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# Investigation of carbon dioxide fluxes and possibility its storage in Georgia

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**Abstract**

The major objective of investigation was study the natural $CO_2$ sources, to investigate the properties of rocks, which contain and absorb $CO_2$ during its emission. Later mentioned rocks will be considered as an underground Carbon dioxide reservoirs. For this case it is important to determine the potential of save sequestration in Carbon dioxide reservoirs and aquifers and to understand the geochemical and mechanical processes associated with long-term storage of $CO_2$ including methods to assess zones of weakness.

## Field study

In this period, to conduct the joint researches, German partners arrived in Georgia and was organized the complex expedition to the South Georgia and Kazbegi region.

In order to study the $CO_2$ distribution and define its quantitative characteristics the field work was organized on the territory of South Georgia, Tbilisi and Kazbegi region were studied all main $CO_2$ sources which in the gas composition contain mostly carbon dioxide – Vardzia, Naqalaqevi, Tmogvi, Akhaltsikhe, Truso and Kazbegi springs.

Fig.# 1 Spring with $CO_2$ and sampling process in Kazbegi (left) and Vardzia (right) region

For field studies the mobile group was equipped with special devices and moved by car along the pre-defined routes and carried out the sampling of natural and artificial springs. For field measurements they used WTW340i (for pH, conductivity, temperature, free oxygen) as well as “SISIE” and “INGEM-1” for Radon and Helium measurements (1,2). Also, special equipment for gas content measuring had been purchased, namely PGD3-IR (Methan, Oxigen, CO2 and HS). Selected points were sampled for typical chemical analysis ((Na, Ca, K, Mg, $HCO_3$, $SO_4$ და Cl) and the samples were shipped to the laboratory (Tbilisi) for further analyze.

Fig #2 Sampling and gas composition measurement process

Fig #3 Radon measurement process on the Tmogvi and Vardzia borehole

The sampled points were mapped by GPS and on the next step the data was processed by ArcMap. By the same software the results of water and gas hydrochemical analysis, as well as geological, hydrogeological and hydrochemical data of the region have been processed. This gave us the possibility of complex studies

During field work had been observed hydrochemical parameters (Na, Ca, K, Mg, $HCO_3$, $SO_4$ and Cl) in underground waters as well as gas content and general peculiarities of Radon distribution. For all observed parameters were determined the background values.

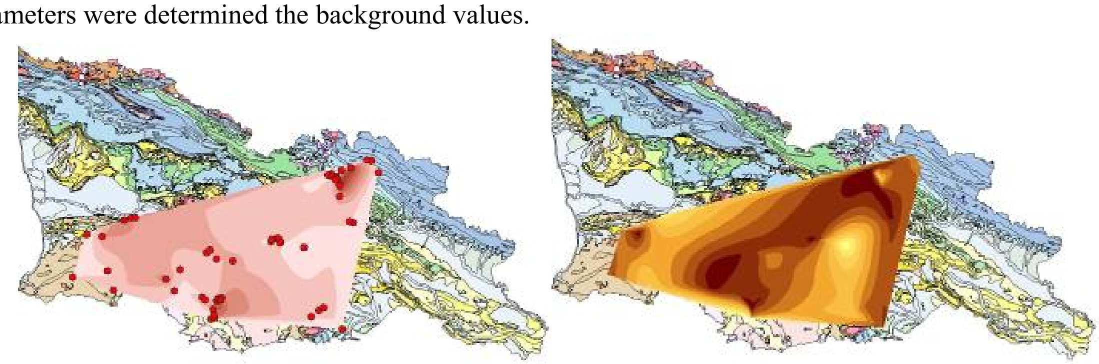

Fig.# 4 Distribution of mineralization (left) and $HCO_3$ (right) of groundwater between difference Geological region

Natural gases are a very sensitive indicative for geological, especially for geotectonic state. As it was expected in distributing of gas associations the properties of the geological structure of Georgia has been obviously revealed. Researches were done in two zones:

1. the northern zone – containing much carbonic acid gases;
2. The southern zone– with the content of nitrogen and carbonic acid gases.

