REGIONAL GROUNDWATER FLOW COMMISSION

ANNUAL PROGRESS REPORT

(January – December 2019)

1. Sessions at Conferences

The Laboratory of Georesources (LGR) at the "Centre for Water Research and Technologies (CERTE)" and the "Tunisian Committee of Hydrogeology (TCH)" at the "Association Eau et Développement (AED)", which is the Tunisian Chapter of "International Association of Hydrogeologists (IAH)", were pleased to organize the 2nd Atlas Georesources International Congress (AGIC 2019) in Hammamet, Tunisia. It brought together researchers, research scholars, experts and policymakers to share their research, experiences and discuss recent advances in Applied Geosciences for Groundwater. The conference covered many aspects related to groundwater and had a special session entitled "Regional Groundwater Flow Systems". It anticipated analysing issues connected to groundwater management and related environmental protection defining physical and chemical degradation in the context of groundwater flow system functioning. Contributions related to alternative methods of defining groundwater flow components and their application in establishing, regulating and mitigating negative environmental impacts to and from groundwater were presented.

Our Commission co-sponsored two sessions at the European Geosciences Union (EGU) General Assembly, 7–12 April 2019, Vienna, Austria: "Geofluids as natural resources or sources of contamination: Research and Innovation (supported by RGFC-IAH and ENeRAG)" convened by Daniele Pedretti, Alex Russell, Ádám Tóth, Frank McDermott, Marie-Amélie Petré and "Groundwater flow understanding in water management and environmental problems" convened by Manuela Lasagna, Daniela Ducci, Jim LaMoreaux, John Molson, Judit Mádl-Szőnyi.

The 1+2 oral blocks and the related poster sessions attracted 7+13 oral presentations and 18+16 posters. The freshly launched geofluid session received very positive feedback, its multidisciplinarity and the wide range of topics fostered new ideas and synergies. The "regular" groundwater flow system session was again a great success, it included a broad range of topics and techniques such as groundwater management, geochemical characterization of groundwater flow systems and knowledge of groundwater flow system from local to regional scale. All of the presentations attracted great attention, especially the dynamic poster walk-through session.

Moreover, RGFC and the ENeRAG Geofluids H2020 project had a joint meeting. The collaborators could discuss future activities planned in cooperation, such as a Special Issue on Geofluids.

Session conveners, presenters and RGFC representatives: John Molson (Canada, RGFC Co-chair), Judit Mádl-Szőnyi (Hungary, RGFC Chair), Wouter Zijl (Belgium), Hanneke Verweij (the Netherlands, RGFC Co-chair) and Marie-Amélie Petré (France)

The 2019 GAC-MAC-IAH/CNC Conference was held in Quebec City, Canada from May 12-15th 2019 and was a great success. This conference was a combined event, hosting three related associations – the Geological Association of Canada, the Mineralogical Association of Canada, and of course, the Canadian National Chapter of the IAH. As North American co-chairs of the IAH Regional Groundwater Flow Commission, Dr. John Molson (Université Laval) and Dr. René Lefebvre (INRS) participated on the local organizing committee which was chaired by Dr. Michel Malo of the INRS Institute, Quebec City.

Over 740 participants registered for the 3-day conference, including 63 members of IAH/CNC and 19 student IAH members. The conference also included several short courses held on Sunday, and field trips, including to the Charlevoix impact crater about 100 km east of the city. The impact occurred over 400 million years ago and is visible today as a 50-km diameter basin on the edge of the Canadian Shield. The rocks associated with this impact are highly fractured and faulted; of note in the area is the famous Logan Fault which separates units of the Appalachian Orogeny from Palaeozoic sedimentary rocks. Evidence for prior hydrothermal activity was also noted. The area is the most seismically active zone in eastern Canada.

