

Deep-time Digital Earth DDE Report to IUGS

The **Mission of DDE** is to harmonise global Deep-time Digital Earth data and share global geoscience knowledge. Its **Vision** to transform Earth science.

For the data driven knowledge discovery four **major scientific questions** were identified. These are:

- Evolution of Life
- Evolution of Earth materials
- Evolution of Geography
- Evolution of Climate

Which leads directly to 10 major scientific **research directions**:

1. Integrating a uniform high-resolution earth time system
2. Origin and evolution of life and biodiversity
3. How did the sedimentary matter evolve and cycle?
4. Reconstructing earth climate and atmosphere history from big data of multiple geochemical indices
5. Global sea-level change through deep time
6. Quantifying plate tectonics and deformation in four dimensions
7. 4D architecture and evolution of deep-earth materials and dynamics
8. Mineral evolution beyond 4D
9. Establishing a globally shared big-data energy resource system for sustainable development
10. Big data system of geophysical fields for prediction of seismic hazard

The governing structure of DDE so far comprises a Governing Council (GC) and Executive Committee (EC) and a Scientific Committee (SC) for its governance. These three bodies shall be overarched by an independent international Board to oversee the progress of DDE. The DDE science communities are based on the four major scientific questions and supported by A secretariat, Working Groups (WG) and Task Groups (TG) as well as Research Centers of Excellence (RCE).

At present 17 members constitute the **Governing Council** mainly from Geological Surveys and Scientific Associations.

1. British Geological Survey (BGS)
2. China Geological Survey (CGS)
3. Geological Survey of Canada (GSC)
4. Russian Geological Research Institute (VSEGEI)
5. American Association of Petroleum Geologists (AAPG)
6. Commission on the Management & Application of Geoscience Information (CGI)
7. Commission for Geological Map of the World (CGMW)
8. Russian Federal Geological Foundation (FBGU)
9. International Association of Geomorphologists (IAG)
10. International Association on the Genesis of Ore Deposits (IAGOD)
11. International Association for Mathematical Geosciences (IAMG)

12. International Association of Sedimentologists (IAS)
13. International Commission on Stratigraphy (ICS)
14. International Palaeontological Association (IPA)
15. International Lithosphere Program (ILP)
16. Coordinating Committee for Geoscience Programs in East and Southeast Asia (CCOP)
17. Korea Institute of Geoscience and Mineral Resources (KIGAM)

This body held its constitutional first meeting that was foreseen to be held during IGC in Delhi as a zoom meeting on October 21.

The **Executive Committee**, recently established, held its first as webinar on October 19 and 20. This body is responsible for responsible for day-to-day operations according to statutes and bylaws, shall propose any working groups and task groups and set key performance indicators for a DDE Board. It is represented by:

- Chair: Chengshan Wang, Academician, Chinese Academy of Sciences, Professor, China University of Geosciences, Beijing
- Head of the Secretariat: Junxuan Fan, Professor, Nanjing University
- Treasurer: Susan Nash, Director, Innovation & Emerging Science and Technology, AAPG
- Councilor: Natarajan Ishwaran, Visiting Professor, HIST, Beijing and Nanjing Agricultural University.
- Councilor: Mikhail Fedonkin, Academician, Russian Academy of Sciences

The **Science Committee** is composed of 15 members with a reasonable regional distribution but imbalanced in gender. It is thought to provide thorough scientific evaluation of proposals of WG and TG submitted to DDE and to list their priority based on scientific needs and expected impact for final decision by EC and GC. Its members are:

Asif Khan, Muhammed,	Pakistan
Cavazza, William,	Italy
Cloetingh, Sierd,	Netherlands
Da Silva-Schmidt, Renata,	Brasil
Gupta, Harsh K.,	India
Hazen, Robert M.,	United States of America
Hou, Zengqian,	China
Muller Dietmar,	Australia
Narbonne, Guy M.,	Canada
Nurgaliev, Danis,	Russia
Oberhänsli, Roland,	Germany
Peters, Shanan E.,	United States of America
Suyehiro, Kiyoshi,	Japan
Thybo, Hans,	Denmark
Whaler, Kathy,	United Kingdom

