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Using Isotope Application for Assessment Water Origin in the Kakheti Region

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Abstract

In order to assessment water origin and pathway, was organized monitoring network in East Georgia's lowland - Alazani and Shiraki catchments. Observation set up with the aim to study the evolution of water isotopic composition from precipitation to groundwater and stream, what allowed determining the residence time of groundwater flow. The network estimated groundwater flow directions and velocities between recharge and discharge areas, as well as groundwater age for East Georgia catchments. Snow cover measurement was organized, also.

***Key words*: groundwater origin and pathway, isotopic analysis.**

Introduction

Study area is represented by a valley surrounded by the Greater Caucasus Mountains (altitudes up to 3500 m a.s.l.) in the north and lower Gombori Range (altitudes up to 2000 m a.s.l.) in the south (Fig 1). The valley is drained by the Alazani river. Another important source of water is the groundwater from numerous boreholes and wells. The origin of the groundwater remains unknown.

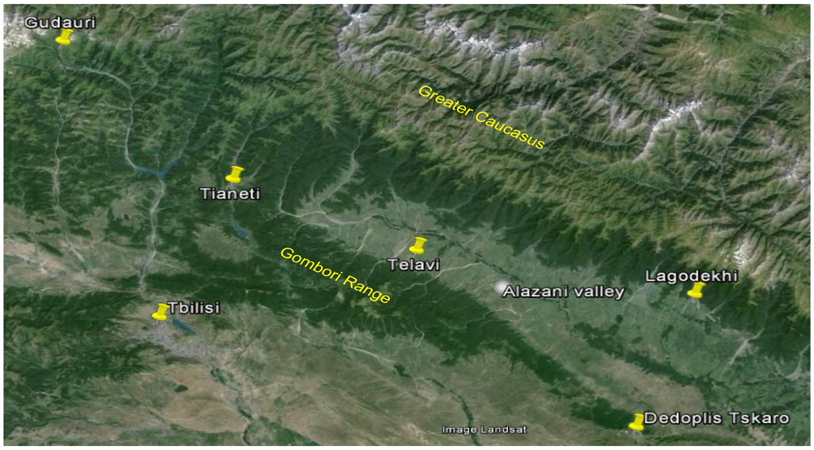

Fig. 1. Study area - the Alazani river valley (Google Earth) and location of stations collecting monthly composite precipitation samples; GNIP station Tbilisi which is relatively close to the study area is shown as well; the distance between Tianeti and Telavi is about 47 km.

Previous investigations carried out within the project [1-3] revealed three types of geochemically different groundwaters:

- old groundwaters which recharged before the 1950
- younger groundwaters containing higher amounts of total dissolved solides.
- groundwater of the Alazani series, Kvareli aquifer and springs which are of modern origin

Perceptual model of the study area built by the counterpart on the basis of hydrogeological knowledge assumes that the last group of groundwater originates by infiltration of precipitation falling on southern slopes of the Greater Caucasus. The water percolates into the Alazani valley which is filled by Quarternary sediments and is used in the boreholes and also becomes source of water for the river during the dry periods [4-5].

Monitoring network was set up with the aim to study the evolution of water isotopic composition from precipitation to groundwater. The database of isotopic data contained over 600 samples. Isotopic analyses were made using the Picarro laser analyser obtained within projects. Overview and interpretation of available data are summarised below.

Evaluation of available data

Isotopic composition of precipitation was studied on the basis of monthly composite samples from stations located at altitudes 400-1100 m a.s.l. (Tianeti, Telavi, Lagodekhi, Dedoplis Tskaro; Fig. 1). The highest altitudes of the Greater Caucasus are sparsely inhabited which prevented monitoring of isotopic composition of precipitation. Data on precipitation depths for each station need be completed in cooperation with the national hydrometeorological service.

Available data on isotopic composition of precipitation is presented in Figs. 2-4. Several samples, especially from the most arid conditions at Dedoplitskaro were affected by evapotranspiration (Fig. 2). Evaporated samples mostly did not occur in the hottest months which indicates that evaporation probably occurred either in the gauge or after sampling. Such samples should be excluded from further processing. Isotopic composition of precipitation at Dedoplis Tskaro between August and October 2013 and then November to February 2014 (Fig. 3) did not show any variability which is unusual and does not resemble to data from other stations.

Isotopically the lightest precipitation was measured at stations Lagodekhi and Tianeti. That would agree with expectations. However, according to the coordinates of stations provided the elevation of station Legodekhi is only about 400 m a.s.l. This should be checked when newer samples are analysed and an attempt to estimate possible altitude gradient of isotopic composition of precipitation is made. Additional data from Gudauri, if available should be used as well to evaluate the gradients at least for the limited period of December 2014 to April 2015. In months where rainfall and snowfall were measured separately, the weighted averages should be calculated.

