Shallow seismic measurements in the Alai valley

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

CATENA
CLIMATIC AND TECTONIC NATURAL HAZARDS IN CENTRAL ASIA

Christian Haberland (GFZ)
with Trond Ryberg (GFZ), Ulan Abdybachaev & Azamat Sharshebaev (CAIAG), Magda Patyniak, Manfred Strecker (U Potsdam)

CATENA Workshop, September 24-25 2020

Project outline

- Shallow seismic profiling at paleo-seismological trenching sites (Alai valley, Pamir Frontal Thrust, PFT)
- Spatio-temporal evolution of earthquakes at the Main Pamir Thrust MPT (and the Pamir frontal Thrust PFT)
- How much of the PFT is activated during EQ
- Slip history: timing of EQs
- Providing structural information at a larger scale („seismic trenching“, e.g., Sheley et al., 2004)
- Geometry of faults; physical/ mechanical properties of units; diff. fault strands (?), hidden faults (?)
- Different scales (hundred m – few km long; <10m - ~1000m deep)
- Different P and S sources
- Cooperation with shearwave source development
- Seismic field work in August/Sept. 2019

Shallow Seismics @ trenching sites

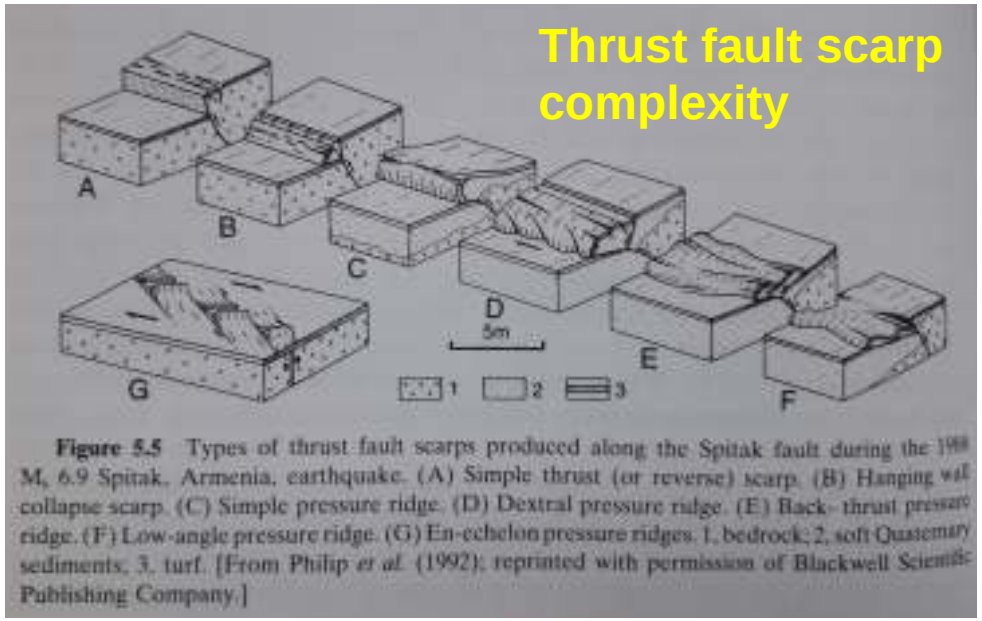
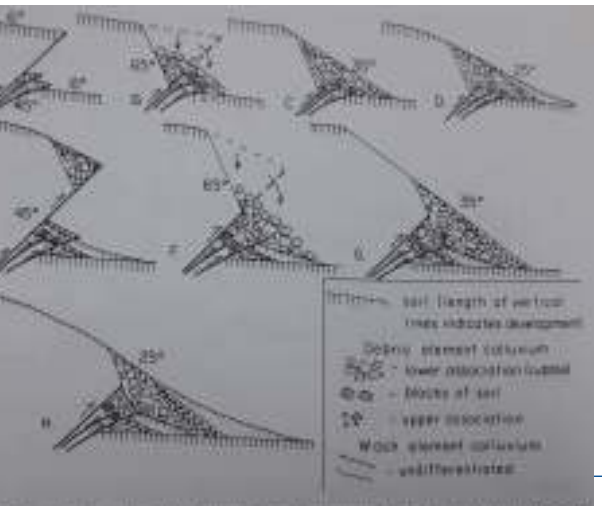
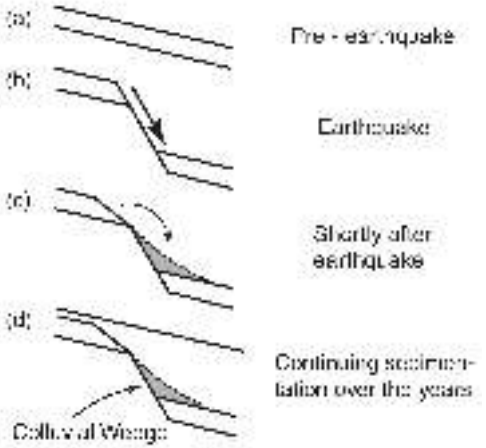


Figure 5.5 Types of thrust fault scarps produced along the Spitak fault during the 1988 M, 6.9 Spitak, Armenia, earthquake. (A) Simple thrust (or reverse) scarp. (B) Hanging wall collapse scarp. (C) Simple pressure ridge. (D) Dextral pressure ridge. (E) Back-thrust pressure ridge. (F) Low-angle pressure ridge. (G) En-echelon pressure ridges. 1, bedrock; 2, soft Quaternary sediments; 3, turf. [From Philip *et al.* (1992); reprinted with permission of Blackwell Scientific Publishing Company.]



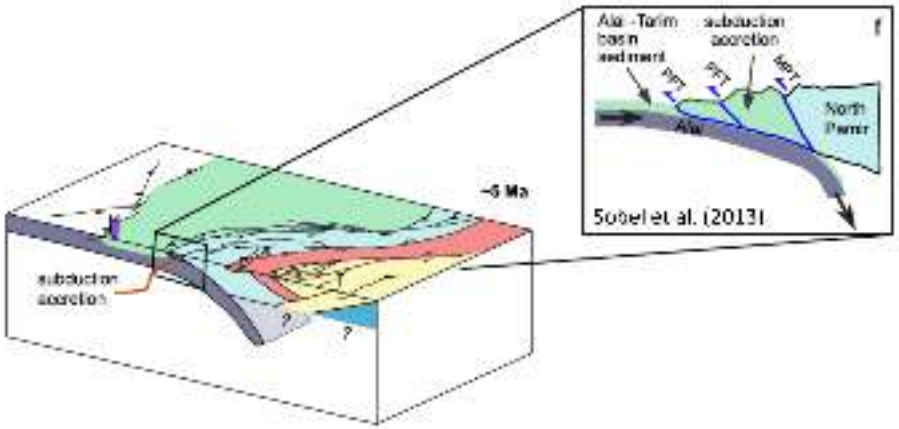
Carver & McCalpin (1996)

