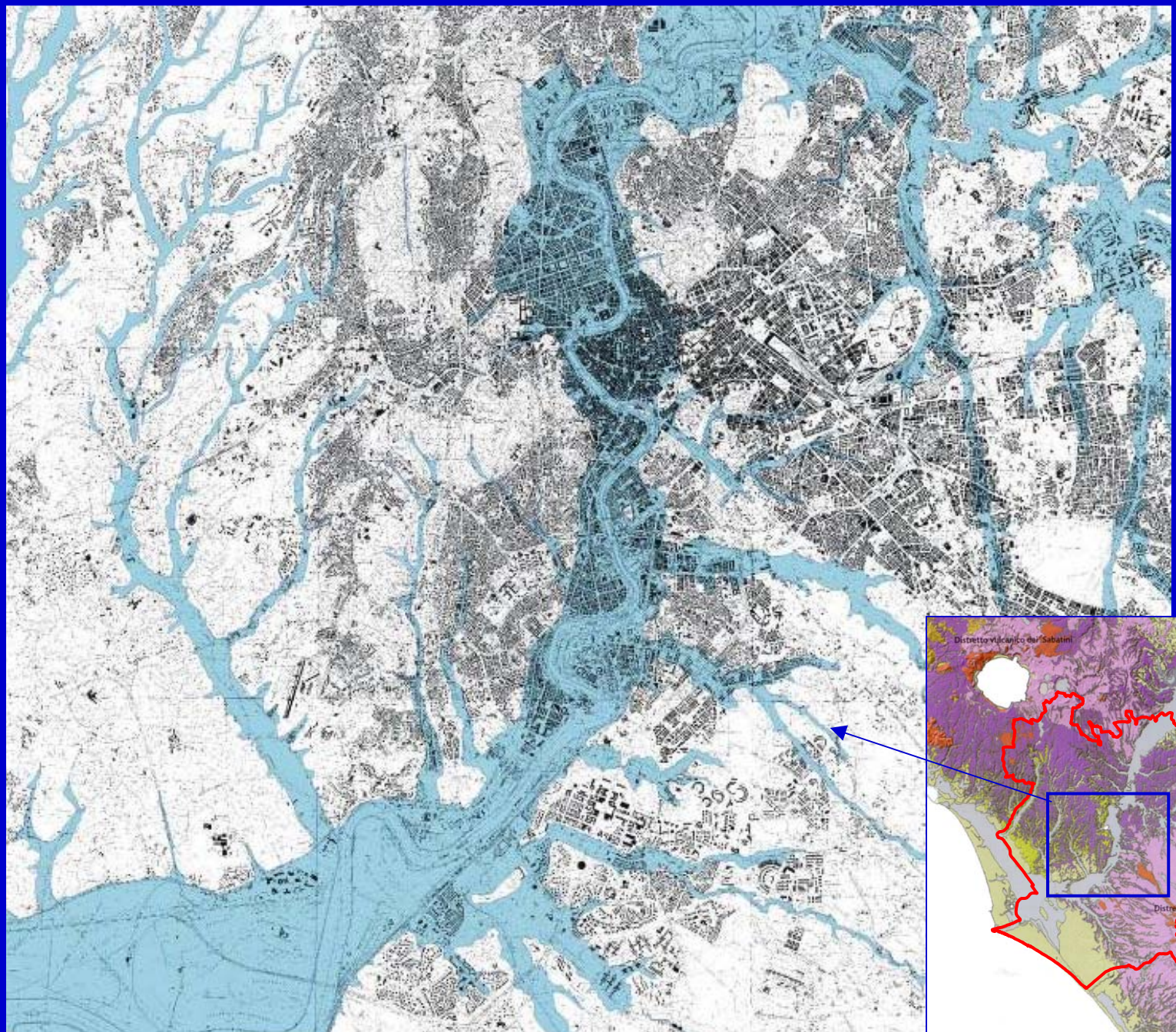

FIANO ROMANO
0
4
8
12
16
20
24
28
32
36
Max
min

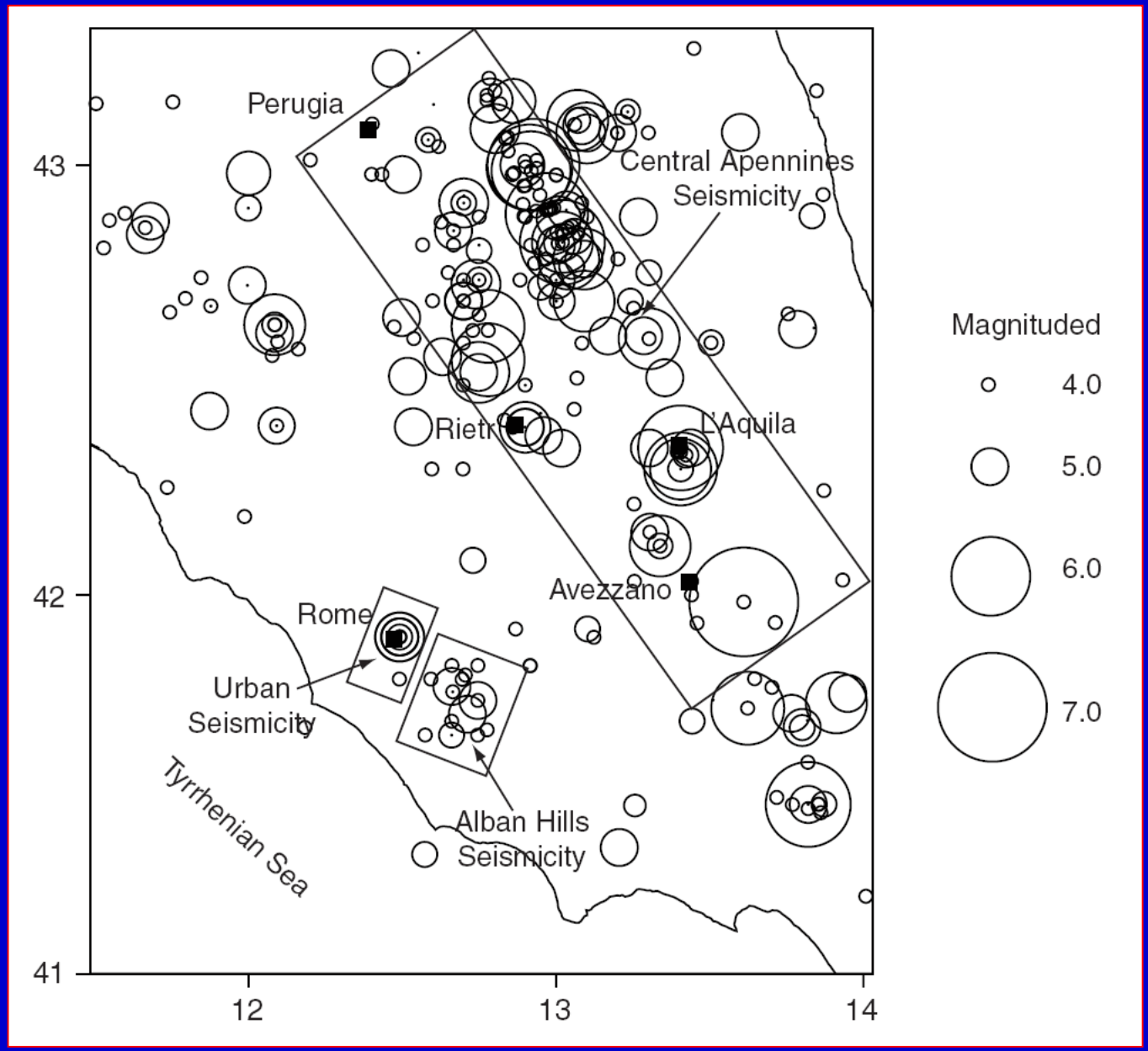
0-1 Hz peak velocities for M=5.3 Colli Albani