River water was systematically monitored at GNIR station Shakriani near Telavi, about 40 km from the place where the Alazani River leaves the Greater Caucasus Mountains and enters the Alazani valley. Shorter data series were available from Dedoplis Tskaro. The isotopic composition of the Alazani river near Telavi presented in Fig. 4 shows that the river is contributed mainly by isotopically light water from higher altitudes. Deuterium excess has higher values which are typical for mountain precipitation and snow in other mountain ranges, e.g. in the Carpathians. Seasonal variability of $\delta^{18}O$ and $\delta^{2}H$ indicates an influence of snowmelt in spring 2013 (Fig. 5). Minimum values occurred in May 2013. Isotopically light (probably snowmelt) water in 2014 was observed already in January. It indicates snow-poor and warm winter. Amplitudes of $\delta^{18}O$ and $\delta^{2}H$ in precipitation (Lagodekhi) and in the river suggest the mean transit time of river water at Shakriani of about of about 15 months according to exponential model (the sine curves method).

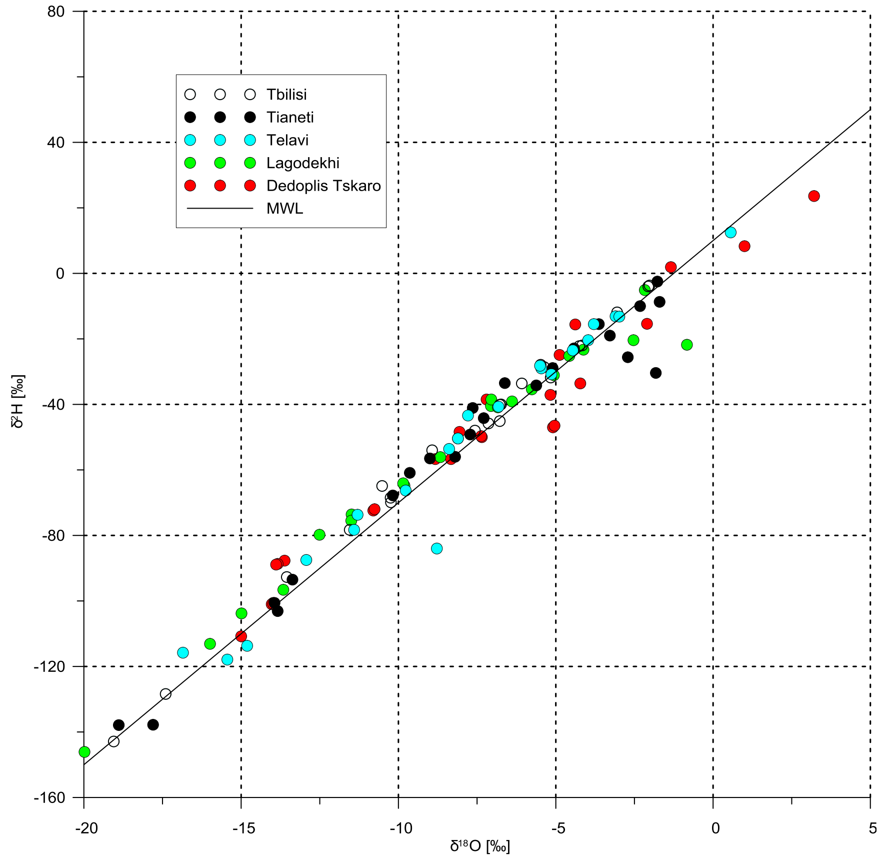

Fig. 2. Position of precipitation samples along the global meteoric water line.

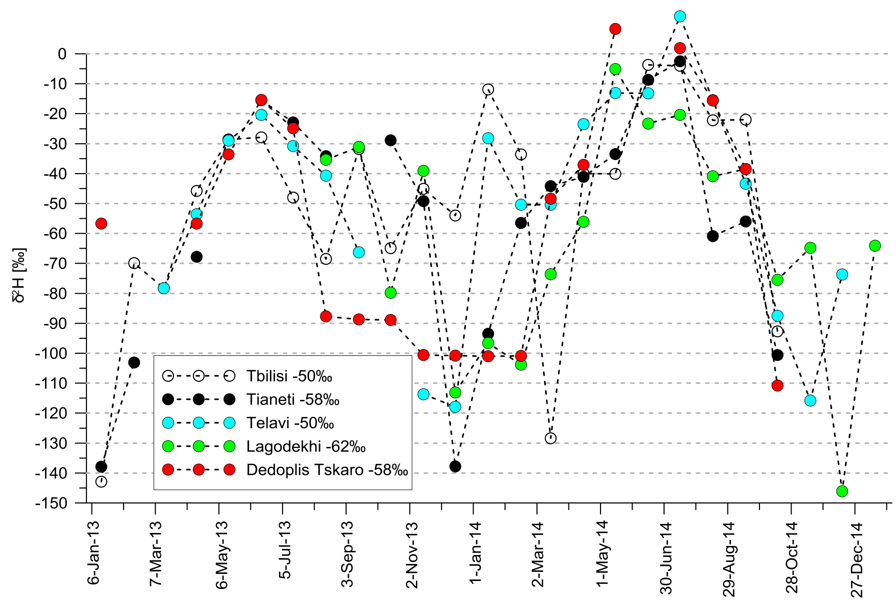

Fig. 3. Seasonal variability of δ^2H in precipitation; evaporated samples are excluded.

