

An abstract 3D graphic of a ribbon or strip of material, colored in a gradient from yellow to green to blue, curving and looping across the cover. The background is a light yellow-green color with a subtle grid pattern.

**16th INTERNATIONAL MULTIDISCIPLINARY
SCIENTIFIC GEOCONFERENCE
SGEM 2016**

Book 1
Science and Technologies in Geology,
Exploration and Mining

CONFERENCE PROCEEDINGS
Volume I

GEOLOGY
HYDROGEOLOGY
ENGINEERING GEOLOGY & GEOTECHNICS

**16th INTERNATIONAL MULTIDISCIPLINARY
SCIENTIFIC GEOCONFERENCE
S G E M 2 0 1 6**



**SCIENCE AND TECHNOLOGIES IN GEOLOGY,
EXPLORATION AND MINING
CONFERENCE PROCEEDINGS
VOLUME I**

GEOLOGY

**HYDROGEOLOGY, ENGINEERING GEOLOGY AND
GEOTECHNICS**

**30 June – 6 July, 2016
Albena, Bulgaria**

DISCLAIMER

This book contains abstracts and complete papers approved by the Conference Review Committee. Authors are responsible for the content and accuracy.

Opinions expressed may not necessarily reflect the position of the International Scientific Council of SGEM.

Information in the SGEM 2016 Conference Proceedings is subject to change without notice. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, for any purpose, without the express written permission of the International Scientific Council of SGEM.

Copyright © SGEM2016

All Rights Reserved by the International Multidisciplinary Scientific GeoConferences SGEM

Published by STEF92 Technology Ltd., 51 "Alexander Malinov" Blvd., 1712 Sofia, Bulgaria

Total print: 5000

ISBN 978-619-7105-55-1

ISSN 1314-2704

DOI: 10.5593/sgem2016B11

**INTERNATIONAL MULTIDISCIPLINARY SCIENTIFIC GEOCONFERENCE SGEM
Secretariat Bureau**

Phone: +359 2 4051 841

Fax: +359 2 4051 865

E-mails: sgem@sgem.org | sgem@stef92.com

URL: www.sgem.org

ORGANIZERS AND SCIENTIFIC PARTNERS

- BULGARIAN ACADEMY OF SCIENCES
- ACADEMY OF SCIENCES OF THE CZECH REPUBLIC
- LATVIAN ACADEMY OF SCIENCES
- POLISH ACADEMY OF SCIENCES
- RUSSIAN ACADEMY OF SCIENCES
- SERBIAN ACADEMY OF SCIENCES AND ARTS
- SLOVAK ACADEMY OF SCIENCES
- NATIONAL ACADEMY OF SCIENCES OF UKRAINE
- INSTITUTE OF WATER PROBLEM AND HYDROPOWER OF NAS KR
- NATIONAL ACADEMY OF SCIENCES OF ARMENIA
- SCIENCE COUNCIL OF JAPAN
- THE WORLD ACADEMY OF SCIENCES (TWAS)
- EUROPEAN ACADEMY OF SCIENCES, ARTS AND LETTERS
- ACADEMY OF SCIENCES OF MOLDOVA
- MONTENEGRIN ACADEMY OF SCIENCES AND ARTS
- CROATIAN ACADEMY OF SCIENCES AND ARTS, CROATIA
- GEORGIAN NATIONAL ACADEMY OF SCIENCES
- ACADEMY OF FINE ARTS AND DESIGN IN BRATISLAVA
- TURKISH ACADEMY OF SCIENCES
- BULGARIAN INDUSTRIAL ASSOCIATION
- BULGARIAN MINISTRY OF ENVIRONMENT AND WATER

