Geotechnical Aspects of the August 15, 2007 M_w 8.0 Pisco, Peru Earthquake: Preliminary Observations

Presented by

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GEESD IV

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National Science Foundation
WHERE DISCOVERIES BEGIN

Outline

- General Information
- Ground Motions
- Liquefaction observations
  - Spatial distribution
  - Case histories
- Canchamaná Lateral Spread
- Landslides


Image NASA
Image © 2007 TerraMetrics
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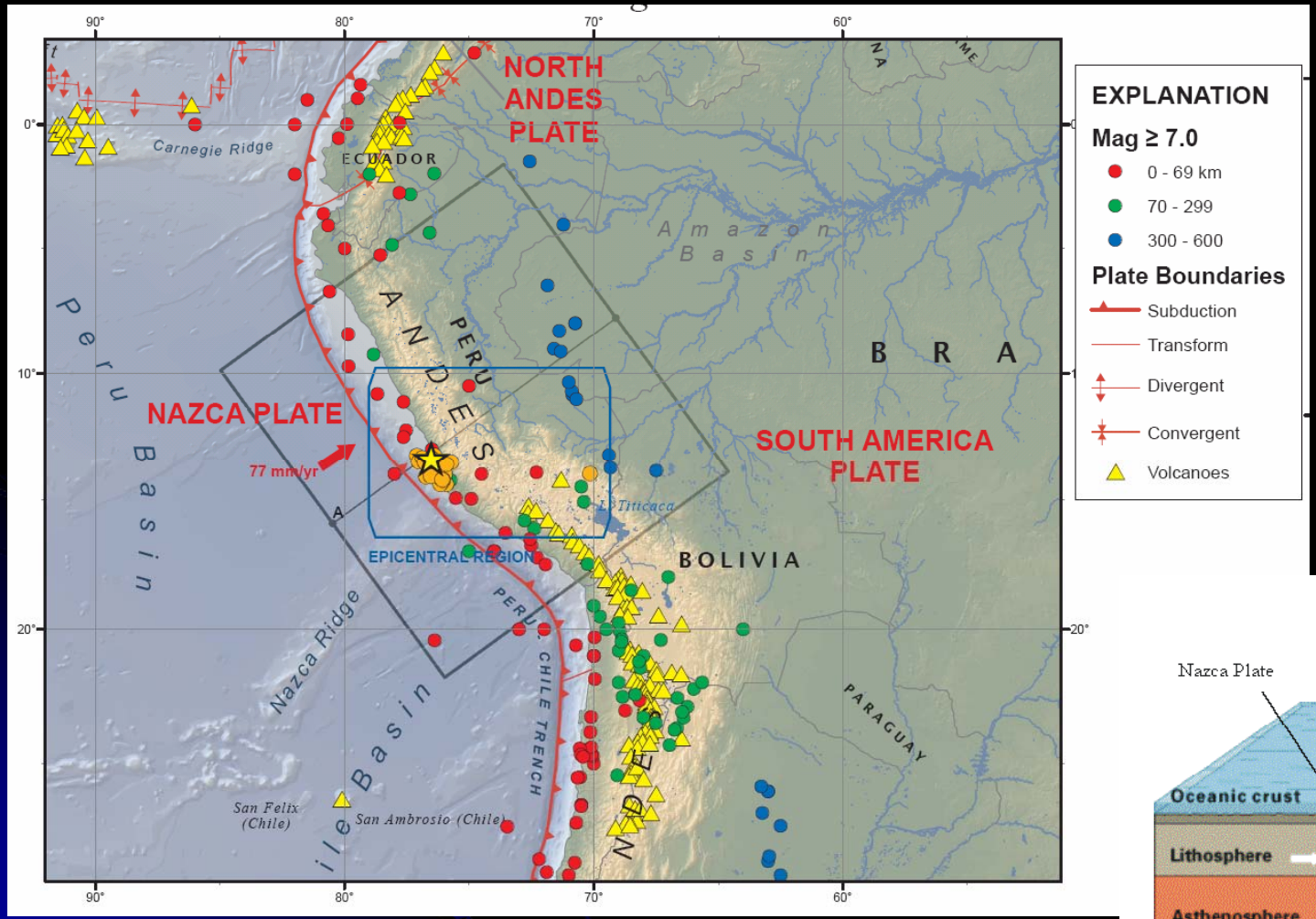
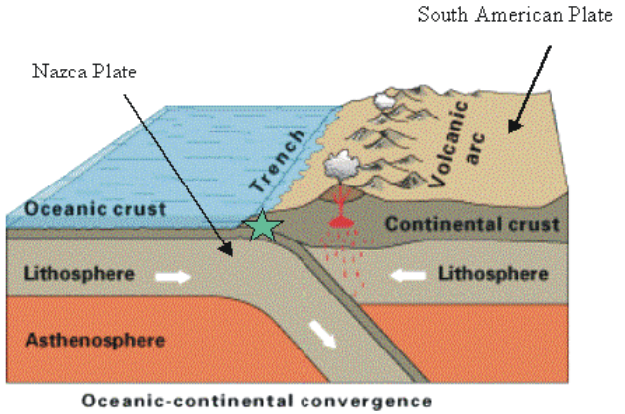
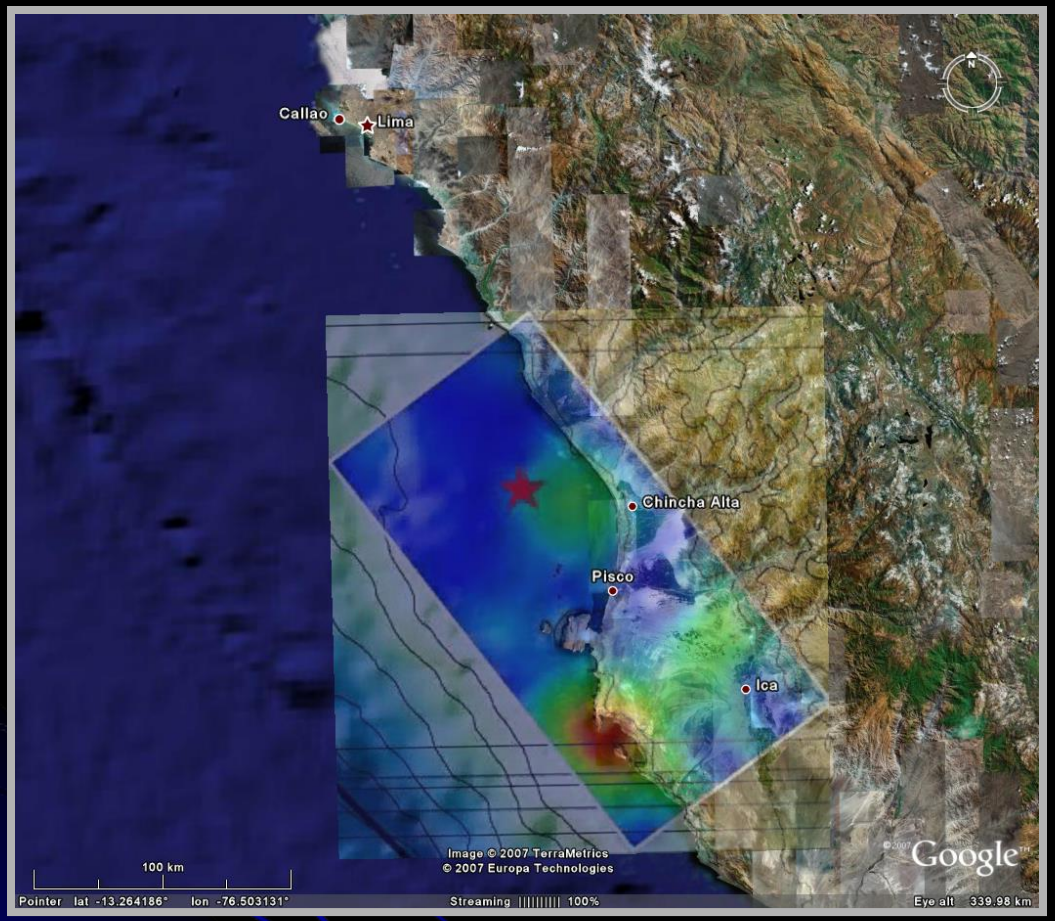
Pointer lat -14.623281° lon -73.782104°
Streaming 100%
Eye alt 7095.56 km

Tectonic Setting





Seismological Information



Ji and Zeng (USGS)

