New development of IGCP/SIDA 598 “Environmental Change and Sustainability in Karst Systems (2011-2015)”

Zhang Cheng¹, Chris Groves², Yuan Daoxian¹

1 Key Laboratory of Karst Dynamics, MLR/GZAR, Institute of Karst Geology, CAGS /International Research Center on Karst under the Auspices of UNESCO(IRCK), Guilin 541004 China

2 Department of Geography and Geology, Western Kentucky University, Bowling Green, KY 42101 USA

IGCP/SIDA 598 is the 5th karst related IGCP project sponsored by UNESCO/IUGS and the Swedish International Development Cooperation Agency (SIDA). It is a successor project of IGCP 299, IGCP 379, IGCP448, and IGCP 513. Its background, basic Ideas, objectives was introduced in newsletter 2011 of the project (Zhang, 2011). A summary of the major past accomplishments of IGCP 598 and the previous IGCP karst projects was published in 2012 as an invited contribution to the 40th anniversary celebration of IGCP held in Paris in February 2012 (Groves et al., 2012).

In line with the four objectives of the project, the achievements are summarized on the basis of the presentations and discussions at the symposia held in Bowling Green, USA (July, 2011), Brisbane Australia (August, 2012), Guilin China (April, 2013) and Ankara Turkey (May, 2014); the field excursions on June 9, 2011 in USA, august 11, 2012 in Australia and April 13, 2013 in China; as well as the reports from National Working Groups.

Karst carbon sink potential and climate change

The impact of geological processes on the carbon cycle, in particular the interactions between carbonate rocks and atmospheric CO₂, is receiving increasing attention among scientists in the geologic community. Several scientists and laboratories affiliated with IGCP/SIDA 598 made contributions in this area, quantifying in particular the impact of karst geochemical processes and human activities such as land use change on the carbon cycle. Studies are simultaneously underway to understand how aquatic vegetation utilizing HCO₃⁻ as a carbon source in karst surface river systems may influence measurements of the relevant carbon sinks. Montety et al. (2011) studied the influence of diel biogeochemical cycles on carbonate equilibrium in a karst river and suggested that large systems with abundant subaquatic vegetation may act as natural sink of carbon. Zhang et al. (2012) studied the carbon sink effect of subaquatic vegetation photosynthesis in Guancun River, an underground stream-fed river, Guangxi, China. The loss of inorganic carbon along its flow path is estimated to be about 94.9 kg/day along the 1350 m of the Guancun River. It means that bicarbonate entering the river from karst underground stream was consumed by plants or trapped in the authigenic calcite and thus constitutes a natural sink of carbon for the Guancun karst system.

Data from monitoring and experimental sites in southwestern China area showed that karst processes, as a low-temperature geochemical open system, are very sensitive to environmental change and are a special geological process that is involved in the short-term carbon cycle (land use change impact). Carbon sink rates within terrestrial ecosystems may increase with vegetation development or re-forestation, here it was shown that similar processes caused by karst dissolutional denudation can occur underground as well. Chris

Groves and others (Groves et al. 2013; Polk et al., 2013a) discussed water-gas-rock interactions and seasonal control of geochemical environments in the epikarstic zone of the Pennyroyal Plateau, Kentucky, USA. Chinese and American scientists continued to develop collaboration in establishing a standard methodology for high-resolution carbon sink monitoring with an initial pair of reference sites established at the Maocun Basin in Guangxi China and Lost River Cave in Kentucky USA in early 2013.

Karst aquifer systems and water resource processes

In examples reported at IGCP/SIDA 598 sponsored conferences, Brenè (2013) described advances in the understanding of regional groundwater flow in karstic regions of Slovenia and Istria; Anita Eröss et al. (2013) reported on radionuclides as natural tracers for identification of mixing of thermal waters; and Amélie Dausse et al. (2013) discussed scale effects and hierarchy of groundwater flow paths: the case of a Mediterranean karst system. Heath (2012) reported on conditions and processes within South Africa related to karst development in the dolomite rocks of the 2.6 billion year old Transvaal Supergroup. In South Africa significant environmental challenges exist, especially with regard to catastrophic sinkhole development. Auler (2011) analyzed the hydrochemistry and sulfur isotope in the semi-arid dolomitic Una Group karst of northeastern Brazil. The results demonstrated that both mechanisms (sulfide oxidation and evaporative concentration) are operative in the area. Chris Groves et al. (2013) developed a monitoring strategy that allows for quantitative characterization of flow and hydrochemical behavior of autogenic recharge of soil-mantled karst aquifers travels through the epikarstic zone before entering the main part of the aquifer. Tobin et al. (2011) assessed the recharge elevations for karst springs of the Kaweah River basin, California. Seasonal variations in isotopic values indicated seasonal shifts in the dominant recharge source from higher elevation snowmelt runoff during high flow conditions to more locally derived recharge during base flow.

