Damage to and Vulnerability of Industry in Earthquakes in Turkey

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with
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Impact of Earthquake on Industry

- Direct physical damage
- Indirect physical damage and losses (fire, hazardous material release, chemical spills)
- Economic losses (business interruption, loss of market, loss of demand etc.)

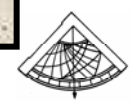
Assessment of these losses can be done at different levels of resolution

▼

Industrial losses in general

Industrial sector

Industrial facility



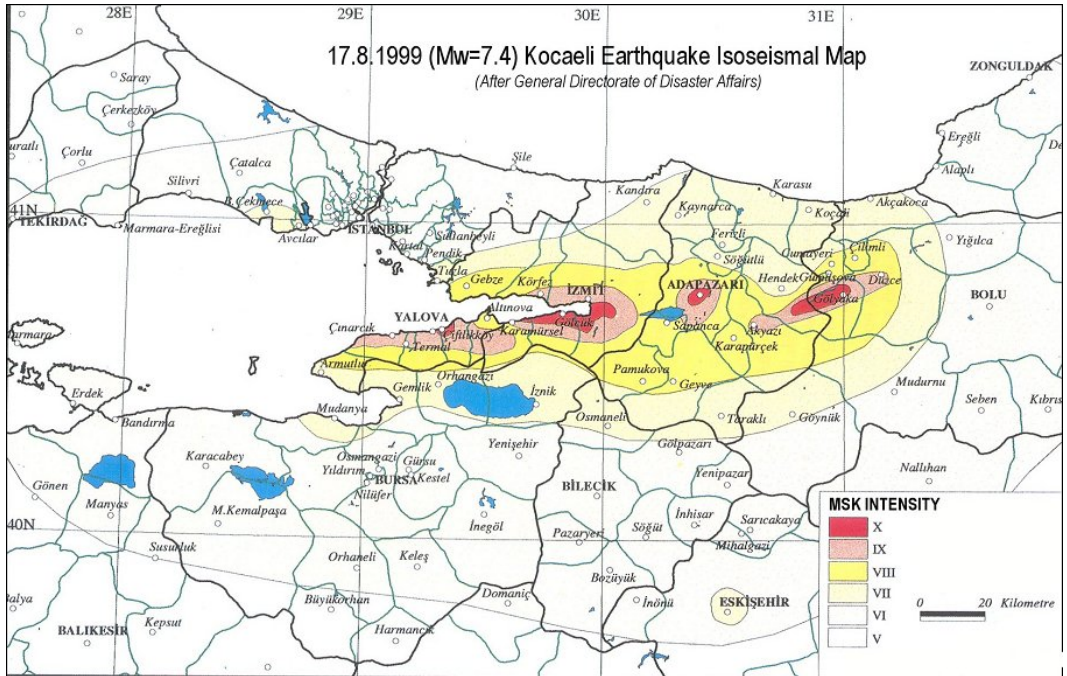
Primary factors for the assessment of direct physical damage and indirect losses

- Building Losses
- Machine and Equipment Damage
- Stock Damage
- Business Interruption, Loss of Market etc

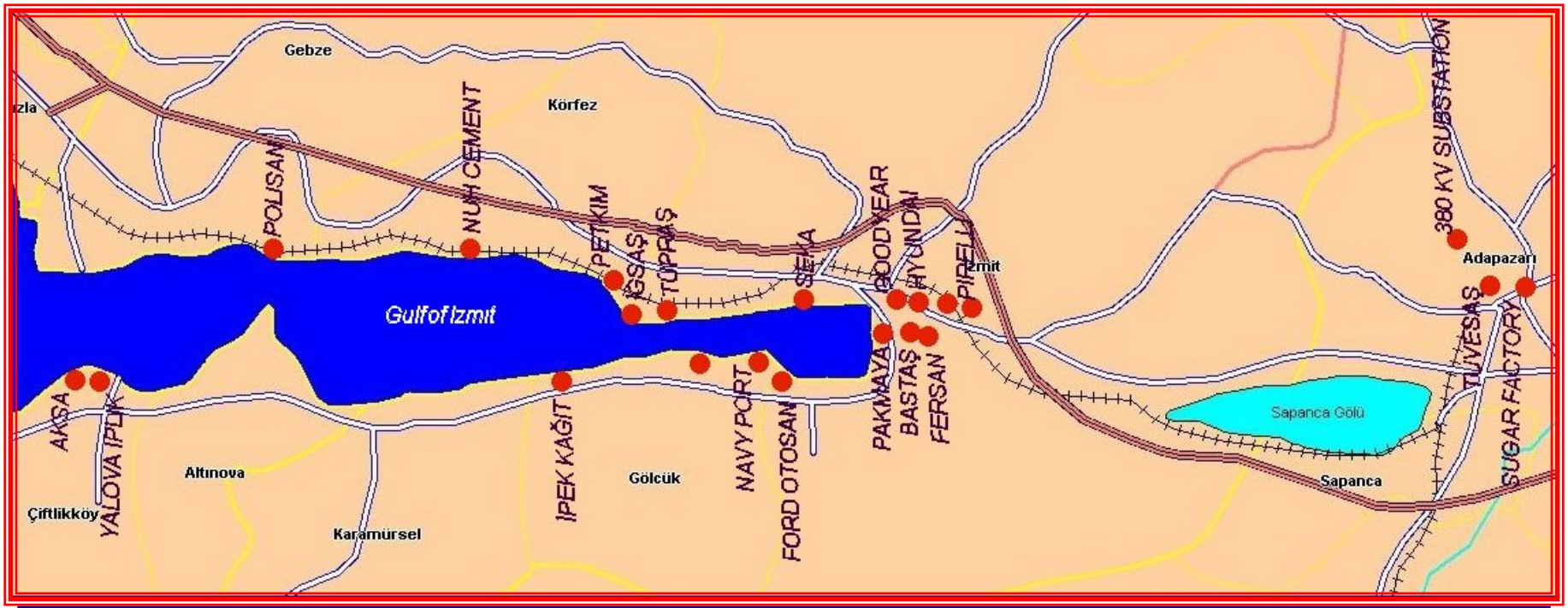
17 August 1999 Kocaeli Earthquake
Ms 7.8, intensity X

General observations:

- Largest industrial damage since the 1906 San Fransisco ve 1923 Tokyo earthquakes
- 70% of the total insured losses was direct damage, 30% of losses due to business interruption
- Total insured loss 1,5-3,5 billion $
- Losses paid by the insurance sector 550-750 million $



Important Industrial Facilities with Damage



- Heavy industry, petrochemical facilities, car factories, chemical, cement, textile, steel, energy, paper production.
- Observed damage larger than earthquakes with similar levels of ground motion
- Significant losses due to business interruption and loss of market

Surveys of the Kocaeli ve Adapazarı Chambers of Industry and Commerce

Damage

30% of their members had damage

34% of small- and medium size and 26% of large scale facilities damaged

Earthquake Insurance

All large scale facilities insured

53% of the small- and medium size firms had no earthquake insurance

Capacity

Average capacity before the earthquake 70%

after one month after the earthquake 31%

after six months 54%

Business Interruption

Average business interruption 35 days

TÜPRAŞ, Damaged Tanks

TÜPRAŞ, Fallen Stack

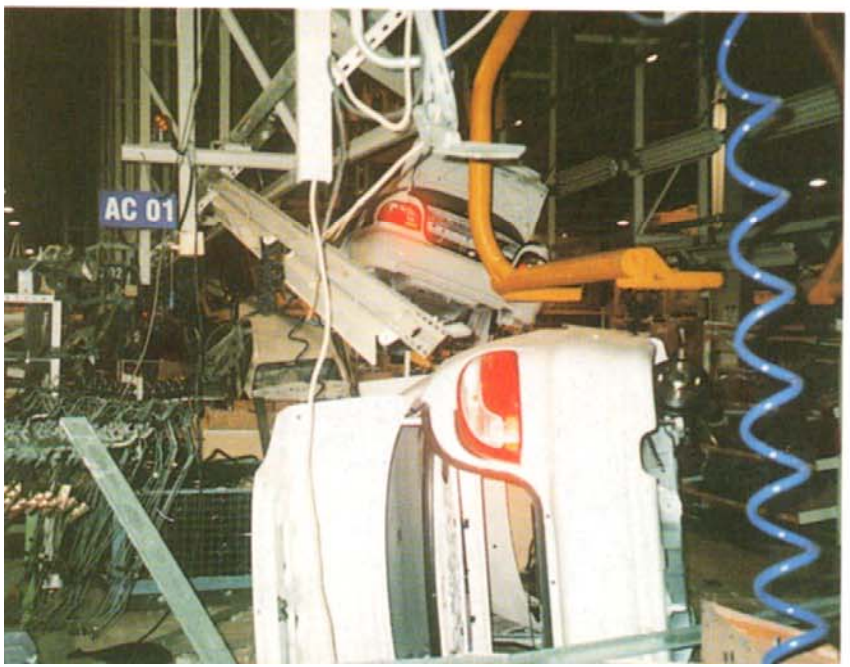
Adapazarı 380 kV Substation

Damage to prefabricated factory buildings

Adapazarı rail car factory, damaged steel frame

Damaged electrical equipment


AC 02
LC


AC 01


HYUNDAI CAR FACTORY

Stock damage

Questionnaire Survey of Industrial Damages

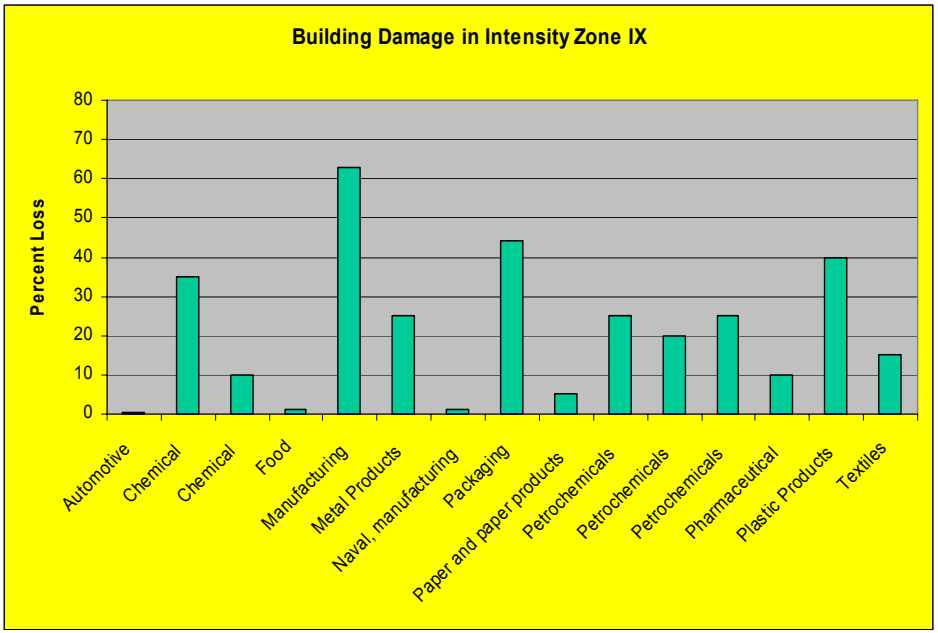
Aimed at collecting information on:

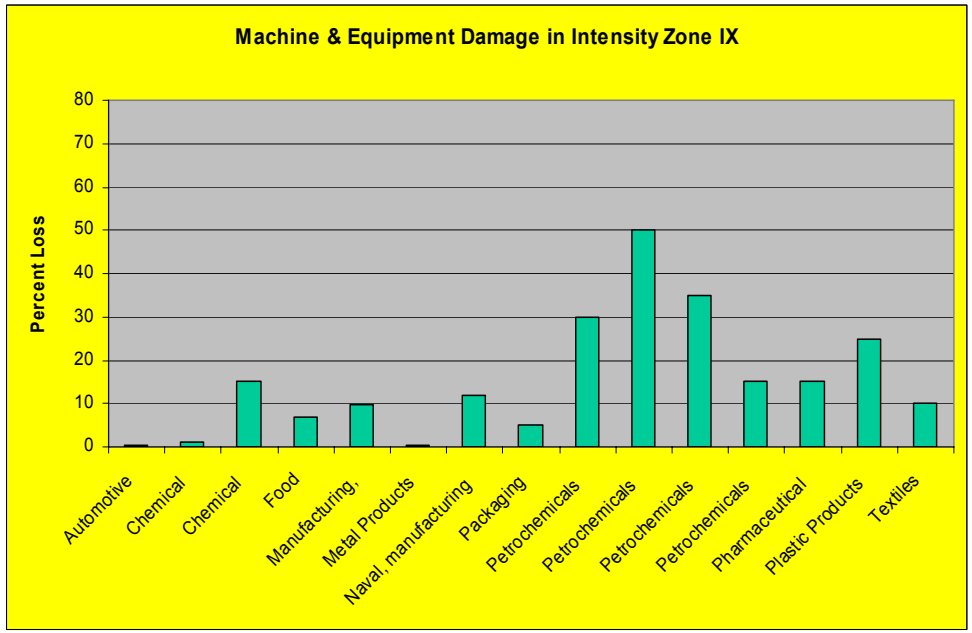
- Generals of the facility
- Direct physical damage
- Losses due to business interruption
- Buildings and their usage

