4-D active monitoring of time-variant ocean bottom structure including a gas chimney type deposit methane hydrate by using seismic wave simulations

*Masashi Mogi[1], Kayoko Tsuruga[2]

1.Graduate School of Tokyo University of Marin Science and Technology, 2.Tokyo University of Marine Science and Technology

Recently the studies of methane hydrate (*ie.*, MH) have been developed and a lot of MH reservoir areas were found around Japan. They are characterized by following two types of origin/deposit (1) thermal decomposition origin (*ie.*, gas chimney type deposit) and (2) biodegradation origin (*ie.*, sand filling type deposit) (Matsumoto *et al.*, 2009). Some 3-D seismic surveys were conducted in the Sea of Japan to clarify the feature of an ocean bottom structures with a gas chimney type deposit of MH (*e.g.*, Saeki *et al.*, 2009). To avoid any environmental pollution accompanying to MH developments in future, it is necessary to actively and continuously monitor the changes of geophysical and geochemical properties of the ocean bottom structure including MH deposit. We therefore have developed a 4-D active monitoring methodology and technology to observe a time-variant reservoir such as MH or oil-gas reservoir under the water (*e.g.*, Tsuruga *et al.*, 2013).

In this study we show the preliminary results of characteristic wave phases of reflected wave from MH reservoirs and some effective seismic source- receivers array designs through simulating the seismic wave filed by means of a finite difference method (Larsen, 2000). We calculated seismic waveform records on three types of underground seismic structure models as follows: (Model-1) a horizontal multilayered structure model, (Model-2) a horizontal multilayered structure model including a thin MH layer and (Model-3) a horizontal multilayered structure with a chimney type MH deposit in a sand stone layer. The horizontal multilayered structure model consists of four layers with a sea water, a MH or sand stone, mud stone, over an igneous basement rock.

As the results, Model-1 is the horizontal multilayer structure, so no characteristic wave phase is observed. Then the reflect wave from the MH deposit travels faster than that from sea water in the Model-2. It is because MH deposit has higher velocity. Finally, the MH deposit in Model-3 is in the sand stone layer, so the wave that is not reflected from the horizontal layer is observed. Also, we found some effective seismic phase to monitor the time-variant MH reservoir and then tried to optimize an effective source-receivers array design, the preliminary result showed that two types of receivers arrays are effective to monitor the changes of seismic velocity in a MH reservoir by using some particular seismic phases reflected at the boundary of a surface-type MH layer. One of the arrays is constructed my both a horizontal array and a vertical one with seismic active sources located at the sea bottom as we call it, ‘T-type array’. Also the other is called ‘H-type array’ which consists of a horizontal array and two vertical arrays with the seismic source at the sea bottom.

Keywords: Methane hydrate, Monitoring, Time-lapse

