

Impact of the 6 February 2023 Earthquake in Türkiye on Borjomi Mineral Water Wells

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Abstract

The study of Borjomi mineral water deposit starts from the 30 s of XIX century. Chemical composition of Borjomi deposit mineral water is of great importance for study of issues of mineral water formation, creation of geodynamic model of the deposit and increasing of useful resources. The impact of several strong earthquakes in the region on the wells of the deposit is described. Stability of chemical composition of Borjomi deposit mineral water is proved.

Keywords

Borjomi Mineral Water Deposit, Useful Resources of Mineral Water, Earthquake, Chemical Composition, TDS

1. Introduction

Exploration of the Borjomi mineral water deposit started in 30 s of the 19th century. Since then many Georgian and foreign scientists have been involved in exploring the deposit. As a result of the research it was established that “Borjomi” is a carbonate, hydrocarbonate-sodium mineral water.

The goal of this paper is to study and analyze the impact of earthquakes that occurred in the region on wells of Borjomi mineral water deposit, their regime (output, level) and chemical composition.

2. Analysis

Georgia and the regions adjacent to the Black and Caspian Seas are part of the global seismic belt. Several earthquakes of magnitude M6 and above have occurred in Georgia and neighboring countries. **Table 1** shows a list of earth-

quakes that occurred between 1902 and 2011, compiled from various catalogues [1].

Borjomi mineral water deposit is situated in the central part of the Small Caucasus, in a seismic active region where earthquakes of magnitude 3 - 4 are recorded several times a year. Earthquakes recorded in the area of the Borjomi mineral water deposit are shown in **Figure 1**.

On 6 February 2023, a M7.6 magnitude earthquake struck the Türkiye-Syria border region in a fault zone in southeastern Türkiye, destroying thousands of buildings, killing more than 50,000 people and crippling many more. The earthquake had some impact on the Borjomi mineral water deposit (see **Table 2**). The effect of the earthquake on the deposit was manifested in changes in the level in some of the wells. Particularly, level rise within a range of 0.68 - 3.68 m was observed in Wells NN103, 41, 131 and 132 of the Central site; in Wells NN38, 25, 47, 70 of Vashlovani-Kvibisi site the level rise was 4.94 - 25.73 m; in Wells NN 39, 143, 144 of Zanavi site the level rose by 7.54 - 25.29 m; in Well N54 of Likani site the level continued to fall as it was before the earthquake and was -1.18 m, from which we can conclude that this well was not affected by the earthquake (see **Figure 1**). According to the data presented in **Table 3**, the TDS of mineral water in the wells in all four sites of the deposit was virtually the same before the earthquake (January 2023) and after the earthquake (March 2023)].

Figures 2-4 show the impact of the 6 February 2023 earthquake in Türkiye on the output, level and TDS of the Borjomi mineral water deposit wells.

We have analyzed the available stock material and scientific articles on the stability of Borjomi mineral water. In the process of work the following facts were brought to our attention:

- After the Akhalkalaki earthquake (magnitude 6.2) of December 19, 1899 the output of the Ekaterininski spring increased up to 10,000 - 12,000 buckets (1 bucket = 12.3 liters) without changing its chemical composition (before the

Table 1. $M \geq 6$ earthquakes within Georgia and adjoining countries in 1902-2011 [1].

Location	Date	Epicenter	Magnitude	Depth (km)
Kartli	20.02.1920	42.02, 44.1	6.2 ± 0.3	11
Erzurum (Türkiye)	13.09.1924	40.0, 42.0	6.9 ± 0.1	15
Tabatskuri	07.05.1940	41.7, 43.8	6.0 ± 0.2	19
Chkhalta	16.07.1963	43.25, 41.58	6.4 ± 0.2	5
Narmar (Türkiye)	30.10.1983	40.330, 42.187	6.8	15
Spitak (Armenia)	07.12.1988	40.987, 44.185	6.9	5
Racha	29.04.1991	42.453, 43.673	7.0	17
Georgia	23.10.1992	42.589, 45.104	6.4	30
Georgia	07.09.2009	42.660, 43.443	6.0	15
Van (Türkiye)	23.20.2011	38.721, 43.508	7.1	18

Table 2. Chemical composition of Borjomi mineral water wells in 1983-2021.