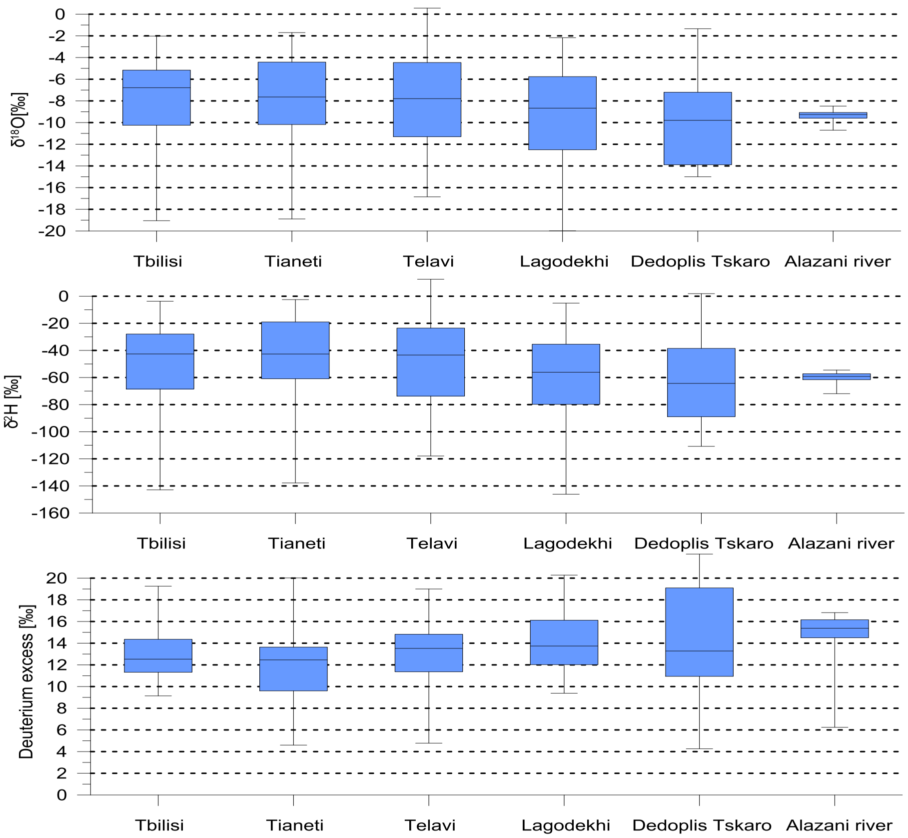

Fig. 4. Box-whisker plots of monthly precipitation (samples approximately between January 2013 and October 2014) and Alazani river water from January 2013 until February 2015.

Evaporated samples are excluded; the whiskers represent minimum and maximum; stations are plotted approximately from the west to the east (see Fig. 1); statistics from the Dedoplis Tskaro station are affected by suspicious samples from August 2013 to February 2014 (see Fig. 3); the data series from Lagodekhi is shorter.

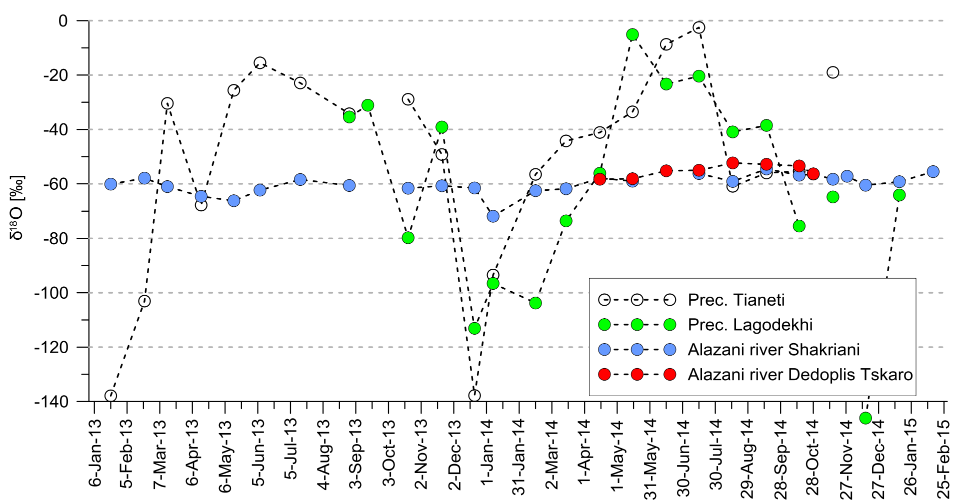

Fig. 5. Temporal variability of δ^2H in precipitation and in the Alazani river at Shakriani (near Telavi) and at Dedoplis-Tskaro.

