

Part I New Development of IGCP448 in 2001

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1. Website addresses related to the Project

<http://www.karst.edu.cn> (for general informations of the Project)

<http://www2.wku.edu/~grovecg/> (for IGCP448 past meeting, and future meeting in 2003,USA)

<http://www.hidrogeo.uma.es> (for 448 meeting in 2002, Spain)

2. Summary of major past achievements of the Project

In the first year of the Project(2000), besides organizing works, such as defining the model of a karst ecosystem; methodologies of correlation; selecting correlation sites; and figuring out work plan in the 5 years of the Project, some concrete results in line with the 4 objectives of the Project were also achieved.

(1) World Comparison of Karst Ecosystem

The major comparisons on world karst ecosystem in 2000 were carried out in two excursions in Northwest Romania and Lagoa Santa Karst of Eastern Brazil. Meanwhile, the Vietnamese Working Group provided a report of tropical karst ecosystem, the Cuc Phuong National Park, and the Slovenia Group reported an ecosystem of the Classic Karst, the world heritage site Skocjanske Jama. In the Northwest of Romania(Bihor Karst), the vegetation is in general very good, except in areas of timbering, grazing and mineral deposit prospecting. The characteristics of karst ecosystem in Lagoa Santa, Brazil are brought about by Proterozoic carbonate rock; a stable Gondwana land surface; and a subtropical humid warm climate.

(2) Geological Background of Karst Ecosystem and Vegetation

The Bihor Karst in NW Romania was found to be an ideal site for world correlation on karst ecosystem, because its biodiversity is a result of many controlling factors including geography, lithology, topography, and Cenozoic history. The grasslands of *Sesleria rigid* are an important link in the grassing of rock and rock afforestation. The Bihor karst vegetation also enjoys some relict species, such as the Tertiary relict of Transylvanian *lilac*, the glacial relicts of *pedicularis limmogena*, *Eriophorum Vaginatum*. In Brazil, under the long term denudation of the stable Gondwana land with a subtropical humid climate, many typical karst features are well

developed in Phanerozoic sandstones and Proterozoic quartzites of Cratonic Covers and fold belts.

(3) Subterranean Karst Ecosystem

The major achievements in this objective in 2000 included the microbiology in cave and its impacts on weathering and depositional processes; behaviors of underground animals such as beetles, some vertebrates; and description of cave fauna. The ecosystem in Movile Cave of Romania was found to be entirely dependent on chemoautotrophic microorganisms. The Villa Luz Cave in Mexico is also a chemoautotrophic ecosystem based on sulfur-loving organism. The behaviors of some cave living fishes and amphibians, including their diurnal activity, alarm, aggressive, and sexual behaviors were studied. Some new cave fishes were found in Guangxi, China: *Parasilurus Cochinchinensis* and *Parasinilabeo assimlis Wu et Yao*.

(4) Human Impact on Karst Ecosystem

The Lagoa Santa Karst of Eastern Brazil was considered as the most endangered karst in the country. It is the results of urban expansion, increasing mining for cement plants. Groundwater, vegetation and soil are under severe stress. Catastrophic karst collapse happened. Around the Idrija Mercury Mine, Slovenia, 20kg of mercury were emitted into the atmosphere per day, and brought about endemic disease. The impacts from a big limestone quarry at Koper, Slovenia on karst ecosystem include pollution of karst springs, destroying some karst features with scenic value; and removing karst sediments with important informations for scientific research on paleoclimatic reconstruction.

3. Achievements of the Project this year

3.1 General scientific achievements (including societal benefits)

The scientific achievements of the Project's second year is characterized by an international comparison of various karst ecosystem along a north-south transect in East Asia, i.e. from tropical ones to boreal ones. Concrete achievements of the Project this year could be summarized according to its 4 objectives on the bases of presentations and discussions in symposia, field excursion and reports from National Working Groups.