Well N	Date	Salinity	Na ⁺ + K ⁺		Ca ²⁺		Mg ²⁺		Cl ⁻		HCO ₃ ⁻	
			g/l	mg/eq.%	g/l	mg/eq.%	g/l	mg/eq.%	g/l	mg/eq.%	g/l	mg/eq.%
1	24.01.1983	5.9551	1.5060	87.89	0.0962	6.46	0.0490	5.44	0.3972	15.03	3.8552	84.80
	10.03.2006	5.9161	1.4918	87.51	0.1002	6.76	0.0510	5.73	0.3970	15.09	3.9308	84.75
	02.03.2017	5.8915	1.5280	89.20	0.0840	5.66	0.0452	5.14	0.3820	14.56	3.8430	85.08
	27.06.2019	5.9139	1.5340	88.68	0.0980	6.57	0.0420	4.70	0.3810	14.49	3.8583	85.58
41	24.01.1983	6.0203	1.5235	87.97	0.0962	6.39	0.0486	5.38	0.3972	14.87	3.9040	85.00
	12.02.2003	6.0138	1.5239	87.97	0.1002	6.65	0.0486	5.38	0.3976	14.87	3.9040	87.97
	09.02.2015	6.1464	1.5166	89.24	0.0840	5.68	0.0450	5.08	0.3880	14.89	3.8120	85.11
	13.10.2021	5.9172	1.5200	88.83	0.0940	6.32	0.0432	4.84	0.3862	14.63	3.8735	85.37
54	24.01.1983	5.6648	1.2431	76.64	0.1443	10.21	0.1093	12.92	0.2556	10.21	3.8552	89.62
	12.02.2003	5.6242	1.2425	77.02	0.1403	9.99	0.1094	12.99	0.2556	10.26	3.8308	89.54
	18.08.2016	5.6028	1.2548	76.92	0.1240	8.74	0.1220	14.33	0.2570	10.30	3.8430	89.64
	12.08.2019	5.6012	1.2370	76.90	0.1480	10.71	0.9960	12.02	0.2471	9.88	3.8583	89.80
25	08.12.1983	6.9988	1.9074	95.43	0.0320	1.84	0.0270	2.57	0.4402	14.27	4.5384	85.62
	11.01.2006	7.1675	1.9380	94.79	0.0481	2.71	0.0267	2.50	0.4260	13.50	4.6848	86.33
	10.05.2016	7.1224	1.9578	95.74	0.0320	1.80	0.0263	2.46	0.4083	12.99	4.6970	86.98
	13.10.2021	7.2565	1.9850	95.57	0.0400	2.21	0.0240	2.21	0.4189	13.07	4.7885	86.93

Table 3. Data reflecting the impact of the February 6, 2023 earthquake on the wells of the Borjomi deposit.

Well N	Data before the earthquake 06.02.2023			Data after the earthquake 10.02.2023			Level change rise/drop	Depth of well, m
	Output m ³ /day	Level. m	Salinity g/l (January)	Output m ³ /day	Level. m	Salinity g/l (March)		
Central site								
103	30.50	-50.86	5.0	30.00	-48.74	5.0	+2.12	1000
41	180.80	-8.93	5.9	181.10	-7.65	5.9	+1.28	190
131	124.50	-9.21	5.9	124.50	-8.50	5.8	+0.71	282
Likani								
54	104.50	-52.00	5.6	101.50	-53.18	5.6	-1.18	1400
Vashlovani-Kvibisi								
38	36.00	-36.80	6.6	39.20	-21.22	6.7	+15.58	1370
25	138.00	-21.87	7.2	136.00	-10.84	7.1	+11.03	1500
47	100.00	-35.27	6.9	100.00	-21.22	7.1	+14.05	1350
70	60.50	-27.33	7.0	61.30	-22.38	7.1	+4.95	1300
Zanavi								
39	30.40	-23.45	3.0	30.40	-12.49	3.1	+10.96	1400
143	11.10	-25.53	2.6	17.60	-0.53	2.7	+25.00	1600
144	30.20	-21.96	3.0	30.30	-14.62	3.2	+7.34	1800

