COOPERATION BETWEEN IGCP AND UNESCO WATER DIVISION
PROPOSAL FOR THEMES OF MAJOR COMMON INTEREST

IGCP was established in 1974, and has included a number of projects, attaining project number 523 in 2005. The programme has been successful, and has produced a large number of scientific papers, scientific meetings and training courses, a broad international network and a positive impact for society is based on this fundamental research. An international evaluation carried out in 2003 concluded that the output was comprehensive especially in relation to the levels of funding. The funding to each individual project has decreased considerably during the past decade, if the inflation rate is taken into consideration.

In the IGCP Guidelines it is clearly stated that all projects shall be relevant for societies. Many of the projects have included a strong applied component. Also the international evaluation of IGCP highlighted the importance of outreach, and recommended that there should be an even stronger focus on applied science.

In March 2005 IUGS appointed an ad hoc committee to examine the future of IGCP. The mission of the group was to give recommendations regarding:

- How to modernize IGCP, including its scientific Board
- How to make IGCP more society relevant
- How to ensure a dialogue between IGCP and other UNESCO scientific programmes
- How to raise the funding for IGCP

In the final report from the group, groundwater is identified as one of the more important tasks of IGCP in the years to come.

The main purpose of this document is to establish a dialogue between IGCP and UNESCO Water Science efforts. Our joint important task is to work together in order to create a future scientific activity that is on a high scientific level, at the same time as it contributes to a better understanding of our water resources.

WATER SCIENCE IN IGCP

IGCP has its strong focus on geology. Within the field of water science it means:

- An understanding of properties of groundwater system; where is the water stored and how does it flow
- An understanding of the interaction between underground fluids, rocks and minerals
- An understanding of the dynamics of all water on the Earth's surface over longer time intervals (more than a decade)
- An understanding of sediment transport and deposition in rivers and lakes
- Sustainable management of water as a natural resource

This has always been and will remain some of the specialities of the geological communities. In IGCP projects the fields above have been included during many years. As an example one notes IGCP 184, “Palaeohydrology of Low Latitude Deserts”, which lasted from 1981 – 1985.

According to the speciality of IGCP, projects should focus on the geological part of water science. Basically, this can be grouped into two main categories:
- Groundwater
- Palaeohydrology

Within both these fields there are some urgent needs for research.

It is only recently that IGCP created a group directly focussed on water. This was done in 2003, when a fifth working group of IGCP was devoted to hydrogeology. This was to acknowledge that groundwater is a very important resource on the Earth, and that it, accordingly needs special attention.

GROUNDWATER

The great importance of groundwater is recognised by scientists within both the field of hydrology and the field of geology.

- Groundwater is the largest freshwater resource on the Earth’s surface
- Groundwater forms an increasing part of the drinking water resources worldwide

Groundwater is closely linked to the geological formations, and is therefore a main research topic for a number of geologists. In particular the International Association of Hydrogeologists, which is an affiliate member of IUGS, promotes such studies and form an important network for hydrogeologists all over the world.

Since the creation two years ago of the working group of IGCP on hydrogeology, the answers to the calls for proposals are both few in number and not of the general international standard we normally require. It is important to improve the situation, and this is partly the reason why we wish to pursue collaboration between IGCP Groundwater and the UNESCO Water Division.

Most studies of groundwater have been related to groundwater as a drinking water resource. Well monitoring, water quantities and qualities have been in focus.
Less focus has been on the long-term dynamics of groundwater systems. However, there are also other important tasks, which are of great importance in hydrogeology, some of them are listed below.

Several factors explain the lack of response to the call for groundwater projects in IGCP:

- There may be a too weak scientific focus of the calls for proposal;
- Although the number of people working with groundwater in the world is quite large, the scientific community of hydrogeologists is rather small, compared to other geological communities.
- The same small society already has a considerable support from important funding from several international programs.
- There is not good enough distribution and information concerning the calls for proposal. IGCP has traditionally not focused on groundwater at all, and it will

take time before the community of hydrogeologists become aware of IGCP.

