Water resources response on glacier dynamics in Central Asia transboundary river basins

Tamara Tuzova

Head research officer

Institute of Water Problems and Hydro Power

National Academy of Sciences of the Kyrgyz Republic, Bishkek

Tv_tuzova@mail.ru

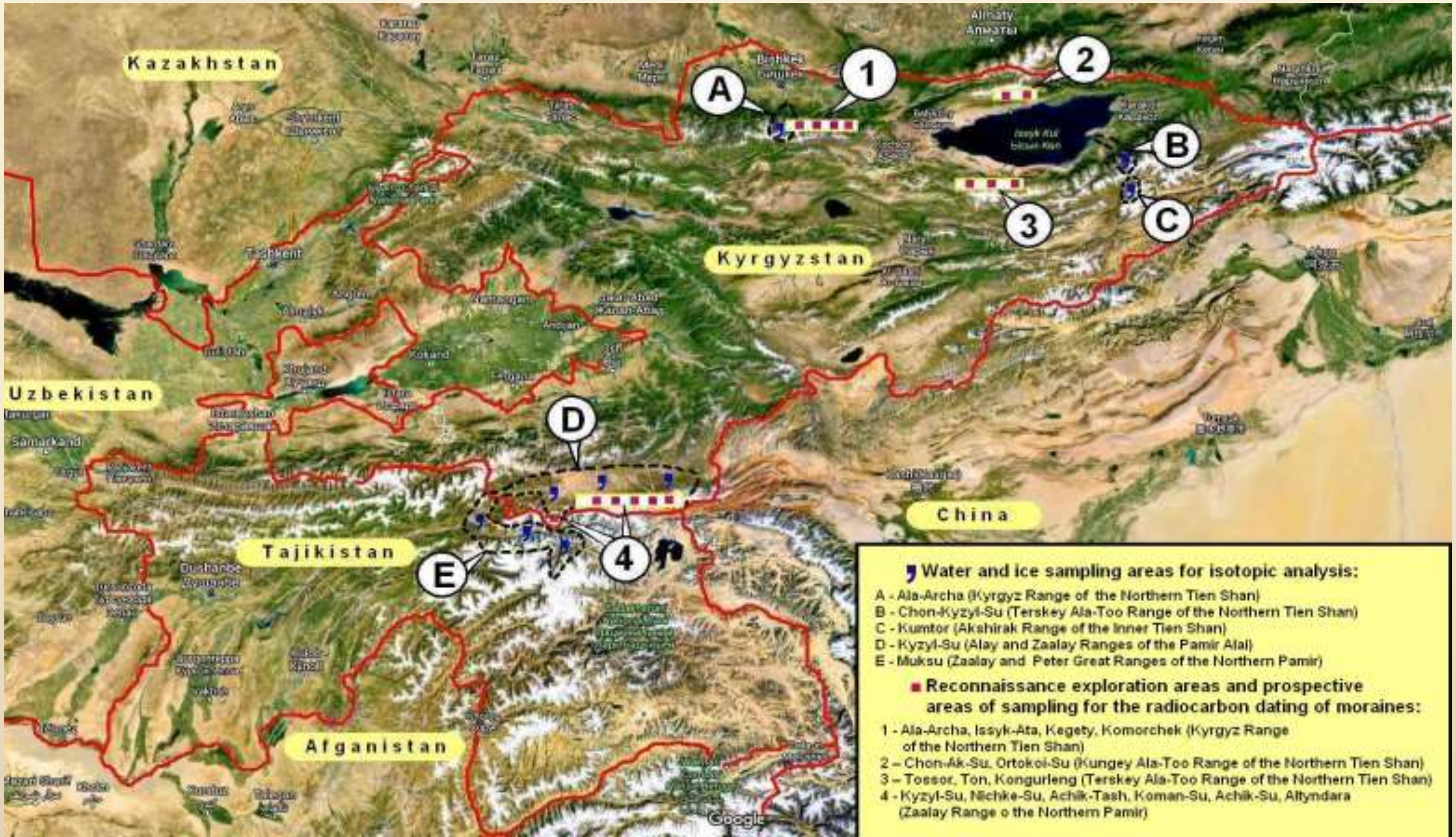
Tel. +996 312 323 728; +996 555-44-09-10

Central Asia PEER Forum

December 3-5, 2018, Almaty, Kazakhstan

Project objectives:
Develop a robust basis for long-term glaciation and climate modeling in Central Asia. Study patterns of Holocene deglaciation in Central Asia and its impact on water resource generation in understudied mountain river basins in the context of climate change using data fromthe Tien Shan and Pamir regions.

Target region:

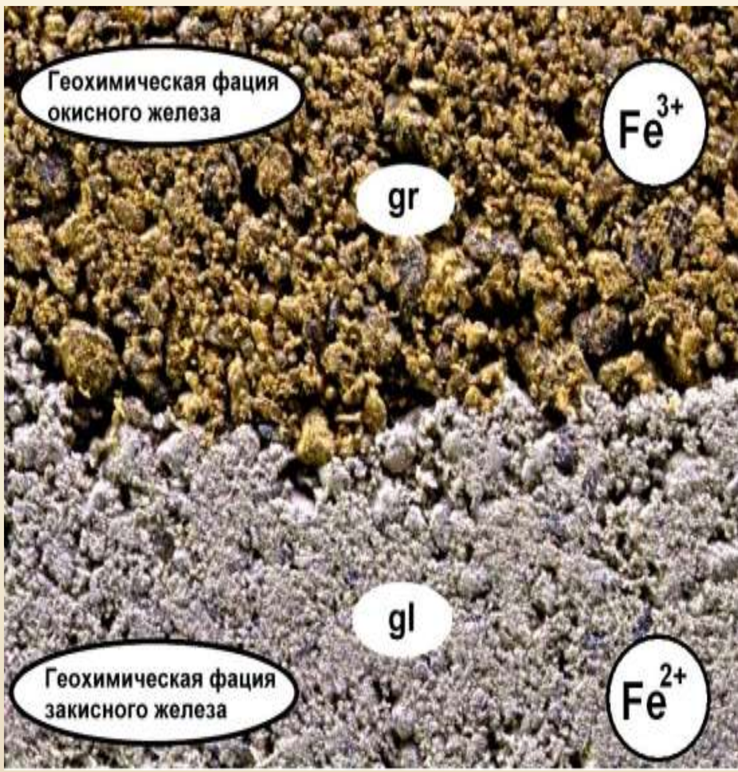


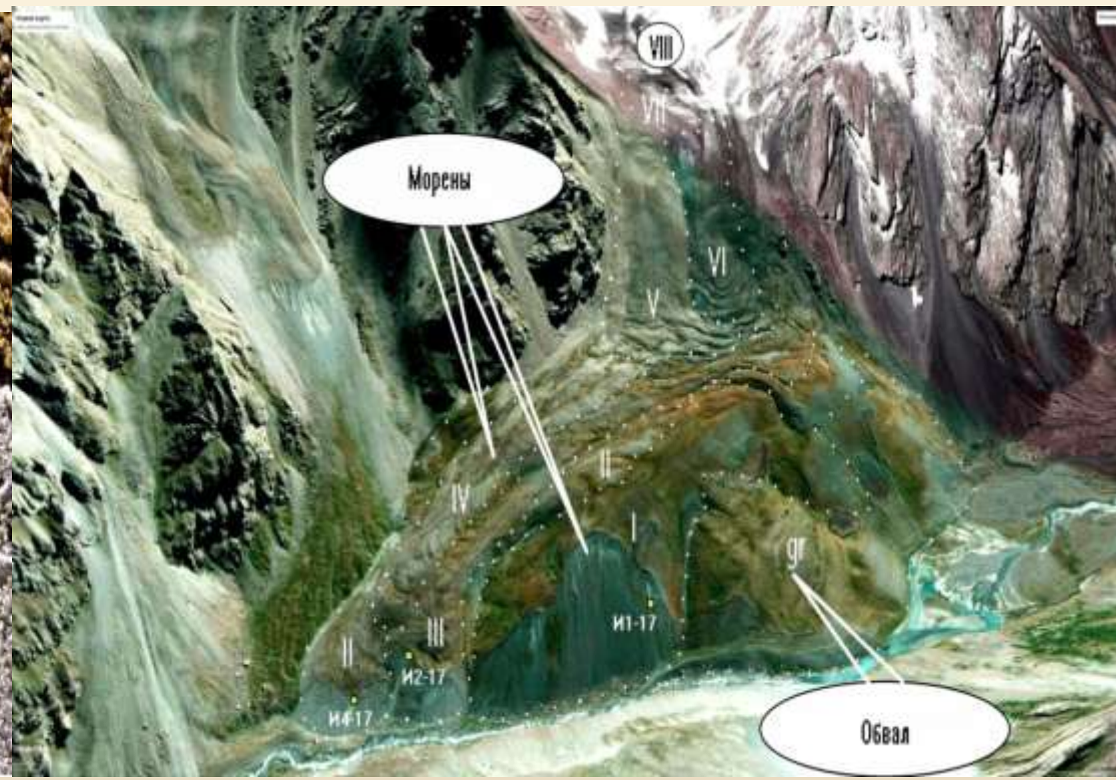
Key project tasks:

1. Confirm the earlier established pattern of Holocene and Pleistocene deglaciation in Central Asia;
2. Improve the radiocarbon dating method that uses autochthonous organic matter dispersed in moraine deposits and obtain radiocarbon data for all stages of Holocene glaciation;
3. Carry out radiocarbon dating and uranium isotope tests on stadial moraine and glacier deposits of the Holocene time;
4. Detail the earlier proposed long-term forecast model of natural glacial changes;
5. Identify genetic types of water in the source areas of understudied river basins in the Kyrgyz Republic and Tajikistan based on uranium isotope data and estimate the contributions of glacier melt, surface runoff and groundwater;
6. Calculate the percentage of the main genetic streamflow components in the source areas of target river basins;
7. Provide a predictive radioecological assessment of ice and water resources in the Kyrgyz Republic;
8. Organize and hold international workshops and trainings on the use of isotope methods in applied geology, hydrology and ecology for young professionals; and
9. Prepare research papers to draw attention of the academic world to our research with the aim of joining international efforts in long-term forecasting of climate, glacial and streamflow changes.

