Pros and Cons of Human Exploration for Explorations of Planetary Interior

（内部構造探査に対する無人/有人探査のメリット）

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ABSTRACT

Exploration of planetary interior provides important opportunities to constrain its bulk composition and thermal evolution. At the same time, there are various challenges concerning actual observations to probe the internal structure of planets and satellites. In this presentation, I will discuss the problems and challenges of explorations of internal structure, especially with seismic approaches. I will conclude with discussion pros and cons of of human exploration of seismic observation.

With various constraints for space mission, we need to make a choice between having small number of high quality seismic stations of larger number of seismic stations with quality good enough for seismic observation. The former shall include recent broadband seismometers and/or small arrays. This will enable exploration of deep interior through observation of long wavelength seismic waves. On the other hand, most of the seismic investigation requires location of seismic source which is difficult to constrain with observation at single or small number of stations. This requires soft landing for the lander and proper installation system for seismometers. Station good enough for seismic investigation should be equipped with short period seismometer that enables us to pick signal arrivals and travel time analyses to constrain source locations and the internal structure. Such approach will depend mostly on travel time analyses for the internal structure which leaves uncertainties compared to

investigations with multiple approaches for broadband observation. Technical requirements for such stations are much less severe compared to stations with broadband seismometers and likely to be deployed with hard landing.

For future seismic exploration, both approaches are equally important and the key question will be how to establish a network. Source locations are primary and essential information for seismic investigations and establishment of global network will be a most promising path for this. Thus, we should take advantage of all the launch opportunity. For manned missions, it would most likely be soft landing. Thus, I propose that all future manned mission should be equipped with broadband seismometers. At the same time, technical investigation should be continued for installation system that enables astronauts to install properly under extraterrestrial condition (e.g. low gravity, limited view and activity with spacesuit). In terms of budget and resources, launch opportunity is smaller for manned mission than unmanned mission. Thus, even the mission can be equipped with broadband seismometers, it would be challenging to establish global network. Thus. we should make the best of launch opportunities for unmanned missions. We should aim to increase number of stations and expand the network. This should include both hard landing mission with short period seismometers and soft landing missions with broad band seismometers. For example, Japanese penetrator enables us to establish global network with less resource compared to soft landing mission. We should be ready for all possibilities to increase the number of stations for larger network and have as much as possible stations equipped with broadband seismometer within the network.