HONORED ORGANIZER



BULGARIAN ACADEMY OF SCIENCES

EXCLUSIVE SUPPORTING PARTNER



INTERNATIONAL SCIENTIFIC COMMITTEE

Science and Technologies in Geology, Exploration and Mining

- PROF. JEAN-PIERRE BURG, SWITZERLAND
- ACAD. DMITRY Y. PUSHCHAROVSKY, RUSSIA
- PROF. YEVGENY KONTAR, USA

46. MATERIAL COMPOSITION OF COASTAL MARINE PLACER DEPOSITS OF THE ARABIAN SEA COAST (KOLLAM, KERALA, INDIA), L.M. Sitdikova, E.A. Ibragimov, O.R. Badrutdinov, N.M. Khasanova, I.I. Mukhamatdinov, Kazan (Volga Region) Federal University, Russia.....	361
47. MATERIAL COMPOSITION OF THE UPPER JURASSIC HORIZON OF TEVLINSKO-RUSSKINSKY FIELD (WEST SIBERIAN OIL AND GAS PROVINCE), L.M. Sitdikova, V.G. Izotov, L.N. Bruzhes, E.U. Sidorova, I.I. Mukhamatdinov, Kazan (Volga Region) Federal University, Russia.....	369
48. MICROFACIES OF THE ANISIAN – LADINIAN CARBONATES IN THE TRANSYLVANIAN FACIES FROM THE NORTHERN COMPARTMENT OF THE CRYSTALLINE MESOZOIC AREA OF THE EASTERN CARPATHIANS, Popescu Daniela Alexandra, Popescu Liviu Gheorghe, Stefan cel Mare University of Suceava, Romania	377
49. MINERALOGICAL AND CHEMICAL FEATURES OF BRINES AND MODERN EVAPORITES OF TALOE LAKE TRACT (REPUBLIC OF KHAKASSIYA), Student Mariya Ivanova, Assoc.Prof. Platon Tishin, Assoc.Prof. Alexander Arkhipov, Tomsk State University, Russia	389
50. MINERALOGICAL AND GEOCHEMICAL CHARACTERISTICS OF MARBLE: A CASE STUDY FROM THE MUSTAFA KEMALPASA-BURSA AREA, NORTHWEST TURKEY, Assist. Prof. Dr. Oya Cengiz, M.Sc. Ertan Ozgedemir, Suleyman Demirel University, Turkey.....	397
51. MINERALOGICAL AND PETROGRAPHIC CHARACTERISTICS OF THE MIOCENE RESERVOIR ROCKS FROM BAICOI OIL FIELD (CARPATHIAN FOREDEEP, ROMANIA), Dr. Eng. Gheorghe-Adrian Branoiu; Assoc. Prof. Dr. Eng. Maria Stoicescu; Lecturer Dr. Eng. Doru Stoianovici, Petroleum-Gas University of Ploiesti, Romania.....	405
52. MINERALOGICAL METHODS INVESTIGATION OF PATHOLOGICAL BIOMINERALS, Ass.Prof. Oksana V, Bukharova, Lect. Evgeniya M. Asochakova, Stud. Aleksander E. Marfin , Tomsk State University, Russia	413
53. MINERALOGY AND GEOCHEMISTRY OF THE KIZILTEPE (CAMARDI-NIGDE) MN PROSPECT IN CENTRAL ANATOLIA, TURKEY, Asst. Prof. Dr. Abdurrahman Lermi, Asst. Prof. Dr. Mustafa Sonmez , Prof. Dr. Faruk Aydin, Nigde University, Turkey.....	421
54. MINERALOGY AND PORE-SIZE DISTRIBUTION OF FINE-GRAINED SEDIMENTARY ROCKS OF CARBONIFEROUS AND CRETACEOUS AGE, ZONGULDAK COAL BASIN, NW TURKEY, Levent Bayram, Prof. Dr. Ali Ihsan Karayigit, Dr. Maria Mastalerz, Hacettepe University, Turkey	429