3.1.1 World Comparison of Karst Ecosystem

Based on the 2001 field correlation in subtropical karst of SW China and semiarid karst in western Beijing of North China, integrating with reports from Eastern Siberia (Russia), and tropical karsts of Ryukyu Island (Japan), Vietnam, Malaysia, and Indonesia, the Project got a whole transect of karst ecosystems in East Asia from tropical, subtropical, coastal, semiarid to boreal karst ecosystems. This is a major step for the Project toward understanding karst ecosystem of the world. Yuri

Trjzhtsinski reported the characteristics of boreal karst ecosystem in Eastern Siberia(50-60° North Latitude), underlain by Cambrian strata of carbonate-evaporite mixture formations. The boreal karst ecosystem used to enjoy shallow groundwater perched on permafrost, which support vegetation. But global warming and series of reservoirs constructed on Angara River since 1960s had brought about vanishing of permafrost, draining of shallow groundwater, and damaging the Taiga Forest. The reservoirs also activate the dissolution of evaporite-carbonate rock formation, and result in serious karst collapse problems. In some parts on the west bank of Bratsk Reservoir, the density of the collapse pit could be 2.5-200/km². The pollution from metallurgical and coal industries along the reservoirs has endangered fisheries. The 60,000 km² tropical karst on Paleozoic and Triassic carbonate rocks in Vietnam(15-22° N) which covers 18% of the country is characterized by peak cluster-depression in mountainous area and tower karst on the coast. Do Tuyet finds its good biodiversity, e.g, the thick vegetation cover of evergreen tropical rainforest enjoys approximately 2000 species of *cormophytes*, the phylum *chordatas* is represented by 541 species, and the Class *Insecta* has about 2000 species. But processes of rock desertification, under the impacts of human activities, like those occurred in SW China also happened in the karst of Northwest Vietnam. Sambudhi Sudibyo discussed the tropical ecosystem of the karst belt underlain by Tertiary limestone at southern peripheries of Java island(7-8° S), the Yogyakarta Province of Indonesia. It is about 1000km long in east-west direction, and 20~30km wide in north-south. Under the prevailing climatic conditions marked with seasonal extremes of water and heat, the population pressure, and bad land use planning have transformed the karst ecosystem into a rocky barren landscape that almost devoid of soil and vegetation. The remaining soils on karstland are confined in dissolutional fissures or holes distributed in a patchy patterns between limestone outcrops or boulders. Local peasants cultivate their soil like growing plants in pots, the so-called “pot culture”. Moreover, Sambudhi Sudibyo also reported that some cash crops are calciphile and can grow well on limestone and benefit local people, such as mango, cashew, and *Gnetem gnemon* (“Mlinjo” in Indonesian language). Such ecological scenario and experiences are quite comparable with those of SW China Karst, although the plant species of Indonesia are more tropical.

In the middle part of the great East Asia transect lies the broad karst areas in China. Chinese colleagues provided 5 different karst ecosystems with different geological, topographical, climatic, vegetational, and human activity background. They are: Western Mountain in Beijing(40° N), Jinfo Mt. Nature Preserve, Chongqing(29° N), Liupanshui City, Guizhou(26° N), Stone Forest, Kunming(24° N), and Guilin(25° N).

The semiarid karst In the mountainous region at western suburb of Beijing is

underlain by Cambrian-Ordovician limestone, with a periglacial form featured by limestone peaks, the “Pseudo Cone Karst” developed on Proterozoic siliceous carbonate rocks along the Juma River. The abundant speleothem well-decorated in the 2500m long Shihua Cave which developed in Ordovician limestone are considered to be deposited in some warm humid period of the geological history, such as the stable isotopic stage 5e 130ka ago. The karst vegetation is getting better in the areas near Beijing city and some scenic resorts, but still showing bare rock in remote parts. Impacts of human activities (limestone quarry, cement manufactory, and excess buildings in scenic areas, and etc) on karst ecosystem were discussed.

The Jinfo Mountain Nature Preserve with more than 5000 species of plants and 500 species of wild animals, is about 200km south of Chongqing city, or 100km south of Yangtze River. Although based on a subtropical monsoon humid climate, the high relief (500m-2200m asl) of Jinfo Mt., and its wide geological coverage (from Cambrian dolomitic limestone at its foot to Permian limestone on the top of plateau) bring about various karst ecosystems. People experienced how karst features, soils, water chemistry, vegetation changed in accordance with the changing altitude and stratigraphy. Some particular species were examined, e.g. *Cathaya argyrophylla* which used to be widespread in Northern Hemisphere during Cretaceous and Tertiary, but declined in Glaciations, now remains only in Jinfo Mt. because of its special geographical situation. *Liriodendron Chinese*, now only available in China and North America, and being considered as an evidence of continental drift, is distributed at 1200m to 1800m in Jinfo Mt. There are ten thousand hectares of *Chimonobambusa utilis*, a particular species of bamboo with rectangular cross section spreading on the top of Jinfo Plateau. On the mountain slope, a demonstration village for ecological rehabilitation (Dahe Village) was visited.