E-W *N-S* *Vertical*

Olsen et al, 2005

ALLUVIAL DEPOSITS IN THE CENTRAL SECTOR OF THE CITY

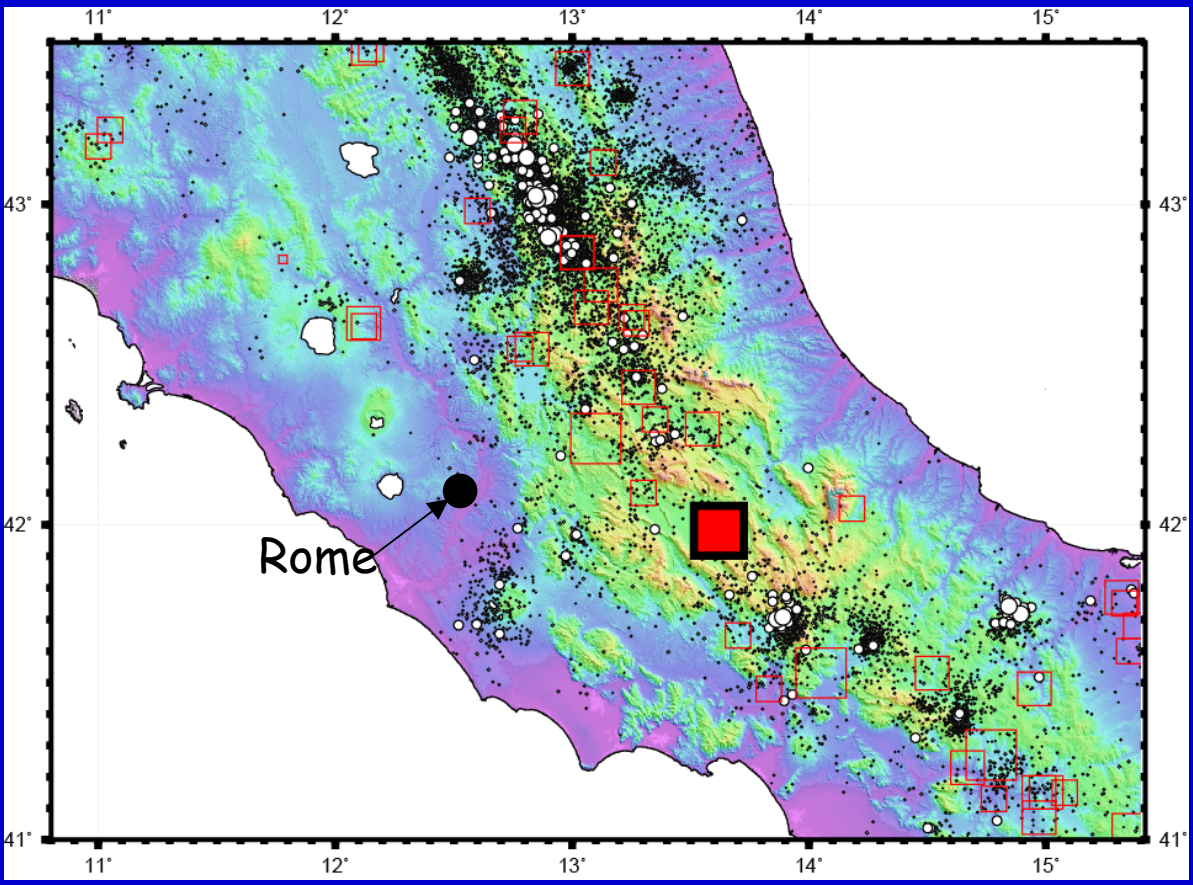




The peculiar near-surface geology of the city implies

possible significant amplification of ground motion at local scale

FUCINO EARTHQUAKE 13/01/1915

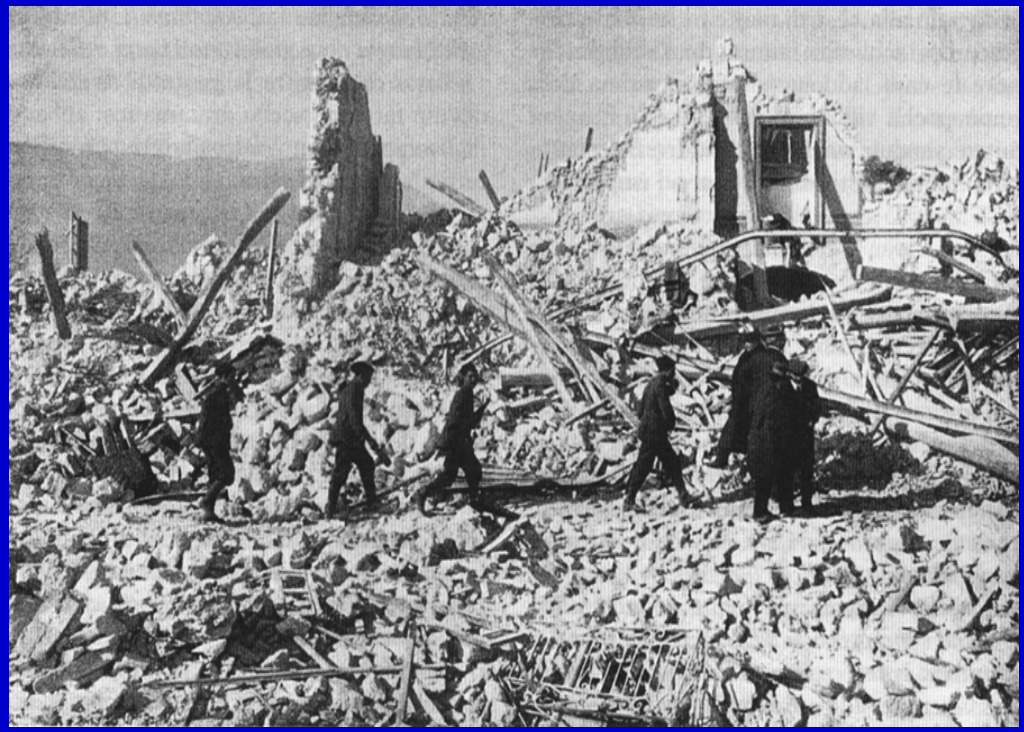


- Me=6.9 - I=XI (CFTI)
- Number of victims: 33000 units
- Epicentral zone: Avezzono (Marsica)
- A very larg area (350Km^2) was completely destroyed

DAMAGES INDUCED BY FUCINO EARTHQUAKE 13/01/1915

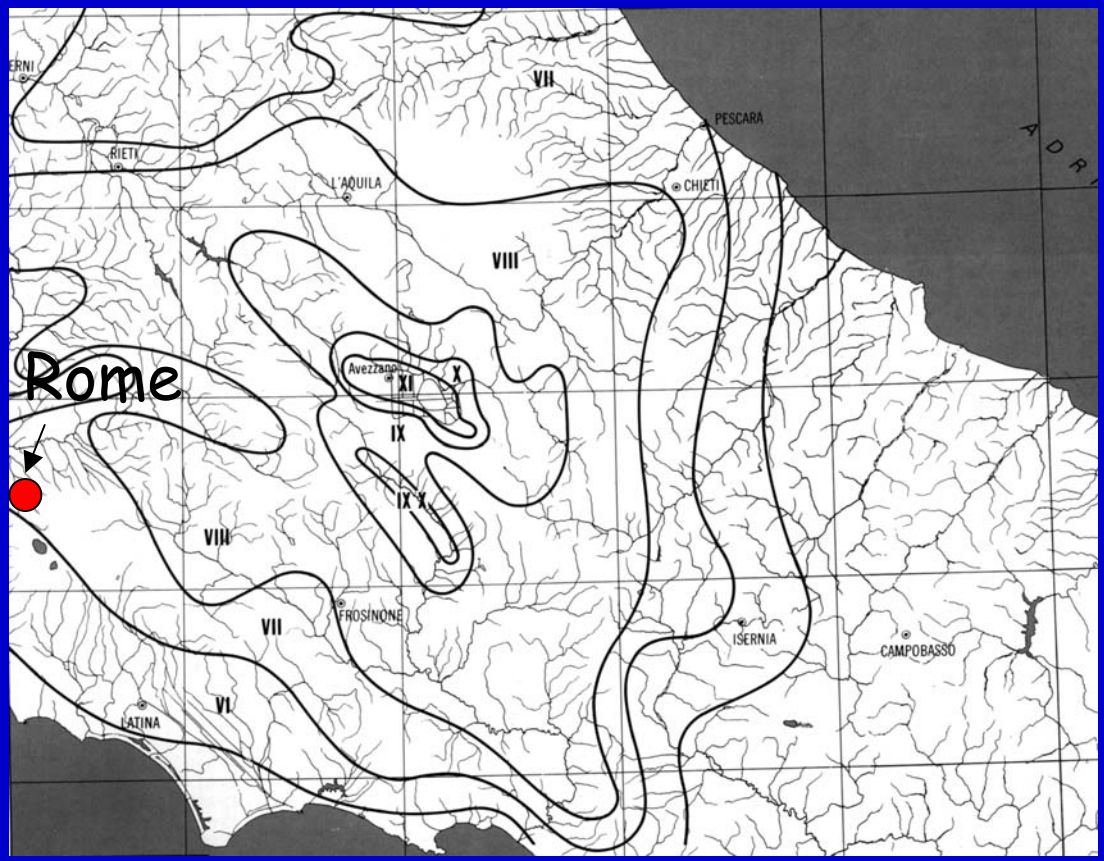
Avezzano Cathedral (Servizio Sismico Nazionale, 1999)

OTHER DAMAGES INDUCED BY FUCINO EARTHQUAKE 13/01/1915



Avezzano, ruins (Servizio Sismico Nazionale, 1999)

Sora, Orto dei Santi square
(Servizio Sismico Nazionale, 1999)

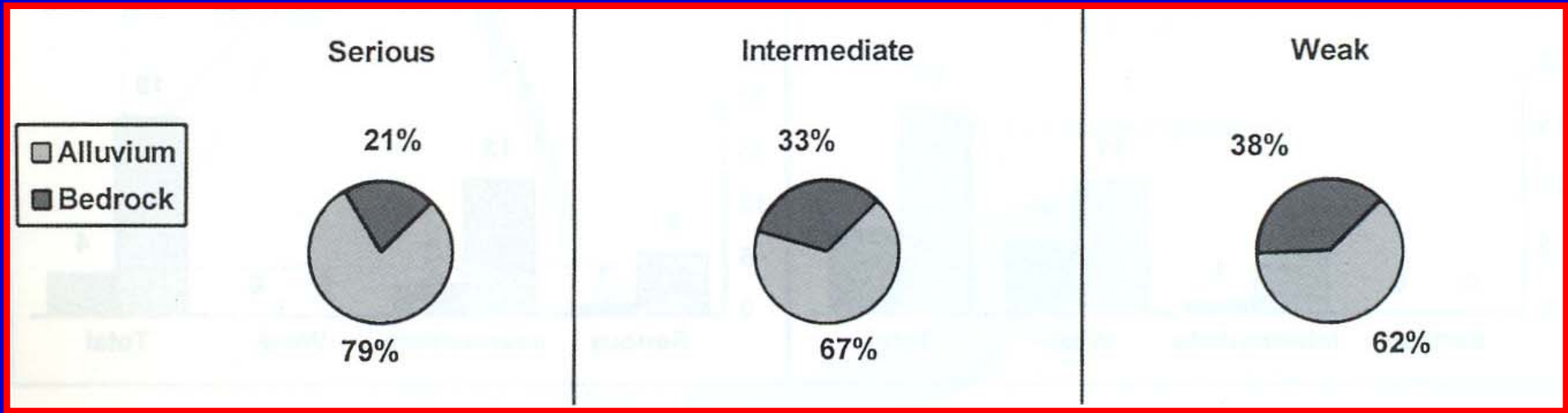


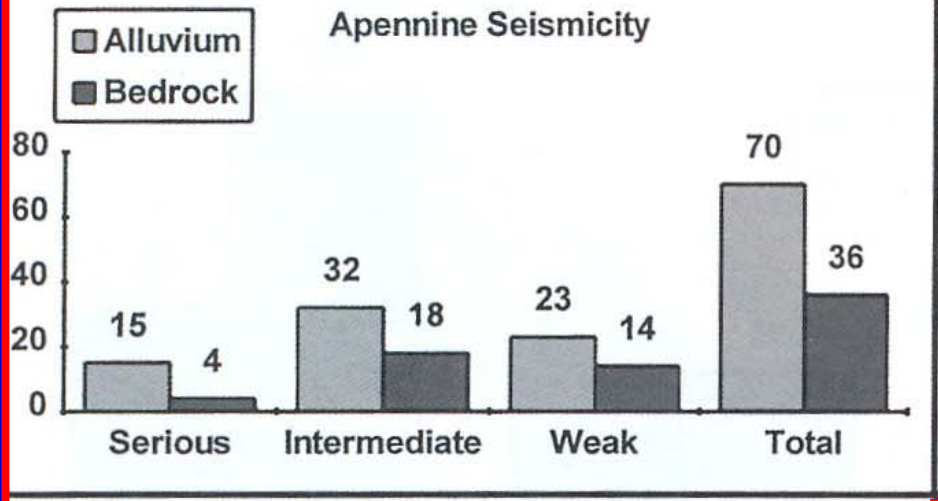
Macroseismic intensity map (P.F.G., 1985)

