

Table 4. Major oxide (%) and trace elements concentration for the samples of Abakaliki Shale.

| Sample No | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | Average | PAAS |
|--------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|
| Depth (m) | 11.5 | 79 | 83.6 | 92.6 | 98.6 | 111.6 | 128.6 | 137.6 | 146 | 157.6 | 159.6 | 161.6 | - | - |
| SiO ₂ | 47.02 | 48.45 | 47.09 | 45.19 | 46.78 | 48.02 | 46.15 | 45.61 | 44.25 | 45.09 | 44.89 | 45.76 | 46.19 | 62.40 |
| Al ₂ O ₃ | 23.04 | 15.85 | 19.40 | 20.87 | 20.04 | 21.33 | 21.59 | 21.77 | 20.76 | 21.72 | 21.00 | 21.78 | 20.76 | 18.78 |
| Fe ₂ O ₃ | 8.21 | 6.56 | 7.26 | 9.15 | 8.61 | 8.64 | 8.67 | 9.32 | 9.36 | 7.21 | 8.54 | 9.07 | 8.38 | 7.18 |
| MgO | 1.19 | 2.19 | 1.97 | 2.12 | 1.74 | 1.94 | 2.12 | 1.79 | 2.02 | 1.77 | 1.96 | 2.14 | 1.91 | 2.19 |
| CaO | 0.34 | 14.62 | 6.35 | 0.20 | 0.24 | 0.15 | 0.21 | 0.90 | 1.45 | 1.92 | 0.74 | 1.39 | 2.38 | 1.29 |
| Na ₂ O | 1.29 | 1.03 | 1.19 | 1.23 | 1.38 | 1.36 | 1.34 | 1.37 | 1.34 | 0.97 | 0.94 | 0.90 | 1.20 | 1.19 |
| K ₂ O | 2.40 | 1.84 | 2.78 | 2.87 | 2.36 | 2.84 | 2.95 | 3.78 | 3.56 | 3.96 | 3.77 | 3.70 | 3.07 | 3.68 |
| TiO ₂ | 0.99 | 0.76 | 0.99 | 1.00 | 0.92 | 0.95 | 1.04 | 0.96 | 0.97 | 0.99 | 0.97 | 0.92 | 0.96 | 0.99 |
| P ₂ O ₅ | 0.08 | 0.20 | 0.12 | 0.08 | 0.11 | 0.05 | 0.07 | 0.12 | 0.24 | 0.22 | 0.19 | 0.10 | 0.13 | 0.16 |
| MnO | 0.03 | 0.10 | 0.07 | 0.03 | 0.03 | 0.03 | 0.03 | 0.05 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.11 |
| LOI | 15.41 | 8.39 | 12.76 | 17.25 | 17.77 | 14.67 | 15.82 | 14.21 | 15.98 | 16.09 | 16.93 | 14.18 | 14.96 | - |
| Total | 100.00 | 99.99 | 99.98 | 99.99 | 99.98 | 99.98 | 99.99 | 99.88 | 99.99 | 99.99 | 99.98 | 99.99 | 99.98 | |
| Sc | 21.20 | 11.30 | 14.20 | 19.70 | 18.40 | 17.70 | 19.10 | 19.50 | 19.00 | 18.90 | 18.80 | 19.20 | 18.08 | 16.00 |
| V | 132.00 | 87.00 | 114.00 | 125.00 | 134.00 | 122.00 | 125.00 | 130.00 | 127.00 | 150.00 | 129.00 | 136.00 | 125.92 | 150.00 |
| Co | 26.90 | 20.50 | 33.00 | 35.60 | 31.90 | 15.40 | 14.60 | 21.10 | 22.50 | 23.50 | 16.30 | 24.80 | 23.84 | 23.00 |
| Cr | 95.80 | 61.60 | 88.90 | 102.60 | 95.80 | 88.90 | 88.90 | 136.80 | 68.40 | 123.20 | 95.80 | 109.50 | 96.35 | 110.00 |
| Ni | 43.60 | 37.30 | 41.10 | 58.10 | 58.20 | 49.80 | 49.70 | 52.30 | 48.70 | 56.40 | 45.30 | 60.40 | 50.08 | 50.00 |
| Cu | 28.06 | 23.17 | 21.61 | 27.86 | 41.41 | 28.95 | 33.37 | 31.30 | 37.60 | 44.96 | 37.21 | 38.27 | 32.81 | 85.00 |
| Zn | 126.90 | 103.80 | 98.40 | 119.60 | 221.50 | 105.50 | 178.40 | 98.70 | 104.50 | 105.80 | 94.80 | 102.20 | 121.68 | 85.00 |
| Y | 19.70 | 17.40 | 14.30 | 18.70 | 21.10 | 14.90 | 18.60 | 16.90 | 14.20 | 14.90 | 19.30 | 15.80 | 17.15 | 27.00 |
| Zr | 40.50 | 38.50 | 44.20 | 39.90 | 42.80 | 39.20 | 39.40 | 39.80 | 38.80 | 40.30 | 36.90 | 33.90 | 39.52 | 210.00 |