- Date: August 15, 2007
- Magnitude: Mw = 8.0
- Type: Interface subduction event
- Hypocentral depth = 39 km
- Fault dimensions:
  - 190 km along strike
  - 95 km down dip

http://earthquake.usgs.gov/eqcenter/eqinthenews/2007/us2007gbcv/finite_fault.php

Overview

- Severe damages in cities of Pisco, Ica, Chincha Alta
  - 519 people were confirmed dead
  - 42 more unaccounted for and 1,874 reported injured
  - 54,926 buildings were destroyed
  - 20,958 buildings were damaged
- Extensive damage to transportation infrastructure

Shaking Intensity

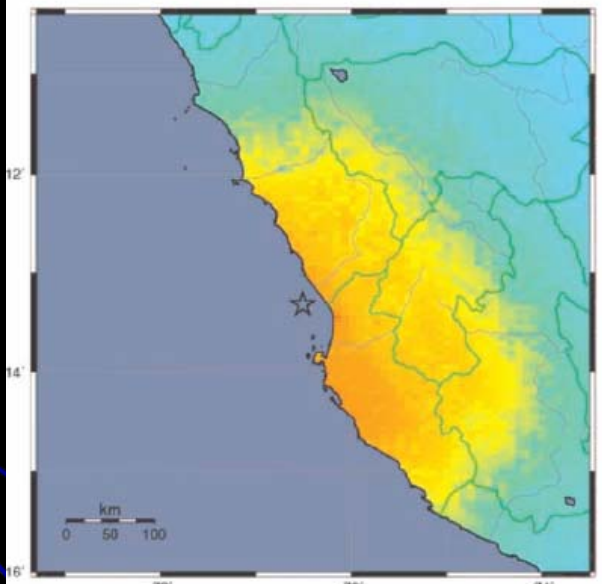
Prompt Assessment of Global Earthquakes for Response (PAGER)

PAGER V2(Thu Aug 16, 2007, 12:26:04 PM GMT)

M8.0 NEAR THE COAST OF CENTRAL PERU

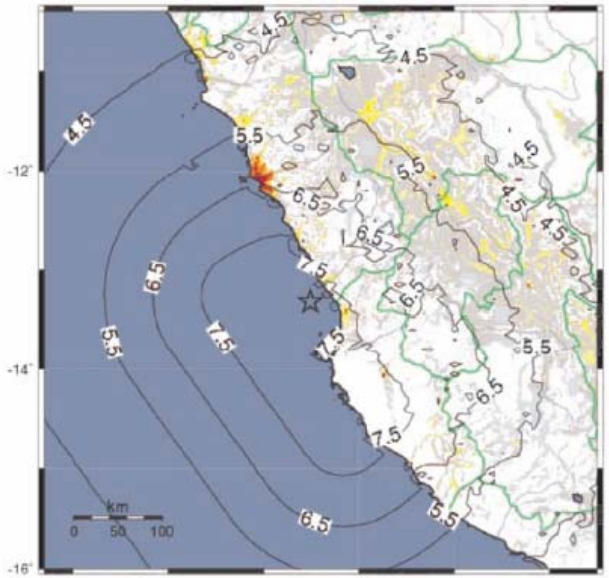
S13.32 W76.50 30.2km Wed Aug 15, 2007 11:40:58 PM GMT

Shaking Intensity



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Population per km^2



(Data from LandScan 2003)