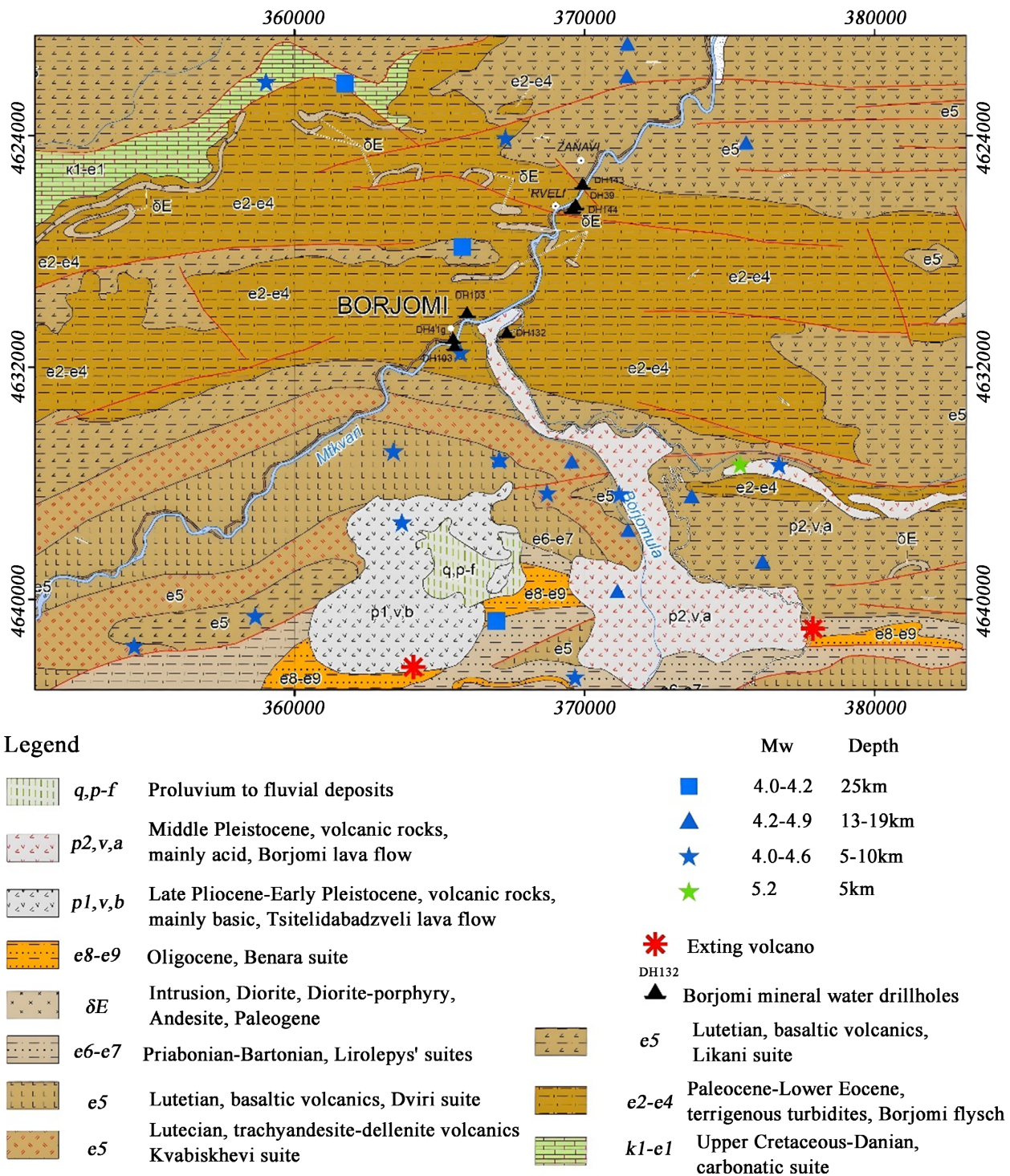


Figure 1. Borjomi mineral water deposit surrounding area is a remarkable site of moderate seismicity [2].