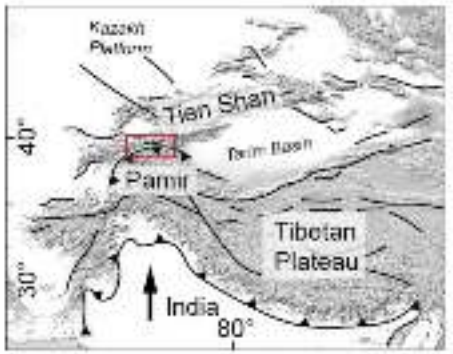


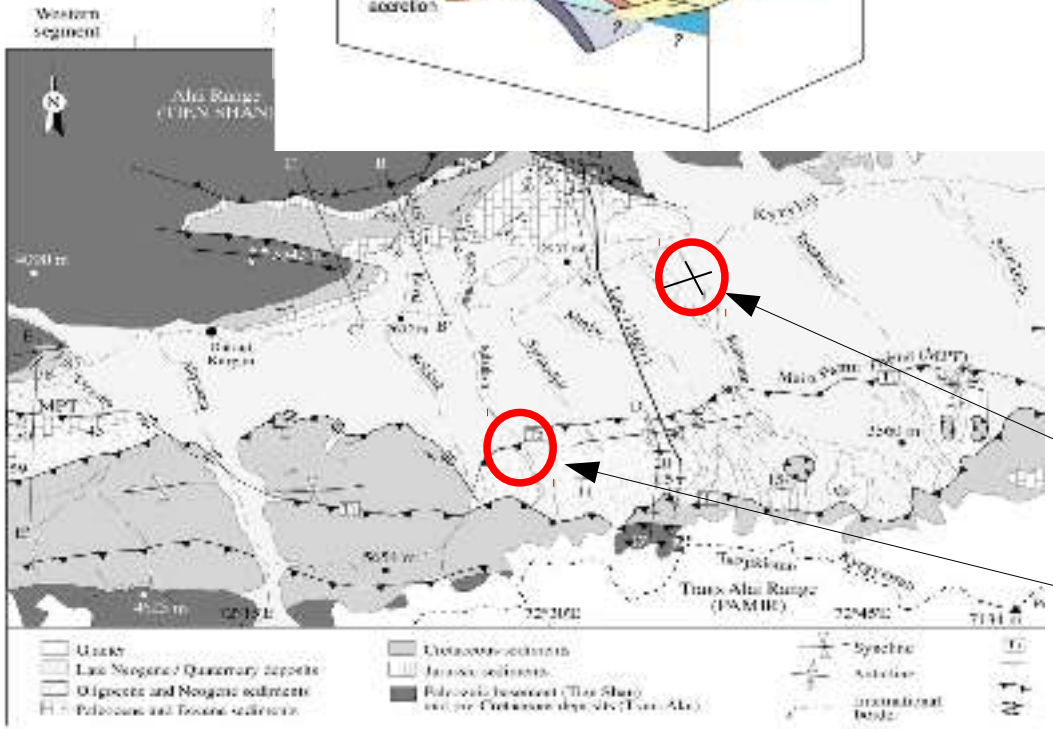
Moorey & Schuster, 1999; Buddensiek et al., 2008

- **Faults may be hidden**
- **Understanding structure on larger scale**

Study area





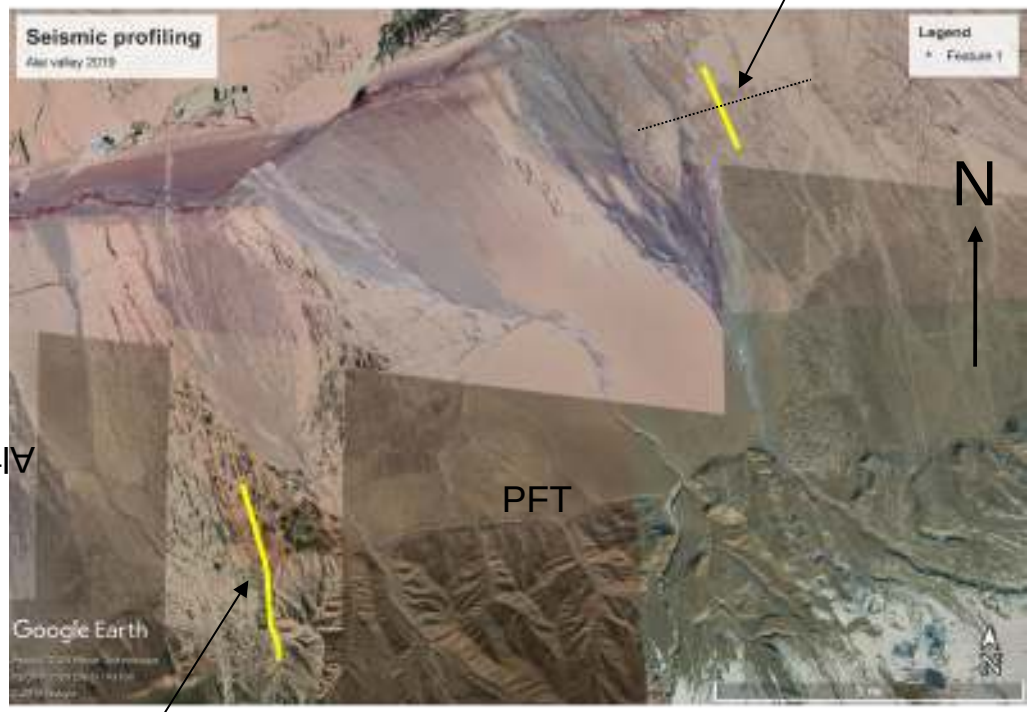


2. Koman fault

1. Achyk Suu

Coutand et al., 2002

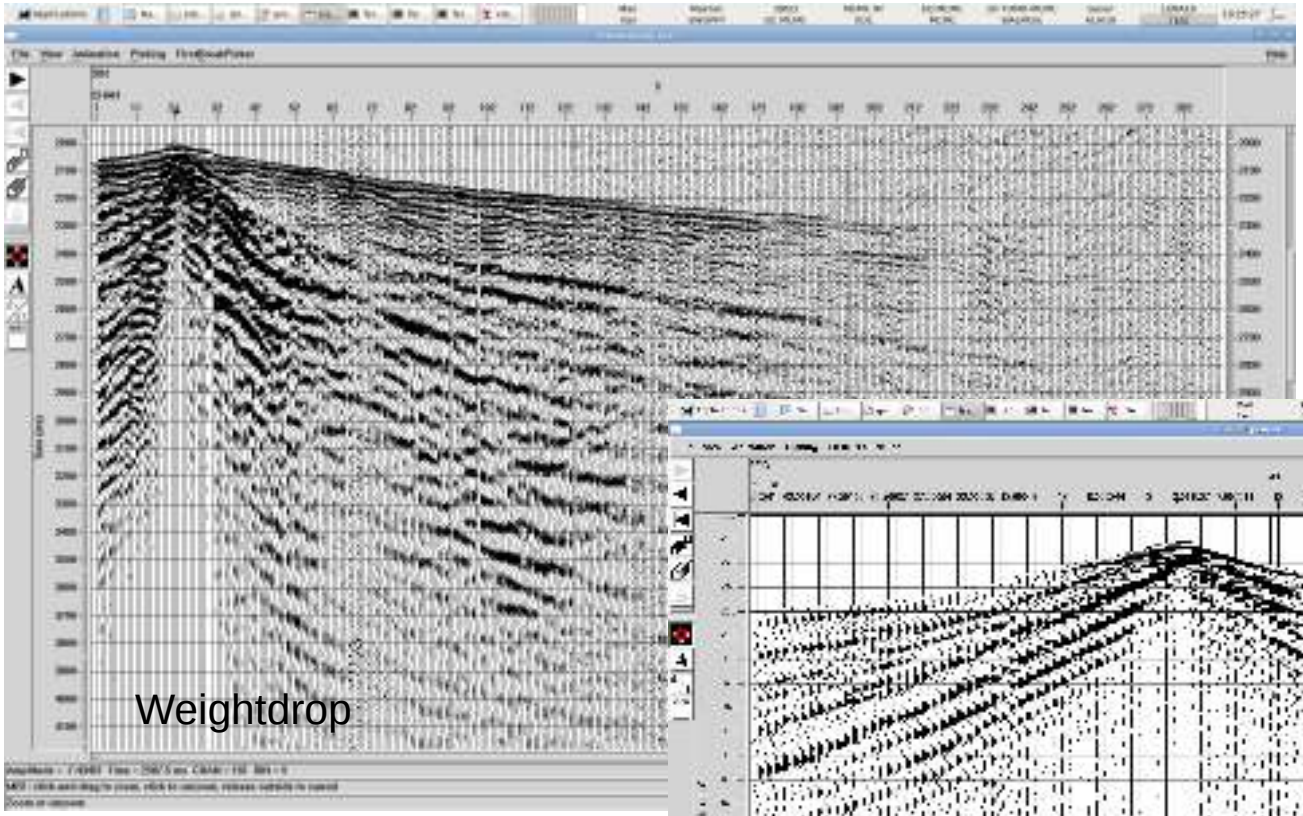
Shallow seismic measurements Alai valley 2019