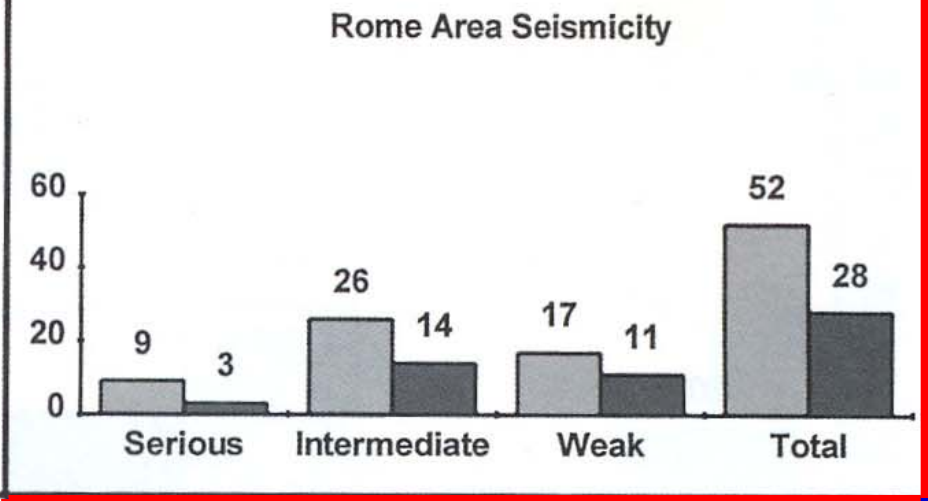
Earthquake was felt in most of Central Italy

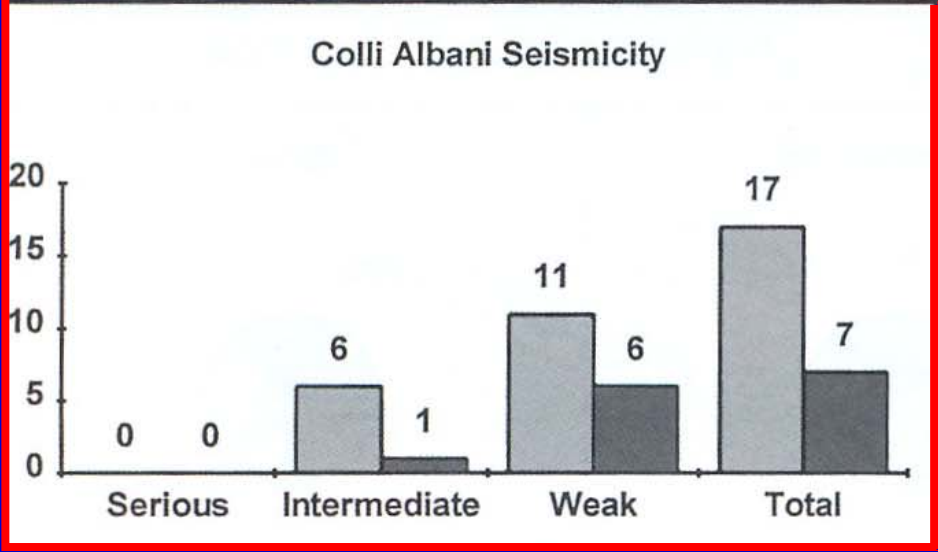
In the city of Rome buildings and monuments were severely damaged

STATISTICAL DISTRIBUTION OF SEISMIC DAMAGE ON MONUMENTS OF ROME (EVENTS FROM 441 B.C. to 1995) AS A FUNCTION OF NEAR-SURFACE GEOLOGY