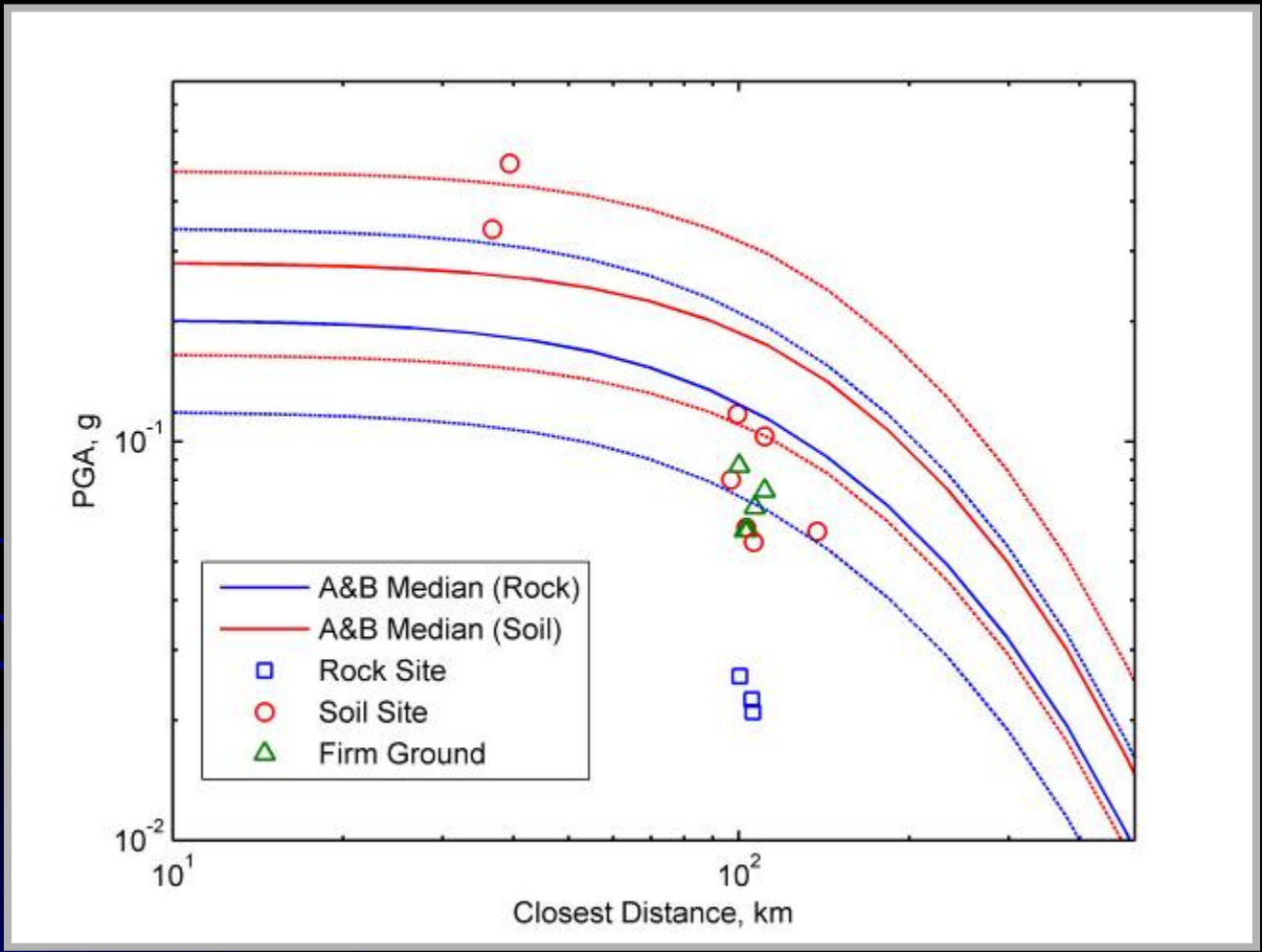
Population exposed to shaking

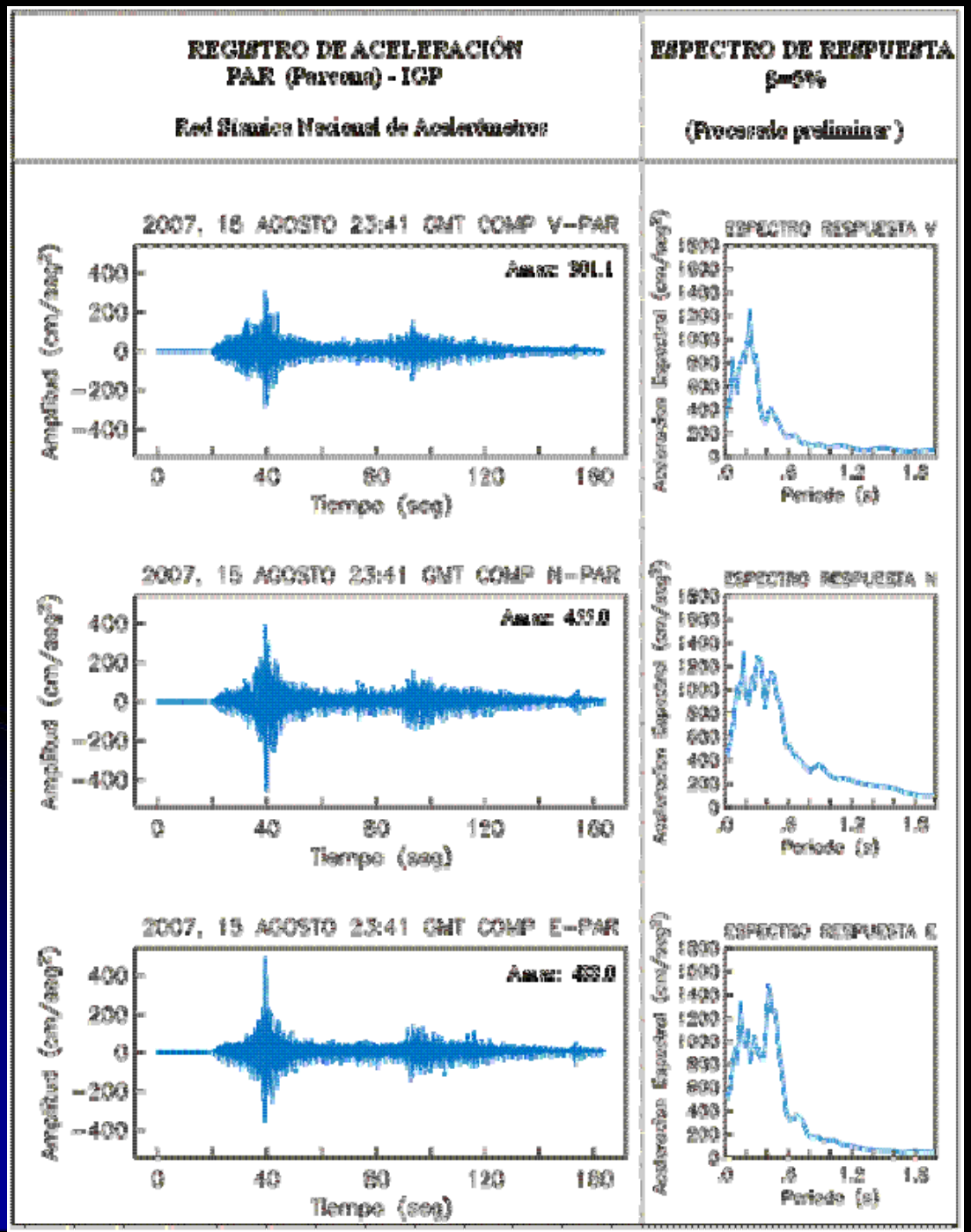
MMI Intensity	Population
VIII	583,000
VII	846,000
VI	8,410,000*

Pisco

Recorded Ground Motions

- 16 Ground motions within 150 km of fault plane

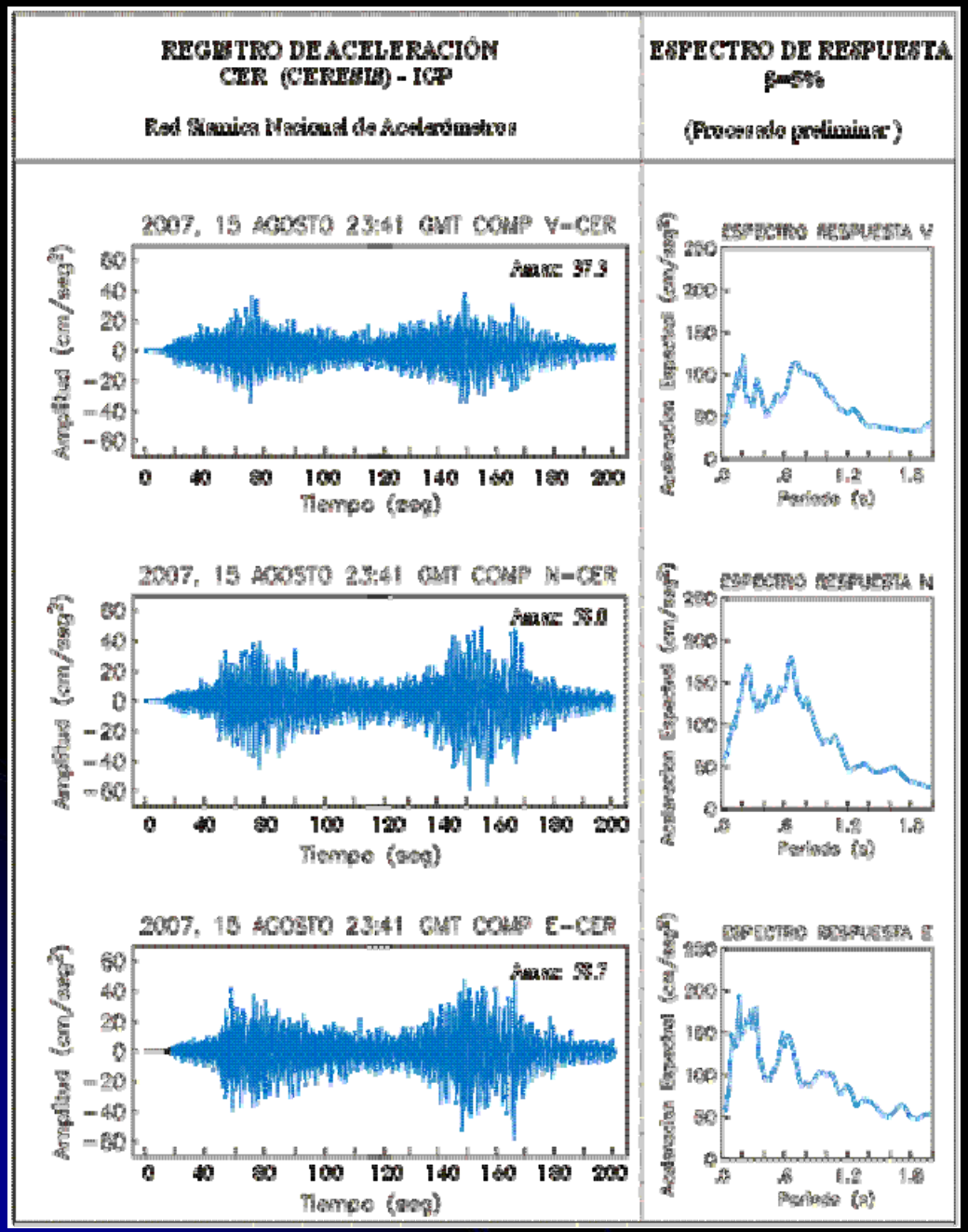




Parcona Record (ICA)

