Addis Ababa University, Ethiopia
October / November 2013

CZECH REPUBLIC
DEVELOPMENT COOPERATION

AZERBAIJAN

Landslide in motorway construction from Baku to Russia

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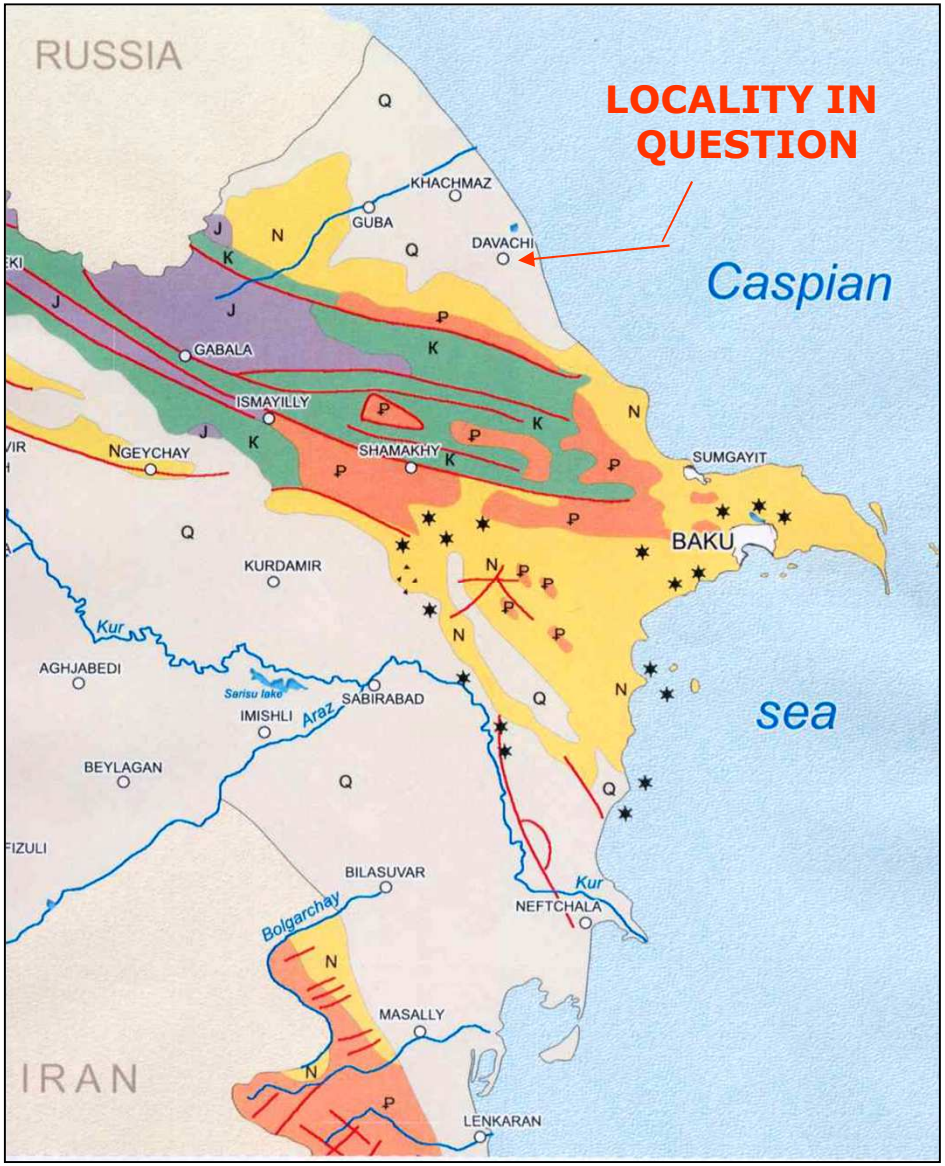
Azerbaijan, landslide in motorway construction from Baku to Russia

Construction of motorway from Baku to Russia, landslide near village Devechi

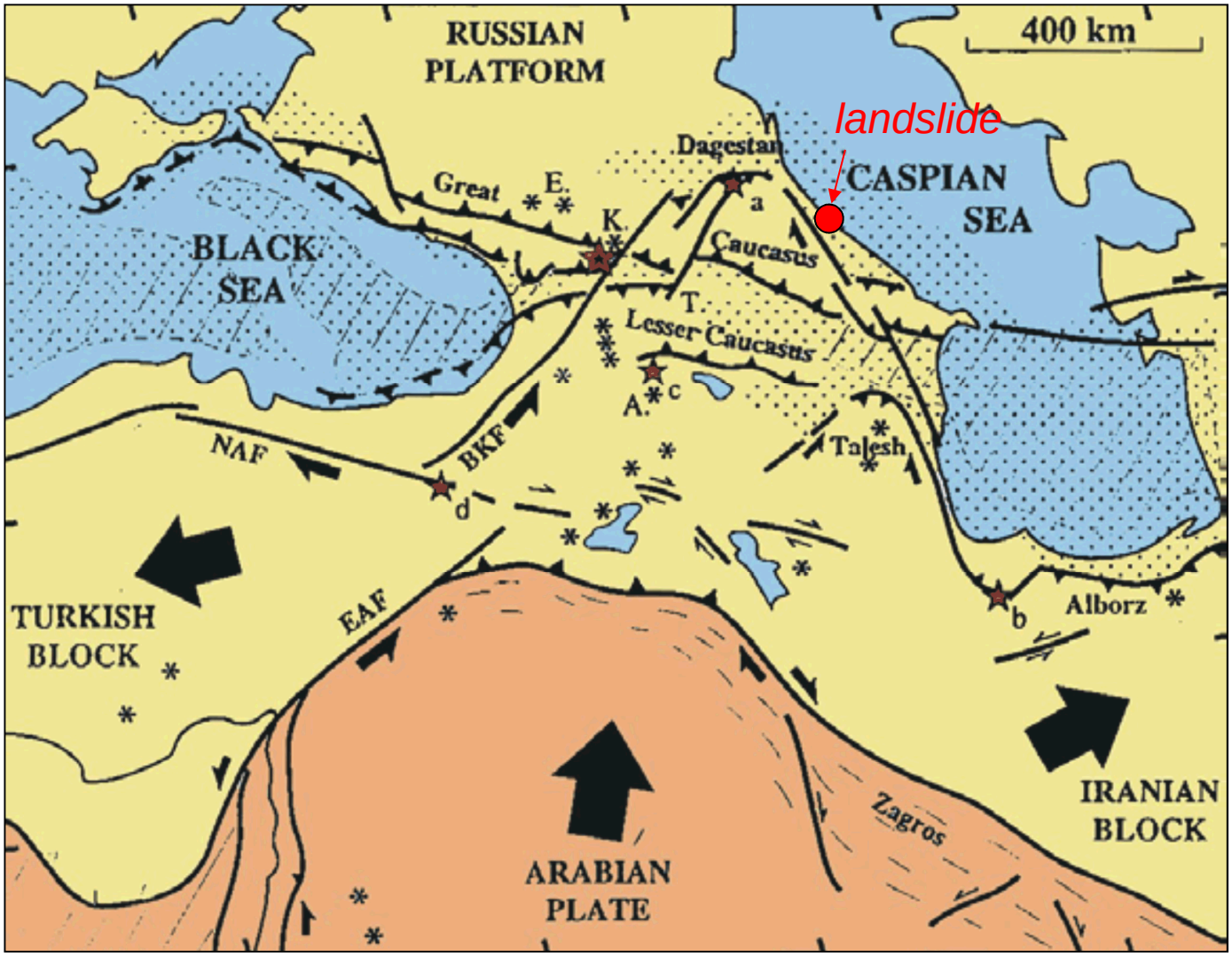
Azerbaijan, landslide in motorway construction from Baku to Russia

GEOLOGICAL CONDITIONS



Azerbaijan, landslide in motorway construction from Baku to Russia

TECTONICS/SEISMICITY



Azerbaijan, landslide in motorway construction from Baku to Russia

Destructive seismic events:
(destruction of buildings and loss of lives)

427 Gyanya
1139 Gey-Gel
1235 Gyanya
Shemakha 1669
Shemakha 1828
Mashtaga 1842
Shemakha 1859
Shemakha 1875
Shemakha 1902
Lyankaran 1913
Ardelbil 1924

Richter Magnitude	Mercalli Intensity	Description
2	I	Usually not felt, but detected by instruments.
	II	Felt by very few people.
3	III	Felt by many, often mistaken for a passing vehicle.
	IV	Felt by many indoors, dishes and doors disturbed.
4	V	Felt by nearly everyone. People awakened. Cracked walls, trees disturbed.
5	VI	Felt by all. Many run outdoors. Furniture moves. Slight damage occurs.
	VII	Everyone runs outdoors. Poorly built buildings suffer severe damage. Slight damage every where else.
6	VIII	Everyone runs outdoors. Moderate to major damage. Minor damage to specially designed buildings. Chimneys and walls collapse.
7	IX	All buildings suffer major damage. Ground cracks, pipes break, foundations shift.
	X	Major damage. Structures destroyed. Ground is badly cracked. Landslides occur.
8	XI	Almost all structures fall. Bridges wrecked. Very wide cracks in ground.
	XII	Total destruction. Ground surface waves seen. Objects thrown into the air. All construction destroyed.

Prevails shallow earthquake
In depth up to 30 km
Richter M = 6-6,5
Intensity MM = VIII-IX

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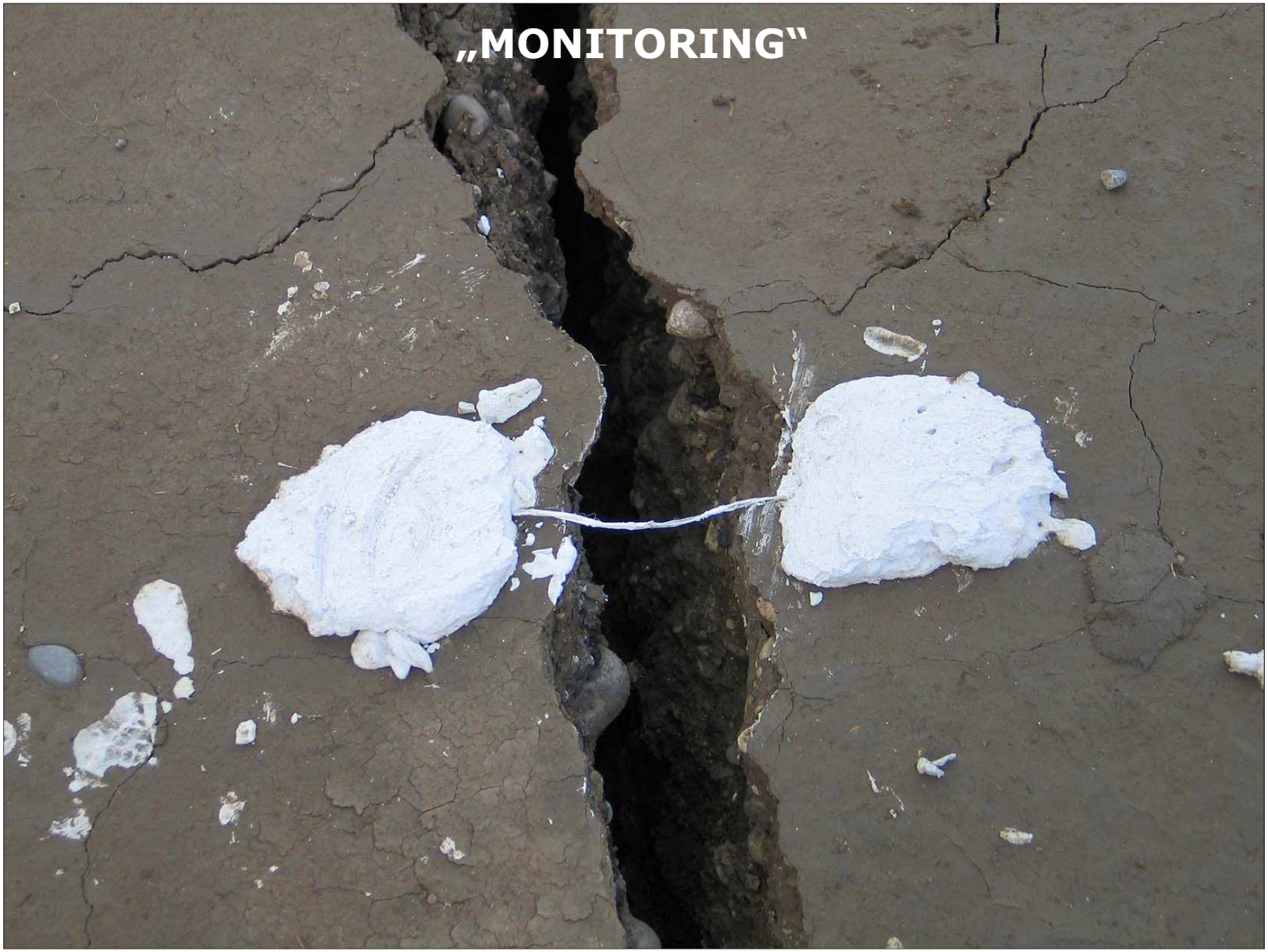

