CLIMATIC AND TECTONIC NATURAL HAZARDS IN CENTRAL ASIA

New findings related to seismic hazards in the Alai Valley

S.Zh. Orunbaev, Central Asian Institute of Applied Geosciences
M.V. Rodkin, Institute of Earthquake Prediction Theory and Mathematical Geophysics

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Content

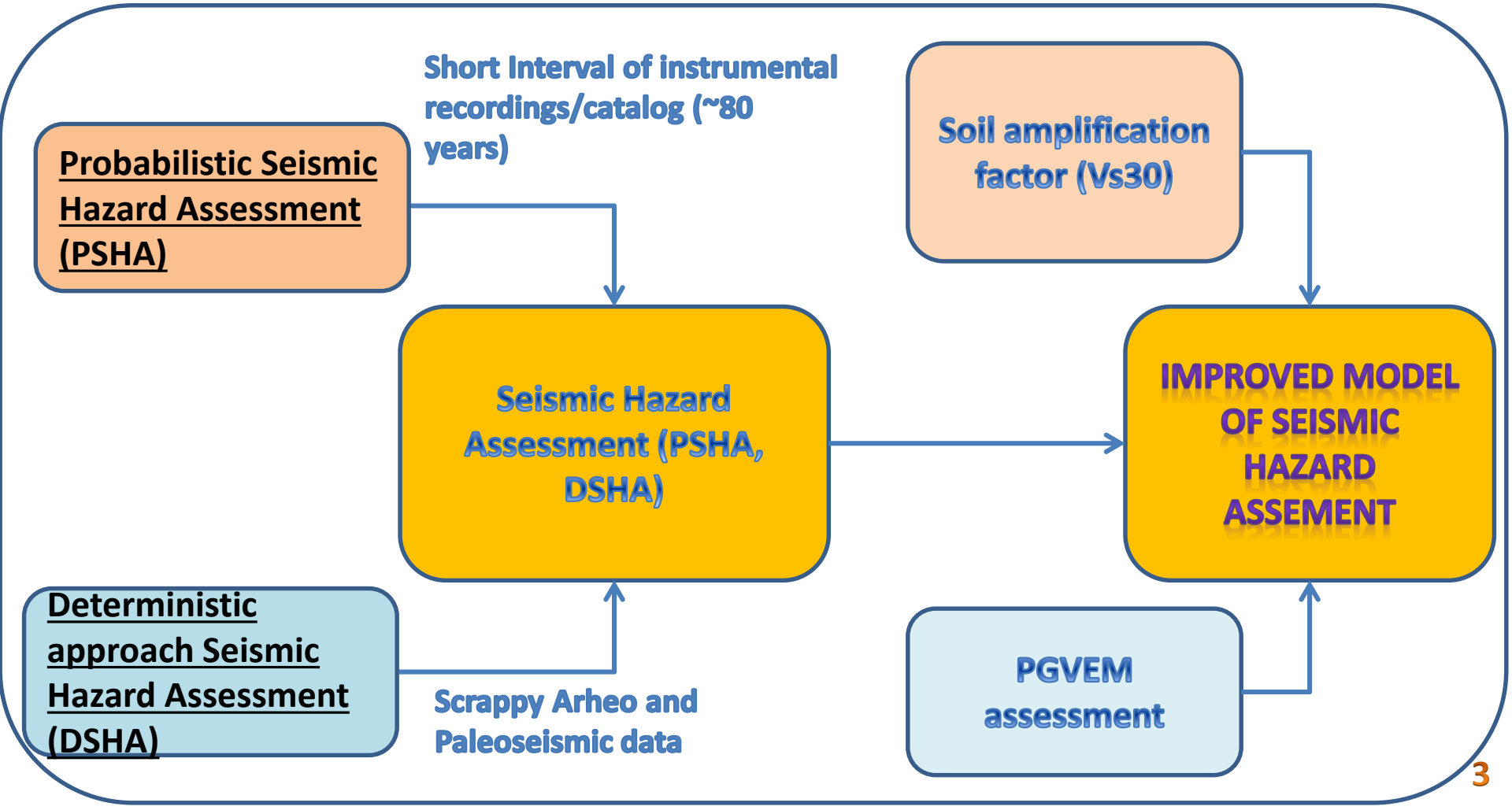
- Seismic Hazard Assessment history
- Peak Ground Velocity Estimation of Maximum mass velocity (PGVEM method)
- Estimation of shallow S-wave velocity structure

Aim of the study:

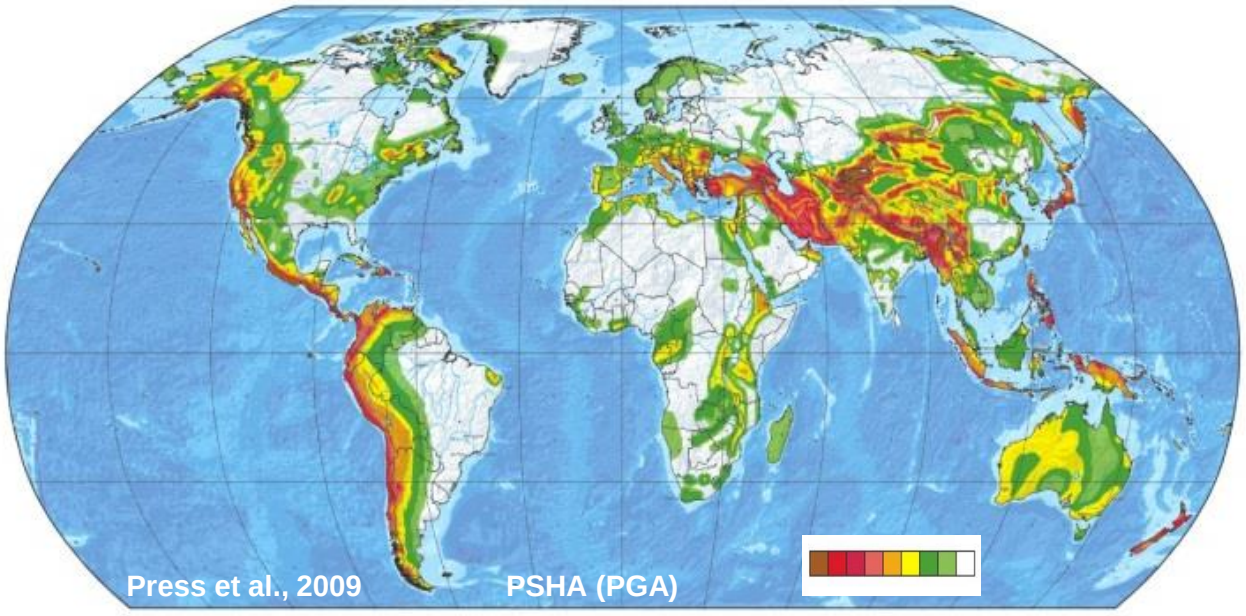
Fulfil more precise definition of seismic hazard assessment within the measurements on

(1) deformations and displacements in rock massifs (max ΔI ~ 3) and

(2) shear wave velocity on upper 30 meter ground (max ΔI ~ 1)



1. History of Seismic Hazard Assessment

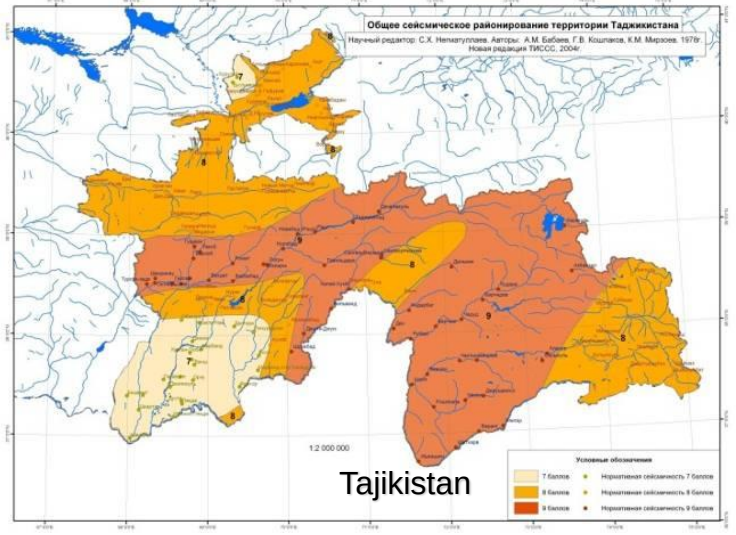


Уломов В.И., Аптикаев Ф.Ф., Гусев А.А., Медведев С.В. и др.

