2nd International KACST-KAUST-JCCP Workshop on Surface and Subsurface 4D Monitoring

1. Introduction

JCCP engaged in a joint project with King Abdulaziz City for Science and Technology (KACST) to develop ground deformation assessment technologies, which lasted until fiscal 2012. From fiscal 2013, it launched the "Joint Project on CCS Monitoring Technology for the Underground Storage of CO_2 Produced in Oil Refineries" based on the precursor study with the participation of Kawasaki Geological Engineering Co., Ltd. (See *JCCP NEWS* No. 118 for details.)

As part of the project, KACST, King Abdullah University of Science and Technology (KAUST) and JCCP jointly held the 2nd International KACST-KAUST-JCCP Workshop on Surface and Subsurface 4D Monitoring on the KAUST campus in the suburbs of Jeddah, over a three-day period from March 4 – 6, 2014.

The first workshop was held by KACST and JCCP in January 2012 on the KACST campus in Riyadh, and the second workshop held after two years was jointly sponsored by three parties, namely KACST, JCCP and KAUST, with the new addition of KAUST.

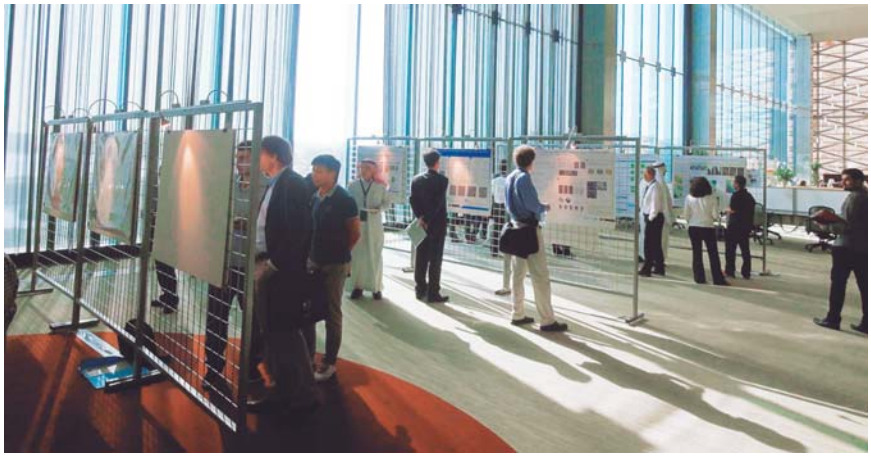
KAUST was established in 2009 as a graduate university, and in 2013, welcomed Dr. Jean-Lou Chameau, formerly president of the California Institute of Technology (Caltech), which ranked the first in the World University Rankings for 2013-2014, as the new president of KAUST. Under the sponsorship of the Custodian of the Two Holy Mosques, King Abdullah Bin Abdulaziz Al Saud, the university is pursuing the goal of achieving the status of leading institution for science and technology not only in the Islamic world but also in the entire world, and mustered top-level researchers from around the globe.

2. Surface and Subsurface 4D Monitoring Technology and CCS

What is surface and subsurface 4D monitoring technology? Put simply, in cases where the target site can be directly accessed, surface and subsurface monitoring is the act of analyzing how sound waves and vibrations are directly and actively transmitted, using underground radar, a seismic vehicle or observation wells on land or a seismic survey vessel at sea, and assessing subsurface conditions by changes in conductivity detected by electrical logging. In cases where the site in question cannot be directly accessed or is located in a vast desert or sea, surface and subsurface conditions are assessed through remote sensing technology employing a radar satellite or an airplane.

Dr. Jean-Lou Chameau, President, KAUST;
Mr. Morihiro Yoshida, Managing Director of JCCP;
Dr. Khalid Al-Damegh, Director, KACST

Dr. Chameau giving an opening speech



Poster session

Countries around the world are pursuing studies of 4D monitoring technology with hopes of utilizing it not only for resource exploration and reservoir management, but also for monitoring landslides and ground subsidence, and eventually predicting volcanic eruptions and earthquakes. During the cold war era, various monitoring and detecting technologies were used, such as the synthetic aperture radar technology (particularly InSAR interferometric synthetic aperture radar technology) that was developed to detect hidden underground missile silos, and airborne multi-sensors and other submarine detection technologies including MAD-magnetic anomaly detection technology. However, with the end of the cold war, efforts were directed to apply these technologies to civil use for resource exploration, disaster prevention and other peaceful purposes. This in itself could certainly be considered one of the fruits of peace. Furthermore, with the emergence of 4D technology, it would become possible to monitor chronological changes through continuous monitoring and to assess surface and subsurface conditions by time-lapse analysis.

In oil and gas exploration, geophysical exploration surveys, seismic surveys and 3D analysis are costly business that requires an enormous fund. However, once oil or gas is discovered and production begins, it is rarely possible to implement such surveys again and capture time-lapse changes to assess ground behavior once production starts. This is because the economic advantages of examining changes in existing oil and gas fields cannot surpass the advantages of performing geophysical exploration surveys, seismic surveys and 3D analysis for a completely new development project.