earthquake the output was 7 000 buckets). This earthquake triggered a seismic survey. A seismic station was built in Borjomi in 1913 to monitor the seismic phenomena and their impact on the mineral springs, and accurate equipment was installed [3];

- T. Chichua in his work published in 1956 noted (p.39): “For the Borjomi

mineral waters (which have been extracted by drilling at different periods of exploration) a decrease in the output is considered as typical. The character of the decrease in the output from the tapped wells turned out to be the same. A characteristic feature of all the springs should be considered constancy of the chemical composition in time, fluctuations within a significant range of the output are not accompanied by changes in the components: it was so

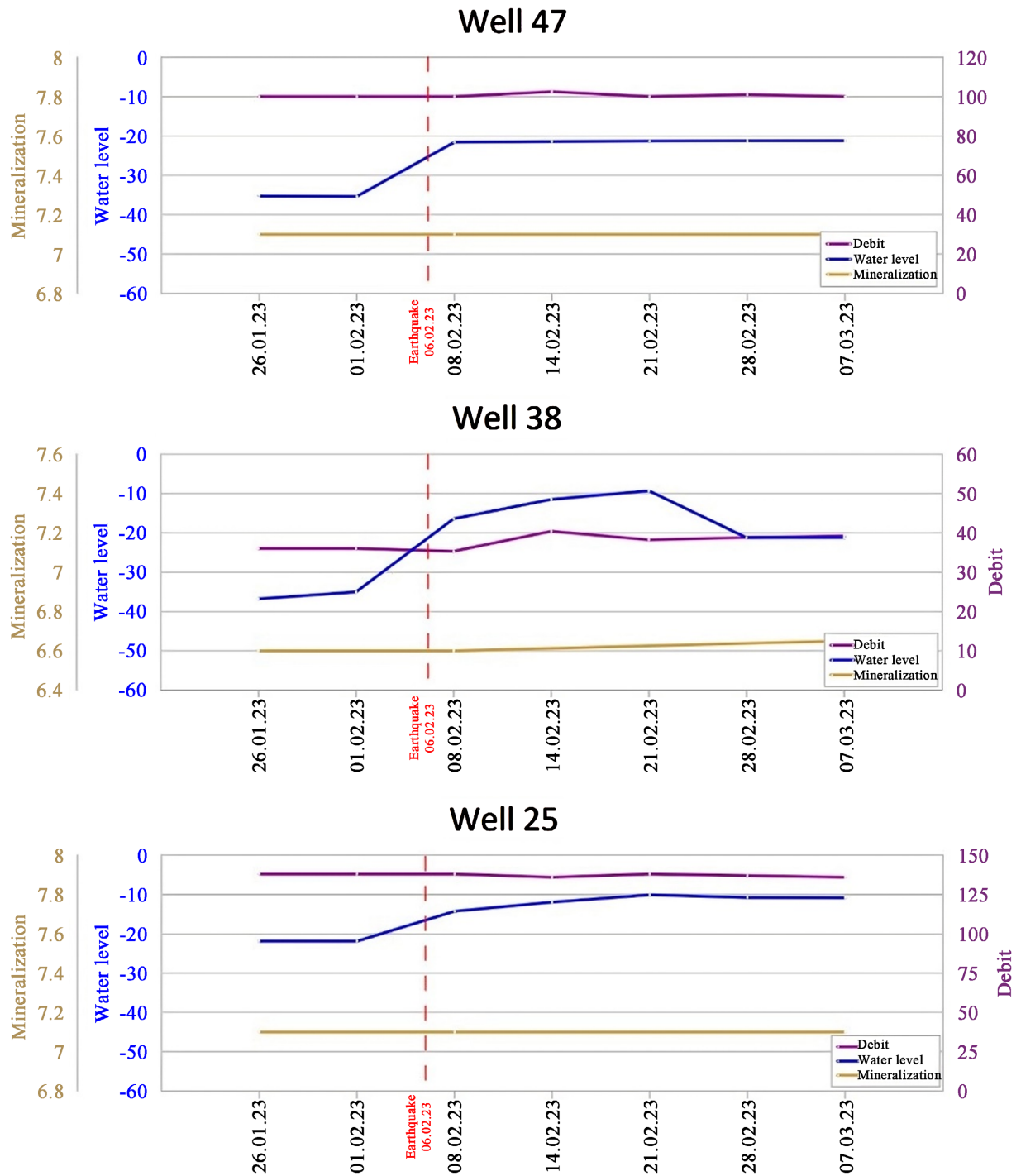


Figure 2. The impact of the February 6, 2023 earthquake in Türkiye on the wells №47, №38 and №25 of the Kvibisi site.