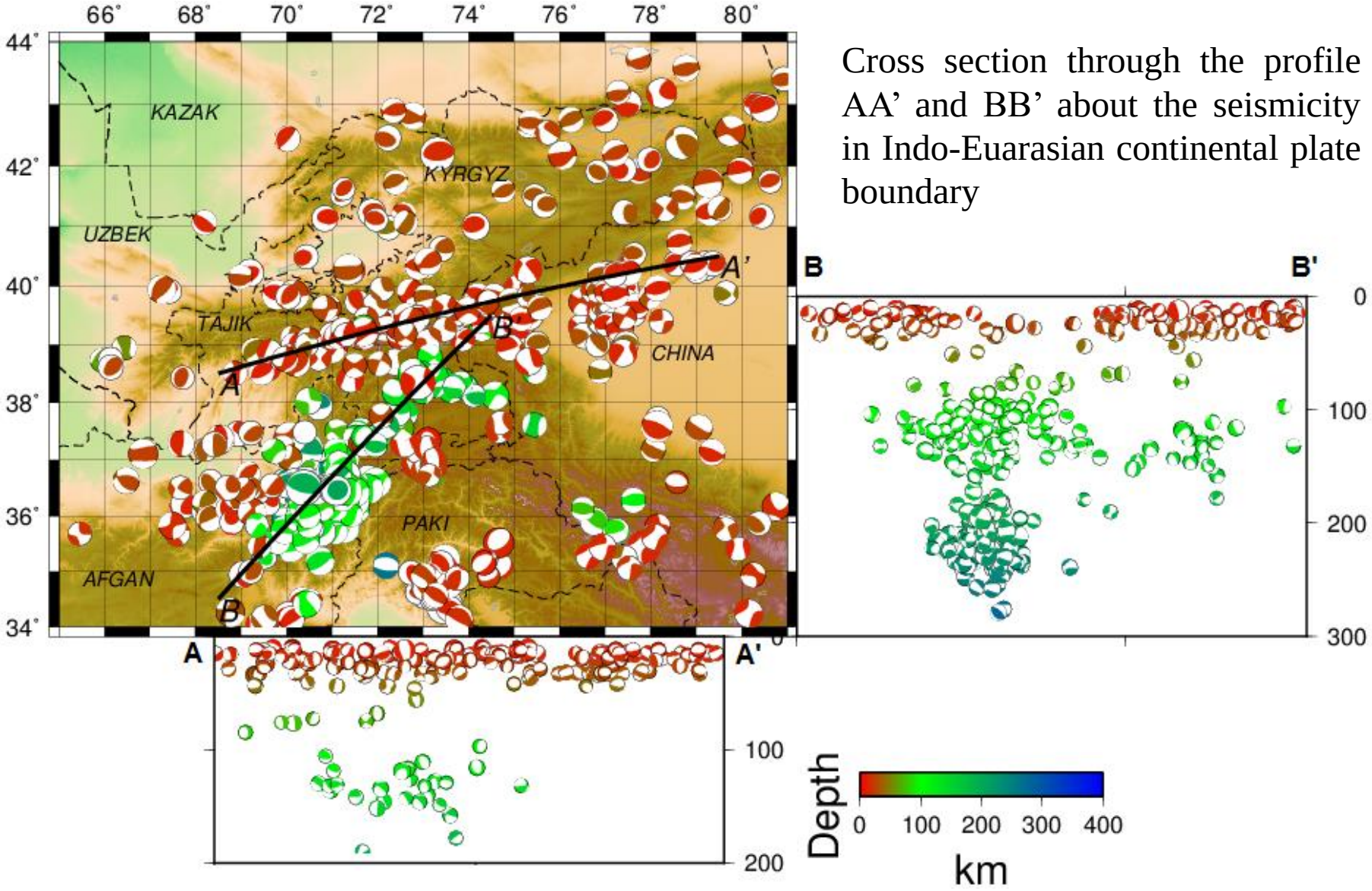
Турдукулов С., Абдрахматов К.Е., Алдажанов С.А., Ищук А.Р,

Hager B.H., Hamburger M.W., Bindi D., Molnar P.

- *Methodical disjoining results*
- *Classical use «Intensity – maximum acceleration»*
- *Transition from MSK64 to EMS98*



Seismicity of the Alai-Pamir-Hindukush region



Cross section through the profile AA' and BB' about the seismicity in Indo-Euarasian continental plate boundary

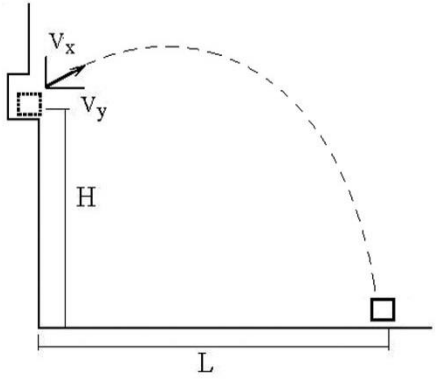
The profile AA' lies along the Alai valley

2. Peak Ground Velocity Estimation of Maximum mass velocity from macroseismic data (Rodkin et al. 2012; 2014)

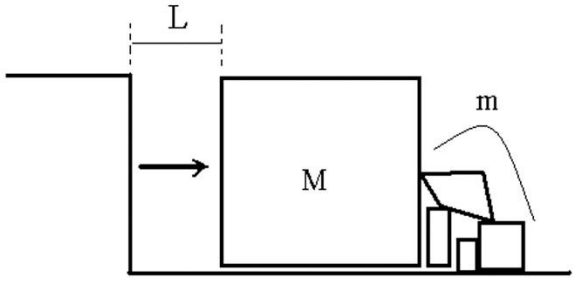
In our research we are studying places where rocks are displaced from their original location by a past earthquake. The direction and size of the displacement gives information on the respective PGV value of the past earthquake and thereby information on the hazard. The calculation of displacement usually used the Peak Ground Velocity (PGV) method and Estimation of maximum mass velocity from macroseismic data (PGVEM). Certainly, isolated instance of displacement was not accepted.

