Table 1 Test results of the NB algorithm.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Real |  | Classification | | | |  | Percent success |
|  | IAG | OIG | MORG | Total |  |
| IAG |  | 32 | 3 | 4 | 39 |  | 82.05% |
| OIG |  | 19 | 71 | 12 | 102 |  | 69.61% |
| MORG |  | 2 | 3 | 44 | 49 |  | 89.80% |
| total |  | 53 | 77 | 60 | 190 |  | 77.37% |

Table 2 Classification percent success and prediction percent success of the NB algorithm

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Real |  | Classification | | |  | Prediction | | |  |
|  | IAG | OIG | MORG |  | IAG | OIG | MORG |  |
| IAG |  | 82.05% | 7.69% | 10.26% |  | 60.38% | 3.90% | 6.67% |  |
| OIG |  | 18.63% | 69.61% | 11.76% |  | 35.85% | 92.21% | 20.00% |  |
| MORG |  | 4.08% | 6.12% | 89.80% |  | 3.77% | 3.90% | 73.33% |  |

Table 3 Distribution of the elements of IAG (1). The unit of major elements are wt%, and the unit of trace elements are ppm. See text for the meanings of D, P1, P2, p0, and Min.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SiO2 | TiO2 | Al2O3 | FeOT | CaO | MgO | MnO | K2O |
| D | N | G | N | N | N | L | G | G |
| P1 | 48.398 | 2.224 | 17.829 | 8.738 | 11.486 | 2.005 | 10.173 | 0.842 |
| P2 | 3.680 | 0.367 | 3.954 | 2.487 | 2.801 | 0.467 | 0.016 | 0.640 |
| *p0* | 0.000 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.013 |
| *Min* | 38.80 | 0.05 | 0.129 | 0.06 | 3.95 | 0.162 | 0.05 | 0.01 |

Table 4 Distribution of the elements of IAG (2). The unit of major elements are wt%, and the unit of trace elements are ppm. See text for the meanings of D, P1, P2, p0, and Min.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Na2O | P2O5 | Ni | Sr | Y | Zr | Ba |
| D | N | L | L | G | G | G | G |
| P1 | 2.185 | -2.559 | 3.810 | 1.694 | 2.558 | 1.104 | 1.040 |
| P2 | 1.121 | 1.173 | 1.106 | 223.184 | 6.097 | 41.041 | 150.859 |
| *p0* | 0.005 | 0.091 | 0.284 | 0.068 | 0.294 | 0.354 | 0.291 |
| *Min* | 0.02 | 0.000 | 1.00 | 4.80 | 1.48 | 0.90 | 0.71 |

Table 5 Distribution of the elements of OIG (1). The unit of major elements are wt%, and the unit of trace elements are ppm. See text for the meanings of D, P1, P2, p0, and Min.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SiO2 | TiO2 | Al2O3 | FeOT | CaO | MgO | MnO | K2O |
| D | N | G | N | N | N | L | N | G |
| P1 | 46.802 | 1.362 | 15.227 | 9.834 | 12.271 | 2.052 | 0.153 | 0.798 |
| P2 | 3.384 | 1.558 | 4.294 | 3.642 | 2.850 | 0.585 | 0.049 | 0.771 |
| *p0* | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.047 | 0.025 |
| *Min* | 35.150 | 0.030 | 3.860 | 1.210 | 3.130 | 1.490 | 0.030 | 0.010 |

Table 6 Distribution of the elements of OIG (2). The unit of major elements are wt%, and the unit of trace elements are ppm. See text for the meanings of D, P1, P2, p0, and Min.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Na2O | P2O5 | Ni | Sr | Y | Zr | Ba |
| D | L | L | G | G | G | G | L |
| P1 | 3.359 | -2.099 | 0.929 | 2.158 | 2.074 | 1.032 | 0.984 |
| P2 | 0.659 | 1.427 | 209.269 | 209.871 | 9.322 | 110.257 | 178.511 |
| *p0* | 0 | 0.036 | 0.103 | 0.031 | 0.107 | 0.045 | 0.129 |
| *Min* | 0.09 | 0.010 | 1.000 | 13.400 | 0.970 | 0.990 | 3.090 |