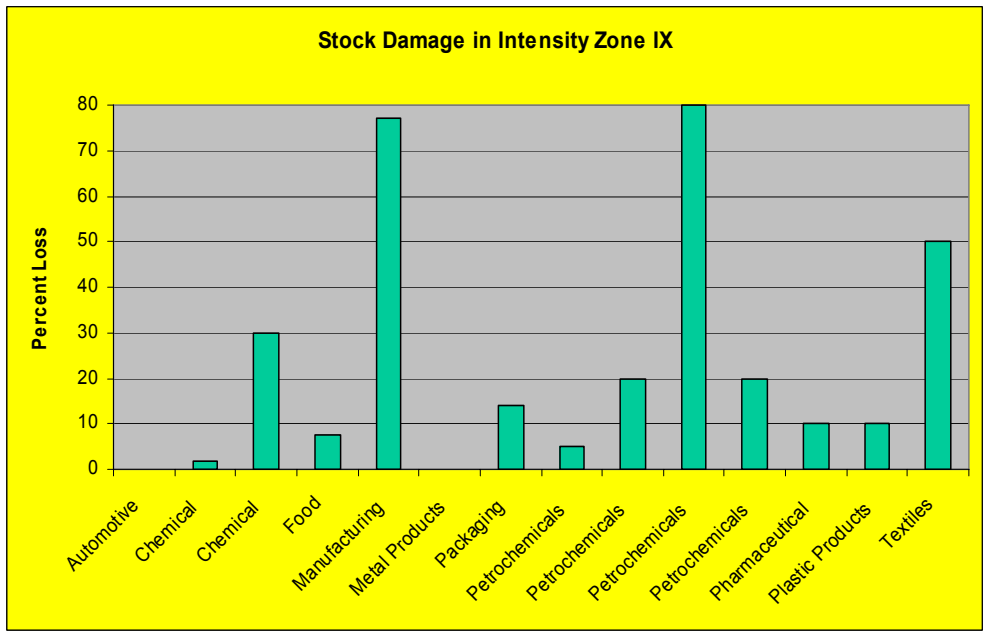
Forms were sent out to 100 firms, response from 43 firms