55. MORPHOLOGICAL AND GENETIC TYPES OF UNCONVENTIONAL RESERVOIR ZONES WITHIN BASEMENT OF THE TATAR ARCH, E.U. Sidorova, L.M. Sitdikova, Y.V. Onishchenko , Kazan (Volga Region) Federal University, Russia.....	437
56. NOTORIOUS ROMANIAN GEOLOGISTS, Asoc. Prof. Dr. Eugen Mihail Ionescu, Assoc. Prof. Dr. Maria Stoicescu, Petroleum-Gas University of Ploiesti, Romania.....	445
57. OIL GENERATION POTENTIAL OF THE PERMIAN DEPOSITS OF TATARSTAN BASED ON THE CONTENT, STRUCTURE AND THERMAL STABILITY OF ORGANIC MATTER IN ROCKS, G.P.Kayukova, I.P.Kosachev, I.N.Plotnikova, D.A.Feoktistov, VA Vakhine, A.E. Arbutov Institute of Organic and Physical Chemistry KSC RAS, Russia.....	453
58. PALEOGENE STRATIGRAPHY AND MOLLUSCA FAUNA OF NORTHERN PART OF THE BIGA PENINSULA: FICITEPE FORMATION BETWEEN LAPSEKI-SEVKETIYE, CANAKKALE, Birben Gursoy, Sevinc Kapan, Canakkale Onsekiz Mart University, Turkey	461
59. PALEO GEOGRAPHIC FACTORS OF THE FORMATION OF PERMIAN RESERVOIR ROCKS OF BITUMEN DEPOSITS IN THE EAST OF THE RUSSIAN PLATE (RUSSIA), Assoc. Prof. DSc Rinat Khasanov, Almaz Mullakaev, Kazan (Volga Region) Federal University, Russia	469
60. PECULIARITIES GYPSUM CRYSTALS STRUCTURE BASED ON ELECTRON PARAMAGNETIC RESONANCE RADIATION DEFECTS, Assoc. Prof. Dr. N.M. Khasanova, Assoc. Prof. Dr. R.A. Khasanov, Assoc. Prof. Dr. N.M. Nizamutdinov, Prof. Dr. D.K. Nurgaliev, Kazan (Volga Region) Federal University, Russia	475
61. PLIOCENE STAGE STRATOTYPES IN THE BUZAU LAND GEOPARK (ROMANIA), Dr. Rodica Macalet, Dr. Titus Brustur, Dr. Dan Jipa, Dr. Andrei Briceag, Geologist Ion Stanescu, National Institute of Marine Geology and Geoecology GeoEcoMar, Romania	483
62. POLLUTION EVALUATION OF HEAVY METALS IN SEDIMENTS FROM THE CAKIT STREAM, ULUKISLA (NIGDE), TURKEY, Asst. Prof. Dr. Abdurrahman Lermi, Nigde University, Turkey	491
63. POTENTIAL DATA INTERPRETATION AND 2½D MODELLING AIMING TO DECIPHER AN ELEVATED STRUCTURE REVEALED BY 3D SEISMIC ON THE ROMANIAN OFFSHORE, Dr. Radu G. Dimitriu, Prof. Dr. Corneliu Dinu, Dr. Ioan Munteanu, Irina M. Stanciu, National Institute of Marine Geology and Geoecology GeoEcoMar, Romania	499

**MINERALOGICAL AND CHEMICAL FEATURES OF BRINES AND
MODERN EVAPORITES OF TALOE LAKE TRACT (REPUBLIC OF
KHAKASSIYA)**

Student **Mariya O. Ivanova**

Acad. **Prof. Platon A. Tishin**

Acad. **Prof. Alexander L. Arkhipov**

Tomsk State University, **Russian Federation**

ABSTRACT

This work is dedicated to study of mineralogical and chemical features of modern evaporites and producing brines. The subject of inquiry is tract of Taloe lake (Republic of Khakassiya), which represents isolated basin. This basin consists of two temporary reservoirs with areas 3300×960 m and 1610×385 m, located at different hypsometric levels.

Mineral composition has been studied with use of X-ray diffraction analysis and raster electronic microscopy methods. As a result, it's found out that every hypsometric level has its certain complex of minerals. For the lower level there are halite, thenardite, astrahonite, gypsum, calcite, dolomite, plagioclase, quartz, mica and chlorite. For the reservoir at the upper level halite, calcite, gypsum, astrahonite, quartz, plagioclase, mica, chlorite are typical. Lateral zonality of minerals formation, which consists in regular change of minerals from bank to central part of the reservoir, has been stated at this level.