Work completed under the glacial subproject:

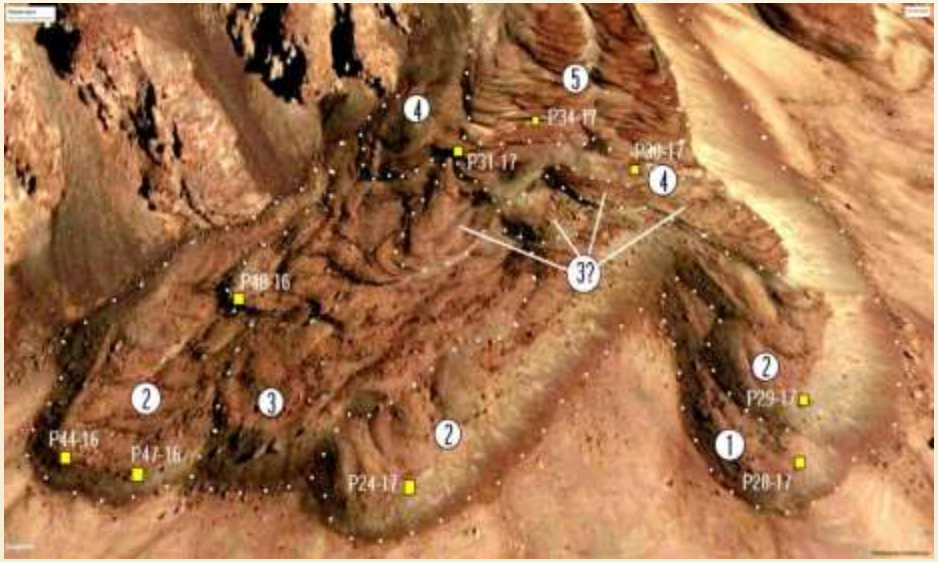
A method of *distinguishing true moraines from pseudo-moraines based on geochemical and grain size (granulometric) data* (*ferric/ferrous oxide factor* is 0.03-0.07 for true moraines and 0.3-1.0 for pseudo-moraines; *shalinessfactor* is 0.08-0.11 for true moraines and 0.16 for pseudo-moraines) was proposed. These difference were identified on satellite images of glaciers and through direct observations.

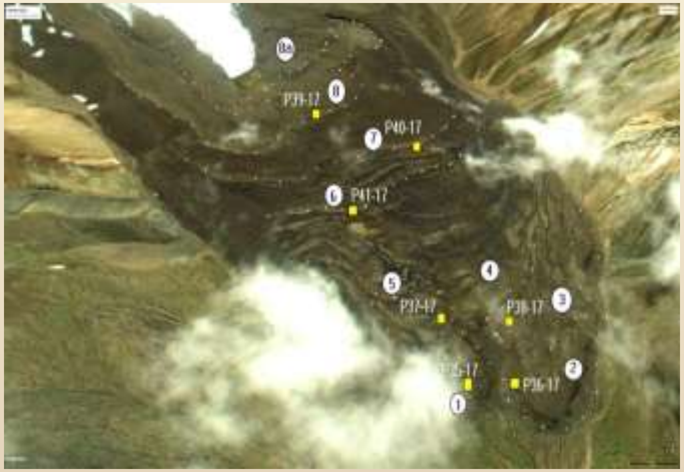




2. Deglaciation in the Tien Shan region was demonstrated to be a staged process:

And at the Pamir





3. Eight stages of Holocene deglaciation were identified in Central Asia; the last stage consists of three time spans: 200, 500 and 1500 years.

4. Methods of extracting organic matter from moraine deposits were proposed: excavating pits in the target moraine down to the buried ice, sampling ice with fine soils and organic matter, and extracting organic matter from the ice.

5. Hundreds of unique organic matter specimens were collected **from moraine deposits, including juniper seeds and their fragments, organic detritus, mollusk shells and turf.**

6. **The method of sample preparation for radiocarbon dating of extracted organic matter was optimized. (https://scorcher.ru/glaciology/c_dating.php)**

AMS-based radiocarbon tests were carried out in three independent laboratories. Weizmann Institute of Science, Israel; Institute of Nuclear Research Hungarian Academy of Sciences; AMS/Radiocarbon Dating Institute of EZ Archäometrie, Gemany

Lab#	Field ID	**Type**	C%	pMC ± pMC	14C age ±1σ year BP	Calibrated range ±1σ	Calibrated range ±2σ	Exp. Age , ky
RTD 8957	49-16	Seed	35.7		11515±42	13410 (68.2%) 13310BP	13450 (95.4%) 13275BP	1-10
RTD 8954	35b-16	Seed	38.5		**8846±69**	8200 (20.7%) 8110BC 8090 (11.2%) 8040BC 8010 (36.3%) 7830BC	8230 (95.4%) 7740BC	1-10
RTD 8956	42-16	Seed	36.6		**8760±35**	7940 (4.2%) 7925BC 7920 (7.3%) 7900BC 7870 (56.6%) 7730BC	7955 (95.4%) 7655BC	1-10
RTD 8959	62-16	Seed	35.6		**1377±27**	640 (68.2%) 670AD	610 (95.4%) 680AD	1-10
RTD 8952	39-16	Seed	40.9		**1285±22**	680 (40.4%) 7154AD 745 (27.8%) 765AD	670 (59.5%) 730AD 735 (35.9%) 770AD	1-10
RTD 8950	57-16	Seed	41.8		**305±33**	1520 (50.9%) 1592AD 1620 (17.3%) 1645AD	1480 (95.4%) 1655AD	1-10
RTD 8951	52-16	Plant	40.9		**8140±47**	7180 (68.2%) 7065BC	7305 (17.3%) 7210BC 7200 (78.1%) 7050BC	1-10
RTD 8953	46a-16	Plant	42.7		**327±21**	1515 (11.1%) 1530AD 1540 (43.8%) 1600AD 1620 (13.3%) 1635AD	1490 (75.7%) 1605AD 1610 (19.7%) 1640AD	1-10
RTD 8962	64b-16	Plant	25.7	**123.51±.29**		[AD 1959- 1961] 0.433 [AD 1982- 1983] 0.567	[AD 1959- 1961]0.465 [AD 1982- 1984]0.535	1-10
RTD 8955	53-16	Plant	45.7	**102.69±.41**		Calibration gives 1955-56. However, as the curve is only till 2009, such values can also be post 2009.		1-10
RTD 8958	56-16	Plant	34.4	**102.21±.27**		Calibration gives 1955-56. However, as the curve is only till 2009, such values can also be post 2009.		1-10
RTD 8960	65a-16	Shell	8.2		**12252±64**	14265 (68.2%) 14045BP	14540 (95.4%) 13960BP	30-40
RTD 8961	P43-16	Sediment	.04			Very low concentration of carbon		1.

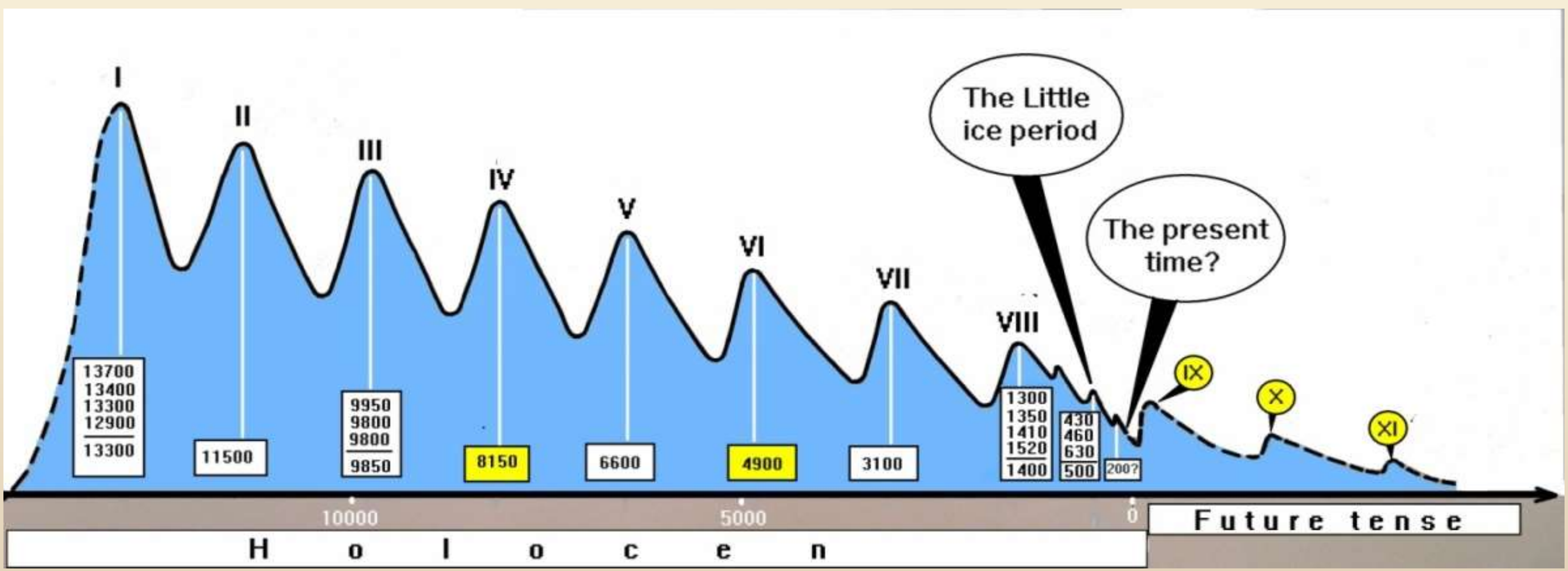
7. An 8-stage model of glacial changes in the Holocene time with a 1700-year interval between glacial maxima was developed based on multiple radiocarbon dates.