Karst watersheds sustainable protection

As in past years, this topic has been a major emphasis of both research and training activities. This was highlighted in the Karst Hydrology course in the WKU Karst Field Studies Program (USA), the Hydrokarst course that was held at the University of Malaga (Spain) and the Guilin (China) IRCK training course. At that training course George Veni (USA) gave lectures on hydrological and geochemical monitoring of wells and springs in karst aquifers, dye tracing techniques for karst groundwater basin delineation, and environmental impact assessments. Jonathan Arthur (USA) lectured

on aquifer vulnerability modelling in karst, and Zoran Stevanovic (Serbia) lectured on methods in karst aquifer characterization, water budget and reserve assessments.

In addition, Tim Slattery is leading an effort to understand and find solutions to karst water-related environmental problems caused by urban development in Bowling Green, Kentucky USA. Vitor Moura and Brazilian colleagues studied monitoring procedures for management and protection of caves in Brazil and identified aquatic cave fauna from the Serra do Ramalho. The waters of the Jeita spring of Lebanon, a water supply for Beirut, are being threatened with pollution sources and a multi-agency effort is underway to understand and identify solutions to these challenges. The results from Kentucky indicate that significant precipitation events affect both the storage properties and rapidly impact the various pathways and timing of contaminant transport through the epikarst zone (Vanderhoff et al., 2011). Investigation indicated that there is an overall positive effect of 5% (geodiversity) on the biodiversity of terrains in Florida in or near sinkholes (Booth, 2011). The Karst Disturbance Index (KDI) is a holistic tool used to measure anthropogenic impacts on karst environments, and has been applied and refined in studies performed in USA (Florida), Puerto Rico (Arecibo) and Italy, yet still remains untested and susceptible to modification for other areas.

Environmental change records in karst systems

With the ever increasing concern and interest in climate-change science, including identifying records of past climate, understanding the records contained within karst systems remains an active area of research. Gilman Ouellette and Jason Polk (2013) are developing a high-resolution reconstruction of Late Holocene precipitation and climate variability on the island of Barbados from multiple speleothems. Proxy climate records from speleothem stable oxygen isotope records combined with high-resolution uranium-series dating are being used to address water resource issues in Caribbean island karst aquifers. Jason Polk et al. (2013b) is conducting additional work on drought and storm event impacts in the Caribbean on karst water resources in Belize using cave deposits. Li Hongchun (2013) emphasized the influence of the Asian Summer Monsoon on the moisture budget of the karst region of Southwest China during the last millennium. Truebe et al. (2011) developed a process model of cave dripwater $\delta^{18}\text{O}$ values as a test of reconstructing decadal variability in speleothem climate records. This suggests that some background level of variance in speleothem oxygen isotope records could be due to non-climatic processes, such as subsurface water storage and mixing. Casteel et al. (2011) reported speleothem paleoclimate records from twelve years of cave monitoring studies in Texas, USA. The results demonstrate that high-frequency speleothem Mg/Ca and Sr/Ca variation may provide insight into the controls of paleo-drip water compositions. McDermott et al. (2011) analyzed the nature and possible causes of changes in speleothem $\delta^{18}\text{O}$ gradients across Europe during the Holocene. Overall, the data indicate that zonal flow and Atlantic moisture sources were dominant throughout the entire Holocene.

Capacity building

SIDA added funding for the strong capacity building element of the project, with directions to especially strengthen capacity development in Africa, the Arab countries, and Iran. To this end, we

actively worked to expand these regional efforts over the past four years. In December from year 2011 to 2013, the International Training Courses on Karst Hydrogeology and Hydrogeochemistry, co-sponsored by IRCK and the IGCP/SIDA 598, were offered. Over nine students and geo-environmental researchers from these regions participated the courses.

The project has a mandate to enhance capacity building in Africa, the Arab Countries, and Iran. The workshop on sharing experiences in karst water resources in the middle east in Ankara, Turkey, as joint project of IGCP598 and the IHP MEDFRIEND program, was very much a contribution in line with the goals of SIDA for IGCP598. Participants in the workshop represented 11 countries, including Iran, Lebanon, Jordan, Morocco, Palestine, Algeria, Turkey, US, Spain, Switzerland, France and Spain.