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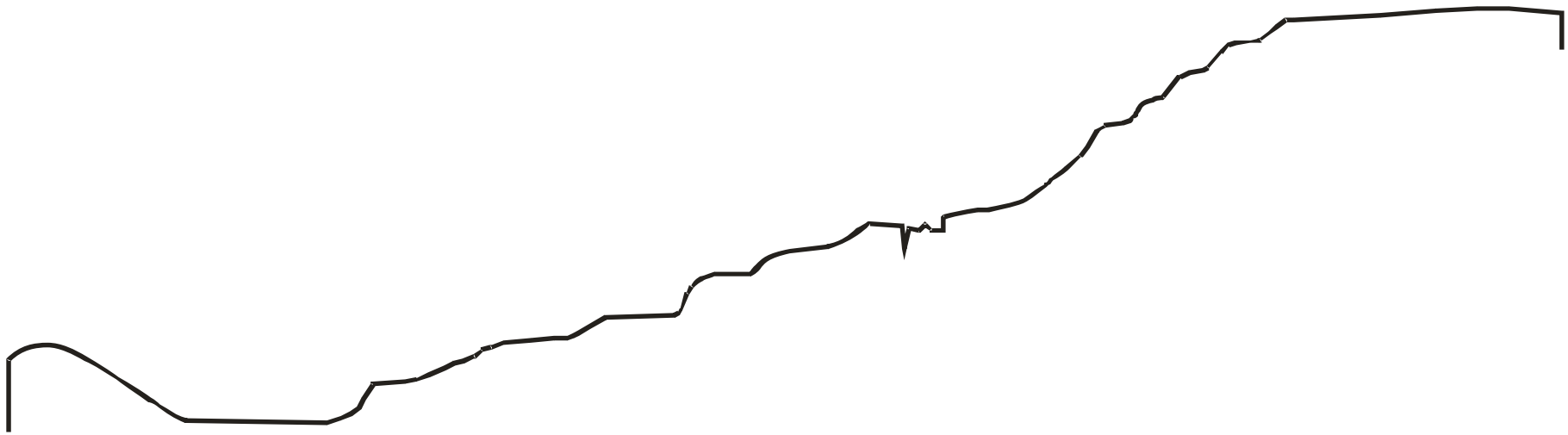
Characteristic terrain profile across the landslide



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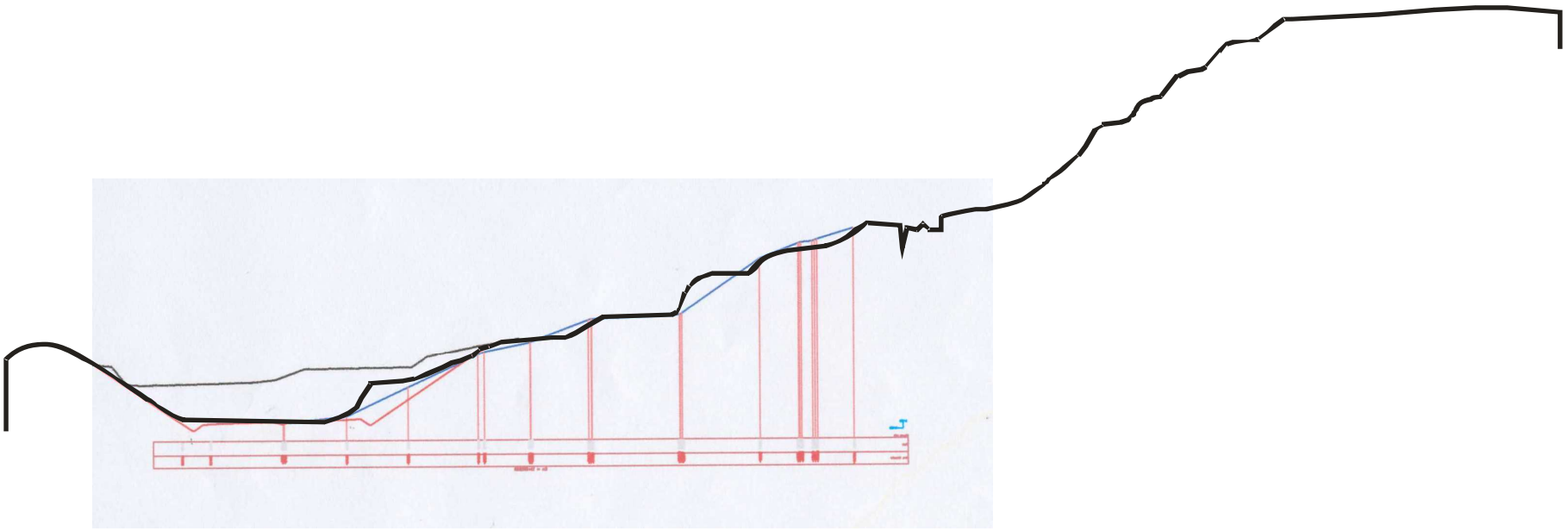

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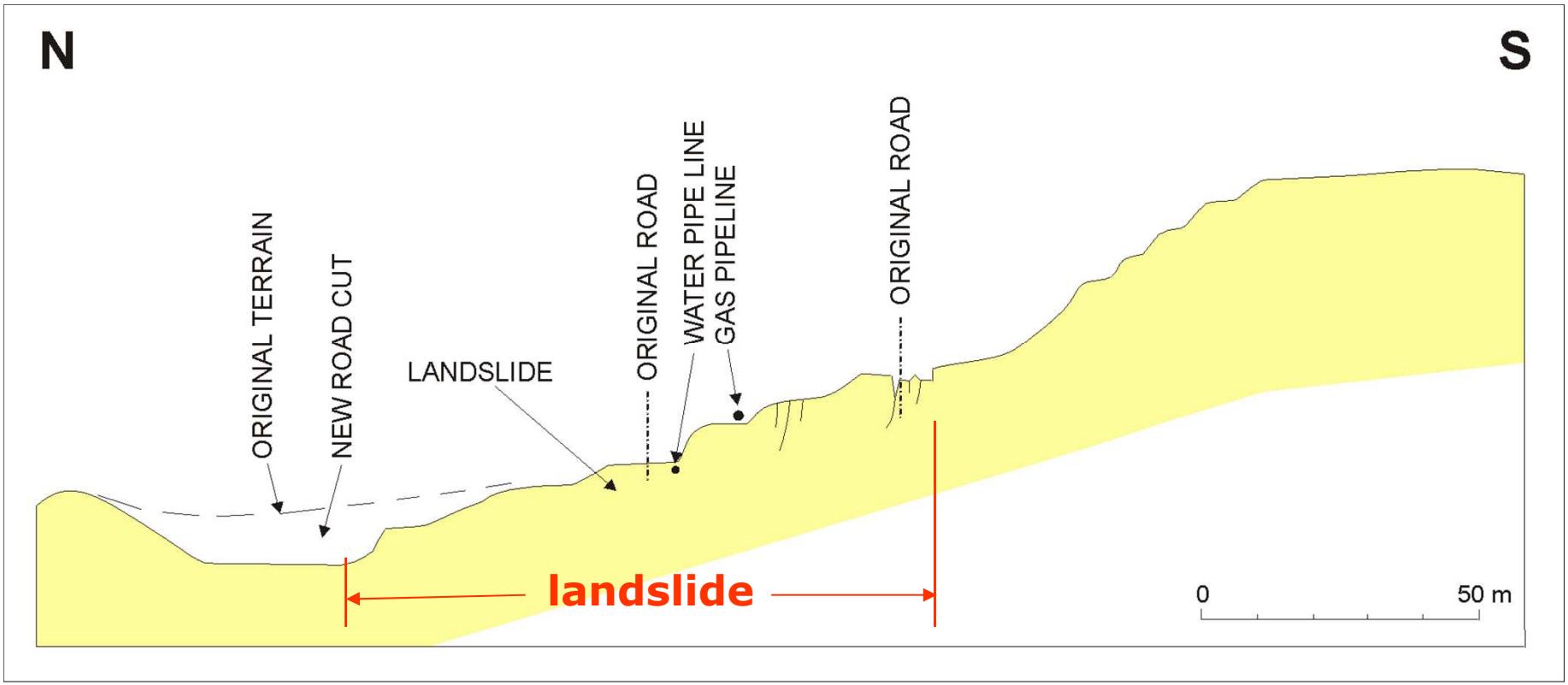

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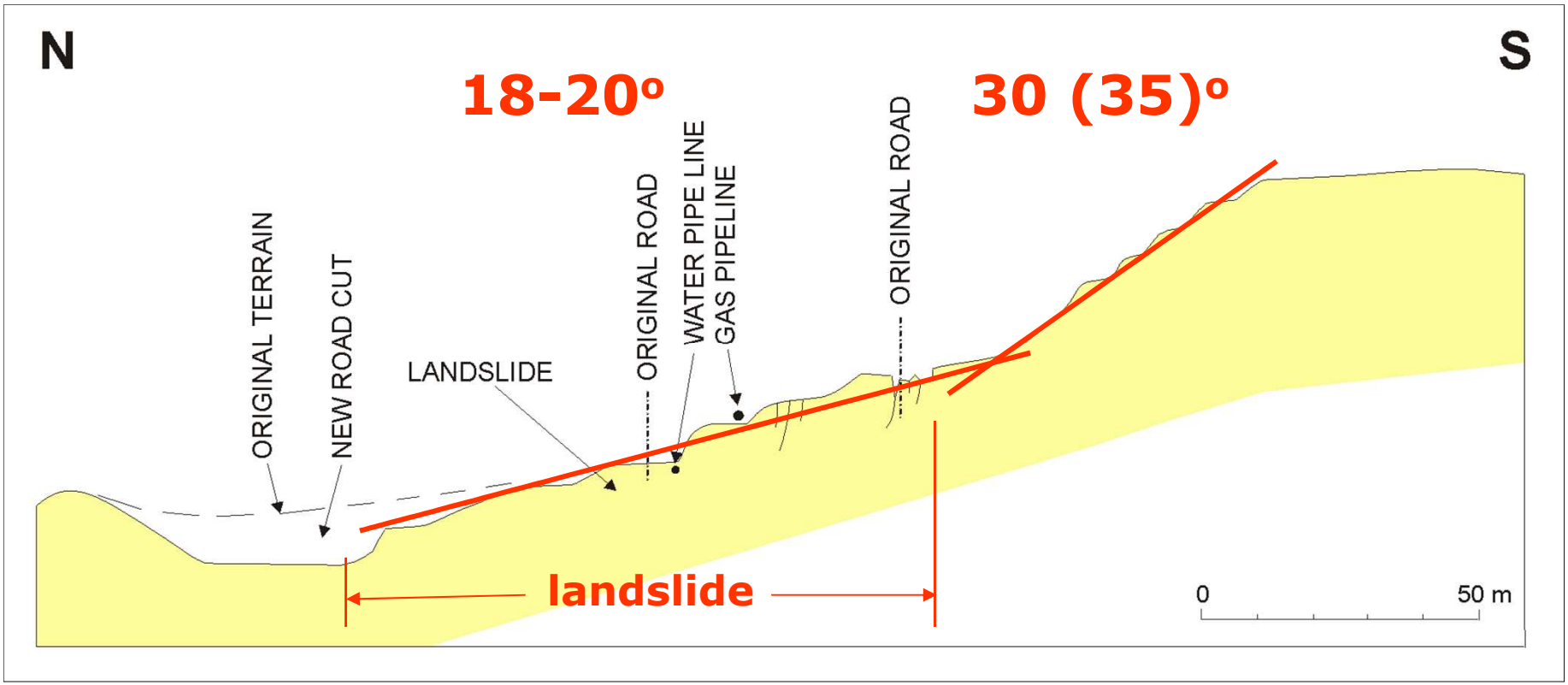

