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The volcanic stratigraphy and its hydrogeological controls in the northeastern Jeju Island, South Korea

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Jeju Island, the largest volcanic landform in South Korea, has been built by repeated volcanic eruptions from about 1.8 Ma to a thousand years ago. As a result, the main body of the island comprises accumulations of plateau- and shield-forming lavas with numerous volcanic cones, which are underlain by basaltic volcaniclastic and fossiliferous deposits during the onset of volcanism in a continental shelf setting. In this study, for more improved understanding of subsurface geology of Jeju Island, we focus on detailed subsurface volcanic stratigraphy and its relationship with the groundwater behavior in the northeastern coastal area of Jeju Island. Borehole cores and well-logging data (electrical conductivity, EC) from 7 drilling sites were analyzed in terms of mineralogy, lithology, texture and structure to establish subsurface stratigraphy.

Based on the analyses of lithology and lithofacies, the borehole cores are divided into 10 major lithostratigraphic units. Major lithological units of the borehole core are stacked volcanic rocks and clastic sedimentary deposits. The volcanic rocks occur above the depth of -90.5 $\sim$ -134.5 m El., while the sedimentary rocks are mainly recovered at the depths between -58.4 m and -82.2 m as well as below -90.5 $\sim$ -96.9 m. Depending on abrupt changes in mineralogy and texture, and occurrence of weathering surfaces and paleosol layers, the volcanic rock intervals are divided into 18 to 34 units (0.2$\sim$57.0 m thick) in each borehole cores. Most of the volcanic rock units are interpreted to have been emplaced from pahoehoe lava flows in subaerial condition. In the middle to lower parts of the volcanic successions (-33.9 $\sim$ -134.5 m in depth), one or two hyaloclastite units resulting from lava-seawater interaction are correlated all over the borehole cores. The hyaloclastites are characterized by abundant angular basaltic lithic fragments (one to several tens of centimeters in diameter) with chilled margins and unconsolidated yellow-colored matrix. In 4 borehole cores, the hyaloclastites are underlain by shell-bearing marine sediments. This is strongly suggestive of a relative sea-level rise or marine transgression. On the other hand, the sedimentary strata below the main interval of volcanic successions (>-90.5 m in depth) consist dominantly of sand- to silt-sized clastic and biogenic grains without recognizable primary sedimentary structures.

In the study area, aquifer generally starts at about 1 m below ground surface. Based on the EC logging data, groundwater can be divided into three zones: fresh water zone (<1,700 μS/cm), brackish water zone (1,700 $\sim$ 17,350 μS/cm), and saline water zone (>17,350 μS/cm). The thickness of fresh water zone gradually increases going inland. Except in two borehole sites, a sudden increase in the EC value (i.e. thin brackish water zone) is observed in association with hyaloclastite units which are characterized by complicated dense fracturing with numerous joints. This suggests that the hyaloclastite units act as major pathways for seawater penetration into the inland fresh water aquifer. Although rock joints are also recognized in the pahoehoe lava flow units, they seem to be less significant in the study area because they show relatively poor lateral connectivity.