Limited data from the downstream part of the river at Dedoplis Tskaro (Fig. 5) show an increase of heavier isotopes by about 0.3-0.5‰ for $\delta^{18}O$ and about 1-3‰ for δ^2H. Snapshot sampling along the Alazani river on 28 October 2014 (Fig. 6) indicates that isotopic composition of river water in the Alazani valley evolves according to a line parallel with the global meteoric water line. Isotopic composition of the river near the outlet of the headwater part of the catchment (Omalo) changes as the river enters the Alazani valley. $\delta^{18}O$ in Omalo and Shakriani differ while the δ^2H are similar.

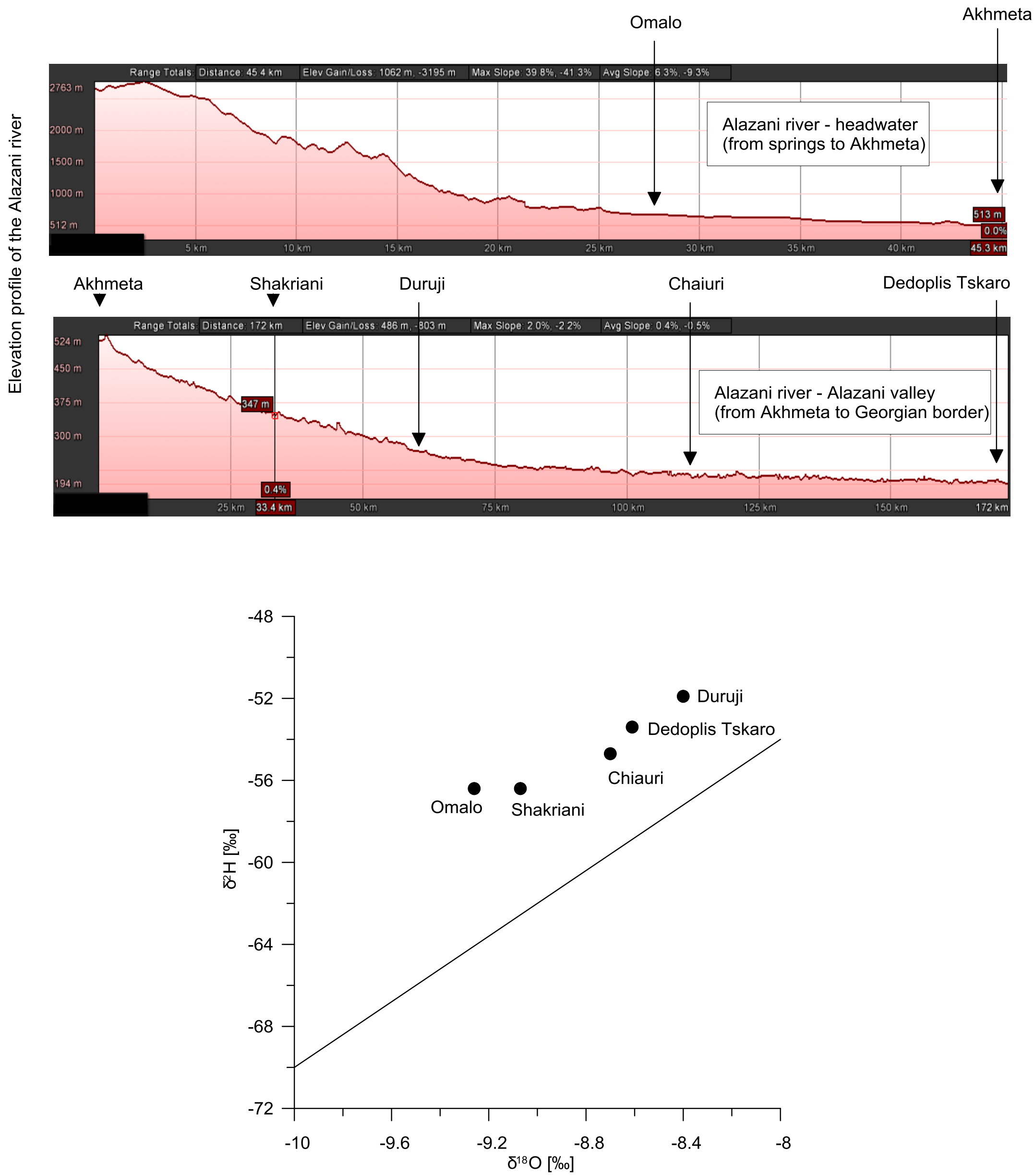

Fig. 6. Elevation profile of the Alazani river (modified from Google Earth) and position of samples from the snapshot sampling along the river on 28 October 2014 with regard to global meteoric water line.