Most of the examples and models of velocity value (PGV) are usually uniformly
and extremely high - till 1-5 m/s.
Therefore, in order to justify outcomes, only accepted systematically repeated cases: «PGV + azimuth effect»,

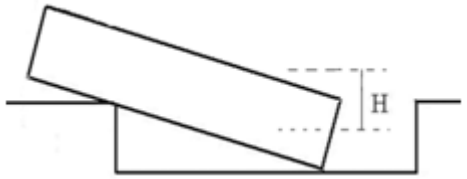
Peak ground velocity estimation method (PGVEM)



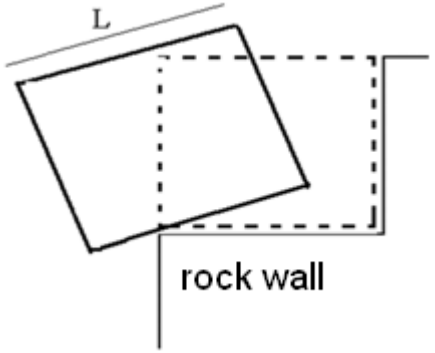
Model 1, "flying" block
$V = g H(\sqrt{(1 + (L/H)^2)} - 1)$



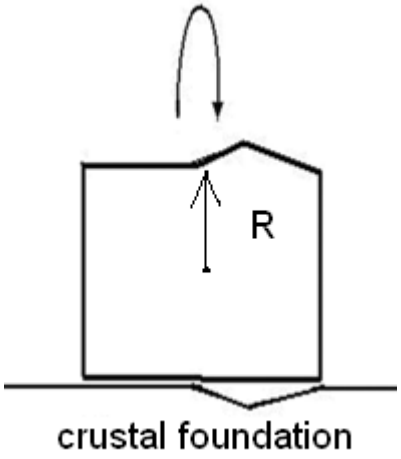
$V = \sqrt{\{(2k\ g\ L)(1 + m/M)\}}$



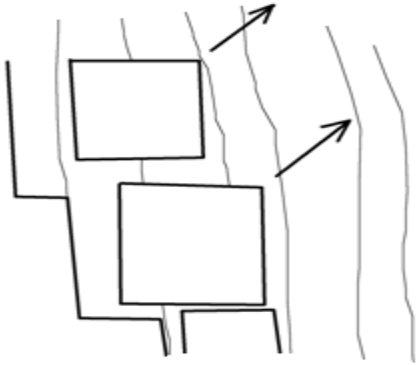
Model 4, throwing of block
$V = \sqrt{4\ g\ H}$



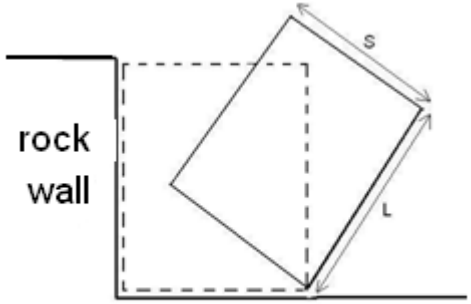
Model 6, sliding rock block V=V kgL



Model 5
Rotated rock unit
$V = \sqrt{(2R\ g)}$



Model 3, shift of rocky block sideways on a slope
$V = \sqrt{2(kg\sqrt{(H^2 + L^2)} - gH)}$



Model 7, rolling block
$V = \sqrt{g\{(S^2 + L^2)^{1/2} - L\}}$

Some of the models
depend on the coefficient of friction *k*
***"rock along rock"* - (black)**
others are independent of *k* value (red).

1. Estimation of maximum mass velocity in the Alai valley (PGVEM method)

Method of evaluation of PGVEMs from macroseismic measurements for the area of the Alai valley (fields works August 2019 performed with Dr. Mikhail Rodkin)

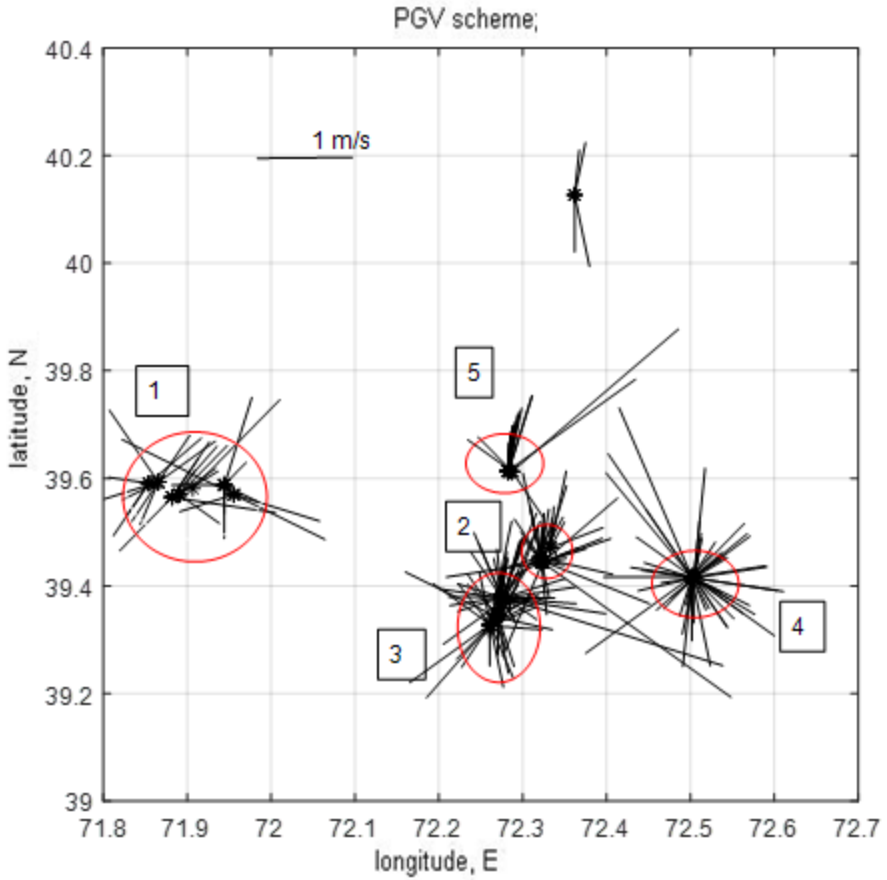
Preliminary results obtained in partial fulfilment of CATENA project

The aim is to evaluate the long-term maximum values of peak-ground velocities for the seismic hazard assessment.

Green mark – investigated area for maximum mass velocity defining

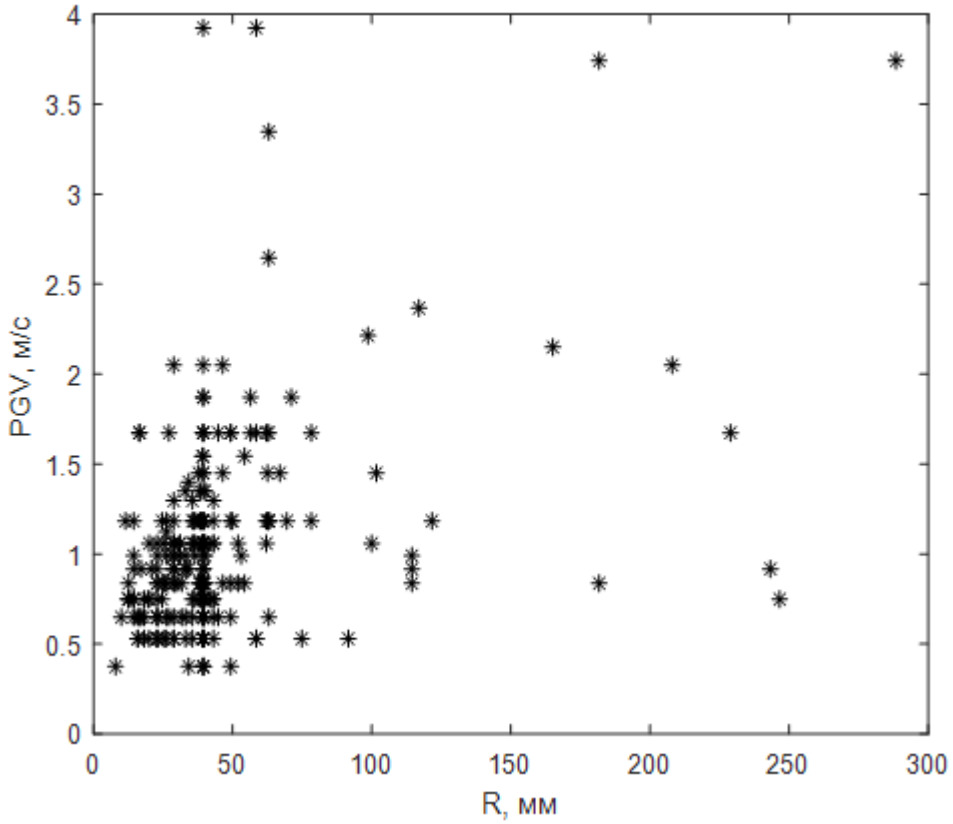
Blue points – villages, where carried out seismic measurements for Vs30

Results of examination in the Alai valley



Red – number of groups, black lines – estimated velocity (PGV)
In total about 250 cases in the study area

<u>Preliminary</u> results for the part of the examined area along the mountain ridges seismic zone (on the western part of the Alai valley)



Relationship between PGV values and the characteristic size R of displaced rock units.