One very important task is to define specific scientific niches where IGCP funding could generate good scientific results of great practical importance. We believe that this generally requires that

- The scientific themes are so broad so that a larger part of the earth science community can feel associated with the problems to be studied.
- Definition of central fields for collaboration between groundwater specialists and geologists should be defined, in order to bridge the gap between the two communities.
- Information about IGCP should be announced in various newsletters (UNESCO Water Science Bulletin, IAH Groundwater eNews, etc.) and international journals (EOS, Episodes, etc.);

Proposition of some themes corresponding to these criteria (these idea were discussed during WHYMAP Meetings):

- Water and basins: monitoring groundwater systems in sedimentary basins with a collaboration between hydrogeologists and petroleum geologists using expertise of the latter;
- Water and space techniques: use of remote sensing (space gravity , cf. GRACE time-variable gravity observations) to evaluate hydrologic variables and changes in groundwater and produce basin-scale estimates of terrestrial water storage with a strengthening of the collaboration between hydrogeologists/climate modellers and space-observation scientists;
- Water and tectonics: understanding the role of fluids circulation in fault behaviour, earthquake nucleation and, more globally, the hydrogeologic responses to earthquake;
- Water and geochemistry: use of geochemical indicators to understand gradual or catastrophic changes in groundwater resources;
- Water and climate changes: develop predictive models of the modification of ground-water recharge and discharge in relation with different global warning scenario.
- Geological and structural control of groundwater accumulation
- Understanding the underground part of the water cycle, inclusive groundwater-dependent ecosystems.
- Groundwater-rock interactions, including karst processes, groundwater quality and vulnerability
- Characterization of groundwater reserves (reservoir modelling).
- Enhanced aquifer recharge (minimize evaporation losses, increase security of water supplies).
- Water science and mining
- Geomedical aspects of water (geothermal and thermal groundwater).
- Exploration of transborder aquifers.

Groundwater is in many cases a non-renewable resource. Groundwater balance is closely linked to climate variability, and in many parts of the world the water is extracted from fossil aquifers, where very little or no recharge occurs today. Therefore, an understanding of the entire groundwater system (recharge, flow paths, and discharge) is necessary in order to secure such critical resources.

Furthermore, global climate change will to a great extent change the present groundwater budget in many areas. During desertification present recharge-systems may become fossil and discharge of groundwater into rivers may drop drastically. A good example is the warning signals for the Colorado River, where the river discharge has decreased over a number of years. These questions are closely linked to studies of palaeo-climate, where palaeo-groundwater in many cases is one of the components studied.

Climate change in combination with sea-level rise may result in a dramatic degeneration of coastal groundwater bodies. Recent studies in Greece have shown that after a few years of drought, and a high extraction of groundwater, a major intrusion of saline water has occurred into some aquifers. Modelling of the same aquifers has shown that it will take hundreds to thousand of years before the original balance is re-established. A detailed understanding of the groundwater dynamics over time is needed to protect the important coastal groundwater resources.

Dating of groundwater is still a field that needs more research. Here, an intimate cooperation between hydrologists, hydrogeologists and geologists is needed.

We, therefore, strongly recommend a co-operation between UNESCO Water Science Division and IGCP, with particular focus on the following themes:

- Studies of regional groundwater systems with restricted and climate-dependent recharge
- Establishing the recharge/discharge relation in groundwater systems during different global climate variability scenarios. Conceptual and mathematical modelling focused in preventing and attenuating consequences of climatic change
- Artificial recharge for groundwater systems.
- Coastal groundwater resources under stress: urban hydrgeology, sea-level rise, risk of contamination. A large number of big cities obtain fresh water supply from coastal aquifers.
- Modelling of coastal groundwater systems during sea-level rise.

Groundwater in biodiversity is closely related to other important areas, climate change and land degradation. Projects targeting dynamic management of groundwater systems represent crosscutting issues (water, land, wetlands habitats etc) and could facilitate integration between ecology and earth science.

SURFACE HYDROLOGY

There should also be a communication between IGCP and UNESCO Water Science for projects related to surface waters. The world faces the situation that there are extreme situations with too little water (droughts) and too much water (floods). Recently very much attention has been on floods. Studies of floods are important because they:

- Are the most frequent of all natural catastrophes
- Affect almost every part of the World
- Affect a great part of the World’s population because so many people live along rivers and on flood-plains
- Have castastrophic effects that are closely linked to the man’s manipulation of natural systems

Throughout the geological history mega-floods have occurred all over the world. The floods have had major impact on geomorphology, and during the Quaternary also on human societies. The cause of the floods varies, from drainage of ice-dammed lakes to the huge rainfalls associated with tropical cyclones.

