

A Study on the Origin of a Spring in Tottori Sand Dunes using various geophysical and hydrological methods

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There is an oasis that changes its appearance depending on the season in the depression south of Umanose (horseback), which is a symbol of the undulations of Tottori Sand Dunes. This oasis is not always visible. It disappears during the summer. The influent that constantly flows over the ground surface into the oasis depression forms Shirinashigawa River when oasis is gone, as the inflow water permeates into the sand or evaporates. By what mechanism does this oasis appear and disappear? That is, where does this influent come from and where does it go? This question about the oasis spring has been a scientific interest for a long time. For example, there have been a proposal that the rainwater from rain in the sand dunes became groundwater, some of which formed a spring and appeared on ground surface again(Akagi, 1991), a proposal that the rainwater permeating into the sand dunes with low water-holding property accumulated as groundwater near the impermeable stratum of the bedrock or volcanic ash layer with low water permeability and formed spring (Natural Parks Beautification and Management Foundation, 1995), and a recent study that investigated the relevance of oasis formation and the changes in water level in Tanegaiké which is located south of the sand dunes (Hoshimi, 2009).

To answer this question, that is, to search for the origin of the spring in sand dunes (oasis), this study was conducted on the subsurface structure and circulation of groundwater in Tottori Sand Dunes. We estimated the subsurface structure of Sand Dunes and obtained basic data on groundwater existence, mode of its flow, the base structure of sand dunes using various nondestructive geophysical exploration methods, and tried to elucidate the origin of the oasis spring and the quantitative rise and fall mechanism also incorporating hydrological methods. While the specific methodologies used here will be described in a later section, we applied electrical resistivity imaging method, 1 m-depth geothermal prospecting, self-potential method, tremor probing and gravity probing to estimate the former subsurface structure and introduced continuous water level observation on oasis and analysis of evaporation quantity, groundwater level survey in oasis and its proximity, and analysis on stable isotope ratio of oasis spring water and water sampled from Tanegaiké for the latter. For the former application, we conducted a GPS survey using a differential method so that we could understand the positions of observation points and grasp the overall topography of the sand dune area. For the latter application, we conducted a survey using total station to grasp the microtopography of the oasis area and its proximity.

As a result, we reached a conclusion as described below regarding the subsurface structure of Tottori Sand Dunes and the origin of the spring in sand dunes (oasis). “ Rainwater permeates into the sand dunes and form groundwater. A part of it is lead to the aquifer mainly formed on the volcanic ash layer (as perched water) and flows into the oasis spring. Then, the oasis spring flows into the sea through underground of Umanose. There is no simultaneous or direct relevance between oasis spring and the water in Tanegaiké. We found association between the overall groundwater distribution in Tottori Sand Dunes area (sand dunes for sightseeing) and the undulations of the bedrock structure estimated by the subsurface structure analysis.” It is surmised that this study verified these things from quantitative observation values including subsurface structure, changes in water level, changes in isotopes and so forth of sand dunes had significance of its own. This article will report on the basic scientific background, an outline of the study, the results of multiple surveys and their interpretation, and an overall summary of them.

Keywords: Tottori sand dunes, underground water, geophysical exploration methods