Groundwater sampling was generally conducted in the NE-SW transects, i.e. from the southern slopes of the Greater Caucasus across the Alazani valley (Fig. 7). The sampling sites comprise springs, boreholes and structures of the local water supply systems. Most samples were collected during snapshot sampling campaigns. Available isotopic data indicate several groups of groundwaters (Fig. 8). Samples from Akhmeta, Telavi and Gurjani are isotopically similar. Groundwaters in Kvareli and Lagodekhi are isotopically disctincylt lighter, but they plot along similar meteoric water line as the above group. Groundwaters from the Sighnaghi area probably contain evaporated water.

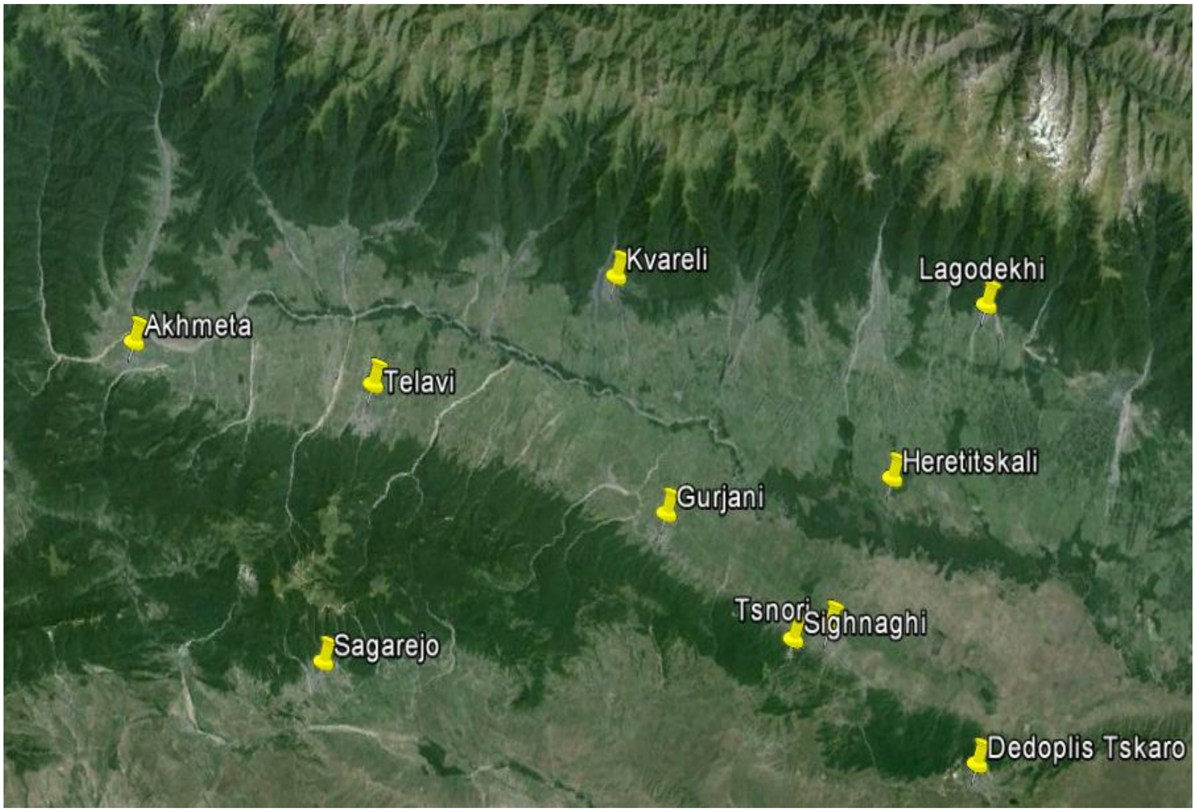

Fig. 7. The main groundwater sampling sites (Google Earth); the Sagarejo site is located in the neigbouring catchment (the Iori river) at the foot of the Gombori range; the distance between Akhmeta and Dedoplis Tskaro is about 97 km.

Samples from Dedoplis Tskaro form two groups. Part of the water (from the Samtatskaro borehole) probably represents older waters. The rest of samples are modern water which partially underwent evaporation. The Sagarejo waters do not form one group. The most variable are samples from Tsnori. The data presented in Fig. 9 and generalised in Fig.10 indicate the evolution of groundwater isotopic composition from the recharge area in the mountains through river valley to exfiltration areas. The concept which is in agreement with hydrogeological knowledge of the area is presented also in Table 1.