Industrial Losses in Intensity Zone IX

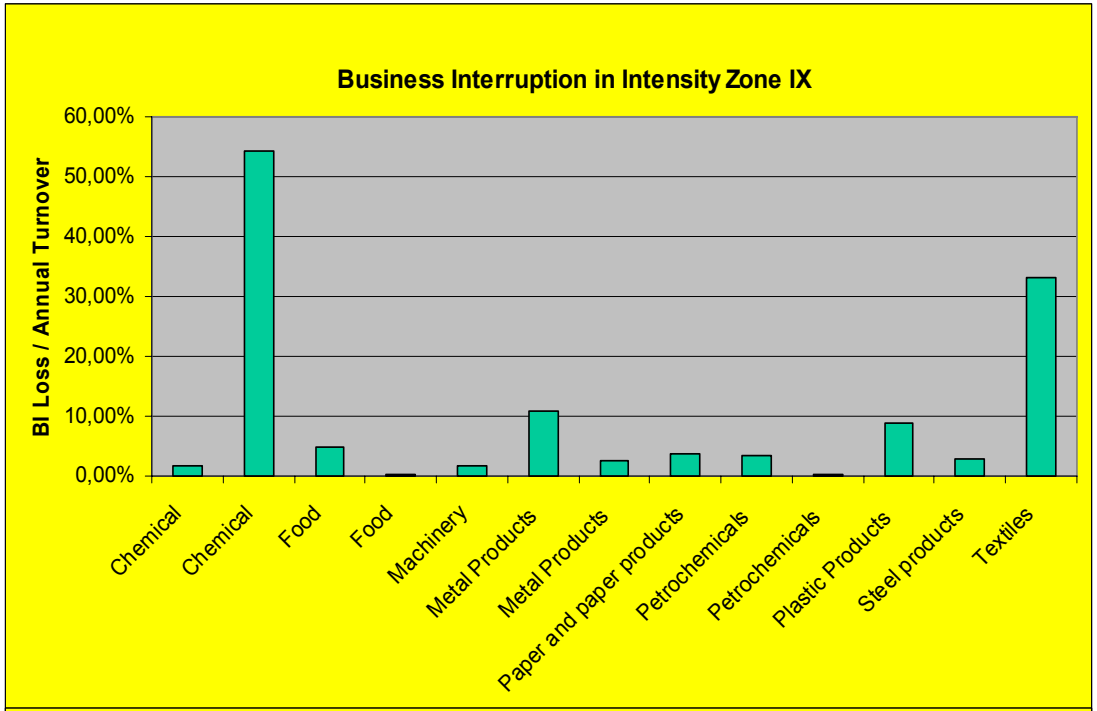
Building, Machine and Equipment, Stock

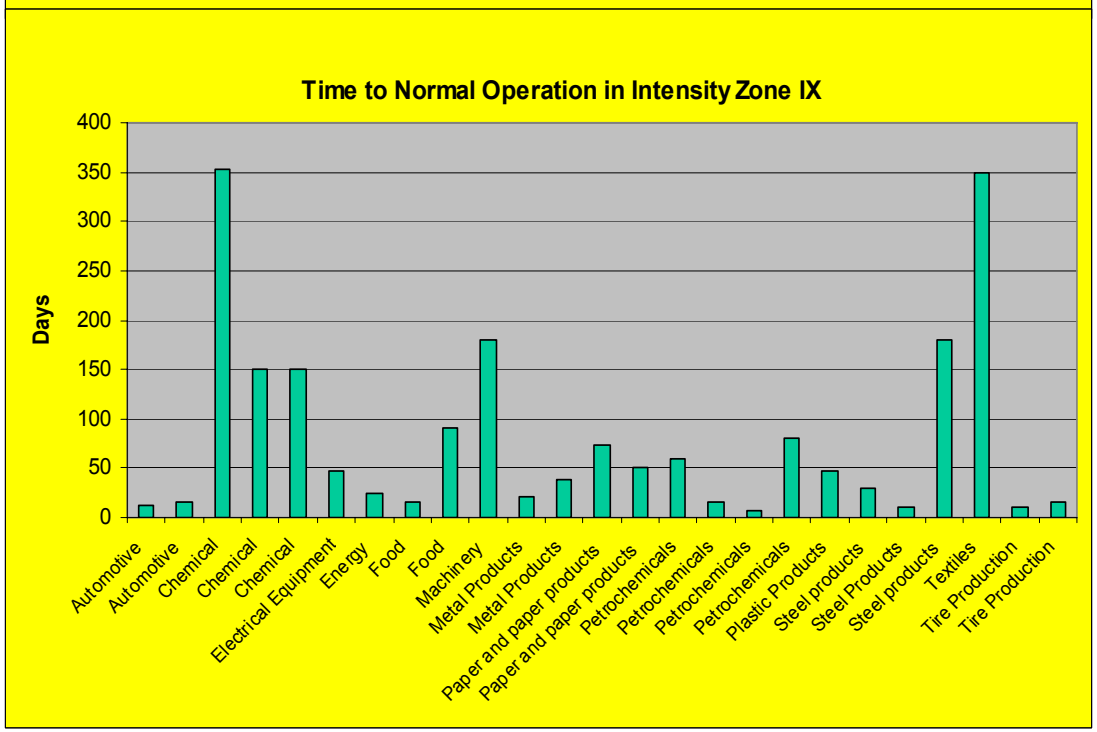






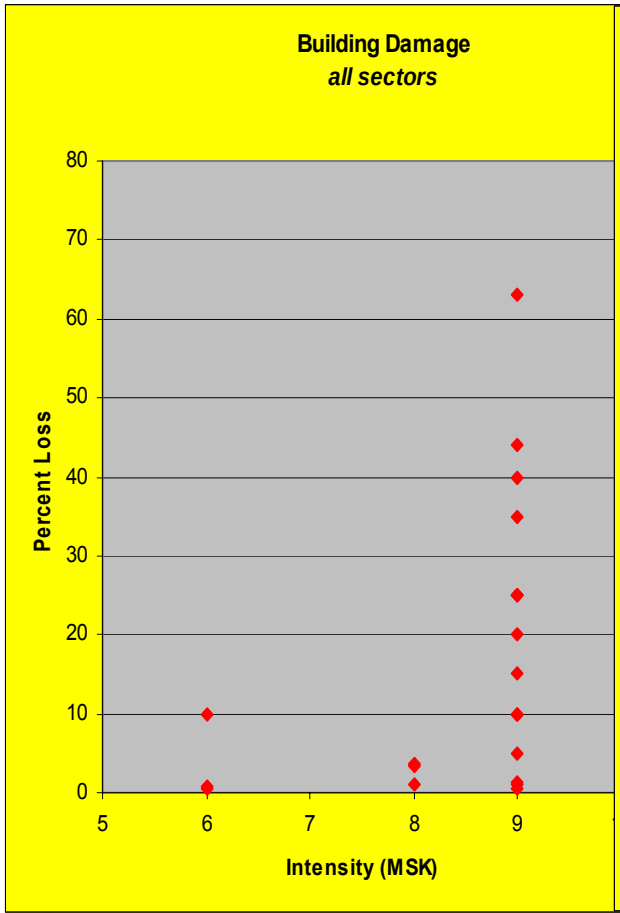
Intensity IX

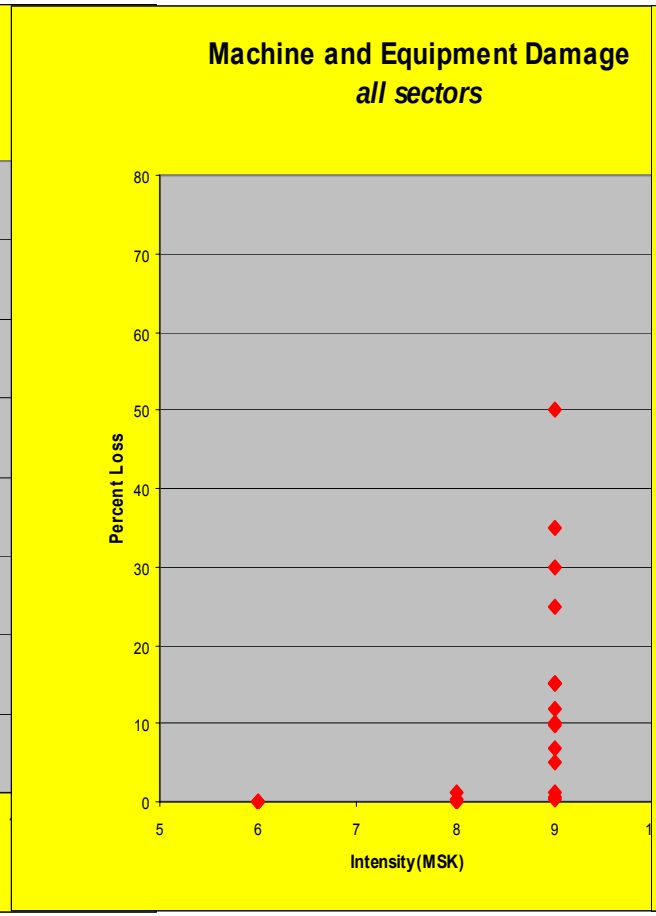


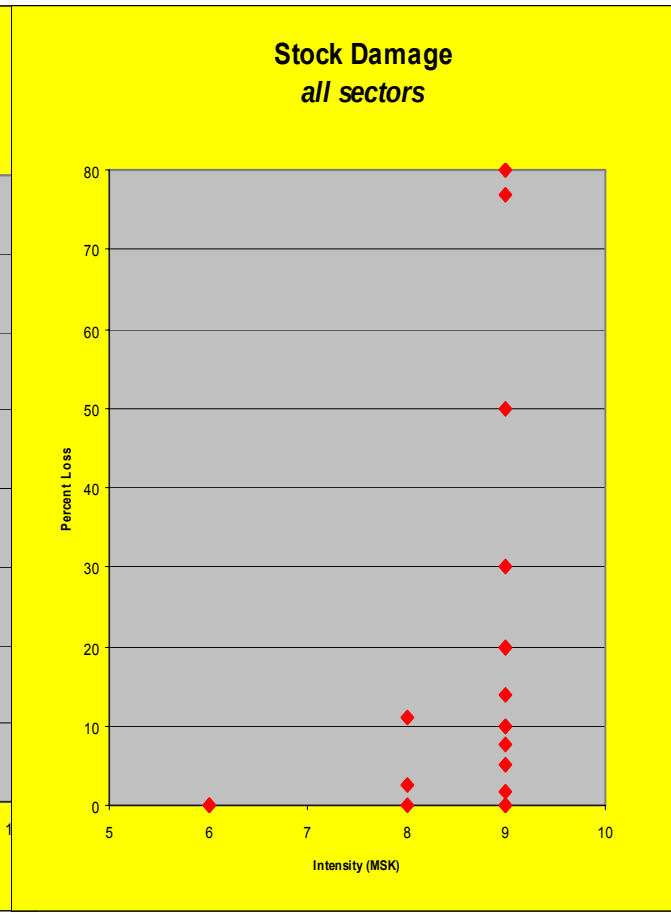


Quantification of Industrial Damage during the Kocaeli Eq.

Building, Machine & Equipment, Stock all industrial sectors



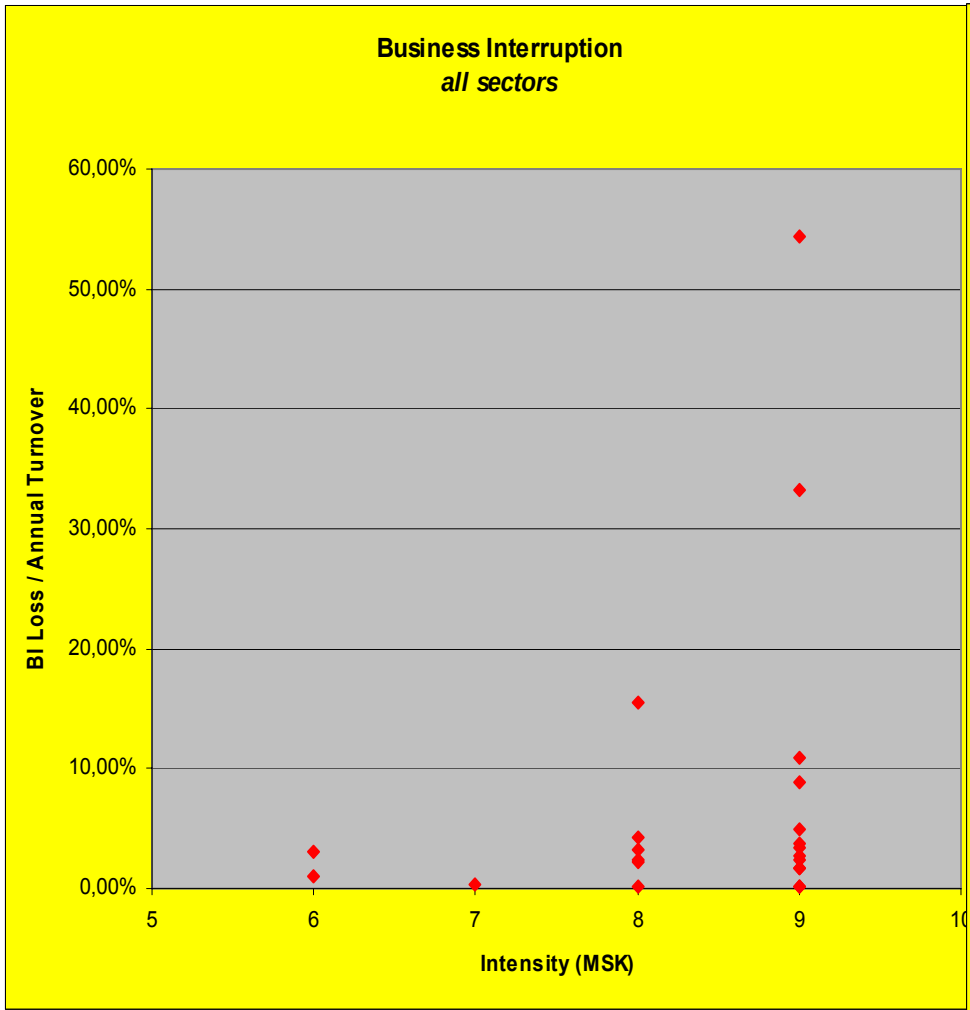


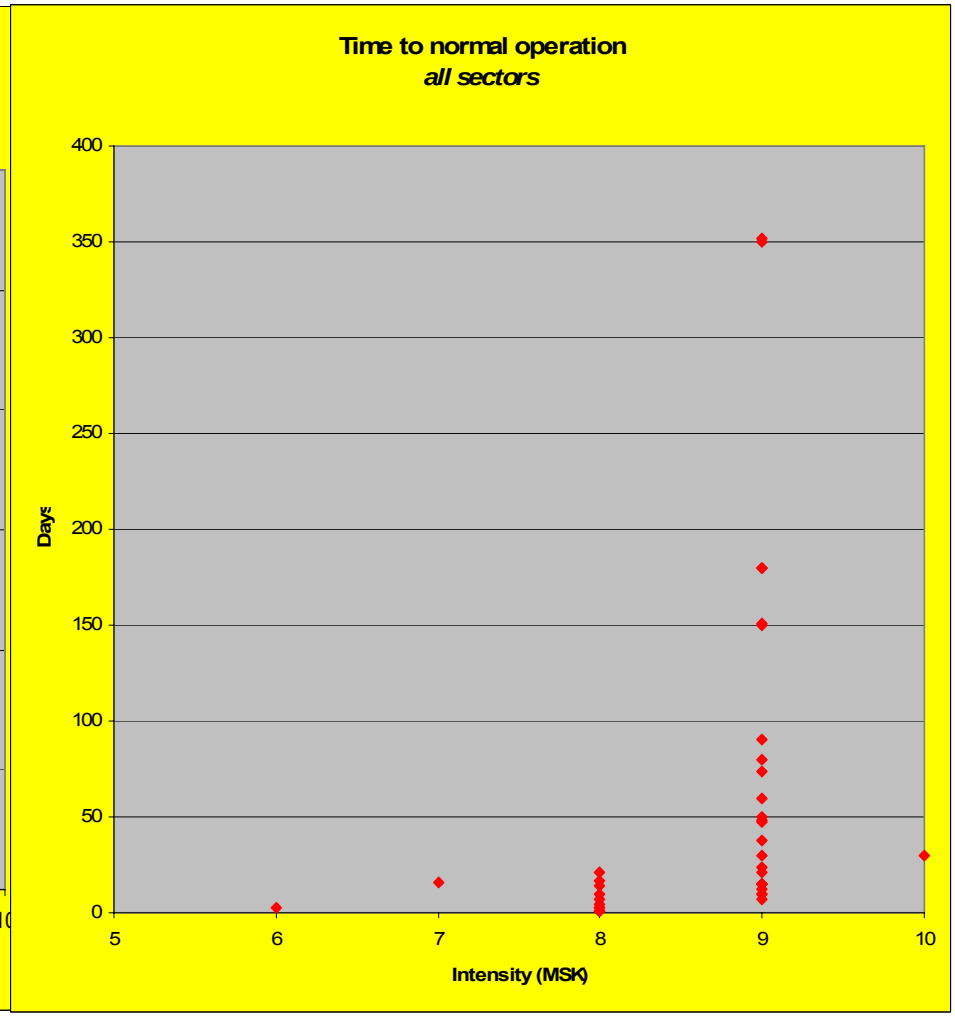


Quantification of Industrial Damage

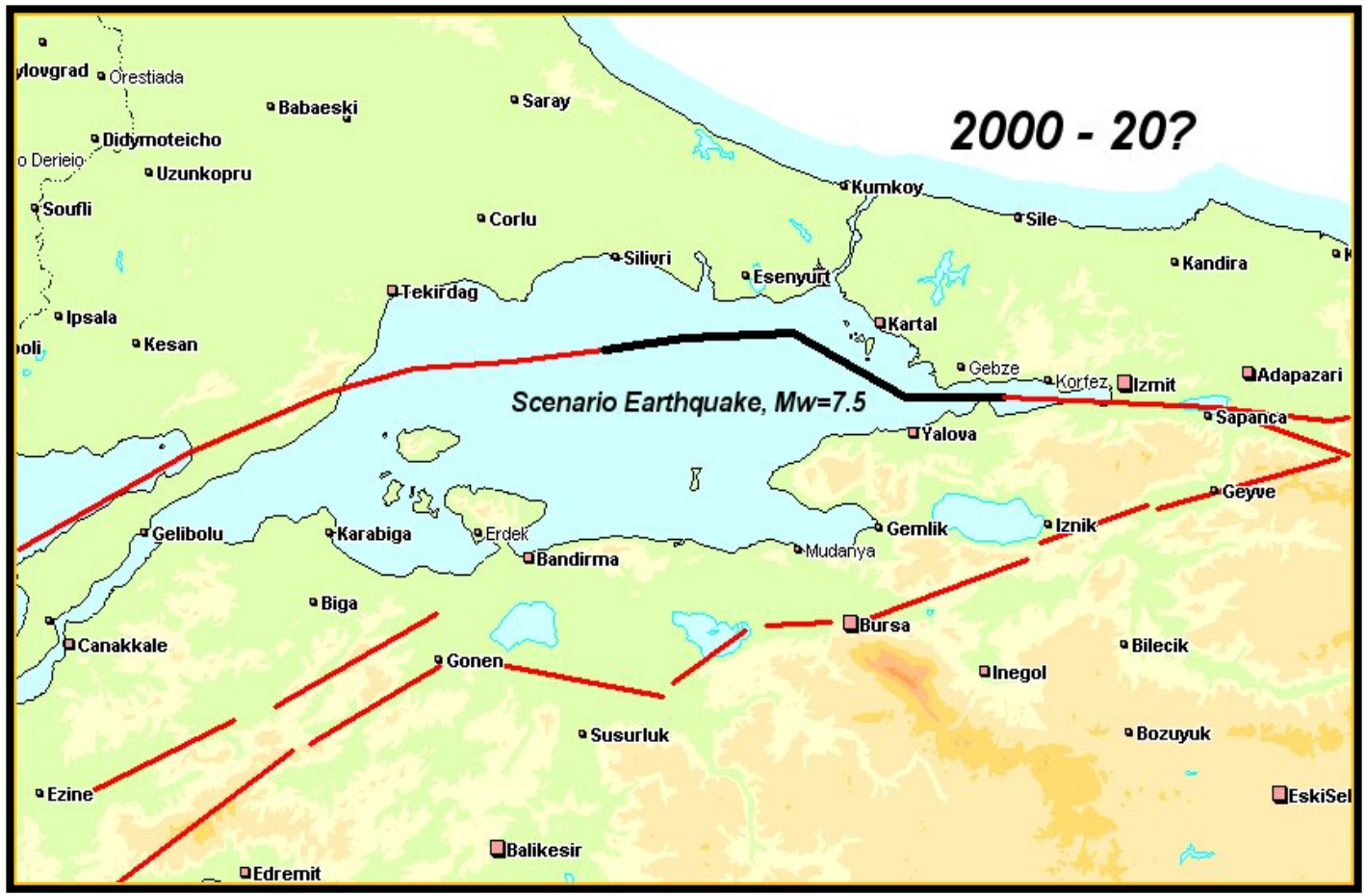
Business Interruption and Time to Normal Operation