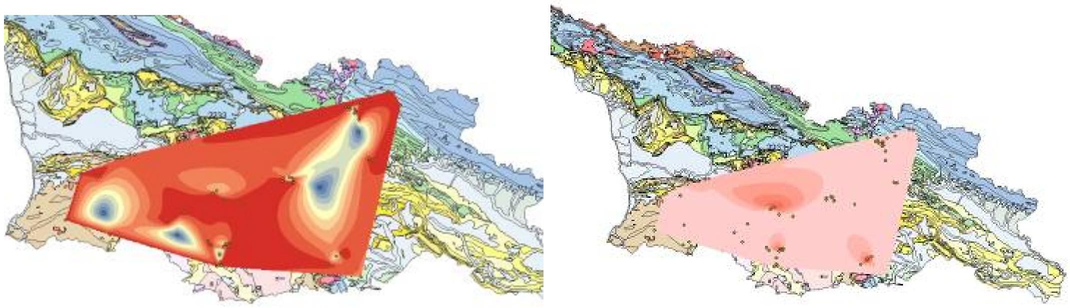

Fig.# 5 Distribution of $CO_2$ (left) and $CH_4$ (right) value of groundwater between difference Geological region

The northern zone contains two geotectonic elements – the main Caucasian anticline block and the great Caucasian folded ridge without the extreme segments in the east and west.

In gas associations of these zones that are connected especially with mineral waters, Carbon dioxide obviously dominates. Investigations do not reveal a clear chemical link between underground waters and carbon dioxide, but the bulk of its exposure is connected with Narzan, the main type of mineral waters on the given territory.

The total content of free $CO_2$ in the waters of North zone, as it was mentioned above, is 1-2 g/l. So high concentration is related with special groups of underground waters and shows the genetic connections of $CO_2$ concentration with magmatic-metamorphic processes. So, the It is evident the volcanic origin of $CO_2$

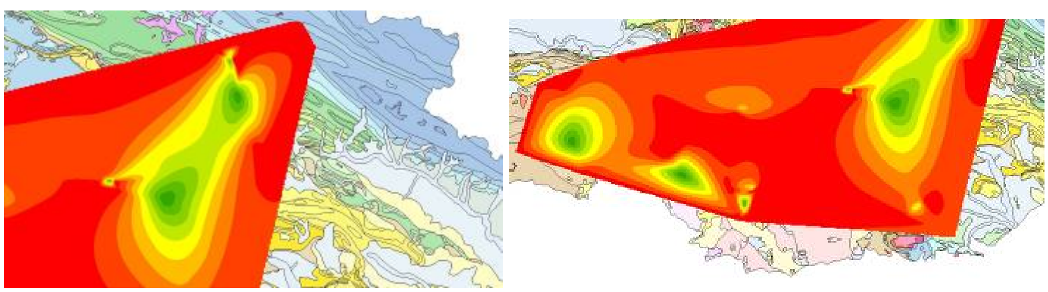

Fig.# 6 Distribution of $CO_2$ value in the North (left) and South (right) region

Carbon dioxide gas exposures in the southern zone are very numerous. Gas factor of Borjomi group as well as Vardzia, Nakalakevi and others often reach 7-10 g/l. Besides, the horizon pressure is quite high (25 atmospheres in a bore hole). Seldom, but dry outlets of carbon dioxide gas are observed anyway. Exposed carbon dioxide amounts to 2 g/l.

All the above mentioned refers to the existence of strong carbon dioxide escalations. Genetic links of carbon dioxide and the young post-magmatic processes cannot be doubtful; besides, the Quaternary lava discovered here refers to the recent volcanic activity (3).

The gas content rock samples were taken from above mentioned places and were sent to Germany for laboratory investigations (Tab. #1).