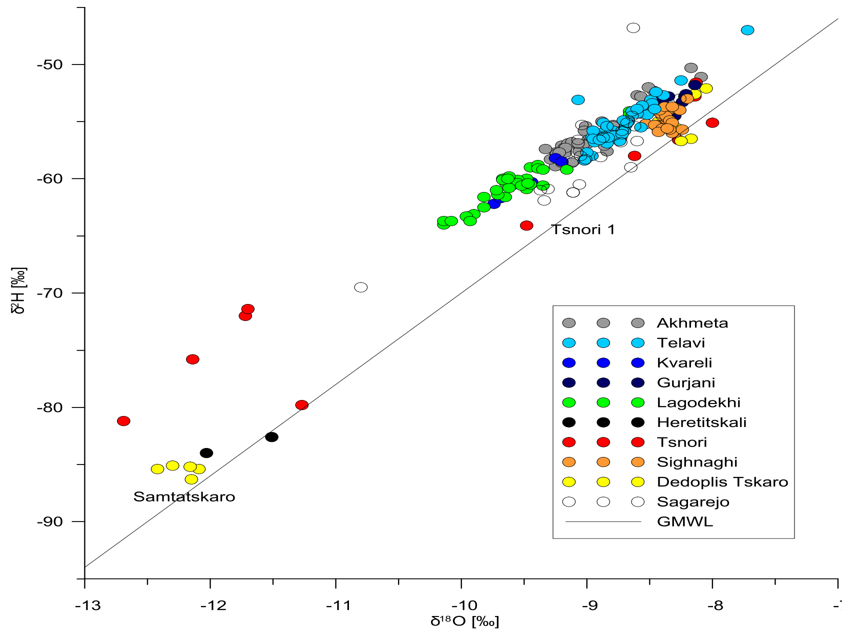

Fig. 8. Isotopic composition of groundwater samples.

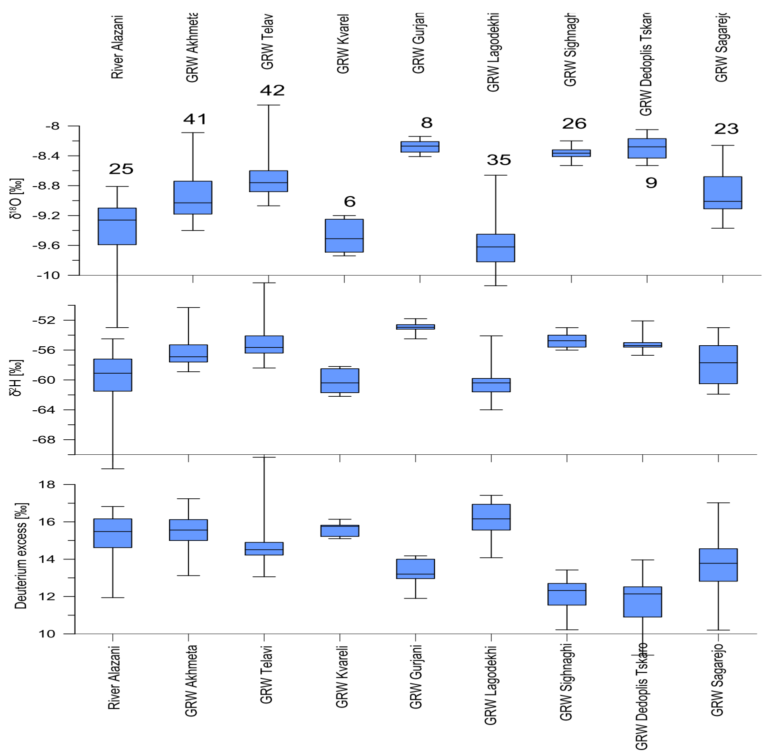

Fig. 9. Box-whiskers plots of the isotopic composition of Alazani river at Shakriani and groundwaters (old groundwaters are excluded); whiskers represent minimum and maximum; the number of samples for each boxplots is given in the graph for $\delta^{18}O$.

