Pemodelan Sistem Geotermal Berdasarkan Inversi 3-Dimensi Data Magnetotellurik pada Daerah Prospek Geotermal "M" = Modeling of Geothermal System Based on 3-Dimensional Inversion of Magnetotelluric Data in "M" Geothermal Prospect Area

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Abstrak

Daerah penelitian “M” merupakan salah satu daerah yang memiliki potensi geotermal di Indonesia. Hal tersebut ditunjukkan dengan adanya struktur geologi dan kemunculan manifestasi di permukaan yang dapat membantu dalam mengidentifikasi keberadaan sistem geotermal di bawah permukaan. Penelitian ini menggunakan inversi 3-dimensi magnetotellurik untuk mengetahui distribusi resistivitas di bawah permukaan, penentuan area prospek, serta pembuatan model konseptual dengan integrasi data magnetotellurik dan data pendukung berupa data geologi, geokimia, dan gravitasi. Berdasarkan data pendukung geologi, daerah “M” terdiri dari susunan produk vulkanik berumur kuarter dan struktur geologi dengan arah barat laut-tenggara. Dari data pendukung geokimia, ditemukan endapan travertine di sekitar manifestasi mata air panas yang relatif bersifat netral, temperatur cukup tinggi, dan berasosiasi dengan struktur geologi. Fluida di mata air panas tersebut dominan bertipe bicarbonate water yang menandakan fluida berasal dari reservoir dan dominan telah terkontaminasi oleh meteoric water. Fluida tersebut juga dominan memiliki nilai klorida tinggi yang menandakan bahwa lingkungan manifestasi mata air panas berada di lingkungan vulkanik. Selain itu, perhitungan dengan geotermometer diperoleh dugaan temperatur reservoir berkisar antara 160°C-180°C. Berdasarkan hasil pemodelan inversi 3-dimensi magnetotellurik dan data pendukung berupa model forward2-dimensi gravitasi diketahui sebaran dari variasi resistivitas dan densitas bawah permukaan yang menggambarkan lapisan clay cap, top of reservoir, dan bentuk updome yang kemungkinan merupakan heat source. Lapisan dengan nilai resistivitas rendah diduga merupakan clay cap atau batuan penudung berupa sebaran batuan beku yang mengalami alterasi. Di bawah lapisan clay cap terdapat sebaran resistivitas medium yang diindikasikan sebagai reservoir berupa batu gamping bahbotala. Di bagian bawahnya terdapat lapisan dengan resistivitas tinggi yang kemungkinan adalah batuan metamorf yang menjadi batuan dasar/basement. Diantara basement ini terdapat bentuk updome dengan resistivitas sedikit lebih tinggi yang diduga merupakan batuan terobosan atau intrusi yang dapat menjadi sumber panas bagi sistem geotermal. Sumber panas ini diduga berasal dari Dolok Tinggi Raja dikarenakan terbentuknya dome di permukaan yang mungkin diakibatkan oleh adanya larutan magma yang tidak tererupsikan keluar permukaan sehingga membentuk batuan terobosan di bawah permukaan. Adanya sumber panas ini dapat menimbulkan aliran fluida panas secara vertikal (upflow). Berdasarkan integrasi data-data tersebut, area prospek geotermal di daerah “M” diperkirakan berada di sekitar Dolok Tinggi Raja melebar ke arah timur laut, timur, dan selatan.

.....The research area "M" is one of the areas with geothermal potential in Indonesia. This is indicated by the presence of geological structures and the appearance of manifestations on the surface which can assist in identifying the presence of subsurface geothermal systems. This study uses 3-dimensional magnetotelluric inversion to determine the distribution of resistivity below the surface, determine prospect areas, and construct a conceptual model by integrating magnetotelluric data and supporting data in the form of

geological, geochemical and gravity data. Based on supporting geological data, the "M" area consists of volcanic products of quarter age and geological structures in a northwest-southeast direction. From supporting geochemical data, travertine deposits around hot spring manifestations were found which were relatively neutral, had relatively high temperatures, and were associated with geological structures. The fluid in the hot springs is dominant of the bicarbonate water type, which indicates that the fluid comes from a reservoir and has been predominantly contaminated by meteoric water. The fluid also dominantly has a high chloride value which indicates that the manifestation environment of the hot springs is in a volcanic environment. In addition, calculations with the geothermometer obtained an estimated reservoir temperature ranging from 160°C-180°C. Based on the results of 3-dimensional magnetotelluric inversion modeling and supporting data in the form of a 2-dimensional forward gravity model, it is known that the distribution of resistivity and subsurface density variations describes the clay cap layer, top of reservoir, and up-dome shape which may be a heat source. The layer with a low resistivity value is thought to be a clay cap or a cap rock in the form of a distribution of altered igneous rocks. Beneath the clay cap layer, there is a medium resistivity distribution which is indicated as a reservoir in the form of bahbotala limestone. At the bottom, there is a layer with high resistivity which is probably the metamorphic rock that became the basement. Among these basements, there is an up-dome with slightly higher resistivity which is thought to be a breakthrough or intrusive rock which can be a heat source for geothermal systems. This heat source is thought to have originated from Dolok Tinggi Raja due to the formation of a dome on the surface which may be caused by the presence of magma solution that has not erupted off the surface to form breakthrough rock below the surface. The existence of this heat source can cause a vertical flow of hot fluid (up-flow). Based on the integration of these data, the geothermal prospect area in the “M” area is estimated to be around Dolok Tinggi Raja, widening to the northeast, east, and south.