Working Groups and **Task Groups** provide the operational capabilities to manage the program and to support individual DDE projects. So far 22 working groups and 6 TG are active. WG focus on scientific topics ranging from paleontology, stratigraphy, tectonics, sedimentology, paleomagnetism, geophysics, mineralogy, geochemistry, hydrogeology, geothermic, geomorphology, geochronology, metamorphic petrology, igneous petrology,

petroleum geology, paleogeography, geo-education, geological mapping, data science, mathematic geology, big-data handling, and data platforms. TG are cover broader ranges regionally or combining topics and concentrate on dinosaurs, paleoclimate, marginal seas, Southeast Asia, Central Asia and Standards.

Since the kick-off meeting October 2019 in Beijing members of the DDE community searched for potential partners. Up to now a link to CODATA the data platform of the International Science Council ISC was established with a joint project and a memorandum of understanding. Similar endeavors are planned with the International Discovery Program IODP. Several Publishing houses have been contacted to learn about a principle preparedness towards data linking.

With respect to outreach, publications and communication DDE was successfully represented at 7 international meetings: 34th IAS meeting; 2019 IODP Forum, STRATI 2019, 21st China Mining Conference and Exhibition, AAPG Annual Meeting, IAMG annual meeting, 2020 SPE Engenious conference. A draft of a white paper being finalized after feedback from the first GC meeting (October 21, 2020) Website and Brochures were produced and Information to IUGS was presented in 6 E-bulletin newsletters and a paper in EPISODES. IN addition, 5 scientific papers have been published and 2 articles on DDE in Science journals have been published by journalists.

Papers:

- Cheng, Q., Oberhänsli, R. & Zhao, M. (2020). A new international initiative for facilitating data-driven Earth science transformation. Geological Society, London, Special Publications, 499.
- Jun-xuan Fan, Shu-zhong Shen, Douglas H. Erwin, Peter M. Sadler, Norman MacLeod, Qiu-ming Cheng, Xu-dong Hou, Jiao Yang, Xiang-dong Wang, Yue Wang, Hua Zhang, Xu Chen, Guo-xiang Li, Yi-chun Zhang, Yu-kun Shi, Dong-xun Yuan, Qing Chen, Lin-na Zhang, Chao Li, Ying-ying Zhao. (2020) A high-resolution summary of Cambrian to Early Triassic marine invertebrate biodiversity. Science, 367(6475), 272-277.
- Oberhänsli, R. (2020) Deep-time Digital Earth (DDE) the First IUGS Big Science Program. J Geol Soc India 95, 223–226.
- Stephenson, M. H., Cheng, Q., Wang, C., Fan, J., & Oberhänsli, R. (2020). Progress towards the establishment of the IUGS Deep-time Digital Earth (DDE) programme. EPISODES Published online June 1, <https://doi.org/10.18814/epiugs/2020/020057>.
- Stephenson, M. (2019). On the cusp of a revolution. Geoscientist, 29(10), 16-19.
- Wang, C., Shen, S., Zhou, C., Hou, Z., Cheng, Q., Oberhänsli, R. & Stephenson, M. (2019) Decodification of Earth Evolution in Deep-Time. Acta Geologica Sinica-English Edition, 93(S1), 1-2.

Abstract volume:

- Edited by: Liu Lian, Fei Hongcai, Hao Ziguo, Situ Yu, Li Wei (2019) Dee-time Digital Earth, Acta Geologica Sinica 93,1, 1-180.

News Articles:

- Denis Normil (2019) Earth scientists plan a ‘geological Google’. Science, 1. March 2019, Vol 363, Issue 6430, 917.
- Michael Dumiak (2020) Ambitious Data Project Aims to Organize the World’s Geoscientific Records. Deep-time Digital Earth will link hundreds of bespoke scientific databases in one easy-to-search network. SPECTRUM; 21 Feb 2020.

