Earthquake Research in China

Volume 33, Number 2, 2019
DOI: 10.19743/j.cnki.0891-4176.201902015

Preface to the Special Issue on Active Source Research

WANG Baoshan[1)] and CHEN Yong[2)]

1) School of Earth and Space Sciences, University of Science and Technology of China, Hefei 230006, China
2) School of Earth Science and Engineering, Nanjing University, Nanjing 210046, China

The seismic waveforms may present subtle changes related to the external loadings such as earthquakes (Pei Shunping et al., 2019) and landslides (Larose E. et al., 2015). Monitoring subtle changes provides a complementary tool for studying the dynamic processes (e.g., Niu Fenglin et al., 2008), which has long been a major subject in seismology.

The subsurface can be monitored by using natural repetitive events including repeated earthquakes (e.g., Song Xiaodong et al., 1996) and ambient seismic noises (e.g., Mao Shujuan et al., 2019). However, only the use of repeatable active sources can achieve long-distance and high-precision monitoring (Chen Yong et al., 2017).

Different active sources have been used to perform seismic monitoring at different scales (e.g., Niu Fenglin et al., 2018; Yamaoka K. et al., 2001). Among all sources, the airgun was one of the earliest used sources (e.g., Reasenberg P. A. et al., 1974) for this purpose. Science 2006, large-capacity airguns were used as a seismic source to explore and monitor the in-land crustal structures (Chen Yong et al., 2007). Until now, three Fixed Airgun Signal Transmitting Stations (FASTS) have been established to monitor the local subsurface changes in Yunnan, Xinjiang and Gansu with the anticipations of better understanding the physical process of earthquakes (Chen Yong et al., 2017). The Mobile Airgun System (MARS) is also used in exploring the crustal structures in different areas (e.g., She Yuyang et al., 2018).

Recently, three special issues or sections on active source studies have been published in the *Earthquake Research in China*, *Earthquake Research*, and *Seismological Research Letters* (Chen Yong and Wang Baoshan, 2016; Niu Fenglin et al., 2018). To introduce the rapid progresses on active source studies, one more special issue is presented here, including 14 papers.

The source characteristics are of key importance in seismic monitoring. The source characteristics of the Binchuan FASTS were investigated by She Yuyang et al. and Sun Nan and Sun Yanchong with seismic observation and numerical simulations, and the seasonal variations of the Hutubi FAST signal characteristics have been studied by Su Jinbo et al. A newly developed domestic airgun firing system is reported by Yang Wei et al., which is used to refine the source signature through asynchronous shots.

Signals from an active source are generally very weak, and some specially designed

techniques are required to detect the weak signals. By using seismic arrays, the airgun signal can be detected at larger distances than using just one signal station (Wang Weijun et al.). Li Jun et al. proposed an automatic data selection strategy based on the statistical characteristics of signal amplitudes. The Curvelet filters are used by Tan Junqing et al. to extract the airgun signals from the strong background noises.

One of the most important applications of the active source is the imaging the subsurface structures at various scales. Guo Yang et al. reported recent active source experiments using MARS around the Pingtan island. Prior to seismic imaging, phase picking is usually required, Xu Zhen et al., proposed a novel technique to pick the first arrivals automatically through machine learning. The crustal P-wave velocity structure of the North China Craton imaged with active source waveform modeling was presented by Liu Hanqi et al.

Another important application of the active source is to monitor subtle velocity changes. Seismic velocity changes associated with local earthquakes measured by the Binchuan FASTS which reported by Yang Jianwen et al. and Liu Zifeng et al. is very similar to those reported by Zhang Yuansheng et al., 2017 and Wei Yunyun et al., 2016. Although the airgun source is highly repeatable when shooting under the same working conditions (Wang Baoshan et al., 2018). However, when fired under different working conditions, the characteristics of the airgun may change, which in turn affects the velocity measurement. These effects were studied by Xiang Ya et al. Most of the papers in this special issue comes from the studies using airgun sources. Studies from other active sources including chemical explosion is also included. Wang Weitao et al. reported a new type of seismic source generating seismic signal through detonation of methane and oxygen mixture. This new source is environmentally friendly, producing only carbon dioxide and water vapor after combustion. The preliminary results indicate that the methane seismic source replaces some chemical explosions which are widely used.

In this special issue, it is worth mentioning that the seismic array is first used as a receiver for better detection and analysis of active source characteristics (She Yuyang et al., Wang Weijun et al.). Secondly, some peculiar data processing techniques are now gradually applied to active source data processing (Tan Junqing et al., Xu Zhen et al.). In summary, this special issue presents some timely results related to the active source studies in China. We would like to thank all the authors and reviewers. Without their contribution, this special issue can't be published on time.