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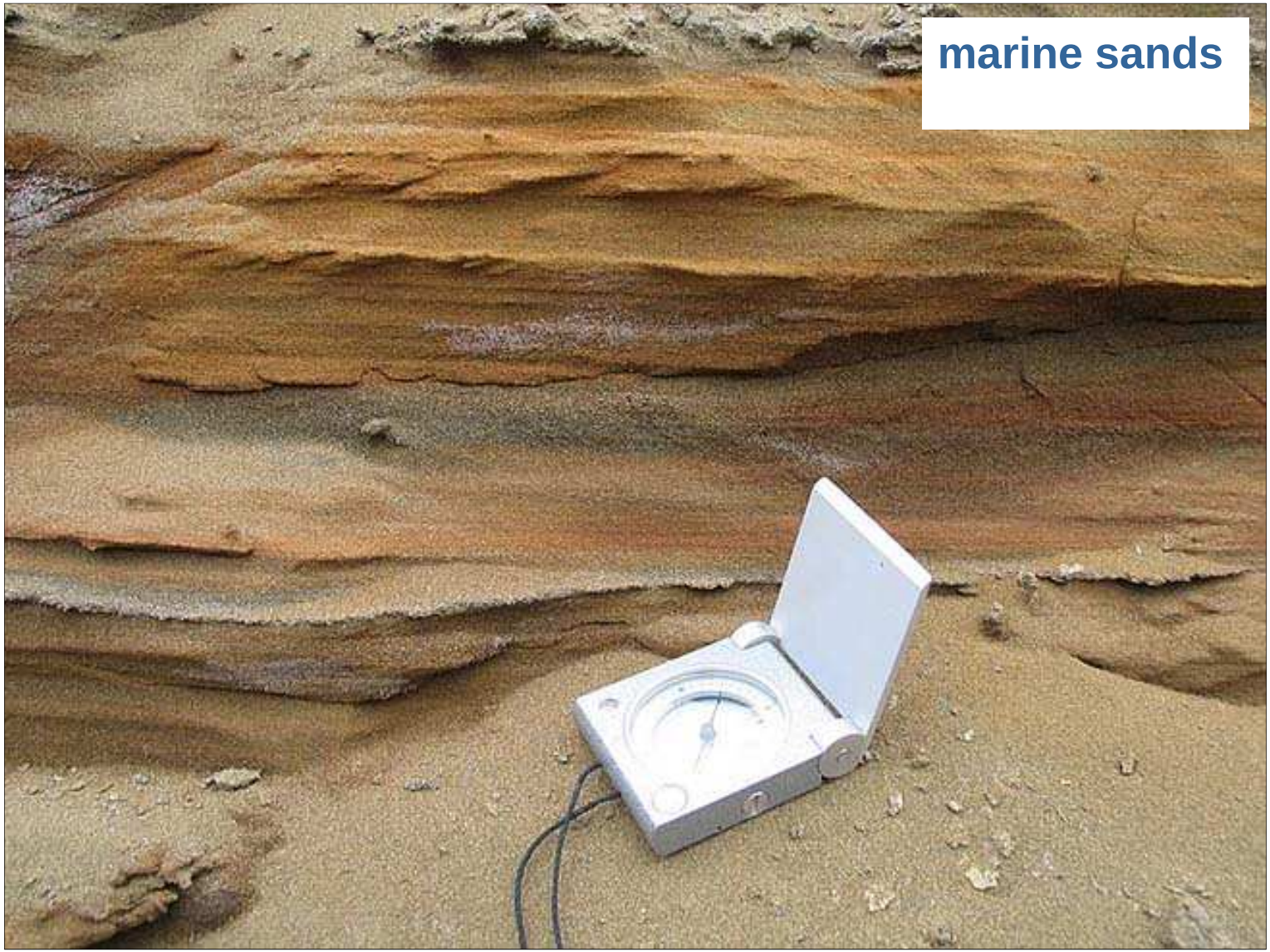

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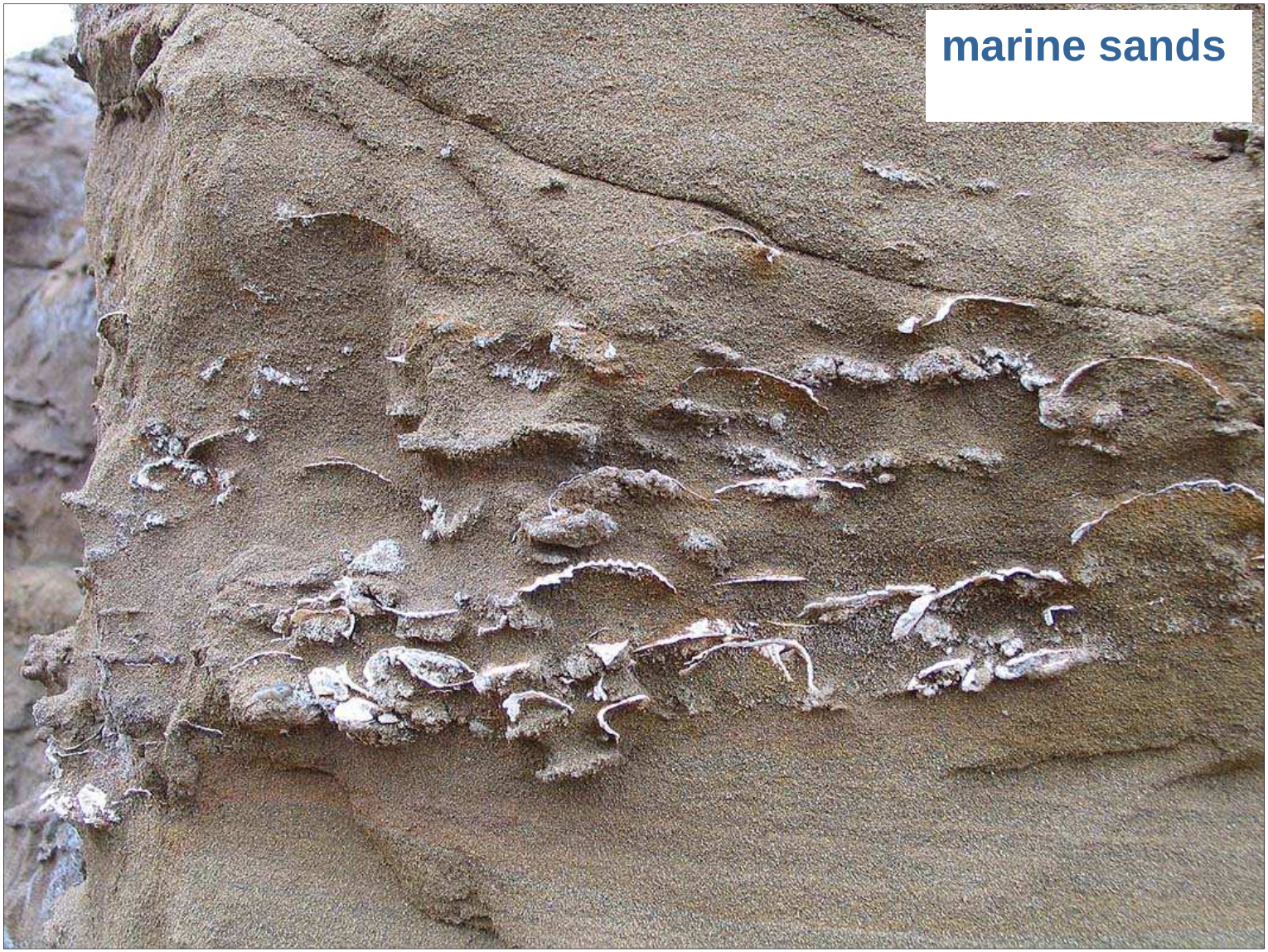

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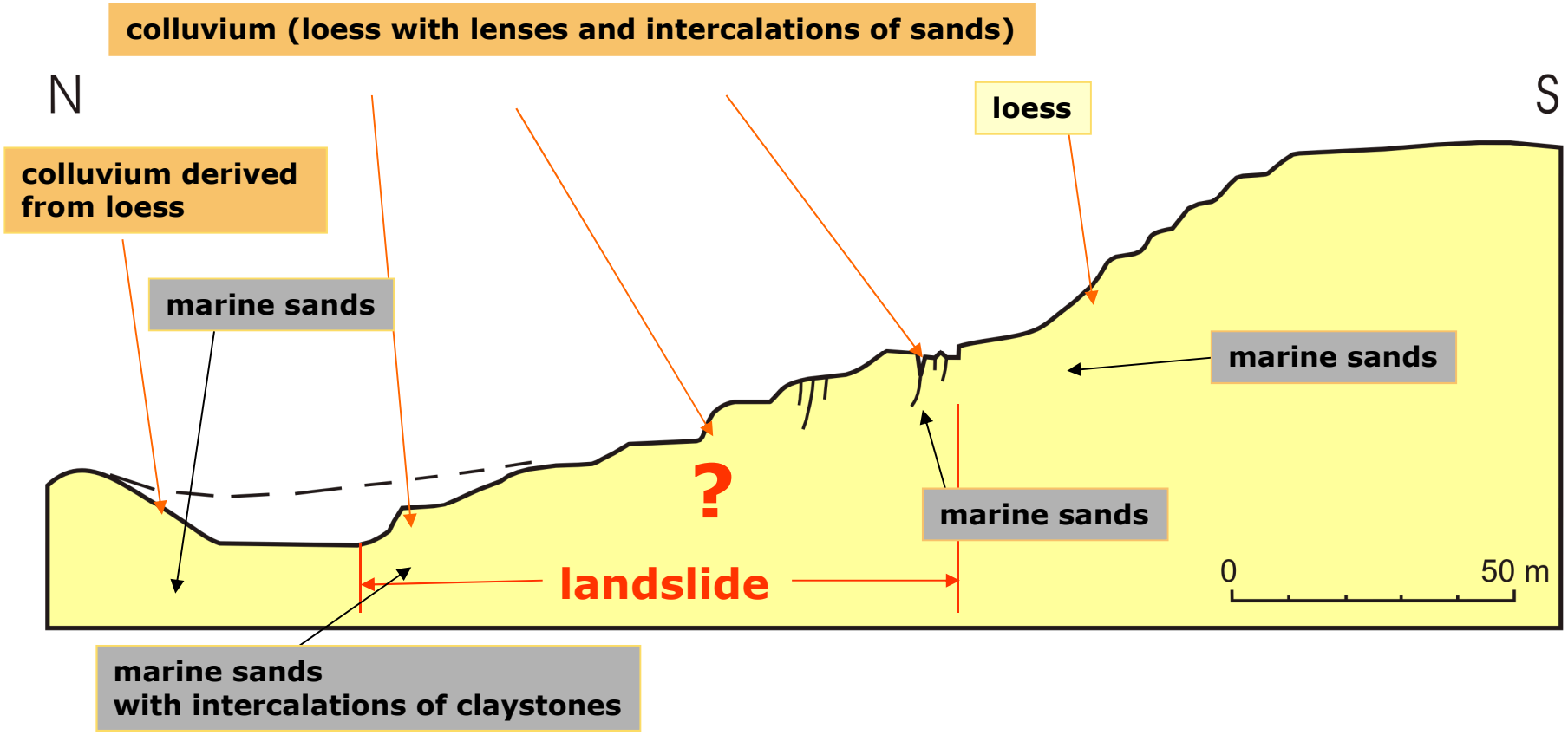
Geology of landslide and its vicinity