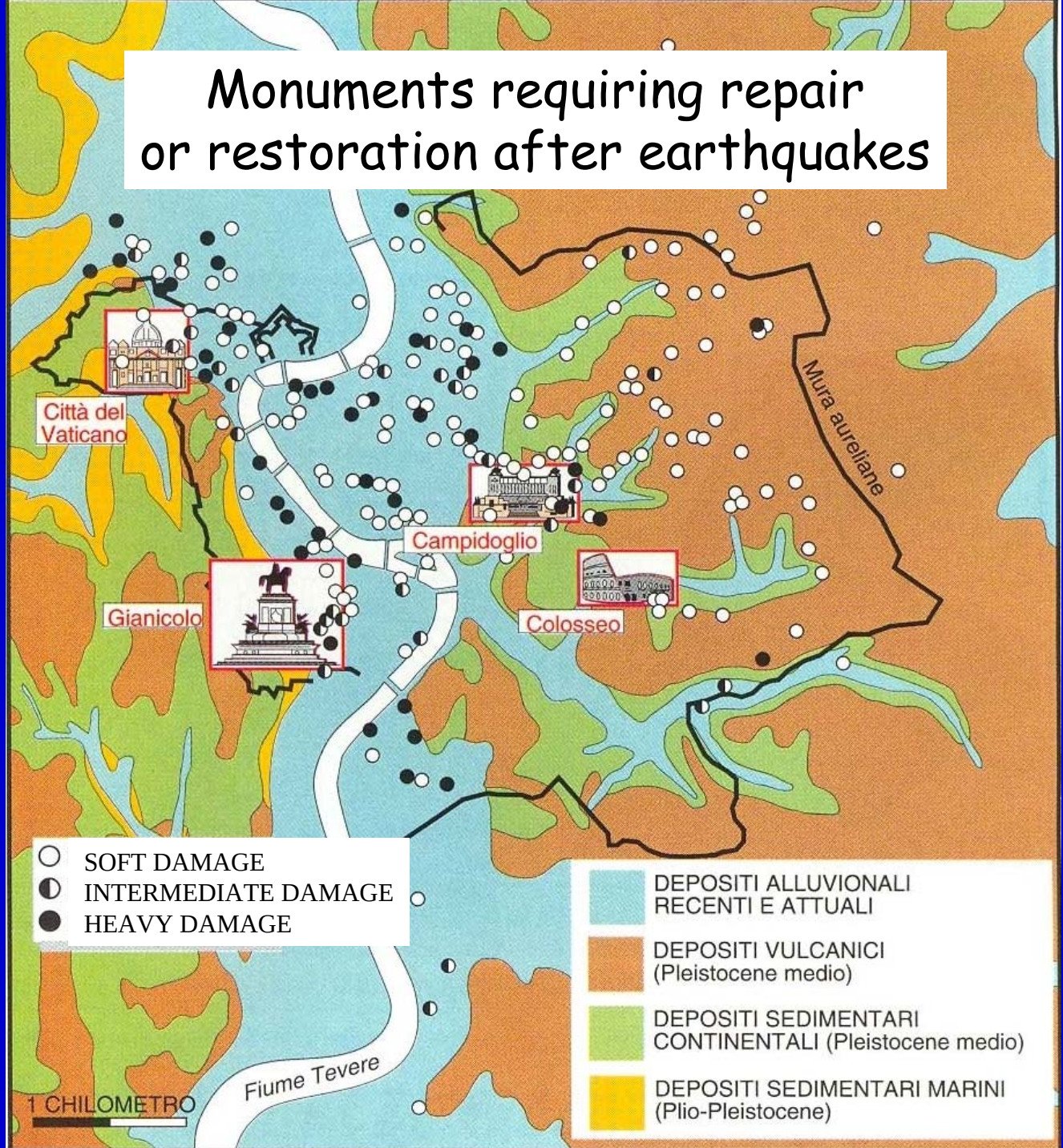


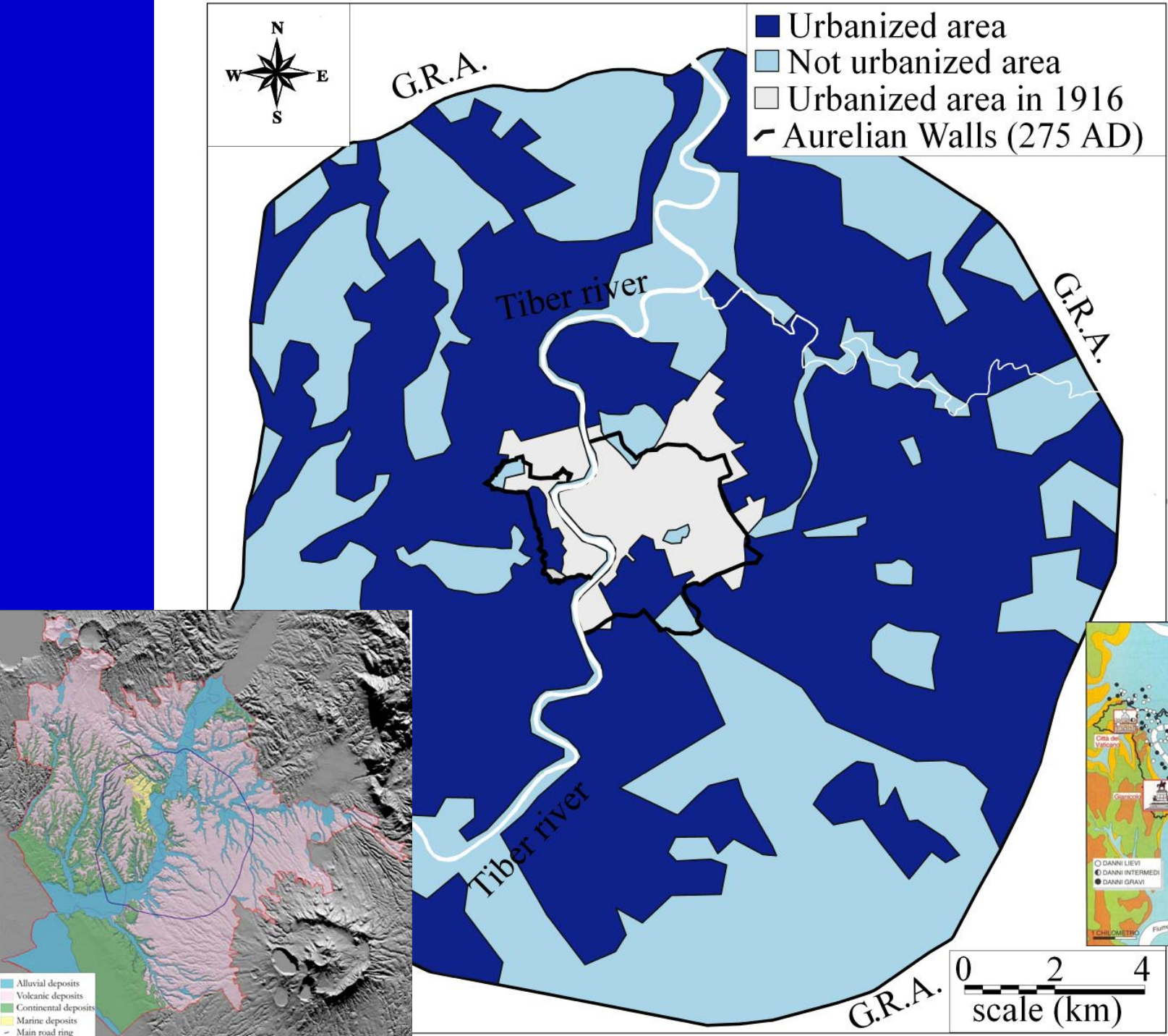

Alluvium
Bedrock
Apennine Seismicity
80
60
40
20
0
15
4
32
18
23
14
70
36
Serious
Intermediate
Weak
Total

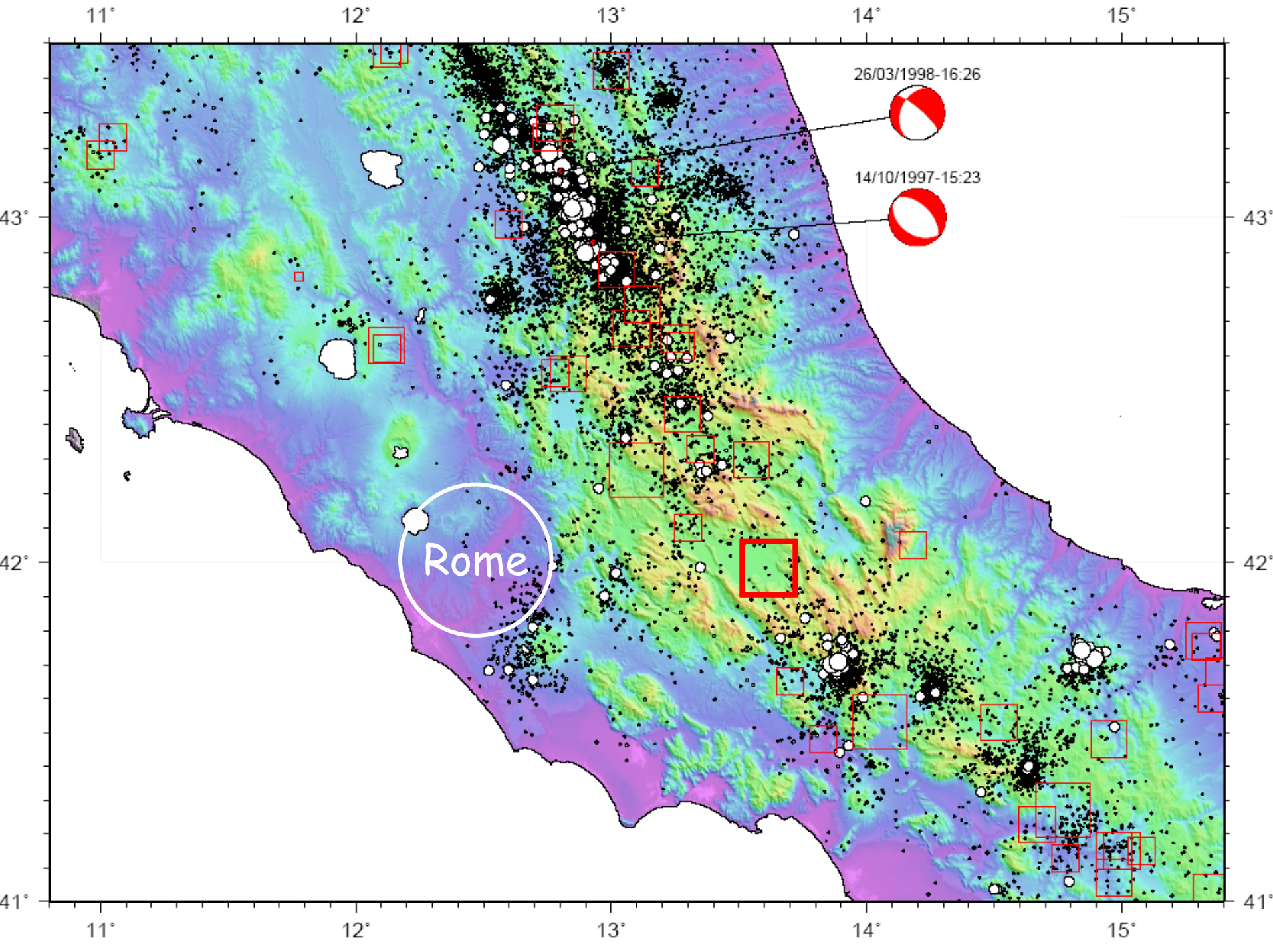

Rome Area Seismicity
60
40
20
0
9
3
26
14
17
11
52
28
Serious
Intermediate
Weak
Total


Colli Albani Seismicity
20
15
10
5
0
0
0
6
1
11
6
17
7
Serious
Intermediate
Weak
Total

Monuments requiring repair or restoration after earthquakes




N
W
E
S
Urbanized area
Not urbanized area
Urbanized area in 1916
Aurelian Walls (275 AD)
G.R.A.
Tiber river
G.R.A.
Tiber river
G.R.A.
0 2 4
scale (km)
Alluvial deposits
Volcanic deposits
Continental deposits
Marine deposits
Main road ring
Città del Vaticano
Campidoglio
Colosseo
Fiume Tevere
DANNI LIEVI
DANNI INTERMEDI
DANNI GRAVI
DEPOSITI ALLUVIONALI RECENTI E ATTUALI
DEPOSITI VULCANICI (Pleistocene medio)
DEPOSITI SEDIMENTARI CONTINENTALI (Pleistocene medio)
DEPOSITI SEDIMENTARI MARINI (Plio-Pleistocene)

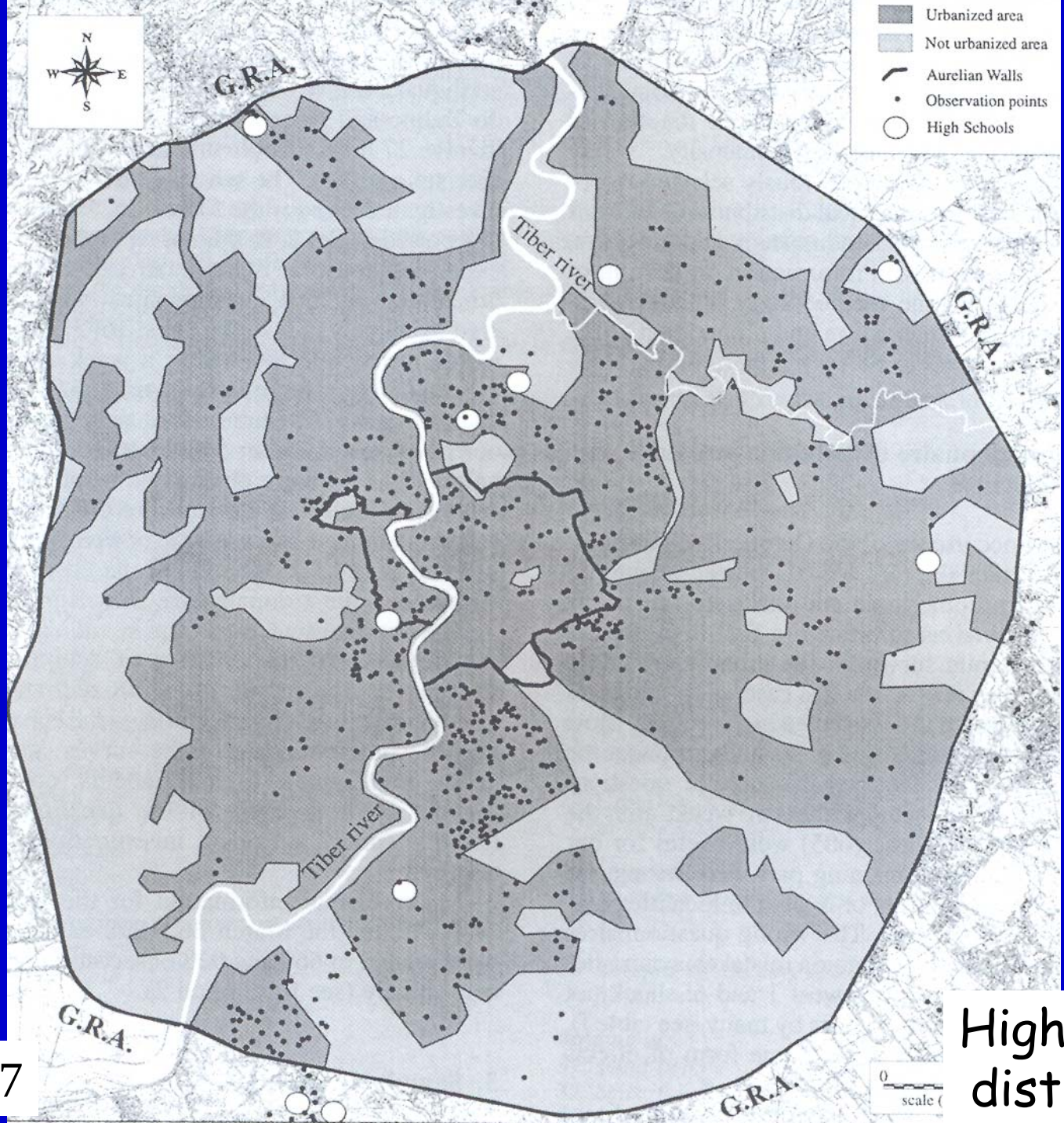

11°
12°
13°
14°
15°
43°
42°
41°
26/03/1998-16:26
14/10/1997-15:23
Rome

SCIENTIFIC OBJECTIVE

- Investigate the relationship between seismic intensity and local geology for the MODERN urban area of Rome, an issue yet to be examined in contemporary times