all sectors



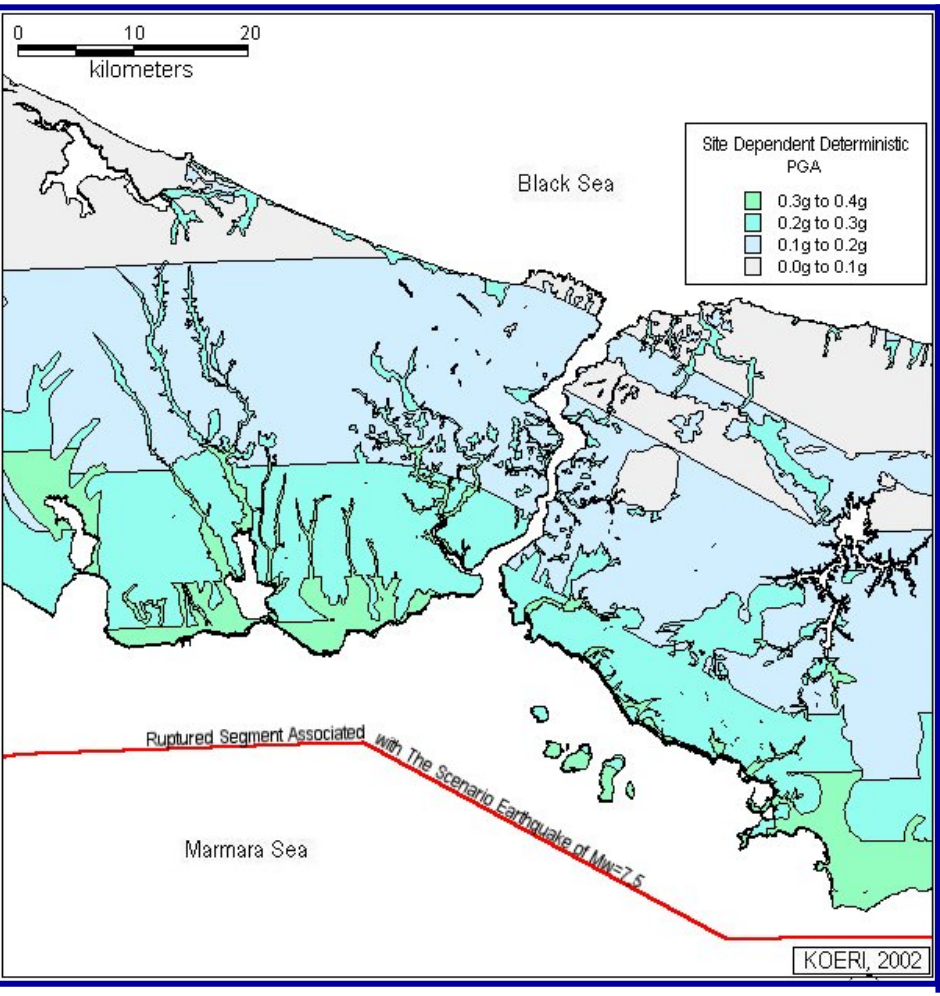


Scenario Earthquake for Istanbul

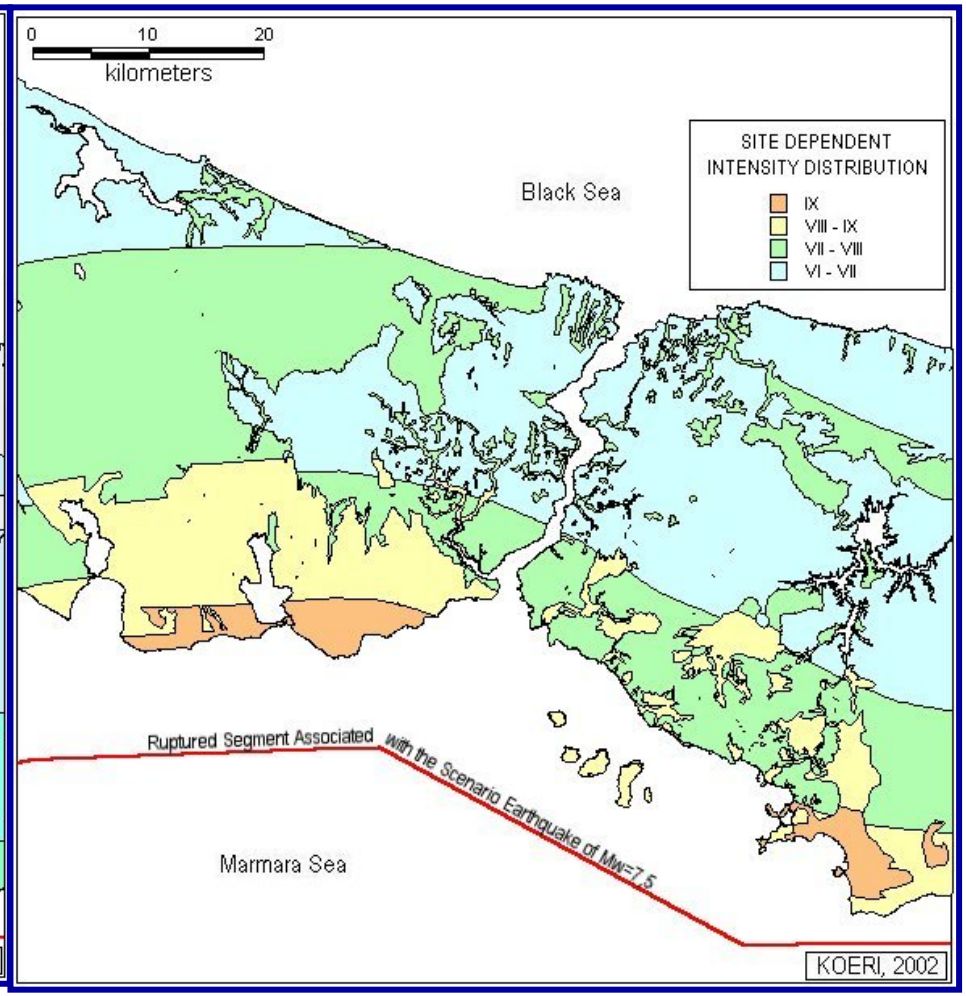


40-60 % probability for a M>7 earthquake in 30 years
(Parsons, 2000, 2004)

Site Dependent
Peak Ground Accelerations



Site Dependent
Earthquake Intensities



Estimated Losses in the Istanbul Scenario Earthquake

(Mw=7.5)

- Heavily damaged - collapsed: 40,000 - 50,000 buildings (out of about 800.000 buildings in Istanbul), 4,000 – 5,000 of them total collapse
- 200,000 families in need of emergency shelter
- 40,000 deaths, 160,000 hospitalized injuries
- Loss due to building damage 8 - 10 billion $
- Industrial losses: 6 - 8 billion $
- 250,000 – 300,000 jobs lost
  (especially due to damage to the small-scale firms)
- **Total physical loss : 25 - 35 billion $**

Chemical and Petrochemical Products

Total registered number of firms: 8453

Number of people in Istanbul working in the sector: 80.000

http://sanayi.tobb.org.tr

Textile Industry

Total registered number of firms: 16597

Number of people in Istanbul working in the sector: 290.000

http://sanayi.tobb.org.tr

Paper and Paper Products

Total registered number of firms: 1948

Number of people in Istanbul working in the sector: 27.000

http://sanayi.tobb.org.tr

Electric and Gas: Production and Distribution

Total registered number of firms: 123

http://sanayi.tobb.org.tr

Assessment of Industrial Risk in Istanbul

I. An inventory of industrial facilities is created for
- Medium and small size facilities
- Large scale industrial facilities
- Industrial parks

II. Grouped in sectors, shown on intensity maps

III. Assessment of vulnerabilities and losses

Assessment of Industrial Risk in Istanbul

Industrial inventory from

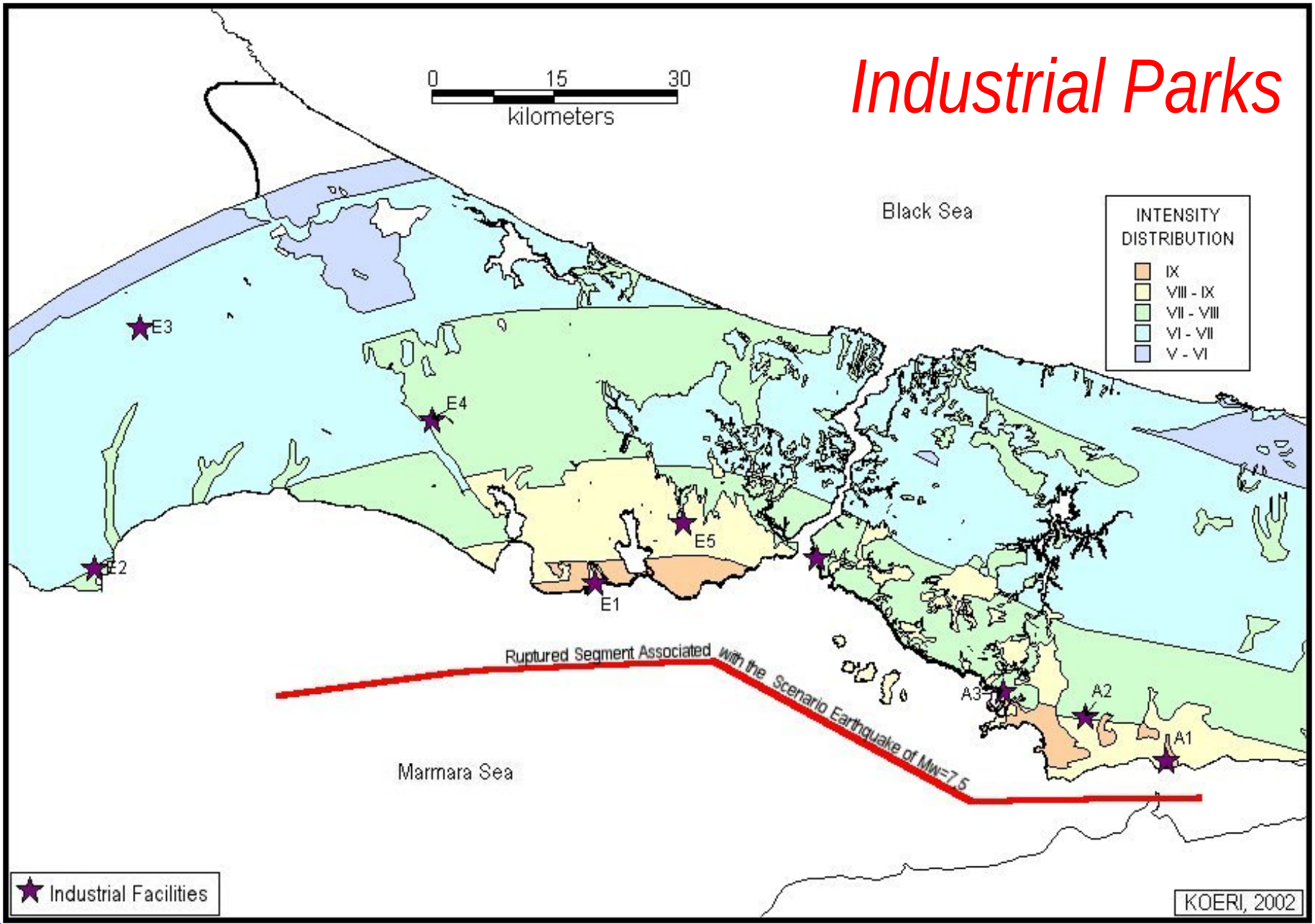
- **1:1000 Turkish Telecom Analog Maps (3000)**
- **Helicopter Flights (İBB)**
- **Site visits**
- **Satellite images**

