LUNAR BASALT EXPERIMENTAL FIELDS DETECTIONS AND SUGGESTIONS FOR FUTURE LUNAR MISSIONS. H. W. Yang[1], W. J. Zhao[1], S. Q. Xiong[2], B. Z. Feng[3], Q. Wang[4], B. K. Yan[2], H. J. He[3], H. Q. Guo[4], J. C. Yu[2], D. R. Wang[4], [1]Chinese Academy of Geological Sciences, [2]ARGS, China Geological Survey, [3]China Geological Survey in Gansu Province, [4]BGP INC., China National Petroleum Corporation, Email: [1]yhw1106@163.com

Introduction: Experiences on detection of the Earth tell us that basalt rocks are erupted from deep interior of the planet, and have close relations to tectonics and evolution of the planet. Distributed on the nearside, with coverage of more than 17% over the globe[1], lunar basalts are responsible for knowledge of the evolution of the moon and formation of the KREEP, special rocks on the Moon. Although in future missions there is still a great deal of potentials of remote sensing of materials on lunar surface, deep structures and extents of the mare basalts are the primary issue to understanding their evolutionary process. From the Apollo program to recent missions, including Apollo-17[2][3], SELENE[4] and Chang'E-3[5], subsurface structures of the mare basalts have been detected for several times based on radar measurements on satellite or rover. Two questions should be keep in our mind. Firstly, identification of several shallow subsurface interfaces at different depths from the three different missions, even at the same cross-section in Mare Serenitatis[6]. Secondly, it has not been confirmed that whether the basaltic units erupted in distinct magmatic episodes could be responsible for the different layered structures. Accordingly, we must construct the effective program and necessary equipments for the future missions to detect the lunar basalt. Our group has found and established in China a lunar basalt experimental field, where there is a certain large area of basalts with a particular environment similar to that on the moon. Recent results in this field had led to the effective approaches available for future lunar program and considerations for the required equipments in future plans.

Selection of Experimental Fields: To make effective the results from the experimental field, several conditions should be fulfilled as far as possible, A) extremely arid environment, similar to that on the Moon; B) a certain large area of basalt exposed; C) main body of basalt not metamorphosed by late geological process or other rocks; D) originated from deep source. To fulfill these conditions, through the explorations and comparison of almost every basalt region throughout the China, our group at final found the most similar region to the Moon located in the northwest of China, termed as 'LY Field' in the following passage. The extend of the basalt exposed on surface with around 70 kilometers in East-West and 16 kilometers in North-South is illustrated in Google Map (the area surrounded by red line in Fig. 1). Formed by weathering of the severe temperature variance from 35 ^{o}C to -35°C, the fragment and debris of basaltic rocks is similar to those on lunar surface (Fig. 2). Approximately 48.4mm of water falls as precipitation each year.

Fig. 1 LY Basalt Field and its extend in Google Map (survey along the red dashed line)

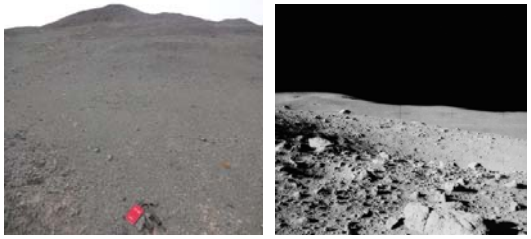

Fig.2 Debris of basaltic rocks in LY field and around Apollo17 landing site

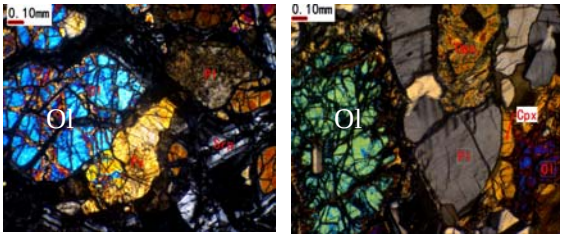

Fig.3 Petrographic microscopic structure of one sample (in orth-polarized light, Ol: Olivne)

Geology and Geochemistry: The flood basalts in LY field belongs to continental rift type[7] and are dated in Carboniferous-Permian period, contacting with Carboniferous granite rocks to the North and with Carboniferous-Permian sedimentary rocks to the South. The sample rocks are mainly composed by clinpyroxene and orthpyroxene and plagioclase. Olivine has been discovered in some samples (Fig. 3). Others include chlorite and serpentine as the cover of most of the samples.

Remote Sensing Detection: We derived the geological interpretations of this region (Fig. 4) based on measurements of Wordview2(425nm~950nm) and ASTER(560nm~2400nm), which were compared with the similar band of Clementine(415nm~2000nm).

