

# XXXVIII IAH Congress

Groundwater Quality Sustainability  
Krakow, 12–17 September 2010

## Extended Abstracts

**Editors:**  
Andrzej Zuber  
Jarosław Kania  
Ewa Kmiecik



University  
of Silesia  
Press 2010



abstract id: **428**

topic: **2**

**Groundwater and dependent ecosystems**

**2.4**

**Water in extreme conditions (arid and polar regions)**

title: **Characteristics of chemical weathering in a periglacial catchment of the Obrucheve Glacier (Polar Urals, Russia)**

author(s): **Łukasz M. Stachnik**

Jagiellonian University, Institute of Geography and Spatial Management, Poland,  
[l.stachnik@uj.edu.pl](mailto:l.stachnik@uj.edu.pl)

keywords: chemical weathering, Polar Urals, Obrucheve Glacier, periglacial basin

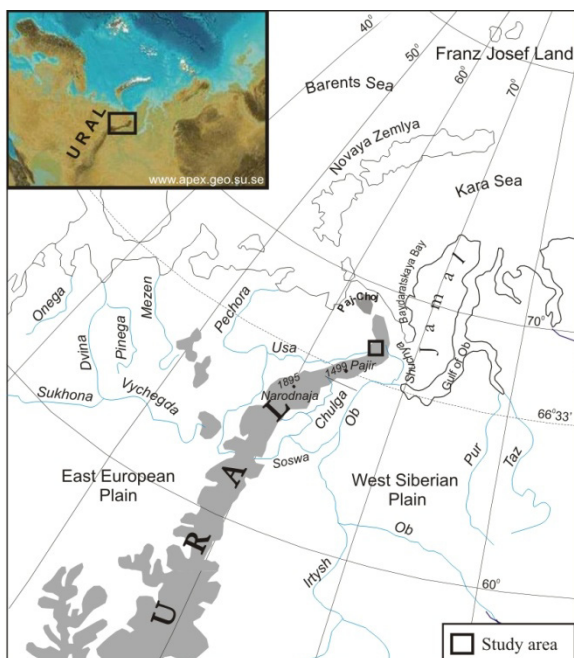
## INTRODUCTION

Modern hydrochemical research in polar and alpine regions tends to be focused primarily on glaciated basins (Collins, 1979; Tranter et al., 1996; Hodson et al., 2000; Brown, 2002). The hydrochemical properties of periglacial basins, however, have not received as much attention (Caine, 1992; Darmody et al., 2000; Beylich et al., 2004).

Hydrochemical investigations were carried out in the periglacial basin of Obrucheve Glacier (Polar Urals, Russia) in order to provide main features of chemical weathering occurring during the ablation season. Additionally, mineral composition of rocks and deposits was taken into account.

## STUDY AREA

The Obrucheve Glacier Basin (OGB, Fig. 1) is 12.83 km<sup>2</sup> in area (glacier covers about 2%). The study area is characterized by changes in elevation up to 900 m. The depth of snow cover varies from 0.5 m in open areas to 50 m in cirques (Tushinkiy, 1963).



**Figure 1.** Study area.

From point of view of geology, OGB is located in a Mid-Ural zone formed primarily of paleozoic metamorphic rocks (phyllite, chlorite schist, sericite schist and rarely gneiss). Mineral composition comprises primary of silicate minerals such as micas (mainly muscovite) as well as small amounts of paragonite, quartz, chlorite and feldspars (mainly plagioclases).