Documented outcrops in distance 100-150 m on both sides from characteristic profile



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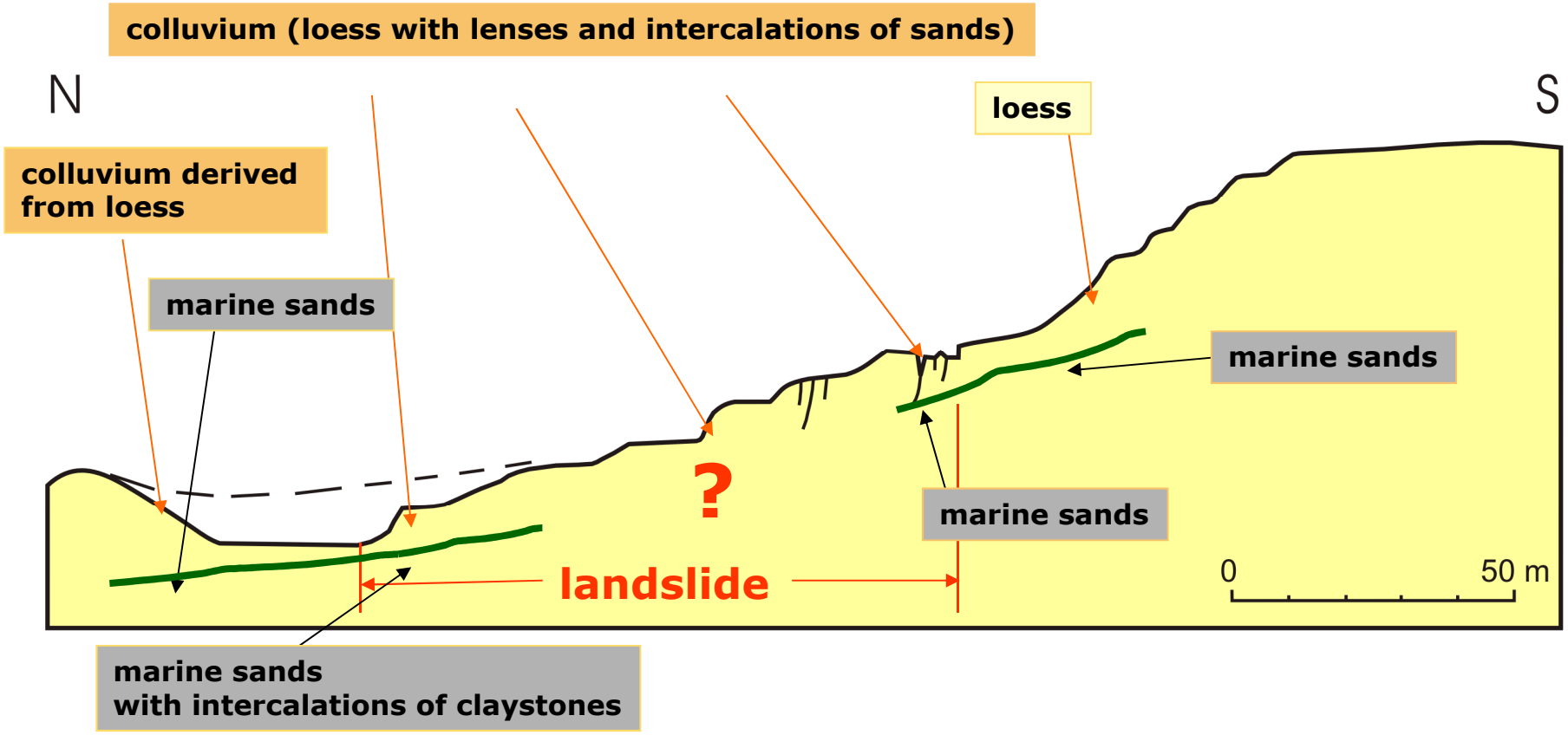

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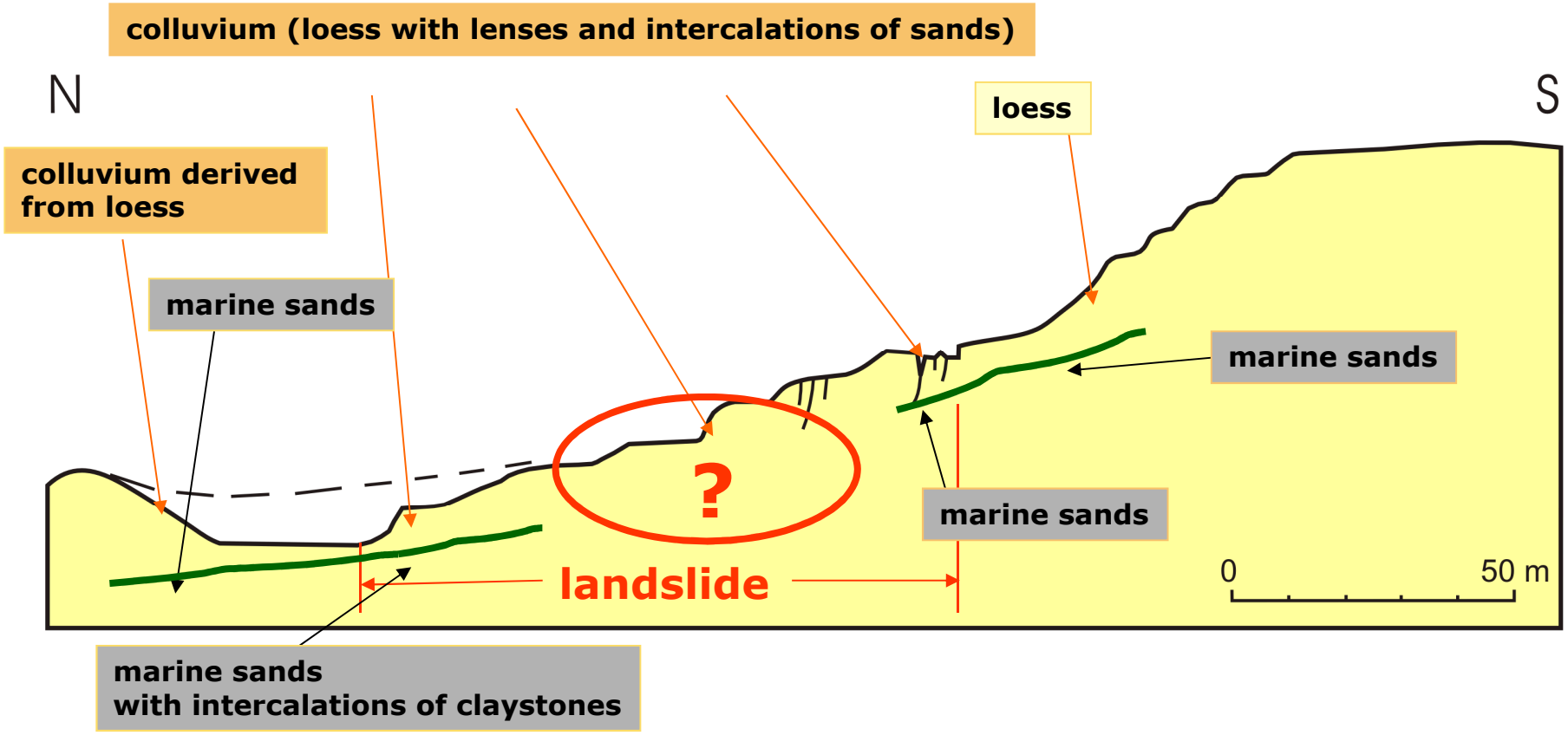

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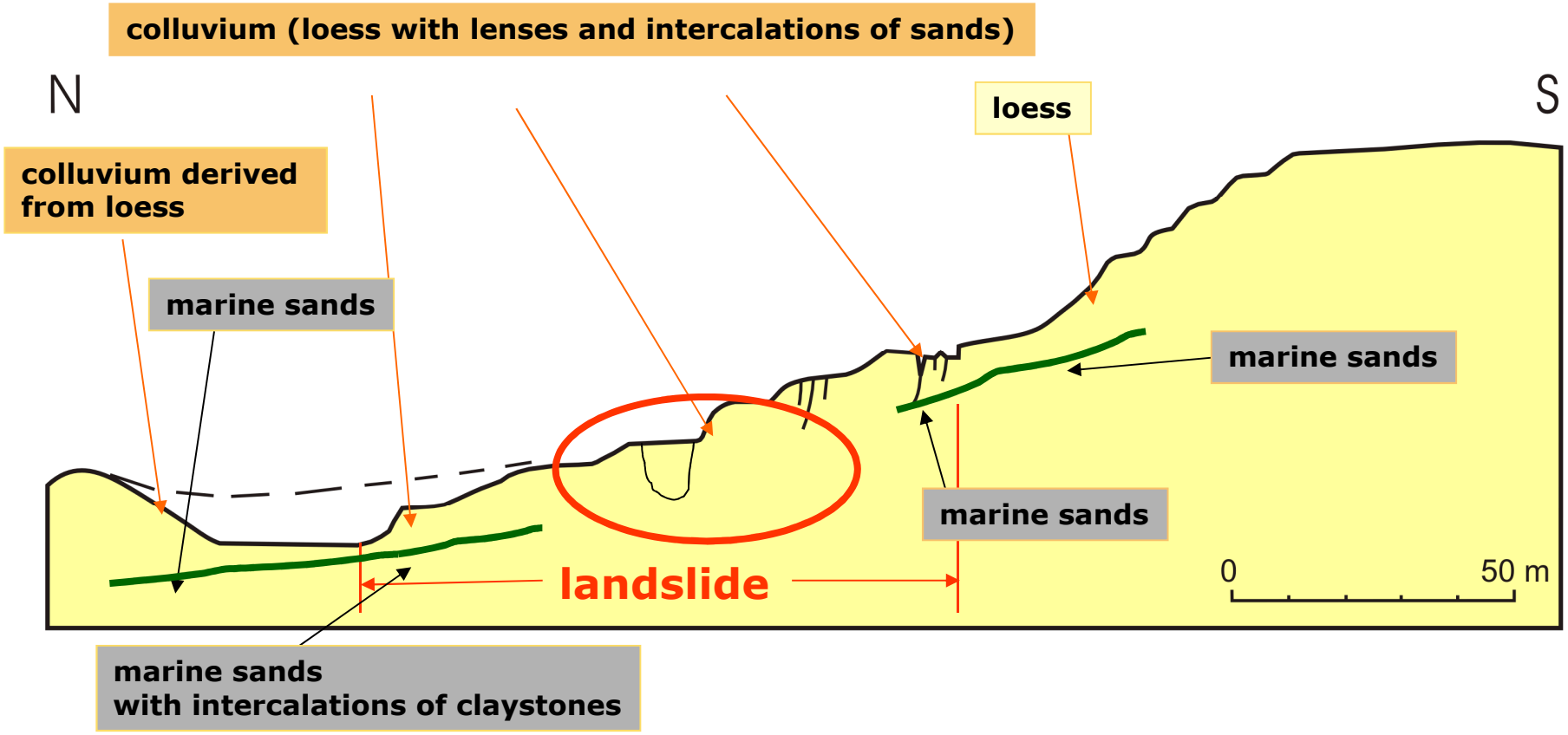