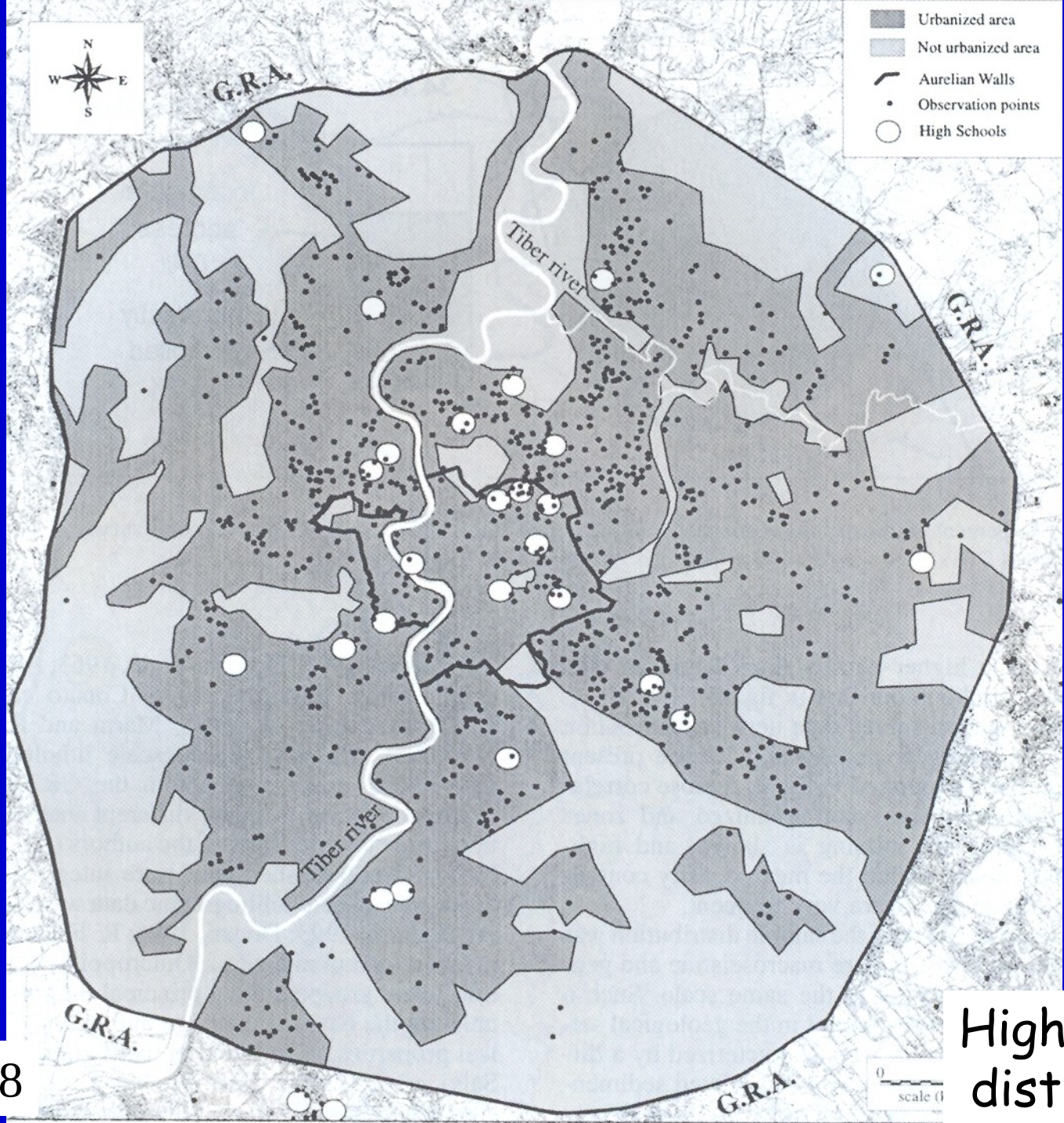
METHODOLOGY

-Macroseismic survey: systematic collection of macroseismic data by means of questionnaire survey in high schools



14/10/1997

High-schools distribution



26/03/1998

High-schools distribution

THE QUESTIONNAIRE COMPILATION

How to fill in the questionnaire:

1. **Read** all the questions.
2. **Interview** most number of people present in the same place (home, workplace, etc.) during the occurrence of the earthquake. Questionnaire should be filled only by getting information from at least one person living in highest and lowest levels of the building.
3. **Answer** the questions synthesising all the available information.
4. **Write** the number of interviews done: _____
5. **Write** the correct address of the observation point, in order to identify its exact topographic location: street _____, house-number _____, nearest cross-road _____
6. **Note** other possible observations not indicated in the questionnaire (car alarm triggering, damage to buildings, animals disturbed, etc.) and every additional comment

Questions

1 *Shock not felt*

2 *Shock felt only by some people at rest in upper floors of buildings*

3 *Shock felt by few people and not recognised as an earthquake*

4 *The shock caused skidding of cars*

Shock felt indoors (houses, schools, cinemas, churches, etc.) by:
5 *few people*
6 *many people*
7 *most people*

Shock felt outdoors (squares, roads, fields, etc.) by:
8 *few people*
9 *many people*
10 *most people*

The earthquake awoke:
11 *no one*
12 *few people*
13 *many people*
14 *most people*

The earthquake frightened:
15 *no one*
16 *few people*
17 *many people*
18 *most people*

19 *Chandeliers swung on lower floors of houses*

Slight rattling of doors, windows, furniture; slight vibration of chairs, beds, etc.:
20 *on upper floors only*
21 *on all floors*

22 *Liquids in full containers disturbed*
23 *spilled slightly*
24 *overflowed*

Rattling of glass in windows and furniture or glassware and crockery:
25 *on upper floors only*
26 *on all floors*

27 *Creaking of furniture and/or beams and rafters in the ceilings*

Hanging pictures:
28 *swung or banged against the wall*
29 *fell*

30 *Banging or opening of doors, windows or furniture doors*

Ringing of:
31 *small bells*
32 *bells in bell-towers or towers*

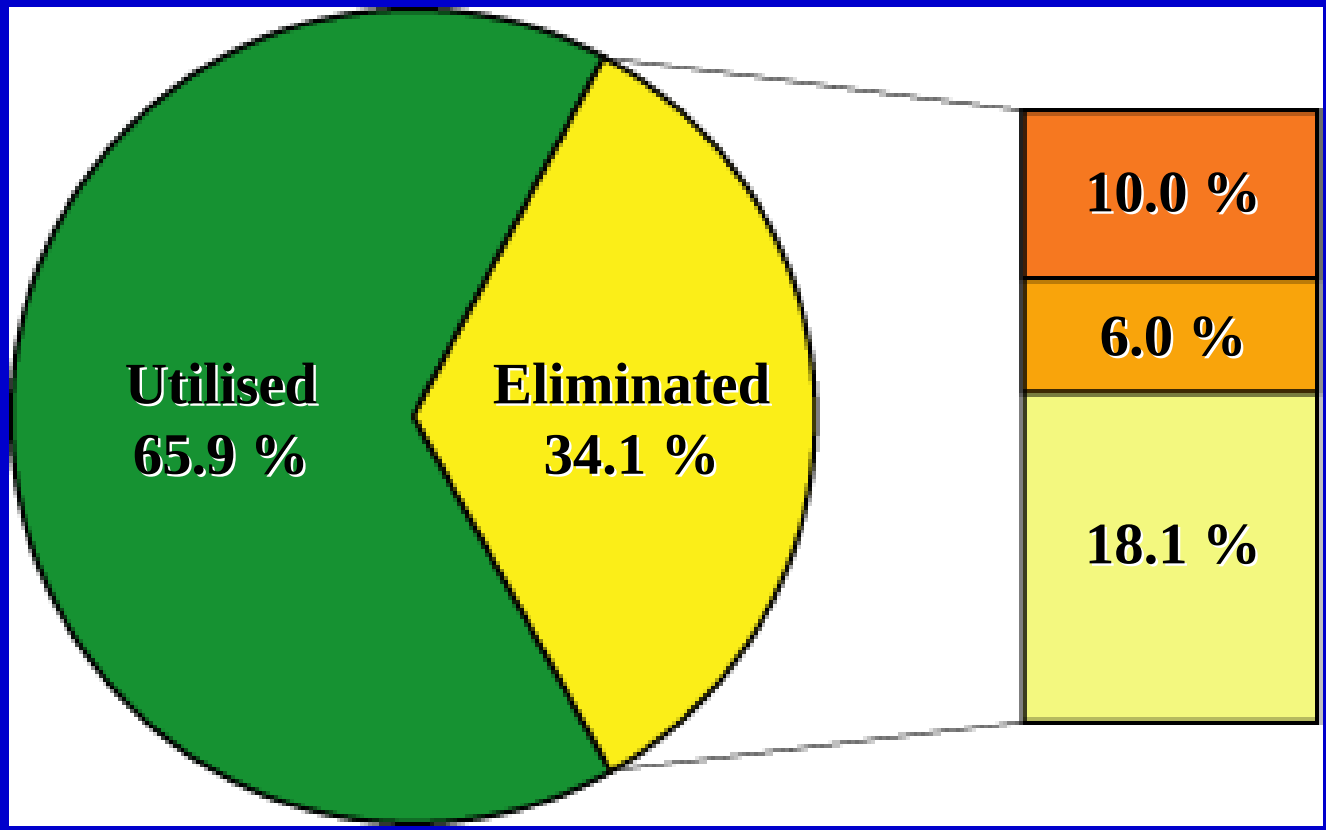
Small objects:
33 *were displaced*
34 *fell*