Table 7 Distribution of the elements of MORG (1). The unit of major elements are wt%, and the unit of trace elements are ppm. See text for the meanings of D, P1, P2, p0, and Min.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | SiO2 | TiO2 | Al2O3 | FeOT | CaO | MgO | MnO | K2O |
| D | N | L | N | L | N | G | L | L |
| P1 | 49.667 | -0.664 | 16.426 | 1.858 | 12.057 | 9.192 | -2.041 | -2.974 |
| P2 | 2.575 | 0.887 | 3.085 | 0.326 | 1.871 | 1.028 | 0.384 | 0.806 |
| *p0* | 0.000 | 0.000 | 0.000 | 0.271 | 0.000 | 0.000 | 0.000 | 0.098 |
| *Min* | 37.570 | 0.050 | 3.700 | 1.944 | 4.840 | 1.670 | 0.010 | 0.010 |

Table 8 Distribution of the elements of MORG (2). The unit of major elements are wt%, and the unit of trace elements are ppm. See text for the meanings of D, P1, P2, p0, and Min.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Na2O | P2O5 | Ni | Sr | Y | Zr | Ba |
| D | N | L | L | N | L | L | G |
| P1 | 2.732 | -3.370 | 4.685 | 149.200 | 2.553 | 3.226 | 2.310 |
| P2 | 0.789 | 1.079 | 0.775 | 35.182 | 0.746 | 0.847 | 5.168 |
| *p0* | 0.002 | 0.109 | 0.045 | 0.019 | 0.032 | 0.039 | 0.143 |
| *Min* | 0.080 | 0.010 | 2.000 | 7.170 | 0.448 | 0.607 | 0.900 |

Table 9 Results of the mathematical model.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Real |  | Classification | | | |  | Percent success |
|  | IAG | OIG | MORG | Total |  |
| IAG |  | 333 | 51 | 11 | 395 |  | 84.03% |
| OIG |  | 27 | 929 | 17 | 973 |  | 95.48% |
| MORG |  | 23 | 21 | 495 | 539 |  | 91.84% |
| total |  | 383 | 1001 | 523 | 190 |  | 92.13% |

Table 10 Classification percent success and prediction percent success of the mathematical model. The calculation of this table is the same as Table 2

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Real |  | Classification | | |  | Prediction | | |  |
|  | IAG | OIG | MORG |  | IAG | OIG | MORG |  |
| IAG |  | 84.30% | 12.91% | 2.78% |  | 86.95% | 5.09% | 2.10% |  |
| OIG |  | 2.77% | 95.48% | 1.75% |  | 7.05% | 92.81% | 3.25% |  |
| MORG |  | 4.27% | 3.90% | 91.84% |  | 6.01% | 2.10% | 94.65% |  |