On Guizhou Plateau a deteriorated karst ecosystem (the karst rocky desert) and its rehabilitation were examined. The vegetation cover between Guiyang and Liupanshui city is only 3.15%(for Puding country) and 1.14%(Shuicheng country). The causes of karst rock desertification were discussed including population pressure(135p/km²), bad land use in cultivating slope steeper than 25°, poor soil formation on limestone under intensive karst processes, and slow growth rate of vegetation on the plateau climate and rocky land. On the other hand, an ecological rehabilitation area at Baihe village, 5km west of Liupanshui city was also visited. Through years of afforestation, 8668mu(1 acre=6.07mu) of secondary forest has been developed, including 1000mu dense forest. Biodiversity has been observed in the rehabilitation so that the secondary forest includes not only local prevailing species, such as *Pinus armandii*, *Pinus Yunnanensis*, but also many other species, e. g. *Coriaria Sinica*, *arbutus* (*Myrica rubra*), *walnut*, *poplar*, *birch*. The rehabilitation has also improved the eco-hydrological system. An epikarst spring becomes permanent

with a discharge of 20l/s, and facilitate villagers with water supply.

Stone Forest, the unique karst features are developed on Permian limestone on the plateau surface 1800~1900m asl. Here the most characteristic pinnacle karst of the world and its varieties were investigated. The origin and the evolution history of such karst landscape were discussed. In the Naigu Stone Forest area, participants examined on the spot the action of aerial blue Algae in the formation of micro karst features and their function of water detention on the surface of limestone rock. (Reported by Tian Youping and Cao Jianhua at the symposium in Beijing). The importance of such phenomena for the rehabilitation of karst rocky desert was stressed.

Guilin is a paradise of world karst geomorphologists, especially for those who devote to the study of tropical karst. The tower karst in Guilin is developed on the pure, massive limestone of upper Devonian, with altitudes from 150m asl(the plain surface) to 200-400m asl(stone peak surface). It is divided into two subtypes, i.e, the peak cluster(fengcong) and the peak forest(Fengling). The former enjoys a common stony basement, but the latter is a group of peaks separated each other by a flat plain. Participants made intimate investigation on the peak shape's varieties and distribution of subtypes from different angles. Hot discussions on the origin and history of the two subtypes of tower karst were made. A karst Hydrogeological Experimental Site started in 1980s for a Sino-French cooperative Project, and continuously used by several IGCP Karst Projects was visited. The KHES is situated near Yaji village at east of Guilin. Automatic data log were demonstrated, and the results of 16 years of monitoring for the water cycle and carbon cycle at the Site were noted. Some relationship between ecosystem and hydrochemistry, microclimate were found. Since early 1990s, the catchment area of the site has been closed for vegetation recovery. Now it is in a positive evolution stage from rocky desert to secondary grass-bush vegetation, with *Vitex negundo*, *Loropetalum chinensis*, *Phyllostachys sulphurea*, and *Rosa cymosa* as predominant species. The monitoring data reveals, that following the recovery of vegetation, the P_{CO_2} in soil atmosphere and the Ca^{2+} , HCO_3^- content in karst water are all increased remarkably. Moreover, it is found by data log that the conductivity in the borehole water is increased, and Ph value reduced during a storm. The phenomena are considered to be a result of pushing CO_2 into the borehole by the storm water. Meanwhile, the microclimate in the Site is still worse than in the nearby karst forest on the boundary between Guangxi and Guizhou. For example, the annual variation of temperature and humidity in the Site is 33°C, and 80% respectively, but in the karst forest, they are only 18.3°C and 35%. Moreover, the temperature on the surface of bare limestone in the summer could be as high as 58°C, a condition that very unfavourable for the rehabilitation of karst rock desert.

In this year, we also got some correlation reports from European countries, e.g,

an overview of karst ecosystem in Albania was given by Halil Hallaci et al; A.Tyc talked about karst ecosystem of temperate climate in Poland.