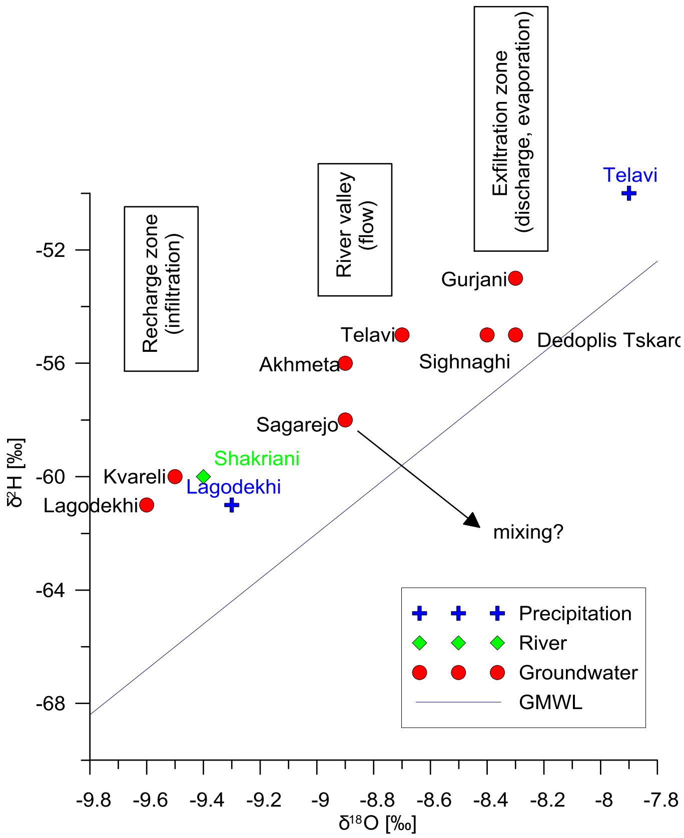

Fig. 10. Evolution of isotopic composition of groundwater in the study area (average values).

Table 1

Average values of isotopic composition of precipitation, river and groundwater samples and perceptual model of groundwater movement (column groundwater zone).

Groundwater zone	Site	^{18}O average [‰]	^{2}H average [‰]	Deuterium excess average [‰]
	Precipitation Telavi	-7.9	-50	12.9
	Precipitation Lagodekhi	-9.3	-61	14.1
	River Alazani (Shakriani)	-9.4	-60	15.3
Recharge area	GRW Kvareli	-9.5	-60	15.6
	GRW Lagodekhi	-9.6	-61	16.1
River valley	GRW Akhmeta	-8.9	-56	15.4
	GRW Telavi	-8.7	-55	14.6
Exfiltration	GRW Gurjani	-8.3	-53	13.3
	GRW Sighnaghi	-8.4	-55	12.1
	GRW Dedoplis Tskaro	-8.3	-55	11.7
Mixed water (Iori river basin)	GRW Sagarejo	-8.9	-58	13.6

Perceptual model suggested by current data on water isotopic composition should be validated when all samples are analysed and water chemistry data is available. Validated perceptual model will be useful in groundwater modelling.

Climatic data presented in Fig. 11 indicate that favourable conditions for snow cover formation probably occur only at higher elevations. Winter precipitation is small and maximum daily air temperature rarely drops below the freezing point even at Tianeti (elevation 1112 m a.s.l.).

