ABSTRAK

MODEL GEOBIOKIMIA PERMUKAAN LAPANGAN MIGAS BERBASIS PENGINDERAAN JAUH DAN GEOLOGI DI CEKUNGAN SEDIMEN PRODUKSI HIDROKARBON JAWA BARAT UTARA

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Indikasi adanya migas di bawah permukaan bumi dapat diidentifikasi dengan adanya rembesan migas, berupa *macroseepage* ataupun *microseepage*. Diperkirakan *macroseepage* terjadi pada 75% cekungan sedimen, dan *microseepage* terjadi pada hampir semua cekungan sedimen. Keberadaannya menjadi salah satu parameter penting untuk eksplorasi migas. Rembesan secara umum bermigrasi secara vertikal dan atau mendekati vertikal ke permukaan tanah dengan mekanisme yang meliputi efusi, difusi, pelarutan dan gelembung gas yang naik. Rembesan migas di permukaan mengakibatkan terjadinya perubahan mineral lempung, *geobotany*, oksida besi *ferric* dan *ferrous*, delta karbon dan peningkatan gas hidrokarbon dan non hidrokarbon dalam tanah. Berdasarkan hal tersebut maka dilakukan penelitian model geobiokimia permukaan lapangan migas berbasis penginderaan jauh dan geologi di lapangan Tugu Barat, cekungan Jawa Barat Utara. Tujuan penelitian ini adalah membuat algoritma untuk pemetaan distribusi mineral lempung total, smektit, kaolinit dan hematit serta model geobiokimia permukaan lapangan migas berdasarkan integrasi data penginderaan jauh dan geologi.

Data penginderaan jauh yang digunakan Landsat 8 OLI/TIRS tanggal 25 September 2015, SRTM tahun 2010 dan DEM TerraSar tahun 2014. Tahapan penelitian yang dilakukan meliputi kajian literatur, pengumpulan data, pengolahan data penginderan jauh, analisis indeks vegetasi, mineral lempung dan oksida besi, survei lapangan untuk pengukuran fisik vegetasi, spektral vegetasi dan tanah, analisis komposisi mineral tanah, pembuatan algoritma mineral lempung total, smektit, kaolinit dan hematik, analisis model geobiokimia permukaan dan pelaporan. Pengolahan data penginderaan jauh meliputi koreksi radiometrik, koreksi geometrik, analisis indeks vegetasi, indeks mineral lempung, indeks oksida besi dan indeks hidrokarbon. Pengembangan algoritma untuk pemetaan distribusi mineral lempung total, smektit, kaolinit dan hematit dilakukan menggunakan metode *best subsets* dan analisis regresi untuk menghasilkan kombinasi saluran terbaik dan menghasilkan algoritma baru. Model geobiokimia dianalisis secara deskriptif untuk menggambarkan perubahan kondisi permukaan akibat adanya migas di bawahnya sebagai manifestasi adanya *microseepage.*

Hasil indeks mineral lempung, indeks vegetasi dan kondisi fisiknya, indeks oksida besi, indeks hidrokarbon, suseptibilitas magnetik dan radon menunjukkan adanya anomali permukaan di lapangan Tugu Barat yang membentuk model geobiokimia. Perubahan tersebut diindikasikan lebih intensif di tepi dibandingkan di tengah lapangan migas. Hal ini ditunjukkan dengan turunnya konsentrasi mineral lempung total, smektit, oksida besi *ferric* dan suseptibilitas magnetik; naiknya konsentrasi kaolinit, oksida besi *ferrous* dan radon, dan tingginya nilai indeks deteksi hidrokarbon di tepi lapangan migas. Analisis korelasi indeks mineral lempung dan indeks oksida besi dengan konsentrasi mineral penyusun tanah menunjukkan nilai koefisien determinasi yang rendah. Analisis metode *best subset* dilakukan untuk mengembangkan algoritma baru untuk pemetaan mineral-mineral penyusun tanah tersebut. Hasilnya pemetaan mineral mineral penyusun tanah dapat dirumuskan: (1) mineral lempung total = 0,658 – 32,09B1 + 49,3B2 + 20,01B3 + 4,45B4 + 4,09B6-7,73B7, (2) smektit = 0,611 – 35,66B1 + 50,5B2 – 13,46B3 + 5,29B6 – 9,00B7, (3) kaolinit = 0,068 + 4,26B2 -9,17B3 + 6,88B4 – 1,852B5, dan (4) hematit = 0,033 – 1,25B1 + 2,7B2 – 3,514B3 + 2,514B4 – 0,581B5, dengan B1, B2, B3, B4, B5, B6 dan B7 adalah saluran/kanal pada Landsat 8 OLI.