3.1.2 Geology and Karst Ecosystem

There were many papers dealing with the relationship between geological factors and karst ecosystems. A lot of plant species that grow on carbonate rocks are identified as calciphile. Some of them are beneficial, such as *Zenia insignis chun*, *Lonicera hypoglauca* Miq, *Camellia Kuding*, *Nervilia fordii*(Hance) Schltr, *Eucommia Ulmoides*. Others are found to be harmful, such as *Pteridium*, *Kudzu vine*, *Euratorium adenophorum*. Zhang Weiji discussed the formation type of red soils in Yunnan Province of China and its relation with ecology, especially with agriculture, forestry, water conservancy and environmental protection. Dora Angelova reported the ecological consequences of paleoearthquakes in the karst terrains along the Northern Bulgaria Black Sea Coast: rearrangement of karst water basins; cave deformation or collapse; oil, gas and salt intrusions. Vyda Elena Gasiuniene analysed the impacts of paleokarst and its reactivation on ecosystems in Akmenė and Karpenai of Northern Lithuania: groundwater quality; geohazards; and quarry. Hiroyasu Furukawa and others found the high permeability of Quaternary coral reef limestone at Ryukyu Island, Japan brings about severe water shortage due to rapid leakage, although the annual mean precipitation is as high as 2300mm. Based on the research in Nongla, Guangxi, a subtropical peak-cluster depression mountainous village, Jiang Zhongcheng discussed the relationship between element migration (K, Na, Ca, Mg, Si, Al, Fe, Mn) in rock, soil, water and karst ecosystem, especially the development of precious medicinal herb.

3.1.3 Subterranean Karst Ecosystem

Silviu Constantin reported with a video tape the biospeleologic findings by Christian Lascu and Serban Sarbu at Movile Cave, southeast coast of Romania. The cave is developed in limestone of upper Miocene, with a passage a little lower than modern sea level. Through diving in a siphon, a totally closed chamber 24m³ in volume was found to be dwelt by 1000 of cave animals from 33 species including centipedes and spiders. The closed condition of the cavity with temperature 25-30°C and its high concentration in methane(1% v/v) and H₂S bring about the idea that the cave fauna are entirely dependent on chemoautotrophic microorganisms. Li Wei and Yu Longjiang studied the subsoil bacteria in 4 different karst ecosystems of SW China. The bacteria that produce Carbonic Anhydrase (CA) which can accelerate dissolution of CO₂ in water and thus enhance karst processes were screened out. It is found that the activity of CA in subsoil bacteria is related to vegetation. Perrin J and others reported results of investigating faecal bacteria in a karst aquifer of Milandre Test Site, Swiss Jura. Tian Youping identified 188 species of aerial blue algae on the surface of carbonate rocks in the Stone Forest Resort, Yunnan, China, and discussed

their actions on the formation of micro karst features. Based on a study at Barkly Karst, Northern Australia, Russell Drysdale reported his findings on the role of some aquatic insect larvae (Orders of *Diptera*, *Lepidoptera*, *Trichoptera*) in travertine building. The results of subterranean ecosystem researches in Guizhou Plateau were demonstrated with an example at Zhengjiadadong cave, 1315asl. 6 classes, 11 orders and 20 families of cave animals were identified from the cave. The tendency of each Family's preference to stay in the entrance belt, twilight belt, or dark belt of the cave is studied on the based of statistics. The availability of *beetles*, birds and *Noctuidae*, *Orthomorpha sp.* are compared between caves in Guizhou and other parts of the world.

3.1.4 Effects of human activities on karst ecosystem.

A lot of papers dealing with the impacts of urbanization, agriculture, mining, groundwater extraction, quarrying, and construction of reservoirs, highways on the karst ecosystems and relevant investigation or remedation measures. Tan Boon-Kong provided an overview of karst engineering geology in Malaysia, with special discussions on rockfall, sinkhole and karst foundation problems. V. V. Tolmachev reported the karst hazards on sulphate-carbonate rocks in the European part of Russia, and suggested three protective measures for civil and industrial buildings. Milena Samalikova discussed the karst formation at Moravia in eastern part of Czech, and relevant problems such as rock fall, sinkhole foundation, quarrying, and ecological aspects of civil engineering works. Shane Fryer talked about the vulnerability of karst terrain to contamination with a dramatic incident of 3800 gallons diesel oil leakage happened recently in the Mammoth Cave region, USA. De Beer Johannes discussed the ground deformation problems in the karst of South Africa, especially those related to gold mining.