**Appendix A. Matrixes of Σ of The Established Copula Function**

Table A.1 Matrix of Σ*ia* of the copula function established by IAG samples

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TiO2 | Al2O3 | FeOT | CaO | MnO | K2O | Na2O | Ni | Sr |
| TiO2 | 1.000 | -0.049 | 0.536 | -0.317 | 0.425 | 0.482 | 0.544 | -0.187 | 0.205 |
| Al2O3 | -0.049 | 1.000 | -0.248 | 0.250 | -0.413 | 0.020 | -0.007 | -0.175 | 0.362 |
| FeOT | 0.536 | -0.248 | 1.000 | -0.098 | 0.581 | 0.055 | 0.077 | -0.076 | 0.034 |
| CaO | -0.317 | 0.250 | -0.098 | 1.000 | -0.225 | -0.545 | -0.642 | 0.154 | -0.122 |
| MnO | 0.425 | -0.413 | 0.581 | -0.225 | 1.000 | 0.097 | 0.161 | -0.035 | -0.132 |
| K2O | 0.482 | 0.020 | 0.055 | -0.545 | 0.097 | 1.000 | 0.646 | -0.193 | 0.425 |
| Na2O | 0.544 | -0.007 | 0.077 | -0.642 | 0.161 | 0.646 | 1.000 | -0.106 | 0.281 |
| Ni | -0.187 | -0.175 | -0.076 | 0.154 | -0.035 | -0.193 | -0.106 | 1.000 | -0.246 |
| Sr | 0.205 | 0.362 | 0.034 | -0.122 | -0.132 | 0.425 | 0.281 | -0.246 | 1.000 |

Table A.2 Matrix of Σ*oi* of the copula function established by OIG samples

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TiO2 | Al2O3 | FeOT | CaO | MnO | K2O | Na2O | Ni | Sr |
| TiO2 | 1.000 | -0.215 | 0.763 | -0.424 | 0.360 | 0.635 | 0.496 | -0.517 | 0.547 |
| Al2O3 | -0.215 | 1.000 | -0.548 | 0.194 | -0.463 | 0.045 | 0.399 | -0.411 | 0.149 |
| FeOT | 0.763 | -0.548 | 1.000 | -0.474 | 0.590 | 0.314 | 0.103 | -0.145 | 0.222 |
| CaO | -0.424 | 0.194 | -0.474 | 1.000 | -0.446 | -0.613 | -0.486 | 0.149 | -0.218 |
| MnO | 0.360 | -0.463 | 0.590 | -0.446 | 1.000 | 0.239 | 0.119 | 0.034 | 0.064 |
| K2O | 0.635 | 0.045 | 0.314 | -0.613 | 0.239 | 1.000 | 0.794 | -0.602 | 0.554 |
| Na2O | 0.496 | 0.399 | 0.103 | -0.486 | 0.119 | 0.794 | 1.000 | -0.706 | 0.497 |
| Ni | -0.517 | -0.411 | -0.145 | 0.149 | 0.034 | -0.602 | -0.706 | 1.000 | -0.404 |
| Sr | 0.547 | 0.149 | 0.222 | -0.218 | 0.064 | 0.554 | 0.497 | -0.404 | 1.000 |

Table A.3 Matrix of Σ*mor* of the copula function established by MORG samples

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | TiO2 | Al2O3 | FeOT | CaO | MnO | K2O | Na2O | Ni | Sr |
| TiO2 | 1.000 | -0.537 | 0.114 | -0.383 | 0.765 | 0.329 | 0.446 | -0.528 | 0.052 |
| Al2O3 | -0.537 | 1.000 | -0.221 | 0.095 | -0.753 | 0.003 | 0.128 | 0.302 | 0.433 |
| FeOT | 0.114 | -0.221 | 1.000 | -0.181 | 0.175 | -0.075 | -0.018 | -0.094 | -0.250 |
| CaO | -0.383 | 0.095 | -0.181 | 1.000 | -0.361 | -0.312 | -0.353 | 0.105 | -0.136 |
| MnO | 0.765 | -0.753 | 0.175 | -0.361 | 1.000 | 0.189 | 0.201 | -0.393 | -0.130 |
| K2O | 0.329 | 0.003 | -0.075 | -0.312 | 0.189 | 1.000 | 0.342 | -0.217 | 0.236 |
| Na2O | 0.446 | 0.128 | -0.018 | -0.353 | 0.201 | 0.342 | 1.000 | -0.520 | 0.674 |
| Ni | -0.528 | 0.302 | -0.094 | 0.105 | -0.393 | -0.217 | -0.520 | 1.000 | -0.155 |
| Sr | 0.052 | 0.433 | -0.250 | -0.136 | -0.130 | 0.236 | 0.674 | -0.155 | 1.000 |