Preliminary results of PGVs evaluation in Alay valley:

The PGVs estimations according to the new Aptikaev's scale appear to correspond seismic intensity I: 8.5 – 9 on the northern part of Alai valley and I: 9.0-9.5 on the southern part of the Alay valley. This value agrees with

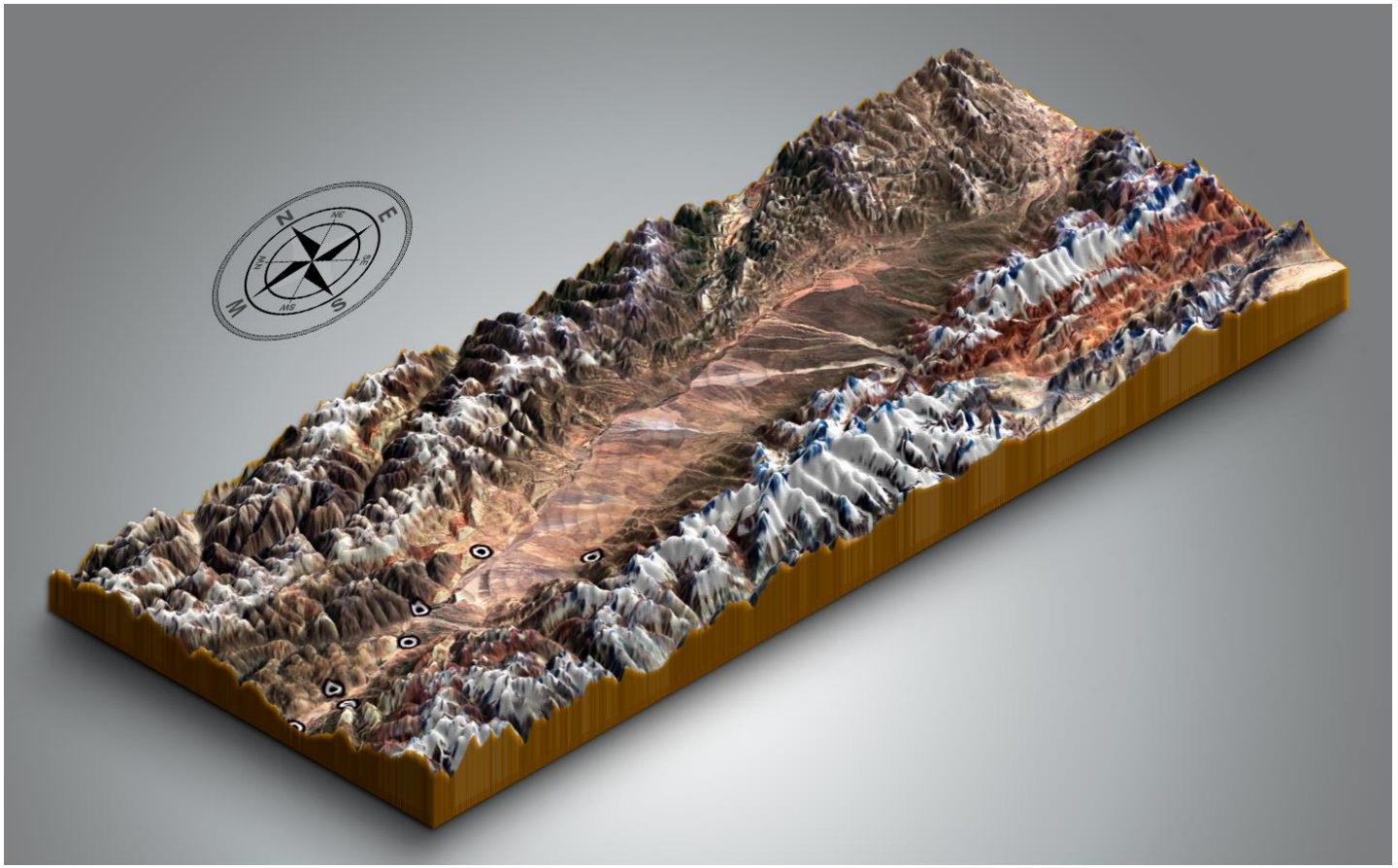
The averaged characteristics for all five groups

Number of displacements	Latitude, N	Longitude, E	Height, m	PGV, $Q_{0.5}$, cm/s	PGV, $Q_{0.8}$, cm/s
34	38.58	71.9	2770±76	90	140
38	39.45	72.32	2975±120	80	90
73	39.35	72.27	3076±70	90	130
53	39.42	72.50	3450±29	100	130
33	39.61	72.28	2910±23	80	105

Values of velocities, accelerations and final displacements of the ground at different seismic intensity I (points) (EMS-98)

I	5	5.5	6.0	6.5	7.0	7.7	8.0	8.5	9.0	9.5
PGV, см/с	1.3	2.2	3.8	6.5	11	19	33	57	98	170
PGA, $см/с^2$	17.5	28	44	70	110	175	280	440	700	1100
PGD, см	1.4	3.0	6.6	14	32	70	150	330	720	1600

3. Estimation of shallow S-wave velocity structure



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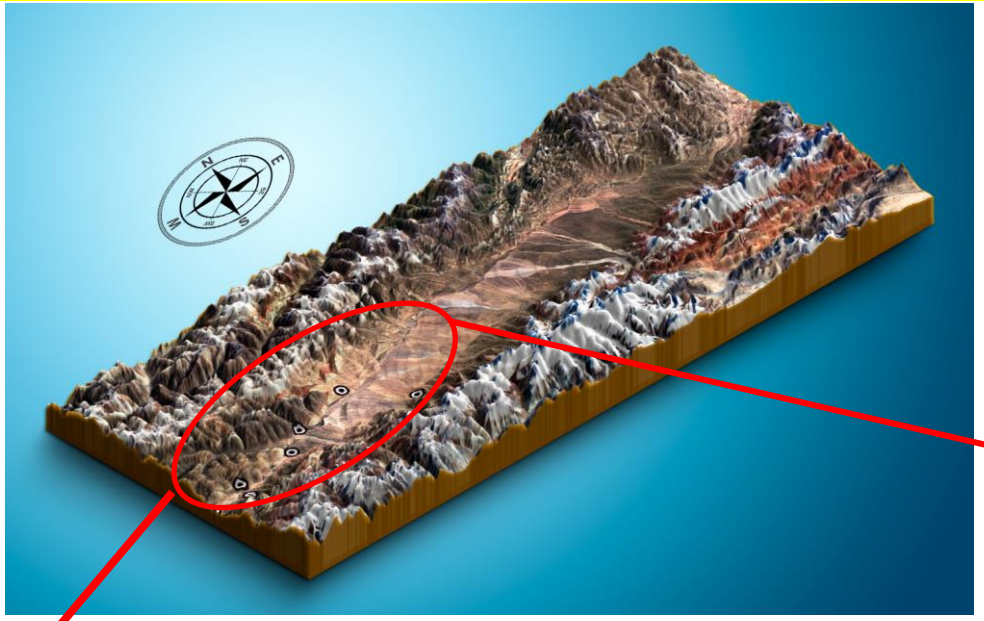


Background: Purpose of the study

- To estimate the Vs structure in the villages of Alay valley using Spatial Auto-Correlation (SPAC) method and microtremor records from the circular deployed arrays.
- This method can be used for seismic microzonation study in Kyrgyz Republic to mitigate earthquake disaster in urban areas in future.