| Nb | 18.79 | 16.42 | 19.34 | 19.45 | 16.49 | 19.52 | 20.49 | 18.62 | 19.76 | 19.90 | 18.62 | 17.50 | 18.74 | 1.90 |
| Hf | 1.23 | 1.18 | 1.45 | 1.22 | 1.32 | 1.27 | 1.21 | 1.23 | 1.26 | 1.33 | 1.23 | 1.09 | 1.25 | 5.00 |
| Rb | 158.80 | 117.40 | 164.70 | 160.80 | 146.20 | 160.40 | 172.90 | 162.10 | 197.40 | 213.30 | 194.20 | 191.90 | 170.01 | 160.00 |
| Sr | 262.00 | 367.00 | 329.00 | 248.00 | 285.00 | 276.00 | 280.00 | 265.00 | 235.00 | 233.00 | 237.00 | 209.00 | 268.83 | 200.00 |
| Ba | 380.00 | 380.00 | 514.00 | 455.00 | 442.00 | 438.00 | 490.00 | 454.00 | 684.00 | 673.00 | 644.00 | 704.00 | 521.50 | 650.00 |
| Pb | 16.19 | 29.42 | 47.34 | 29.53 | 33.45 | 13.86 | 14.99 | 16.80 | 25.43 | 22.79 | 25.13 | 30.21 | 25.43 | 20.00 |
| Th | 29.20 | 17.60 | 22.50 | 26.10 | 19.50 | 21.60 | 27.80 | 25.90 | 26.80 | 24.10 | 25.90 | 23.60 | 24.22 | 14.60 |
| U | 2.60 | 2.20 | 2.60 | 2.50 | 3.00 | 2.50 | 2.50 | 2.50 | 2.60 | 2.60 | 2.80 | 2.70 | 2.59 | 3.10 |
| Ga | 33.55 | 23.65 | 29.25 | 30.72 | 29.91 | 32.85 | 34.05 | 31.78 | 32.64 | 34.44 | 32.54 | 31.66 | 31.42 | 20.00 |
| CIA | 81.66 | 74.63 | 73.71 | 79.65 | 79.86 | 79.47 | 79.25 | 73.70 | 71.53 | 74.40 | 76.02 | 75.77 | 76.64 | 69.00 |
| PIA | 88.80 | 80.33 | 80.75 | 88.85 | 87.50 | 88.24 | 88.21 | 82.79 | 79.32 | 84.55 | 86.93 | 85.71 | 85.17 | 77.00 |
| ICV | 0.63 | 1.71 | 1.06 | 0.80 | 0.76 | 0.75 | 0.76 | 0.83 | 0.90 | 0.78 | 0.81 | 0.83 | 0.88 | 0.91 |
| Si/Al | 2.04 | 3.06 | 2.43 | 2.17 | 2.33 | 2.25 | 2.14 | 2.10 | 2.13 | 2.08 | 2.14 | 2.10 | 2.22 | 3.32 |
| Al/Ti | 23.27 | 20.86 | 19.60 | 20.87 | 21.78 | 22.45 | 20.76 | 22.68 | 21.40 | 21.94 | 21.65 | 23.67 | 21.74 | 18.97 |
| K/Na | 1.23 | 1.18 | 1.54 | 1.54 | 1.13 | 1.37 | 1.45 | 1.82 | 1.75 | 2.70 | 2.65 | 2.70 | 1.76 | 2.03 |
| K/Rb | 125.36 | 130.37 | 140.30 | 148.06 | 134.11 | 147.18 | 141.75 | 193.58 | 149.71 | 154.30 | 161.23 | 160.03 | 148.83 | 192.00 |
| Rb/Sr | 0.61 | 0.32 | 0.50 | 0.65 | 0.51 | 0.58 | 0.62 | 0.61 | 0.84 | 0.92 | 0.82 | 0.92 | 0.66 | 0.80 |
| Th/Sc | 1.38 | 1.56 | 1.58 | 1.32 | 1.06 | 1.22 | 1.46 | 1.33 | 1.41 | 1.28 | 1.38 | 1.23 | 1.35 | 0.91 |
| Zr/Sc | 1.91 | 3.41 | 3.11 | 2.03 | 2.33 | 2.21 | 2.06 | 2.04 | 2.04 | 2.13 | 1.96 | 1.77 | 2.25 | 13.13 |
| Th/Co | 1.09 | 0.86 | 0.68 | 0.73 | 0.61 | 1.40 | 1.90 | 1.23 | 1.19 | 1.03 | 1.59 | 0.95 | 1.11 | 0.63 |
| Th/Cr | 0.30 | 0.29 | 0.25 | 0.25 | 0.20 | 0.24 | 0.31 | 0.19 | 0.39 | 0.20 | 0.27 | 0.22 | 0.26 | 0.13 |
| Th/U | 11.23 | 8.00 | 8.65 | 10.44 | 6.50 | 8.64 | 11.12 | 10.36 | 10.31 | 9.27 | 9.25 | 8.74 | 9.38 | 4.71 |
| Sr/Ba | 0.69 | 0.97 | 0.64 | 0.55 | 0.64 | 0.63 | 0.57 | 0.58 | 0.34 | 0.35 | 0.37 | 0.30 | 0.55 | 0.31 |

CIA: Chemical Index of Alteration (after Nesbitt & Young, 1982); PIA: Plagioclase Index of Alteration (after Fedo et al., 1995); ICV: Index of Compositional Variability (after Cox et al., 1995).