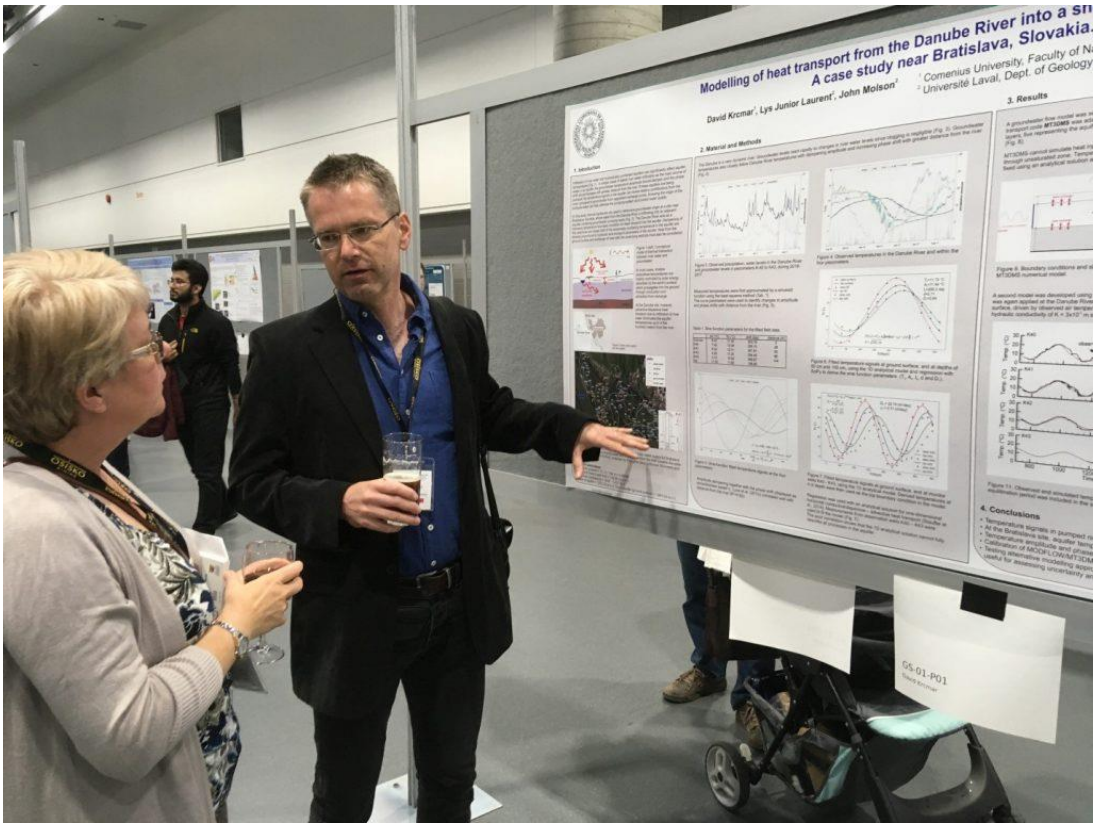
Another field trip entitled *Champlain Sea Deltas* focussed on Quaternary geology and hydrogeology of landforms resulting from the invasion of the Champlain Sea into the St. Lawrence River Valley following the retreat of the glaciers about 10,000 years ago. Fluvioglacial deposits have formed many good aquifers in the St. Lawrence Valley, while marine clays from the Champlain Sea serve as confining layers which still contain significant chloride concentrations which can degrade water supplies.

Dr Barbara Sherwood Lollar, of the University of Toronto, and 2019 recipient of Canada's highest research award, the Gerhard Herzberg Medal, gave the IAH/CNC keynote address, with an inspiring talk on 1-2 billion-year-old groundwater discovered in deep mines of the Canadian Shield, and of evidence for microbial communities at

these depths. Dr. Dick Jackson, of the University of Waterloo and GeoFirma Ltd., and 2013 recipient of the Farvolden Award in Hydrogeology, gave an engaging lunch-time talk on resource development and risks to groundwater.

