Features of pressure wave in water to accompany the underwater explosion

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Underwater explosion pressures are studied experimentally by dynamite in shallow water. To investigate scaling lows of underwater explosion as an analogue of volcanic underwater explosion, pressures of shock wave and bubble pulse and the period of bubble pulse were analyzed.

In the present experiments, the scaling depth (water depth/explosive weight to the 1/3th power) is an order of magnitude larger than in a shallow water explosion. The features of pressures formed during an underwater explosion in shallow water are still not very well understood. In shallow water, the pressure field in the water is usually complicated by reflections from the surface and bottom, the reflected wave from a free surface being negative and from a rigid surface positive. The resultant pressures observed are superpositions of the direct and reflected waves.

In this experiment, we exploded 100 to 4000 grams dynamite in various depths in water at the point of 34.3m depths on Toya Lake, Hokkaido. We used two tourmaline underwater blast ICP pressure sensors (PCB PIEZOTORONICS, INC., Model 138A01 and 138A05) at a depth of 5 meters in water, horizontal distance from explosive of 12 and 45 meters respectively and data logger (KINKEI SYSTEM Co. EAT-7000) with 10kHz sampling for pressure wave recording.

We recognized two types of pressure waves by total 13 shots.

1) One pulse accompanied with plural pulses whose rising become less steep.

2) Three pulses accompanied with plural pulses whose rising become less steep.

Type 1 is shallower than 0.79 meters in water, while Type 2 is deeper than 3.15 meters in water. The first pulse of both Type 1 and 2 is shock wave by underwater explosion. The second and the third pulse of type 2 are bubble pulse by pulsating bubbles of hot gases formed during an underwater explosion. Following pulses are of reflections from the surface and bottom.

The maximum pressure of shock wave by suspended explosions except one applies to the scaling low of underwater explosion in deep sea, while maximum pressures of bubble pulses do not apply to the scaling low of underwater explosion in deep sea. Furthermore the period of bubble pulse do not apply to the scaling low (charge weight to the power of 1/3 multiplied water depth to the power of -5/6) at different scaled depth Ds (water depth/charge weight to the power of 1/3). The scaling low of this experiment is that the period of bubble pulse = explosive weight to the power of 1/3 multiplied water depth to the power of -5/18. That is to say, total energy of hot gases formed during an underwater explosion is proportion to charge weight multiplied water depth to the power of 5/3. The decrease of the total energy accompanied with decrease of water depth is considered to be one proof of bubble deformation and split.