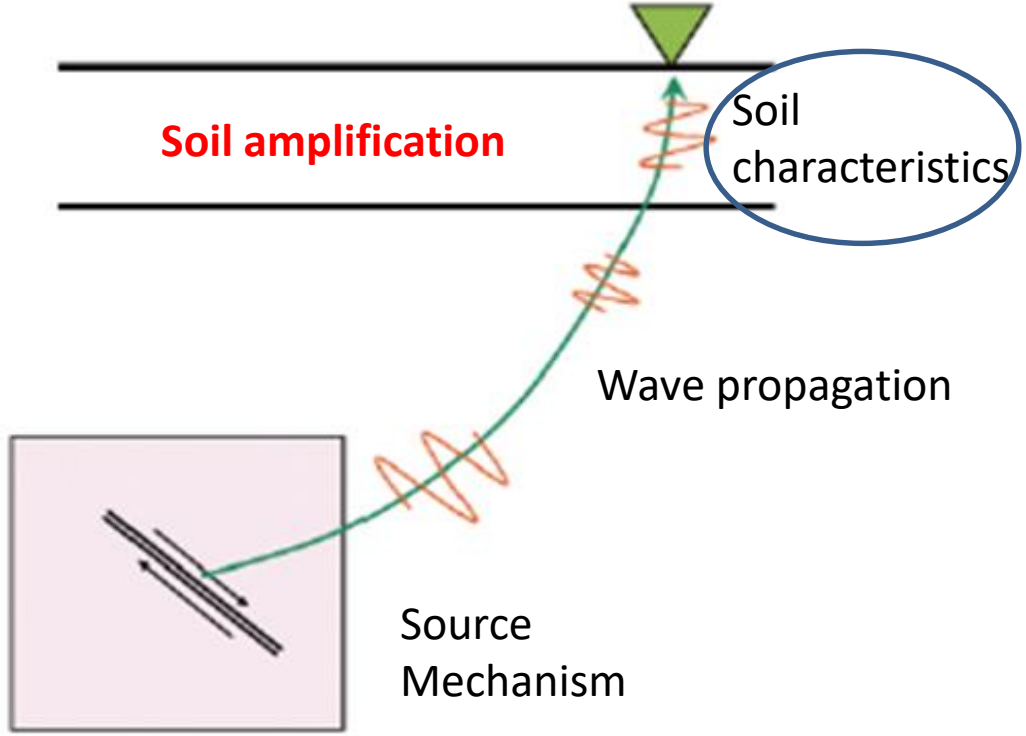
Main villages which was caused by past earthquakes

3. Estimation of shallow S-wave velocity structure

Shear wave velocity is an important parameter for hazard assessment

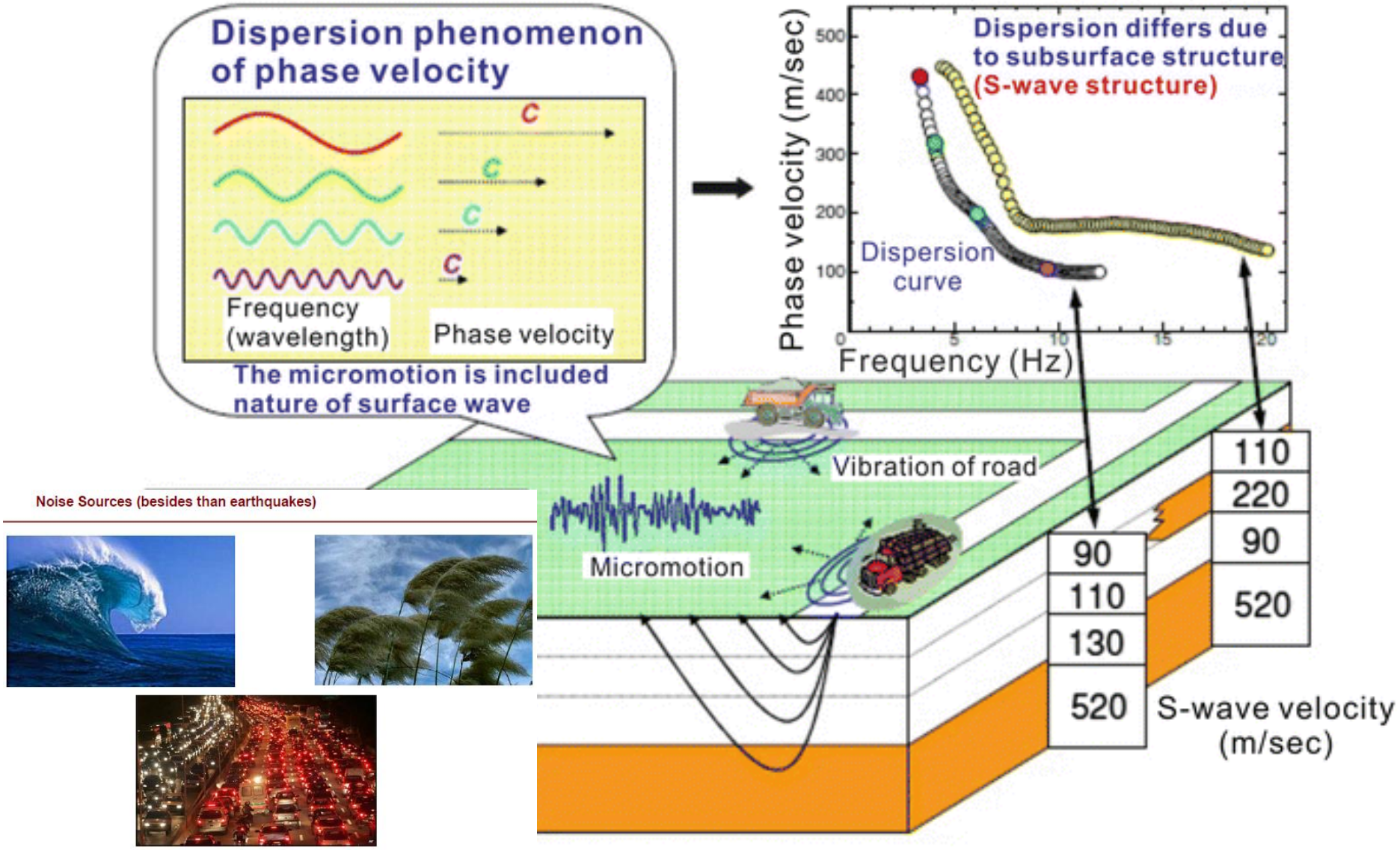
Seismic wave propagation = **Source x propagation** (PGVEM) x **Soil amplification** (Vs30)