The reciprocal changing of biodiversity in the Stone Forest area, Yunnan, China in the past half century provides a good example of relation between human activity and Biodiversity. People noticed that in the center part of Big Stone Forest, the evergreen broadleaf endemic flora with nice view represented by *Pistacia Weinmannifolia*, *Pistacia Chinensis*, *Nicondra Physaloides*, and etc are surrounded by uni-species artificial forest of *Pinus yunnanensis*, and *Pinus armandii* widespread outside the Big Stone Forest region. The explanation of such phenomena was given from a historical point of view. Early last century, deforestation happened here following intensive timbering and mining activities. Since 1950s, the planting of selective fast growing and economically beneficial species such as *Eucalyptus*, pine trees has brought about quick afforestation on one hand, but reduction of biodiversity on the other. Later, the disadvantages of uni-species forest, such as frequent large scale Pine moth hazards happened. In late 1980s, decision was made to protect biodiversity in the center part of Stone Forest Scenic Resort. Some planted species

were cut. Under the favourable climatic condition, biodiversity is improving in the central part but uni-species forest still remains in the surrounding areas.

The Lionne Karst Spring at Swiss Jura is a test site of COST (European Commission: Cooperation of Science and Technology), Action 620, for Karst Hydrogeology and Vulnerability Study. Its catchment area is 1300-1500m asl at the southern side of Joux Lake, and underlain by Jurassic limestone outcropped at series of NE anticlines and synclines (from north to south: Chaumilles anticline, Grand Essert syncline, and Bucley anticline). It covers an area of about 30km², i. e., 10km long from SW to NE, and about 3km in width. The Jurassic limestone is gently dipped and favourable for karstification and infiltration, but becomes steep near the Lionne Spring, where the argillaceous bed of Cretaceous blocks the hydrological system, and makes the spring flowing out. The discharge of the spring ranges between 100 l/s and 8500 l/s. A series of research works on this typical karst system have been done by the Center d'hydrogéologie de Neuchâtel, including hydrogeological survey, caving, tracing, infiltration test, hydrological, hydrochemical, bacteriological, and meteorological monitoring. Two approaches of vulnerability assessment and mapping for the karst system have been worked out, and were explained in the excursion. The first one is the EPIK method being put forward by N. Doerflinger (BRGM, France) and P.Y. Jeannin, F. Zwahlen of Neuchâtel, Switzerland. Vulnerability is here defined as the intrinsic geological and hydrogeological characteristics which determine the sensitivity of groundwater to contamination by human activities. The EPIK method is a multi-attribute method for vulnerability mapping and based on a conceptual model of karst hydrological system with 4 karst aquifer attributes: E-Epikarst; P-Protective cover; I-infiltration condition; K-karst network distribution. This method was applied to several sites in Switzerland where agriculture contamination problems have frequently occurred. This application resulted in recommending new boundaries for karst water protection zone. Another is the VULK model. It also takes into account the characteristics of 4 layers in the catchment area. Taking the Lionne spring catchment as an example, they are: the thickness of top soil; the thickness of subsoil (0-3.5m); the thickness of non-karstic bedrock; the thickness of non-saturated zone (15-350m); and the flow velocities in the non-saturated zone (1-100m/h). A contaminant transit time map was demonstrated, which is compiled through calculating transit time for 10 selected sites in the catchment area of the Lionne Karst Spring. It shows 6 categories of transit time: 0-10h; 10-20h; 20-50h; 50-100h; 100-200h; and 200-400h, and provides bases for vulnerability assessment.

3.1.5 Societal Benefits

(1) The Excursion in China benefits both China and other countries. Officials of local government at different level took part in the events and heard suggestions

and comments from foreign and Chinese experts, including better land use planning, especially for limestone quarries; to improve management of show caves and other karst scenery, such as tufa deposits; environment educations; to improve karst water exploration and protection by using advanced programs; to improve monitoring works; and cooperation between administration, legislation and education institutions. All the points will help the rehabilitation of rocky desert in SW China karst. On the other hand, participants found the international correlation and principles of IGCP very helpful for the development of geosciences. Some people said this excursion will have deep influence on their future karst research. Sambudhi Sudibyo said he will ask the Agricultural Department of Indonesia learn the experiences of “Ecological Agriculture” on karstland he saw in some demonstration sites during the excursion.

(2) *Zenia insignis chun*, a petrophile and calciphile species growing on limestone rock in SW China is found to contain protein as high as 19.62% in its leaves, and therefore can be used as a good fodder for animal husbandry. 16 thousand hectares of such tree have been planted on limestone rocky area in Guangxi Province, China.

