

Delineasi Potensi Geothermal dan Karakterisasi Reservoir pada Lapangan Panas Bumi "YRS" Menggunakan Metode Inversi Data Magnetotellurik (MT) 3-Dimensi dan Analisis Geokimia = Delineation of Geothermal Potential and Reservoir Characterization in the "YRS" Field Using the 3-Dimensional Magnetotelluric (MT) Data Inversion Method and Geochemical Analysis

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Abstrak

Pulau Sumatera memiliki potensi panas bumi yang signifikan, namun informasi detail mengenai sebaran reservoir serta karakteristik fluida di beberapa area prospek masih terbatas sehingga memerlukan kajian lebih mendalam. Penelitian ini bertujuan untuk mendelineasi potensi panas bumi dan mengkarakterisasi sistem reservoir di lapangan panas bumi "YRS" melalui integrasi metode inversi magnetotellurik (MT) tiga dimensi dan analisis geokimia fluida. Daerah penelitian terletak pada zona pull-apart basin yang terbentuk akibat aktivitas Sesar Sumatera dan sesar turunannya, yang berperan sebagai jalur migrasi fluida hidrotermal. Akuisisi data MT dilakukan pada 3 lintasan pengukuran dan diolah melalui tahapan seleksi time-series, transformasi Fourier, robust processing, seleksi cross power, koreksi static shift, hingga inversi 3 dimensi. Analisis geokimia dilakukan terhadap parameter ion balance, komposisi kimia air, dan isotop stabil dari beberapa manifestasi panas bumi di permukaan. Hasil pemodelan resistivitas menunjukkan adanya zona konduktif dengan nilai resistivitas <15 m yang diinterpretasikan sebagai graben infill, menutupi zona resistivitas sedang 16–63 m yang diasosiasikan sebagai reservoir geotermal dengan top reservoir teridentifikasi pada kedalaman sekitar -500 mdpl. Zona resistivitas tinggi >158 m diduga merupakan batuan basement, sedangkan heat source berada pada elevasi lebih dari -1500 mdpl. Analisis geokimia menunjukkan fluida bertipe immature water dengan dominasi ion bikarbonat serta indikasi pencampuran dengan air meteorit, yang mencerminkan sistem outflow yang belum setimbang dengan batuan reservoir. Integrasi data geofisika, geokimia, dan geologi menghasilkan model konseptual sistem panas bumi bertipe fault-controlled pada zona pull-apart basin, yang dikontrol oleh aktivitas Sesar Sumatera. Temuan ini diharapkan dapat menjadi dasar bagi kegiatan eksplorasi lanjutan dan mendukung pengembangan potensi panas bumi di wilayah penelitian.

.....Sumatra Island has significant geothermal potential; however, detailed information regarding reservoir distribution and fluid characteristics in several prospective areas remains limited and requires further investigation. This study aims to delineate geothermal potential and characterize the reservoir system in the "YRS" geothermal field by integrating three-dimensional magnetotelluric (MT) inversion and fluid geochemical analysis. The study area is located within a pull-apart basin formed by the activity of the Sumatra Fault and its subsidiary faults, which serve as migration pathways for hydrothermal fluids. MT data acquisition was conducted along three survey lines and processed through several stages, including time-series selection, Fourier transform, robust processing, cross-power selection, static shift correction, and three-dimensional inversion. Geochemical analysis was carried out on ion balance, water chemistry composition, and stable isotopes from several surface geothermal manifestations. The resistivity model reveals a conductive zone with resistivity values of <15 m, interpreted as graben infill covering a medium-

resistivity zone ranging from 16 to 63 m, which is associated with the geothermal reservoir, with the top reservoir identified at a depth of approximately -500 meters above sea level. A high-resistivity zone (>158 m) is interpreted as the basement rock, while the heat source is estimated to be located below -1500 meters elevation. Geochemical interpretation indicates immature water dominated by bicarbonate ions with strong evidence of mixing with meteoric water, reflecting an outflow system that has not yet reached equilibrium with the reservoir rocks. The integration of geophysical, geochemical, and geological data produces a conceptual model of a fault-controlled geothermal system within the pull-apart basin, governed by the activity of the Sumatra Fault. These findings are expected to serve as a basis for further exploration and to support the development of geothermal potential in the study area.