The model demonstrates the cyclic nature of glacial and climatic changes in the Holocene time and provides a forecast for the future.

The last glacial maximum was 1400-1500 years ago.

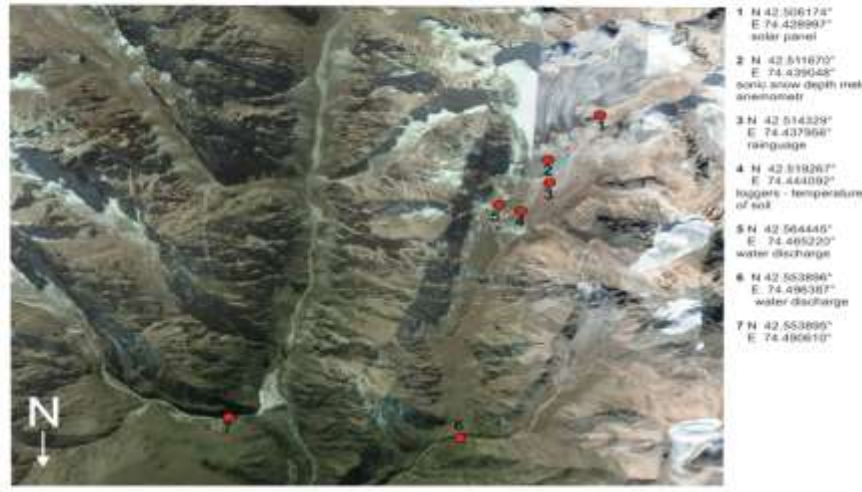
The next glacial maximum should be expected in about **300** years, while the **modern warming period is expected to end (and a new cooling period to begin) a little earlier, perhaps, in 100-200 years**.

The model needs to be updated though further research in other regions.



Uranium isotope subproject summary:

1. Recommendations on sampling of waters with ultralow uranium concentrations (rainfall, glacial melt and periglacial waters in mountain river basins), uranium adsorption from such water samples, radiochemical removal of other radionuclides, and uranium isotope measurements were proposed.



Осаждение урана из вод на активированном угле

Осаждение урана на гидроксиде железа в полевых условиях

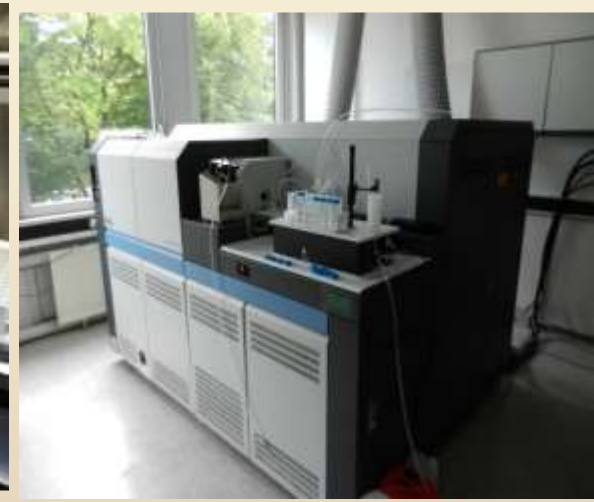
2. Two independent methods of measuring the $^{234}U/^{238}U$ ratio were recommended: high-resolution alpha spectrometry and inductively coupled plasma mass spectrometry.
The two methods showed good repeatability of measurement results.

After uranium extraction from water in the field or laboratory, the majority ofsamples were analyzed by alpha spectrometry.

Both methods are expensive and labor-intensive, so currently they are not used on low radioactivity samples in both Kyrgyzstan and Tajikistan.

An isotope laboratory is highly needed to use isotope methods in applied hydrology and geophysics. However, building such a laboratory will require significant financial investment and high-level staff training in radiochemistry and laboratory equipment maint

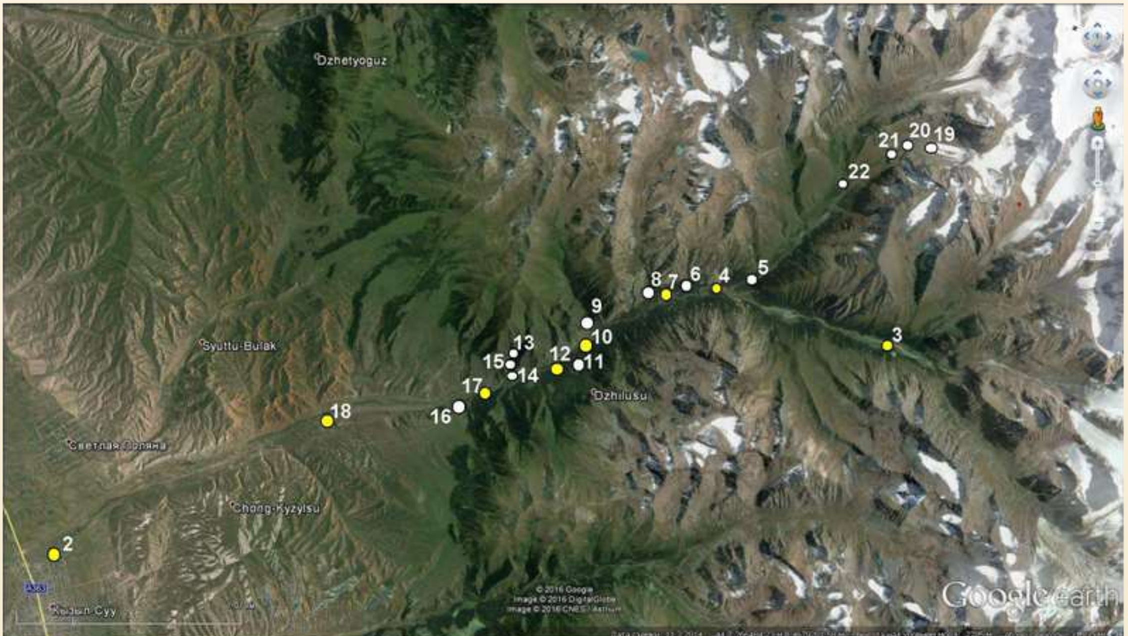




3. Uranium isotopic analysis was carried out on several hundreds of water and ice samples from the source areas of transboundary rivers in the Tien Shan (Kyzysu, Kumtor, Issyk-Ata, Alamedin, Ala-Archa, Naryn and Kara-Darya) and Pamir (Kyzyl-Suu, Muksu, Vakhsh, Gunt and Panj) regions.

- Glacial and rainfall waters returned ultralow (**below 0.5×10^{-6} g/t**) uranium concentrations with an equilibrium ratio of **$^{234}U/^{238}U=1.05\pm0.05$** (in units of radioactivity).
- Samples collected in high-water periods during the project (2015-2018) were compared with the historical samples (1988-2014). The analysis showed how uranium concentrations and $^{234}U/^{238}U$ ratios have changed over time in each water source.