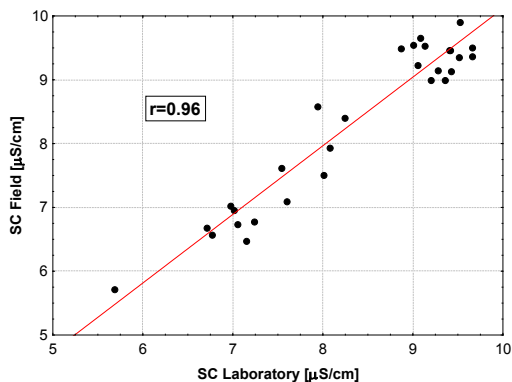
## METHODS

Specific conductivity and temperature of water were obtained by ELMETRON conductometer CC-315 (conductivity sensor CFT-201,  $k=0.1/\text{cm}$ ). Before investigations, conductivity sensor was calibrated by the Hamilton conductivity standard ( $147 \mu\text{S}/\text{cm}$ ). During field work, water samples were filtered using membrane nylon filters (Whatman  $0.45 \mu\text{m}$ ) and Sartorius filtration kit. The filtered water samples were kept in a dark place at temperatures below  $4^\circ\text{C}$ . Collected water samples were analyzed by the ion chromatograph ICS-2000 DIONEX (detection limits are shown in Tab. 1) at the Hydrochemical Laboratory of the Institute of Geography and Spatial Management at the Jagiellonian University in Kraków (Poland).

**Table 1.** Detection limits of the ion chromatograph DIONEX ICS-2000 RFIC.

Ion	Detection limit [ppb]
$\text{Ca}^{2+}$	5.0
$\text{Mg}^{2+}$	5.0
$\text{Na}^+$	10.0
$\text{K}^+$	5.0
$\text{NH}_4^+$	5.0
$\text{Li}^+$	5.0
$\text{HCO}_3^-$	25.0
$\text{SO}_4^-$	10.0
$\text{Cl}^-$	2.5
$\text{NO}_3^-$	2.5
$\text{NO}_2^-$	2.5
$\text{PO}_4^{3-}$	10.0
$\text{F}^-$	1.0
$\text{Br}^-$	5.0

Assuming very low ion concentration, charge balance error was rather low (on average 5.7%; Tab. 2). Additionally, relationship between conductivity measured in the laboratory and in the field were significant and positive ( $r=0.96$ ; Fig. 2). The research was performed during the ablation season (summer) during the following two periods: 1) with snow cover – July 11, 2008 to Aug. 2, 2008), and 2) without snow cover – Aug. 2, 2007 to Aug. 20, 2007).



**Figure 2.** Comparison of Specific Conductivity (SC) measured in the laboratory and in the field.

## RESULTS AND CONCLUSIONS

According to Polish standard for acceptable charge balance error (PN-89/C-04638/02), very low TDS allows to interpret water analyzes, even if charge balance error is slightly higher than 10%. Moreover, significant and positive correlation coefficient between conductivity measured in the laboratory and in the field also enables to use these hydrochemical data to describe main features of chemical weathering in OGB.

The total dissolved solids (TDS) in the surface waters of the investigated basin is very low (4.48–7.92 mg dm<sup>-3</sup>). It is most of all due to harsh local climate conditions, resistant geologic structure (mainly chlorite-sericite schist and phyllite) as well as small extent of geochemically active moraines from Last Glacial Maximum (LGM). These factors contribute to the low rate of chemical weathering in the study area. The concentration of dissolved solids in the waters of the investigated basin can be as much as several times lower than that in periglacial basins located on the Scandinavian Peninsula (Beylich et al., 2004; Darmody et al., 2000) and in the Rocky Mountains (Caine, 1992).

Calcium (1.27 mg dm<sup>-3</sup>, on average) and HCO<sub>3</sub><sup>-</sup> (3.32 mg dm<sup>-3</sup>, on average) dominated the chemical composition of water samples. Moderate concentrations of the following ions were detected: SO<sub>4</sub><sup>2-</sup> (0.74 mg dm<sup>-3</sup>, on average), Na<sup>+</sup> (0.51 mg dm<sup>-3</sup>, on average), NO<sub>3</sub><sup>-</sup> (0.34 mg dm<sup>-3</sup>, on average), Cl<sup>-</sup> (0.32 mg dm<sup>-3</sup>, on average); (Tab. 2).

**Table 2.** Descriptive statistics of chemical composition of surface water (N=34) from the Obruchev Glacier Basin; Av - average, Min - minimal, Max - maximum, Sd - standard deviation, Cv - coefficient of variation.