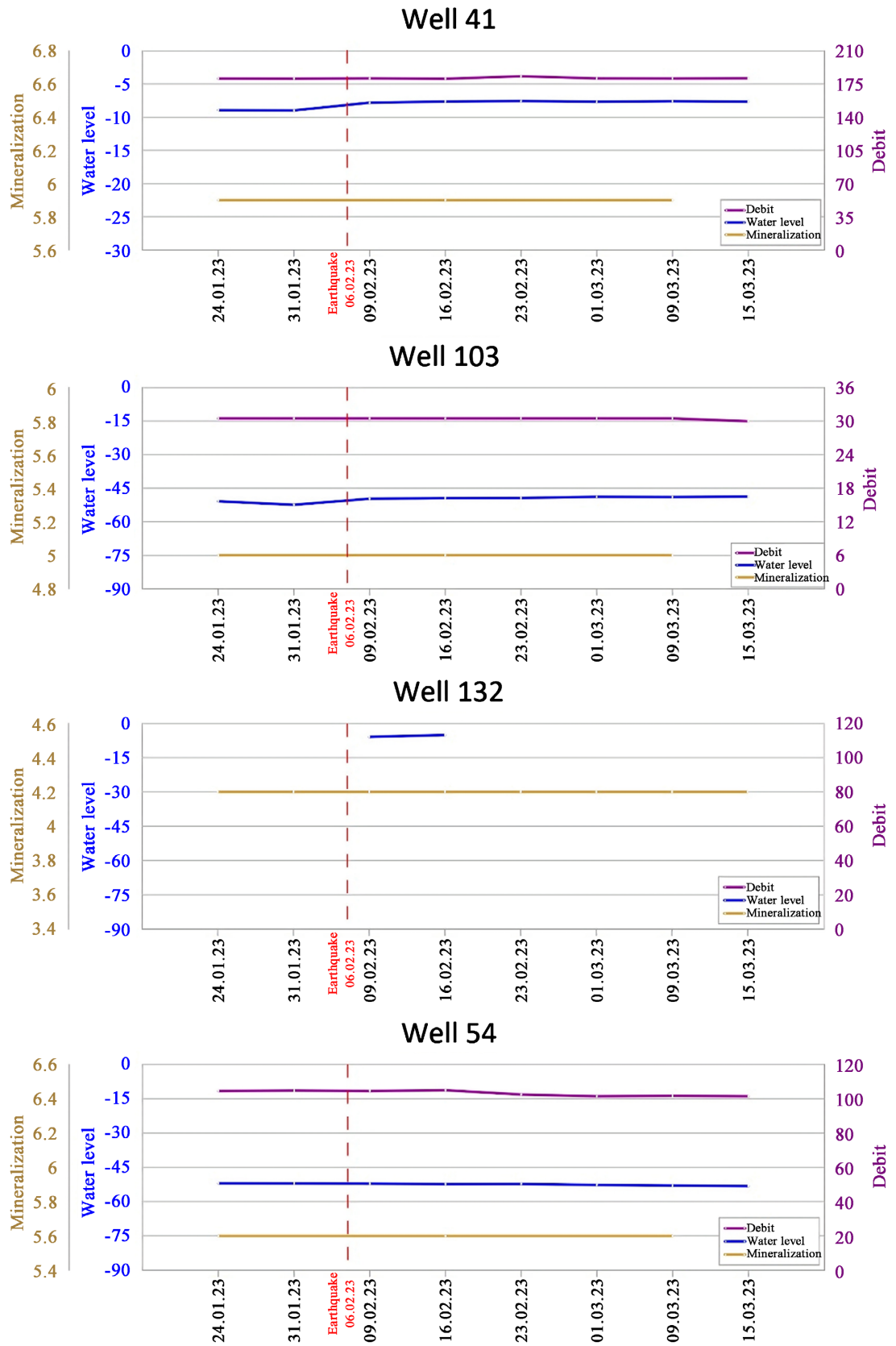


Figure 3. The impact of the February 6, 2023 earthquake in Türkiye on the wells of the Central (№41, №103, №132) and Likani (№54) sites.