References

- Auler, A. S., 2011. Sulfide oxidation and evaporative concentration: competing mechanisms in the semi-arid karst of northeastern Brazil. In: Proceedings of 2011 International Conference on Karst Hydrogeology and Ecosystems, Bowling Green, KY, USA. pp.85-86.
- Booth, B., 2011. A report on the positive effect of geodiversity on biodiversity in Florida. In: Proceedings of 2011 International Conference on Karst Hydrogeology and Ecosystems, Bowling Green, KY, USA. pp.86-87.
- Brenè, M., 2013. Regional groundwater flow in karstic regions of Slovenia and Istria. In: Proceedings of International Symposium on Hierarchical Flow Systems in Karst Regions, Budapest, Hungary. pp.54.
- Casteel, R., Banner, J. L., Wong, C., Feng, W. and James, E.W., 2011. Implications for speleothem paleoclimate records from twelve years of cave monitoring studies in Texas, USA. In: Proceedings of Climate Change – The Karst Record (KR6) conference, Birmingham, UK. pp. 29.
- Dausse, A., Léonardi, V., Jourde, H., 2013. Hierarchization of groundwater flow paths and scale dependency of the hydrodynamic properties in karst. In: Proceedings of International Symposium on Hierarchical Flow Systems in Karst Regions, Budapest, Hungary. pp.61.
- Eröss, A., Mádl-Szőnyi, J., Horváth, Á., Goldscheider, N., 2013. Radionuclides as natural tracers for identification of mixing of thermal waters. In: Proceedings of International Symposium on Hierarchical Flow Systems in Karst Regions, Budapest, Hungary. pp.64.
- Groves, C., Polk, J., Miller, B., Kambesis, P., Bolster, C., Vanderhoff, S., Tyrie, B., Ruth M., Ouellette, G., Osterhoudt, L., Nedvidek, D., McClanahan K., Lawhon, N., and Hall, V., 2013. The Western Kentucky University Crumps Cave Research and Education Preserve, in proceedings of the 20th conference of National Cave and Karst Management Symposium: a changing climate, Carlsbad, New Mexico, USA, pp.105-110.
- Groves, C., Zhang, C. and Yuan, D., 2012. IGCP 299, 379, 448, 513, and 598: Global efforts to understand the nature of karst systems: over two decades with the IGCP. In Derbyshire E. (Editor), *Tales Set in Stone – 40 Years of the International Geoscience Programme*. Paris: UNESCO, pp. 80-87.
- Heath, G., Richardson, S. and Bosch, P., 2012. The dissolution of 2600 million year old karst, Transvaal Supergroup: South Africa. In: Proceedings of the 34th International Geological Congress, Brisbane, Australia. pp.142.
- Li, H., 2013. Influence of Asian summer monsoon on the moisture budget of karst region in the southwest China during the last millennium, in proceedings of International Symposium of Karst Water Under Global Change Pressure, Guilin, China, pp.23.
- Montety, V., Martin, J. B., Cohen, M. J., Foster, C., Kurz, M. J., 2011. Influence of diel biogeochemical cycles on carbonate equilibrium in a karst river. *Chemical Geology*. 283 (1-2): 31–43.
- McDermott, F., Atkinson, T.C., Fairchild, I.J., Baldini L.M. & Mattey, D.P., 2011. The nature and possible causes of changes in speleothem $\delta^{18}\text{O}$ gradients across Europe during the Holocene. In: Proceedings of Climate Change – The Karst Record (KR6) conference, Birmingham, UK. pp. 90.
- Ouellette, G., Polk, J. S., 2013. A multiproxy approach to reconstructing paleoenvironmental conditions from speleothems in Barbados to address

- groundwater vulnerability. in proceedings of the 16th International Congress of Speleology, Brno, Czech Republic, pp 490-493.
- Polk, J. S., Vanderhoff, S., Groves, C., Miller, B., and Bolster, C., 2013a. Complex epikarst hydrogeology and contaminant transport in a south-central Kentucky karst landscape, in proceedings of the 16th International Congress of Speleology, Brno, Czech Republic, pp110-115.
- Polk, J.S., North, L. A., Miller, B., Oglesby, J., McClanahan, K., Neeper, L., Holland, A., and Strenecky, B., 2013b. Understanding and managing karst water resources in Belize: Case studies of both past and present in a changing climate. In proceedings of the 20th conference of National Cave and Karst Management Symposium: a changing climate, Carlsbad, New Mexico, USA, pp.25-31.
- Tobin, B., Schwartz, B., 2011. Assessing recharge elevations for karst springs of the Kaweah River, Sequoia and Kings Canyon National Parks, California. In: Proceedings of 2011 International Conference on Karst Hydrogeology and Ecosystems, Bowling Green, KY, USA. pp.106-107.
- Truebe, S. A., Ault, T. R., and Cole, J. E., 2011. A process model of cave dripwater $\delta^{18}\text{O}$ values: a test of reconstructing decadal variability in speleothem climate records. In: Proceedings of 2011 International Conference on Karst Hydrogeology and Ecosystems, Bowling Green, KY, USA. pp.107.
- Vanderhoff, S. M., "Multiple storm event impacts on epikarst storage and transport of organic soil amendments in south-central Kentucky" (2011). Masters Theses & Specialist Projects. Paper 1128. <http://digitalcommons.wku.edu/theses/1128>.
- Zhang, Cheng, 2011. An introduction to IGCP/SIDA 598: its background, basic Ideas, objectives and work schedule, in: Lu Qian and Zhang Cheng (Eds.), 2011 newsletter of the project 598: Environmental Change and Sustainability in Karst Systems, pp.1-13.
- Zhang, C., Wang, J., Pu, J., Yan, J., 2012. Bicarbonate daily variations in a karst river: the carbon sink effect of subaquatic vegetation photosynthesis. *Acta Geologica Sinica (English Edition)*. v. 86(4), pp. 973–979.