North Tien Shan uranium isotope water sampling model



Бассейна р.Ала-Арча

Верховьев р.Кумтор

Uranium isotope data forChon-Kyzylsuperiglacial waters

Sample ID - year	Sample location	Coordinates	Elevation, m	$^{234}U/^{238}U$	$C_U.10^{-6}$ g/l
Кap1-15	Young ice from the Karabatkak glacier	N42°09’14.82 E78°16’08.95	3500	1.00±0.04	0.17±0.04
Кap2-15	Old ice from the Karabatkak glacier	N42°09’22.50 E78°16’10.55	3385	1.05±0.05	0.32±0.05
KZS19-16	Ice from the surface of the Karabatkak glacier	N42°09’14.8 E78°16’08.95	3387	1.29±0.17	0.14±0.04
KZS20-16	KarabatkakLake	N42°09’32.50 E78°16’13.55	3383	0.84±0.07	0.40±0.06
KZS6-16	Stream from the Ailama glacier	N42°11’58” E78°11’48”	2610	0.99±0.09	0.20±0.03
KZS21-16	Kashkator River,upstream the AilamaRiver	N42°14’10.4 E78°14’15.30	2942	1.00±0.08	0.36±0.06
KZS3-16	Chon-Kyzylsu River,upstream the Kashkator River	N42°11’04 E78°12’30	2600	1.17±0.17	0.43±0.14
Weighted average				1.03±0.03	0.2±0.1

Uranium content of waters in the source area of the Chon-Kyzylsu River

Sample ID – year	Sample location	Coordinates	Elevation, m	$^{234}U/^{238}U$
Kap4-15	Spring from under the Kashkator glacier	N42°10'17.39 E78°15'00.39	2980	0.92±0.08
Kap5-15	Kashkatov River, glacier tongue	N42°10'15.39 E78°15'00.03	2962	1.00±0.05
KZS5-16	Kashkator River mouth	N42°14'10.43 E78°14'15.30	2942	1.09±0.03
KZS22-16	Ailama River mouth	N42°10'17.39 E78°15'00.39	2940	1.07±0.05
KZS3-16	Chon-Kyzylsu River, upstream the Kashkator River	N42°11'04 E78°12'30	2600	1.17±0.17
KZS4-16	Chon-Kyzylsu River, downstream the Kashkator River	N42°11'37" E78°12'04"	2580	1.10±0.03
KZS7-16	Chon-Kyzylsu River, downstream its first tributary	N42°12'24" E78°11'24"	2490	1.10±0.04
KZS-16-16	Left tributary, downstream thermal water sources	N42°11'37" E78°12'04"	2380	1.06±0.13

4. Three genetic types of water were identified in each river basin based on the uranium isotope data:

Precipitation and glacial melt waters with $^{234}U/^{238}U$= 1.00±0.05 (equilibrium ratio) and ultra-low, though measurable (by both methods) uranium concentrations (below 0.1-0.3 ppb);

Deep ground waters in rocks (fault zones), with the highest deviation from the $^{234}U/^{238}U$ equilibrium (up to 200%) and low uranium concentrations primarily due to the leaching of ^{234}U (a more mobile daughter isotope) from rocks;

Ground waters of active water exchange zones in near-surface clastic/poorly consolidated rocks, with higher uranium concentrations and a relatively small deviation from the equilibrium of even isotopes primarily due to uranium dissolution in water-bearing rocks.

5. A **method of calculating the contributions of these 3 genetic water types** to transboundary rivers in CA and building illustrative uranium isotope based genetic water profiles was proposed for each river basin was proposed.

$$V_1 + V_2 + V_3 = 1$$

$$C_1 + C_2 + C_3 = C$$

$$\gamma_1 C_1 + \gamma_2 C_2 + \gamma_3 C_3 = \gamma C$$

$$V_1 = \frac{\gamma C(C_3 - C_2) + \gamma_2 C_2 (C - C_3) + \gamma_3 C_3 (C_2 - C)}{\gamma_1 C_1 (C_3 - C_2) + \gamma_2 C_2 (C_1 - C_3) + \gamma_3 C_3 (C_2 - C_1)}$$

$$V_2 = \frac{\gamma C(C_1 - C_3) + \gamma_3 C_3 (C - C_1) + \gamma_1 C_1 (C_3 - C)}{\gamma_1 C_1 (C_3 - C_2) + \gamma_2 C_2 (C_1 - C_3) + \gamma_3 C_3 (C_2 - C_1)}$$

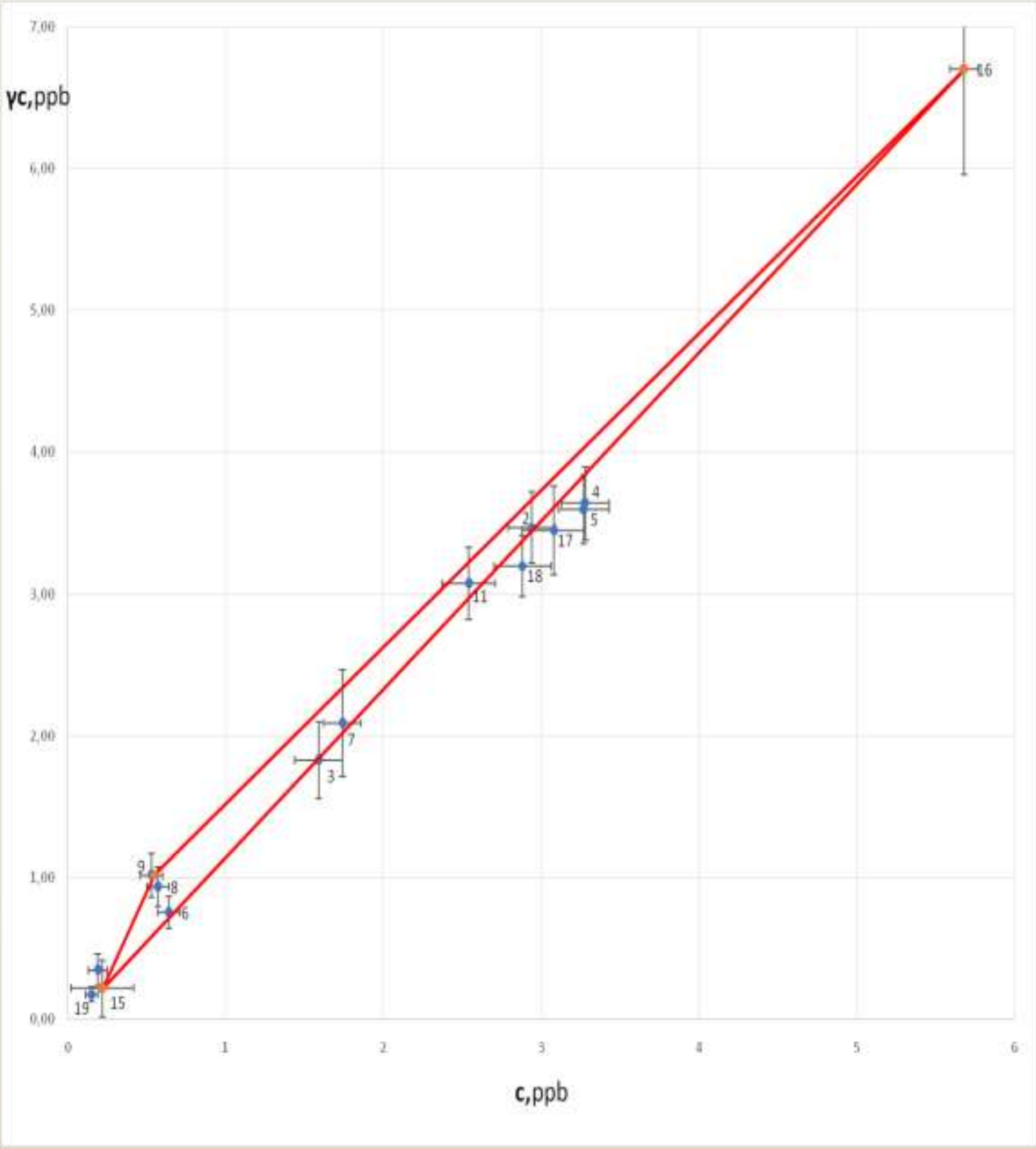
$$V_3 = \frac{\gamma C(C_2 - C_1) + \gamma_3 C_3 (C - C_2) + \gamma_1 C_1 (C_1 - C)}{\gamma_1 C_1 (C_3 - C_2) + \gamma_2 C_2 (C_1 - C_3) + \gamma_3 C_3 (C_2 - C_1)}$$

$$\gamma = U^{234} / U^{238}$$

C_1, C_2, C_3; $\gamma_1, \gamma_2, \gamma_3$ -

координаты вершин треугольника;

C; γC - в каждой пробе



Uranium isotopes in glacial waters in the upper reaches of the Adygene River

Sample code – year of sampling	Location	$^{34}U/^{238}U$	Uranium content, 10^{-6} g/l
1A-2014	Adygene glacier snow	1.00±0.04	0.11± 0.01
3A-2014	Lake 1P – Periglacial	1.00±0.04	0.33±0.04
5A-14	Lake 7T Thermocarstic	0,98±0,04	1,4±0,2
6A-14	Lake 12TThermocarstic	1,04±0,04	1,40±0,2
4A-2014	Lake 2D – Bolshoe Adygene	1.26±0.10	0.7 ±0.2
7A-2014	Lake 6T – Thermocarstic	1.10±0.05	1.54±0.05
8A-14	Lake 8TThermocarstic	1,14±0,08	1,50±0,08
9A-14	Lake 9TThermocarstic	0,92±0,08	1,99±0,25
10A-2014	Lake 11T - Thermocarstic	0.97±0.08	4.1±0.7
11A-2014	Lake 11T - Thermocarstic	1.01±0.04	54.6±0.2
12A-2014	Adygene River from under the moraine	1.16 ±0.08	1.9 ±0.2
KZS-27-16	Adygene River , mouth	0,91±0,10	0,31±0,05

Uranium isotopes in waters in the source area of the Ala-Archa River					
Sample ID - year	Sample location	Coordinates	Elevation, m	$^{234}U/^{238}U$	$C_U.10^{-6}g/l$
KZS-24-16	Ala-Archa River, upper reaches	N42° 54’98.30 E74° 48’69.63	2260	1.17±0.03	4.06±0.16
KZS-25-16	Aksai River, upstream its confluence with the Ala-Archa River	N42° 54’9830E74° 48’69.63	2253	1.02±0.02	5.14±0.18
KZS-28-16	Spring on the right bank of the Ala-Archa River	N42 ° 57’21.98 E74 ° 48’2171	2093	1.10±0.11	6.45±0.22