Example of seismic recordings

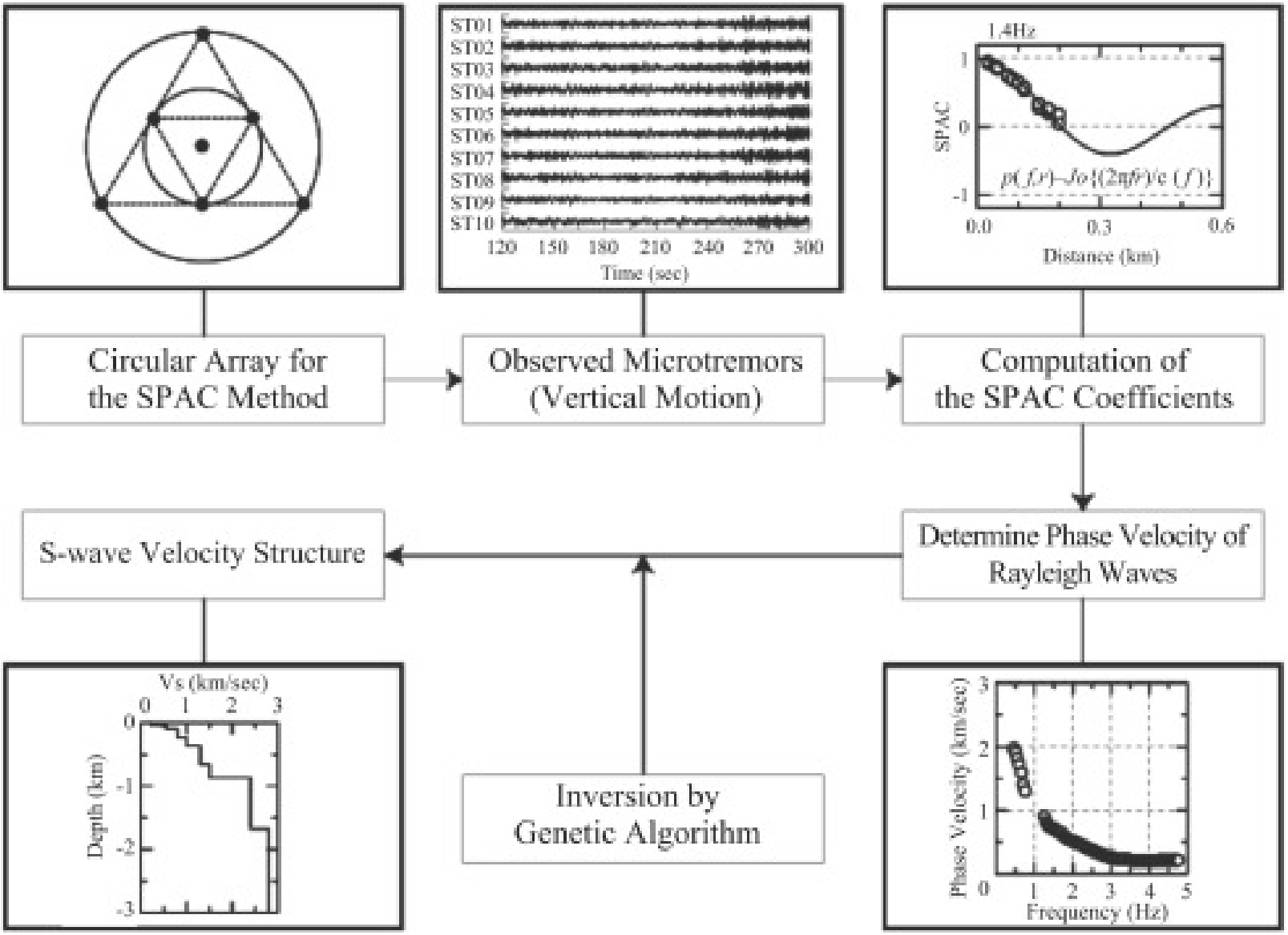


The worse situation in the villages during the earthquake is collapsing a houses, which are usually located on the mellow soil.