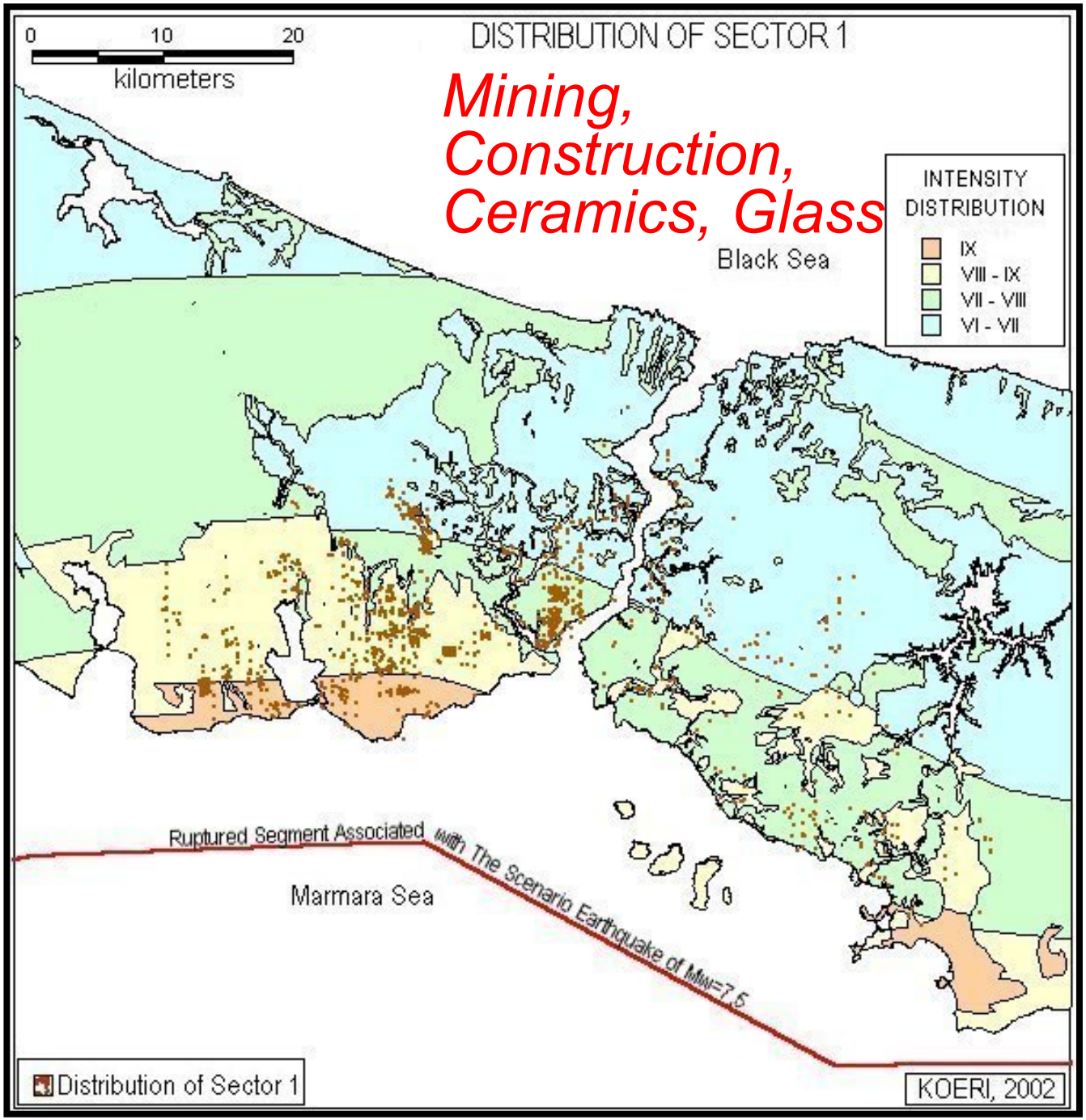
Data groupes in 8 sectors:

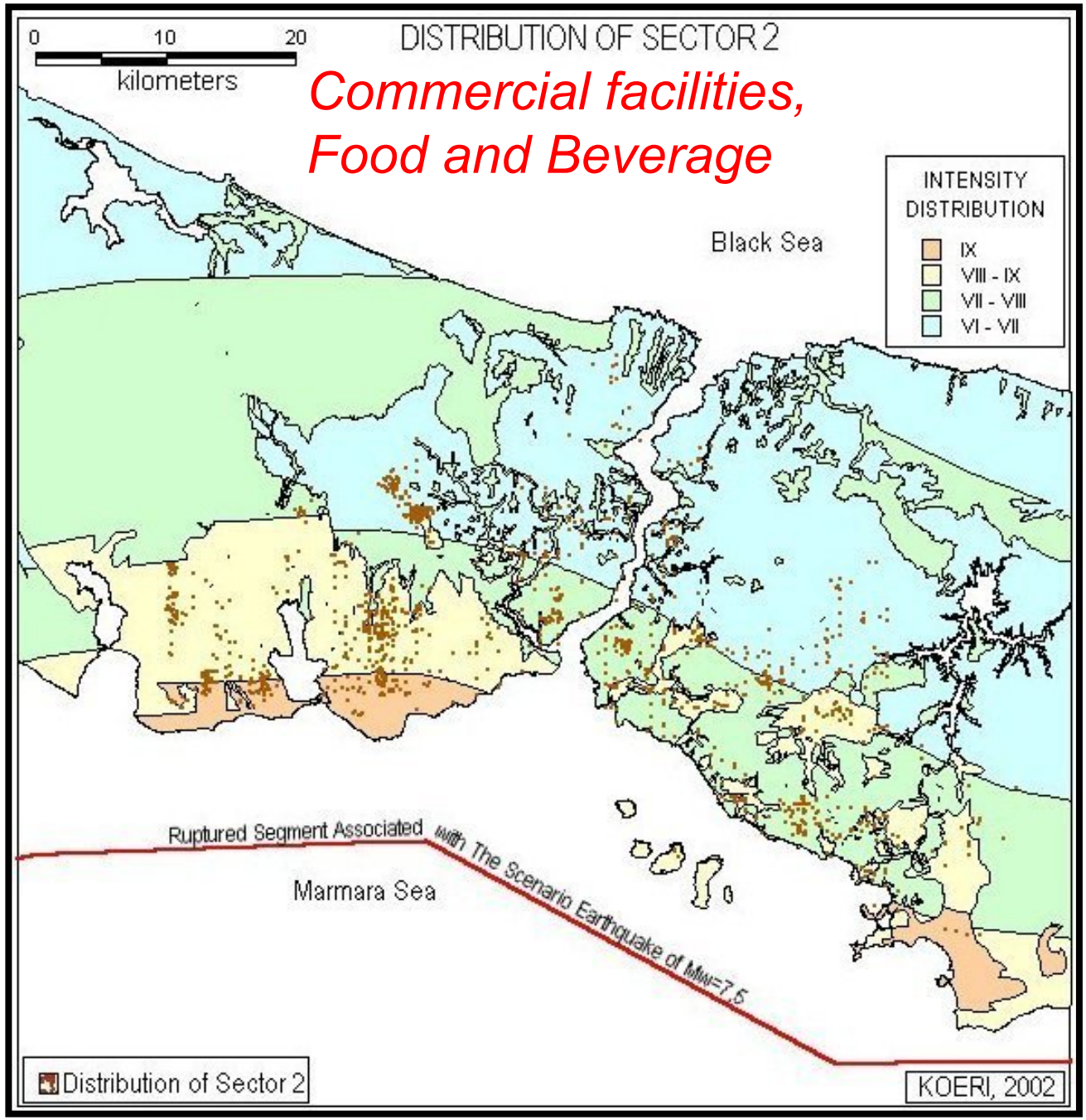
- **Mining, Construction, Ceramics, Glass**
- **Commercial facilities, Food and Beverage**
- **Textile, Leather**
- **Wood products, furniture, agriculture**
- **Chemical and petrochemical products**
- **Iron, steel and other metals**
- **Machinery and automotive**
- **Transportation and telecommunication**

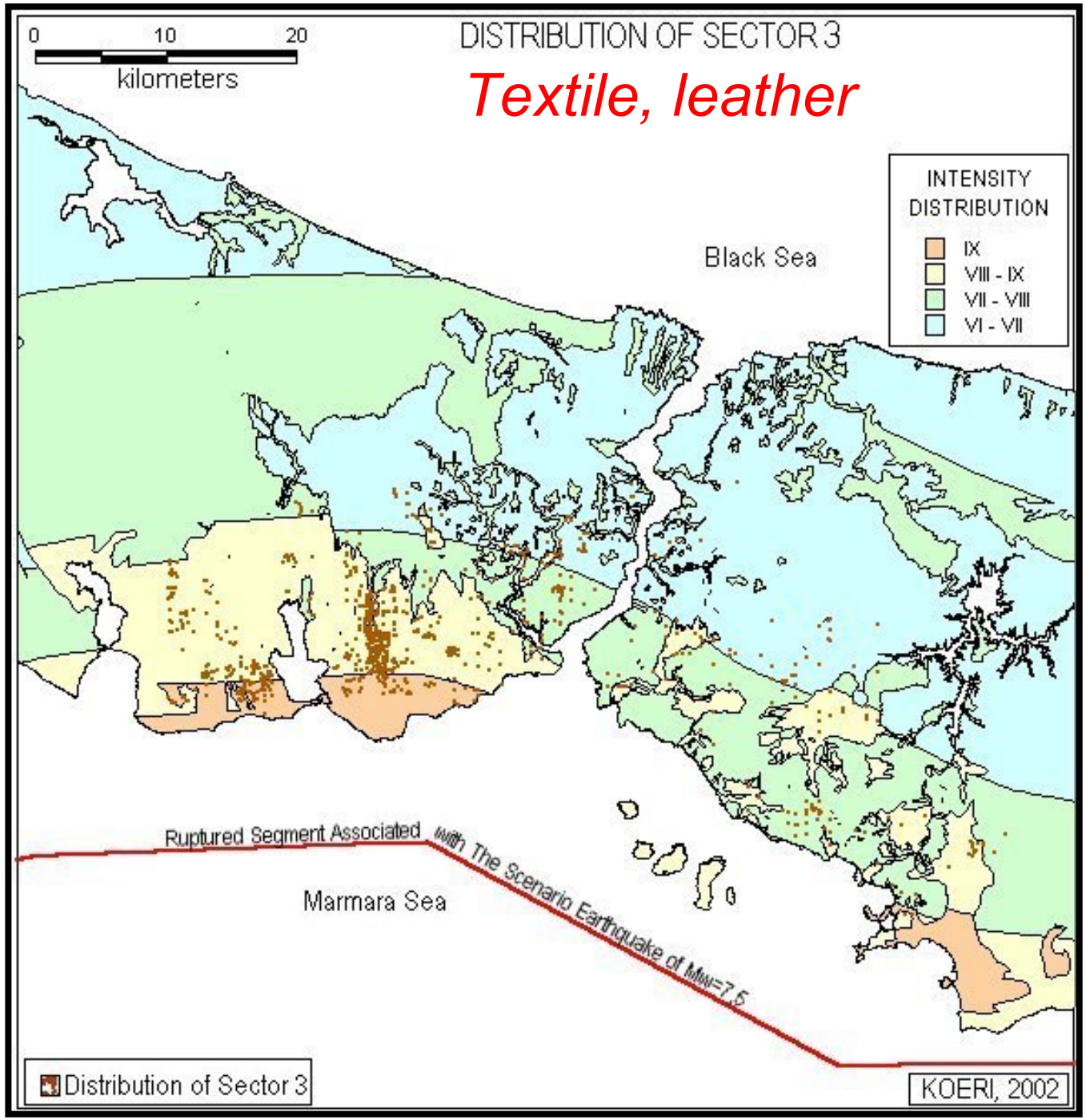
Şiddet Bölgesi	Sek.1	Sek.2	Sek.3	Sek.4	Sek.5	Sek.6	Sek.7	Sek.8
VI – VII	188	357	70	72	159	87	81	11
VII – VIII	393	339	148	113	184	147	196	43
VIII – IX	656	490	517	204	296	202	259	69
IX	160	113	110	72	75	47	48	17