- Distance = 39.4 km
- Instrument on soil
- PGA = .498g
- Duration = 86 s

Courtesy of IGP

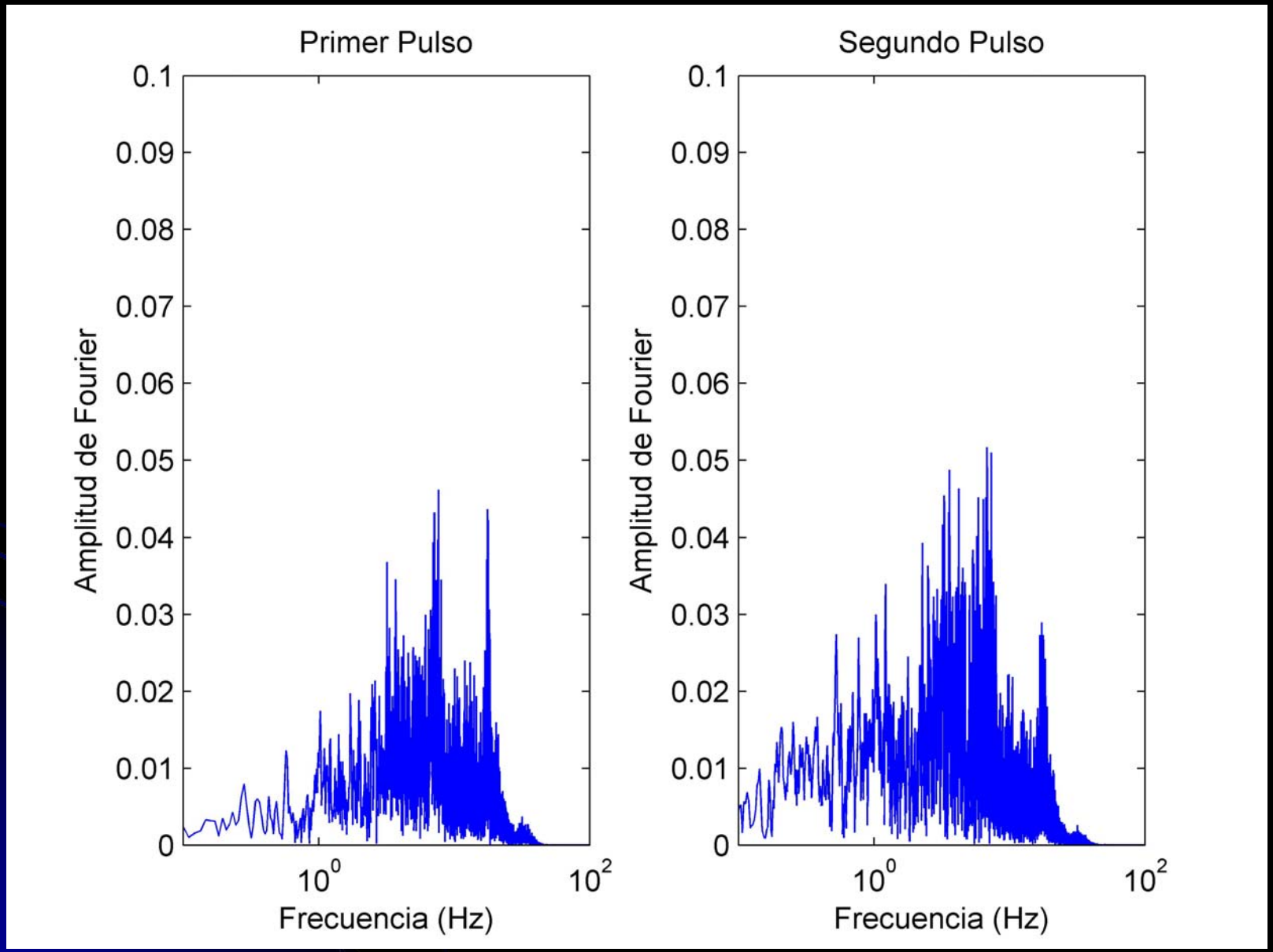


CERESIS Record (Lima)

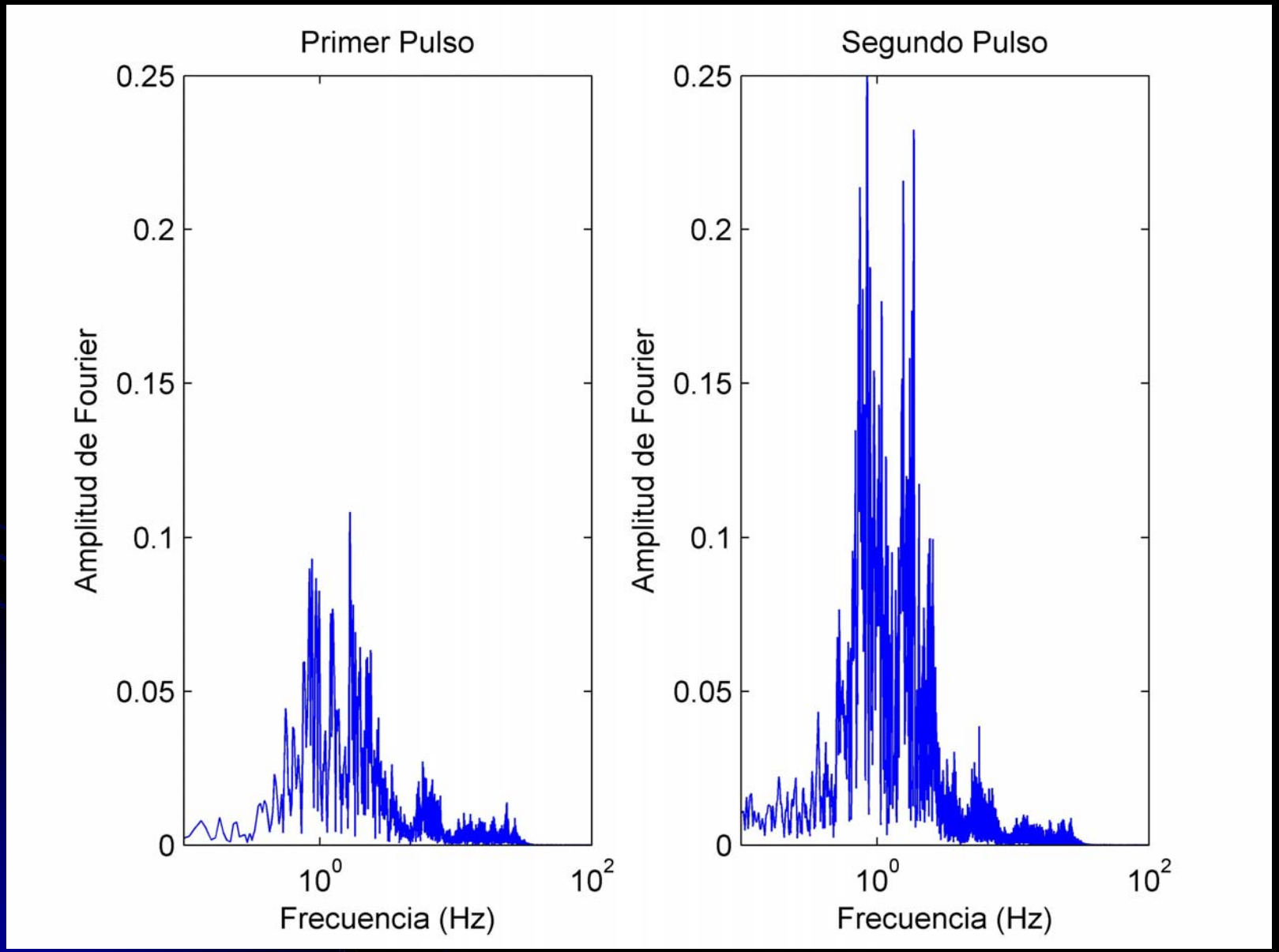
- Distance = 102 km
- Instrument on v. stiff soil
- PGA = .06 g
- Duration = 101 s

Courtesy of IGP

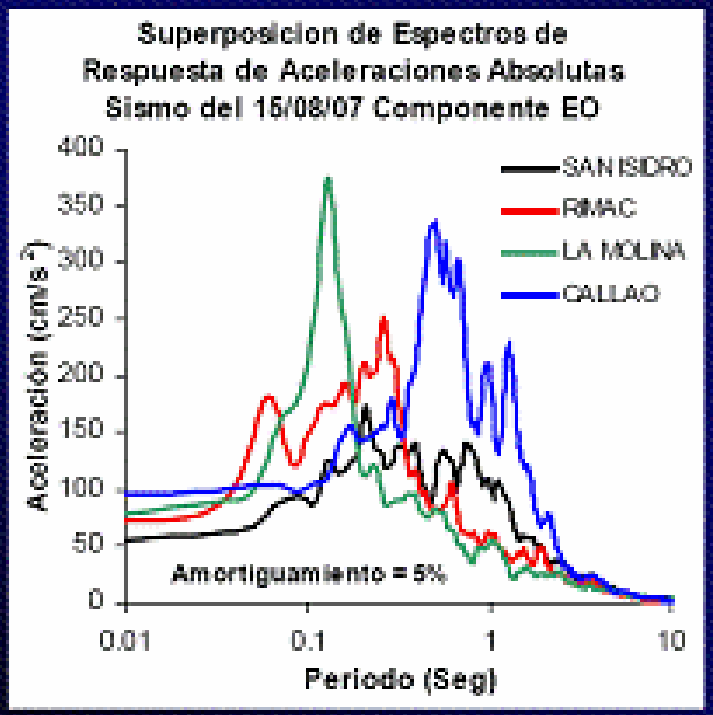
Rimac Record (Gravel)