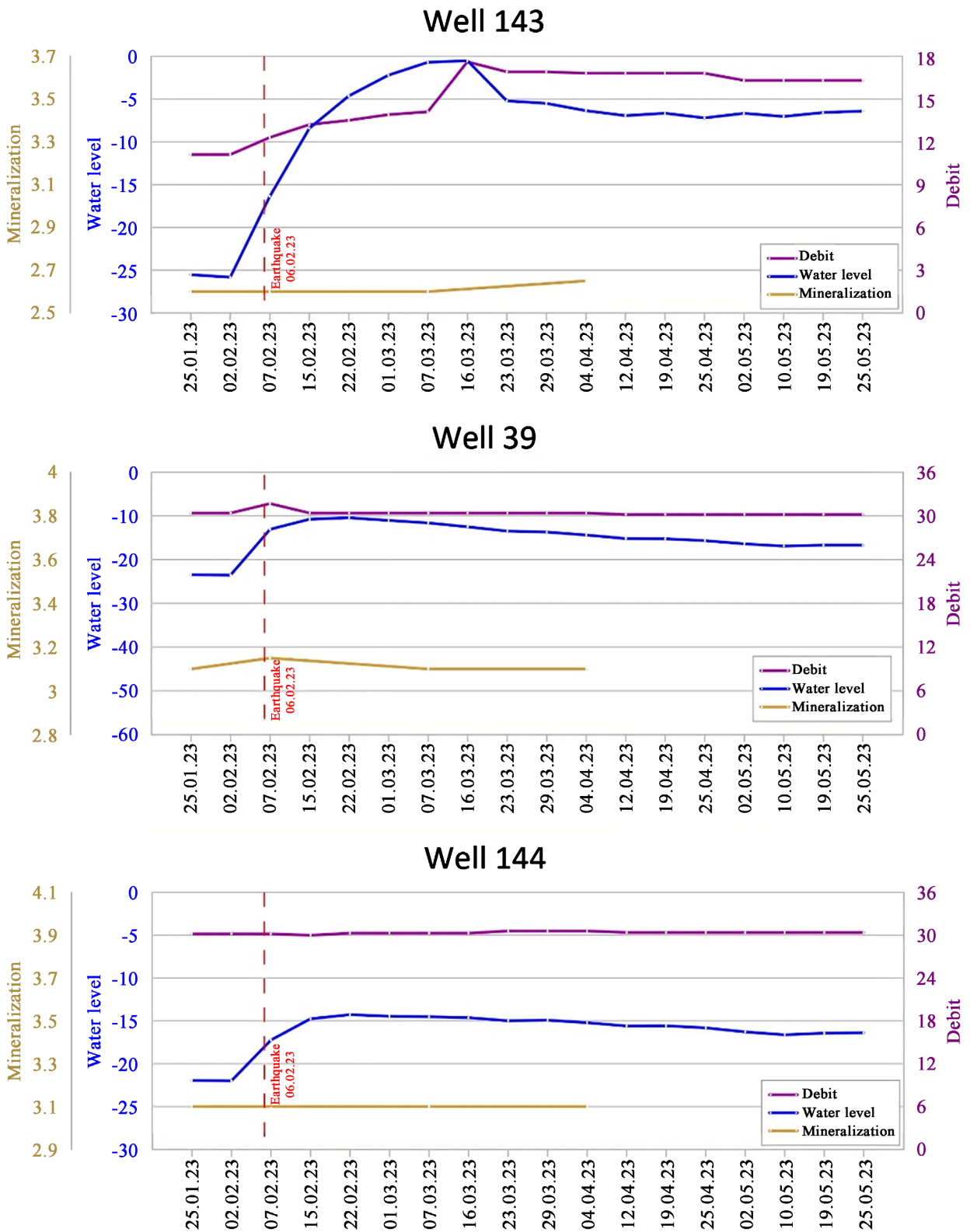


Figure 4. The impact of the February 6, 2023 earthquake in Türkiye on the wells №143, №39 and №144 of the Zanavi site.

before and it continues now” [4].

- S. Chikhelidze in his monograph “Mineral Waters of Georgia” notes: “Bor-

jomi's new tapped wells almost completely repeat the chemical composition of the old wells. Despite dramatic changes in the regime (output) during drilling and thereafter, the chemical composition of individual wells is quite stable and remains within the range of insignificant changes. In particular, water obtained by drilling from Well N 1 of the Park is identical in chemical composition to water of tapped well N 1 (former the Ekaterininski spring), although its temperature is 4° higher than that of Ekaterininski spring" [5].

- On 29 October 2018, a magnitude 4.3 earthquake was recorded in the village of Rveli of Borjomi municipality [2]. The response to the earthquake in the Vashlovani-Kvibisi wells was more significant than in the Central site, as it was located closer to the earthquake epicenter. As a result of the earthquake, levels in the Central site dropped by 0.2 - 2.2 m, while levels in the Vashlovani-Kvibisi wells recovered by 2.5 - 47.8 m. In contrast to the Central site, peaks in the Vashlovani-Kvibisi site were detected asynchronously, indicating the existence of different fracture systems within the boundaries of this site. Nevertheless, there were no changes in the chemical composition of water obtained from wells in these sites [6].