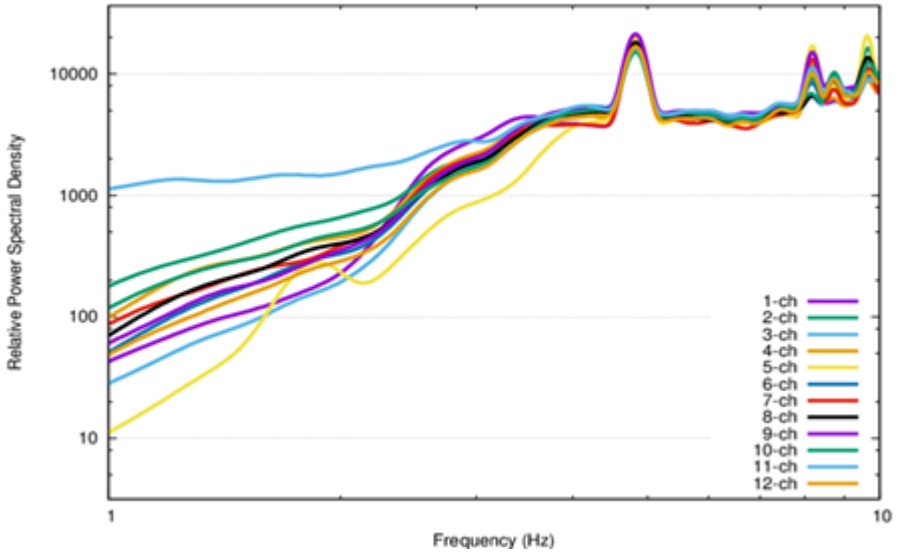
Seismic noise (microtremor) study

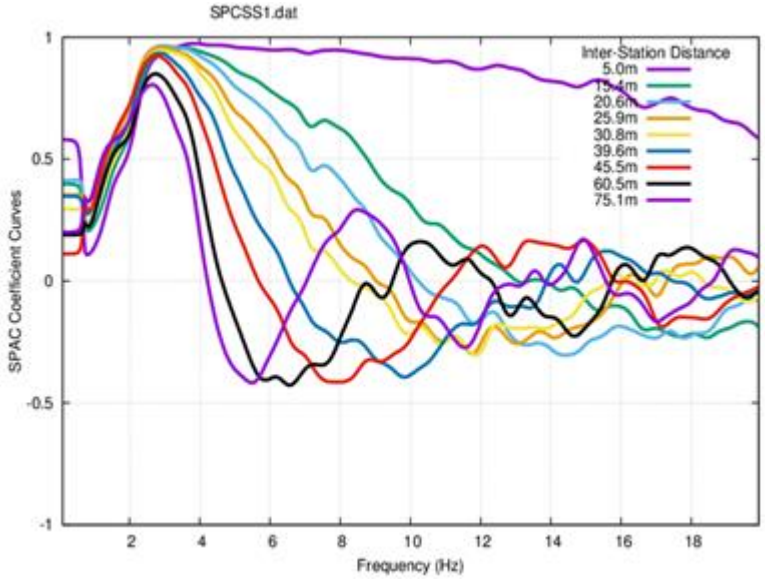


Estimation of shallow S-wave velocity structure

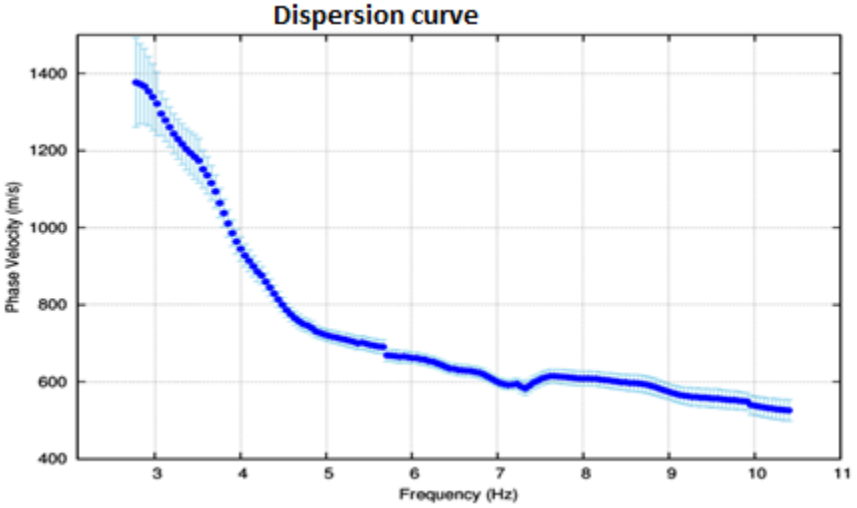


Analysis: SPAC in village Kabyk



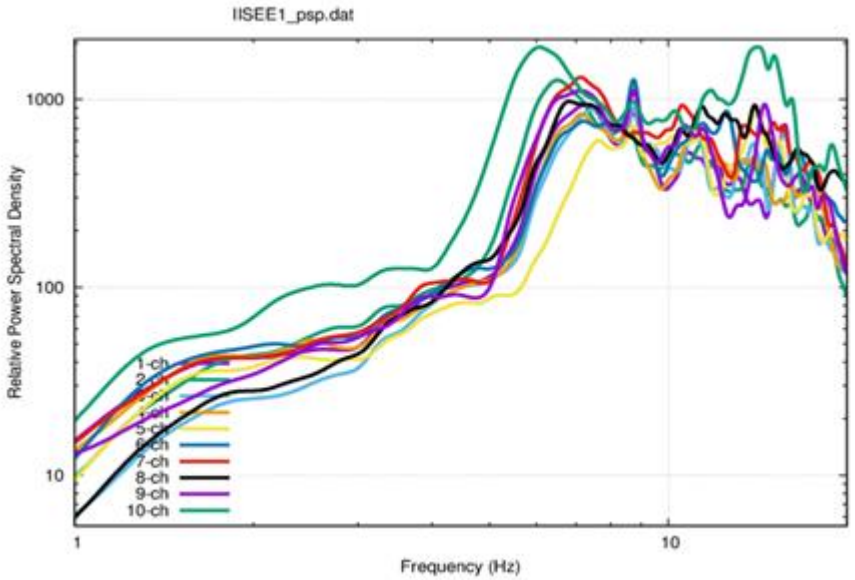


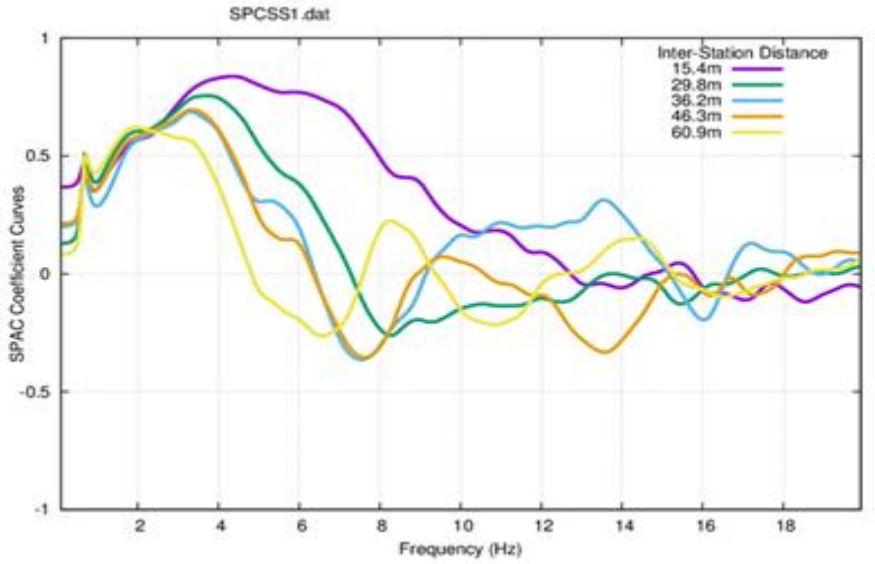
For station pairs of long distance, such as 75.1m, the curves of SPAC coefficients have its maximum value in lower frequencies than those for pairs of short distances.



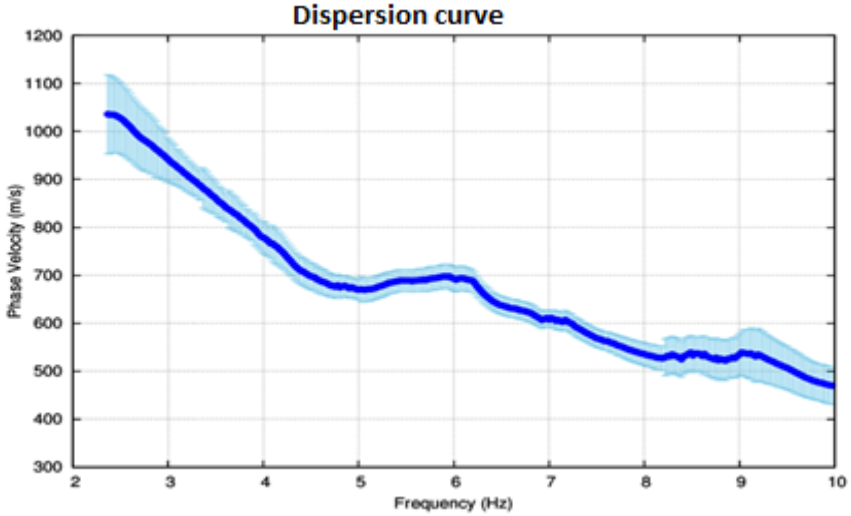
Determined dispersion curve. Phase velocity variation is 500-1400 m/s