REFERENCES

Chen Yong, Zhang Xiankang, Qiu Xuelin, Ge Hongkui, Liu Baojin, Wang Baoshan. A new way to generate seismic waves for continental crustal exploration[J]. *Chinese Science Bulletin*, 2007, 52(16): 2264-2268, doi: 10.1007/s11434-007-0247-4.

Chen Yong, Wang Baoshan, Yao Huajian. Seismic airgun exploration of continental crust structures[J]. *Science China Earth Sciences*, 2017, 60(10): 1739-1751, doi: 10.1007/s11430-016-9096-6.

Chen Yong, Wang Baoshan. Preface[J]. *Earthquake Research in China*, 2016, 32(2): 165-167(in Chinese).

Larose E., Carrière S., Voisin C., Bottelin P., Baillet L., Guéguen P., Walter F., Jongmans D., Guillier B., Garambois S., Gimbert F., Massey C. Environmental seismology: what can we learn on earth surface processes with ambient noise? [J]. *Journal of Applied Geophysics*, 2015, 116: 62-74, doi: 10.1016/j.jappgeo.2015.02.001.

Mao Shujuan, Campillo M., van der Hilst R.D., Brenguier F., Stehly L., Hillers G. High temporal resolution monitoring of small variations in crustal strain by dense seismic arrays[J]. *Geophysical Research Letters*, 2019, 46(1): 128-137, doi: 10.1029/2018GL079944.

Niu Fenglin, Silver P.G., Daley T.M., Cheng Xin, Majer E.L. Preseismic velocity changes observed from active source monitoring at the Parkfield SAFOD drill site[J]. *Nature*, 2008, 454(7201): 204-208, doi: 10.1038/nature07111.

Niu Fenglin, Yamaoka K. Preface to the focus section on nonexplosive source monitoring and imaging[J].

Seismological Research Letters, 2018, 89(3): 972-973.

Pei Shunping, Niu Fenglin, Ben-Zion Y., Sun Quan, Liu Yanbing, Xue Xiaotian, Su Jinrong, Shao Zhigang. Seismic velocity reduction and accelerated recovery due to earthquakes on the Longmenshan fault[J]. *Nature Geoscience*, 2019, 12(5): 387-392, doi: 10.1038/s41561-019-0347-1.

Reasenberg P., Aki K. A precise, continuous measurement of seismic velocity for monitoring in situ stress[J]. *Journal of Geophysical Research*, 1974, 79(B2): 399-406, doi: 10.1029/JB079i002p00399.

She Yuyang, Yao Huajian, Zhai Qiushi, Wang Fuyun, Tian Xiaofeng. Shallow crustal structure of the middle-lower Yangtze River region in eastern China from surface-wave tomography of a large volume airgun-shot experiment[J]. *Seismological Research Letters*, 2018, 89(3): 1003-1013, doi: 10.1785/0220170232.

Song Xiaodong, Richards P.G. Seismological evidence for differential rotation of the earth's inner core[J]. *Nature*, 1996, 382(6588): 221-224.

Wang Baoshan, Tian Xiaofeng, Zhang Yunpeng, Li Yulan, Yang Wei, Zhang Bo, Wang Weitao, Yang Jun, Li Xiaobin. Seismic signature of an untuned large-volume airgun array fired in a water reservoir[J]. *Seismological Research Letters*, 2018, 89(3): 983-991, doi: 10.1785/0220180007.

Wei Yunyun, Wang Haitao, Su Jinbo, Chen Xiangjun, Wang Qiong. The preliminary study on travel time abnormal variation of reflection wave phase of air-gun in Xinjiang before two earthquakes with M_S5.0[J]. *Earthquake Research in China*, 2016, 32(2): 270-281(in Chinese with English abstract).

Yamaoka K., Kunitomo T., Miyakawa K., Kobayashi K., Kumazawa M. A trial for monitoring temporal variation of seismic velocity using and ACROSS system[J]. *Island Arc*, 2001, 10(3/4): 336-347.

Zhang Yuansheng, Wang Baoshan, Chen Yong, Wang Lanmin, Zou Rui, Qin Manzhong, Guo Xiao, Shen Xuzhang, Wei Congxin, Liu Xuzhou, Wang Yahong, Sun Dianfeng, Guo Yingxia, Yin Liang. Travel-time variations before and after two major earthquakes derived from active-source seismic data[J]. *Chinese Journal of Geophysics*, 2017, 60(10): 3815-3822(in Chinese with English abstract).

Baoshan Wang