SUMMARY OF IGCP 2017

IN GLOBAL CHANGE THEME

FEBRUARY 2018

Projects are listed following Geologic Time (from Cenozoic to Paleozoic):

IGCP 639 Sea Level Changes from Minutes to Millennia

Duration: 5 years (2016-2020)

Aim: Sea-level changes over timescales from minutes to millennia are of great concern to coastal communities. Long-term changes in sea level due to the solid earth's response to glaciation and tectonics are the background rate upon which the hazard from anthropogenic sea-level change and extreme inundation from tsunamis and storms must be superimposed. Short-term measurements from instrumental and historical records provide short glimpses at the hazard posed by sea-level change over varying temporal scales but must be placed within the long-term context that only geological and archaeological records provide. IGCP 639 provides a platform for the development of integrated records of sea-level change and coastal hazards obtained from instrumental, historical, archaeological, and geological records, focusing on Africa, South America, and the Middle East.

Three temporal levels of sea-level change are analysed by IGCP 639:

- Coastal hazards that range from **minutes to decades** – storms, tsunamis, and coastal earthquakes
- Coastal hazards that range from **years to centuries** – deltas and land subsidence
- Coastal hazards that range from **centuries to millennia** – ice budgets, sea level, and geological evolution

The overarching aims of IGCP 639 are:

- To gain a greater insight into coastal hazards by integrating different methodologies that consider varying timescales
- To bring together specialist scientists from related disciplines (e.g. historians, archaeologists, modellers, geodesists)
- To transfer knowledge of basic science methodologies developed over multiple IGCP projects (e.g., protocols for reconstructing geological records of relative sea level) to developing nations.

Achievements: They published 50 papers including in leading journals such as Proceedings of the National Academy of Sciences, Nature Communications, Geophysical Research Letters, Earth Science Reviews, and Quaternary Science Reviews. A Conference in Oman was organized and they submitted a meeting report to EPISODES for publication. Also a publication of a special issue arising from the EGU session on Extreme Wave Events is done and it will publish in Marine Geology. They reached over 300 followers across social media platforms. Formation and staffing of three working groups based on the project themes identified the proposal was also reported.

IGCP 610 From the Caspian to Mediterranean: Environmental Change and Human Response during the Quaternary

Duration: 5 years (2013-2017)

Aim: This Project investigates the influence of environmental change on the development of humankind for the entire Caspian-Black Sea-Mediterranean Corridor ["CORRIDOR"] that encompasses the Eurasian intercontinental basins of the Caspian, Black, Marmara, Aegean, and Eastern Mediterranean seas with their connecting straits and coasts. During the Quaternary, these basins were repeatedly connected and isolated from each other. This predetermined their environmental conditions and hydrologic regimes and imposed specific impacts on diverse biological populations, including humans inhabiting the coastal domains.
The goal of IGCP 610 is to provide cross-disciplinary and cross-regional correlation of geological, archaeological, environmental, and anthropological records in order to:

- explore interrelationships between environmental change and human adaptation during the Quaternary,
- create a networking and capacity-building structure to develop new interdisciplinary research initiatives, and
- provide guidance to heritage professionals, policy makers, and the wider public on the relevance of studying the "CORRIDOR" for a deeper understanding of Eurasian history, environmental changes and their relevance, and likely future impact on humans.

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Six dimensions of evidence are integrated into this project: 1) geological investigations of the sedimentary record of vertical sea-level fluctuations and lateral coastline change; 2) paleoenvironmental evidence integrating paleontological, palynological, and sedimentological records to reconstruct paleolandscapes; 3) archaeological evidence from cultural remains; 4) paleoanthropological evidence of responses of different *Homo* species to environmental change; 5) mathematical modeling of climate, sea-level change, and human dispersal linked to environmental change; and 6) geo-information studies to explore the "big picture" of geoarchaeological events throughout the Quaternary.

Achievements: The leaders cited 17 major achievements of this project. As an example it could mention: In-depth study of the Quaternary stratotypes, archaeological monuments, and anthropological remains in countries surrounding the CORRIDORS; reference collection of Mediterranean, Caspian, and Black Sea foraminifera as well as the Ponto-Caspian molluscs, palynomorphs, NPP, artefacts, and anthropological records; Series of regional paleogeographic, tectonic, and geological maps. Among the multiples social benefits, it can be mentioned: implementing cultural heritage projects, open-air site museums, training centers for conducting experimental research, working together with local Governmental and Non-Governmental Organizations; among others.