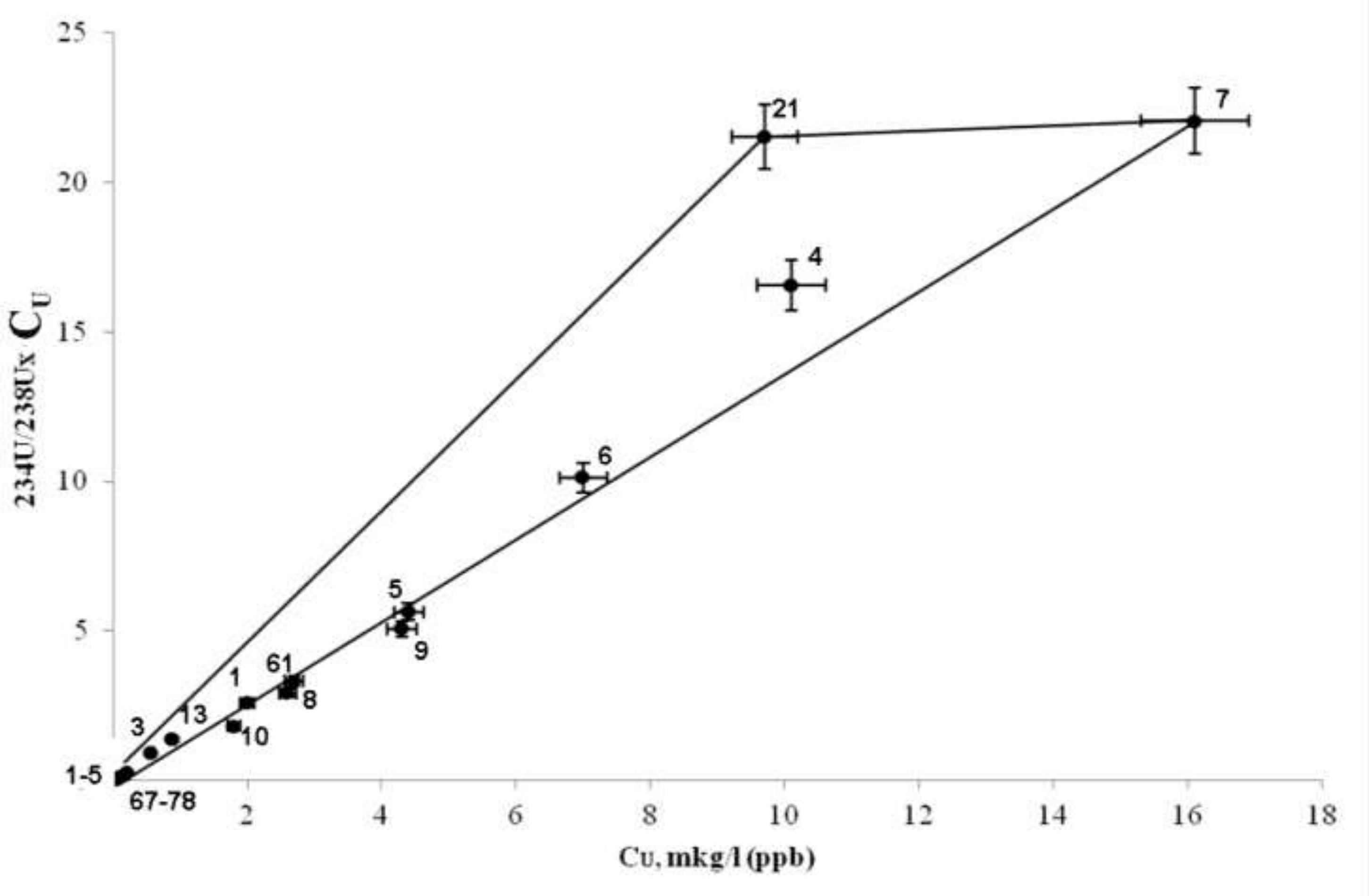
Изотопы урана в зоне формирования стока р.**Аламедин, отбор 28-30.06.2017 г.**

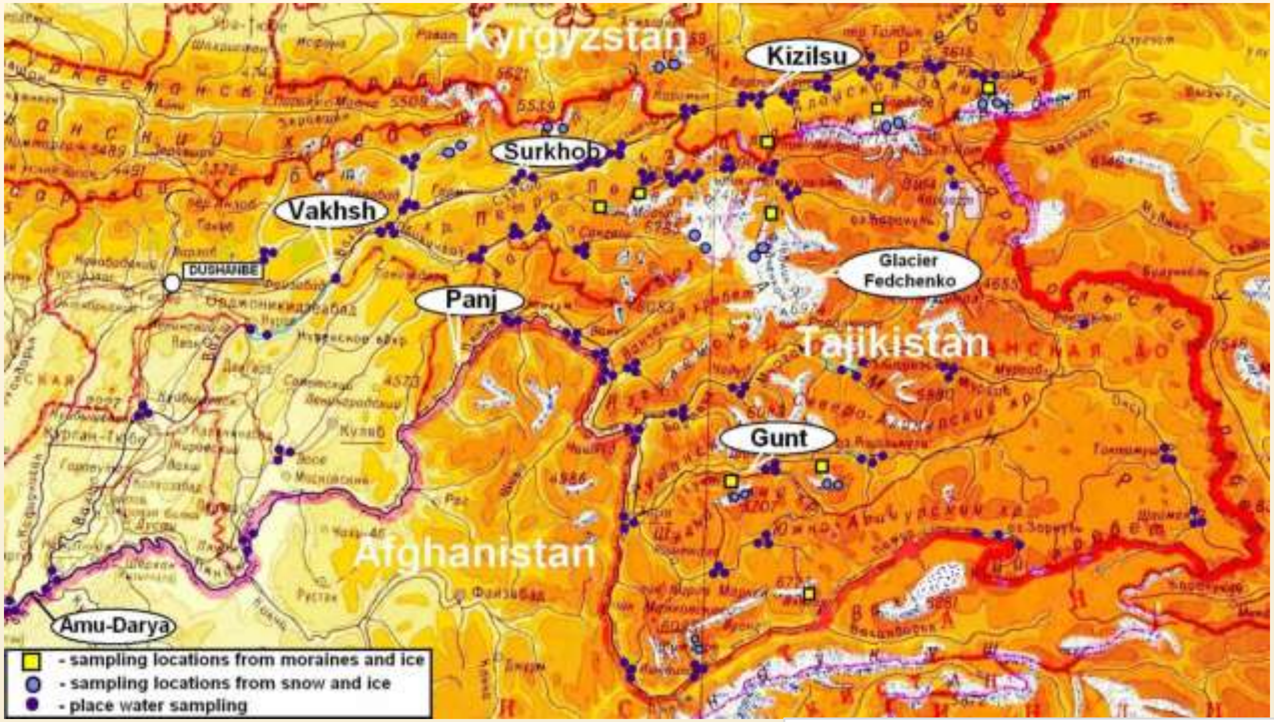
Шифр проб	Место отбора	Координаты	Высота, м	$^{234}U/^{238}U$	C_U, mkg/l	Доля стока, %
1Ал-17	Р.Ашутор	N42,452696 E 74,695544	3091	1,17±0,05	1,7±0,1	
2Ал-17	Исток р.Аламедин	N42,450838 E 74,672995	2839	1,18±0,04	4,0±0,2	20±5
3Ал-17	Левый безымянный ледник	N42,459198 E 74,62313	2755	1,16±0,04	2,7±0,2	
4Ал-17	Родник	N 42,466301 E 74,669110	2734	1,31±0,07	1,4±0,1	
5Ал-17	Безымянный правый приток	N 42,472022 E 74,666091	2680	1,06±0,06	1,1±0,1	
6Ал-17	р. Алтын-Тор до слияния с Ашутором	N 42,490367 E 74,649337	2388	1,07±0,04	2,9±0,2	25±5
7Ал-17	р.Аламедин после Алтын-Тор и Ашутор	N 42,496366 E 74,654447	2337	1,11±0,03	3,4±0,1	45±5
8Ал-17	р.Салык, устье	N 42,560878 E 74,663944	2020	0,97±0,02	10,1±0,3	20±4
9Ал-17	р.Аламедин после р.Салык	N 42,562343 E 74,662447	1992	1,01±0,03	5,4±0,2	65±4
10Ал-17	р.Ачикташ	N 42,577195 E 74,660919	1955	1,10±0,04	1,7±0,1	35±4
11Ал-17	р.Аламедин после р.Ачикташ			1,09±0,01	4,0±0,1	100