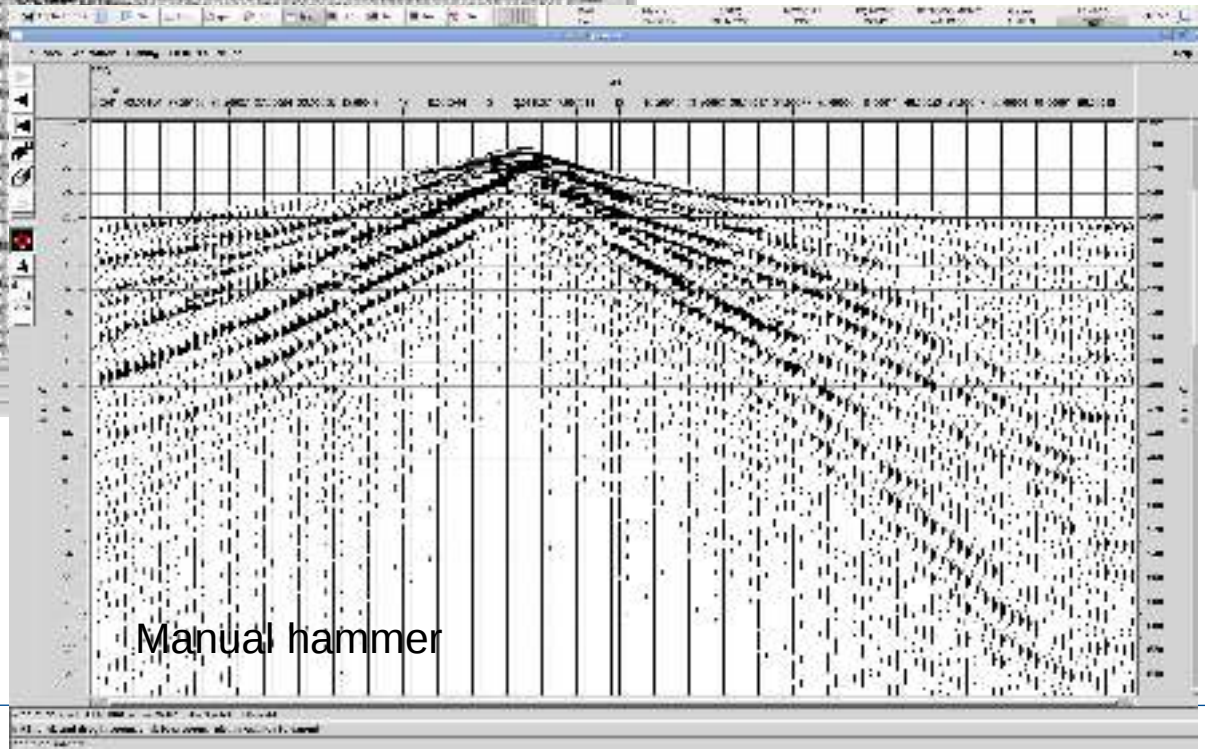


- August/September 2019 (3 weeks)
- 4 Germans + 4 Kyrgyz
- Two locations: Koman (fault) & Achyk Suu
- At each location:
  1 long profile (4.8 & 2.4 km)
  1 – 2 short profiles (250m)
- Shot spacing: 20m / 2m
- Receiver spacing: 5 m / 1 m
- „big“ weight drop (vertical)
- Sledge hammer (vertical & horizontal)
- Test DIGOS source
- 250 – 300 receivers
- First-arrival tomography (P- and S)
- Reflection imaging