35 *Falling of crockery, glassware or books*

Heavy and stable objects:
36 *were displaced*
37 *fell*

38 *Light furniture was displaced*

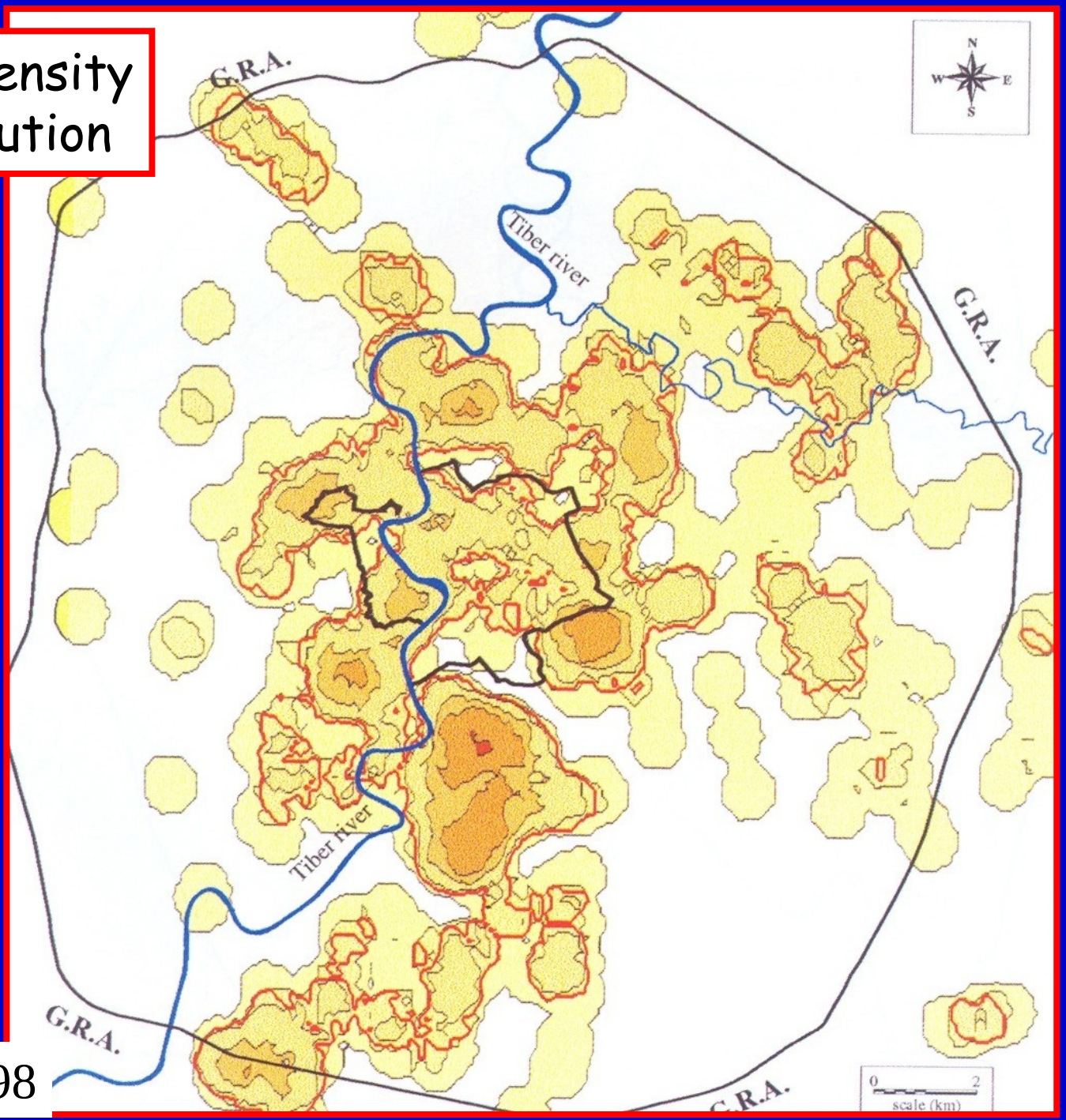
Heavy furniture:
39 *was displaced*
40 *fell*


Utilised
65.9 %
Eliminated
34.1 %
10.0 %
Other localities
6.0 %
Incomplete address
18.1 %
Incorrectly compiled

Details for the 14 October 1997 and the 26 March 1998 Surveys

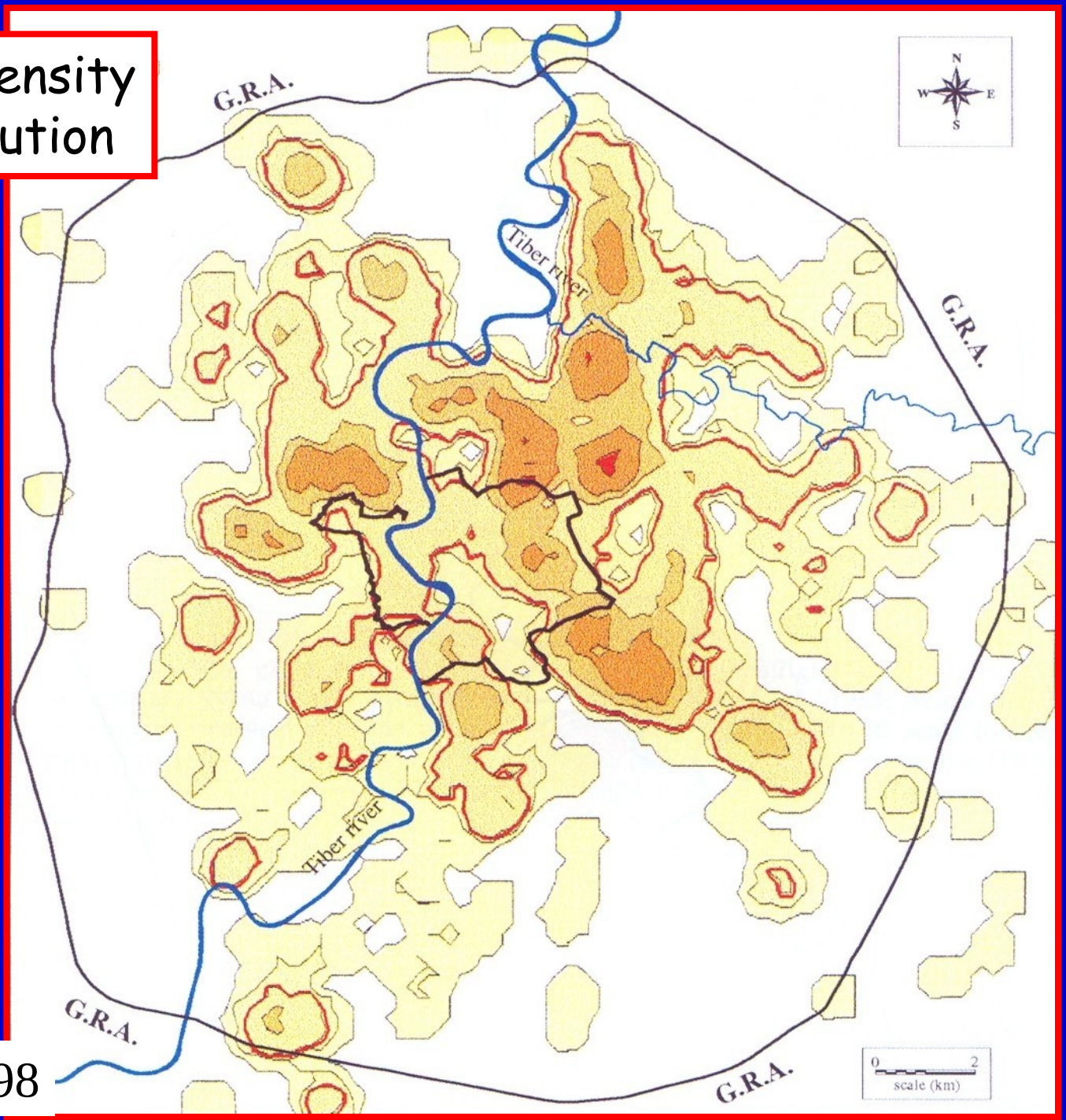
Survey	Elapsed Time	Number of Schools	Collected Forms	Useful Collected Forms (UCF)	Direct Investigation Forms (DIF)	Used forms (UCF + DIF)	Number of Interviews	Intensity Points
14 October 1997	2 weeks	10	1222	605 (49.5%)	344	949	1842	669
26 March 1998	1 week	27	1643	1083 (65.0%)	0	1083	2529	926

