

## Feasibility of a pop-up ocean bottom seismometer with an atomic clock

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The Accuracy of timing is one of most important elements in seismic observation. Timing from GPS signal is used for ordinary observation. Accuracy of the timing depends on the internal clock for pop-up ocean bottom seismometers (OBS). Accuracy of 0.1 s in one year is available through the internal crystal clock, which is sufficient for hypocenter determination and velocity-structure surveys.

Analysis of ACROSS signal requires stacking, in which timing error should be less than one sampling interval. Furthermore arrival time variation of 0.1 ms can be detected with cross-correlation technique from the ACROSS signal. Timing accuracy of  $10^{-11}$  is necessary to keep error less than 0.1 ms in three month observation. Accuracy of a crystal clock is about  $10^{-7}$ - $10^{-8}$ , which is greater than the required level.

Chip-size atomic clocks have been developed recently. Accuracy of  $10^{-10}$ - $10^{-11}$  is available with the atomic clock. It is enough to retrieve the ACROSS signal through stacking. However it might be insufficient to detect 0.1 ms arrival time change. Reductions in size and energy consumption of atomic clocks are being improved.

Size and energy consumption are important factors for installation in a pop-up OBS. An atomic clock of volume  $50 \text{ cm}^3$  is available, which is small enough. Total energy consumption of a pop-up OBS is less than 0.5 W. The power of a currently available atomic clock is several watts, which is too large for a pop-up OBS. There is a prototype atomic clock of about 0.1 watts energy consumption. It would not be so long until atomic clocks suitable for the OBS become available.