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On lunar broadband seismic observation in SELENE-2

KOBAYASHI, Naoki[1*], SHIRAISHI, Hiroaki[1], OKAMOTO, Taro[2], TAKEUCHI, Nozomu[3], MURAKAMI, Hideki[4], KUGE, Keiko[5], ZHAO, Dapeng[6], OGAWA, Kazunori[1], Yuichi Iijima[1], KAKUMA, Hideaki[7], TANAKA, Satoshi[1], YAMADA, Ryuhei[15], KAWAMURA, Taichi[1], ISHIHARA, Yasushi[8], ARAKI, Eiichiro[8], HAYAKAWA, Masahiko[1], SHIRAI, Kei[1], FUJIMURA, Akio[1], YAMADA, isao[9], Philippe Lognonne[10], David Mimoun[11], Domenico Giardini[12], Antoine Mocquet[13], Ulrich Christensen[14], Peter Zweifel[12], Davor Mance[12], Jan ten Pierick[12], Raphael Garcia[11], Jeannine Gagnepain-Beyneix[11], Sebastien de Raucourt[11]

[1]ISAS/JAXA, [2]Dept. Earth and Planet. Sci., Tokyo Tech, [3]ERI, University of Tokyo, [4]Dept. Applied Science, Kochi Univ., [5]Dept. Geophysics, Kyoto Univ., [6]Dept. Geophysics, Tohoku Univ., [7]Assoc. Develop. Earthquake Predict., [8]JAMSTEC, [9]Chubu Univ., [10]IPGP, [11]University of Toulouse, [12]ETHZ, [13]University of Nantes, [14]MPI, [15]NAO Rise project

SELENE-2 is the first lunar landing mission of Japan. We are developing a broadband seismometer system as a powerful candidate for a payload instrument. In this presentation, we demonstrate the necessity of broadband seismometer observation, its scientific targets inspired by the results of the Apollo passive seismic experiment and current status of the development of the seismometer system. The Apollo projects in 1970's installed an equilateral triangle seismograph network at apexes where Apollo 12, 14, 15 and 16 landed, with a side of about 1,000 km long. The observation had lasted for over 7 years until September 1977 and it provided us with the first information on the lunar seismicity and the lunar structure down to a depth of 1,000 km. It, however, had two drawbacks: (1) the size of the network is limited within 1,000 km, and (2) the sensitivity of the seismometers with a limited narrow band of 0.17 Hz is marginal to detect the small deep moonquakes which occurred frequently. In addition, due to the strong scattering of seismic waves, P and S wave arrivals could not be picked up accurately, and the typical picking error is up to 10 sec. Because of these problems, the lunar velocity models obtained so far are less certain, in particular, at depths greater than 200 km. In the SELENE-2 project we plan to have only one landing site and so we cannot run a seismic network observation by the project alone. Thus, we need to obtain more information from the feeble seismic waveforms using a broadband (0.02-50 Hz) seismometer having 10 times higher sensitivity than that of the Apollo seismometers to overcome the drawback (2) as mentioned above. The characteristic frequency of the shal- low layer is about 0.12 Hz for the seismic velocity model of Nakamura (1981). Below that frequency, we expect clear detection of seismic phases reflected and converted at an internal discontinuity such as the core-mantle boundary. The long-period seismic waveforms may provide us not only information on the depth of an internal discontinuity but also seismic velocity contrast at the boundary. Long-period seismology will definitely open a new frontier of lunar science. Another scientific target of our project is to determine the corner frequency of deep moonquakes which can provide us information on the physical state in the source region. Although it was suggested that the corner frequency of deep moonquakes is much longer than that of earthquakes, the result is not conclusive because of the narrow band of the Apollo seismometers. To realize the highly sensitive broadband seismic observation in a timely manner, we make use of the heritage of a short-period seismometer (SP) developed in the past Lunar-A project and a long-period broadband seismometer VBB (LP) developed in the ExoMars project. We customize these seismic sensors to work properly under the severe conditions at the lunar surface. The thermal shield module is the key technology to realize high performance in the seismic observation on the moon.

Keywords: moon, moonquake, internal structure, broadband seismometer