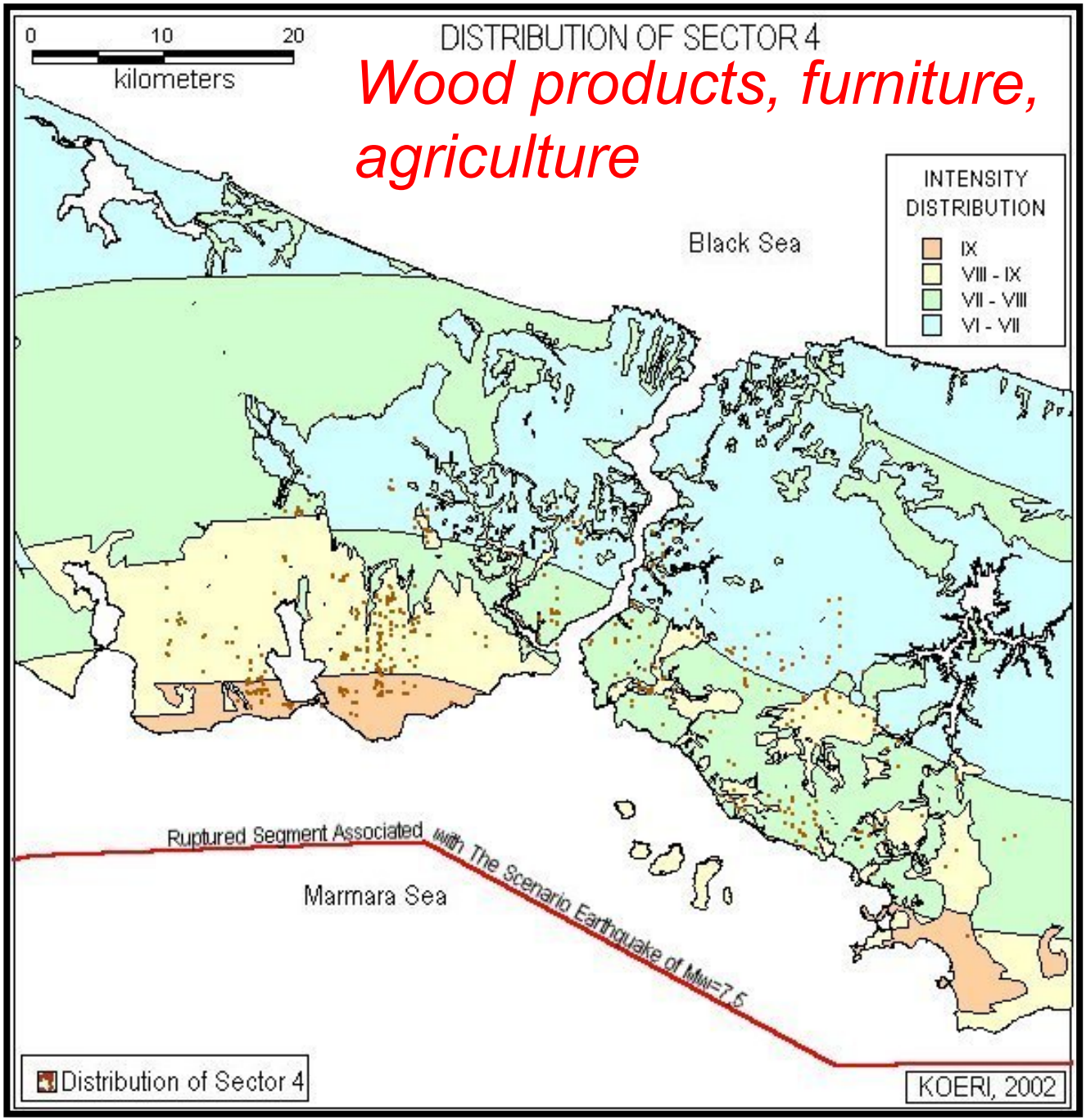
Industrial Parks

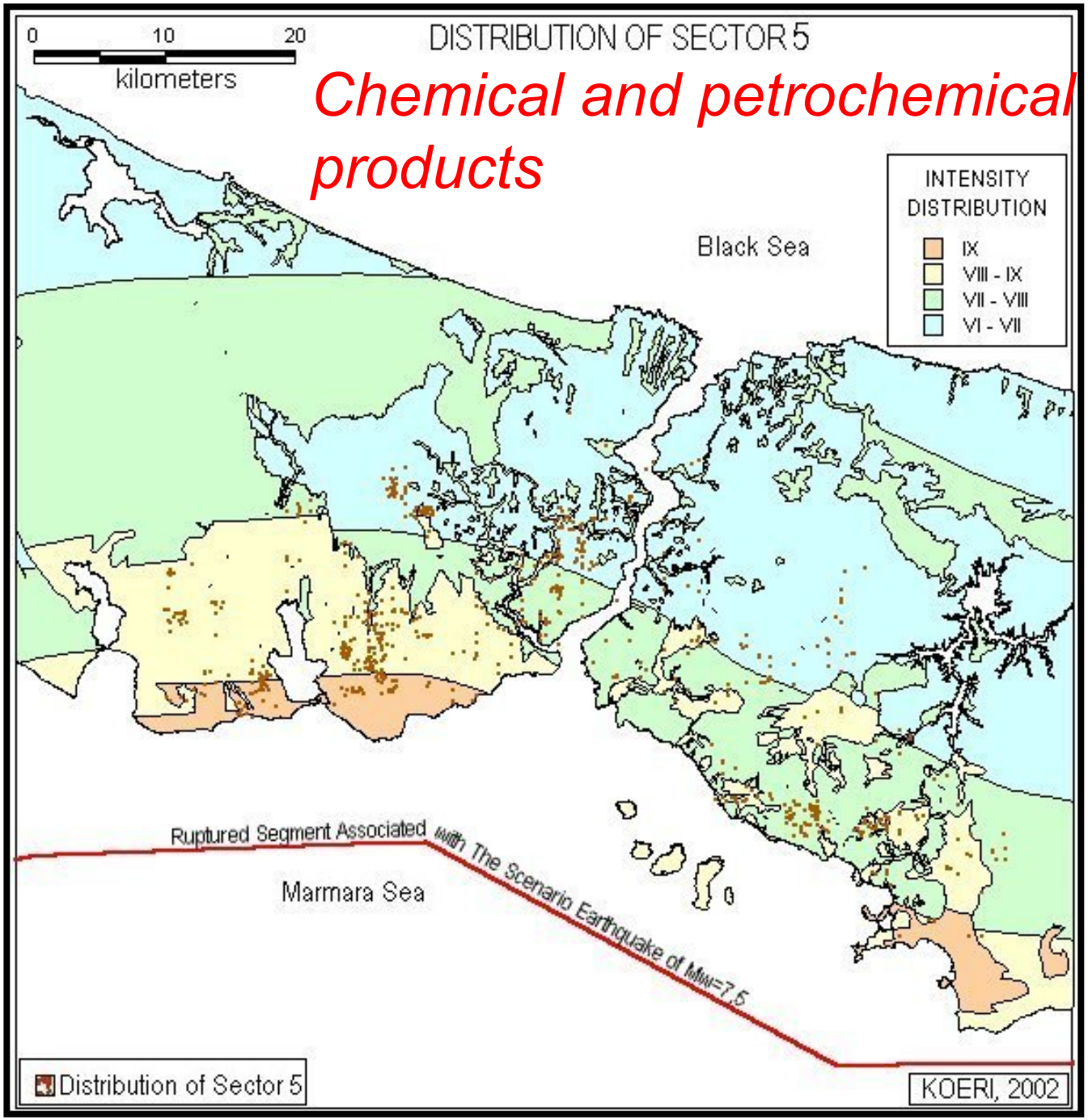


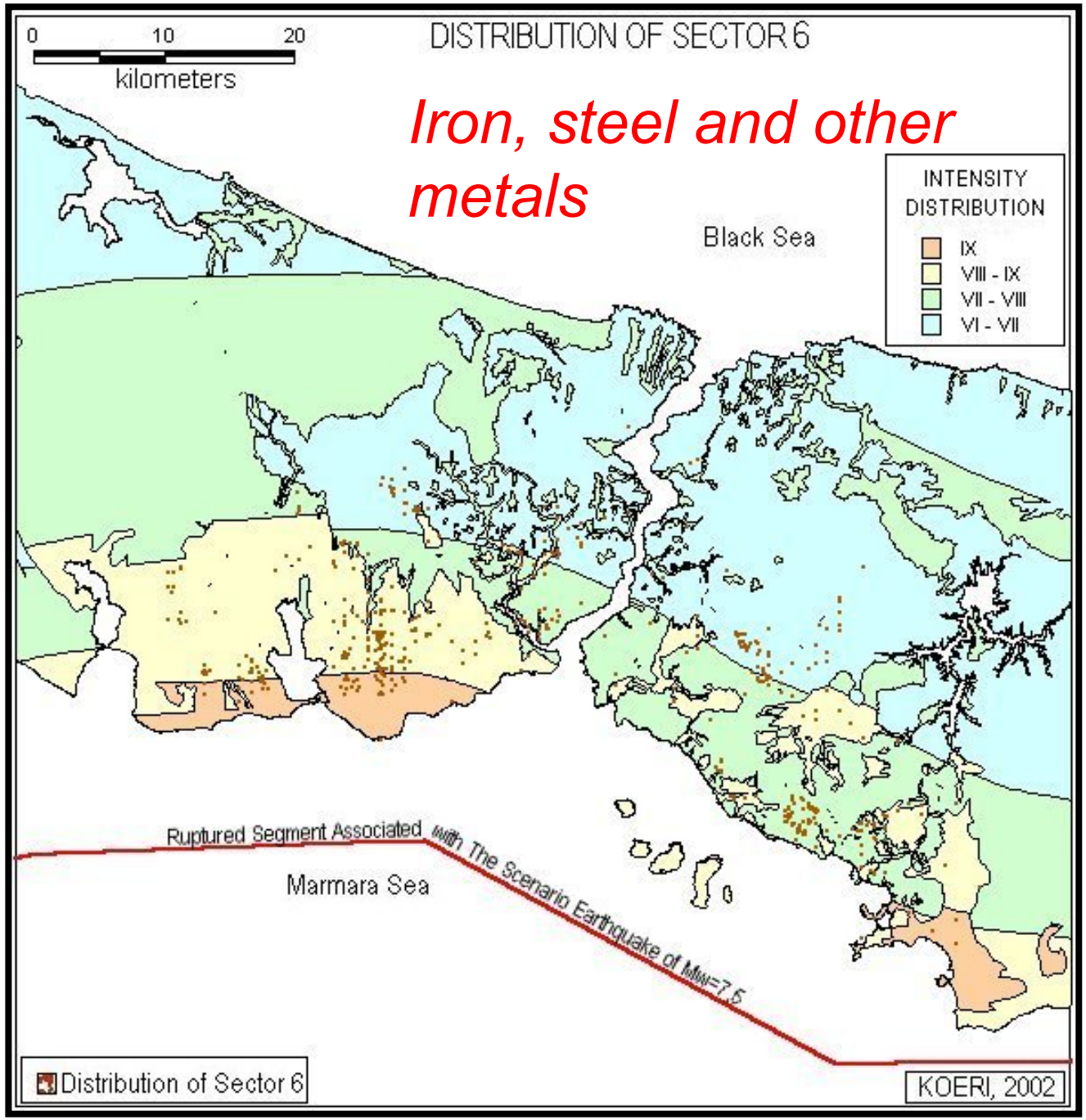

DISTRIBUTION OF SECTOR 1
0
10
20
kilometers
Mining,
Construction,
Ceramics, Glass
Black Sea
INTENSITY
DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Ruptured Segment Associated with The Scenario Earthquake of Mw=7.5
Marmara Sea
Distribution of Sector 1
KOERI, 2002