During the conference, over 10 special sessions focussed on hydrogeology-related topics, including *Deep groundwater circulation and its potential influence on shallow water resources and ecosystems, Hydrogeology of cold regions, Groundwater nutrients and contaminants affecting surface waters, Geochemical and isotopic tracers in groundwater studies, Groundwater and Climate Change, Challenges in measuring and modeling of groundwater/surface water interactions, Emerging Contaminants in Soil and Groundwater*, and a session on *General Hydrogeology*. A meeting of the IAH/CNC committee was held on Sunday, and the Annual General Meeting was held later Tuesday afternoon, Chaired by IAH/CNC president, Dr. Diana Allen of Simon Fraser University, British Columbia, Canada. A general poster session was held at the end of each day, over a few refreshing cold drinks.

On Tuesday evening, a dinner-cruise on the Saint Lawrence River was enjoyed by many, including a great view of the Montmorency Falls, which we are proud to say are even higher than Niagara Falls!



Poster session: Dr. David Krcmar (Comenius University, Bratislava, Slovakia) explaining his poster to Dr. Diana Allen, president, IAH/CNC Canada

Montmorency Falls, near Quebec City

The RGF Commission organized a special topic at the annual IAH Congress, 22–27 September 2019, Málaga, Spain. The congress of this year devoted special focus on Groundwater Management and Governance: Coping with Water Scarcity.

The topic entitled *Innovative approaches for understanding groundwater flow systems* was supported by the EU H2020 ENeRAG (Excellency Network Building for Comprehensive Research and Assessment of Geofluids) project. The sponsored 4 oral and 1 poster sessions dealt with a wide range of methodologies applied in hydrogeology from the more conventional technologies (such as hydrogeological mapping, hydrodynamics, hydrochemistry, isotopes, tracers, etc.) to the most innovative new trends in modelling. Altogether 19 oral and 11 poster presentations were included, they were attended around 100 delegates of the Congress. We were delighted that many of these provided recent results regarding the theoretical progress, research methods and future development of regional groundwater flow.

Furthermore, RGFC held its annual meeting in Málaga. Review the progress of the on-going RGFC activities and discuss the further steps and new ideas were in focus among the 20 Commission members.

Panoramic view of one of the RGFC's oral sessions

2. Training workshops, short courses

Carlos Molano's Groundwater Spreadsheets short course in Malaga, Spain, was devoted to providing the basic concepts and mechanisms of movement and storage of water and chemical compounds in porous media, applying analytical and numerical modelling using spreadsheets. Spreadsheets are powerful tools we use extensively in our lives for many purposes in many fields and are an excellent means to teach and learn groundwater flow and pollution.

3. Dissemination of Knowledge

RGFC launched its LinkedIn page, which is a forum for scientific discussion, in autumn of 2014 and since then the number of members reached 320 (~10 new members during this report period).

Now, the news and activities of RGFC can be followed on another social media platform. We will share conference pictures and updates @rgfc_iah Instagram profile, as well. You can use hashtag #rgfc_iah if you would like to share a photo of regional groundwater related topics or even a memory of your daily hydrogeology practice. We already have 56 followers!

The Commission launched a ResearchGate project entitled *Selection of papers related to Regional Groundwater Flow*. This project was created and is managed by the Regional Groundwater Flow Commission of the International Association of Hydrogeologists (RGFC-IAH) in cooperation with the József & Erzsébet Tóth Endowed Hydrogeology Chair. This project is a selection of international papers related to the research and practical application of regional groundwater flow theory. The project has 62 followers (~20 new ones) and 648 reads (~300 new ones) at the end of this reporting period.