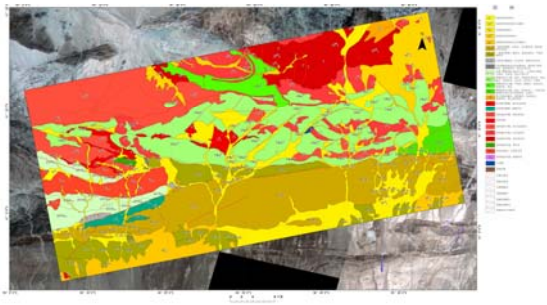

Fig. 4 Geological Interpretation from Earth satellites observations

Structures of the basalt detected by integrated geophysical approaches: As we known, the detection of structures of the basalt is a key to understanding of evolution of basalt and the tectonic process in which the basalt formed. Integrated geophysical approaches have been applied to realize the extent of the basalt beneath the surface. Fig.5, 6 and 7 show the results based on gravity, magnetelluric and seismic observations.

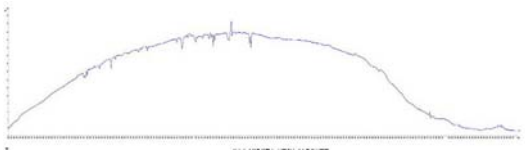

Fig.5 Bouguer Gravity Anomaly along the survey line

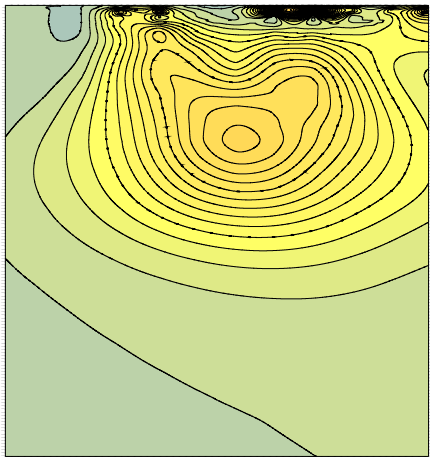

Fig.6 Apparent Electrical Resistance from MT sounding

Interpretations of the basalt and Comparisons with lunar basalt: There are several similar conditions between the basalt in 'LY field' and those on nearside of the Moon, including severe temperature variance, extremely arid environment, especially in weathering surface (Fig.2). Although the remote sensing measurements are significant to detecting the mineral and rocks on this field, the main object of this paper focus on the availability of integrated geophysical approaches for suggestions on detecting structures of mare basalts in future missions. Approximately, the depth of 8~9 kilometers of the lower boundary of the basalt in 'LY field' has been detected by MT and seismic method (particular in low frequency skills) as well. It is determined that there would be a huge potential in detection of basalt with MT. Meanwhile, the shallow structures of around 6km in depth could be detected in detail by active seismic measurements, which could be compare with radar results.

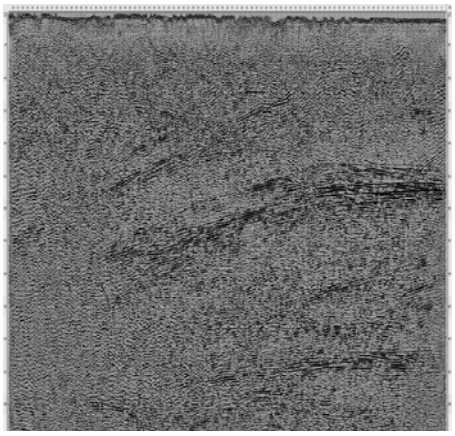

Fig.7 CMP Stack Section

Suggestions for future missions of the Moon: Integrated geophysical exploration of mare basalt on nearside of the Moon will be the key to understanding of evolution of mare basalt and relations with KREEP in Oceanus Procellarum. It could be confirmed that MT measurements on lunar surface would be priority in following missions. Seismic method with low frequency skill would be helpful to detect in detail structures of lunar basalts, combined with radar and electro-magnetic methods.

Welcome any other experts who have the same willing to join our team!!

References: [1] Lucey, et al., Chap.2, New Views of the Moon, 2006; [2] Phillips et al., NASA Spec. Publ. 330(22), 1-26,1973; [3] Phillips et al., Proceedings of the 4th Lunar Science Conference,1973; [4] Ono et al, Space Sci Rev 154, 2010; [5] Long, et al., Science 347, 2015; [6] Yang, et al., Earth Moon and Planets 114, 2015; [7] T. R. McGetchin, R. O. Pepin, R. J. Phillips, et al., Basaltic Volcanism on the Terrestrial Planets, 1971