IGCP 608 Asia-Pacific Cretaceous Ecosystems

Duration: 5 years (2013-2017)

Aim: The Cretaceous "greenhouse" period is known for elevated atmospheric CO_2 levels and much higher global sea levels than today. The Cretaceous Period is thus a geological proxy for understanding the development of ecosystems in greenhouse periods, such as may characterize our planet if present global warming trends continue into the future.
A great variety of well-preserved environments and ecosystems can be found in the Cretaceous geological records of Asia and the Western Pacific rim. The aim of IGCP 608 is to delineate these Cretaceous ecosystems in both marine and terrestrial environments to determine how they responded to paleo-environmental changes. This information is used to ascertain links between global and local environmental changes ecosystems. Close tie-ins with IGCP Project 609 "Cretaceous Sea-level Changes" permit analysis of the biological response to sea level rise during the Cretaceous greenhouse climates.

Achievements: This project includes the current state-of-the-art knowledge of Cretaceous Land, Ocean, Biosphere and Ecosystems in each participating countries: during meetings they overviewed such the topics as 1) biodiversity of terrestrial and marine ecosystems, 2) Cretaceous paleogeography and paleobiogeography, 3) Cretaceous climate and environmental changes, 4) Cretaceous stratigraphy and sedimentology and Cretaceous vertebrates of Asia and the Western Pacific. Four meetings were organized plus several educational trainings. Finally, they reported 109 papers published international journals.

IGCP 609 Cretaceous Sea-Level Changes

Duration: 5 years (2013-2017)

Aim: The recent rise in sea-level in response to increasing levels of atmospheric greenhouse gases and the associated global warming is a primary concern for society. Evidence from Earth history shows that glacial-interglacial and other sea-level changes occurred at rates an order of magnitude or more higher than that observed at present. To predict future sea-levels in a world that is likely to be characterized by increasingly greenhouse conditions, we need a better understanding of the record of past sea-level changes under similar climatic conditions.

IGCP 609 studies sea-level changes in the Cretaceous Period (145-66 million years ago), a greenhouse world with high sea levels and associated palaeoceanographic conditions including periods of global marine anoxia. The long-term sea-level record (i.e. 1st to 2nd order cycles occurring over millions to tens of millions of years, is controlled by the internal dynamic history of the Earth. The changing rates of ocean crust production led first to long-term sea-level rise, high stands, and then decline during Cretaceous times. Superposed shorter-term, 3rd to 4th order cycles (i.e. thousands to hundreds of thousands of years) sea level changes are recorded in Cretaceous sedimentary sequences as well, and the mechanisms for these are less understood, and may include brief glacial episodes, storage and release of groundwater, regional tectonism, and mantle-induced processes that are currently under study by IGCP 609. IGCP 609 is closely associated with IGCP 608 "Asia-Pacific Cretaceous Ecosystems", whose studies include the effects of environmental change on the terrestrial and marine animals and plants that lived during this period of rapid sea-level changes in a greenhouse world.

Achievements: Among numerous scientific achievements, this project obtained empirical evidence for "aquifer eustasy" during the (Cenomanian–Turonian) Cretaceous Super greenhouse period ; Increasing contribution of terrestrial/non-marine data-based studies to understand Cretaceous greenhouse climate and scientific cooperation with young scientists from developing countries within the project and visible in growing number of for publications. They informed two congress and scientific meetings and five educational trainings. The leaders informed a Special Topic "Cretaceous greenhouse palaeoclimate and sea-level changes". Proceedings of the International Workshop on Climate and Environment Evolution in the Mesozoic Greenhouse World (Science China Earth Sciences, 60, Issue 1, 2017). Additionally, 29 papers were published in international journals

IGCP 632 Continental Crises of the Jurassic

Duration: 5 years (2014-2018)