(3) The IUCN (World Conservation Union) shares informations from IGCP448. At the invitation of IUCN, Yuan Daoxian, the co-leader talked about the results of the Project at its Asia Pacific Forum “Karst Ecosystems and World Heritage” held in Mulu Karst, Malaysia, 26-29, May, 2001. IGCP448 Newsletter 2000 were distributed to every participants(70 people from 17 countries, mostly from SE Asia). Later, the Guidebook of IGCP448 excursion in China was sent to IUCN’s SE Asia office, and appreciated as “good information reference for any IUCN staff”. Yuan Daoxian was invited as a member of World Commission on Protected Area(WCPA) of IUCN(July 21, 2001).

3.2 List of Meetings with Approximate Attendance and Number of Countries

(1) Joint Meeting of the “First International Conference on Sustainable Development in Karst Region” and IGCP448, Beijing, China, August 30-31, 2001. 73 people from 18 countries took part in the Conference. A total of 38 papers were presented. 38 people from 12 countries took part in the 4000km long post-conference IGCP448 field workshop, Sept 1-Sept 12, 2001 in Western Beijing and SW China karst(Chongqing, Liupanshui of Guizhou, Stone Forest of Yunnan, and Guilin). A 94-page Guidebook was given to everybody before the Workshop started.

(2) IGCP448 meeting in conjunction with the 7th Conference on Limestone Hydrology and Fissured Media, Besancon, France, Sept 20-23, 2001.

187 people from 17 countries participated the conference. A total of 78 papers were presented.

More than 100 people from 15 countries took part in the one day excursion of

Sept.22, 2001, to examine the COST Action 620 field site of karst vulnerability study at Lionne Karst Spring, Swiss Jura, and the Vallorbe Underground Stream Cave, with a discharge of 3-75m³/s, and a 410cm long straw stalactite, the longest in Europe.

3.3 Educational, Training or Capacity Building Activities

20th Speleological School, Cieszyn-Liptovsky Mikulas, Poland-Czech, Feb 9-15, 2001, organized by Silesia University, Poland. The course includes karst geology, karst geomorphology, karst hydrology, glacier cave, human impacts on karst environment, history of karst research, and informations of IGCP448.

More than 100 people from 13 countries took part in the Course.

3.4 List of Most Important Publications

1. Carlo A. Longo, Bartolome Andro Navarro et al, Comparison of Two Contamination Vulnerability maps obtained by the SINTACS Method in Two Carbonate Aquifers(S Spain), Proceedings of 7th Conference on Limestone Hydrology and Fissured Media, Sept.20-23, 2001, P233-236.
2. Carrasco Cantos Francisco, Jamenez Gavilon Pablo et al, Estudio Comparativo Preliminar del Funcionamiento Hidrogeologico de Varios Acuiferos Carbonatados de la Cordillera Betica, Proceedings of VII Simposio de Hidrogeologia, Spain, Murcia. 28 May-1 June, 2001. Editor: Antonio Fernandez Uria, P381-391.
3. C. Linan, F. Carrasco, B. Andreo, Consideraciones Hidrogeologicas Sobre el Sistema Acuifero de la Sierra de las Nieves(Unidad Hidrogeologica Yunquera-Nieves, Provincia de Malaga), Proceedings of the V Simposio Sobre el Aqua en Andalucia, Almeria, Sept.25-28, 2001, P127-139.
4. D. Angelova, Paleoseismic Events in Karst Terrains along the Northern Bulgarian Black Sea Coast. Acta Geologica Sinica(English Edition). Vol. 75, No.3, 2001, P308-315.
5. Do Tuyet, Characteristics of Karst Ecosystems of Vietnam and Their Vulnerabilty to Human Impact. Acta Geologica Sinica(English Edition). Vol.75, No.3, 2001, P325-329.
6. J. M. Vias, B. Andreo et al, Application of Several Methods of Contamination Vulnerability Mapping in a Carbonate Aquifer from South Spain, Preprints for the Themes 1-3, 3rd International Conference on Future Groundwater Resources at Risk, Lisbon, June 25-27, 2001, 8 pages.
7. Kaijun Jiang, Hirayasu Furukawa et al, Water Resources Development in Quaternary Ryuku Limestone Regions of Japan: Application of the GIS to the Site Selection of Underground Dams. Acta Geologica Sinica(English