Analysis: SPAC in a village Achyk-Suu



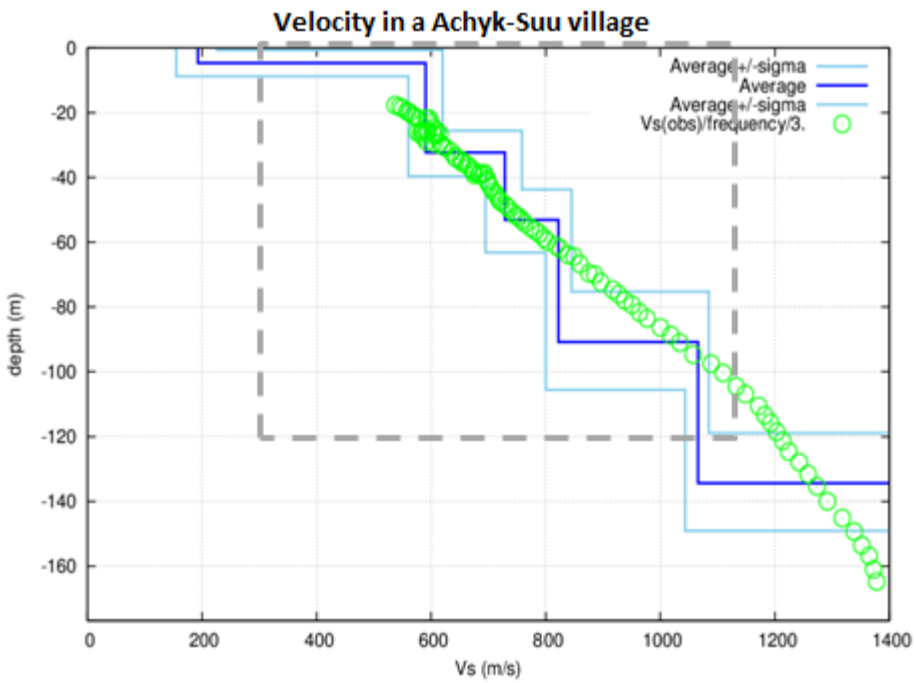


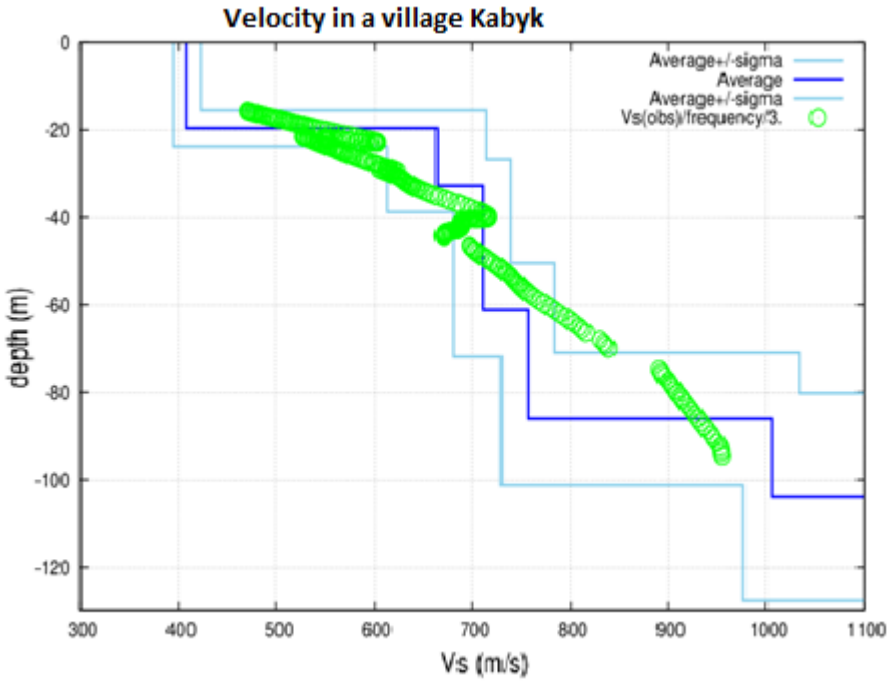
For station pairs of long distance, such as 60.9m, the curves of SPAC coefficients have its maximum value in lower frequencies than those for pairs of short distances.



Determined dispersion curve. Phase velocity variation is 450-1050 m/s

Results and Discussion: Vs30 calculated for Kabyk and Achyk-Suu sites are 550 m/s and 470 m/s respectively, and soil type classified as C (NEHRP)





Vs structure inverted from observed dispersion curve for Kabyk and Achyk-Suu.
(Rectangular of broken lines in the left panel shows the same Vs and depth range as the right panel)

Changes in the Vs30 of the shear wave velocity have been identified throughout the place (south and north).

The southern villages Achyk-Suu, Shibe and Zhar-Bashy identified Vs30=470-480 m/s, other northern villages Karamyk, Zhekendi, Daroot-Korgon and Kabyk identified Vs30=510-560 m/s. The reason behind these variations might be geographical slope and geomorphological terrace of the villages. Our next research will be to find a proxy between Vs30, slope and geomorphological terrace.

Estimated shallow S-wave velocity structure (Vs30)

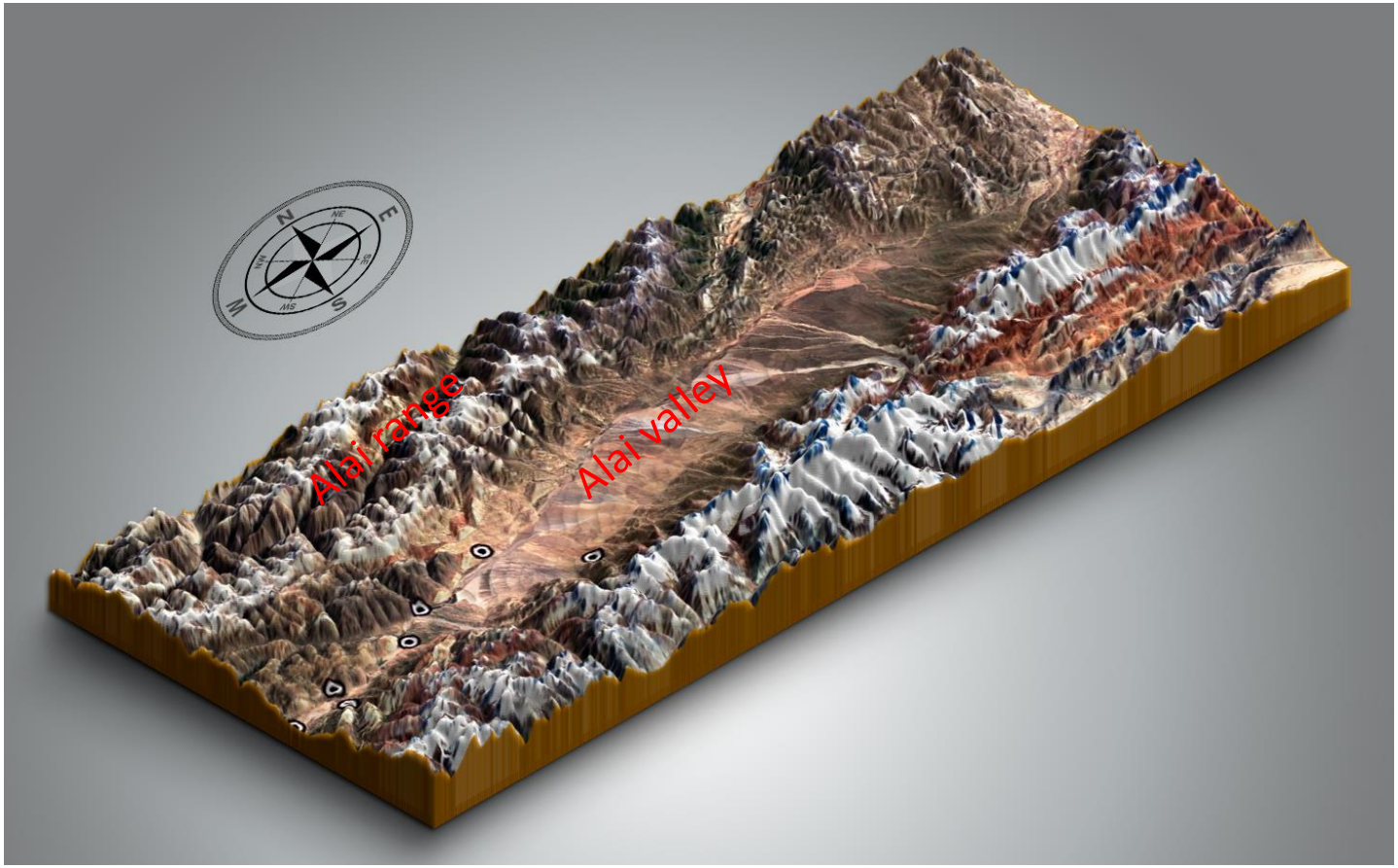
Locality	Recording duration, hour	Local Soil stratigraphy	Average shear wave velocity, Vs30, m/s	Vs30, m/c
Karamyk	2	Macrofragmental soil of all types with aggregate content of more than 30%.	270≤ Vs30<550	510
Zhekendi	1,5	Rocky soils are weathered with a shallow (up to 5 m) cover of loose sediments.	550≤Vs30< 800	560
Shibe	1,5	Coarse and medium gravelly sands, dense, regardless of the degree of water saturation.	270≤ Vs30<550	470
Zhar-Bashy	2	Coarse and medium gravelly sands, dense, regardless of the degree of water saturation.	270≤ Vs30<550	480
Daroot-Korgon	2	Macrofragmental soil of all types with aggregate content of more than 30%.	270≤ Vs30<550	540
Kabyk	1,5	Rocky soils are weathered with a shallow (up to 5 m) cover of loose sediments.	550≤Vs30< 800	550
Achyk-Suu	1,5	Macrofragmental soil of all types with aggregate content of more than 30%.	270≤ Vs30<550	470

Soil Types	Rock/ Soil Description	Average shear wave velocity (V_{S30}) m/s
A	Hard rock	> 1500
B	Rock	760-1500
C	Dense soil/soft rock	360-760
D	Stiff soil	180-360
E	Soft soil	<180
F	Special soils requiring special evaluation	

NEHRP Soil Types based on shear wave velocity of upper 30 m.

Preliminary results of shallow S-wave velocity (Vs30) in Alay valley

Concluding the study and analyzing calculated Vs30, we might argue high amplification on the villages of southern part of the Alay valley than the villages located northern part. Certainly, these results only for soil amplification.



Thank you very much for the Attention