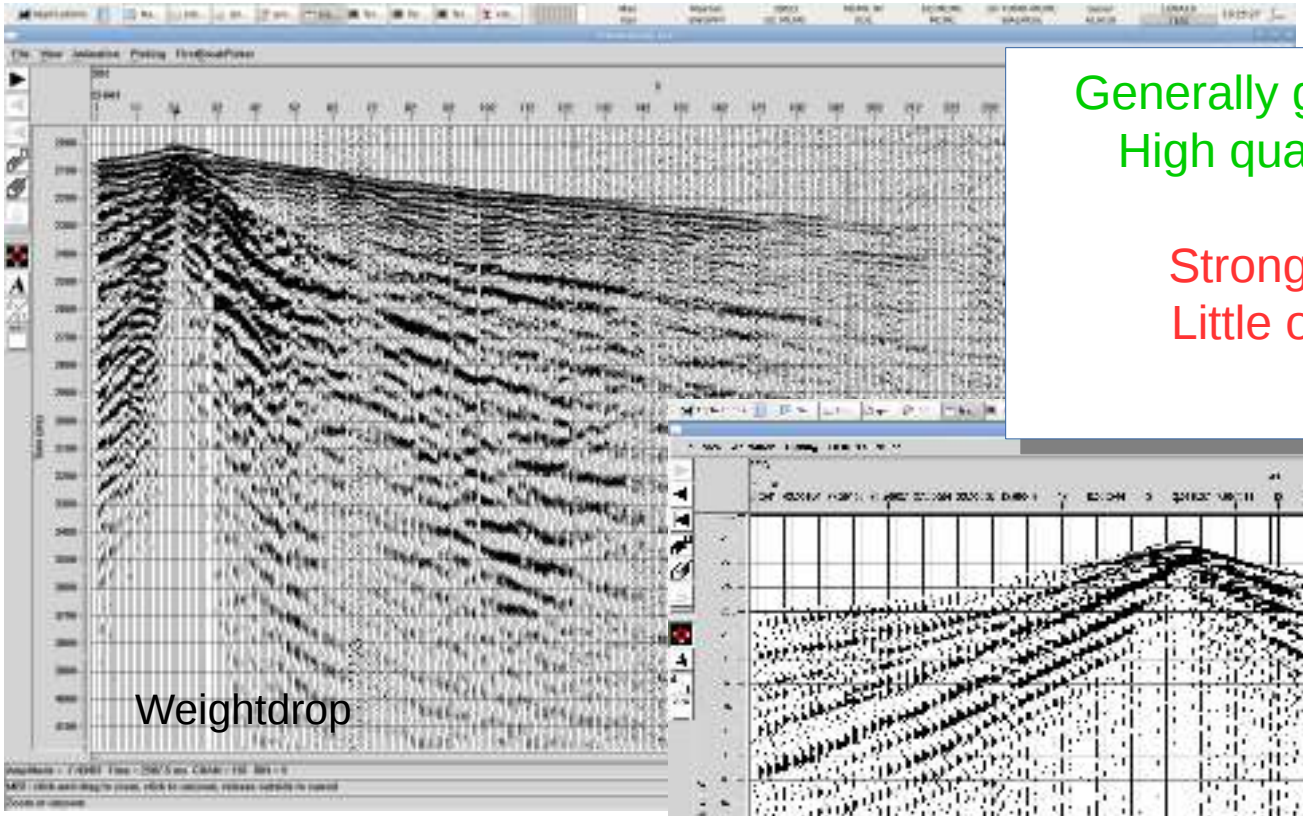
Field impressions

Data example



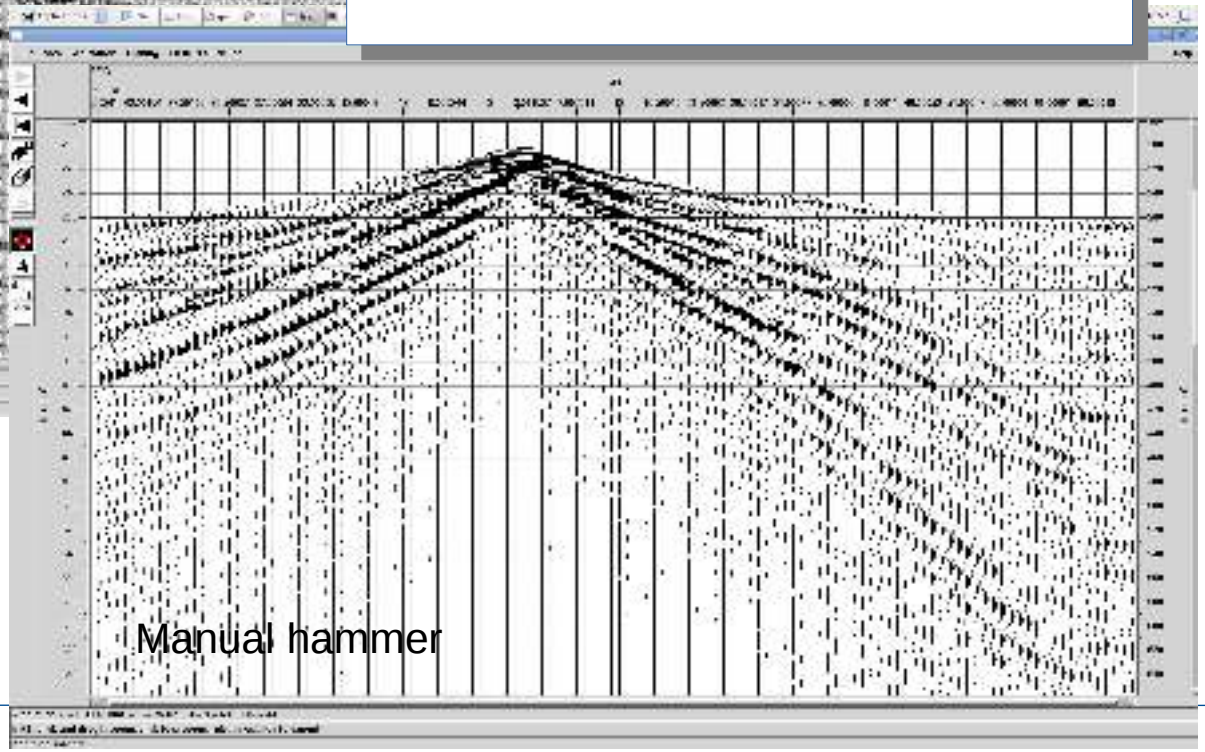


Data example

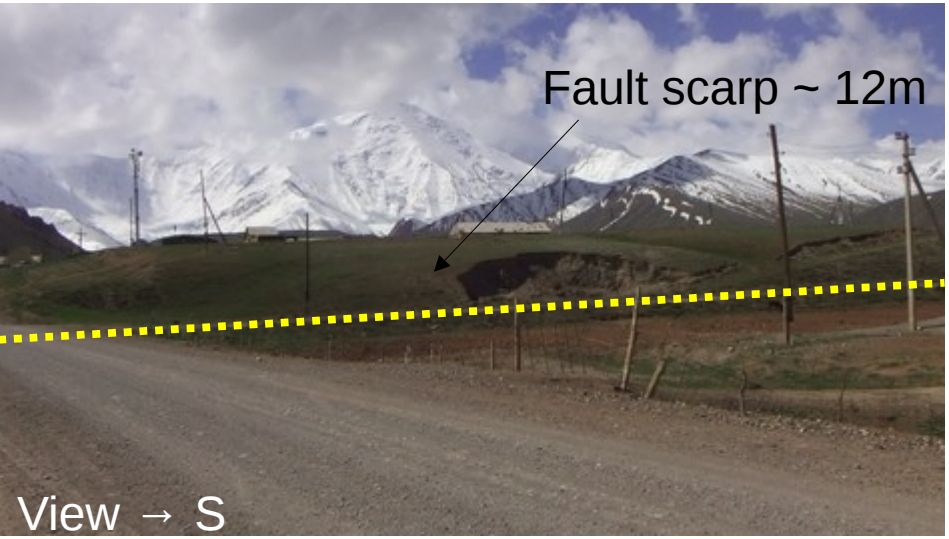


Generally good signal strength
High quality of first arrivals

Strong surface waves
Little or no reflections