Analisis model geobiokimia pada lapangan Tugu Barat dapat dijelaskan sebagai berikut: (1) Model vegetasi menunjukkan di tepi lapangan migas lebih terganggu oleh adanya *microseepage* dibandingkan dengan di tengahnya dengan ciri indeks vegetasi rendah, jumlah rumpun jarang dan tanaman kerdil. (2) Model mineral lempung menunjukkan konsentrasi total mineral lempung dan smektit di tepi lapangan lebih rendah dibandingkan dengan di tengah lapangan, dan konsentrasi kaolinit lebih tinggi di tepi lapangan migas dibandingkan dengan di tengahnya. (3) Model oksida besi *ferric* menunjukkan konsentrasi yang lebih rendah di tepi lapangan migas dibandingkan dengan di tengahnya. Pola oksida besi *ferrous* konsentrasi yang tinggi di tepi lapangan migas dan rendah di tengahnya. (4) Model suseptibilitas magnetik menunjukkan tinggi di tengah lapangan migas dan menurun di tepinya. (5) Model radon menunjukkan pola yang lebih tinggi konsentrasinya di tepi lapangan migas dibandingkan di tengah lapangan migas.

Berdasarkan data bawah permukaan menunjukkan bahwa di tepi lapangan terdapat sesar yang menerus di sebelah timur dan selatan dari formasi Cibulakan Atas ke formasi Parigi. Hal ini diduga memicu berkembangnya *microseepage*, selain faktor *chimney*, *vapor migration* dan peningkatan retakan di tepi lapangan akibat ketidakkompakkan batuan. Model geobiokimia lapangan migas merupakan indikasi adanya migas di bawahnya. Hal ini dapat digunakan untuk menganalisis prospek yang akan dibor sehingga dapat meningkatkan faktor peluang geologi mengenai keberadaan migas yang terperangkap di prospek tersebut. Harapannya analisis model geobiokimia terhadap prospek dapat meningkatkan tingkat keberhasilan pemboran eksplorasi di Indonesia.

Kata kunci: eksplorasi, migas, *macroseepage, microseepage,* mineral lempung, *geobotany*, oksida besi, suseptibilitas magnetik dan radon.

ABSTRACT

GEOBIOCHEMICAL MODEL ON THE OIL AND GAS FIELD SURFACE BASED ON REMOTE SENSING AND GEOLOGY IN THE HYDROCARBON PRODUCTION NORTH WEST JAVA BASIN

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The indication of oil and gas beneath the earth can be identified through their seepage, in the form of macroseepage or microseepage. It is estimated that microseepage occurs in 75% of sedimentary basins, and microseepage occurs in almost all basins. Its existence is one of the important parameters for oil and gas exploration. Seepage generally migrates vertically or near vertical to the soil surfaces through the mechanism of effusion, diffusion, dissolution and gas bubbles. Seepage on the surface results in changes in clay minerals, geobotany, ferric and ferrous oxides, carbon deltas and increased hydrocarbon and non-hydrocarbon gases in the soil. This research was conducted to analyze the geobiochemical model on the oil and gas field surface based on remote sensing and geology in the Tugu Barat field, North West Java Basin. The research was intended to make the algorithms for distribution mapping of clay minerals, smectite, kaolinite and hematite, and to build the geobiochemical model on oil and gas field surface based on remote sensing and geological data integration.