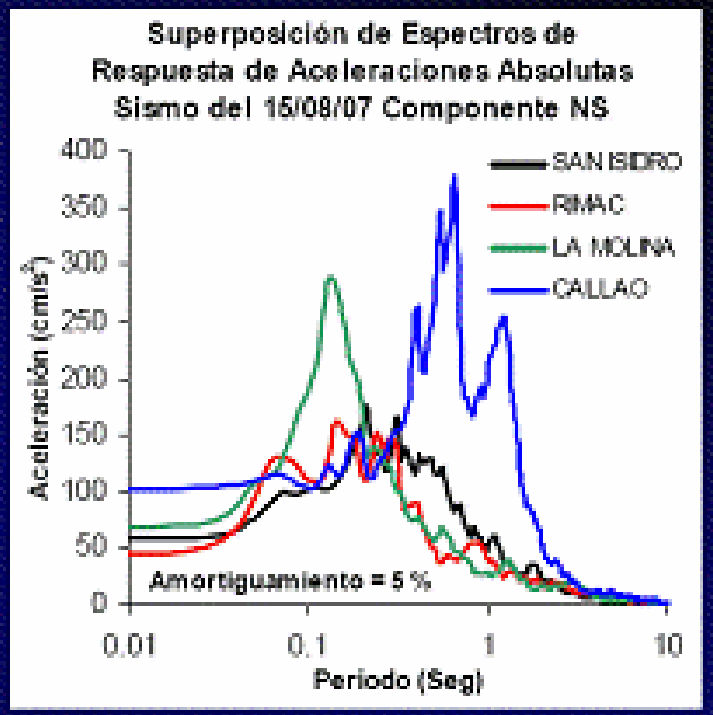


Callao Record (Soft Soil)