Data density distribution



14/10/1998

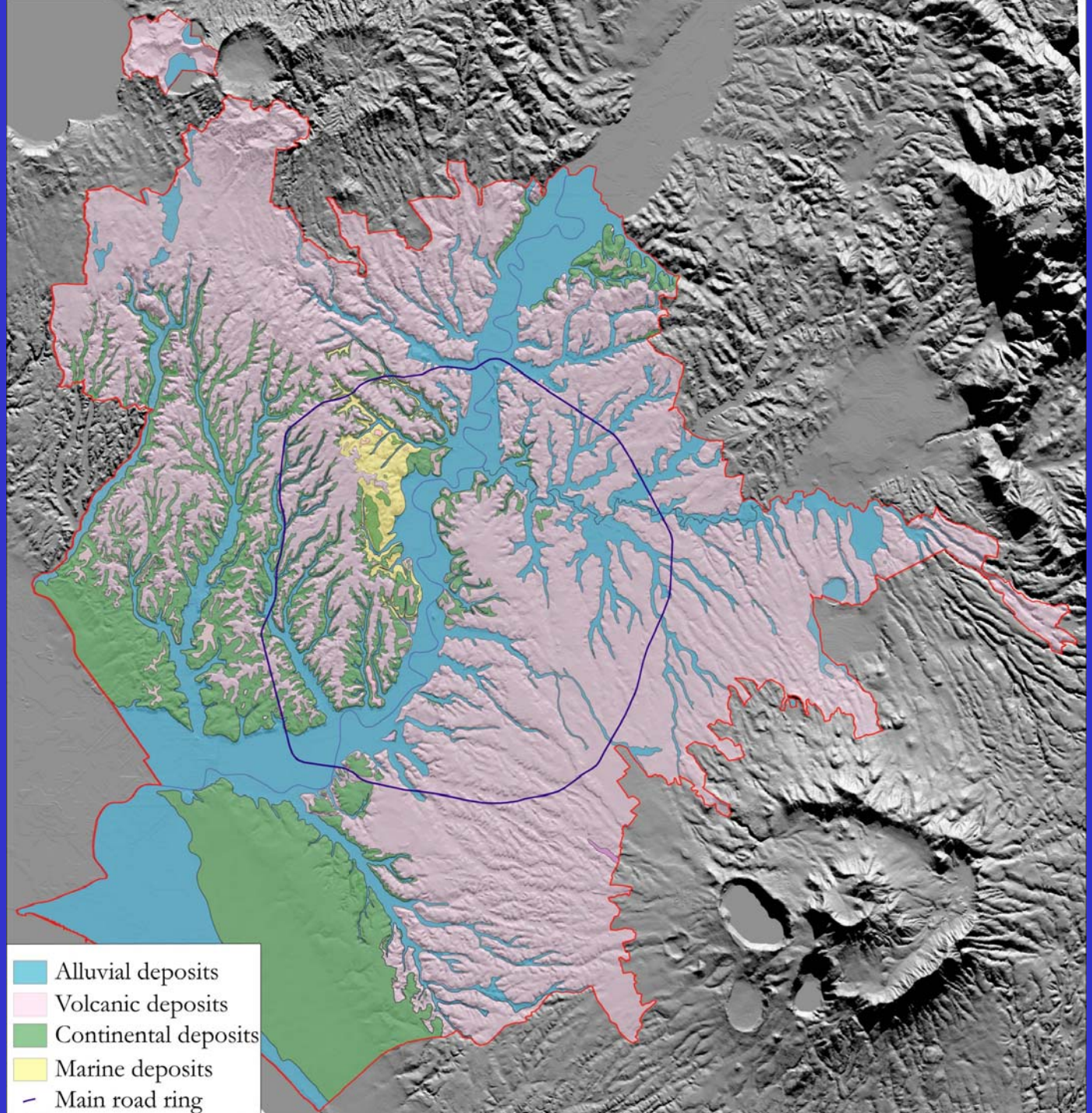
Data density distribution



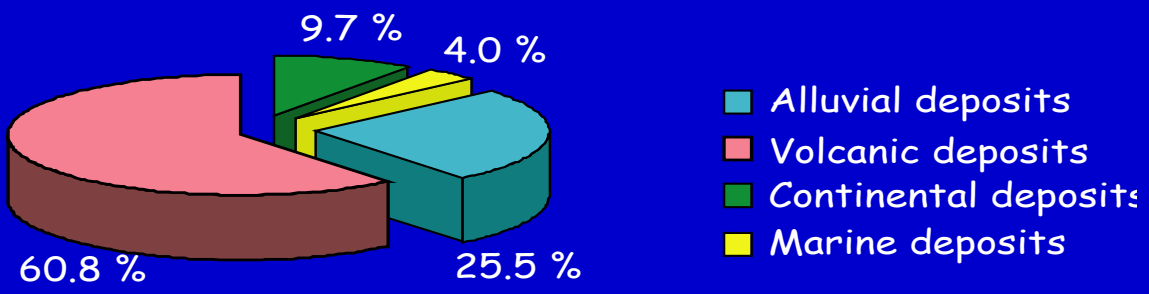
26/03/1998

Gathering of the gological formations into 4 principal lithological units

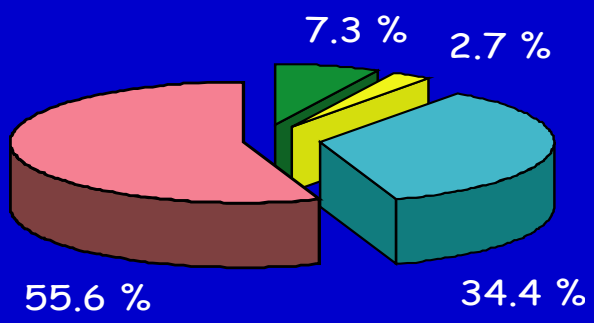
Geological Formation	Period	Lithological unit	Period
Anthropic fills	Holocene	Recent	Holocene
Alluvial deposits	Holocene	Alluvium	
Vitinia Unit	Late Pleistocene		
Aurelia Unit	Late Pleistocene		
San Paolo Unit	Middle-Late Pleistocene	Volcanic products	Middle-Late Pleistocene
Monti Sabatini products	Middle-Late Pleistocene		
Colli Albani products	Middle-Late Pleistocene		
PaleoTiber 2 Unit	Middle Pleistocene		
PaleoTiber 1 Unit	Middle Pleistocene	Continental	Early- Middle
Monte delle Piche Unit	Early Pleistocene	deposits	Pleistocene
Monte Ciocci Unit	Early Pleistocene		
Monte Mario Unit	Early Pleistocene	Marine	Late Pliocene-
Monte Vaticano Unit	Late Pliocene	deposits	Early Pleistocene


Alluvial deposits
Volcanic deposits
Continental deposits
Marine deposits
Main road ring

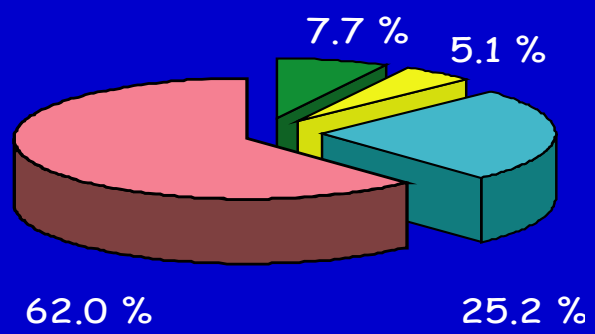
Percentage distribution of the lithological units in the urbanised sector of Rome inside the GRA



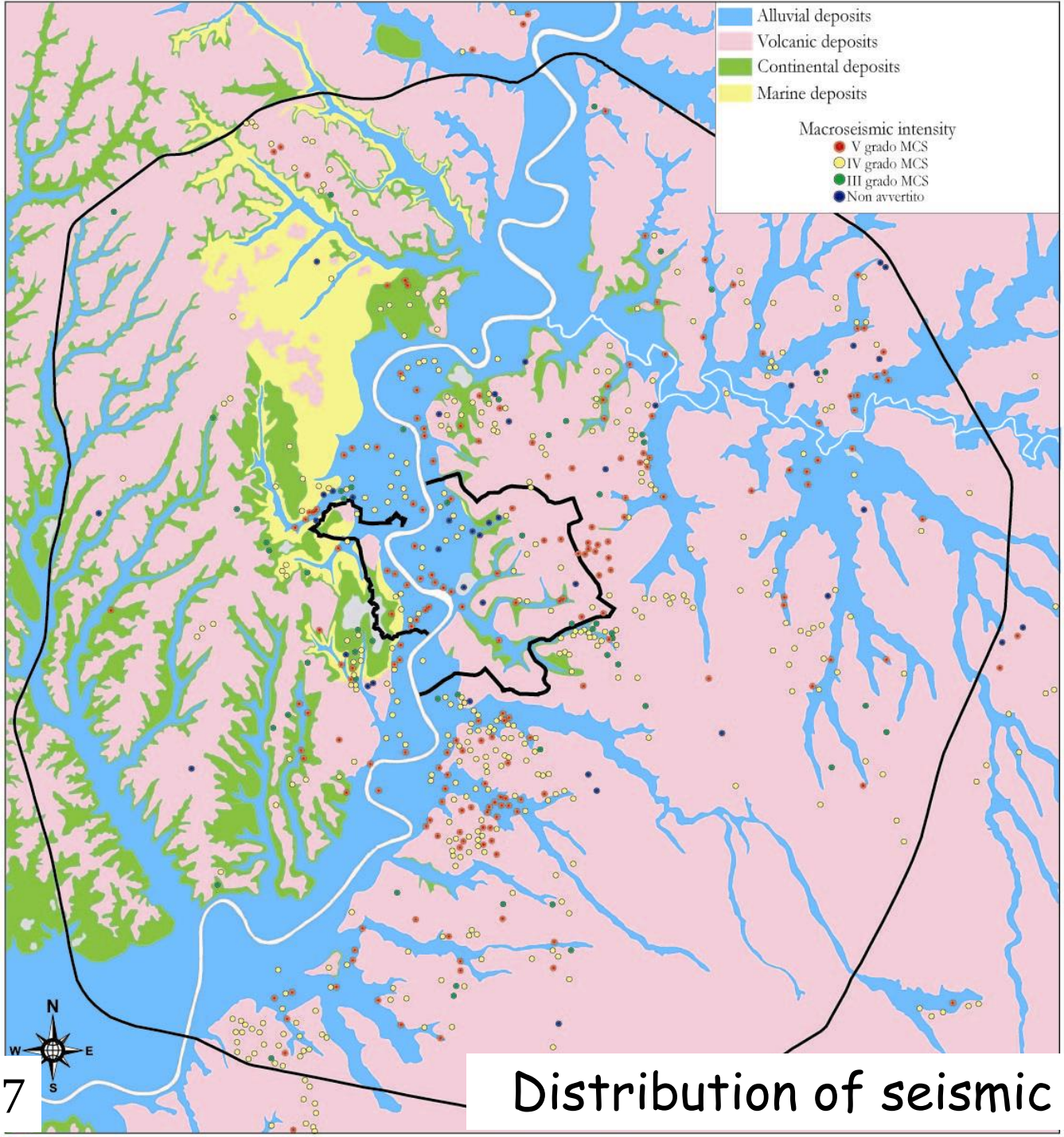
Percentage distribution of observation points with respect to the lithological units