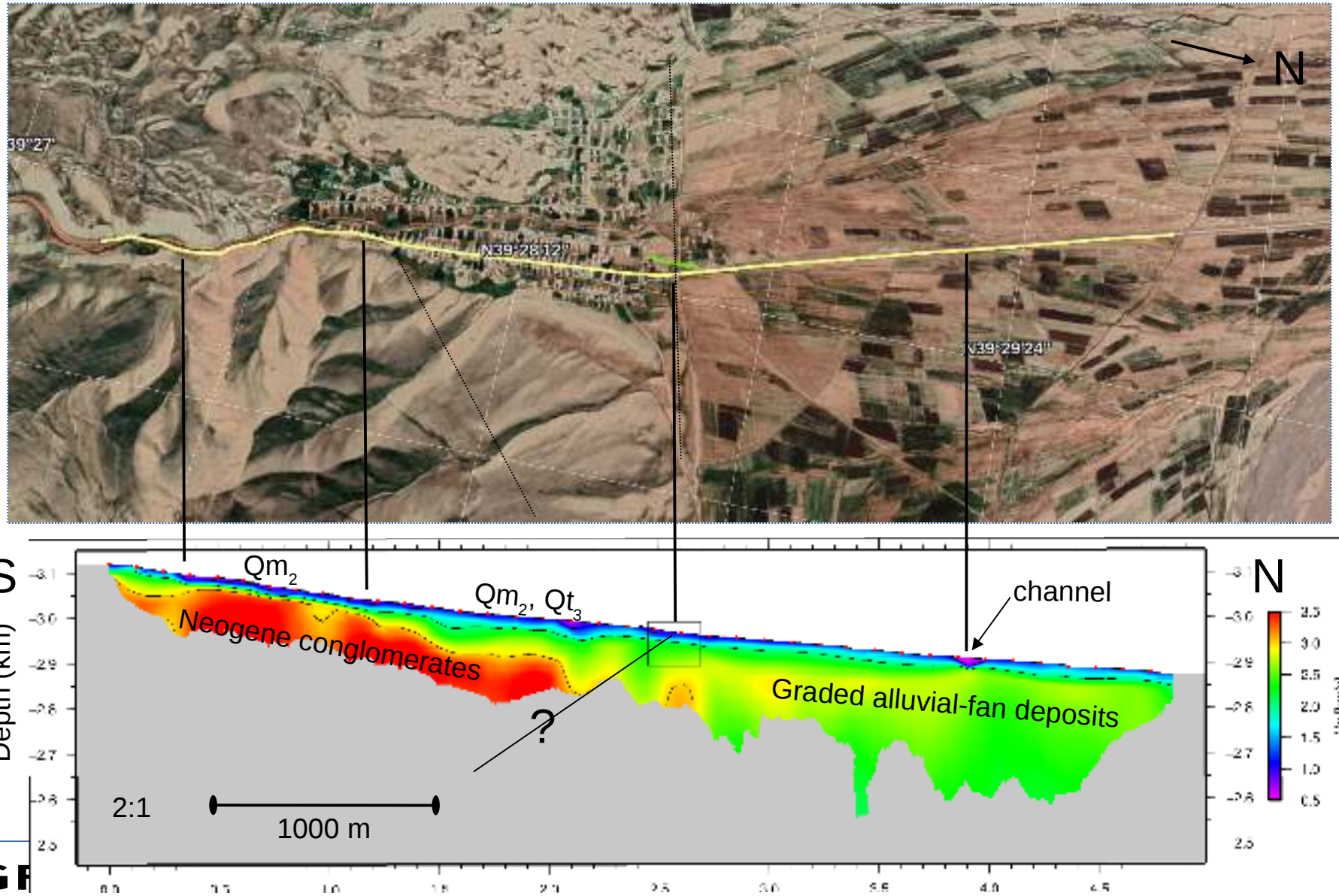
Achyk Suu



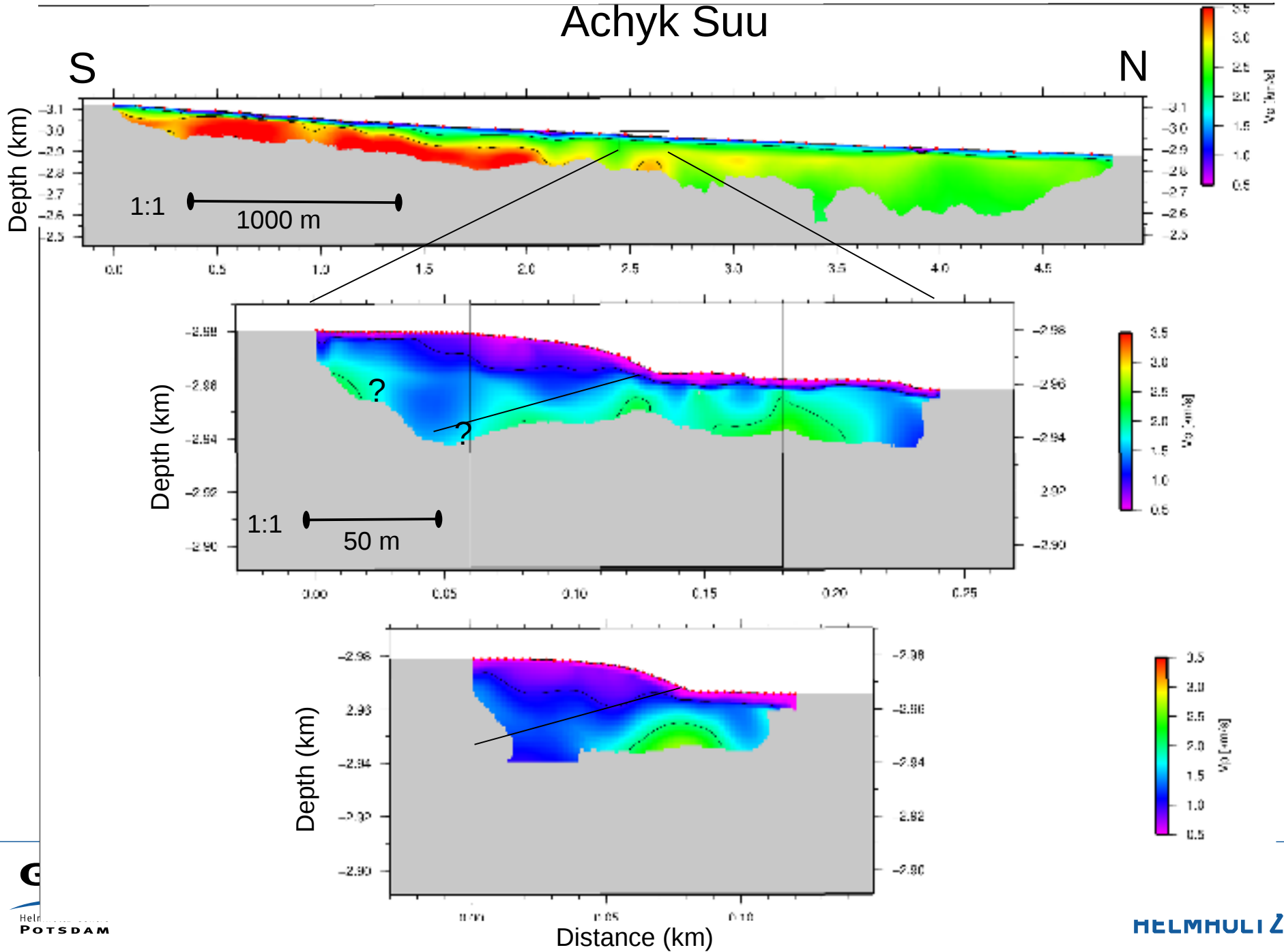
Trench 2017

Patyniak et al., 2018

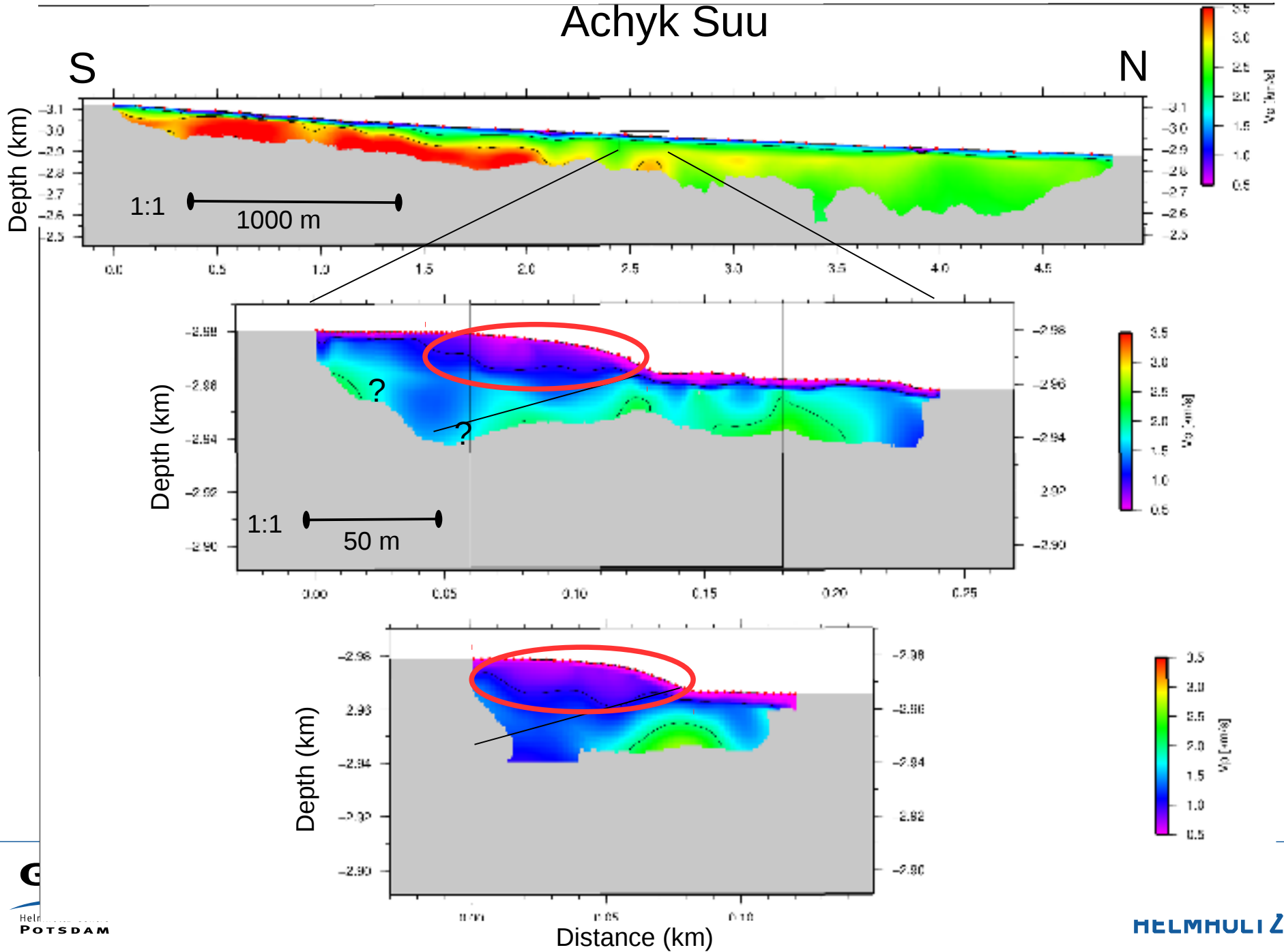
Achyk Suu


N
S
N
Qm2
Qm2, Qt3
Neogene conglomerates
channel
Graded alluvial-fan deposits
?
2:1
1000 m
Depth (km)
Distance (km)

