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論文題目	Water and rock geochemical characterization to clarify fluid circulation process in transitional geothermal reservoir with a case study of the Wayang Windu field, West Java, Indonesia （水と岩石の地球化学的特徴抽出による遷移型地熱貯留層での流体循環プロセスの解明とインドネシア西ジャワ　ワヤン　ウインドゥ地区への適用）		

Formation process of transitional geothermal reservoir has not yet been fully understood due to complexities of hydrothermal fluid circulation and geologic structure. A transitional reservoir was defined as a zone with counter flow of condensates zones in vapor-dominated reservoir that overlays boiling liquid reservoir. To clarify the fluid origin and water-rock interaction (WRI) processes in the system, traditional isotope oxygen-18 and deuterium analysis was improved in order to clarify recharge zones of geothermal fluids, location of the boiling reservoir as the resource of vapor and liquid phases, and features of the most representative fluids in the reservoir called parent fluid. Parent fluid holds important role on controlling fluid circulation and its several processes occurred in the reservoir. Additional analyses of trace elements including rare earth elements and Sr isotopes were integrated in order to characterize hydrothermal flow in the shallower and deeper parts in details.

This doctoral dissertation begins with Introduction, including the research background, general notion of transitional geothermal reservoir, and objectives of this study in Chapter 1. An overview of geological settings and hydrogeology in Chapter 2 cover the highlights of regional and local geology of the study area, which significantly contributes to the characteristics of the reservoir as general information in the field study. The sampling locations and analytical methods of several instruments used in this study are also described in this chapter.

An investigation of the parental fluid, recharge elevation for production wells and surface manifestations, and the specification of a transitional zone by water to rock ratio (*W/R*) were described more in detail in Chapter 3. The water isotope ratios were corrected to remove effects of boiling in well bore and used for identifying the recharge elevations for geothermal fluids in reservoirs and surface manifestations. Clarification of the parent fluid was indispensable for understanding the origin of geothermal fluid and its subsequent flow processes. Geothermal flow patterns from meteoric recharge to discharge, including WRI, boiling, mixing, and evaporation processes, was successfully modeled with *W/R* ratios.

Another important highlight was that fluid evolutions from the reservoir to the surface or from the recharge areas to the reservoir were in a good agreement with the analysis results of fluid evolutions through the conservative elements Cl and B and additionally, alkali metal elements Li, Rb, and Cs in Chapter 4. However, the proposed methodology using alkali earth metals Ba and Sr, as well as transition metals (V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Zr, Mo, Cd, W) and p-block metals (Al, As, Sb, Pb) still need to be considered by speciation models with sufficient thermodynamic database. Nevertheless, the distribution of several trace elements from the surface fluids by interpolating the data with a spline revealed the roles of geological faults on the dilution and shallow water-rock interaction.

To deepening the understanding of shallow hydrothermal processes, another particular series of trace

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elements: rare earth elements (REE) were analyzed from several types of rocks and fluids, including river waters, cold springs, hot springs, well fluids, well rocks, and host rocks from available references in Chapter 5. The process of mixing of meteoric water in oxic environments (referring to the local recharge or the shallow groundwater in Chapter 3) was shown by negative Ce anomalies in the gull-wing diagrams. The river, cold springs, and well fluids were assumed to have contact with oxic waters (meteoric recharge), meanwhile the hot springs have no interface with oxic waters. Geothermal fluid samples were revealed to have interaction of high temperatures chloride fluids with plagioclase in the reservoir (samples with positive Eu anomalies), fluid-alunite interaction, extensive hydrothermal alteration and precipitation of secondary minerals on their way to the surfaces, and undergo mixing with oxic waters.

As for the weathering process, $^{87}Sr/^{86}Sr$ ratio analyses in Chapter 6 revealed interactions of the recharge water with the unaltered volcanic and pyroclastic rocks in the study area. After meteoric water recharged the reservoir fluid, the ascending parent fluid mixed with different groundwater types that shared similar host rocks to appear as cold and hot springs. The results were well agreeable with the *W/R* ratios from Chapter 3. Two different types of aquifers could be differentiated to explain the genesis of cold springs with anthropogenic contaminant, and cold springs that shared the deeper aquifer with several hot springs. On the contrary, the hot springs originated from the aquicludes (perched aquifers) with no availability of oxic water in general. Matrix of *W/R* ratio to %MWE (meteoric water exchange) was also developed to trace the possible zones of meteoric recharge to the geothermal system.

Finally, the main results were summarized with a conceptual model in the last chapter. Chapter 7 also includes the relevant, necessary future works for applying my findings to development of other geothermal fields.