Core-plug velocity measurements for seismic oil/gas reservoir characterization

Ayato Kato[1]; Hisako Mochinaga[1]; Isao Takahashi[2]; Akihisa Takahashi[3]; Takahiro Torigoe[3]

[1] JOGMEC; [2] INPEX; [3] JAPEX

Surface reflection seismic survey, in particular the 3D survey, is the essential technique for oil and gas exploration. Rock physics analysis based on P- and S- wave velocity measurement of reservoir rocks and fluids in the reservoir condition delivers vital information for interpreting the seismic reflection data, i.e., how seismic observations, e.g., velocity and amplitude, are sensitive to reservoir properties, e.g., porosity, water saturation, or pressure. JOGMEC-TRC has conducted such ultrasonic core velocity measurement for various types of sandstones and carbonates from oil/gas fields around the world, including UAE, Iran, Indonesia, and other countries.

The rock physics measurement becomes crucial, in particular, for evaluation of non-conventional reservoirs, such as methane hydrate and heavy oil, both of which contain hydrocarbon in unconsolidated and easily-breakable sandstones. In the Canada Oil Sands Project operated in Athabasca, Alberta, Canada, the SAGD (Steam Assisted Gravity Drainage) method is used for producing bitumen contained in unconsolidated sandstone deposited as fluvial channels. The depth of the target reservoir is around 300m below the surface. The SAGD method makes the bitumen flowable by heating it with injected steam and reducing its viscosity. 4D (time-lapse) seismic survey can be powerful for monitoring the 3-dimensional steam front movement, if, for example, the steam encroachment is visualized as time-lapse seismic amplitude variation. It is, however, not well understood how the seismic amplitude and velocity changes due to the variations of reservoir pressure or temperature during the steam injection.

JOGMEC-TRC hence developed a novel apparatus for measuring ultrasonic core velocities of such fragile and easily breakable samples. Using the new apparatus, we measured and analyzed P- and S-velocities of plug samples of the oil sand, as well as the bitumen fluid itself. The measurement was conducted for a range of temperature and effective pressure conditions, mimicking the reservoir conditions expected during the SAGD process. The measurement revealed that the velocity change caused by the changes of temperature and pressure can be sufficiently large. From the velocity measurements, we simulated the variation of seismic responses before and after the SAGD operation. This analysis concluded that time-lapse reflection survey can make measurable difference between the base-line and monitor surveys, encouraging that 4D seismic survey can be feasible for steam front monitoring.