- R. Khargelia in her dissertation "Hydrochemical and environmental studies of the Borjomi mineral water deposit" noted: as a result of earthquakes registered in the Borjomi region, the debit and chemical composition of the Borjomi mineral water practically did not change, which indicates the hydrochemical stability of the mineral water deposit [7].

Table 2 shows chemical composition of water from 4 wells (NN1, 41, 54 and 25) of Borjomi mineral water deposit in 1983-2021. As is known, since the Borjomi bottling plant was commissioned, the mineral water and finished products have been analyzed both at the Borjomi plant and at external testing laboratories, including those in Georgia and abroad.

3. Conclusions

Based on the study of the impact of the Turkish earthquake on February 6, 2023 on the wells of the Borjomi mineral water deposit, the following conclusions can be drawn:

- 1) Throughout the long history of studying the chemical composition of the mineral water "Borjomi", the results of analyses carried out by various researchers show that the content of chemical elements in the water is stable and remains within insignificant changes. Throughout this period the type of water has not changed and it is hydrocarbonate-sodium. Borjomi mineral water is fully compliant with the standards set by the European Union and has been awarded the highest quality status—the category of natural mineral water.
- 2) The impact of the M7.6 earthquake of February 6, 2023 in the Turkish-Syrian border region on the Borjomi mineral water deposit has changed the water level in some wells and increased the output.
- 3) The stability of the chemical composition is one of the main factors in in-

creasing the useful resources of the Borjomi mineral water deposit.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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