Meanwhile, CCS is pointless if the behavior of CO_2 that is injected underground cannot be monitored. Moreover, since CCS produces no output of value like oil and gas production, it is necessary to minimize costs as much as possible. This is even more so today, given the drop in market prices in emissions trading. Conversely, the ability to monitor subsurface conditions continuously at low cost is attracting the interest of oil companies that have been spending large amounts on seismic surveys and 3D analysis and turning their attention to the possible use of 4D technology to monitor subsurface behavior in crude oil and gas reservoirs with an ultimate target set on EOR (enhanced oil recovery).

3. Overview of the Workshop

The workshop began on March 5 with opening speeches given by Dr. Jean-Lou Chameau, President, KAUST; Dr. Khalid Al-Damegh, Director, Oil & Gas Research Institute, KACST; and Mr. Morihiro Yoshida, Managing Director of JCCP.

In their speeches, they stressed the significance of holding the workshop in Saudi Arabia for the second

Audience listening with keen interest

	Theme	Speaker	Organization
1	[Keynote Presentation 1] Full waveform inversion applied to 4D hydroacoustic tomography	Hitoshi Mikada	Kyoto University
2	Interferometric migration for 4D monitoring	Gerard Schuster (Danglian Zhan)	KAUST
3	The interpretation of time-lapse data obtained by seismic ACROSS source operated in Al-Wasse water pumping field in Saudi Arabia	Junzo Kasahara	Tokyo University of Marine Science and Technology
4	Unraveling waveform inversion with an eye on time-lapse seismics	Tareq Al-Khalifa	KAUST
5	Elastic anisotropies of core samples under very high confining pressure from multi-channel elastic wave velocity measurement	Hisao Ito	University of Tokyo
6	InSAR observations of volcanic and seismic processes in the Middle East	Sigurjón Jónsson	KAUST
7	Advanced InSAR for reservoir monitoring and modeling	Alissio Rucci	TRE Italy
8	Long-term surface deformation monitoring and analysis in water-dissolved gas production areas by time-lapse SAR interferometry	Shuichi Rokugawa	Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
9	Characterizing aquifer and fault hydromechanical properties at basin-scale using InSAR-derived ground deformation	Estelle Chaussard	University of California, USA
Poster Session (KAUST Library)			
10	[Keynote Presentation 2] Paradigm change in large-scale subsurface imaging using 3D inversion of airborne and marine electromagnetic data	Michael S. Zhdanov	University of Utah, USA
11	Deep diagnostic technologies for reservoir mapping and monitoring at a new scale	Alberto F. Marsala	Saudi Aramco
12	Seismic and electromagnetic modeling and inversion to monitor CO_2 geological storage	Jose Marcione	OGS, Italy
13	Permanent monitoring with buried land hydrophones and geophones in a desert environment	Andrey Bakulin	Saudi Aramco
14	Field data observation and numerical study with a permanent seismic source ACROSS towards hydrocarbon reservoir monitoring	Mamoru Takanashi	Japan Oil, Gas and Metals National Corporation (JOGMEC)
15	Marchenko below a complex overburden	Joost van der Neut	Schlumberger
16	Time-lapse monitoring of deep volcanic processes: Lessons from the 2007 SEA-CALIPSO experiment on Montserrat, BWI	Larry D. Brown	Cornell University, USA
17	Improving time-lapse seismic repeatability: Otway site permanent geophone array field trials	David Lurnley	University of Western Australia
18	Time-lapse seismic monitoring of CO_2 injection at Ketzin, Germany: 3D surface and subsurface downhole observations	Stefan Luth	Uppsala University, Sweden
19	Scrutinizing CO_2 sequestration: A case study coupling InSAR and geomechanical modeling to monitor spatial and temporal characteristics of CO_2 injection at In Salah, Algeria	Andrew Shepherd	University of Leeds, UK

Wrap-up discussion by the speakers

time in two years, in a larger scope than the first workshop with the participation of experts in surface and subsurface ground deformation assessment and resource exploration, as well as experts in disaster prevention and other relevant fields. Mr. Yoshida also expressed how he was pleased that the first workshop was not a one-shot success but led to the holding of the second in response to strong requests from the previous participants.

Following a preliminary offshore inspection tour on March 4, the workshop featured two days of presentations and poster sessions on March 5 and 6.

Worthy of special mention is that the results of the KACST-JCCP joint project on the ACROSS (Accurately Controlled Routinely Operated Signal System) technology were presented by Dr. Junzo Kasahara, Professor at Tokyo University of Marine Science and Technology (Advisor at Kawasaki Geological Engineering Co., Ltd.), in his presentation titled "The interpretation of time-lapse data obtained by seismic ACROSS source operated in Al-Wasse water pumping field in Saudi Arabia." Mr. Masaru Takanashi from JOGMEC also made a presentation on oil reservoir monitoring using the ACROSS technology.

The workshop thus provided a forum for introducing and boosting awareness of Japan's ACROSS technology to the international community.

4. What Next?

The workshop provided presentations and active questions and answers on technologies for assessment of ground deformation, and promoted information exchanges on innovative technologies in the field. Those who participated in both the first and second workshops uniformly noted that the first workshop was highly meaningful, but that the second was even better, with upgraded presentations and interactive discussions.

JCCP would like to thank everyone at KAUST and KACST who have made behind-the-scenes efforts to materialize the workshop, which closed with a charged air of expectation for implementation of the third workshop.

<by Sadao Wada, Technical Cooperation Dept.>