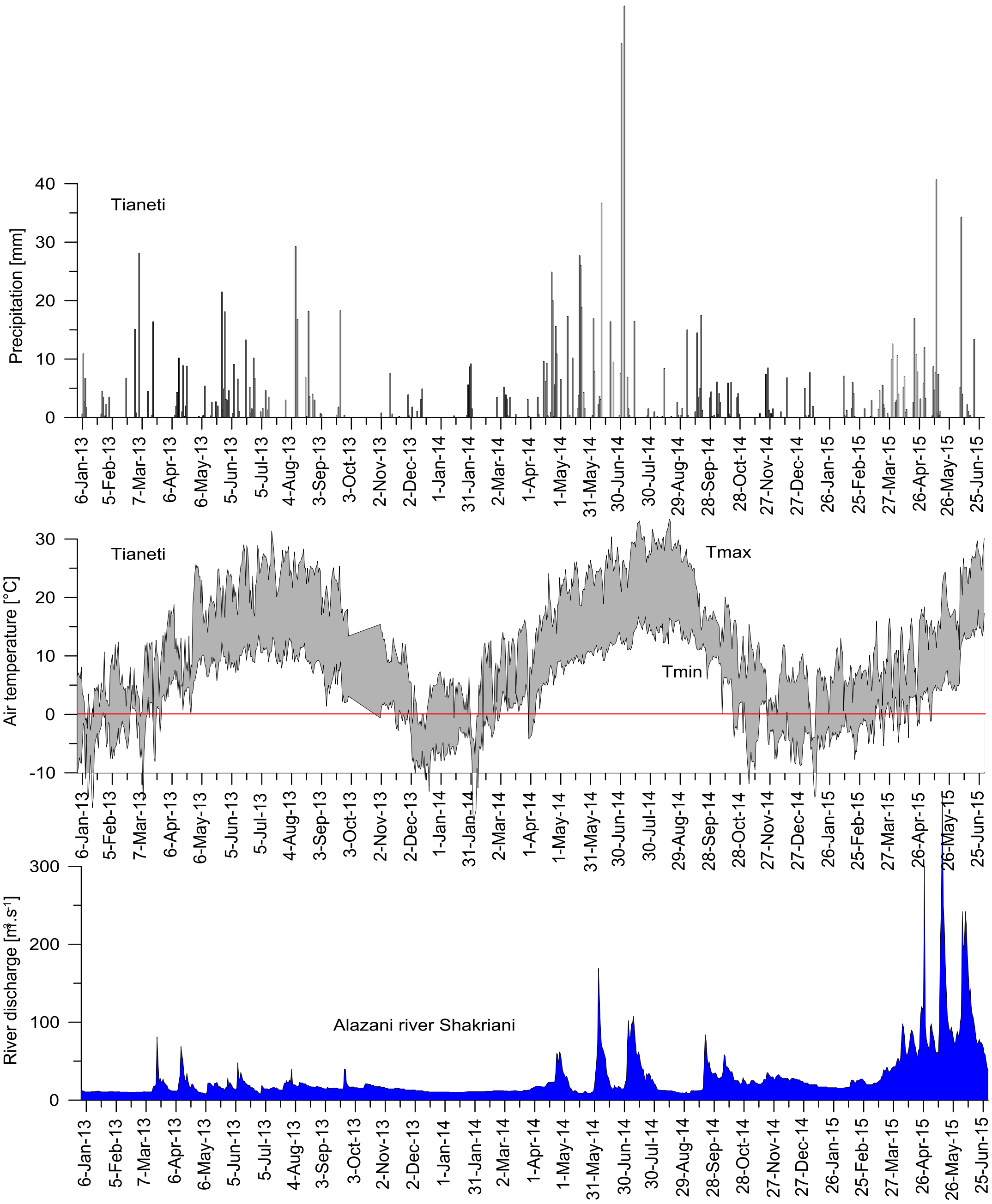

Fig. 11. Daily precipitation and air temperature (minimum, maximum) at Tianeti, daily discharge of Alazani river at Shakriani between 1 January 2013 and 30 June 2015.

Snow cover measurement at 12 snow profiles (281 to 1648 m a.s.l.) was organized by the counterpart on 11th January 2015. The depth of snow cover was only 6 to 17 cm. Comparison of precipitation and discharge data in Fig. 11 and isotopic composition of groundwater and early spring precipitation suggests that replenishment of groundwater storage could also take place in spring months from precipitation. If the seasonal snow cover at the foothills of the Greater Caucasus does not last for a longer period, spring rainfalls might be crucial for groundwater replenishment.

Conclusions

Isotopic composition of river water in the Alazani valley evolves according to a line parallel with the global meteoric water line. Available isotopic data indicate several groups of groundwaters . Some of them probably represents older waters. The most variable indicate the evolution of groundwater isotopic composition from the recharge area in the mountains through river valley to exfiltration areas. The isotopic composition river Alazani near Telavi presented that the river is contributed mainly by isotopically light water from higher altitudes. Deuterium excess has higher values which are typical for mountain precipitation and snow in other mountain ranges. If the seasonal snow cover at the foothills of the Greater Caucasus does not last for a longer period, spring rainfalls might be crucial for groundwater replenishment.

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კახეთის რეგიონში სტაბილური იზოტოპების მეთოდიკის გამოყენება წყლის გენეზისის დადგენის მიზნით

გ. მელიქაძე, ლ. ჰოლკო, ნ. ჯუროვა, მ. თოდაძე, ს. ვეფხვაძე
ნ. კაპანაძე, თ. ჭიქაძე, გ. ქაჯაია

რეზიუმე

მიწისქვეშა წყლების გენეზისის და მოძრაობის გზის შესწავლის მიზნით ორგანიზება გაუკეთდა მათ მონიტორინგს აღმოსავლეთ საქართველოს დაბლობ რაიონებში ალაზანი-შირაქის წყალშემკრებებში. მონიტორინგის მიზანი იყო შესწავლილიყო სტაბილური იზოტოპების ევოლუცია ნალექებიდან, მიწისქვეშა წყლებსა და მდინარის ნაკადამდე, რაც საშუალებას იძლევა დადგინდეს მიწისქვეშა წყლის გადაადგილების დრო, და წყლის ასაკი ალაზანი-შირაქის წყალშემკრებებში. ასევე ორგანიზება გაუკეთდა თოვლის საფარის სიმძლავრის გაზომვებს.

Использование стабильных изотопов для изучения происхождения водных ресурсов в Кахетинском регионе

Г.И Меликадзе, Л. А Голко, Н. О. Жукова, М. Ш.Тодадзе, С. Г. Вепхвадзе, Н. А. Капанадзе, Т. А. Чикадзе, Г.Т. Каджаия

Резюме

С целью выяснения движения и генезиса подземных вод в Восточной Грузии в Алазани-Ширакской низменности был организован их мониторинг. Мониторинговая сеть была создана с целью изучения эвалюции водных изотопов от осадков, поступающих к подземним водам и речным стокам, что позволяет оценить время движения подземного потока, а также возраст воды Алазани-Ширакской водозборов. Также было организовано измерение высоты снежных покровов.