Progress has been made in the realm of cyberinfrastructure under the topic **DDE Data** global earth evolution data shall be harmonized to render the data FAIR: Findable,

Accessible, Interoperable, Reusable. DDE Knowledge shall be available to everyone and play a role as educational platform allowing intelligent search and browsing. A **DDE-Platform** shall provide links and two-way feedback between data platforms and models. **DDE Scholar** is thought to provide a service for visualization of complex scientific relationships. Further progress on the establishment of Research Centers of Excellence (RCE) was made: Discussion of establishing RCE in the USA and UK are vividly ongoing while in China the Suzhou Centre is established and an MOU has been signed by the GC. This now allows the SC to evaluate five international proposals for large grants, provided by the RCE Suzhou. A task that will be completed over the next months.

Despite the fact that DDE was not officially established until October 2020 a short **financial report** covering DDE activities 2019-2020 can be provided. The funding resources are as follows:

- Funding the secretariat received from the Kunshan Government: \$600,000 per year
- Funding from IUGS: \$ 20,000
- Start-up funding of DDE Research Centre of Excellence (Suzhou), especially for 5 projects

Expenditure encompass \$544,789 from Feb. 2019 to Sept. 2020 and \$ 440,962 are in the budget for Oct.-Dec. 2020.

Income 2019-2020

Items	
Fund for Secretariat from Kunshan Government 2019	300,000
Fund for Secretariat from Kunshan Government 2020	300,000
Fund from IUGS	20,000
Total	620,000

Expenditures

Items	
General & Administration	158,500
Meeting & Conference	256,936
36th IGC	81,353
Working & Task group activities	
Projects	
Communication Group	48,000
Total	544,789

General and Administration of the Secretariat

Items	Paid Feb. 2019-Sept. 2020	Expected Oct.-Dec. 2020
Staff's Salary	46,500	33,500
Attend meeting	11,200	2,000
Travel expense	21,000	3,000
Office space renting	67,000	14,500
Communication	7,300	1,500
Vehicle rental and maintenance	5,500	2,000
Others		47,462
Total	158,500	103,962

Meetings organized by DDE

Items	Paid Feb. 2019-Sept. 2020
The 1st Science Committee meeting in Bushan, Jan. 19-20, 2020	77,941
The 1st face-to-face meeting of the DDE Standards task group	24,120
Meeting with 4D	45,000
DDE Kick-off meeting, Feb. 26-28, 2019 (the Fragrant Hill)	44,100
DDE Suzhou Center start-up meeting	36,765
Total	227,926

Meetings attended by DDE

Items	Paid Feb. 2019-Sept. 2020
2019 IODP annual meeting	3,998
2019 IAS annual meeting	4,412
2020 Marginal sea	3,000
URTEC (the Oil group)	600
ST meeting	5,000
Zhao Xixi visiting India	12,000
Total	29,010

Budget for DDE Grants (RCE Suzhou)

project	Funding From DDE, \$		
	2020	2021	2022
Geological Timeline Project- International Commission on Stratigraphy (ICS)	50,000	50,000	50,000
1:5m Digital Geological Mapping- Commission for Geological Map of the World (CGMW)	50,000	50,000	
Geoscience Data Standards- Commission on the Management & Application of Geoscience Information (IUGS-CGS)	30,000	30,000	
Marginal Sea Project- International Association for Mathematical Geosciences(IAMG)	50,000	50,000	50,000
Country Node, China- China Geological Survey (CGS)			

2020 *INFO* BROCHURE



**Deep-time
Digital Earth**
IUGS Big Science Program



MEMBERS

DDE is an international consortium open to international organizations, geological surveys, research institutes and industry.