14/10/1997

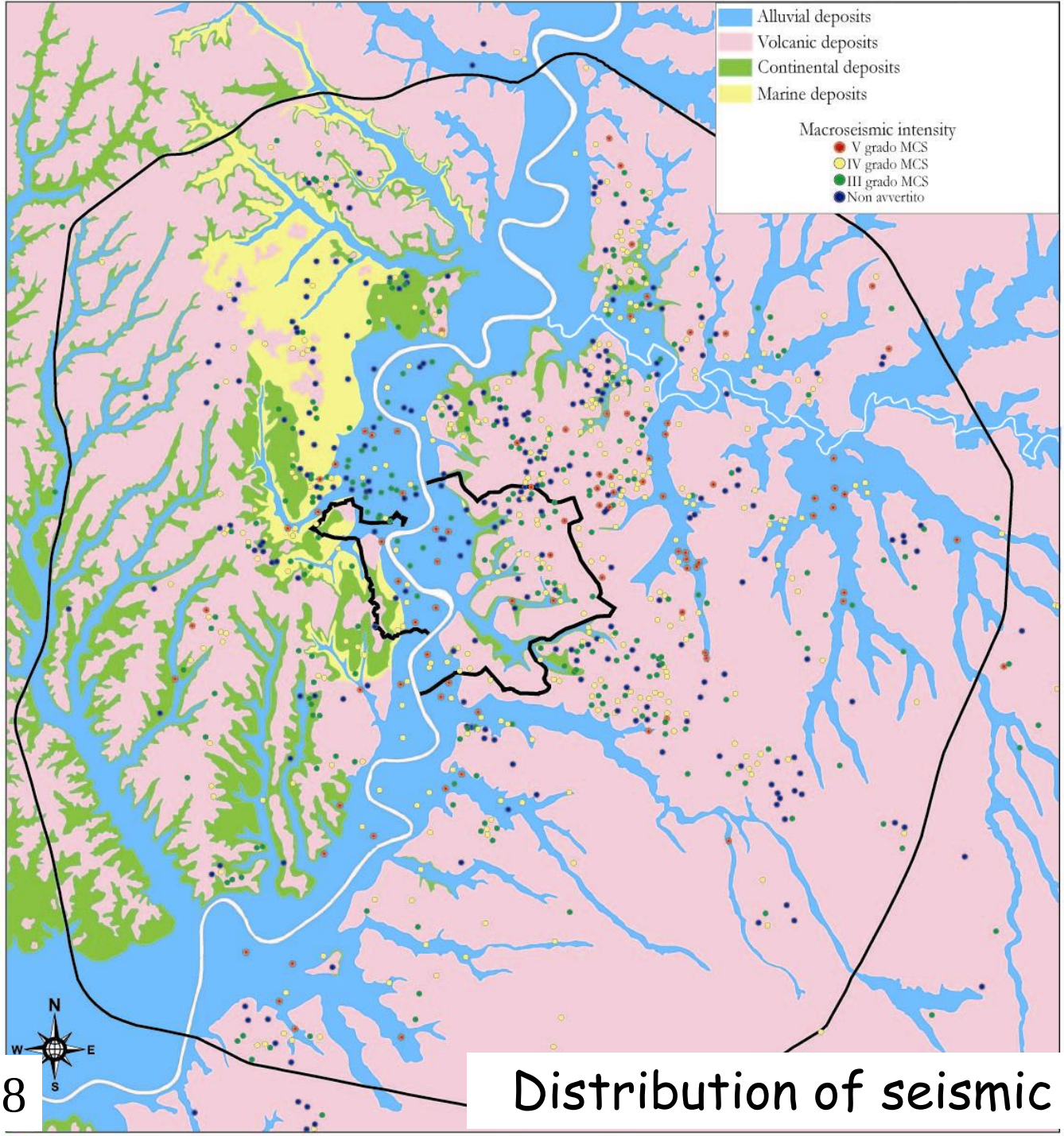


26/03/1998



14/10/1997

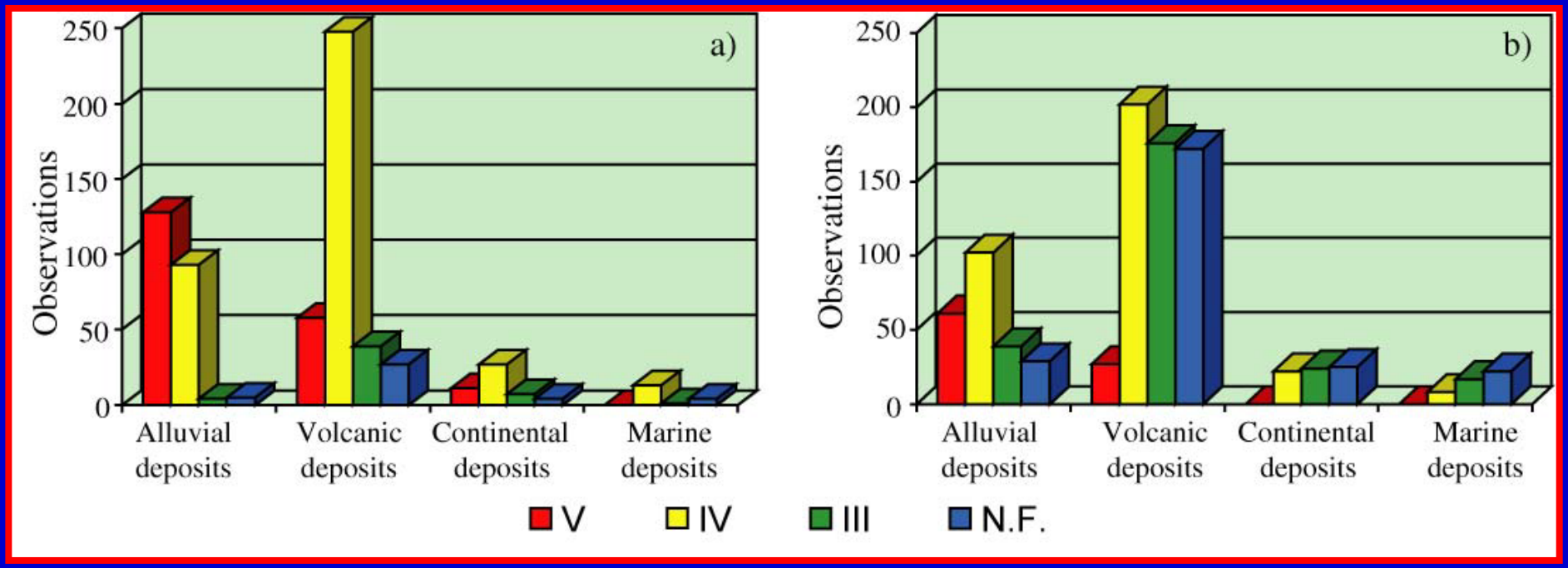
Distribution of seismic effects



26/03/1998

Distribution of seismic effects

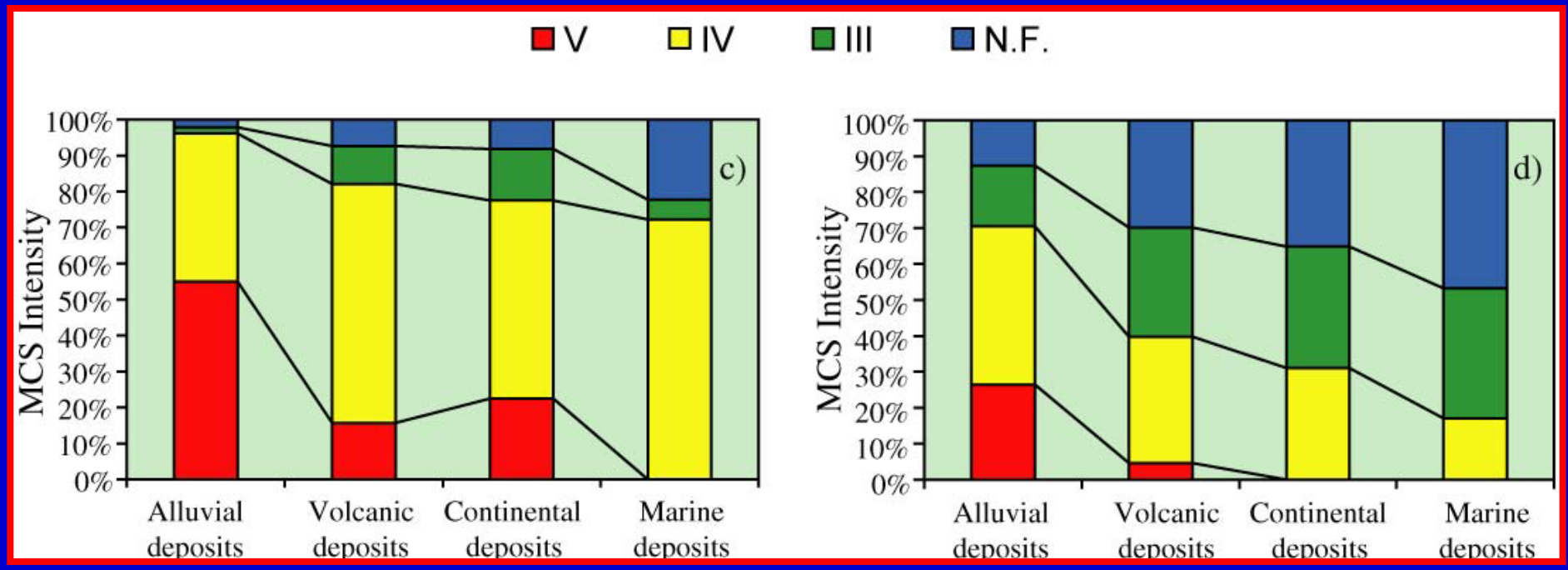
Distribution of the intensity points in Rome as a function of the lithologic units



14/10/1997

26/03/1998

Normalized MCS intensity distribution versus lithologic units



14/10/1997

26/03/1998

CONCLUSIONS

Macroseismic analysis presents several advantages:

-it is simple, fast and cheap in collecting a large number of data

-it is the natural complement to strong motion analysis and a valuable confirmation of numerical modelling

-it makes immediately available the earthquake scenario

-it is a powerful tool in linking information about historical earthquakes (when available) with recent ones

-other methodologies can hardly produce such a high density of observation points

CONCLUSIONS

- For areas of Rome urbanized after the damaging 13 January 1915 Apennine earthquake, these results contribute to a precise hazard assessment of areas located above recent alluvial deposits

- This survey represented an excellent possibility of cooperation between University and school, involving students in a scientific survey

- This experience made teachers and their students, and through them, the general public aware of the complexity of the environmental and geological problems in large urban areas

- This study contributed to demonstrate how the natural hazards interact and influence the life of inhabitants in large urban areas