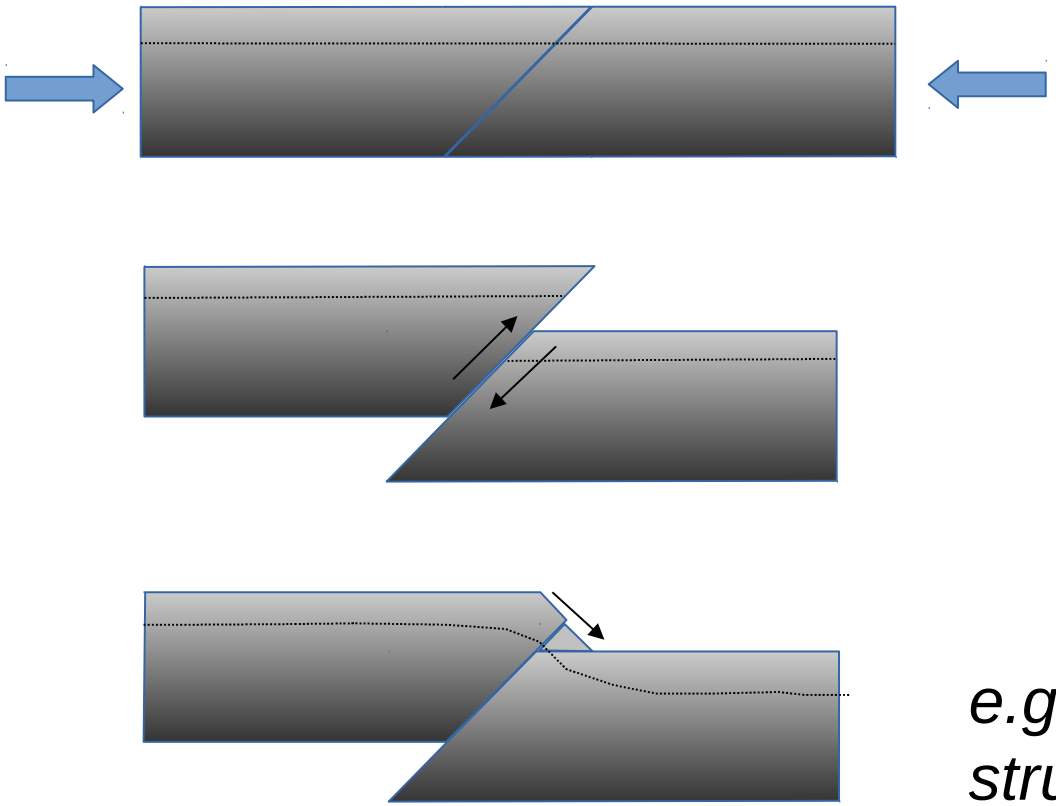
Achyk Suu



Achyk Suu

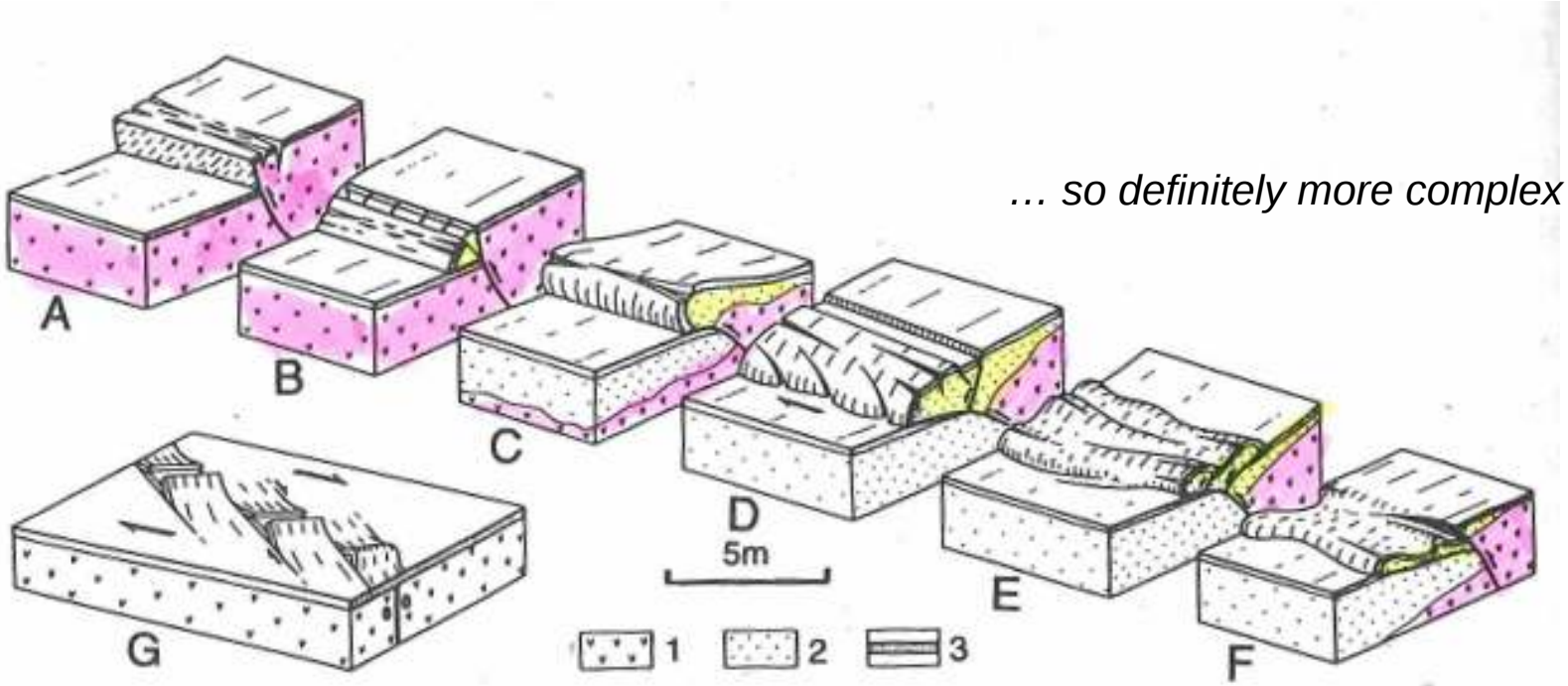


Conceptual sketch...