Aim: IGCP 632 focuses on the interactions between the major events and climate, and the correlations between the evolution of these ancient lacustrine ecosystems and the marine realm during the Jurassic Period (202 to 145 million years ago). The Jurassic period was bound by two mass-extinctions, witnessed the rise to ecological dominance of the dinosaurs, the evolution of birds, extant subclasses of mammals, various major invertebrate fauna and flora, the fragmentation of Pangea, and two huge flood basalt events, both associated with massive biotic change, all in a context of generally elevated CO_2 and muted longitudinal temperature gradients. Despite the high-profile and charismatic nature of Jurassic fauna and environments, most of the major events of the period remain poorly constrained, as does the overall climatic context, especially in high-latitude settings. Particularly poorly understood is the role of zonal climate belts in the greenhouse world of the Jurassic and how the major events of that period are expressed along meridional climate gradients.
This project offers new insights into the timing and causes of major perturbations in the evolution of life on Earth, covering the entire Jurassic-stretching from the Jurassic-Triassic mass extinction event to the development of Early Cretaceous Lake systems. Besides the improved stratigraphy, climate data and global palaeoenvironmental interpretations in the Jurassic period, this project should provide new data and clarify the causal mechanism behind two major events in the Earth history: the Triassic-Jurassic mass extinction event and the Toarcian anoxic event, with implications for climatology, ecology and biodiversity.

Achievements: They published 51 papers including in in prestigious issues such as Nature, among others. They organized the following activities: A field excursion in Colorado Plateau, USA. The field trip looked at largely continental Triassic-Jurassic boundary through Late Jurassic sections. A filed excursion in Thailand was also organized with numerous participants. The project website (www.igcp632.org) has been a highly-visible and widely utilized hub for the continental Jurassic research community and social activities.

IGCP 655 Toarcian Oceanic Anoxic Event: Impact on marine carbon cycle and ecosystems

Duration: 5 years (2017-2021)

Aim: Recent studies suggest that anoxia is increasing in the world's oceans, but the absence of historical oceanographic data on this subject make it difficult to determine causes for this decline in free oxygen. Study of changes in the geologic record can provide a background in which to interpret present and future changes in the world's oceans. Oceanic anoxic events occurred sporadically over Earth history, most commonly during periods of greenhouse climate, and provide ancient counterparts that assist in understanding the causes and potential implications of the current decline in oxygen in the world's oceans.

IGCP 655 is examining the Toarcian Oceanic Anoxic Event (183 million years ago in the early part of the Jurassic Period), a remarkable crisis in the world's oceans and life when large portions of the world's deep-ocean became depleted in free oxygen. This global decline in free oxygen produced an extinction event with up to 90% of all species of marine molluscs going extinct. IGCP 655 is conducting a multidisciplinary study of the Toarcian Oceanic Anoxic Event that integrates fossil data (microfossils, macroinvertebrates and vertebrate assemblages) and abiotic data (sedimentology, cyclostratigraphy, mineralogy, elemental geochemistry, organic geochemistry and isotopic geochemistry) from stratigraphic sections worldwide.

Achievements: Two Congress and four field trips for educational training are reported. Thirty-five scientific papers were published in high-level journals (e.g. *Nature Geoscience*, *Nature Communications*, *Scientific Reports*, *Geology, EPSL*, *Paleo-3*, *Paleobiology*, *Sedimentology*).

IGCP 630 Permian-Triassic climatic and environmental extremes

Duration: 5 years (2014-2018)

Aim: Many marine ecosystems are under threat at the present day. The geological record provides numerous analogues of environmental upheavals and major biocrises, the most disruptive of which occurred during the Permian-Triassic (P-Tr) transition at ~252 million years ago. Many of the factors that contributed to the P-Tr biotic crisis, e.g., increased atmospheric carbon dioxide concentrations, rapid global warming, oceanic anoxia, and hypercapnia (CO_2 poisoning) are also observed in the present day or are anticipated to develop in the near future.

The Permian-Triassic transition may thus record a natural experiment in global-scale ecosystem collapse that, if properly deciphered, could provide important insights into possible responses of modern marine ecosystems to present day climate and environmental change.

IGCP 630 addresses themes related to current global concerns and issues including the response of the biosphere to global warming, sustenance of global biodiversity, and maintaining the habitability of planet Earth. It is investigating the climatic and

environmental extremes and ecosystem's response during the P-Tr mass extinction and its aftermath through analyses of the rock and fossil records worldwide. Through multidisciplinary studies of latest Permian to Early Triassic strata, IGCP 630 is documenting the end-Permian collapse of the global ecosystem and its subsequent early Triassic rebuilding. Ultimately, this project hopes to: (1) reveal climatic and environmental extremes at a global scale and their impacts on ecosystems in seas and on land, (2) elucidate the factors controlling biotic recovery in various habitats and climate zones, (3) determine the similarities and differences in the responses of different marine groups to biotic crisis, and (4) assess the effects of climate or other geological events on the restoration of defaunated ecosystems.