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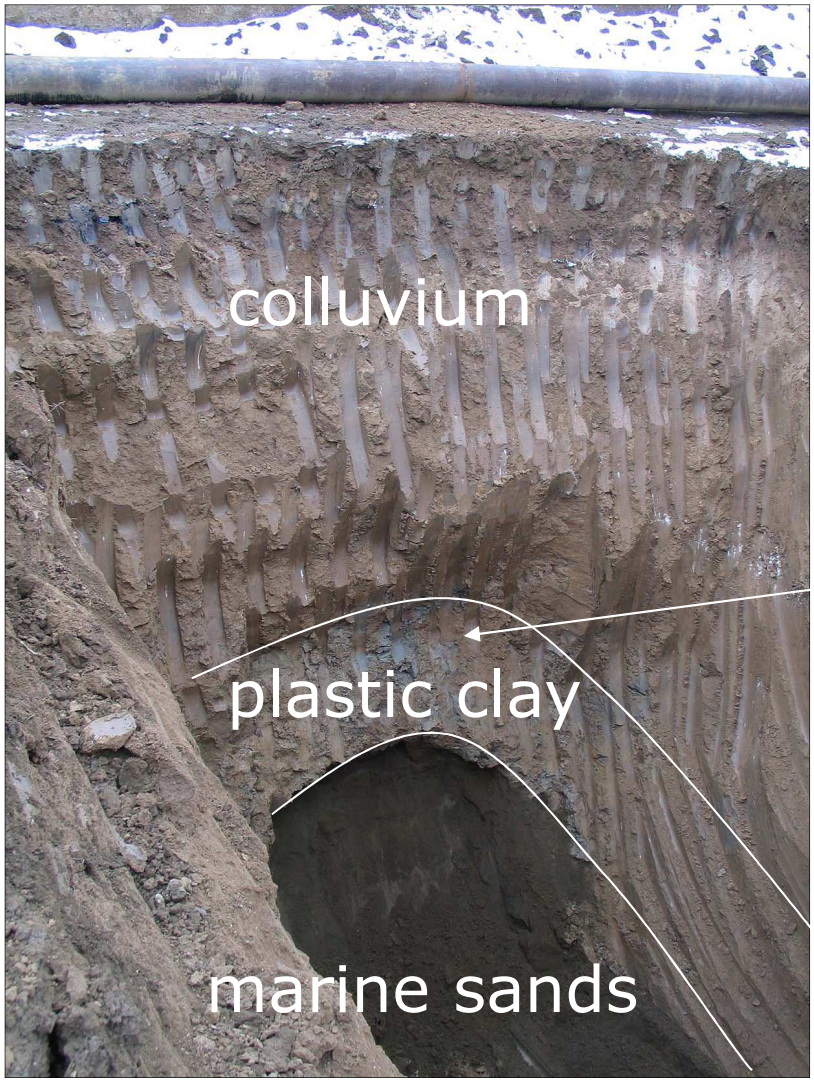

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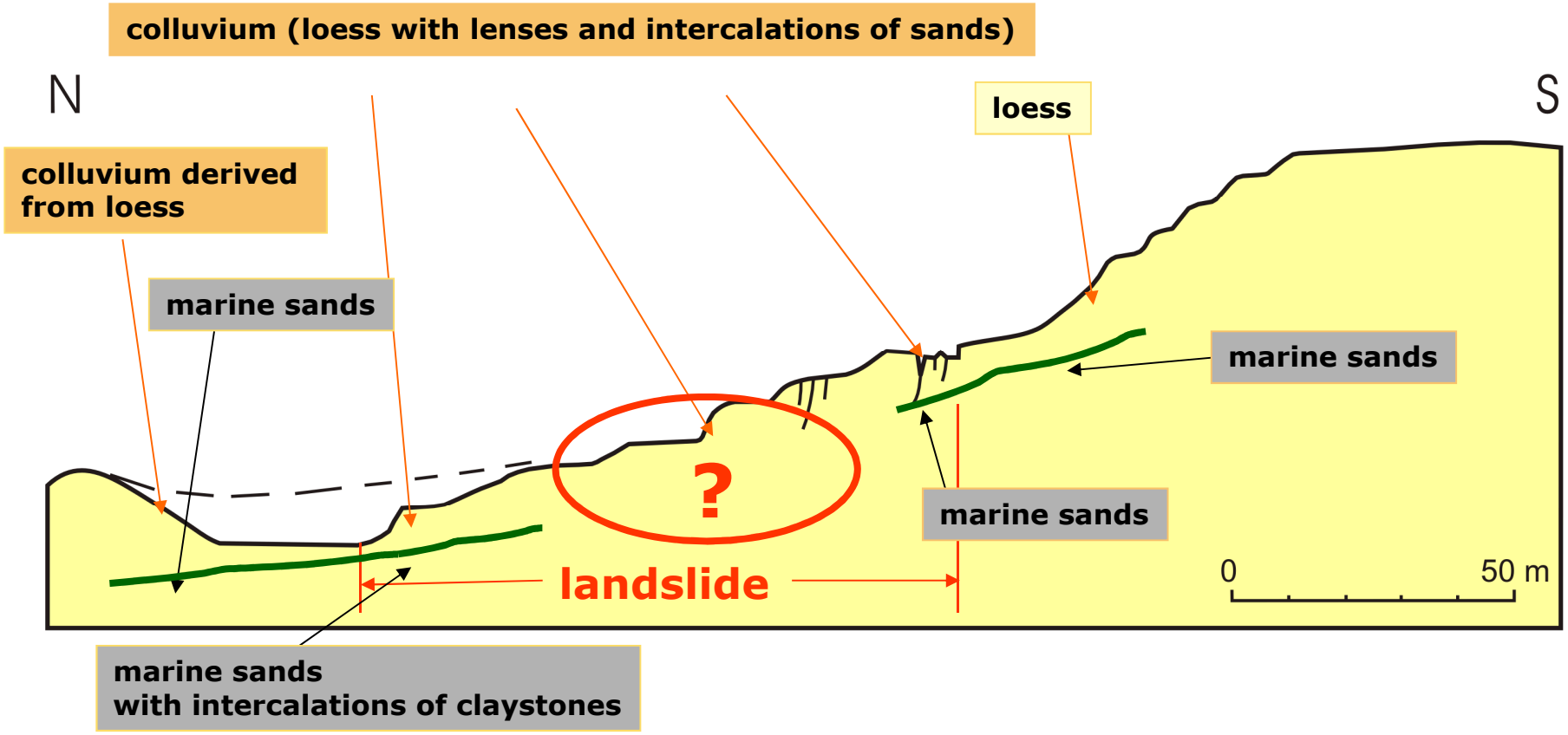

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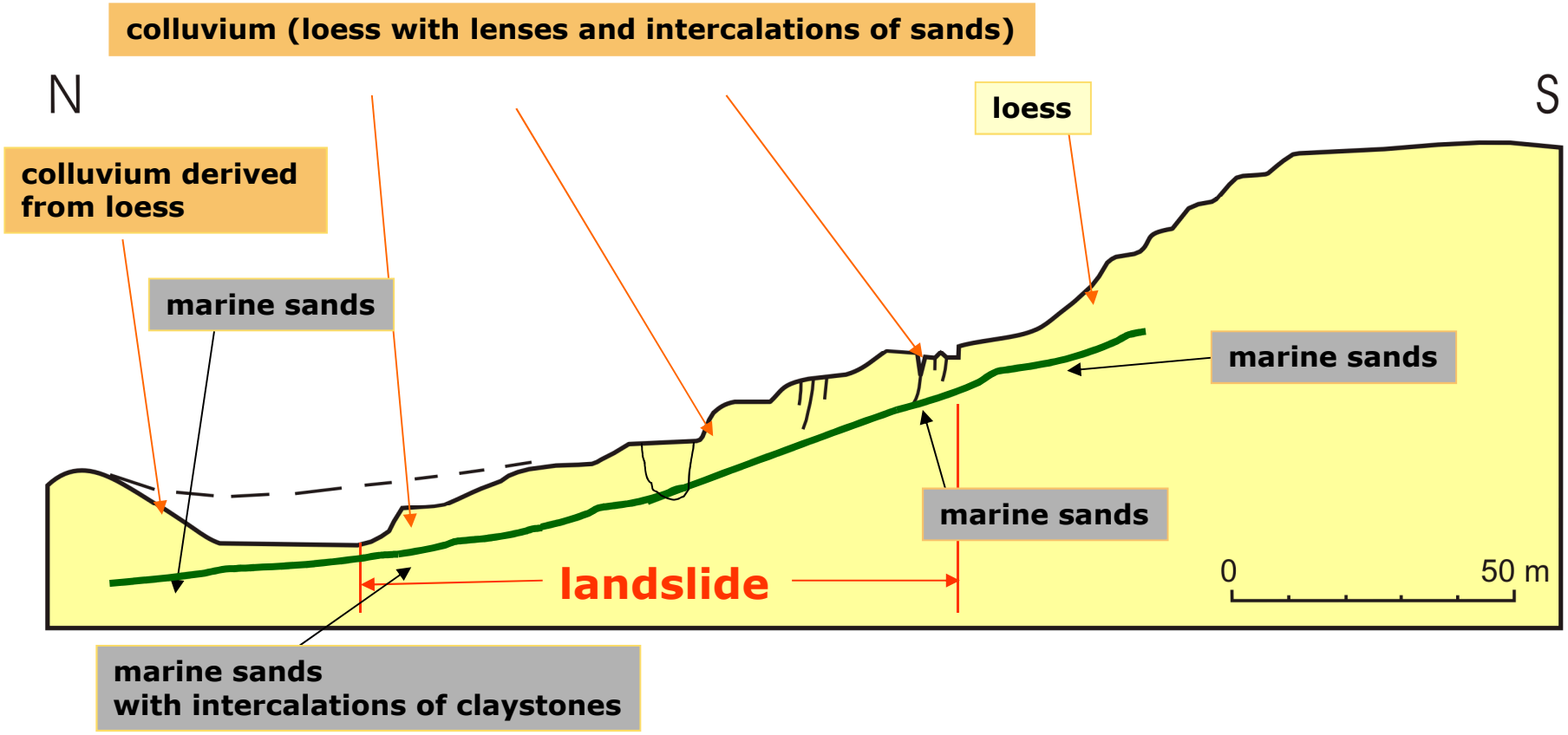

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morphology of the landslide has to be taken account

No rotation, only tensile cracks – prevail displacements parallel to slope gradient