e.g. step in velocity structure

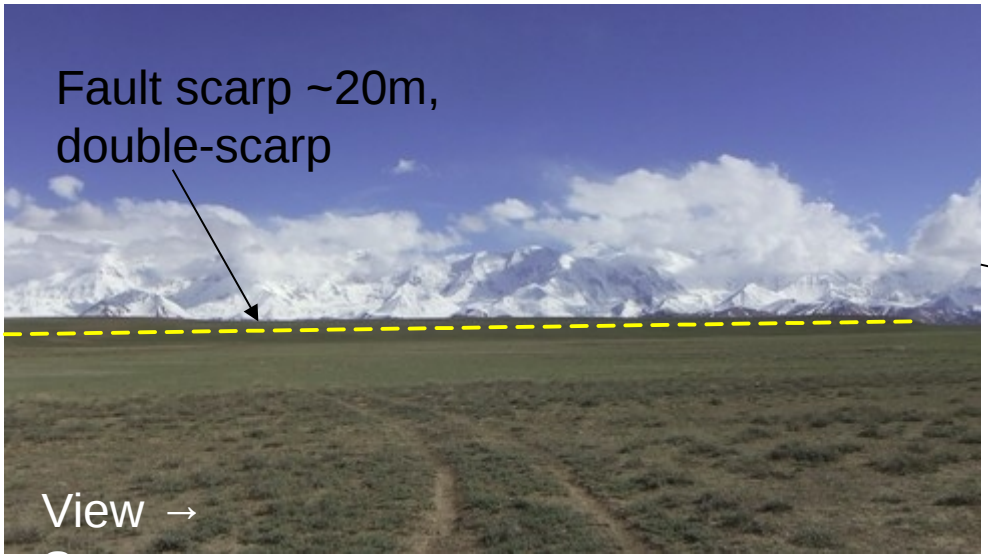
Thrust fault complexity



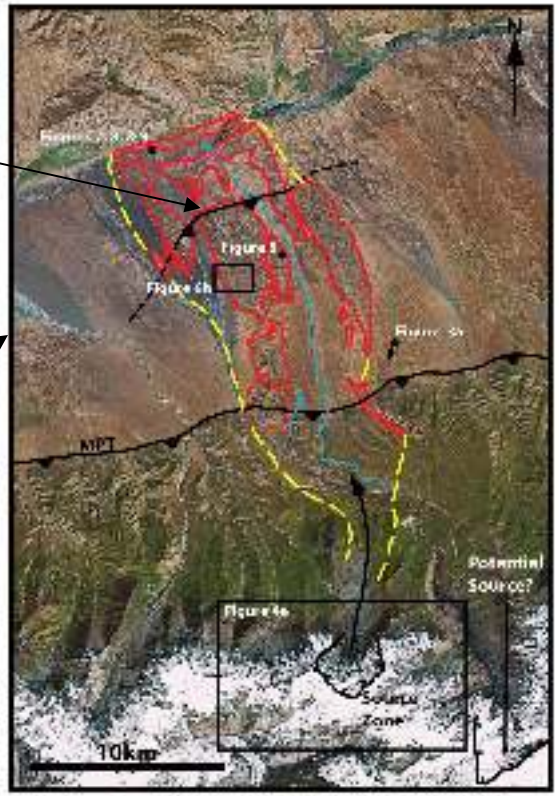
… so definitely more complex

after Philipp et al., 1992

Koman fault

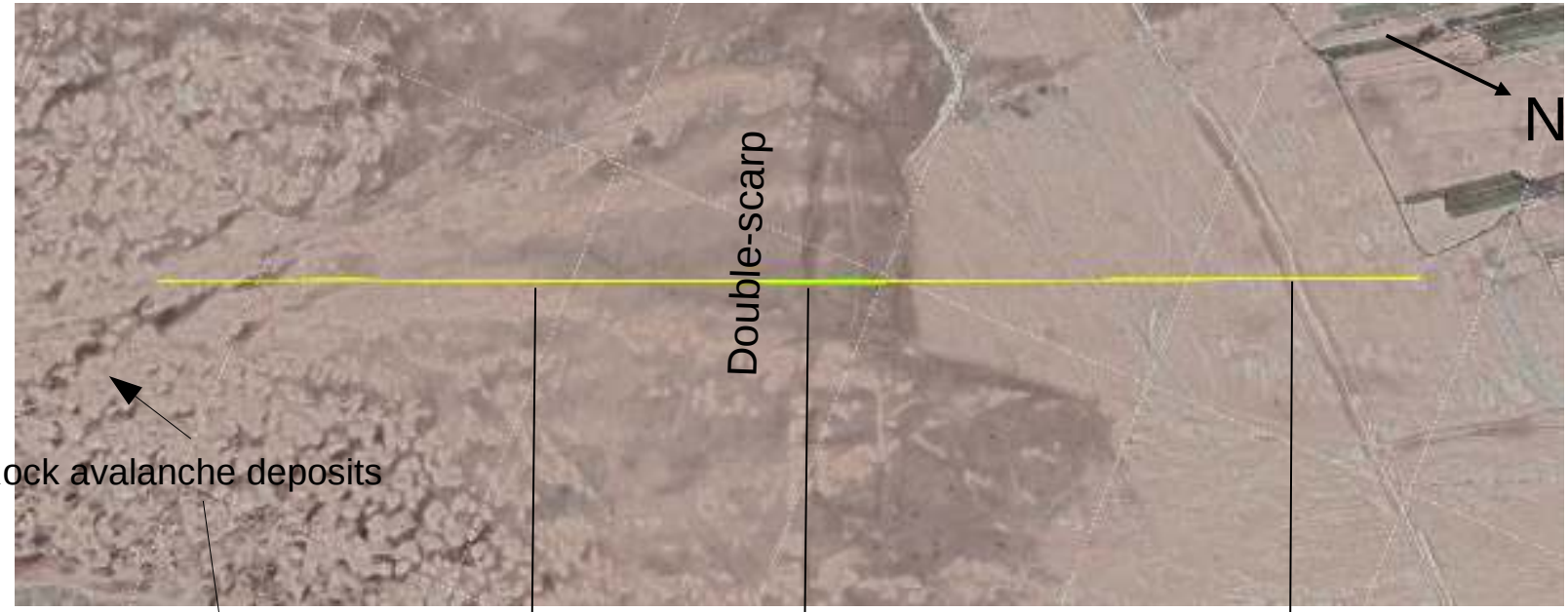


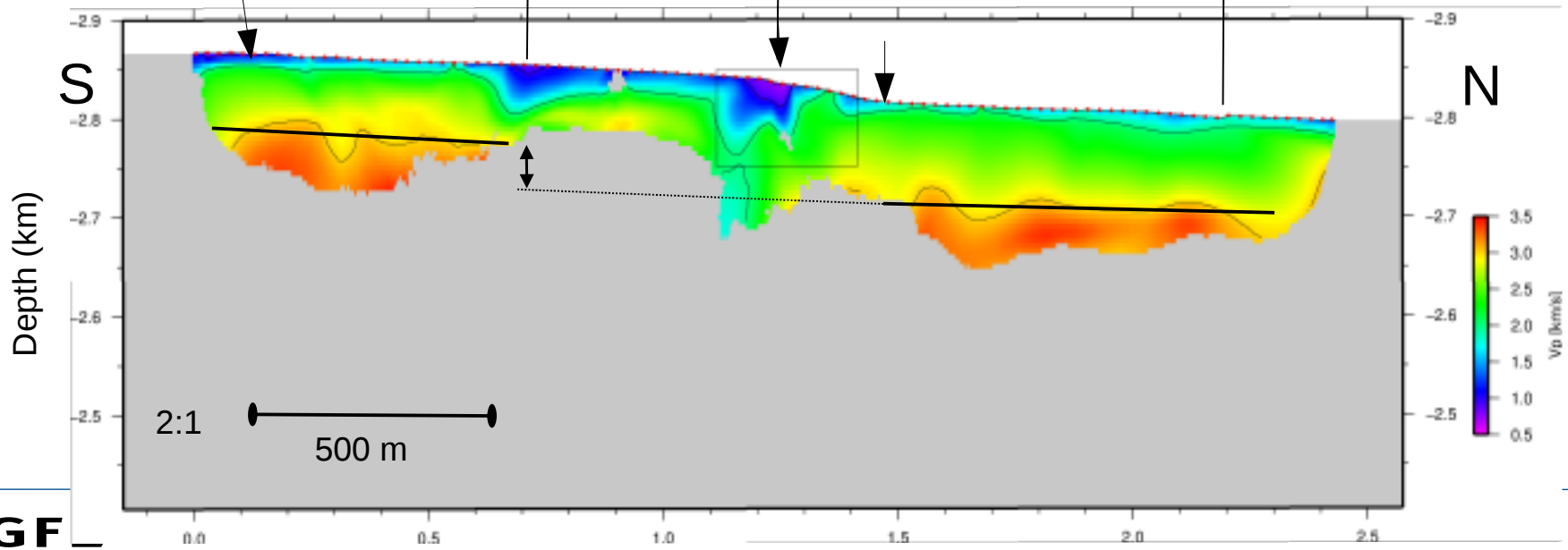
Komansu rock avalanche
~28km long; 5,000-11,000 BC