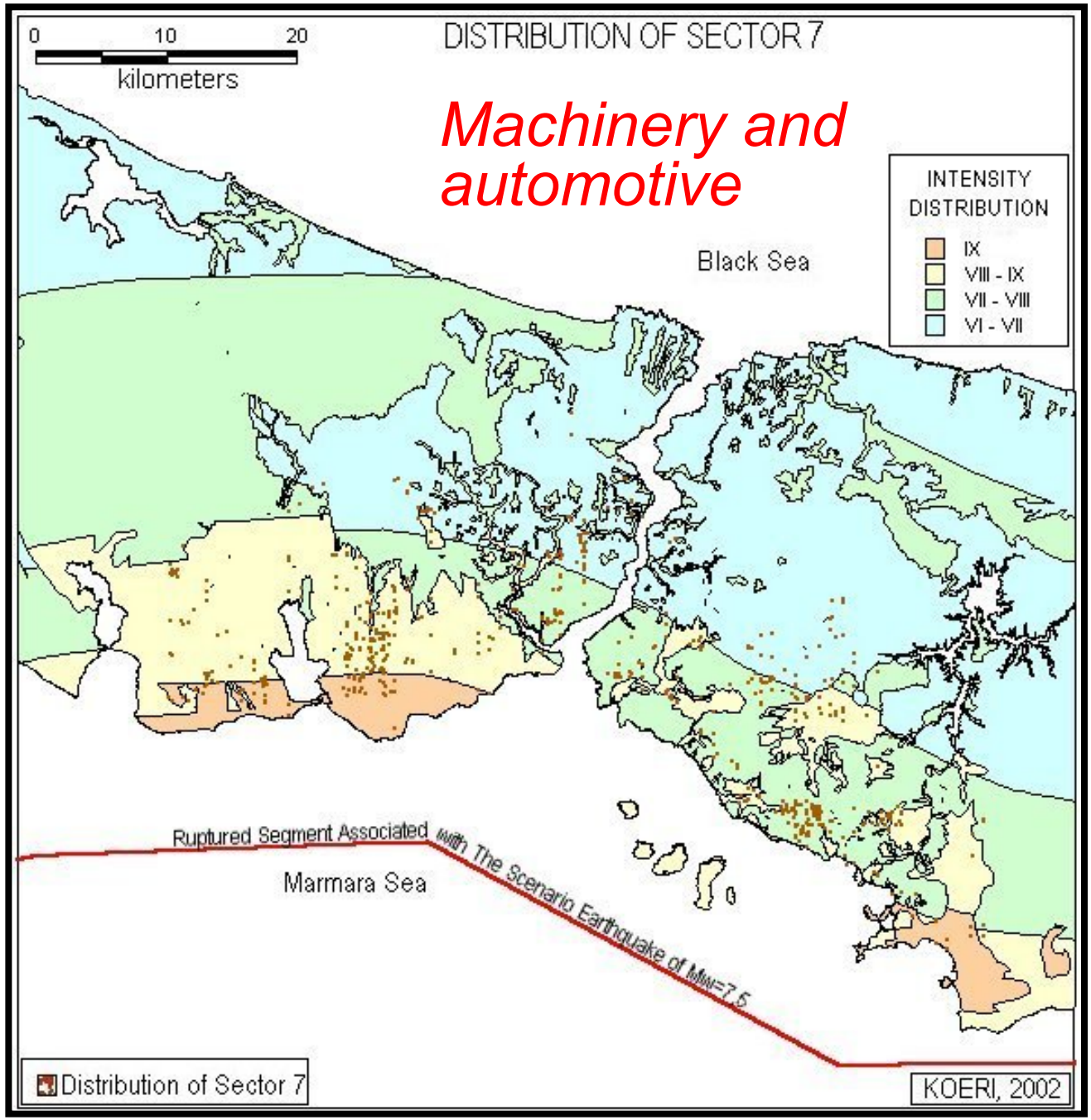

DISTRIBUTION OF SECTOR 2
0
10
20
kilometers
Commercial facilities,
Food and Beverage
INTENSITY
DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Ruptured Segment Associated with The Scenario Earthquake of MW=7.5
Marmara Sea
Distribution of Sector 2
KOERI, 2002

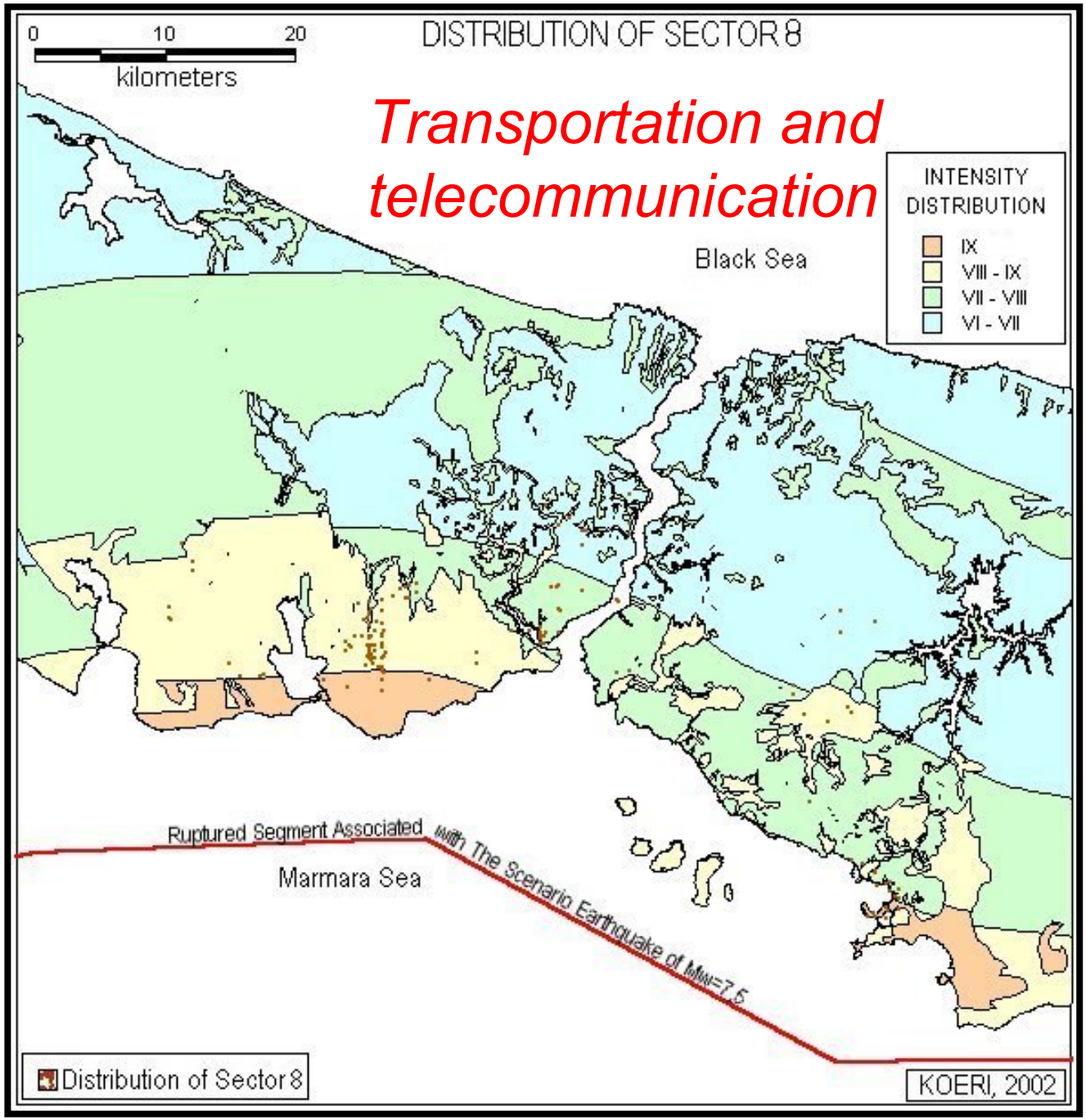

DISTRIBUTION OF SECTOR 3
Textile, leather
0
10
20
kilometers
INTENSITY DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Ruptured Segment Associated with The Scenario Earthquake of MW=7.5
Marmara Sea
Distribution of Sector 3
KOERI, 2002


DISTRIBUTION OF SECTOR 4
0
10
20
kilometers
Wood products, furniture, agriculture
INTENSITY DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Ruptured Segment Associated with The Scenario Earthquake of MW=7.5
Marmara Sea
Distribution of Sector 4
KOERI, 2002

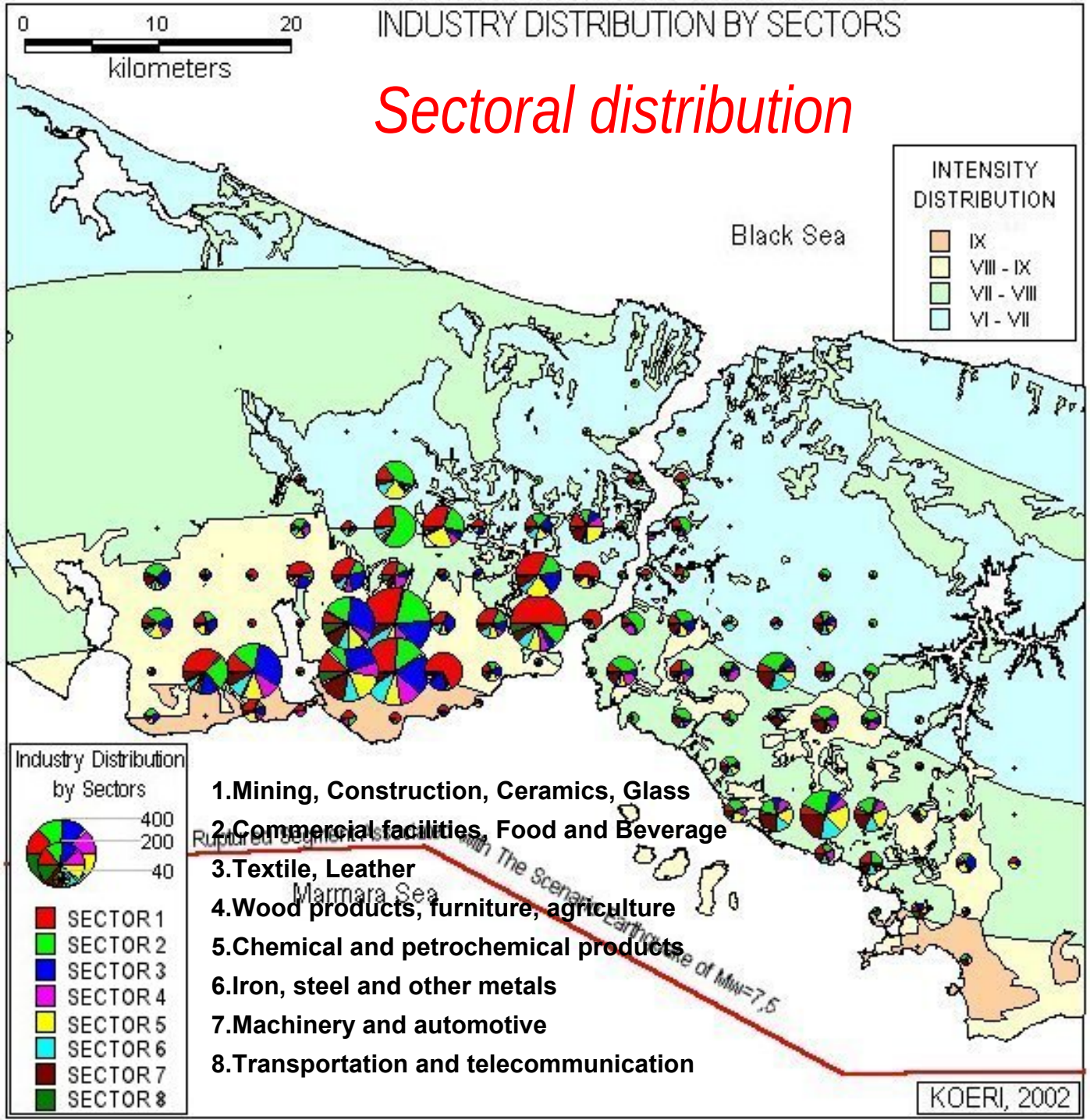

DISTRIBUTION OF SECTOR 5
0
10
20
kilometers
Chemical and petrochemical products
INTENSITY DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Marmara Sea
Ruptured Segment Associated with The Scenario Earthquake of Mw=7.5
Distribution of Sector 5
KOERI, 2002


0
10
20
kilometers
DISTRIBUTION OF SECTOR 6
Iron, steel and other metals
INTENSITY DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Ruptured Segment Associated with The Scenario Earthquake of Mw=7.5
Marmara Sea
Distribution of Sector 6
KOERI, 2002


DISTRIBUTION OF SECTOR 7
0
10
20
kilometers
Machinery and automotive
INTENSITY DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Marmara Sea
Ruptured Segment Associated with The Scenario Earthquake of MW=7.5
Distribution of Sector 7
KOERI, 2002