Chemical composition study is based on titrimetric analysis and inductively coupled plasma mass spectrometry (ICP-MS) results. Samples of surface and subterranean waters have been analyzed. Waters of the reservoirs are mainly of chloride type and are enriched with Li, B and Sr. But according to certain chemical parameters they differ significantly. Reservoir at the lower hypsometric level is notable for high degree of mineralization of surface waters (85,4 g/l) and low degree of mineralization of subterranean waters (4,7 g/l). According to pH value waters are alkaline, this is confirmed by large quantity of Na. Reservoir at the upper hypsometric level characterized by high degree of mineralization of surface (30,4-36,6 g/l) and subterranean (104,9-108,3 g/l) waters. Large quantities of Ca and Mg indicate that waters of this reservoir are hard. According to pH value waters are normal.

With the purpose of determination of brines, which produce evaporites, analysis of trace elements distribution in sediments has been carried out. Besides common level of accumulation, distribution of evaporite and terrigenous constituents has been studied. Enrichment with Li, Sr, V, Ba compounds has been stated.

Keywords: Evaporites, brines, mineral association, microelements.

INTRODUCTION

Study of mineral and chemical compositions of bottom sediments and surface waters and ground waters, which associate with the sediments, allows to solve a number of sedimentological, geochemical and ecological issues [2, 5, 13]. Direct observations of modern "brine – sediment" system enable modeling of chemogenic mineral formation and make extrapolation of the model to old lithologic associations possible [11, 13]. Variants of microelements redistribution between bottom sediments on the one hand and surface and ground waters on the other hand form the informative base of technogenic metals accumulation [7]. In cases when brines represent hydromineral resource, mineralogical and geochemical studying them bears technological meaning [7].

This investigation is focused on determination of degree of surface and ground waters influence on sediments composition in modern enclosed evaporite systems. As an object of research saline enclosed low-mountain sink "Taloe lake tract" (Eastern Siberia) has been considered.

GEOLOGIC AND GEOMORPHIC POSITION

Taloe lake is situated in Eastern Siberia (Republic of Khakassia, Russia) and located on divide of Bidja and Karasuk rivers basins. In the relief sense area of the lake represent hilly plain of denudation with positive landforms up to 540-560 meters high [8]. Climate here is temperately continental, subarctic. Maximal temperature in summer is about +36 °C. Minimal temperature in winter reaches -47 °C. Annual amount of atmospheric presipitaions – 266 mm.

Taloe lake tract is an enclosed sink surrounded by low hills. There are two intermittent reservoirs isolated from each other and allocated at different hypsometric levels. The reservoirs are located in parallel with each other. They both have elliptic shape and elongate in submeridional direction. "Lower" reservoir is located at 390-391 meters high, its' length is 1610 m, width – 385 m. "Upper" reservoir is located at 399-400 m high, its' length is 3300 m, width – 960 m.

Total catchment area of Taloe lake tract amounts about 25 km². Reservoirs recharge realize by means of atmospheric precipitations, snow melting and ground waters inflow. Seat rocks are represented by lower carboniferous samokhvalskaya suite deposits: sandstones, tuffs and tuffites of south-Minusinsk hollow. According to opinion of Rusanov A. V. [10] the source of salt for the lake is an anticlinal structure constituted by a salt dome. Rock salt is washing out and giving out brines, which rise via joints from subsurface to the western part of the lake and even to its' shore.

MATERIALS AND METHODS

As Taloe lake tract is an intermittent basin, it fills with water for a short terms, what is related to snow cover melting and abundant precipitation periods. Hence, only during these short periods it is possible to consider surface waters influence. Materials for this work are represented by samples, that had been collected at 10th of July 2015 nine hours after the rain. According to meteorological station "Abakan" 11.4 mm of atmospheric presipitations fell out during the preceding period.

8 samples of surface water, 7 samples of underwater sediments and 9 samples of salts, which crystallized during the materials collection period, have been collected. Sample of ground water of "Lower" reservoir has been collected from the wellspring. Two samples of ground water of "Upper" reservoir have been collected from technical well at 1 and 3 meters deep.

Mineral composition of sediments and salines were analyzed by means of X-ray diffraction analysis. Study of polymineral saline aggregates carried out by use of XPERT PRO (PANalytical) diffractometer with X-ray tube with Cu-anode. Survey step was 0.02°, 2 θ angles range – 4-60°, rotation speed - 30 turns per minute, exposure time – 0.1 second per point, operational radius - 141 mm. Results interpretation were carried out using PDF-4 [9] and HighScore software packages.