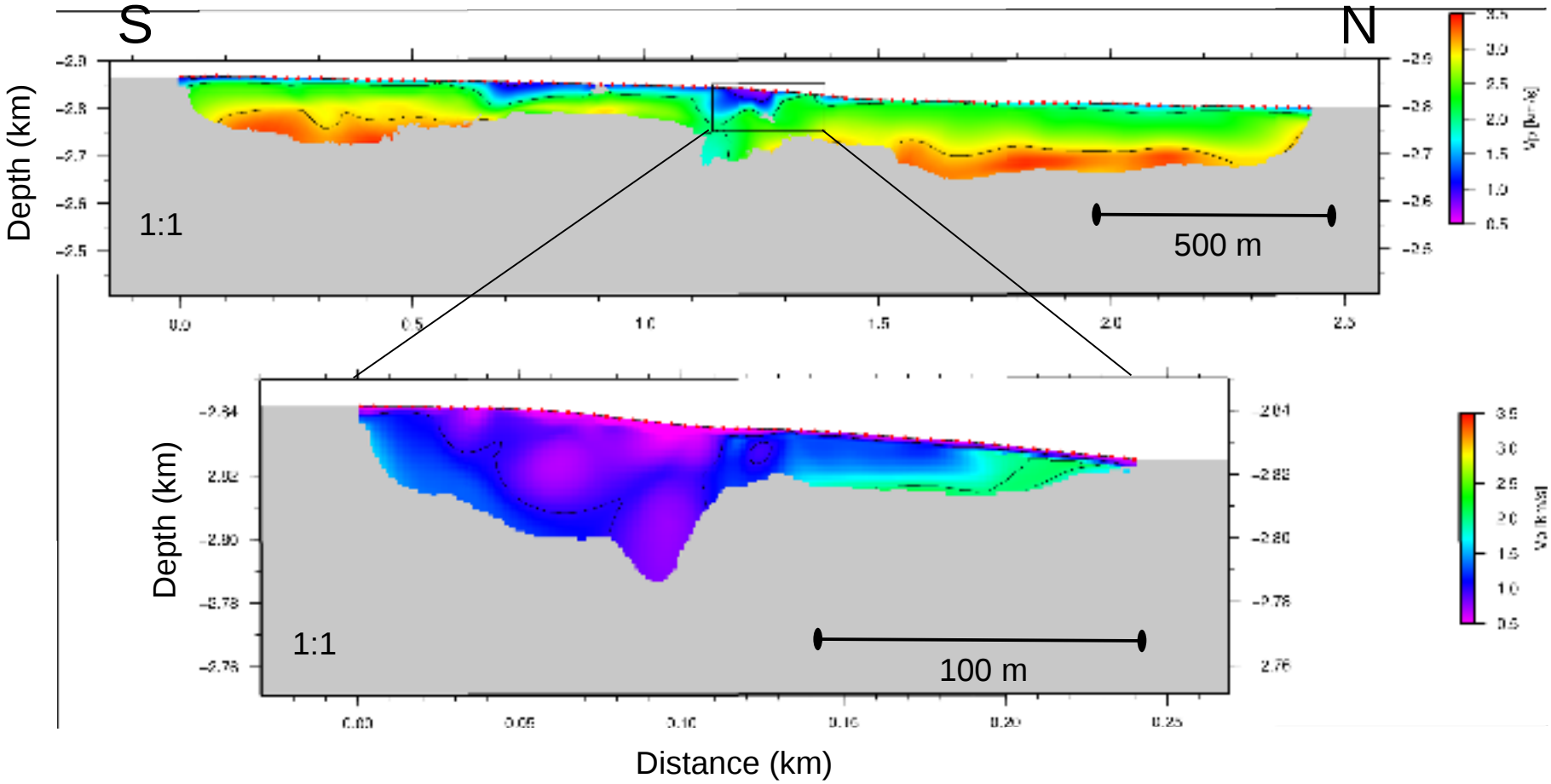
Robinson et al., 2014

KOMAN

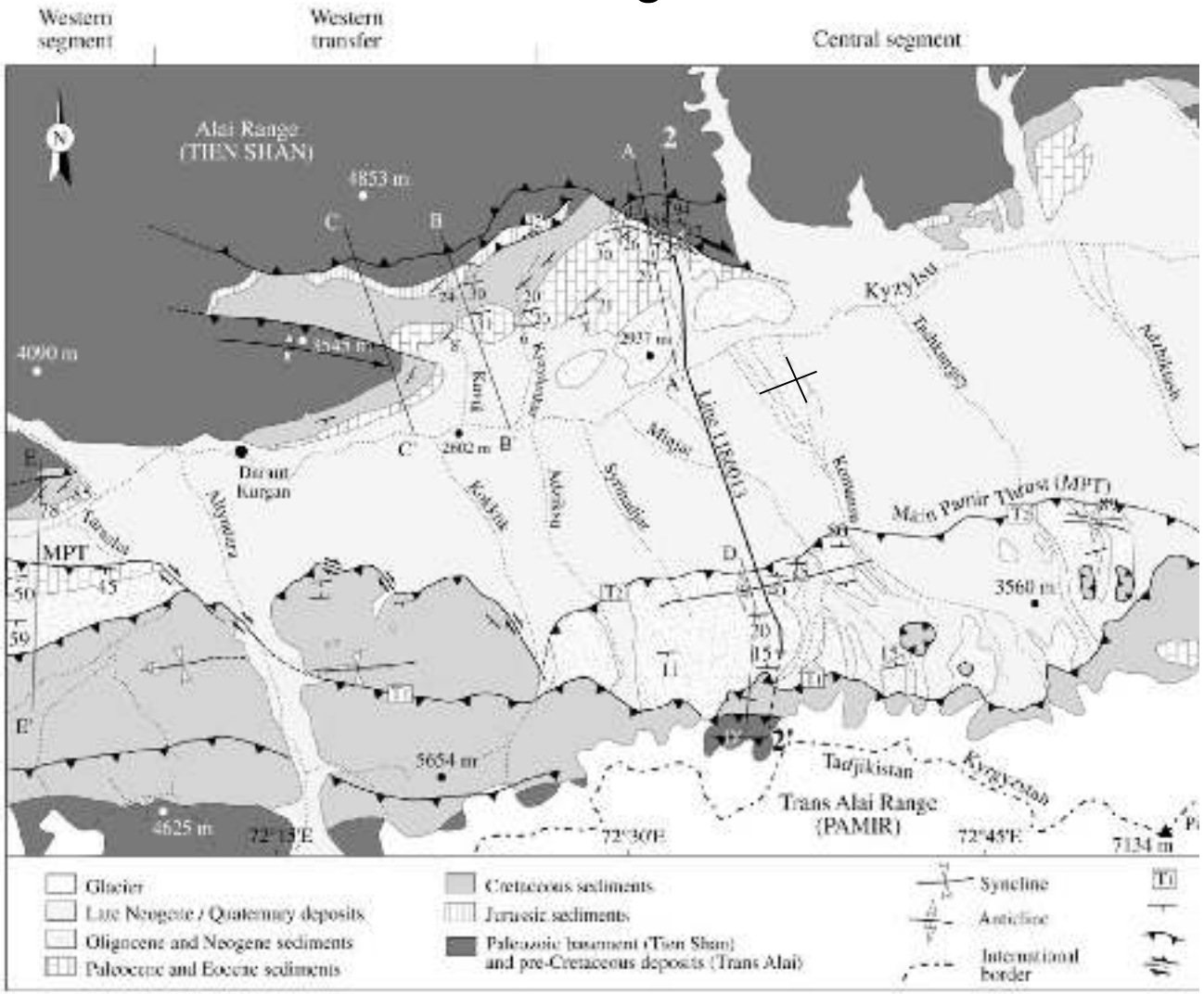

N
Double-scarp
Rock avalanche deposits


S
N
Depth (km)
-2.9
-2.8
-2.7
-2.6
-2.5
2:1
500 m
0.0
0.5
1.0
1.5
2.0
2.5
Distance (km)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Vp [km/s]

KOMAN

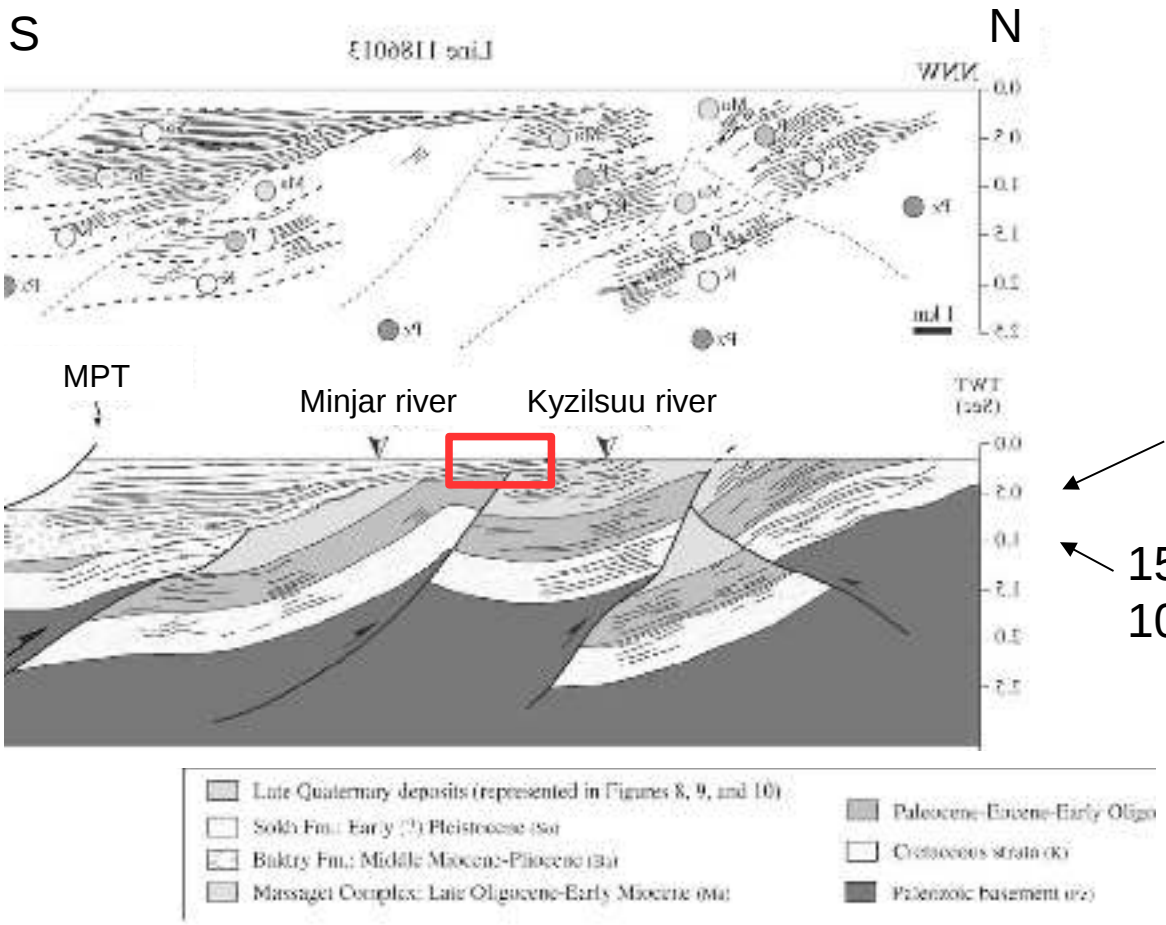


Relation to larger structure



Coutand et al., 2002

Large-scale structure



750 m (@3000m/s)
500 m (@2000m/s)

1500 m (@3000m/s)
1000 m (@2000m/s)

Coutand et al., 2002

Conclusions & Outlook

- Successful shallow seismic measurements
- First tomographic models (P-waves)
- Good correspondence between long and short profiles
- Complex seismic velocity structure, interpretation just started
- Achyk Suu: imaging of large scale structure, low-velocity hanging wall @ small scale, strongly deformed rock mass
- Koman fault: indication for thrust fault @ large scale, low-velocity hanging wall and further complexity @ small scale (?)
- Continue with analysis (S-waves, vp/vs ratio, reflection seismics) and synthesis!

Thank you very much for your attention

Koman