DISTRIBUTION OF SECTOR 8
0
10
20
kilometers
Transportation and telecommunication
INTENSITY DISTRIBUTION
IX
VIII - IX
VII - VIII
VI - VII
Black Sea
Ruptured Segment Associated with The Scenario Earthquake of MW=7.5
Marmara Sea
Distribution of Sector 8
KOERI, 2002

Sectoral distribution



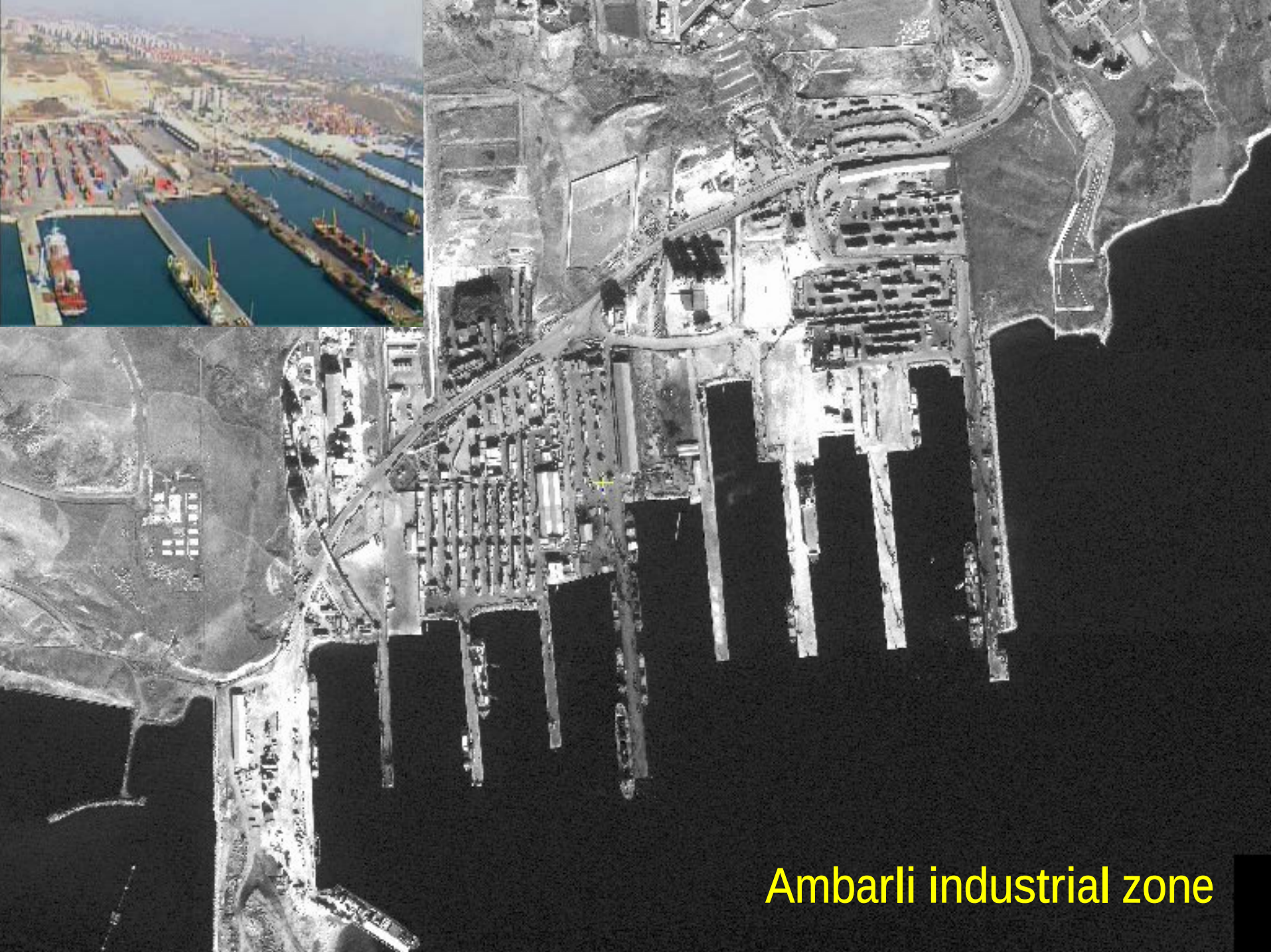
1. Mining, Construction, Ceramics, Glass
2. Commercial facilities, Food and Beverage
3. Textile, Leather
4. Wood products, furniture, agriculture
5. Chemical and petrochemical products
6. Iron, steel and other metals
7. Machinery and automotive
8. Transportation and telecommunication


Ikitelli
Industrial
Region


Leather industry in Tuzla

Shipyards in Tuzla


Ambarli industrial zone


Ambarli industrial zone

Assessment of general industrial losses in Istanbul due to M7.5 earthquake

- The overall loss to industrial buildings assessed between 6-8%.
- In intensity zone IX for all industrial sectors the business interruption losses may be about 5-10% of the annual turnover.

  In chemical, textile and automotive sector they can reach 50%, 30% and 20% respectively.
- Lost jobs about 250,000 - 300,000
- Biggest losses by small and medium size facilities.
- Direct industrial losses in the order 8-10 billion $.
- Additional losses due to loss of market, loss of human resources, reduced demand etc.

Example: Sector based evaluation of earthquake risk

Automotive industry in the Marmara Region

Home to 75% of the main automotive production facilities in Turkey.
100% of passenger car production.

93% of Turkey's vehicle production.

2nd in the country's total exports

SITE VISITS CONDUCTED

AUTOMOTIVE INDUSTRY

- FACILITIES EXPERIENCED 99 KOCAELI EARTHQUAKE:

  FORD, TOYOTA, HYUNDAI,OTOYOL

- OTHER FACILITIES VISITED:

  TOFAS,RENAULT, KARSAN, ASKAM, UZEL, MERCEDES, HONDA

CONSTRUCTION FIRMS

ARUP

INSURANCE CLAIMS EXPERT FIRMS

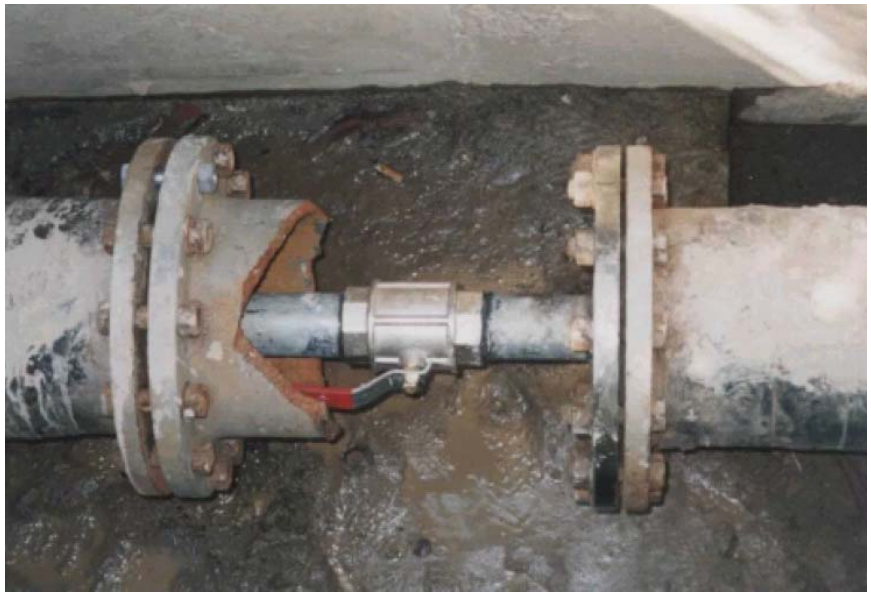
IAS Surveyor

…With the support of Automotive Manufacturers Association

FORD OTOSAN

Ref: Preliminary Reports of the Turkey-US Geotechnical Earthquake Engineering Reconnaissance Team
http://nisee.berkeley.edu/turkey/Fturkch4.pdf
http://gees.usc.edu/GEES/RecentEQ/Turkey/Report/day5rep.htm

TOYOTA



One transformer fell down from its foundation

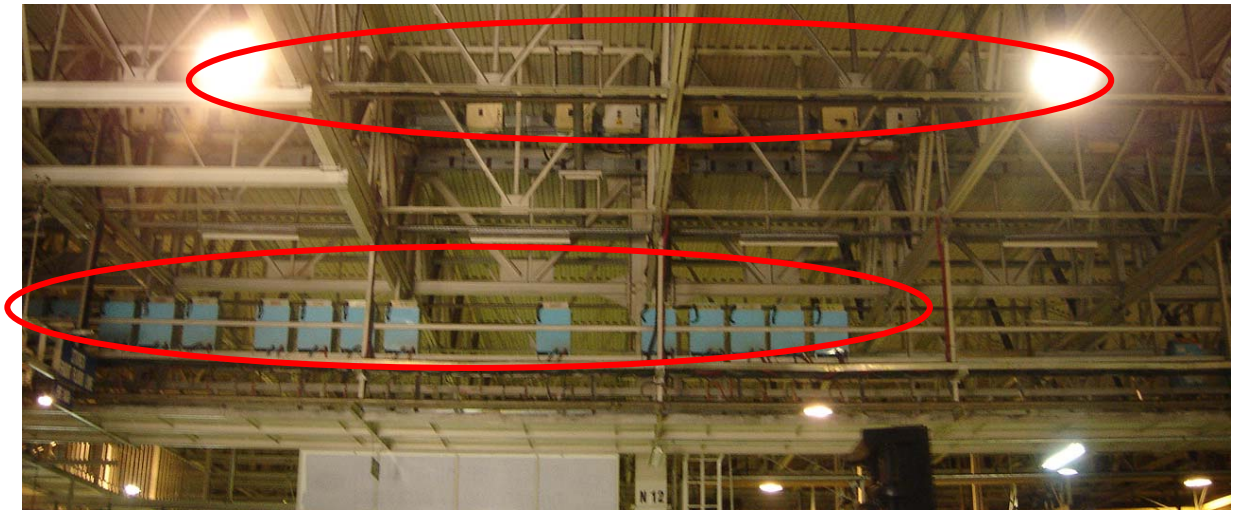
Many rigid pipe-valve connections were broken

RC floor slabs and non-structural walls cracked

Business Interruption 15 days,

Ref: http://nisee.berkeley.edu/turkey/Fturkch4.pdf

HYUNDAI



1. Timers and electrical bus-bar equipments fixed to the roof structures fell down.
2. Nozzles on the painting booths were damaged
3. In all painting booths settlement of paint blocked the pipes
4. Seals at the connection of pipes in paint shop were all damaged
5. The plant stopped for 75 days. Because of that, the welding operators lost their hand skills which took sometime to recover

What happened to the Automotive Industry in the Kocaeli Earthquake ?

- Physical Damages: Buildings 4%
  Machinery and Equipment 1-11%
  Stock 3-6%

Time to normal operation varied between 7-75 days in intensity zone IX.
There was very minor damage to the facilities in intensity zones less than IX.

- Earthquake insurance covers are subjected to a minimum 2% deductible and 20% co-assurance. Earthquake indemnity covers all claims that arise in a 72-hour period after the main shock and business interruption only for 14 days.
  Losses were about 3.5%.

- The earthquake took place at night, when none of the plants was in operation due to the economic conditions in 1999. It is very likely that a day-time event would have caused larger losses.

- 25% decrease in the production with respect to the previous year

In the occurance of an Istanbul earthquake

- The majority of the plants in the region are expected to be in the intensity zone VIII-IX.
- The losses to be sustained by these facilities are expected to be very similar to the types of losses and damages in the same intensity zone in the Kocaeli earthquake.
- In terms of probabilistic earthquake hazard all the facilities in the Marmara region are located in zones marked with high earthquake hazard.
- Thus losses similar to the ones in the Kocaeli earthquake are very likely.

Reduction of Industrial Earthquake Risk

I. Earthquake Contingency and Business Continuity Planning

(For the facility, its immediate vicinity, in regional and national scales)

- Risk assessment and reduction.
- Emergency management planning.
- Restructuring and rehabilitation planning

II. Risk Reduction

I. Structural
II. Nonstructural and non-building (M&E, stock, hazmat)
III. Operational
IV. Human resources

Pre-earthquake

Post-earthquake

III. Rapid Response
IV. Restructuring, Rehabilitation

Thank you !