Microelement composition of the sediments was defined by means of inductively coupled plasma mass spectrometry (ICP-MS) using the Agilent 7500cx unit. Total-rock composition, soluble and insoluble in water parts of the sediment samples were analyzed. Analysis was carried out by original method. Quality of obtained results was estimated on the basis of BCR-2, OIB standards. Analytical work was performed at collective use center «Analytical center of natural systems geochemistry» of Tomsk State University.

Water samples were studied by means of titration and ICP-MS methods. Titrimetry analysis was carried out at PJSC "Tomskgeomonitoring" laboratory with the aim of macrocomponents identification in ground and surface waters composition. ICP-MS analysis was carried out at collective use center «Analytical center of natural systems geochemistry» of Tomsk State University.

RESULTS

Results of sediments mineral composition study confirm conclusions previously made [1] that there are two mineral associations: terrigenous and evaporite ones (table. 1). Terrigenous association is defined on the basis of mineral debris (quartz, plagioclase, hydromica, chlorite), which supposedly have been brought by means of eolian processes. Composition of this association depends on type of rocks disintegrating at nearby outcrops. Evaporite association of the "Lower" reservoir consist of tenardite, halite, gypsum, calcite, astrakhonite. Sediments of the "Upper" reservoir contain halite, gypsum, calcite, astrakhonite.

Table 1

Characteristics of minerals in samples according to X-ray diffraction analysis results

Mineral	Characteristic (d) spacing (Å), intensity (I)	PDF-4 (# card) [9]
Terrigenous association		
Quartz	3,34(10); 4,25(5); 2,45(3)	[01-085-0794]
Plagioclase	3,19(10); 4,03(4); 3,66(4)	[01-089-6426]

Hydromica	10,00(10); 4,49(9); 2,49(2)	[01-070-3754]
Chlorite	14,03(10); 7,05(8); 4,71(4)	[00-052-1044]
Evaporite association		
Halite	2,81(10); 1,99(6); 3,25(2)	[04-002-2489]
Calcite	3,06(10); 2,49(4); 3,84(2)	[01-086-1108]
Gypsum	4,25(10); 7,60(8); 2,89(6)	[01-074-1904]
Tenardite	4,66(7); 3,18(6); 3,84(2)	[00-037-1465]
Astrakhonite	4,50(10); 2,93(4); 2,59(2)	[01-077-1343]

Results of surface and ground waters study are given in table 2. It is shown that brines of "Upper" and "Lower" reservoirs differ on the basis of sulfate, hydrocarbonate and chloride ions content. Herewith, according to hydrogeochemical classification by Kurnakov-Valyashko [12] "Lower" reservoir water is alkaline ($\text{pH} > 8$) sulfate-chloride, while water of the "Upper" one are neutral ($\text{pH} \sim 7$) chloride (fig. 1).

Table 2

Macrocomponent composition (mg/dm^3) of Taloe lake waters (according to titration results)

Sam ple #	Water type	M, g/l	pH	Ca ²⁺	Mg ²⁺	HCO ₃ ⁻	K ⁺	Na ⁺	Cl ⁻	SO ₄ ²⁻
«Upper» reservoir										
1	s.w.	30,4	6,4	641,3	407,4	79,3	59,5	6486	13201	4200,0
2		36,4	6,2	741,5	571,5	91,5	67,5	9530	15372	6000,0
3		35,9	7,2	761,5	541,1	109,8	72,2	8967	15459	6833,3
4		36,6	7,0	761,5	541,1	109,8	70,2	10535	15459	5500,0
5		33,7	6,7	701,4	851,2	79,3	102,6	5880	14417	3600,0
6	g.w.	108,3	7,0	1142,3	2346,9	994,6	72,5	30527	51069	5700,0
6'		104,9	6,9	1122,2	2128,0	988,5	68,4	29155	51243	6900,0
«Lower» reservoir										
7	s.w.	85,3	8,5	10,0	188,5	2343,2	181,6	41650	43078	30000,0
8	g.w.	4,7	8,3	34,1	38,9	561,4	15,3	2450	1024	8250,0

Note: s.w. – surface waters, g.w – ground waters

These elements do not amount considerable quantities in brines. Most high concentrations have been stated for Li, B and Sr (table 3). There is direct relation between concentration of these elements and total level of water mineralization (fig. 2), which is confirmed by contemporary works [3, 4, 6, 7]. Major difference between waters of two reservoirs in respect of microelements accumulation is determined by B and Rb in the "Lower" one and Sr in the "Upper" one concentrations increase.