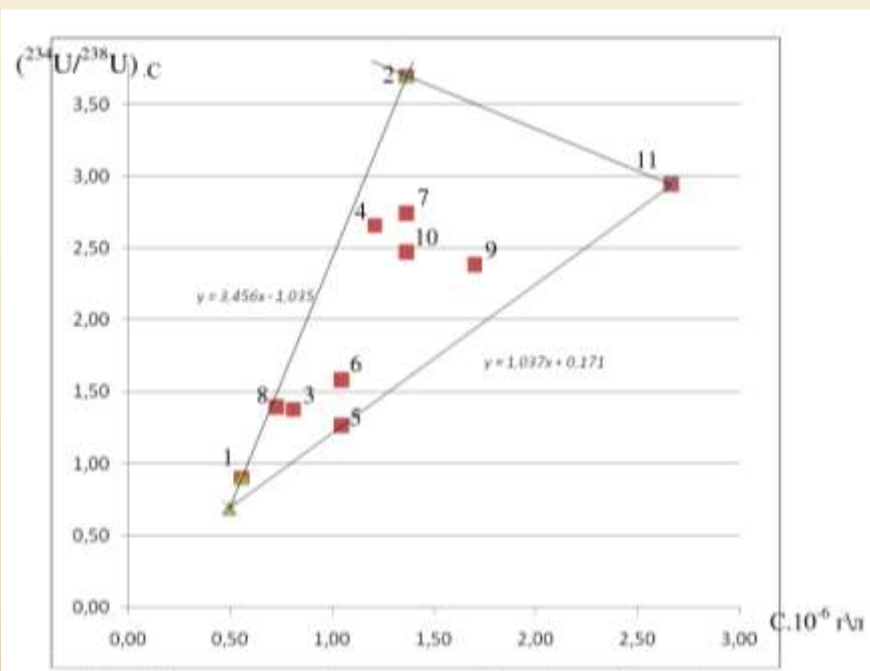
Concentration of uranium in water samples collected from Kyrgyzstan rivers (Tributaries of Syr Darya river)

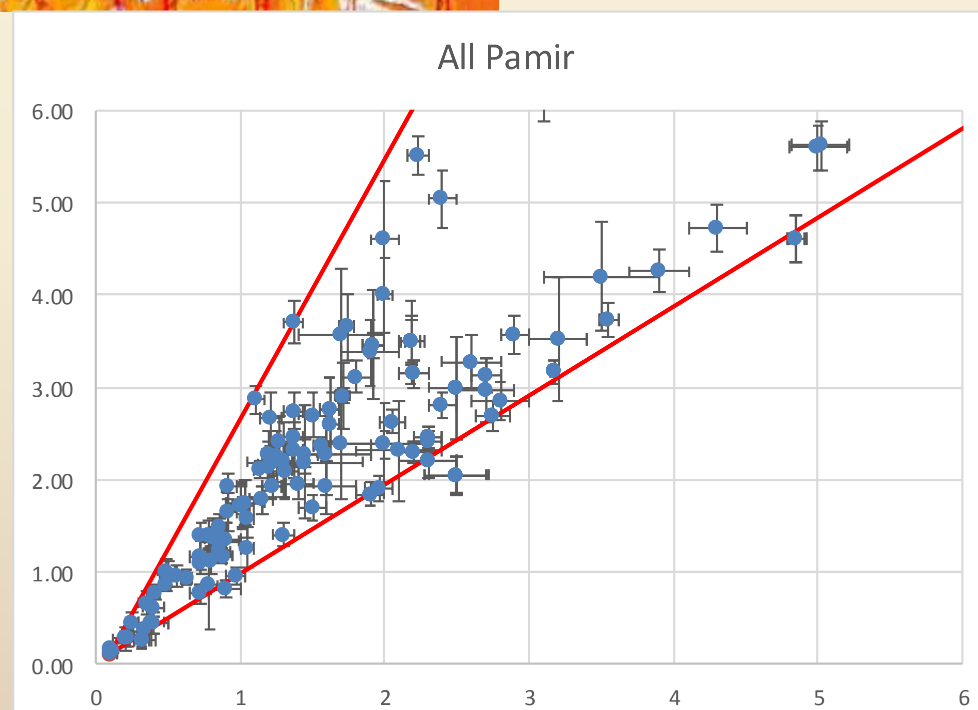
River name	Description	234U/238U	238U. µg/l
Naryn	Toktogul reservoir	1.55±0.04	3.01
	Naryn river, upstream the Toktogul reservoir	1.56±0.06	2.91
	Naryn river, upstream the Toktogul reservoir, near Uch-Terek	1.45±0.03	3.70
	Sargata River, near the highway	1.43±0.03	4.91
	Toktogul reservoir, southern shore, middle	1.67±0.03	2.17
	Naryn River, downstream its confluence with the Karasu river	1.55±0.04	2.65
Mailuu-Suu	Mailuu-Suu River, downstream the town	1.62±0.06	6.31
	Mailuu-Suu River, near the highway bridge	2.42±0.02	6.84
Kara-Unkur	Channel from the Kara-Unkur River	1.44±0.01	1.63
Kugart	Kok-Art (Kugart) River, near the highway bridge	1.52±0.08	5.33
Yassy	Yassy River, clean water	1.59±0.03	2.73
	Yassy River, polluted water near the bridge under construction	1.04±0.02	5.80

URANIUM ISOTOPES IN WATERS AND ICE'S OF THE UPSTREAM OF THE NARYN RIVER




Kyrgyzstan
Kizilsu
Surkhob
Vakhsh
DUSHANBE
Panj
Glacier Fedchenko
Tajikistan
Gunt
Afghanistan
Amu-Darya
- sampling locations from moraines and ice
- sampling locations from snow and ice
- place water sampling


(234U/238U) C
3,50
3,00
2,50
2,00
1,50
1,00
0,50
0,00
0,00 0,50 1,00 1,50 2,00 2,50 3,00
C.10-6 г/л
y = 3,456x - 1,035
y = 1,037x + 0,171
1 2 3 4 5 6 7 8 9 10 11


All Pamir
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0 1 2 3 4 5 6

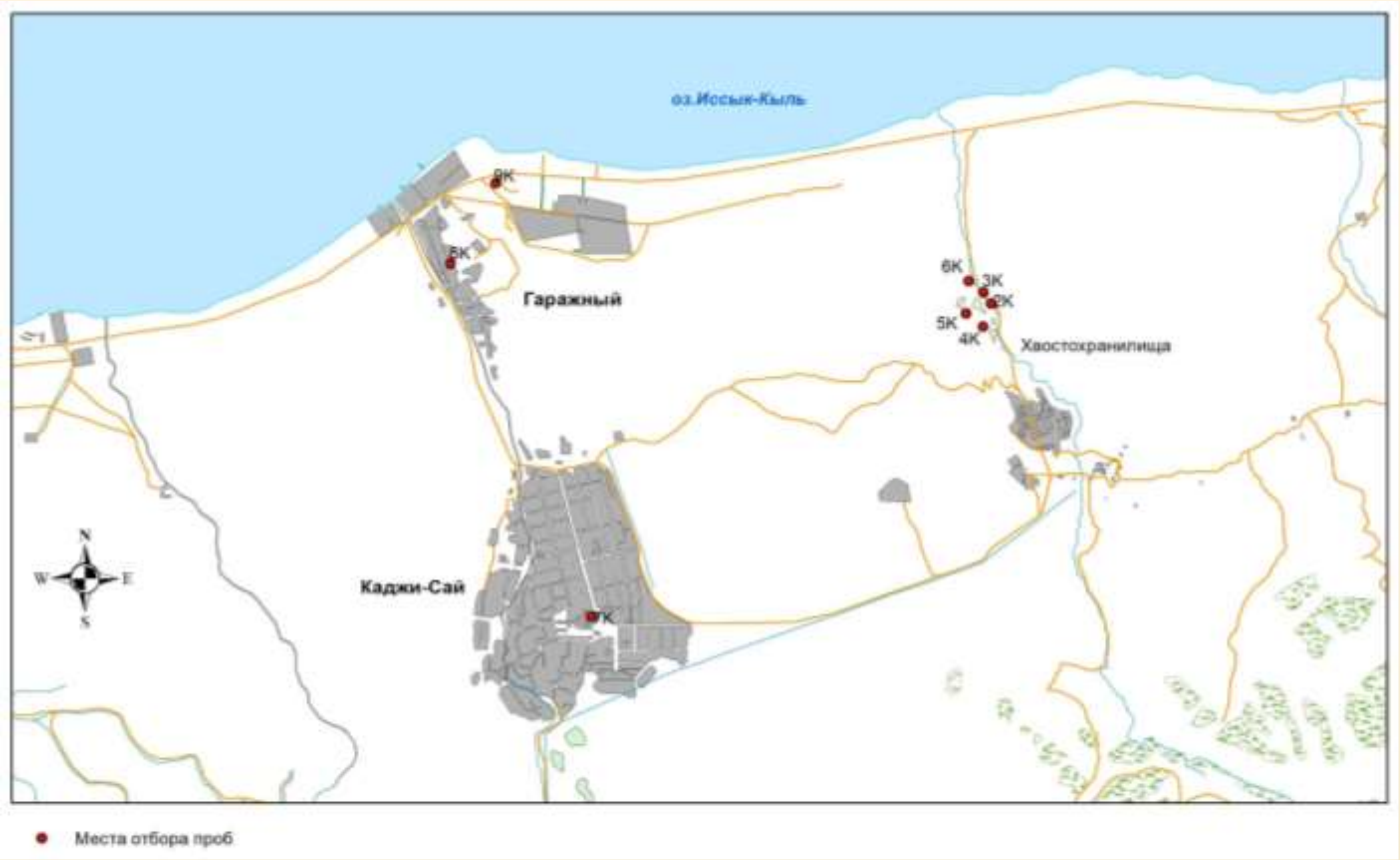
Uranium isotopes in the Kyzyl-suu river waters