- Edition). Vol.75, No.3, 2001, P254-259.
8. Li Wei, Yu Longjiang et al, A Preliminary study on Soil Bacteria in Typical Karst Areas of Southwest of China, Paper Presented at the IGCP 448 Symposium in Beijing, August, 2001. (in press).
 9. Liu Zaihua, Role of Carbonic Anhydrase as an Activator in Carbonate Rock Dissolution and Its Implication for Atmospheric CO₂ Sink. *Acta Geologica Sinica(English Edition)*. Vol. 75, No.3, 2001, P275-278.
 10. Liu Zaihua, Zhao J, Contribution of Carbonate Rock Weathering to the Atmospheric CO₂ Sink, *Environmental Geology*. Vol.39, No.9,2000, P1053-1058(in English)
 11. Liu Zaihua, Yuan Daoxian, Features of Geochemical Variation in Typical Epikarst Systems of China and Their Environmental Significance, *Geological Review*, Vol.46, No.3, 2000, P324-327 (Chinese, English Abstract)
 12. Liu Zaihua, Yuan Daoxian, He Siyi, Zhang Meiliang, Zhang Jiagui, Geochemical Features and Origin of CO₂ in a Geothermal CO₂-H₂O-Carbonate System---Case Examples of Huanglong, Sichuan, Kangding, and Xiagei, Yunnan. *Science in China (Series D)*, Vol.30, No.2, 2000, p209-214 (In Chinese)
 13. M. Martin-Martin et al, Travertinos del Borde Noreste de la Depresion de Granada, In a book “La Cuenca de Granada: Estructura, Tectonica activa, Sismicidad, Geomorfologia y Dataciones Existentes”. Edited by C. Sanz de Galdeano et al, P22-28(in press).
 14. M. Samalikova, Engineering-Geological Problems in the Moravian Karst, Czech Republic. *Acta Geologica Sinica(English Edition)*. Vol. 75, No.3, 2001, P303-307.
 15. Song Linhua and Liang Fuyuan, Distribution of CO₂ in Soil Air Affected by Vegetation in the Shilin National Park. *Acta Geologica Sinica(English Edition)*. Vol. 75, No.3, 2001, P288-293.
 16. Special Issue of *Acta Geological Sinica(English Edition)*, Journal of the Geological Society of China for the “International Working Group Meeting of IGCP 448”. Chief Editor: Cheng Yuqi. Vol.75, No.3, 2001, P239-343.
 17. Tan Boon-Kong, Engineering Geology of Limestone in Malaysia. *Acta Geologica Sinica(English Edition)*. Vol.75, No.3, 2001, P316-324.
 18. V. T. Tam, T. M. N. Vu and O. Batelaan, Hydrogeological Characteristics of a Karst Mountainous Catchment in the Northwest of Vietnam. *Acta Geologica Sinica(English Edition)*. Vol.75, No.3, 2001. P260-268
 19. V. V. Tolmachev, O. B. Neshchetkin, Evaluation of Karst Hazards for Civil

- and Industrial Buildings. *Acta Geological Sinica(English Edition)*. Vol.75, No.3, 2001, P269-274.
20. Yuan Daoxian, On the Karst Ecosystem. *Acta Geologica Sinica(English Edition)*. Vol.75, No.3, 2001, P336-338.
21. Yuan Daoxian, Liu Zaihua et al, Guidebook for Ecosystems of Semiarid Karst in North China and Subtropical Karst in Southwest China. Sept.1-Sept.12, 2001. Published by Karst Dynamic Laboratory, Guilin, China, 94 pages.
22. Yuan Daoxian, Carbon Cycle in Earth System and Its Effects on Environment and Resources. *Quaternary Sciences*, Vol.21, No.3, 2001 P223-232(Chinese, English Abstract)
23. Yuan Daoxian. World Correlation of Karst Ecosystem: Objectives and Implementation plan. *Advance in Earth Sciences*. Vol.16, No.4, 2001, P461-466(Chinese, English Abstract)
24. Zhang Cheng, Yao Changhong, Guo Fang, Newsletter of IGCP 448, 2001. Published by the Karst Dynamics Laboratory, Guilin, China. 105 pages. (hard copy). Available also on website: <http://www.gxnu.edu.cn/KDL>
25. Zhang Meiliang, Lin Yushi, Qin Jiaming, The Form Combinaton and Dynamic Conditions of Dropping Water of Deposition Laminate From Stalagmites in Caves. *Journal of Southwest China Normal University(Natural Science)*, Vol.26, No.4, 2001, P466-470(Chinese, English Abstract)
26. Zhao Jingbo, The Paleosol and the Migration of Climate Zone about 500kaBP in Loess Plateau. *Acta Geographica Sinica*, Vol.56, No.3, 2001, P323-331(Chinese, English Abstract)
27. Zhao Jingbo, Yuan Daoxian, Du Juan, Yue Yingli, Luo Min, Release amount and its change law of CO₂ from soil on July in Xi'an area. *Journal of Shaanxi Normal University(Natural Science Edition)*, Vol.29, No.2, 2001, P81-86(Chinese, English Abstract)
28. Zhu Xueyu et al, Characteristics of Oil Contamination and Numerical Modelling of Its Transport in Fractured-Karst Water in Zibo City, China. *Acta Geologica Sinica(English Edition)*. Vol.75, No.3, 2001, P294-297.