(table 3)

Microcomponent composition of Taloe lake waters (according to ICP-MS analysis results), ppm

Sample	Water type	Li	B	V	Cr	Fe	Sr	Ba	Rb
«Upper» reservoir									
1	s.w.	1,71	4,98	0,18	0,13	15,04	23,39	0,08	0,07
2		1,95	5,34	0,18	0,13	15,42	26,00	0,09	0,06
3		2,00	5,72	0,17	0,12	15,22	28,14	0,08	0,06
4		1,94	5,72	0,17	0,13	15,87	25,80	0,10	0,06
5		2,85	3,39	0,17	0,13	16,26	22,16	0,10	0,06
6	g.w.	5,82	3,33	0,38	0,31	36,81	44,22	0,09	0,16
7		5,97	3,13	0,38	0,31	37,70	44,60	0,08	0,12
«Lower» reservoir									
8	s.w.	3,24	29,64	2,30	2,29	346,67	1,47	0,59	4,17
9	g.w.	0,24	1,26	0,06	0,03	6,39	4,51	0,02	0,02

Note: s.w. – surface waters, g.w – ground waters

CONCLUSION

Stated differences of sediments mineral compositions of two intermittent reservoirs are determined by sodium sulfate (tenardite) presence in association with alkaline sulfate-chloride brines of "lower" level. This show sustainability of main evaporite minerals in waters of appropriate hydrochemical type. In addition, brines pH mostly determine the solubility of microelements [4]. Thus, higher concentrations of Rb, B, Fe, Zn, Cu and other chalcophile elements are typical for alkaline water (pH > 8) of "Lower" reservoir. Neutral brines of the "upper" one are enriched with such alkaline earth elements as Mg, Ca, Sr.

In all of studied water samples there are high concentrations of lithium (from 2 to 6 ppm). However, in contrast with other elements contents lithium does not show clear relation with hydrochemical type of water. The most distinctly Li concentration show

dependence on total brines mineralization (fig. 2). This finding confirms hypothesis of N. A. Makarenko and A. L. Arkhipov about possibility of discovery of lithium commercial content in ground waters of south-Minusinsk hollow in case when total mineralization level is higher than 150-200 g/l [7].

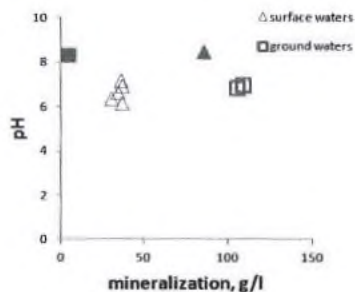


Fig. 1. Relation between pH and water mineralization

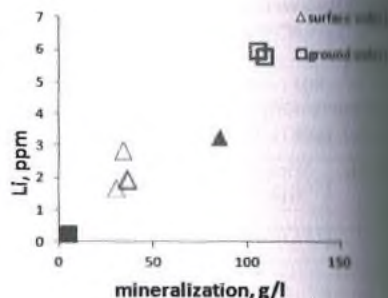


Fig. 2. Relation between Li content and water mineralization

With the purpose of definition of nature of brines which are responsible for evaporite formation microelements accumulation analysis has been carried out. Besides that trace elements distribution between soluble and dissolvable components of sediments has been revealed. Also it has been stated that soluble component enriches with Li, Sr, V and Ba the most. For estimation of different water types influence on soluble part composition Ba/Sr and Sr/Li diagrams have been built. There is single distribution trend for figurative points of sediments and ground water compositions observable at Ba/Sr diagram (fig. 3). This indicates alkaline earth elements input by ground waters. At the Sr/Li diagram (fig. 4) we see that sediments compositions are akin to ones of ground waters. On this basis we can assume that surface waters absorb alkaline elements out of sediments and consequently reduce their quantities there.