● **AAPG**

American
Association of
Petroleum
Geologists

● **BGS**

British Geological
Survey

● **CGI**

Commission on
Geoscience
Information

● **CGMW**

Commission for
Geological Map of
the World

● **CGS**

China Geological
Survey

● **FBGU**

Russian Federal
Geological
Foundation

● **IAG**

International
Association of
Geomorphologists

● **IAMG**

International
Association for
Mathematical
Geosciences

● **IAGOD**

International
Association on the
Genesis of Ore
Deposits

● **IAS**

International
Association of
Sedimentologists

● **ICS**

International
Commission on
Stratigraphy

● **IPA**

International
Palaeontological
Association

● **VSEGEI**

Russian Geological
Research Institute

MISSION AND VISION

■ MISSION

Harmonise global Deep-time Digital Earth data, and share global geoscience knowledge.

■ VISION

Transform Earth science.

WHAT IS DDE ?

Modern Earth systems science requires harmonised global Deep-time Earth data. This harmonisation is now possible through the digital revolution, but new protocols, platforms and programs are needed to secure compatible and interoperable databases, so that the vast amounts of existing (and new) geoscience data can be linked for the benefit of global society. Big Data analytics, internet cloud computing, data mining, machine learning and artificial intelligence, will lead to innovation in understanding the Earth's evolution and applications including the Sustainable Development Goals.

WHY DDE ?

A grand challenge for geoscience is to secure interoperability of databases, as well as improve accessibility. Better organised data will transform Earth science.

A huge amount of digital and machine-readable data is held by geological surveys and in other large big thematic databases. Collective efforts are needed to develop internationally accepted protocols for standardization, harmonisation and association of diverse data so that hubs within a network can be interconnected. While geological survey data generally has wide geographic coverage it has limited diversity of types of data. In contrast, data held by academic institutions and supplementary government data is often wider ranging including a huge resource of information such as pictures and scanned images, tables, notes, sketches, cross sections, videos, samples, measurements scattered in documents and even geoscientists' notebooks. Much is not currently machine-readable and searchable. Freeing this 'volunteer' generated information is fundamental to creating big Earth data. Appropriate mechanisms and artificial intelligence techniques need to be sought to motivate, facilitate and assist organizations and geoscientists to make their data FAIR (Findable, Accessible, Interoperable, and Re-usable).





FOCUS

The program will be conducted through a system of linked networks designed to encourage broad collaboration among experts in branches of the geosciences with other experts including engineers, social scientists and economists.

RESEARCH WILL FOCUS ON:

- 1** Life — global biodiversity patterns are crucial to understanding the evolutionary history of the biosphere. Big Data will help to identify environmental forcing factors on the evolution of life and throw new light on current biodiversity concerns.
- 2** Materials — investigation of spatial and temporal distribution of mineral deposits with respect to their paleogeographical and geological location during Earth history. These are vital for modern industry, technology and decarbonisation.
- 3** Geography — better palaeogeographic reconstructions with improved spatial and temporal resolutions, are required as a basis for palaeotectonic, palaeoclimate, and resource studies.
- 4** Climate adaptation — geoscience will be important to mitigating and adapting to climate change, for example, in providing information on groundwater, which will help populations to adapt to reduced surface water.

DELIVERABLES

- Linked Centres of Excellence that provide interoperable data-bases for data sharing.
- A 4D digital Earth simulation representing the complete evolution of the Earth.
- An open access platform, a 'geological google', intended to guarantee equal accessibility and opportunities for all organisations and individuals from school and university students, to researchers, industry and governments in both developed and developing countries including a desktop system for use by geoscientists as well as students and teachers in the classroom and in the field.
- New IUGS standard references that will be updated periodically.
 - an IUGS palaeogeographic atlas
 - a geoscience knowledge system for machine learning and data mining



MILESTONE MEETINGS AND SESSIONS

- 1 36th International Geological Congress (36th IGC, 2020)
- 2 DDE–Resourcing Future Generations (RFG) 2022
- 3 37th IGC 2024
- 4 DDE–European Geosciences Union 2026
- 5 38th IGC 2028