**Tab. #1 Chemical composition of water and rock from study area**

| Rocks sample | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Components | Borjomi altered | Borjomi fresh | 13_1 fresh | 13_2 altered | 14_1 fresh | 14_2 altered | 14_3 altered | 16A altered | 16B fresh |
| Na2O (%) | 0.94 | 2.09 | 3.76 | 3.71 | 3.77 | 3.58 | 4.41 | 1.59 | 0.86 |
| MgO (%) | 1.89 | 1.27 | 3.05 | 3.00 | 2.79 | 2.74 | 1.64 | 1.43 | 1.10 |
| Al2O3 (%) | 8.00 | 6.42 | 16.92 | 17.42 | 17.02 | 16.38 | 16.36 | 14.66 | 15.92 |
| SiO2 (%) | 44.07 | 40.43 | 61.33 | 61.45 | 60.53 | 58.40 | 67.57 | 70.22 | 68.26 |
| P2O5 (%) | 0.12 | 0.04 | 0.20 | 0.23 | 0.24 | 0.24 | 0.12 | 0.05 | 0.06 |
| K2O (%) | 1.34 | 0.59 | 2.27 | 2.28 | 2.36 | 2.24 | 2.10 | 1.97 | 0.85 |
| CaO (%) | 39.57 | 44.39 | 5.35 | 5.16 | 5.52 | 5.23 | 3.47 | 5.01 | 7.23 |
| TiO2 (%) | 0.38 | 0.23 | 0.70 | 0.74 | 0.72 | 0.71 | 0.52 | 0.34 | 0.37 |
| MnO (%) | 0.20 | 0.51 | 0.11 | 0.10 | 0.11 | 0.11 | 0.07 | 0.05 | 0.04 |
| Fe2O3 (%) | 3.07 | 2.80 | 4.60 | 5.13 | 5.04 | 4.84 | 3.11 | 3.26 | 3.05 |
| Loss on ignition | 11.36 | 26.60 | 0.89 | 1.40 | 0.09 | 1.39 | 0.00 | 7.89 | 7.94 |
| Water samples | | | | | | | | | |
| [mg/L] | Borjomi | | Caucas-1 | | Caucas- | | | Tbilisi | |
| B | 8.40 | | 14.35 | | 12.58 | | | 2.81 | |
| Na | 1380.20 | | 238.90 | | 220.70 | | | 83.64 | |
| Mg | 41.12 | | 35.85 | | 38.35 | | | 0.07 | |
| Al | 0.06 | | 0.10 | | 0.02 | | | 0.04 | |
| P | 0.00 | | 0.16 | | 0.26 | | | 0.04 | |
| K | 31.98 | | 4.88 | | 4.70 | | | 0.65 | |
| Ca | 94.04 | | 114.40 | | 112.50 | | | 2.32 | |
| Mn | 0.05 | | 1.18 | | 0.85 | | | 0.00 | |
| Fe | 2.31 | | 21.30 | | 17.03 | | | 0.01 | |
| Sr | 8.92 | | 1.18 | | 1.21 | | | 0.07 | |
| Ba | 3.58 | | 0.19 | | 0.20 | | | 0.00 | |
| HCO3 | 3837.65 | | 829.76 | | 768.75 | | | 158.63 | |
| Cl- | 245.91 | | 167.52 | | 140.46 | | | 49.37 | |
| SO4(2-) | 0.35 | | 12.98 | | 31.58 | | | 16.86 | |
| F- | 5.73 | | 0.28 | | 0.01 | | | 1.79 | |
| Br- | 0.67 | | 0.37 | | n.a. | | | n.a. | |
| NO3- | 0.37 | | 0.40 | | n.a. | | | n.a. | |

After the analyzing of existing data on geologically safe places for CO2 storage, have been selected few zones: Low craterous age carbonate layer in West Georgia, Middle Eocen age volcanic layer in East Georgia, etc. Tbilisi middle Eocene age thermal and oil bearing horizons have been considered as the best Zone. The suitability of the zone depends on the solidity of cap rocks as well as on possible activation of crack systems in them.