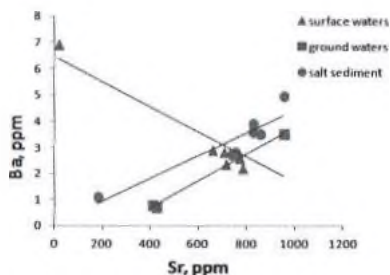


Fig. 3. Ba/Sr ratio

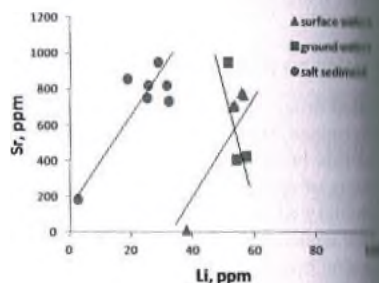


Fig. 4. Sr/Li ratio

In such a way, on the basis of investigation carried out it is stated that:

- 1) Hydrogeochemical type of brines determines microelements content and mineral composition features of precipitating salts;
- 2) Microelements content in sediments mainly is related to insoluble terrigenous component;
- 3) Soluble component of sediments mainly depends on ground waters composition;
- 4) Considerable surface waters enrichment with alkaline elements imply dissolution of sodium sediment salts.

ACKNOWLEDGEMENTS

The work was supported in part by the Ministry of Education and Science of the Russian Federation (State Project No. 2282). The examinations of samples were performed on the equipment of Analytic Center of Natural Systems Geochemistry of Tomsk State University.

REFERENCES

- [1] Arkhipov A., Ivanova M., Tishin P. 15th International Multidisciplinary Scientific Conference SGEM 2015, www.sgem.org, SGEM2015 Conference Proceedings, ISBN 978-619-7105-31-5 / ISSN 1314-2704, June 18-24, 2015, – Book1. – Vol. 1, pp 517-542.
- [2] Banks D., Parnachev V.P., Frengstad B., Holden W., Karnachuk O.V., Vedernikov S.A. The evolution of alkaline, saline ground and surface waters in the southern Siberian steppes // *Applied Geochemistry*. – 2004. – V. 19. – № 12. – pp 1905–1926
- [3] Howell R.J., Parshley J.V. Control of pit-lake water chemistry by secondary minerals, Summer Camp pit, Getchell mine, Nevada // *Chem. Geol.* 2005. V. 215. pp. 373–386.
- [4] Brooks D.G. Eh-pH diagrams for geochemistry. – N.Y.: Springer, 1987, pp 180.
- [5] Drever J.I. Surface and groundwater, weathering, and soils // *Treatise on geochemistry*. Vol. 5. Elsevier, Pergamon, 2005, pp 605.
- [6] Hardie, L.A., Eugster, H.P. The evolution of closed-basin brines. *Miner. Soc. Am. Spec. Publ.* 3, 1970, pp 273–290.
- [7] Makarenko N.A., Arkhipov A.L. Rare metal potential of salts of Taloe lake (Kochishche). *Herald of Tomsk State University*, Tomsk, 2008, pp 172-174.
- [8] Mistrukov A. A. Geomorphological zoning of Nazarovsko-Minusinskaya intermontane trough / SB AS USSR, United Institute of geology, geophysics and mineralogy, Novosibirsk: UIGGM SB AS USSR, 1991, pp 130.
- [9] PDF - 4/Minerals 2014.-International Centre for Diffraction Data. SN: Mine 1 401 38-1374
- [10] Rusanov A. V. Results of geological study at environs of Abakan salt-work, West Siberian Geological trust, Tomsk, 1935.

- [11] Tcharykova M.V., Tcharykov N.A. Thermodynamical modeling of evaporites. *Journal of Earth System Science*, 2003, pp 261.
- [12] Valyashko M.G. Geochemical regularities in the formation of deposits of potassium salts. M.: Publishing, Moscow State University, 1962, pp 397.
- [13] Warren J.K., *Evaporites through time: Tectonic, climatic and eustatic controls on marine and nonmarine deposits*. *Earth-Science Reviews* 98, 2010, pp 217–268.