In January 2000, coastal and lowland Mozambique experienced a period of catastrophic flooding. The floods were caused by a huge amount of rainwater in the big upper catchment, with a confluence towards the low-lying floodplain. The flood could not easily have been predicted, because there is a lack of historical documentation of floods of this magnitude. Local settlements were destroyed, with disastrous consequences for the local population. Afterwards, many flood victims were offered new properties in safer localities. In September 2005 New Orleans became almost completely flooded as a result of the rise of water level related to the hurricane Katrina. The catastrophe was to a great extent the result of human manipulation of the Mississippi River and its delta. The flood history was well known, and a catastrophe of this magnitude had been forecasted by a number of research communities. The effect was almost the same in both cases, and people prefer to move back to their old homesteads, which will be at risk also during future flood events.

Many other parts of the world have experienced mega-floods during the past decades. Whether or not these are related to global warming is a question that is much debated. In many parts of the world, and especially in Africa, there is a great lack of long flood records. There is no documentation about the link between climate events and the magnitude and frequencies of the big floods.

In order to understand this question it is important to look at palaeorecords: Have mega-floods been more frequent during warm than cool climate episodes? And if so, in which part of the world is an increase to be expected during a possible future global warming?

A mega-flood can result in major erosion along the river course, with a subsequent deposition of the eroded sediments. However, in parts of the river catchment it is not easy to trace the flood even a few years later. To understand the frequency and size of ancient floods it is, therefore, important to know where to look for the flood sequences and how to identify them. This expertise is in particular needed in many developing countries.

A catastrophic flood may be of a magnitude never experienced before in a catchment. Direct measurements of flood magnitudes do normally not date back more than a couple of hundred years. Flood statistics and flood frequency curves can, therefore, not account for the really big events. Furthermore, modern flood monitoring is linked to a restricted range of climatic situations. In order to understand what can be expected for future climate changes, it is, therefore, of great importance to gain knowledge about very big floods, which can be identified by studies of sediment records and landforms.

It is important everywhere in the world to get more knowledge about flood sediments, and to know how to convert such information into a flood magnitude scale. Many scientists who study palaeo-floods have been very concerned about this fact. Further work to make palaeo-flood frequency curves comparable with modern flood frequency curves is a very actual task.

We, therefore, strongly recommend a co-operation between UNESCO Water Science Division and IGCP on the following themes:

- Flood sediment records for the last few thousands of years, with particular reference to rivers in Africa. This should be organised as collaboration between African scientists and international experts.

- Link between palaeo-climate and palaeo-floods, with particular reference to areas in the world where such data are lacking.
- The relation between palaeo-flood magnitudes/frequencies and modern flood frequency statistics, in order to link them to the same scales.

ACTION TOWARDS A CLOSER COLLABORATION BETWEEN IGCP AND UNESCO WATER DIVISION

Decision about the profile of the new IGCP will be taken in 2006. We believe it is of great importance that a dialogue about water science starts early in 2006, and that plans for cooperation is in place well before the deadline for new project proposals for 2006. The cooperation is of particular relevance during 2006-2007 when UNESCO focuses so much on water science.

We believe that IGCP should in a more active way announce groundwater in order to attract more project proposals. We need a considerable increase in the number of proposals before water science becomes an important part of the whole IGCP programme. Groundwater is also an important task under the Year of the Planet Earth, and an active announcement in 2006 is needed to ensure that groundwater in IGCP has reached the desired level before the start of the Year of the Planet Earth.

We mention three prioritised topics in IHP, where we believe that the geological expertice in IGCP is particularly important:

Groundwater and global change:

a. The understanding of groundwater systems under climate conditions different from the present. Here the knowledge about past climate variations is crucial: When and under which circumstances are the large groundwater aquifers recharged.
b. What will be the development of the large present groundwater systems under changed future climate.

Coastal groundwater aquifers:

a. What will happen with the coastal aquifers during a rising sea level. The understanding of this requires an understanding of coastal erosion and sedimentation processes in the past and at the present. This should be combined with detailed remote sensing, which in many areas can show details of the changes over the past 50 years.
b. How long time does it take for a coastal freshwater cone to adjust to abrupt climate changes or abrupt changes in extraction of groundwater? Models indicate that this can take many centuries. Understanding of past global sea level variations as well as past climate variations is necessary in order for a sustainable management of coastal aquifers.

Transborder aquifers:

Transborder aquifers require a very detailed understanding of the underground geology. This is critical for the management of the aquifers and for all questions related to the rights to explore the groundwater