

Pemodelan 3D Sistem Geotermal Menggunakan Metode Magnetotellurik dan Analisis Geokimia di Daerah Prospek Geotermal Cubadak, Sumatra Barat = 3D Modeling of Geothermal Systems Using Magnetotelluric Methods and Geochemical Analysis in the Cubadak Prospect Area, West Sumatra

Muhammad Dhian Fathurrahman, author

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Abstrak

Cubadak merupakan salah satu daerah prospek geotermal di pulau Sumatera yang diindikasikan dengan keberadaan 3 manifestasi air panas bertemperatur 68-74,8°C. Penelitian ini bertujuan untuk mengidentifikasi karakteristik sistem geotermal di daerah penelitian melalui pemodelan 3D metode magnetotellurik berdasarkan distribusi resistivitas bawah permukaan. Hasil pemodelan menunjukkan adanya zona konduktif dengan nilai resistivitas $<15 \text{ } \Omega\text{m}$ yang diindikasikan sebagai batuan teralterasi (claycap) dan batuan pengisi graben, zona resistivitas sedang (16–100 $\text{ } \Omega\text{m}$) sebagai zona reservoir, serta zona resistivitas tinggi ($>100 \text{ } \Omega\text{m}$) sebagai basement. Zona recharge terdeteksi pada sisi timur laut (NE) dan barat daya (SW) sebagai jalur masuknya fluida meteorik ke reservoir, sedangkan zona discharge merupakan jalur keluarnya fluida panas dari reservoir. Sumber panas (heat source) sistem geotermal diduga berada pada elevasi $>-1500 \text{ m}$. Manifestasi mata air panas di daerah penelitian terletak pada zona upflow, bersumber dari reservoir bertemperatur 148–178°C, dengan sesar Cubadak sebagai jalur keluarnya. Empat sesar utama, yaitu sesar Andilan, Cubadak, Rantau Panjang, dan sesar X, diduga menjadi kontrol utama pembentukan graben di daerah penelitian. Sistem geotermal ini diklasifikasikan sebagai sistem tektonik dengan dominasi air, di mana graben berperan sebagai zona depresi tempat terbentuknya sistem tersebut. Rekomendasi titik pengeboran berada pada zona upflow di dekat titik MT-15, berdekatan dengan sesar Andilan yang memiliki permeabilitas baik, dengan target temperatur 178°C dan kandungan fluida netral. Batas daerah prospek ditentukan berdasarkan penampang sebaran resistivitas yang diintegrasikan dengan model konseptual penampang MT lintasan 1, berada di antara titik MT-08, MT-09, MT-10, MT-15, dan MT-16.

.....Cubadak is one of the geothermal prospect areas in Sumatra, indicated by the presence of three hot spring manifestations with temperatures ranging from 68–74.8°C. This study aims to identify the characteristics of the geothermal system in the research area through 3D modeling using the magnetotelluric method based on subsurface resistivity distribution. The modeling results reveal a conductive zone with resistivity values $<15 \text{ } \Omega\text{m}$, interpreted as altered rocks (clay cap) and graben infill rocks, a moderate resistivity zone (16–100 $\text{ } \Omega\text{m}$) indicating the reservoir zone, and a high resistivity zone ($>100 \text{ } \Omega\text{m}$) representing the basement. Recharge zones are identified in the northeast (NE) and southwest (SW) as pathways for meteoric fluid entry into the reservoir, while the discharge zone serves as the pathway for heated fluid exit from the reservoir. The heat source of the geothermal system is inferred to be located at an elevation $>-1500 \text{ m}$. The hot spring manifestations in the research area are located in the upflow zone, originating from a reservoir with temperatures of 148–178°C, with the Cubadak fault serving as the conduit for their emergence. Four main faults—Andilan, Cubadak, Rantau Panjang, and Fault X—are inferred to be the primary controls on graben formation in the research area. The geothermal system is classified as a tectonic system dominated by water, with the graben acting as a depression zone where the system is

formed. The recommended drilling point is located in the upflow zone near MT-15, close to the Andilan fault, which indicates good permeability, targeting a temperature of 178°C and neutral fluid content. The prospect area boundary is determined based on the resistivity distribution cross-section integrated with the conceptual model of MT line 1, located between points MT-08, MT-09, MT-10, MT-15, and MT-16.