Response Spectra in Lima

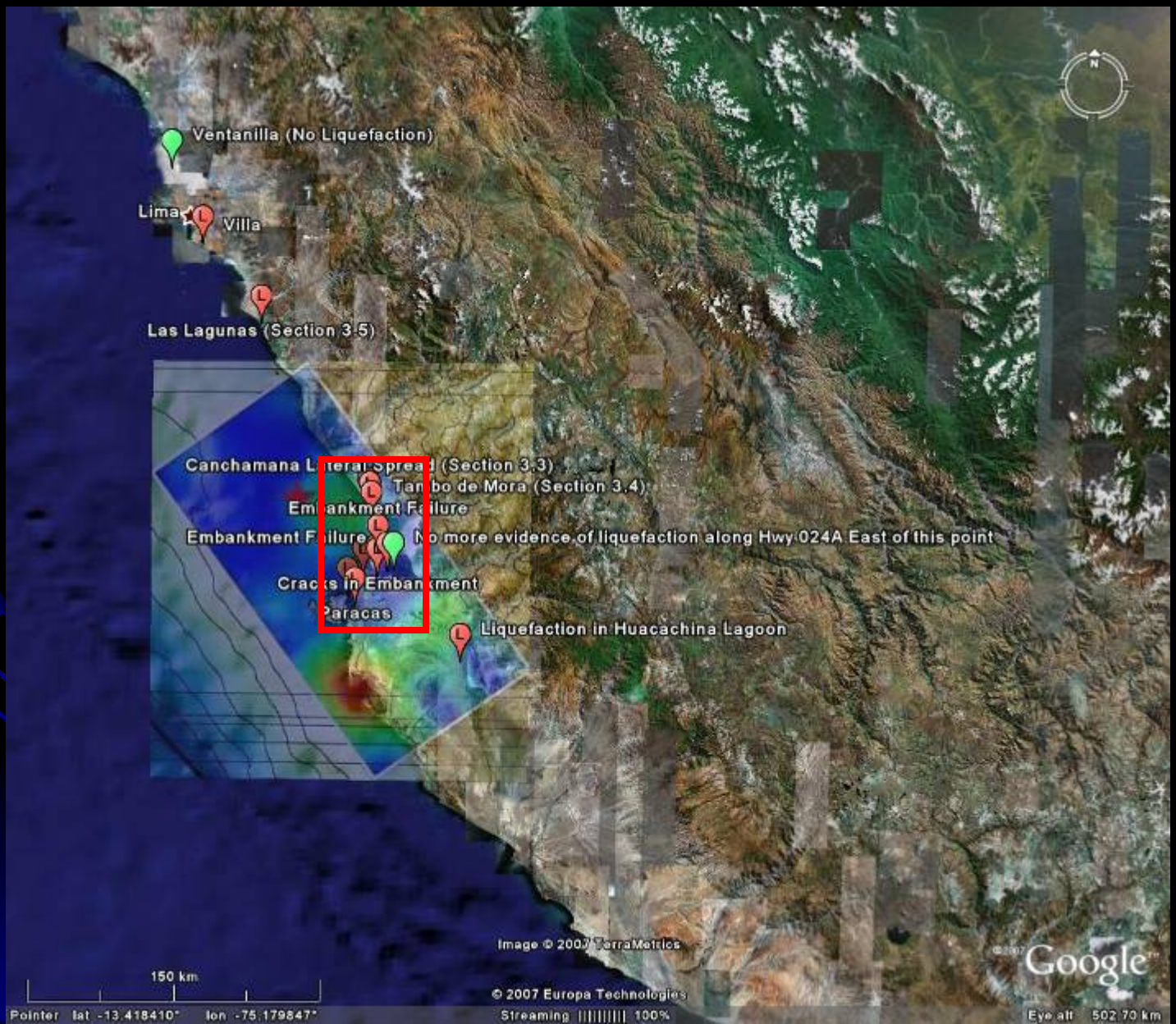




Liquefaction Observations

Las Lagunas

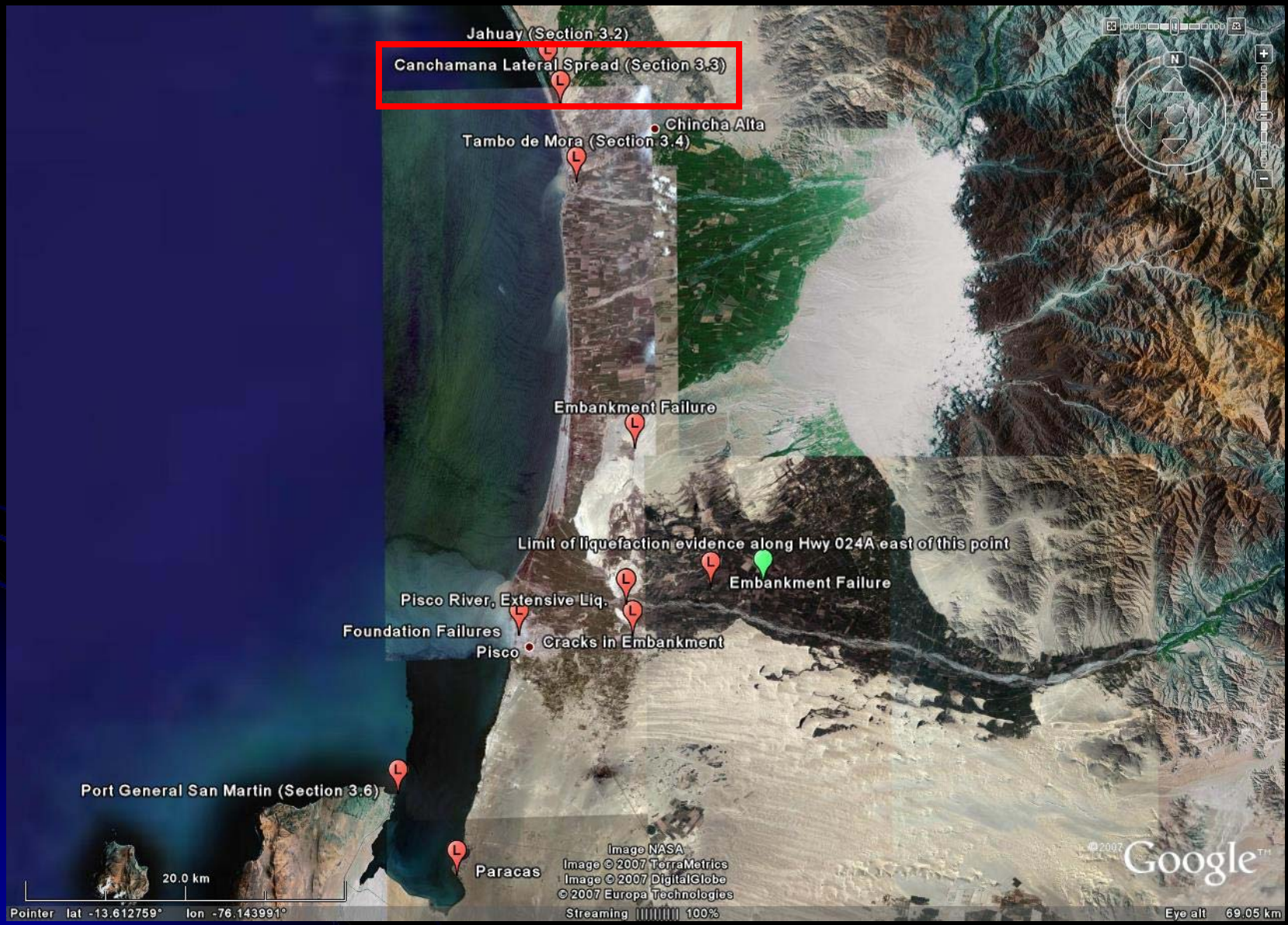
Liquefaction Observations



Road embankment failures

Road embankment failures

Liquefaction Observations

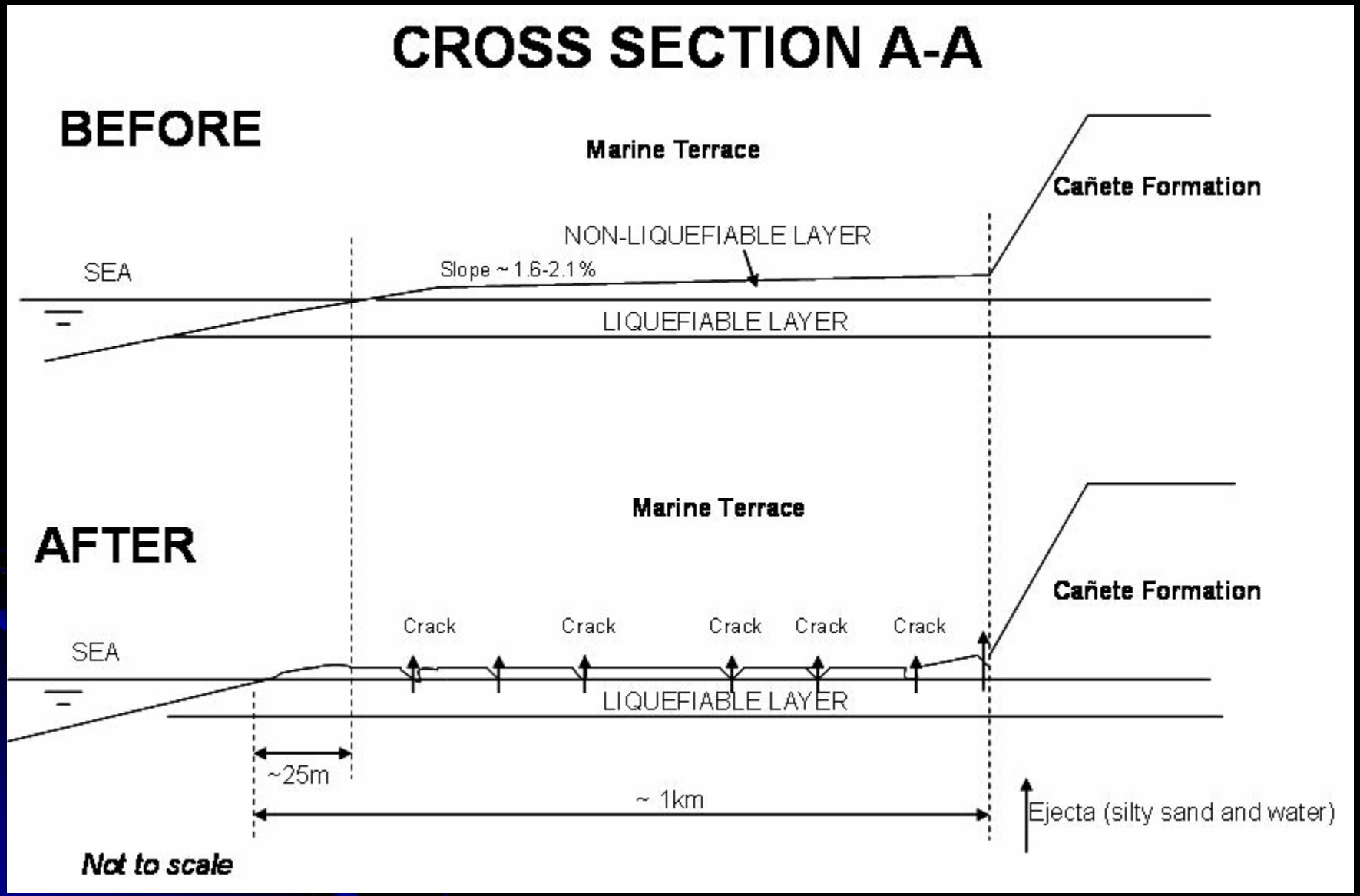


Canchamana Landslide Complex

Believed to be the largest lateral spread ever documented

Area ~ several km^2

Lateral deformations in the order of 6 m ?


CROSS SECTION A-A
BEFORE
Marine Terrace
Cañete Formation
NON-LIQUEFIABLE LAYER
SEA
Slope ~ 1.6-2.1%
LIQUEFIABLE LAYER
AFTER
Marine Terrace
Cañete Formation
Crack
Crack
Crack
Crack
Crack
SEA
LIQUEFIABLE LAYER
~25m
~ 1km
Ejecta (silty sand and water)
Not to scale


At least 3 km
1 km
Canchamaná Massive
Lateral Ground Displacement
3.6.3.7 3.6 Figure No. in text
Tambo de Mora
Google


At least 3 km
1 km
Canchamaná Massive
Lateral Ground Displacement
3.6.3.7 3.6 Figure No. in text
Tambo de Mora
Google


At least 3 km
1 km
Canchamaná Massive
Lateral Ground Displacement
3.6,3.7 3.8 Figure No. in text
Tambo de Mora
Google

Canchamaná Lateral Spread

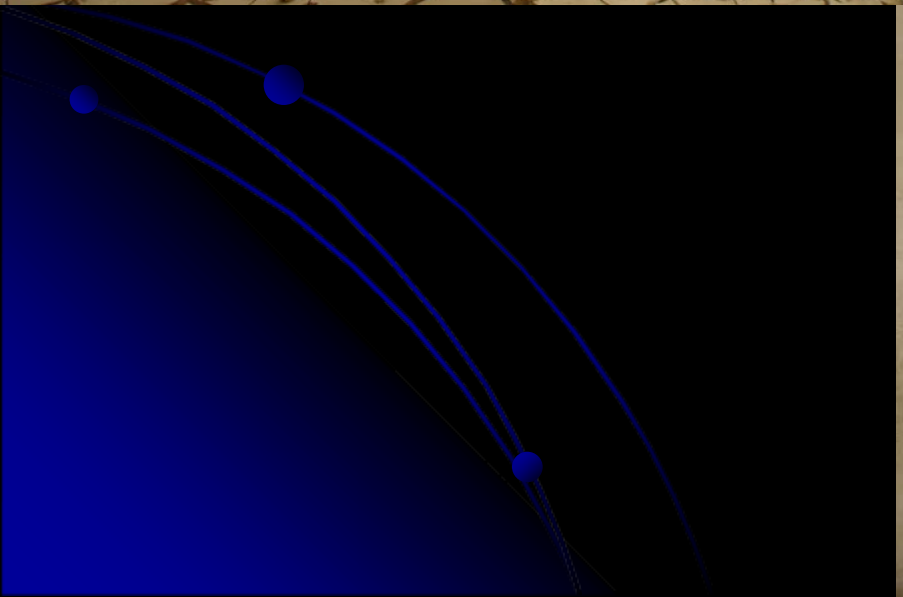
Displacements shown are not correct!!!