Table 5. Rare earth elements concentration (ppm) for the samples of Abakaliki Shale.

| Sample No | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | Average | PAAS |
|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|
| Depth (m) | 11.5 | 79 | 83.6 | 92.6 | 98.6 | 111.6 | 128.6 | 137.6 | 146 | 157.6 | 159.6 | 161.6 | - | - |
| La | 89.70 | 34.20 | 38.70 | 39.60 | 38.10 | 33.40 | 58.40 | 38.60 | 51.20 | 54.70 | 38.60 | 32.80 | 45.67 | 38.20 |
| Ce | 158.35 | 63.60 | 69.87 | 76.26 | 66.35 | 57.77 | 105.32 | 110.40 | 96.70 | 98.62 | 75.37 | 59.16 | 86.48 | 79.60 |
| Pr | 18.10 | 7.50 | 8.50 | 9.00 | 8.50 | 6.60 | 12.00 | 11.80 | 11.60 | 11.30 | 9.20 | 6.80 | 10.08 | 8.83 |
| Nd | 62.60 | 27.30 | 28.70 | 33.40 | 29.50 | 22.60 | 39.70 | 38.80 | 34.50 | 37.50 | 34.90 | 25.00 | 34.54 | 33.90 |
| Sm | 10.00 | 5.70 | 5.40 | 6.10 | 6.20 | 3.50 | 6.20 | 6.10 | 6.50 | 7.10 | 6.90 | 5.40 | 6.26 | 5.55 |
| Eu | 1.30 | 1.40 | 1.10 | 1.00 | 1.20 | 0.70 | 1.00 | 1.20 | 1.30 | 1.40 | 1.40 | 1.00 | 1.17 | 1.08 |
| Gd | 5.00 | 4.40 | 4.00 | 4.30 | 5.20 | 2.90 | 3.30 | 4.80 | 5.10 | 4.90 | 5.40 | 4.00 | 4.44 | 4.66 |
| Tb | 0.80 | 0.60 | 0.50 | 0.60 | 0.80 | 0.50 | 0.60 | 0.80 | 0.50 | 0.70 | 0.80 | 0.50 | 0.64 | 0.77 |
| Dy | 3.40 | 3.30 | 3.20 | 3.20 | 4.40 | 2.80 | 3.60 | 3.50 | 3.80 | 3.50 | 3.80 | 3.00 | 3.46 | 4.68 |
| Ho | 0.70 | 0.70 | 0.60 | 0.60 | 0.80 | 0.60 | 0.70 | 0.50 | 0.60 | 0.50 | 0.70 | 0.60 | 0.63 | 0.99 |
| Er | 1.80 | 1.60 | 1.50 | 1.80 | 1.90 | 1.50 | 1.80 | 1.70 | 1.60 | 1.40 | 1.80 | 1.40 | 1.65 | 2.85 |
| Tm | 0.30 | 0.20 | 0.30 | 0.20 | 0.30 | 0.20 | 0.30 | 0.30 | 0.30 | 0.20 | 0.30 | 0.20 | 0.26 | 0.41 |
| Yb | 1.80 | 1.40 | 1.60 | 1.50 | 1.70 | 1.40 | 1.60 | 1.50 | 1.30 | 1.40 | 1.40 | 1.30 | 1.49 | 2.82 |
| Lu | 0.30 | 0.20 | 0.20 | 0.20 | 0.30 | 0.20 | 0.20 | 0.30 | 0.20 | 0.20 | 0.20 | 0.20 | 0.23 | 0.43 |
| ΣREE | 354.15 | 152.10 | 164.17 | 177.76 | 165.25 | 134.67 | 234.72 | 220.30 | 215.20 | 223.42 | 180.77 | 141.36 | 196.99 | 184.77 |
| Eu/Eu* | 0.56 | 0.85 | 0.72 | 0.60 | 0.65 | 0.67 | 0.68 | 0.68 | 0.69 | 0.73 | 0.70 | 0.66 | 0.68 | 0.63 |
| (La/Yb) _N | 35.75 | 17.52 | 17.35 | 18.94 | 16.08 | 17.11 | 26.18 | 18.46 | 28.25 | 28.03 | 19.78 | 18.10 | 21.80 | 9.15 |
| (La/Sm) _N | 5.79 | 3.87 | 4.63 | 4.19 | 3.97 | 6.16 | 6.08 | 4.09 | 5.09 | 4.97 | 3.61 | 3.92 | 4.70 | 4.33 |
| (Gd/Yb) _N | 2.30 | 2.60 | 2.07 | 2.37 | 2.53 | 1.71 | 1.71 | 2.65 | 3.25 | 2.90 | 3.19 | 2.55 | 2.49 | 1.34 |

N: Chondrite normalized value; Europium anomaly is calculated as: $Eu/Eu^* = EuN / (SmN \times GdN)^{1/2}$