The final round of the Problem Solver Competition for Hungarian students was held on 15 November 2019. This Competition was initiated by the ENeRAG Excellency Network Building for Comprehensive Research and Assessment of Geofluids Horizon

2020 project in collaboration with RGFC-IAH and the József & Erzsébet Tóth Endowed Hydrogeology Chair of the Department of Geology. University students could enter the two-round competition, which included an online test on the system approach of geofluid systems from the fluid side. Our best four groups competed at this open event by delivering their presentations about the practical aspects and application of system approach of geofluids regarding issues and examples from their home country. Issues, challenges, possibilities, regulations and limitations were discussed on Managed Aquifer Recharge (MAR), groundwater reinjection, combined heat and metal production and volcanogenic massive sulfide ore deposit (VMS). The Problem Solver Competition aims the assessment of geofluid resources applying the dynamic system approach by bringing it to university level.

All of the teams gave fantastic talks and highlighted the interaction of geofluids with different origins and characters. Finally, Team Wenger not Arsene (Valerie Wendo and VictorGerald Nzewuji, University of Miskolc) and Team Miyah (Hana Ben Mahrez and Sikandar Hayat, ELTE) excelled and received the first prize and the special prize went to the Team Aquamarine (Petra Baják, Zsóka Szabó, ELTE). Registration for EGU, attendance of ENeRAG's workshop, memberships for the next year and other small gifts were granted to the contestants. According to the decision of the invited judges, all teams qualified for the International Problem Solver Competition.

Team Aquamarine: Zsóka Szabó and Petra Baják; judge Annamária Nádor (Mining and Geological Surveyof Hungary); Team WenGer not Arsene: Valerie Wendo and VictorGerald Nzewuji; Team VMS: Justine Myovela and Yohannes Kelati (absent); Team Miyah: Sikandar Hayat and Hana Ben Mahrez

4. Future plans

- EGU General Assembly, 3–8 May 2020, Vienna, Austria

  Groundwater flow and geofluids system understanding with regard to environmental problems and resource management

  The session aims to bring together scientists studying different aspects related to groundwater circulation, interaction among fluids of different nature and management of groundwater, geothermal energy and hydrothermal mineral resources. Strategic management of resources and understanding of gravitational groundwater flow, which requires knowledge of the prevailing flow system from the local to a regional and basin-scales, are the key of sustainable future development of the environment and economies. In this context of groundwater flow understanding, the session intends to analyze issues connected to geofluids systems and their economic resources, groundwater management and its protection from degradation with respect to quantity and quality (e.g. due to overexploitation, climate change, resource development or contamination). Papers related to methods (hydrological, geochemical, environmental tracers, microbial, numerical and statistical modelling) of defining groundwater flow, and preventing, controlling and mitigating negative environmental impacts related to groundwater, including those in developing countries, are also welcome. The session is sponsored by the RGFC–IAH and the ENeRAG project of EC.

- GeoConvention2020, 11–13 May 2020, Calgary, Canada

  “The Virtual Spring”: effects and manifestations of discharging groundwater

  The session focuses on surface manifestations of flowing groundwater and their application in regional hydrogeological characterization. As flowing groundwater interacts with its environment through various chemical, physical and kinetic processes, it produces numerous in-situ effects detectable on the surface in the discharge area of groundwater flow systems. The concept of “virtual spring” is defined as all groundwater discharge phenomena together in the terminal area of a groundwater flow-system. Phenomena such as springs, distinct water chemistry, soil salinity and mineral deposits, phreatophyte and halophyte plant communities, geothermal anomalies, and certain karstic features carry information about the hydrogeologic environment and can be interpreted in the context of groundwater flow systems. Their observation, interpretation and integration into conceptual and numerical groundwater flow models represent a fundamental component of regional-scale hydrogeological characterizations. The session is organized by the RGFC-IAH and welcomes national and international examples of the application of groundwater-related surface phenomena, as a tool to formulate hypotheses, build conceptual models and/or validate numerical simulations of subsurface flow regimes.