Points	Sampling place	^{238}U Bq/l	^{234}U Bq/l	$^{234}U/^{238}U$	C,10^{-6} g/l	Доля Стока %
01	Inflow at the upper reaches of the Kyzyl-suu	0.007±0.001	0.012±0.001	1,7±0,2	0,56	
02	Kyzyl-suu , upper reach	0.017±0.002	0.046±0.003	2,7±0,1	1.37	25±15
03	Inflow at the upper reaches of the Kyzyl-suu	0.010±0.001	0.017±0.001	1,7±0,2	0.81	10±5
04	Kyzyl-suu river, below inflows 1 and 3	0.015±0.001	0.033±0.002	2,2±0,2	1.21	35±15
05	Achik-Tash river, outlet	0.013±0.002	0.016±0.002	1,2±0,2	1,05	15±5
06	R.Kyzyl-Suu befor Sary-Mogol river confluence	0.013±0.002	0.020±0.002	1,5±0,2	1,05	
07	Kyzyl-Suu after confluence of Sary-Mogol and Achik-Tash rivers	0.017±0.001	0.033±0.002	2,0±0,1	1,37	
08	Kyzyl-Suu befor Altyn-Dara	0.009±0.002	0.016±0.003	1,9±0,5	0,73	50±20
09	Altyn-Dara, outlet	0.021±0.004	0.031±0.004	1,4±0,3	1,70	50±20
10	Kyzyl-Suu after Altyn-Dara confluence	0.017±0.002	0.030±0.003	1,8±0,2	1,37	100
11	Kok-Suu river, outlet	0.033±0.003	0.037±0.003	1,1±0,1	2,67	

Source of waters in the Kyzyl-Suu river basin (%)

Pints	Sampling place	I Glacial water $(^{234}U/^{238}U)_1$=1,3±0,3 C_1=0,6.10^{-6} г/л	II ledge rock water $(^{234}U/^{238}U)_2$=2,7±0,1 C_2=1,3.10^{-6} г/л	III Quarternary sedimnt waters $(^{234}U/^{238}U)_3$=1,1±0,1 C_3=2,7.10^{-6} г/л
2	Kyzyl-Suu river, river head		100	
1,3	Inflows in the upper reaches of Kyzyl-Suu river	85	15	
5	Achik-Tash river	80		20
6	Kyzyl-Suu river before Syry-Mogol confluence	60	20	20
7,8	Kyzyl-Suu river before Altyn-Dara confluence	60	35	5
9	Altyn-Dara river	30	25	40
10	Kyzyl-Suu river after Altyn-Dara confluence	40	35	25
11	Kok-Suu river			100

Isotopes of uranium in the waters of Kadzhi-Sai mine tailings

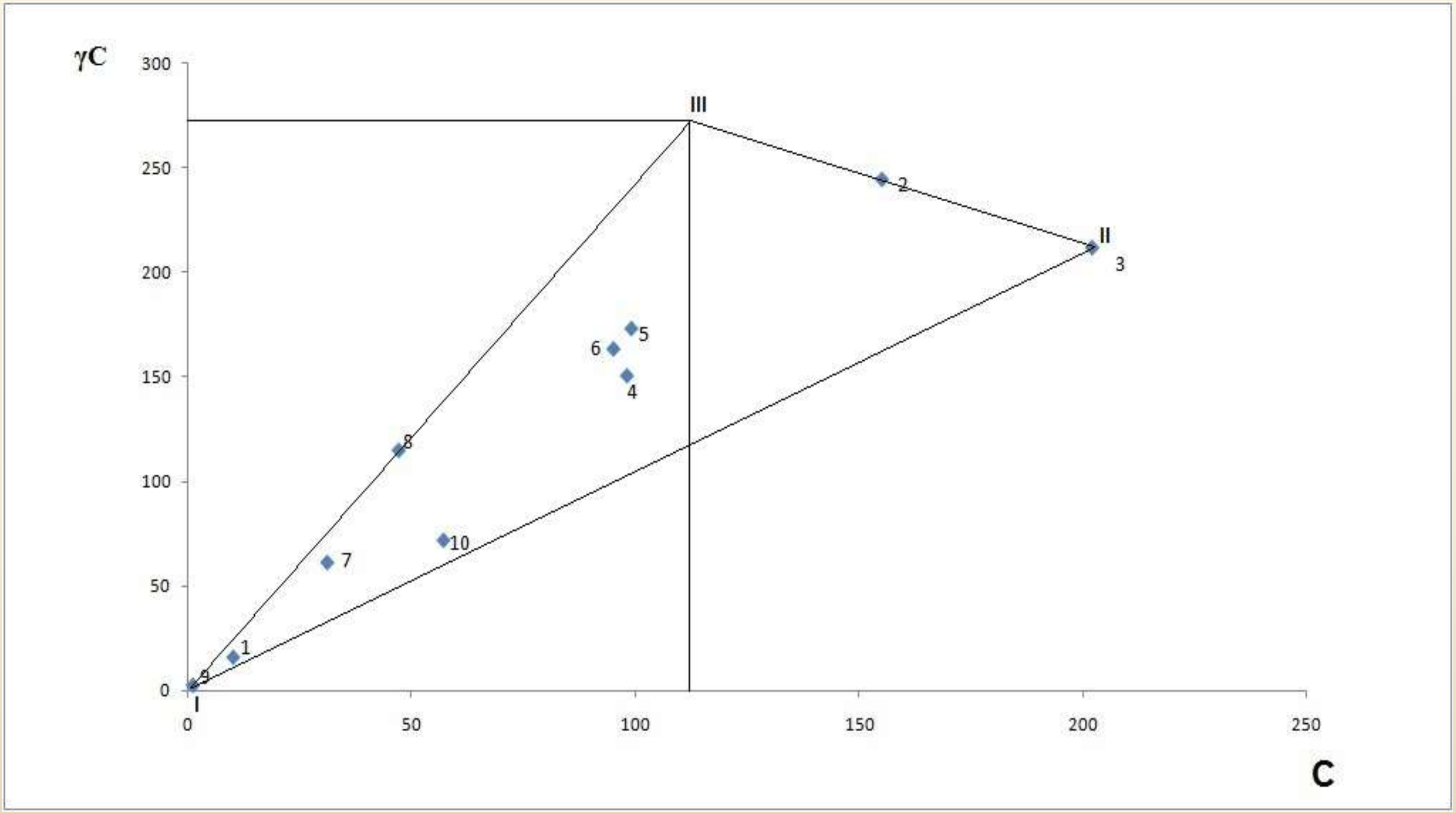


- Uranium-isotope diagram of determination of the genetic composition of water was created and studied. During the work three genetic types of waters were established and their mixing proportions in the investigated water sources were calculated. It was found that drinking waters of Kadzhi-Sai village consist of only 5-7% of waters enriched by uranium; the major part (60-80%) is waters of deep circulation.

Isotopes of uranium in the waters of Kadzhi-Sai

Sample #	Sampling Location	C, 10^{-6} г/л p/pb	$\gamma = {}^{234}U/{}^{238}U$	Water share, %:		
				Depth water	Enriched by uranium	Active water interchange
2	From under the concrete barrier to the south of the settling basin	155±5	1,58±0,02		52±2	48±2
3	From under alluviums of the south eastern concrete barrier	202±7	1,04±0,02		100	
4	Easter source of Jiluu-Bulak	98±5	1,54±0,02	35±2	35±2	30±2
5,6	Outlet from the settling basin	97±5	1,73±0,02	34±2	29±2	37±2
7	Southern water intake of Kadji Sai water supply system	31±2	1,99±0,02	77±2	7±1	16±2
8	Northern water intake of Kadji Sai water supply system	47±2	2,45±0,05	58±2	5±1	37±2
9	Kadji Sai thermal well	1,0±0,2	2,92±0,02	100		
10	Lake Karakul, southern	57±2	1,27±0,02	69±2	25±2	6±1

Uranium Isotopic diagram of the genetic compositions of waters in the Kadji-Sai district



Summary of project results and impacts

The project allowed us to collect data on **temporal variations of natural uranium isotope ($^{234}U/^{238}U$) ratios in waters of Tien Shan and Pamir river basins. Using this data, we calculated the contributions of three genetic types of water (rainfall and glacial melt, deep ground waters, and near-surface ground waters) to those rivers. This is a new source of reliable hydrological information that can be used by both organizations modeling transboundary water resource changes and hydraulic engineering companies operating in transboundary river basins. Measuring the contributions of glacial melt and groundwater to the streamflow of feeding rivers is important for modeling the maximum and minimum flows of the region's largest rivers—Amu-Darya and Syr-Darya.** This is necessary for a new system of water sharing between independent Central Asian countries.

The project will facilitate efficient management of transboundary river resources and adaption to climate changes and will also help identify and mitigate natural disaster risks and impacts (glacial lake outburst floods, mudflows, landslides, and waterlogging of river valleys).

Peer-reviewed Publications and Proceedings

1.Matvejeva, I. V., Tuzova, T. V. Methodical features of pretreatment of water samples of mountain rivers with ultralow concentration of uranium for alfa-spectrometric measurmets // Vestnik Tajikskogo Nacionalnogo Universiteta, 2017, Issue 1/2; pp. 151-151.

2.Tuzova T.V. Distribution of the Flow of Transboundary Mountain Rivers by Uranium-Isotopic Method// Water and Ecological Problems of Siberia and Central Asia, Volume IV, 2017, Barnaul, Siberian Branch of the Russian Academy of Sciences, pp. 126-134.