Map
Satellite

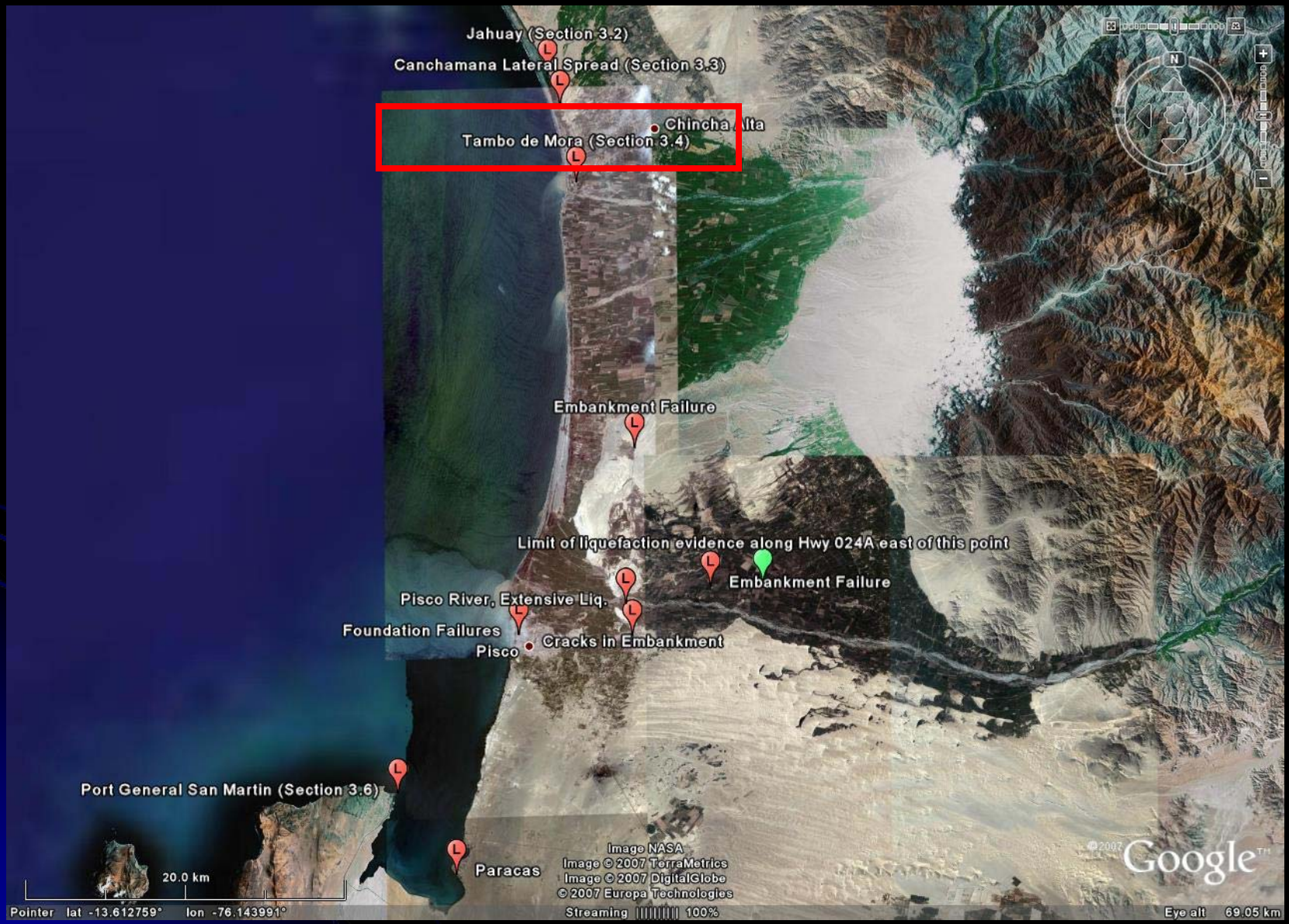
South End

North End


Map
Satellite



Liquefaction Observations



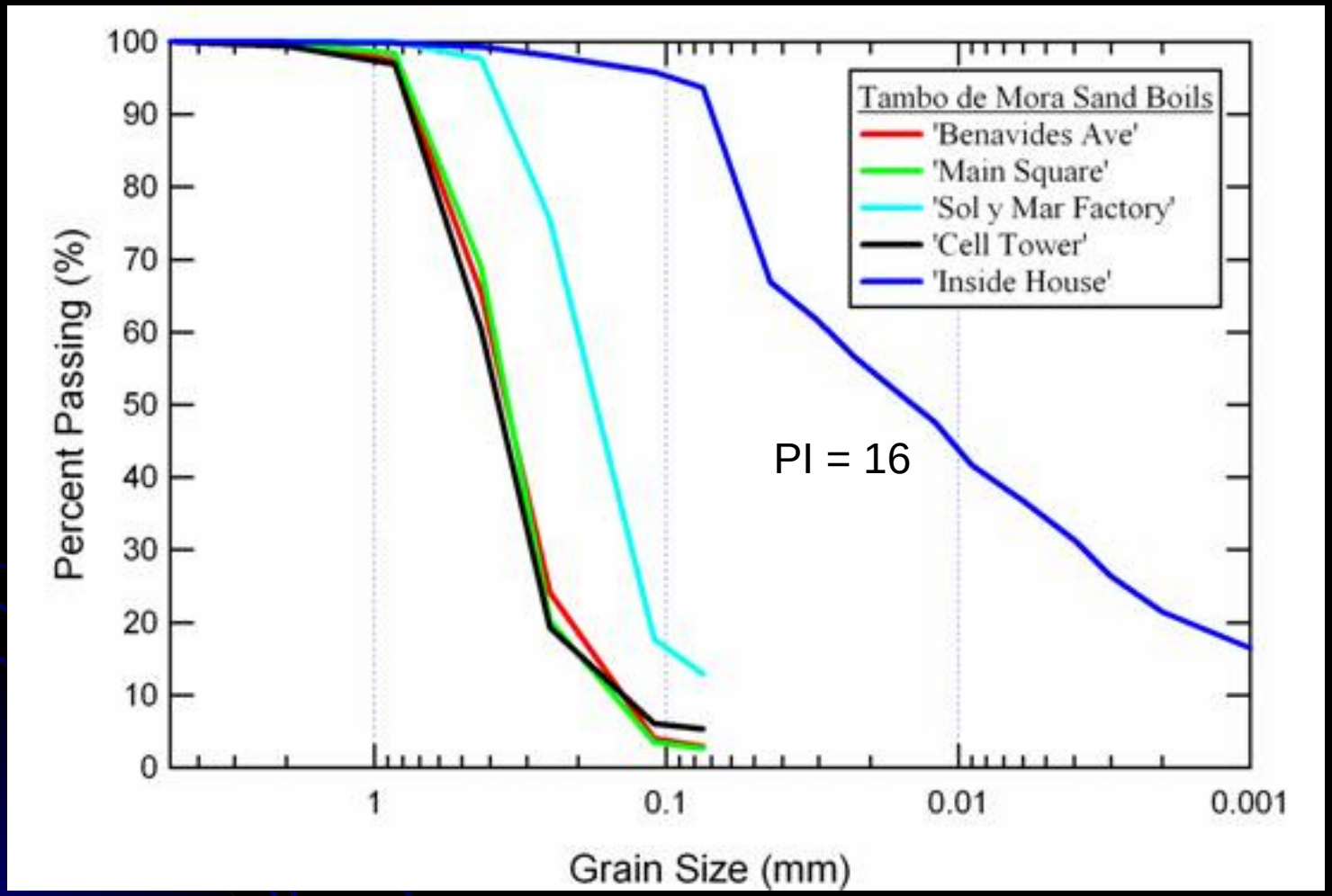
Tambo de Mora

0.9 m settlement

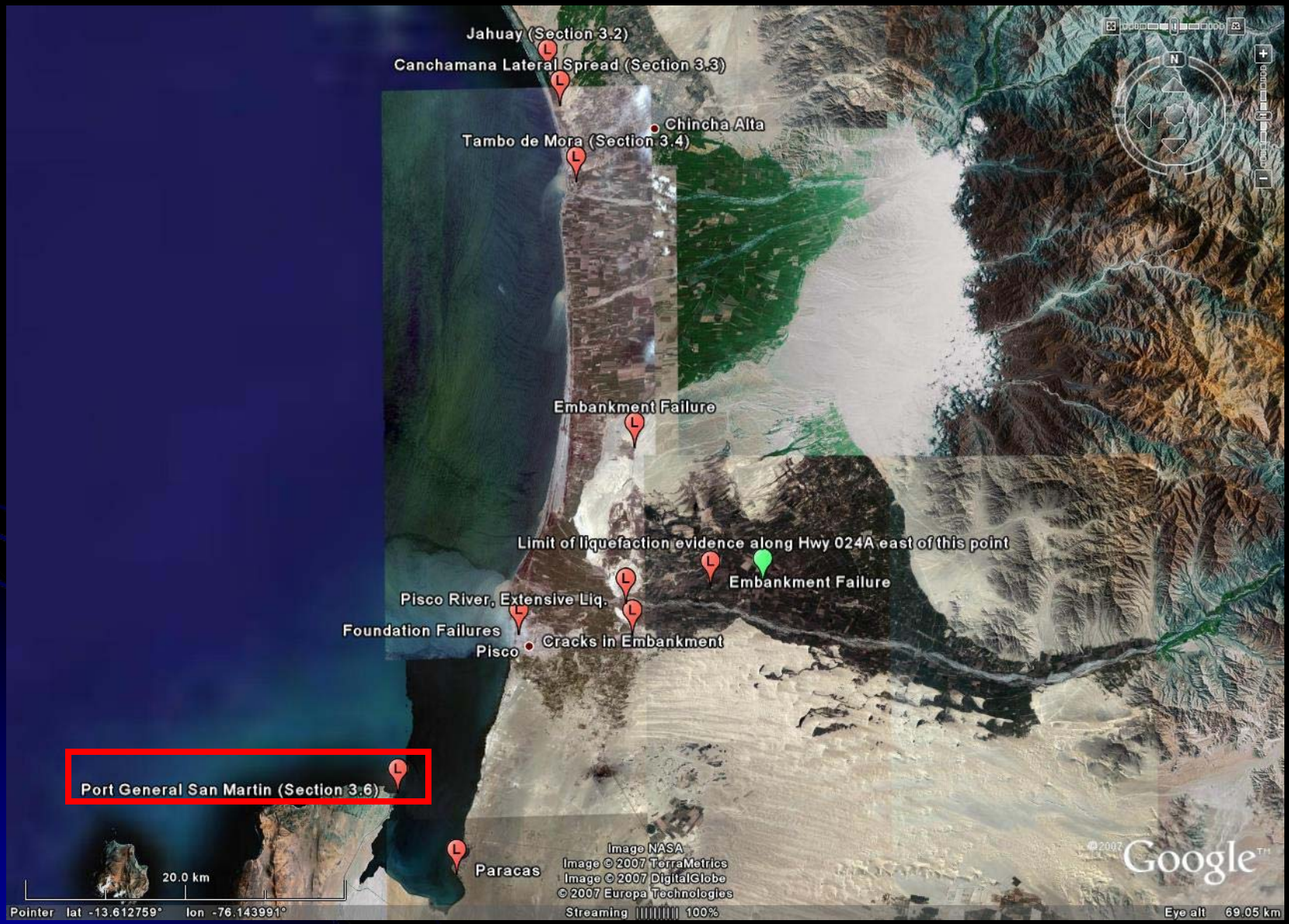
Tambo de Mora

- Large settlements over an area of about 4 city blocks
- Well delimited area of settlements: across the street we saw well performing houses
- One case of ejecta of low plasticity clay

Tambo de Mora



Liquefaction Observations



General San Martin Port

General San Martin Port

0.8 m settlement

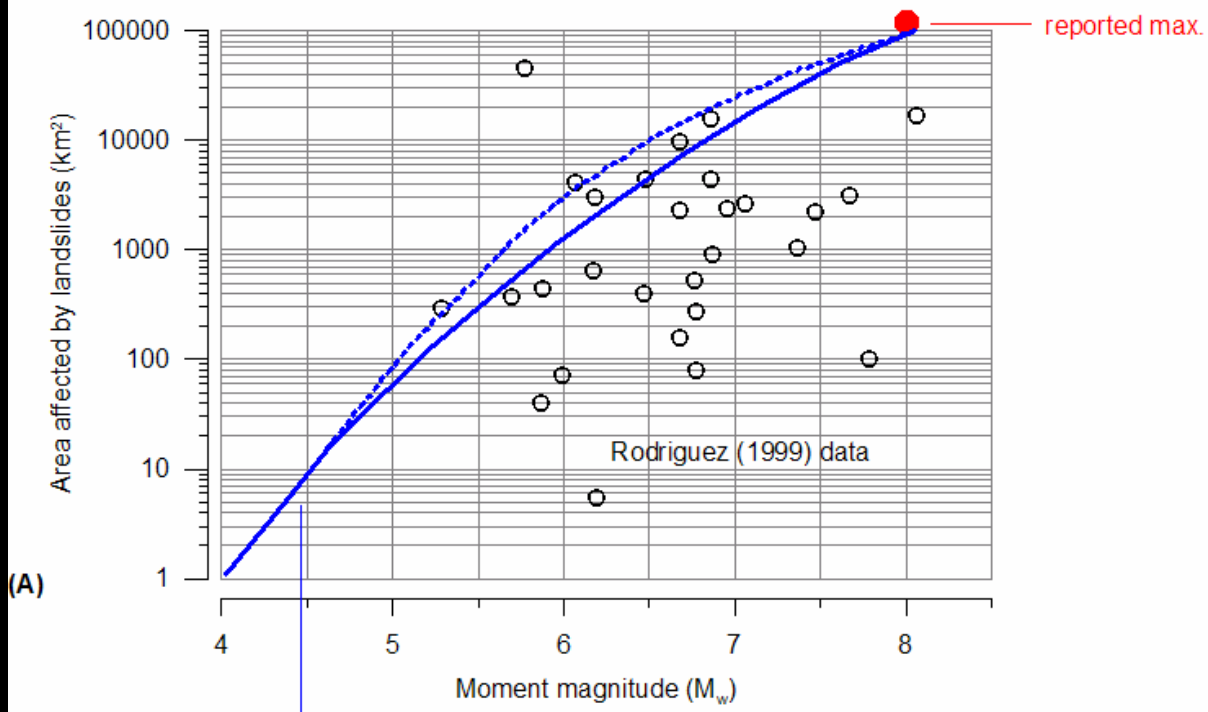
General San Martin Port

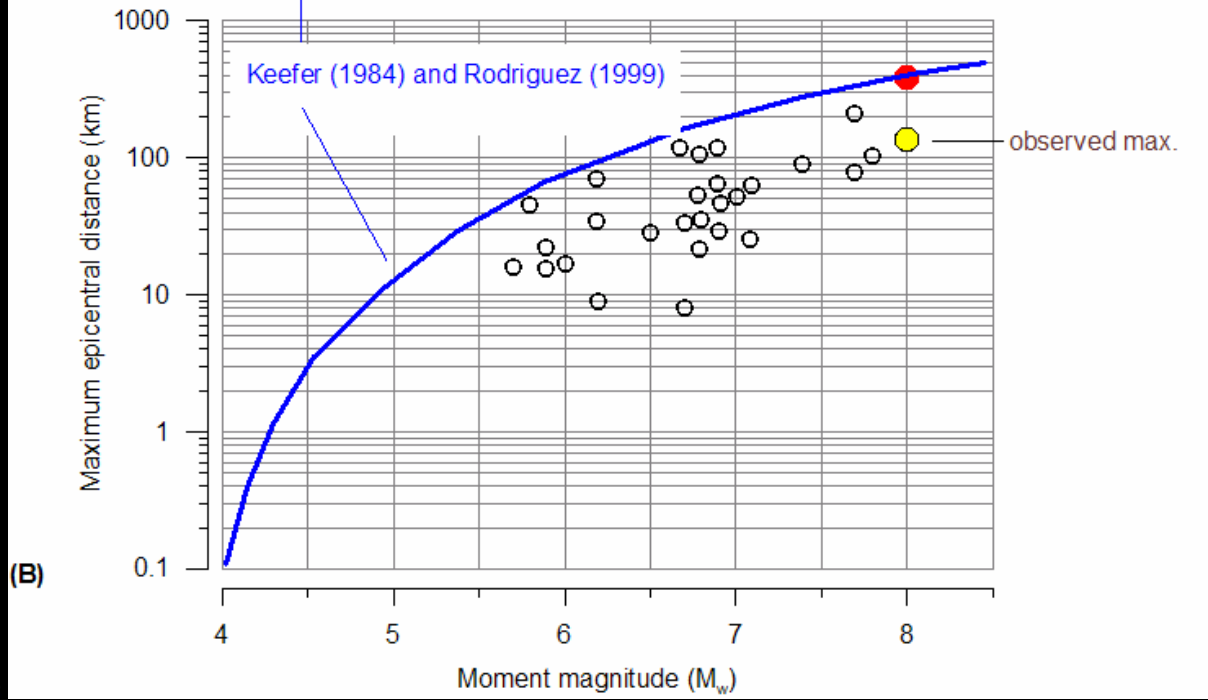
0.5 m lateral displacement of wharf deck

Landslides

- Estimated thousands of landslides (disrupted landslides including rock falls, rock slides, soil falls, soil avalanches, and disrupted soil slides)
- Highway department: rockfalls occurred as far a north as 700 km from the fault plane (small rock falls)
- Culprit of many road closures

Comparison with landslides from other events





Shallow soil slides

Rock slides, falls and avalanches

Disrupted rock/soil slides (rock in soil matrix)

Landslides on natural terrain

Conclusions

- Extensive liquefaction over a widespread area
- Interesting
  - Very large lateral spread
  - Settlement of nearly 1 m of light structures
- Heavy structural damage
  - Mostly to adobe construction
- Recorded time histories
  - Long!
  - Two-phase motion (how does this affect liquefaction?)

- Preliminary report:

http://gees.usc.edu/GEER/recent_geotechnical_engineering.htm

THANK YOU

Pisco: structural damage

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