- International Symposium on Geofluids, 8-10 July 2020, Budapest, Hungary

  The declared objective of the Symposium is to bring together scientists, professionals, stakeholders to share and discuss all kinds of aspects of geofluids, i.e., groundwater, geothermal energy, hydrocarbon, geogenic contaminations and hydrothermal mineral resources, with special emphasis on harmonized exploration and utilization. We, therefore, welcome researchers in all aspects of geofluids' research. The greater the diversity of interests the more significant will be the result.

- International Competition on Geofluids

  International Problem Solver Competition is initiated by the ENeRAG Excellency Network Building for Comprehensive Research and Assessment of Geofluids Horizon 2020 project in collaboration with RGFC-IAH and the József & Erzsébet Tóth Endowed Hydrogeology Chair (JET-EHC, Budapest, Hungary). University students can enter the two-round competition, which includes an online test on the dynamic systems of geofluids from the fluid side. Then the best groups (depending on the number of applicants) will qualify for the second round and receive a topic about the practical aspects and application of dynamic system approach of the ENeRAG regarding issues and examples around the World. The topics will be delivered in the form of 5-minutes-long short movies.

5. Publications

Papers and books

Zhang ZY, Jiang XW, Wang XS, Wan L, Wang JZ 2019: Why mixed groundwater at the outlet of open flowing wells in unconfined-aquifer basins can represent deep groundwater: implications for sampling in long-screen wells. Hydrogeology Journal, 27(1), pp. 409–421.

Lemieux J-M, Fortier R, Murray R, Dagenais S, Cochand M, Delottier H, Therrien R, Molson J, Pryet A, Parhizkar M 2020: Groundwater dynamics within a watershed in the discontinuous permafrost zone near Umiujaq (Nunavik, Canada), Hydrogeology Journal

Cochand M, Molson J, Barth J A-C, van Geldern R, Lemieux J-M, Fortier R, Therrien R 2020: Rapid groundwater recharge dynamics determined from hydrogeochemical and isotope data in a small permafrost watershed near Umiujaq (Nunavik, Canada), Hydrogeology J, http://link.springer.com/article/10.1007/s10040-020-02109-x

Dagenais S, Molson J, Lemieux J-M, Fortier R, Therrien R 2020: Coupled cryo-hydrogeological modelling of permafrost degradation near Umiujaq (Nunavik, Canada), Hydrogeology J

Szijártó M, Galsa A, Tóth Á, Mádl-Szőnyi J 2019: Numerical investigation of the combined effect of forced and free thermal convection in synthetic groundwater basins. Journal of Hydrology 572, pp. 364–379.

Hamzaoui-Azaza F, Trabelsi R, Bouhlila R, Khanfir H 2019: Groundwater management of Skhira aquifer (center east of Tunisia): flow modeling and planning under climate and anthropogenic constraints. Desalination and Water Treatment

Ameur M, Hamzaoui-Azaza F, Cheikha LB, Gueddari M 2019: Geochemistry of high concentrations of fluoride in groundwater at Oued Rmel aquifer (North-eastern Tunisia), and risks to human health from exposure through drinking water. Environmental Earth Sciences 78, 6, pp. 1-9.

Ameur M, Hamzaoui-Azaza F, Gannouni S, Gueddari M 2019: Contribution of remote sensing and geochemistry approaches to identify hydrogeological interconnections between Sminja and Oued Rmel Aquifer System (SORAS) (North-eastern Tunisia). Desalination and Water Treatment 158, pp. 216–222.

Troudi N, Hamzaoui-Azaza F, Zammouri M, and Tzoraki O 2019: Distribution of Trace Elements in the Shallow Aquifer of Guenniche (North Tunisia). Advances in Sustainable and Environmental Hydrology, Hydrogeology, Hydrochemistry and Water Resources, Advances in Science, Technology & Innovation, Springer, Cham, pp. 113–116.

Ghouili N, Zammouri M, Jarraya-Horriche F, Hamzaoui-Azzaza F, Carrillo-Rivera JJ 2019: Groundwater Flow Modelling of a Multilayer Aquifer in Semi-arid Context. Advances in Sustainable and Environmental Hydrology, Hydrogeology, Hydrochemistry and Water Resources. Advances in Science, Technology & Innovation, Springer, Cham pp. 287–289.