3.5 Activities involving other IGCP Projects or the IUGS

(1) IGCP Co-Project. The cooperative Co-IGCP Project of IGCP 413,448,459,464 entitled "Future Human Environments from Past Records" (CHANGES) made headway in the past year. A strategy meeting of the 4 Co-leaders was held January 26th-27th, 2001 at UNESCO Headquarters. A poster of CHANGES was presented at PAGES III meeting (late August, 2001). A database of the

Co-Project with comprehensive indicator was set up at Geography Development, Sheffield University, UK(changes@sheffield.ac.uk). The Co-Project's work in the next few years, especially a symposium in the 16 INQUA, Reno, USA, July, 2003 was discussed.

(2) The Project got continuous support from the Karst Commission of IAH. Prof. Heinz Hotzel, the chairman of the Commission and many other members of the Commission attended the Project's meeting in Besancon, and gave many helpful suggestions, such as more cooperation with COST Action 620.

(3) The cooperation with Karst Commission of IGU has been as usual. In the Project's meeting in China, the Commission was represented by its permanent member, Dr. Andrzej Tyc. He will report all the results of the symposium and excursion of IGCP448 in China to this IGU Commission.

4. Activities planned

4.1 General goals

According to the implementation plan of IGCP448, and the discussions at the Project's International Working Group Meetings in China and France, the third year of the Project will focused on karst ecosystem of Mediterranean realm, with a major meeting and excursion in Spain. Characteristics of Mediterranean karst ecosystem, karst and natural heritage, and human impacts on karst groundwater and caves will be examined. Some meetings in France, Slovenia and Bulgaria sponsored by relevant karst organizations (IGU, UIS) that just follow up our meeting in Spain will also be used as a chance of field comparison and exchange. Moreover, Dr. Chris Groves will organize a short IGCP448 meeting in Lexington, USA to have a preliminary investigation on the karst ecosystem of Eastern North American.

4.2 Specific meetings and field trips

- (1) "Karst and Environment", 2nd Nerja Cave Geological Symposium and 2002 meeting of IGCP 448 Project. Symposium: Sept.15-17, 2002. Nerja(Malaga, Spain), Excursion: Sept.18-19, 2002, Sierra de Libar, the Grazalema National Park, and Sierra de Las Nieves, a karst ecosystem of UNESCO Biosphere Heritage.
- (2) Joint IGCP 448 and Southeastern/North Central Meeting of the GSA (The Geological Society of America). Lexington, Kentucky, USA, April 4-5, 2002.

5. Attach any information you may consider relevant

- (1) The Project's email list gets 160 participants. Its home page gets more than

21000 visitors. The second issue of IGCP448 Newsletter is available on the website (<http://www.glnet.edu.cn/KDL>)

- (2) Russia-Poland-France-China cooperation under framework of IGCP 448. During the 20th Speological School in Cieszyn, Poland, February 11-16, 2001, and the IGCP 448 Excursion in Guilin, Sept.14, 2001, the cooperation between the 4 parties was discussed twice. The scientific program is suggested as “human impact on karst environment in continental scale”. An IGCP 448 meeting in Eastern Siberia, Russia was suggested.
- (3) The Ministry of Science and Technology of China has granted two Key Projects (one million USD each) for karst rocky desert rehabilitation research and demonstration, one in Guangxi Province, with a peak-cluster depression landscape, and the other on the Guizhou Plateau Karst. Many colleagues from the Chinese National Working Group of IGCP 448 involve in the Projects. It will benefit the smooth running of the Project in China.
- (4) Mr. Tian Fengshan, the Minister of Land and Resources of China, and Mr. Xu Guanhua, the Minister of Science and Technology of China attended the IGCP 448 Meeting in Beijing, August. 2001. Mr. Xu Guanhua suggested to establish an UNESCO International Karst Research Center in China. He said if this suggestion meets the approval of UNESCO, he will find money to support this Center.