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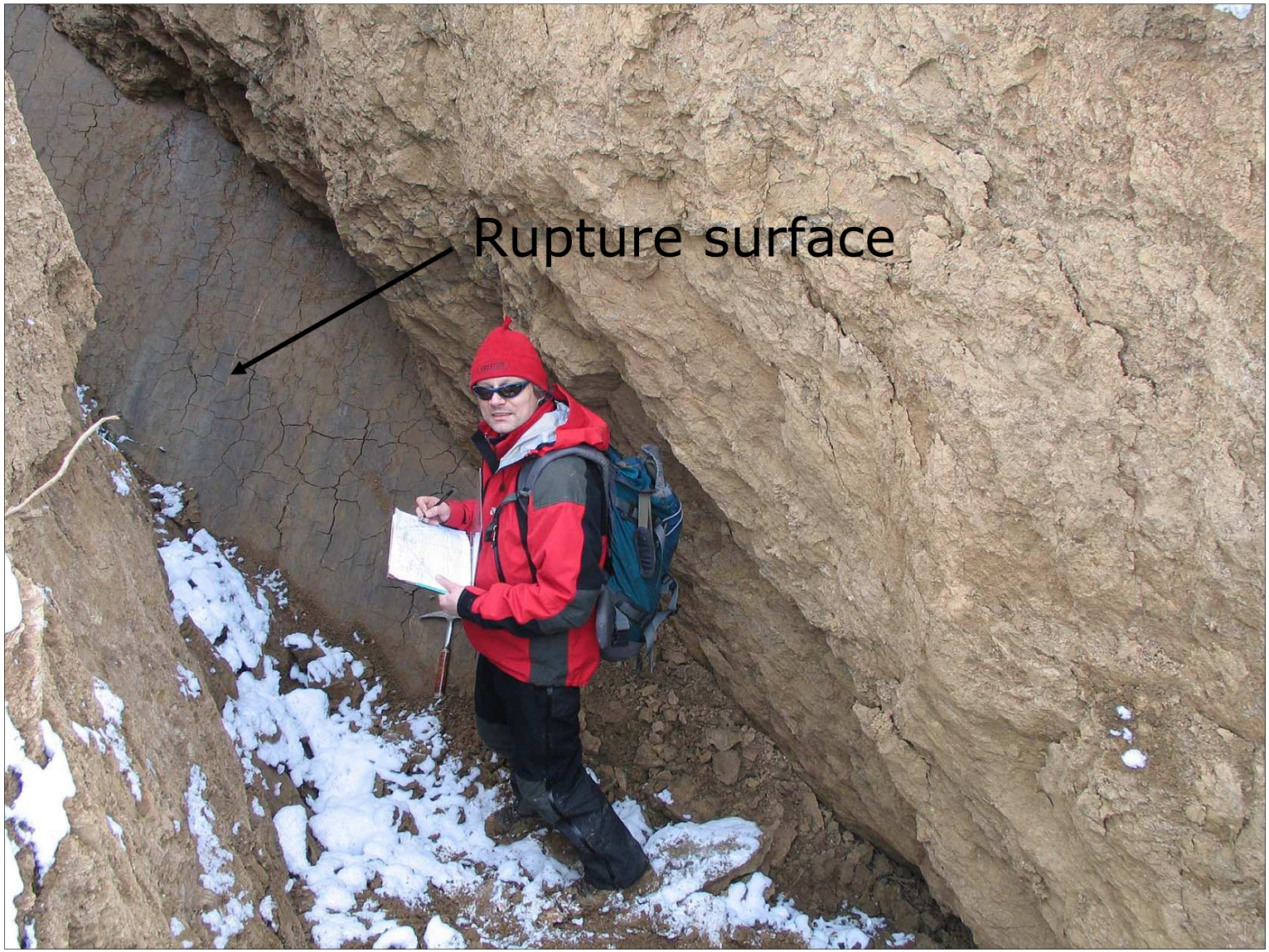

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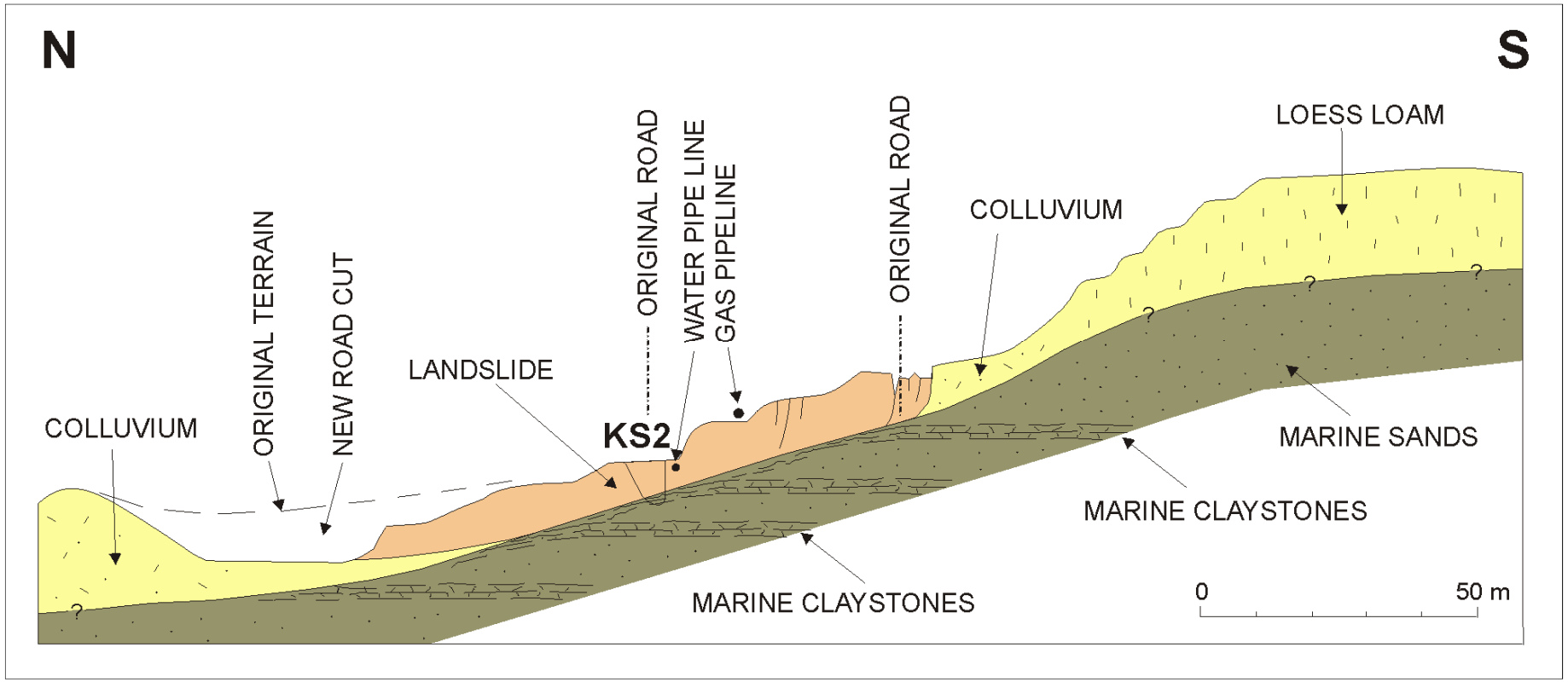
CHARACTERISTIC GEOLOGICAL PROFILE



Conclusion: **Slope stability is influenced by presence of clay intercalations in sands pulled out from their original position by long term slope movements – in this way zone of clay layer parallel to the slope gradient was formed as the weakest point in slope geology (it is the rock where rupture surface can be easily originated)**

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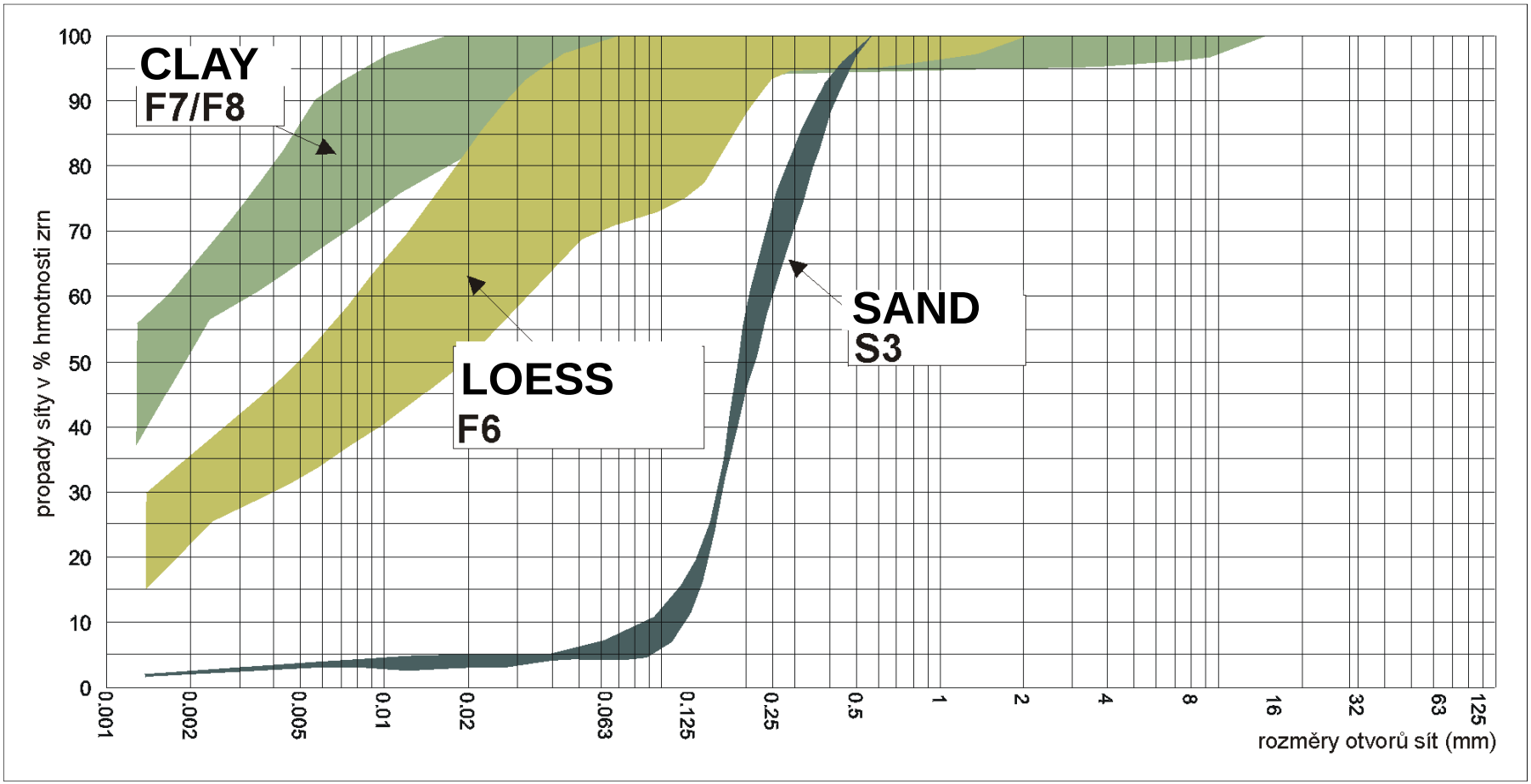
GRAIN SIZE DISTRIBUTION



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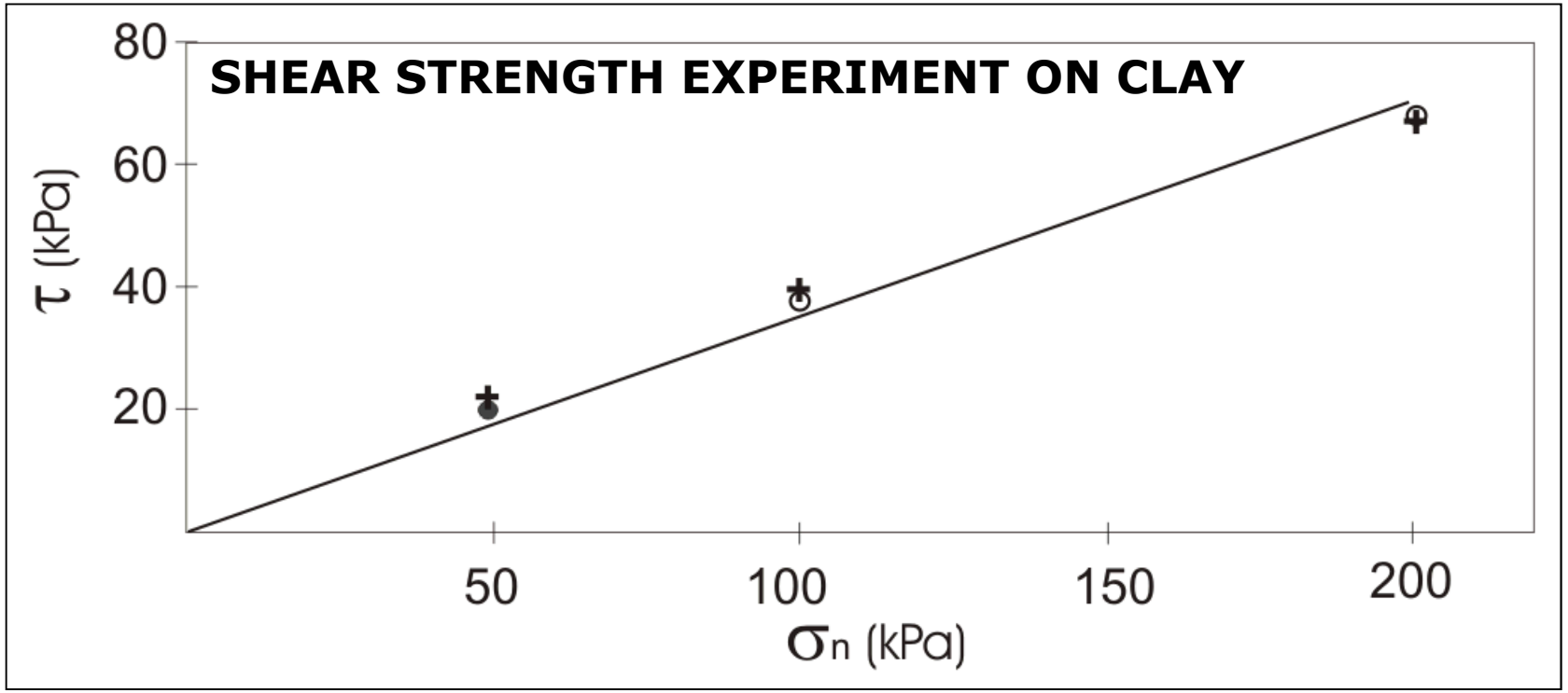
SHEAR STRENGTH EXPERIMENTS, CRITICAL STATE