Conference Presentations

Jiang XW 2019: Physical and Chemical Processes during Regional Groundwater Circulation: Implications for Groundwater Sustainability. Training Courses on Groundwater Monitoring and Groundwater Sustainable Utilization along the Langcang-Mekong River Countries, Beijing, China, 21 March 2019, Invited talk

Aouiti S, Hamzaoui Azaza F, Zammouri Z, Hamdi M, Celico F 2019: Vulnerability assessment using combined remote sensing and GIS. Case study of the Mio-Plio-quaternary aquifer of Hajeb Layoun-Jelma basin (Central Tunisia). 2nd Atlas Georesources International Congress, AGIC 2019 Applied Geosciences for Groundwater, Hammamet, Tunisia, 28–30 March 2019

Ghouili N, Jarraya Horriche F, Hamzaoui Azaza F, Zammouri M, Zaghrani M F, Ribeiro L 2019: Assessment of groundwater vulnerability in the Takelsa aquifer (Northeastern Tunisia) using the Susceptibility Index method. 2nd Atlas Georesources International Congress, AGIC 2019 Applied Geosciences for Groundwater, Hammamet, Tunisia, 28–30 March 2019

Tóth Á, Mádl-Szőnyi J 2019: Where does the drinking water come from? – Interrelationship between surface water and groundwater in a carbonate area, Hungary. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Galsa A, Szijártó M, Tóth Á, Lenkey L, Mádl-Szőnyi J 2019: Interaction of topography- and salinity-driven groundwater flow in synthetic numerical models and a real geological situation. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Mádl-Szőnyi J, Kovács-Bodor P 2019: What do the thermal springs and their related precipitates tell us about interacting geofluid systems? EGU General Assembly, Vienna, Austria, 7–12 April 2019

Szijártó M, Galsa A, Tóth Á, Lenkey L, Mádl-Szőnyi J 2019: Numerical investigation of the interaction of different driving forces on groundwater flow and temperature pattern in a theoretical basin and in the Buda Thermal Karst, Hungary. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Havril T, Tóth Á, Molson JW, Galsa A, Mádl-Szőnyi J 2019: Effects of predicted climate change on groundwater flow systems and its implications for future water management. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Szabó Zs, Zentai-Czauner B, Mádl-Szőnyi J 2019: Fluid flow systems and hydraulic trapping of hydrocarbons – Hajdúszoboszló and Ebes gas fields, Hungary. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Erőss A, Csondor K, Csobaji L, Zentai-Czauner B, Győri O 2019: Characterization of the regional groundwater flow system in South Transdanubia (Hungary). EGU General Assembly, Vienna, Austria, 7–12 April 2019

Baják P, Csondor K, Surbeck H, Izsák B, Vargha M, Horváth Á, Pándics T, Erőss A 2019: A new challenge in drinking water supply - Radionuclide content of groundwater in flow system context. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Pánczél E, Csondor K, Erőss A 2019: Springs as telltales of flow systems: hydrogeological study of the city Esztergom (Hungary). EGU General Assembly, Vienna, Austria, 7–12 April 2019

Csondor K, Baják P, Izsák B, Vargha M, Surbeck H, Horváth Á, Erőss A 2019: Radioactivity assessment of drinking water - a case study from a mixed bank filtered and karst water supply system. EGU General Assembly, Vienna, Austria, 7–12 April 2019

Mádl-Szőnyi J, Szabó Zs, Silva Cisneros C 2019: Recent applications and future prospects for MAR techniques in Hungary. 10th International Symposium on Managed Aquifer Recharge (ISMAR10), Madrid, Spain, 20–24 May 2019

