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Behavior of Pore Air in a Mountainous Catchment Underlain by Volcanic Rock

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In the past few decades, there have been many research activities to clarify the mechanism of storm runoff generation in a forested drainage basin in humid regions. The important issue in catchment hydrology is how do pre-event water stored in the catchment will discharge rapidly during the rainstorm event (Kirchner, 2003). The possible conceptual models to explain the rapid outflow of old water are the role of capillary-fringe groundwater ridging hypothesis (Gillham 198 4), role of pipe flow (McDonnell, 1990), role of bedrock groundwater flow (Anderson et al., 1997) or role of entrapped pore air (Marui et al., 1993).
Focusing on the role of pore air, there are researches suggesting the role of pore air by laboratory experiments or numerical simulations. Torres and Alexander (2002) suggested that rapid increase of discharge by spike increases in rainfall may be attributed to the pressure wave-like responses in the unsaturated zone due to the release of stored soil water. Clock et al., (2006) suggested that such pressure waves may be the possible runoff mechanism in the field. Despite its potential importance to runoff generation only a handful of studies have focused on the effects of entrapped air on rainfall- runoff processes. Marui et al., (1993) have done monitoring observation at the field and experiments in the laboratory to show the effecting process of pore air pressure to the ground water recharge to discharge process. However, they did not monitored the behavior of pore air directly. Also, Kawamoto et al., (2006ab) suggested that it is possible to explain the flux of pore air by Darcian like law using air permeability.
In order to investigate the behavior of pore air directly in field observation, hydrometric, tracer, subsurface water potential and air flow observations are conducted in a small headwater catchment situated in south-west Japan. The catchment is underlain by Tertiary volcanic rock; Andesite. The altitude of the catchment ranges from 322 m to 378 m with an area of 0.01 km2 and the mean hillslope angle is 23.5 degree. Boreholes (depth of 25 m, 60 m, 120 m) were instrumented at the middle part of the catchment. Air pressure in the borehole at borehole capped condition and air runoff volume from the open borehole were observed.
As a result, the air out flow seemed to be occurring induced by the pressure difference between the inner pressure at borehole and atmospheric pressure. Thus, simple simulation using the Boils low has done to show the air out flow mechanism at this slope. Simulated pressure was almost fitted with the observed inner pressure. However during the rainfall event with large precipitation, Inner pressure showed obviously big fluctuation compared to that induced by atmospheric pressure. At this time, shallow pore air was suggested to be entrapped by the saturated shallow soil layer and emerging groundwater table. Further study is expected to clarify the relationship to the runoff process.

Keywords: Headwater Catchment, Volcanic bedrock, Pore Air, Borehole, Air Permeability