Achievements: The participants have achieved in following several aspects; as examples: Early-Middle Triassic biostratigraphy and more precise and comprehensive bio-chronological frameworks were established for the marine and terrestrial Lower and Middle Triassic successions in several major regions: China, India, Pakistan, Madagascar, South Africa, Armenia, Russia, and Spitsbergen; extinction and recovery of several major fossil groups .Thus, various fossil groups experienced different recovery rates after the end-Permian crisis;). Both extreme hot seawater temperature and widespread anoxia were suggested to be major killers for the P-Tr biocrisis and have delayed biotic recovery in Early Triassic; early and Middle Triassic astronomical cyclo-chronologic frameworks are established and update the newest Geological Time Scale (2016); Early Triassic hothouse regimes may have been controlled by obliquity-forced cycles (1.2 myr), while local/regional anoxia were controlled by ~100 kyr eccentricity. Additionally, they reported five scientific meetings plus educational and training activities.

IGCP 652 Reading geologic time in Paleozoic sedimentary rocks

Duration: 5 years (2017-2021)

Aim: Major events punctuated the Paleozoic: ecological crises and diversifications, including shifts in ocean chemistry, climatic changes, etc. One of the key-obstacles in understanding these events lies in the difficulty of providing precise estimates of the duration represented by a sequence of Paleozoic sedimentary rocks. This lack of temporal precision severely hampers the evaluation of forcing mechanisms and rates of climatic, ecological or biogeochemical changes in the Paleozoic. It is therefore essential to first improve the Paleozoic timescale to then unravel the history of the Paleozoic Earth system.

IGCP 652 will utilize and test cyclostratigraphy, a stratigraphic tool that is based on the detection of the Milankovitch cycles in the sedimentary record. Those cycles result from periodic variations in the Earth-Sun system, affecting the distribution of solar energy over the Planet and thus influencing Earth's climate on time scales between 10^4 and 10^6 years. This stratigraphic tool is revolutionizing our ability to subdivide Mesozoic and Cenozoic time but has been relatively little used in the Paleozoic. Through the integration of this astronomical time scale with biostratigraphy and radio-isotopic dating, this project intends to document the environmental evolution during the Paleozoic with a focus on the Ordovician to Devonian (485 – 359 million years). It gathers participants (> 200) from all over the world (36 countries) and promotes the participation of young scientists and scientists from developing countries.

Achievements: The project enhanced the resolution of the geological time scale for the Homerian (Silurian), Pragian and Emsian-Eifelian (Devonian). Furthermore, they also improved the understanding of various major events, with a focus on the Ordovician-Silurian boundary, the Mulde (Silurian) event and the Kacak (Devonian) event. They organized three special sessions at the EGU in Vienna, the IMS in Toulouse, and the AGU in New Orleans. This allowed to reach a vast community and to develop the networking capacity of the project. The website platform was developed, as well as the Facebook page, and the project was advertised through radio interviews and university webpages. A list of 31 scientific papers is attached to the annual report.

IGCP 653 The onset of the Great Ordovician Biodiversification Event

Duration: 5 years (2016-2020)

Aim: IGCP 653 is studying the 'Great Ordovician Biodiversification Event' (GOBE) comprises the rapid diversification of marine organisms during the Ordovician Period. The GOBE completely modified marine food webs and established modern marine ecosystems for the first time. The project focuses on interdisciplinary investigations, including case studies from globally distributed sites, involving specialists from the fields of, for example, palaeontology, sedimentology, stratigraphy, geochemistry, cosmochemistry, climate modelling, palaeooceanography and palaeoclimatology, in collaboration with the Subcommission on Ordovician Stratigraphy (ISOS). The results of the project will contribute to the understanding of the triggers and timing of the establishment of modern marine ecosystems and also provide insight on the reasons of the first collapse of these environments which may have led directly to the world's first large-scale mass extinction of life at the end of the Ordovician.

Achievements: Above question has been discussed in the year 2017 at 7 international meetings, and at a workshop organized for Chinese students. A major achievement of this first year is the discussion on the terminology of the Great Ordovician Biodiversification Event (GOBE), which is now recognized as the sum of individual events, including several Biotic Immigration Events (BIME). The advances obtained up to the present are contained in the 69 papers published in international journals, which include top-tier journals such as *Nature Communications* and *Geology*.