	Av	Min	Max	Sd	Cv
	[mg/L]				[%]
Ca <sup>2+</sup>	1.27	0.92	1.61	0.130	10
Mg <sup>2+</sup>	0.072	0.054	0.084	0.0073	10
Na <sup>+</sup>	0.51	0.36	0.73	0.068	13
K <sup>+</sup>	0.073	0.044	0.24	0.035	48
NH <sub>4</sub> <sup>+</sup>	0.0156	0.0038	0.047	0.010	63
HCO <sub>3</sub> <sup>-</sup>	3.32	2.02	4.17	0.59	18
SO <sub>4</sub> <sup>2-</sup>	0.74	0.57	0.83	0.052	7
Cl <sup>-</sup>	0.33	0.25	0.68	0.082	25
NO <sub>3</sub> <sup>-</sup>	0.35	0.25	0.46	0.057	16
TDS	6.68	4.48	7.92	0.79	12
Charge balance error	5.7	-0.50	12.4	3.0	52

Lower amounts of the remaining ions were detected and their concentration order was as follows: K<sup>+</sup>>Mg<sup>2+</sup>>NH<sub>4</sub><sup>+</sup>>F<sup>-</sup>>NO<sub>2</sub><sup>-</sup>. According to indices of chemical weathering (Hounslow 1995), it appears that several different factors are determining elevated Ca<sup>2+</sup> concentrations. It may be trace amounts of calcium plagioclase in rocks and deposits, aeolian delivery of dust particles from carbonate-dominated basins located to the south (e.g. Pajpudyna River catchment) or an ion exchange process.

Moreover, results obtained indicate that a larger dissolved solids yield was transported during the period with snow cover (106 kg/km<sup>2</sup> day, on average), than at the same time of the year but

without snow cover (13 kg/km<sup>2</sup> day, on average) indicating that melting snow is an important factor impacting the yield of dissolved solids in surface waters.

#### ACKNOWLEDGEMENT

Authors would like to thank Barbara Jaszczyńska and Łukasz Jelonkiewicz (Institute of Geography and Spatial Management, Jagiellonian University) for hydrochemical analysis of water samples; Anna Łatkiewicz (Institute of Geological Sciences, Jagiellonian University) for determining mineral content of rocks and deposits by XRD.

#### REFERENCES

- Beylich A., Kolstrup E., 2004: *Water chemistry and its diversity in relation to local factors in the Latnjavagge drainage basin, arctic-oceanic Swedish Lapland*. *Geomorphology*, 58, pp. 125-143.
- Brown G., 2002: *Glacial meltwater hydrochemistry*. *Applied Geochemistry*, 17, 7, pp. 855-883.
- Caine N., 1992: *Spatial patterns of geochemical denudation rate in a Colorado Alpine Environment*. [ed.] J.C. Dixon, A.D. Abrahams *Periglacial Geomorphology Proceedings to the 22<sup>nd</sup> Annual Binghamton Symposium in Geomorphology*, pp. 63-88.
- Collins N., 1979: *Hydrochemistry of meltwaters draining from an alpine glacier (Gornergletscher, Switzerland)*. *Arctic and Alpine Research*, 11, 3, pp. 307-324.
- Darmody R.G., Thorn C.E., Harder R.L., Schlyter J.P.L., Dixon J.C., 2000: *Weathering implications of water chemistry in an arctic-alpine environment, northern Sweden*. *Geomorphology*, 34, pp. 89-100.
- Hodson A., Tranter M., Vante G., 2000: *Contemporary rates of chemical denudation and CO<sub>2</sub> sequestration in glacier basins: an Arctic perspective*. *Earth Surface Processes and Landforms*, 25, pp. 1447-1471.
- Hounslow A. W., 1995: *Water Quality Data Analysis and Interpretation*. Lewis Publisher. 370 p.
- Tranter M., Brown G. H., Hodson A. J. and Gurnell A. M., 1996: *Hydrochemistry as an indicator of subglacial drainage system structure: A comparison of alpine and sub-polar environments*. *Hydrological Processes*, 10, 4, pp. 541-556.
- Tushinskiy G.K., 1963: *Glaciers, snowfield, and avalanche of the Soviet Union*. State Publishing House of Geographical Literature. Moscow.



**International Association of Hydrogeologists**



**AGH University of Science and Technology**

**2-vol. set + CD**  
**ISSN 0208-6336**  
**ISBN 978-83-226-1979-0**