ϕ_{cr} (CLAY) = 20°

(LOES (SILT)) = 30°



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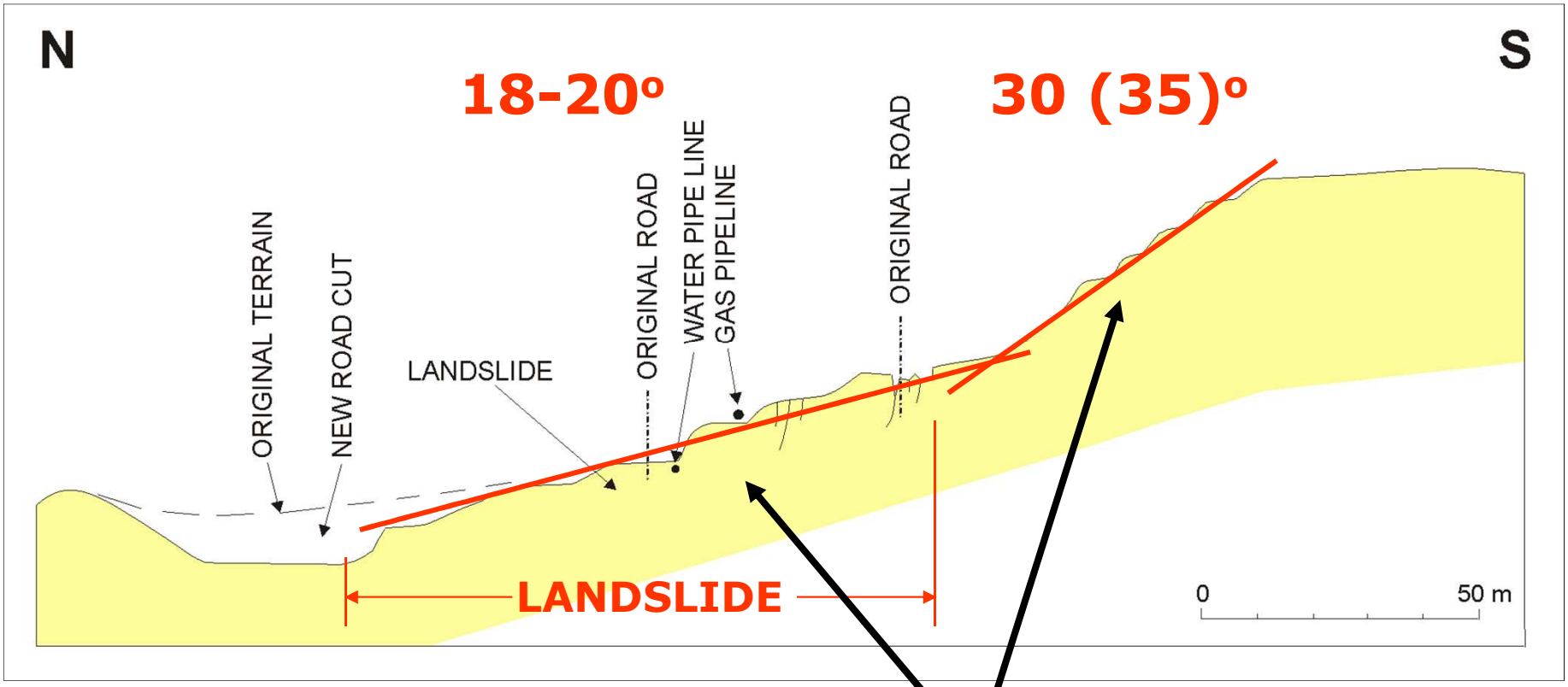

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CONDITIONS OF LANDSLIDE ORIGINATION

- Presence of clay layers pulled out from sands in parallel to slope inclination
- Tectonic distribution (even in colluvium)

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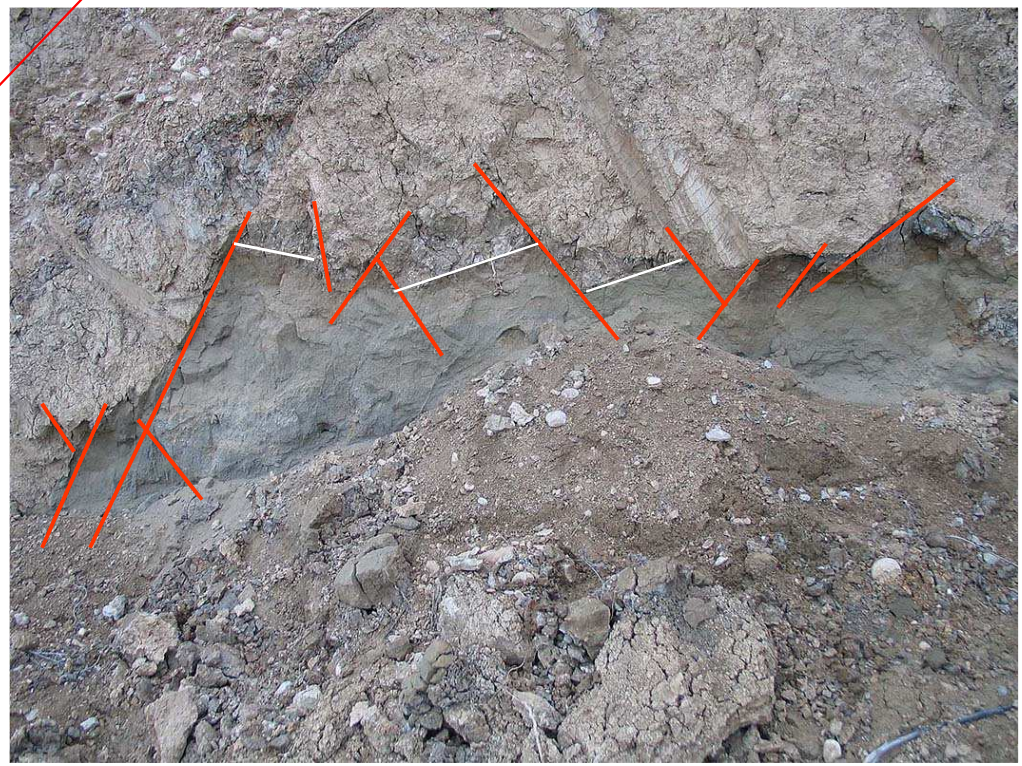

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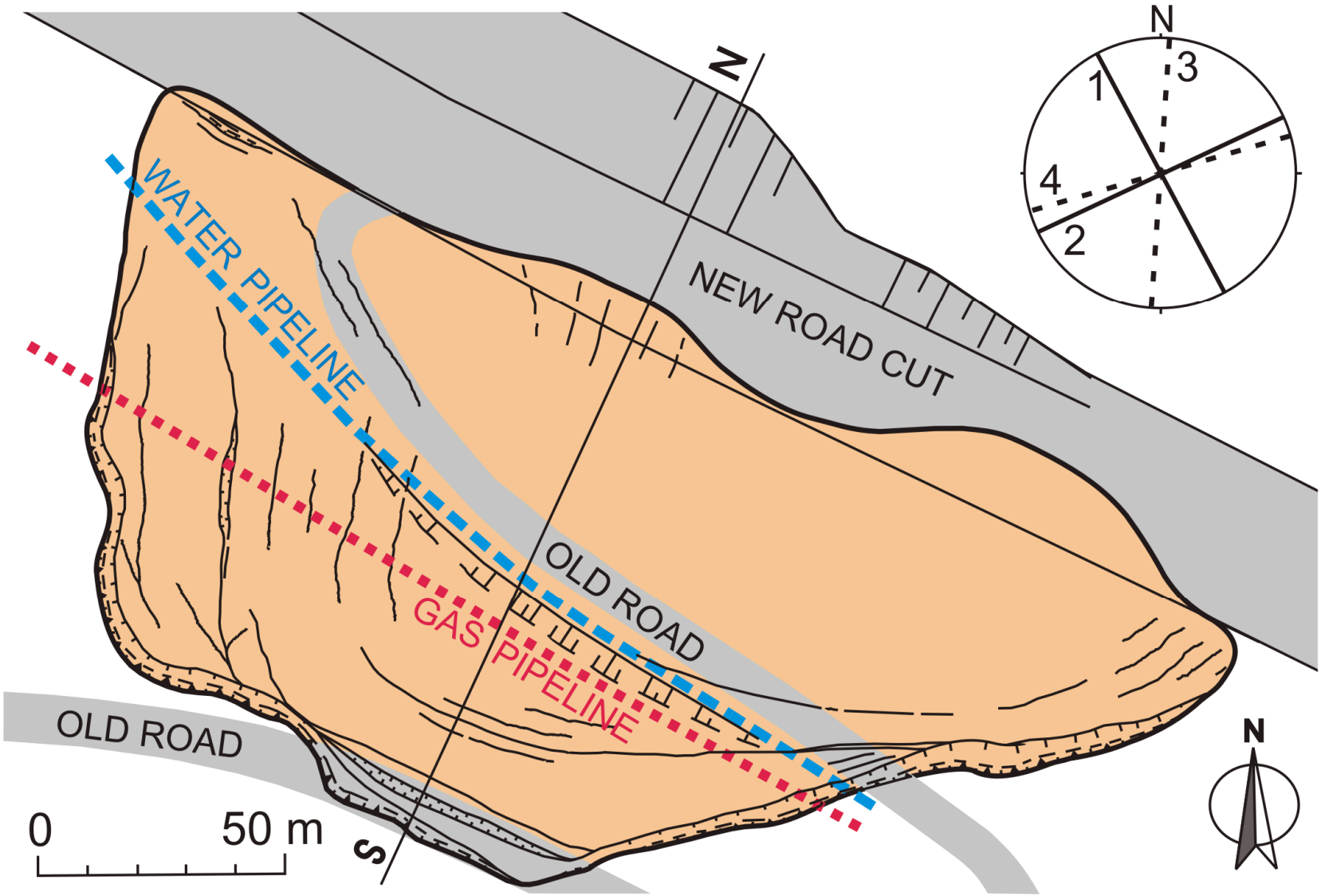