3.Burkitbaev, M.M., Uralbekov, B.M., Tuzova, T.V. Nonequilibrium uranium as a natural indicator of processes in the water and ecological systems of Central Asia//Almaty, Kazakh University, 2017;, p. 160 (Monograph, ISBN 978-601-04-2923-9)

4.Tuzova T.V. Radio-ecological condition of waters of different genesis in the area of the former Kadjisai uranium mine (the Kyrgyz Republic) // Proceedings of the International Scientific Forum on Nuclear Science and Technologies, Institute of Nuclear Physics, Almaty, 2017; pp. 287-293.

5.Usupaev Sh.E., Tuzova T.V., Erokhin S.,Zaginaev, V. Forecast methods for high-mountain lakes in seismically active zones of the Tien Shan and Pamir // Proceedings of the 9th Kazakh-Chinese International Symposium, Almaty; Ministry of Education and Science of the Republic of Kazakhstan, Institute of Seismology, 2017; pp.78-83.

6.Tuzova, T.V., Satylkanov, K.A., Shatravin, V.I., Matvejeva, I.V. Radiological condition of water sources at the Kumtor Gold Mine (Kyrgyz Republic) // Natural resource management issues and environmental situation in European Russia and adjacent areas // Proceedings of the 7th International Scientific Conference in Belgorod; Politera, 2017; pp. 260-264.

7. Z.V. Kobuliev, D.M. Mamatkanov, T.V. Tuzova, Sh.E.Usupaev, A.R.Fazylov EXPERIENCE OF INTERNATIONAL COOPERATION IN THE TRAINING OF HIGH QUALIFICATION FOR SUSTAINABLE DEVELOPMENT OF THE COUNTRIES OF CENTRAL ASIA // // Наука, новые технологии и инновации Кыргызстана, 2018. № 3

8. V.Shatravin, D.Mamatkanov, R.Satylkanov, B. Ermenbaev,D. Watkins ICE RESOURCES OF DEBRIS-COVERED GLACIERS IN TIAN SHAN,там же.

9. T.Tuzova, R.Satylkanov, V.Shatravin, D.Watkins URANIUM ISOTOPES IN ICE'S AND WATERS OF THE upstream of the Naryn, там же.

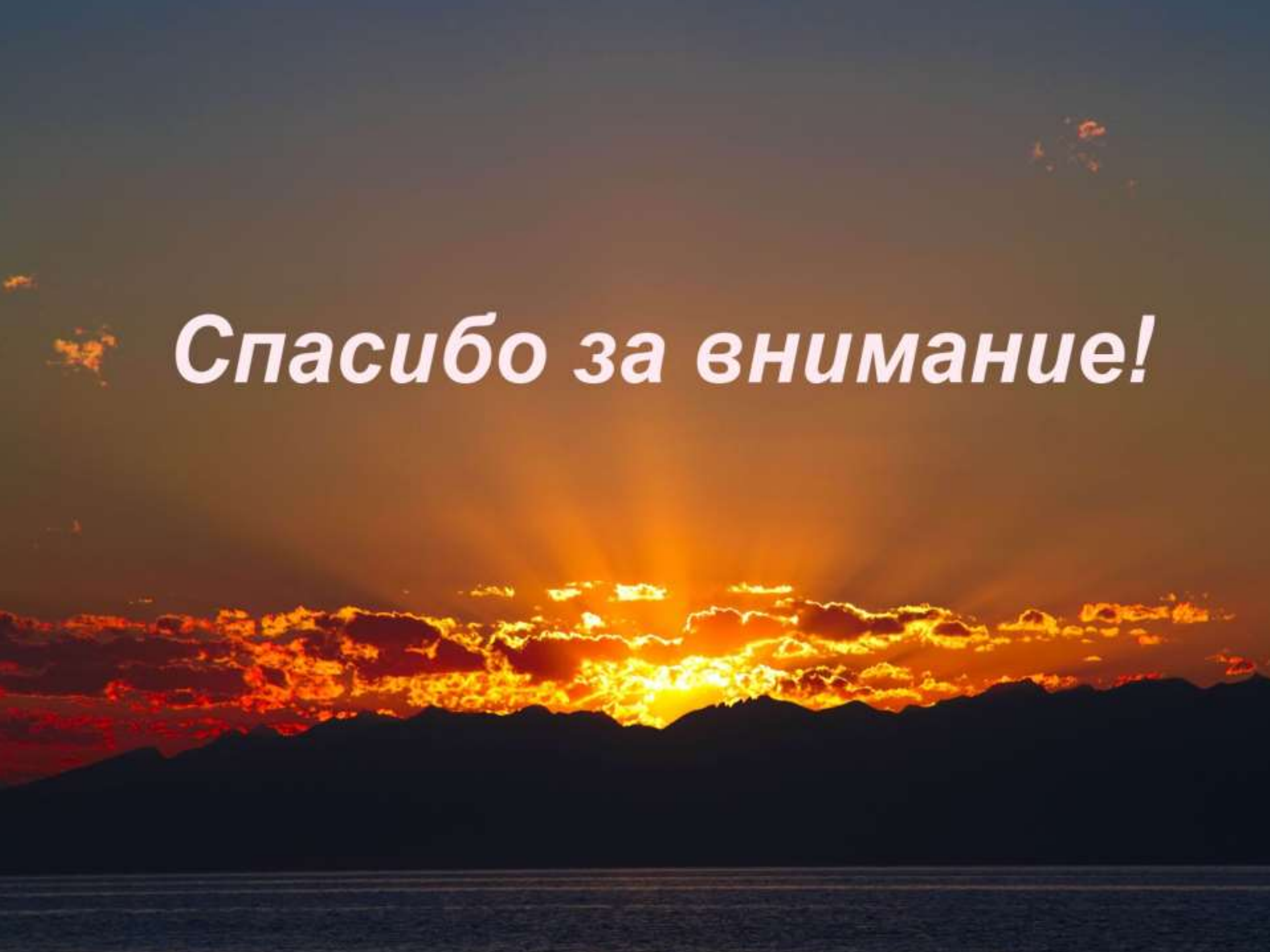
10. I.V.Matveeva, F.S.Meyirman, N.A.Nursapina, B.A.Shynybek METHODS OF CONCENTRATION OF ISOTOPES OF URANIUM FROM WATER IN FIELD CONDITIONS, там же.

11. T.V. Tuzova, V.V. Zaginaev, V.I. Shatravin, D. Watkins, I.V. Matveeva, S.M. Saidov URANIUM IN WATERS OF transboundary river source zones in the Tien Ыhan and Pamir, там же.

12.

Сотрудничество с другими грантополучателями

-Forschungszentrum Julich GmbH Division of Safety and Radiation Protection(Germany - comparing the results of alpha and mass-spectometry measurements of isotopic composition of uranium in water and ice;
-CHARIS Project, USAID, Colorado University, USA - prof. Richard Amstrong, Dr. Alice Hill, Dr. Alana Wilson - capacity building, strengthening regional cooperation and academic exchange in obtaining more accurate information about water resources in transboundary river basins of KR and RT;
-Water Resources Research Center DPRI, Kioto University, Japan – prof. Kenji Tanaka, Dr.Temur Khujanazarov – collaboration research of the high mountain snow cover and glacier area fluctuation under climate change;
-Tien Shan High Mountain Scientific Center - Ryspek Satylkanov - the head of TSHMSC, manager of CHARIS Project - cooperation with the participants of USAID projects "Cooperative Institute for Research in Environmental Sciences (CIRES) and the National Snow and Ice Data Center (NSIDC)" and "The Contribution to High Asia Runoff from Ice and Snow, or CHARIS."
-Institute of Water Problems, Ecology, and Hydro Energy of AS RT - Prof. Kobuliev Z. - organization of fieldwork on the territory of RT, participation in workshops and training.
-Al-Farabi KazNu (Almaty, RK) M. Curie Laboratory of Radiological Ecology, Dr. Bolat Uralbekov, Dr. Ilona Matveeva – uranium isotopic analysis of water, snow and ice samples;
-International Center for Bioslaine Agriculture (ICBA), “Use of Non-Conventional Agricultural Water Resources to Strengthen Water and Food Security in Transboundary Watersheds of the Amu Darya River Basin (UNCAWR)” (Grant Award Number: AID-OAA-A-11-00012) - Dr. Christina Toderish - searching for consensus in carrying out simultaneous PEER Projects on the effect of climate change on water resources in CA.
-Central Asian Regional Ecological Center (CAREC), "Smart Waters" Project - Anna Inozemtseva, manager of Water Initiatives Support Program; coordination of joint works on solving water problems in CA.
-Institute of Nuclear Physics (INP), Ministry of Education of the Republic of Kazakhstan, Almaty; Memorandum of Cooperation to apply isotope methods in geophysics and hydrogeology; Vladimir Solodukhin, Doctor of Science (Geology and Mineralogy), Head of INP; Svetlana Lennik, Laboratory Chief
-Hertelendi Laboratory of Environmental Studies, Institute of Nuclear Research, Hungarian Academy of Sciences, H-4026 Debrecen, Bemter 18/c, Hungary - Scientific Secretary Katalin Hubay
-Klaus Tschira Archäometrie Zentrum Institute of CEZ Archäometrieg GmbH C4, 8 | 68159 Mannheim | Germany, Dr. Ronny Friedrich, Director AMS/Radiocarbon Dating


Спасибо за внимание!