Szabó Zs, Mádl-Szőnyi J 2019: 150 years old IBF systems in Budapest, Hungary - focusing on their sustainability and costs. 10th International Symposium on Managed Aquifer Recharge (ISMAR10), Madrid, Spain, 20–24 May 2019

Tóth Á, Mádl-Szőnyi J 2019: Basin-scale conceptual groundwater flow model for carbonate regions. International Karstological School, Postojna, Slovenia, 17–22 June 2019

Tóth Á, Kovács-Bodor P, Kovács J, Mádl-Szőnyi J 2019: Revealing groundwater flow systems on the basis of statistical spring data analysis. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Szijártó M, Galsa A, Tóth Á, Lenkey L, Mádl-Szőnyi J 2019: Numerical investigation of the combined effect of different driving forces in the Buda Thermal Karst, Hungary. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Kovács-Bodor P, Mádl-Szőnyi J 2019: Biogeochemical precipitates at the terminal points of regional groundwater flow systems as analogs for geothermal plants and past processes. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Mádl-Szőnyi J, Kovács-Bodor P, Tóth Á, Szijártó M, Havril T 2019: Thermal springs as "outcrops" of geofluid systems and provenance of biogeochemical accumulations and environmental impact. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Szabó Zs, Zentai-Czauner B, Mádl-Szőnyi J 2019: The importance of fluid flow system evaluation in the understanding of hydraulic trapping of hydrocarbons – Case study of Hajdúszoboszló and Ebes gas fields, Hungary. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Erőss A, Csondor K, Tóth Á, Dezső J, Zentai-Czauner B, Müller I 2019: Characterization of the regional groundwater flow system and groundwater related phenomena in the Villány thermal karst area (Hungary). 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Baják P, Csondor K, Surbeck H, Izsák B, Horváth Á, Vargha M, Pándics T, Erőss A 2019: Radionuclide content of groundwater in hydrogeological approach. Case study in the adjacent area of a granitic complex. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Verweij H 2019: Integrated approaches to characterize Cenozoic clay-rich layers and investigate their role in regional groundwater flow; Dutch case studies. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Jiang XW, Zhang H 2019: Quantifying the contributions of silicates and calcite to hydrochemistry of groundwater in a sandstone aquifer using Sr isotopes. 46th IAH Congress, Malaga, Spain, 22–27 September 2019

Tóth Á, Mádl-Szőnyi J 2019: Structural constraints of groundwater flow and heat transport in the Lake Balaton region. 14th Workshop of the International Lithosphere Program Task Force Sedimentary Basins, Hévíz, Hungary, 15–19 October 2019

Galsa A, Szijártó M, Tóth Á, Havril T, Mádl-Szőnyi J 2019: Interaction of topography-, salinity- and temperature-driven groundwater flow in synthetic numerical models and along a hydrogeological section. 14th Workshop of the International Lithosphere Program Task Force Sedimentary Basins, Hévíz, Hungary, 15–19 October 2019

Szijártó M, Galsa A, Tóth Á, Havril T, Lenkey L, Mádl-Szőnyi J 2019: Roles of different driving forces in groundwater flow from theoretical models to the Buda Thermal Karst 14th Workshop of the International Lithosphere Program Task Force Sedimentary Basins, Hévíz, Hungary, 15–19 October 2019

Jiang XW 2019: Hydraulics and geochemistry of flowing wells in unconfined aquifers. Southern University of Science and Technology, Shenzhen, China, 17 October 2019, Invited talk

Jiang XW 2019: A comparitative study of groundwater circulation in confined and unconfined aquifers. Beijing Institute of Hydrogeology and Engineering Geology, Beijing, China, 6 December 2019, Invited talk

Jiang XW, Ji TT, Zhang H 2019: The behaviors of Mg and Li isotopes in groundwater with long residence times. 2019 AGU Fall Meeting, San Francisco, USA, 9–13 December 2019

Budapest, 28 January 2020

Ádám Tóth, Secretary of RGFC

Judit Mádl-Szőnyi, Chair of RGFC