In order to estimate the solidity and suitability of the Middle Eocene water bearing horizon as a gas reservoir, the digital modeling will be carried out by the computer programm FEFLOW (4,5).

**Conclusions**

Was study the natural $CO_2$ distribution on the territory of South and North Georgia and investigated the properties of water samples and of rocks which contain and absorb $CO_2$ during its emission. Later mentioned rocks will be considered as an underground $CO_2$ reservoirs. Next, will be study fluid/rock interactions, will allow us to model these effects and make predictions for $CO_2$ storage sites.

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**References**

1. Avtandil G. Amiranashvili, Tamaz L. Chelidze , George I. Melikadze , Igor Y. Trekov , Mariam Sh. Todadze, "Quantification of the radon distribution in various geographical areas of West Georgia", Journal of Georgian Geophysical Association, №12, 2008.
2. [1] Janja Vaupotič, [1] Mateja Bezek, [2] Nino Kapanadze, [2] George Melikadze, [2] Teona Makharadze, RADON AND THORON MEASURMENTS IN WEST GEORGIA, Journal of the Georgian Geophysical Society, Issue A. Physics of Solid Earth, vol. 15A, 128-137, 2012.
3. Buachidze I. M at all, "Hydrogeology of USSR" Book X, Georgia, "Hedra", Moscow, 1970.
4. GENADY KOBZEV, NINO KAPANADZE, GEORGE I. MELIKADZE, NATALIA ZHUKOVA, CREATION OF NUMERICAL MODEL OF TBILISI GEOTHERMAL DEPOSIT, Workshop materials "Exploration and exploitation of groundwater and thermal water systems in Georgia, 110-124, 2010, Tbilisi, GEORGIA
5. Nino Kapanadze, George I. Melikadze, and Genadi Kobzev, 2011, Modeling of the Tbilisi (Georgia) Geothermal Deposit Under Climate Change Conditions, Climate Change and its Effects on Water Resources, Issues of National and Global Security (Edit Baba, A., Tayfur, G., Gunduz, O., Howard, K.W.F., Fridel, M.J., Chambel, A.), 2011, NATO Science Series. Springer. ISBN:978-94-007-1145-7. Chapter 30, pp.277-284.

## Изучение потоков углекислого газа и возможности его захоронение в Грузии

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**Резюме**

Главной целью исследований было изучение источников природного газа $CO_2$, изучение свойств пород, которые содержат и адсорбируют $CO_2$ при их эмиссии. Упоминаемые позже породы будут рассматриваться как подземные резервуары углекислого газа. В этом случае является важным определение потенциала сохранения в резервуарах и водоносных слоях углекислого газа, а также понимание геохимических и механических процессов, связанных с долговременным хранением $CO_2$, включая методы оценки нарушенных зон.

## ნახშიორჟანგის ბუნებრივი ნაკადების და მათი შენახვის შესაძლებლობის შესწავლა

გიორგი მელიქაძე, ოლგა კორტინგ, ნინო კაპანაძე, ბირგიტ მიულერ, მარიამ თოდაძე

აბსტრაქტი

კვლევის მთავარი მიზანი იყო ნახშიორჟანგის ბუნებრივი წყაროების შესწავლა, ნახშიორჟანგის შემცველი ქანების თვისებების შესწავლა. ეს ქანები შემდგომში განიხილება, როგორც რეზერვუარი ნახშიორჟანგის მიწისქვეშა შენახვისთვის. ამ შემთხვევაში მნიშვნელოვანია განისაზღვროს ნახშიორჟანგის რეზერვუარებში და მიწისქვეშა ჰორიზონტებში შენახვის შესაძლებლობის განსაზღვრა, ასევე გეოქიმიური და მექანიკური პროცესების გაგება, რომლებიც დაკავშირებულია ნახშიორჟანგის ხანგძლივი დროით შენახვასთან, მათ შორის რღვევის ზონებში.