This study utilized the remote sensing data from Landsat 8 OLI/TIRS dated 25 September 2015 with path/row 122/065, SRTM in 2010, and DEM TerraSAR in 2014. The stages of the research include: literature review; data collection; remote sensing data processing; analysis of vegetation index, clay mineral index, iron oxide index; field survey for measurement of the physical vegetation condition, leaves and soil spectral; soil mineral composition analysis; the development of algorithms for total clay minerals, smectite, kaolinite and hematite; analysis of surface geobiochemical models; and reporting. Remote sensing data processing include radiometric and geometric correction, vegetation index, clay mineral index, iron oxide index, and hydrocarbon index. The development of algorithms for total clay mineral, smectite, kaolinite, and hematite distribution mapping was analyzed using the best subsets and regression analysis to produce the best channel combination and new algorithms. Geobiochemical models were analyzed descriptively to depict the changes of surface conditions due to oil and gas beneath the earth as manifestations of microseepage.

The results of clay mineral index, vegetation index and physical vegetation condition, iron oxide index, hydrocarbon index, magnetic susceptibility, and radon showed the presence of surface anomalies on the West Tugu field which formed the geobiochemical models. The change is indicated more intensive at the border than the middle of the field. This condition can be explained by the decrease concentration of total clay minerals, smectite, ferric iron oxide, and magnetic susceptibility; and the increasing concentration of kaolinite, ferrous oxide and radon; and the high value of hydrocarbon detection index at the border of the field. Correlation analysis of the clay mineral index and iron oxide index with soil minerals composition showed a low coefficient of determination. Analysis of the best subset method was carried out to develop new algorithms for mapping the soil minerals composition. As a result, soil minerals composition mapping can be formulated: (1) total clay minerals = 0,658 – 32,09B1 + 49,3B2 + 20,01B3 + 4,45B4 + 4,09B6-7,73B7, (2) smectite = 0,611 – 35,66B1 + 50,5B2 – 13,46B3 + 5,29B6 – 9,00B7, (3) kaolinite = 0,068 + 4,26B2 -9,17B3 + 6,88B4 – 1,852B5, and (4) hematite = 0,033 – 1,25B1 + 2,7B2 – 3,514B3 + 2,514B4 – 0,581B5, with: B1, B2, B3, B4, B5, B6 and B7 are channels on Landsat 8 OLI.

Analysis of the geobiochemical models on the West Tugu Field can be explained as follows: (1) vegetation model shows that the border of the oil and gas field is more disturbed by the presence of microseepage compared to the middle, characterized by the low values of the vegetation index, the rare density of clumps and stunted growth. (2) Clay mineral model shows the total clay minerals and smectite is lower at the border than in the middle of the oil and gas field, and the kaolinite concentration is higher at the border than in the middle of the oil and gas field. (3) The ferric iron oxide model shows a lower concentration at the border of the oil and gas field than in the middle. The pattern of ferrous iron oxide concentration is higher at the border of the oil and gas field than in the middle. (4) The magnetic susceptibility model shows heigh in the middle of the field and decreases at the border. (5) The radon model shows higher concentration pattern at the border of oil and gas field than in the middle.

Based on the subsurface data shows that at the border of the oil and gas field there are continuous faults in the east and south of the Upper Cibulakan formation to the Parigi Formation. This is thought to have triggered the development of microseepage, in addition to chimney factors, vapour migration and increased cracks at the border of the field due to rock incompatibility. The geobiochemical model of the oil and gas field is an indication of the presence of the oil and gas below it. It can be used to analyze the prospect prior to drilled to increase the geological chance factor regarding the existence of oil and gas trapped in the prospect. The hope is that geobiochemical model analysis of prospects can increase the success ratio of exploration drilling in Indonesia.

Keywords: exploration, oil and gas, macroseepage, microseepage, clay mineral, geobotany, iron oxide, magnetic susceptibility and radon.