Geophysical implication of the high Vp/Vs zone at depth of approximately 3.6 km obtained by the DAS measurements at the Medipolis geothermal filed

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We conducted the second seismic and temperature measurement at the Medipolis geothermal field in 2019 using optical fiber system in the borehole down to depth of 1,545 m. Using distributed temperature sensors (DTSs), the temperature in the borehole was measured. The temperature was 272˚C and 155˚C at 918 m and 1,530 m, respectively. Offset VSP data were obtained using distributed acoustic sensors (DASs). We operated the MiniVib seismic source at five locations.

The analysis of the P-to-S conversions observed by surface seismometers at the same geothermal field in 2018 suggested the presence of *Vp/Vs*=3 zone at depth of approximately 4 km (Kasahara *et al.*, 2020b) (see Figs.1 & 2). By forward modeling and the migration processing of DAS data in 2019, we obtained *Vp/Vs*=3 zones at depth of approximately 700–900 m, 1,300–1,600 m and 3,600 m (Kasahara *et al*. 2020a). Because ordinary silicate rocks show approximately *Vp/Vs*=1.75 (*e.g.* Hoshino *et al.*, 2001), *Vp/Vs*=3 is quite different from other rocks. Vp/V=3 does not mean exact number, but it means that Vp/Vs is much higher than 1.75 which is that for ordinal silicate rocks.

We considered the geophysical meaning of *Vp/Vs* ˜3. Using the numerous *Vp* and *Vs* measurements under high pressure and temperature by Kern (1978), Kern and Richter (1981), and Kern *et al.* (1997), most quartz-free rocks showed very small temperature dependence of *Vp* and *Vs*. Rocks including quartz minerals demonstrated large temperature dependence on *Vp* due to that phase change from α to β quartz (Kern and Richter, 1981). For quartz-free rocks, *Vp/Vs* remained constant to be approximately 1.75 and *Vp/Vs* ˜3 was not explained. The serpentine rock exhibited large decreases in *Vs* and *Vp* at temperatures higher than 500 ˚C (Kern and Richter, 1981). The amount of velocity decrease at high temperature was explained by the dehydration of antigorite, which is a high temperature-type serpentine mineral. The decrease in *Vs* was larger than that in *Vp*. Water saturation in rocks might be a cause of high *Vp/Vs*. In addition, the *Vp/Vs* is related to the Poisson’s ratio. *Vp/Vs* = 3 corresponds to 0.467 for the Poisson’s ratio. Because the Poisson’s ratio of water is 0.5, the zone at a depth of approximately 3.6–4 km could be filled by water. Winlker and Nur (1985) obtained *Vp/Vs* > 2 for the Massillon sandstone if the sandstone was 100% saturated by water. Considering the above discussion, high *Vp/Vs* suggests the presence of high-water saturation zones at depth of approximately 4 km. Because the temperature at the depth of 914 m is 264 ˚C in the IK-4 well, the zone around 4 km depth might be close to the supercritical state if the zone is filled by low salinity water.

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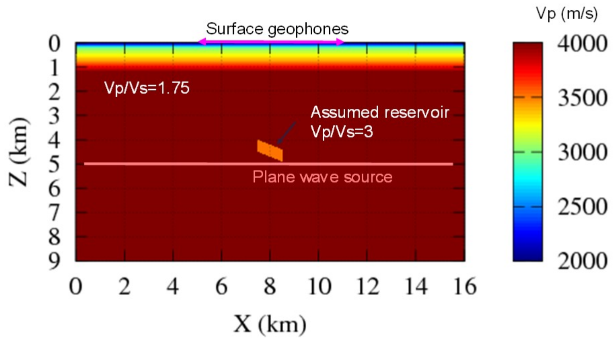

Fig. 1: Model to examine the P-to-S conversion. *Vp/Vs* in the reservoir is assumed to be 3. The plane wave source at 5 km depth. The dip of the reservoir is 20° .

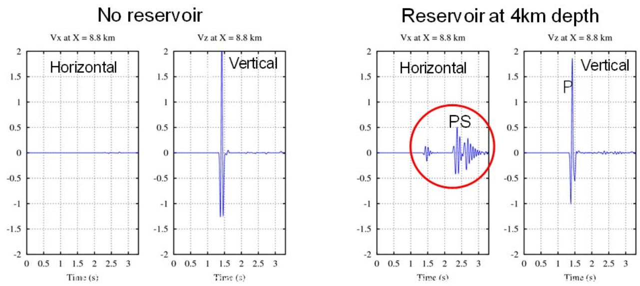

Fig. 2: Waveforms at 8.8 km from the left edge of the model shown in Fig. 5. It is noted that the P-to-S conversion arrival is observed on the horizontal component, but only intense P first arrival is seen on the vertical component for the 4 km-deep reservoir model.