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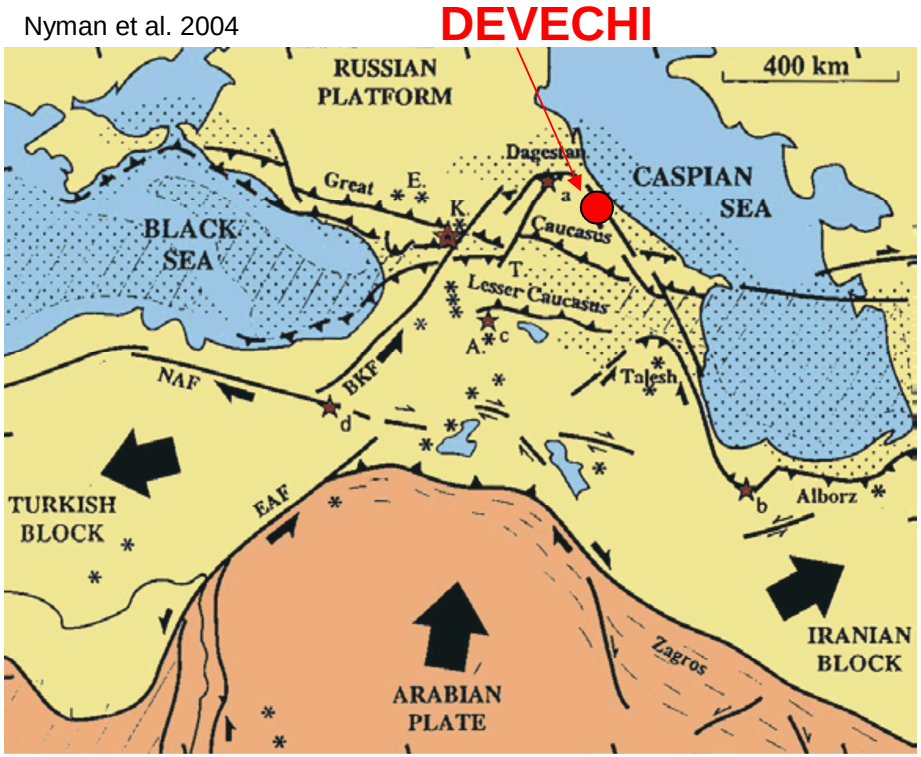
Influence of tectonics to slope stability

Nyman et al. 2004

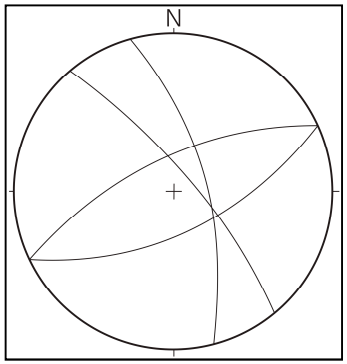


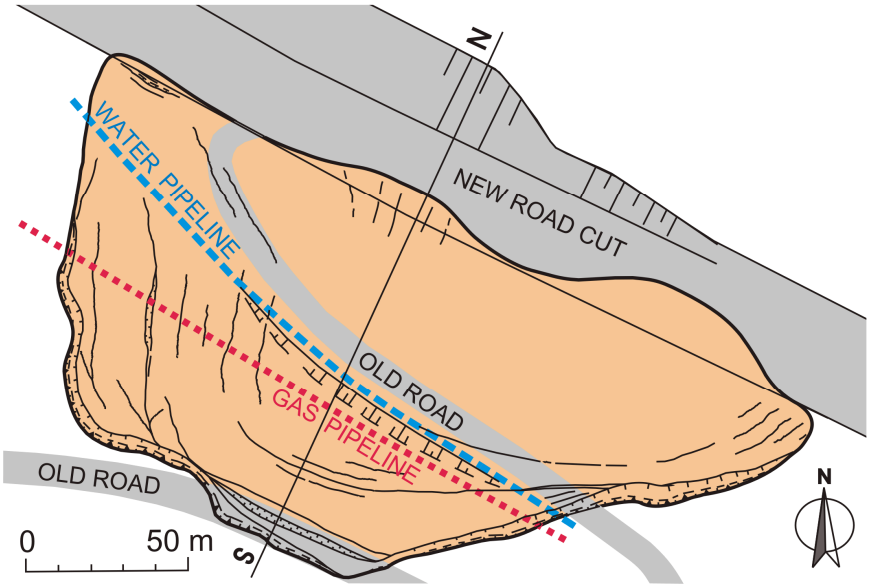
Schematic map of main tectonic features of the Caucasus and adjacent territories (after Philip et al, 1989). 1- active or Quaternary volcanoes; 2 relative motion of plates; 3 strike-slip faults; 4 thrust faults; 5 oceanic or intermediate crust; 6 - continental crust; 7 main sedimentary basin; 8 - recent folding at the border of Arabian Plate; 9 epicentres of major earthquakes.

http://www.iiasa.ac.at/Research/RMS/dpri2002/Papers/Tea.pdf

TECTONIC SITUATION OF THE BROADER REGION

Main discontinuities measured in landslide area





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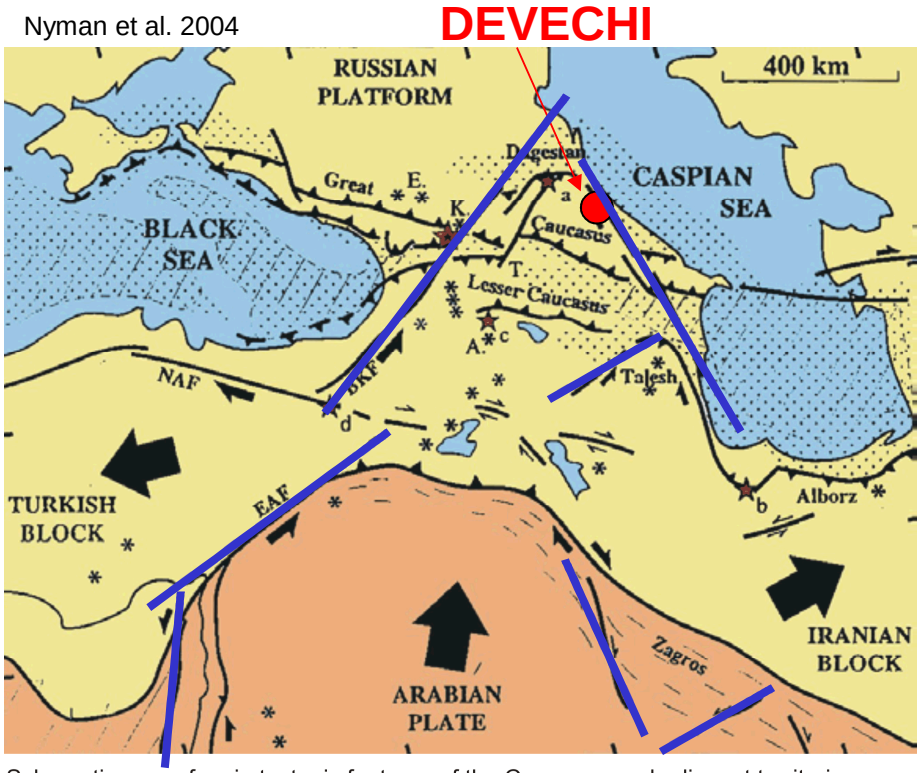

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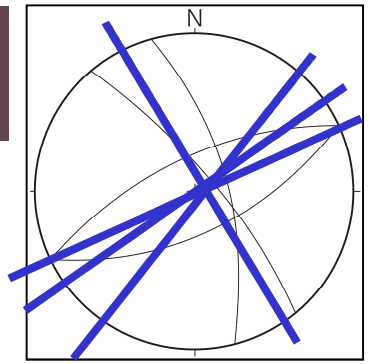

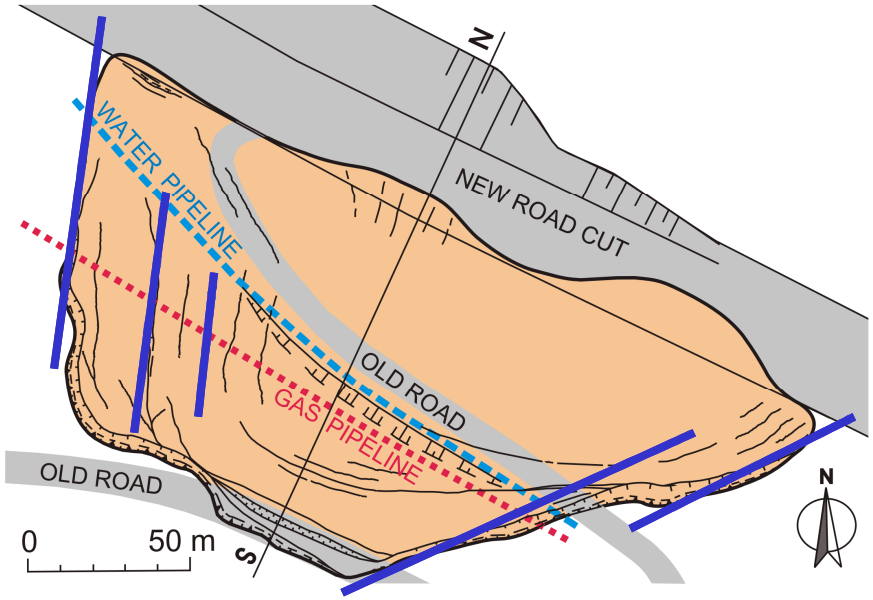

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Factors of landslide origination

- uplift in the bottom of the slope by motorway cut
- natural seismicity

Influence of natural seismicity to slope stability

- earthquake of magnitude M = 5 in near Dagestan on day before landslide origination (**PGA = 0,3 - 0,8 m/s^2**)
- critical acceleration for slope in question according to Newmark (1965)

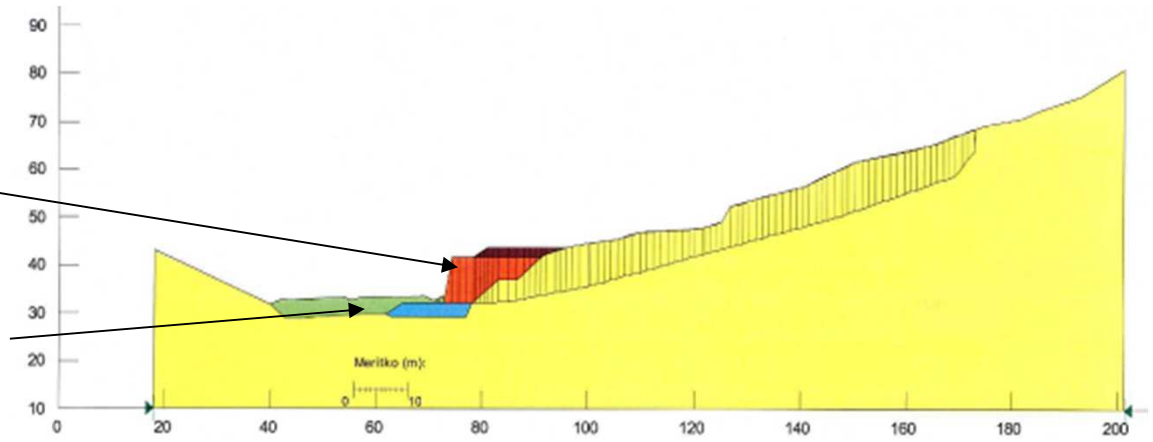
a_{cr} = 0,2 - 0,35 m/s^2 (for FS = 1,05 - 1,1 a ϕ = 20^o)

⇨ **a_{cr} =/< PGA**

Proposed remedy measure

- load in the bottom – reinforced earth construction (buttress)

- load in the bottom – increment of vertical motorway ´s alignment



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Conclusion

- To diminish impact of geological hazards on the construction and operation of roads and pipelines – anticipation of potential geological problems at an early stage of project

- During construction, mistakes from early routing decision is possible to mitigate only in limited extent by rerouting of smaller sections and thus to avoid problems areas

- If it is not possible avoid problems areas - engineering geologist works in cooperation with engineer in order to pass successfully troubleshoot areas or to solve problems that have already occurred.