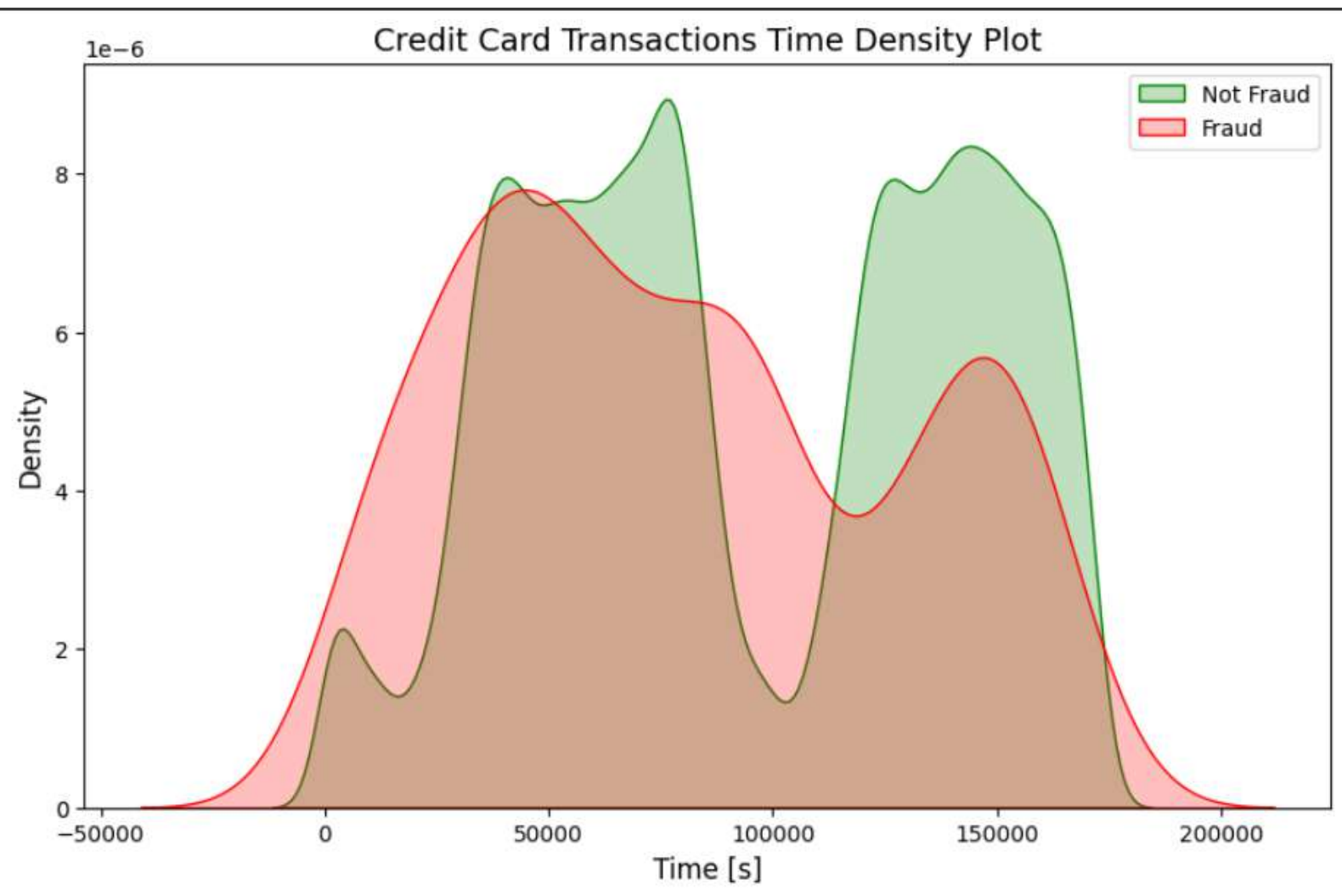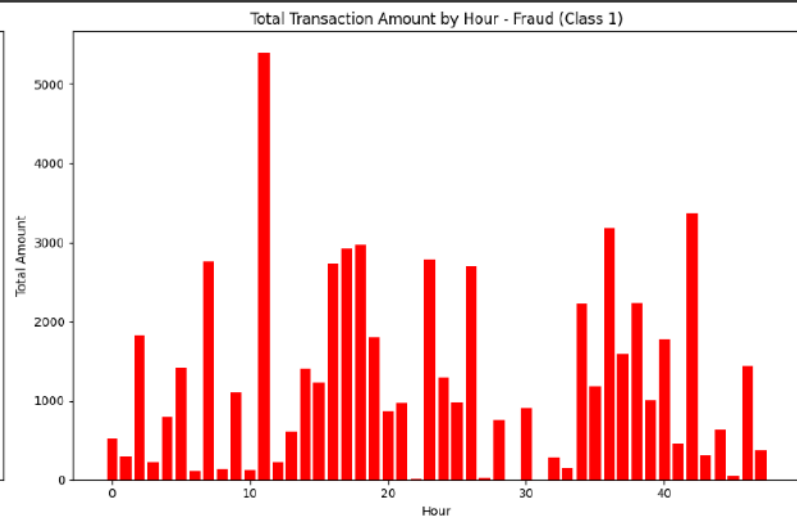Credit Card Fraud Class - Data Imbalance (0=Not Fraud, 1=Fraud)

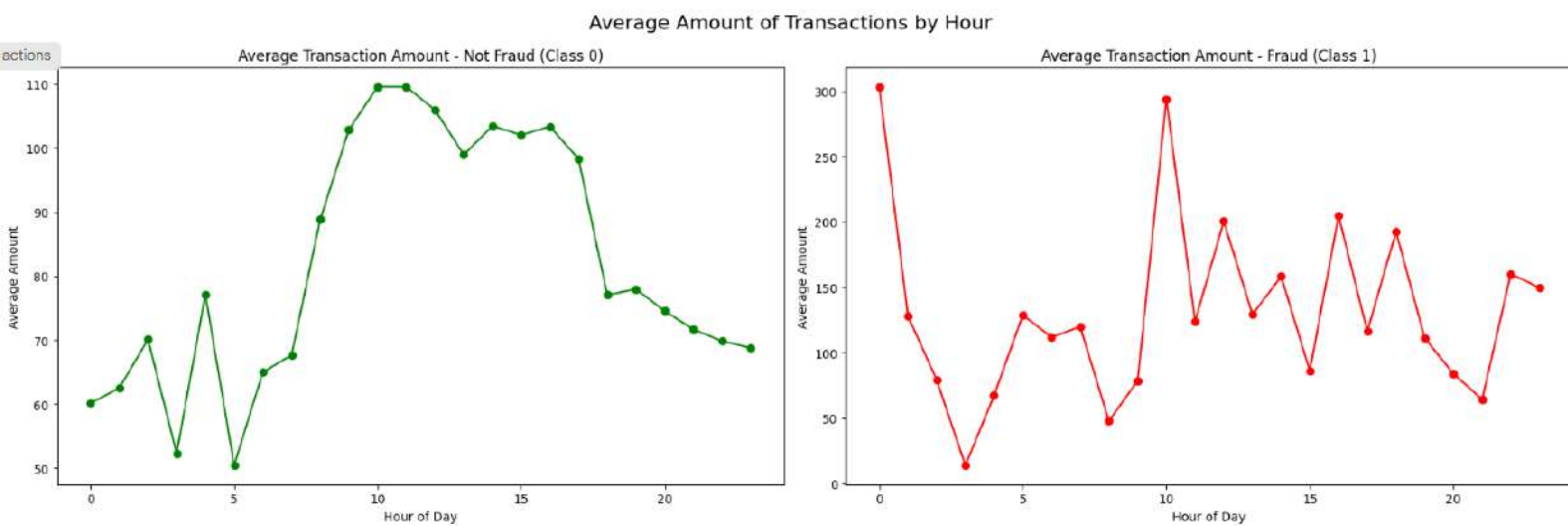Credit Card Transactions Time Density Plot

| | Hour | Class | Min | Max | Count | Sum | Mean | Median | Var |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 0 | 0.00 | 7712.43 | 3961 | 256572.87 | 64.774772 | 12.990 | 45615.821201 |
| 1 | 0.0 | 1 | 0.00 | 529.00 | 2 | 529.00 | 264.500000 | 264.500 | 139920.500000 |
| 2 | 1.0 | 0 | 0.00 | 1769.69 | 2215 | 145806.76 | 65.826980 | 22.820 | 20053.615770 |
| 3 | 1.0 | 1 | 59.00 | 239.93 | 2 | 298.93 | 149.465000 | 149.465 | 16367.832450 |
| 4 | 2.0 | 0 | 0.00 | 4002.88 | 1555 | 106989.39 | 68.803466 | 17.900 | 45355.430437 |
| 5 | 2.0 | 1 | 1.00 | 1809.68 | 21 | 1829.78 | 87.132381 | 1.000 | 155776.441219 |
| 6 | 3.0 | 0 | 0.00 | 1903.26 | 1808 | 94086.79 | 52.039154 | 15.950 | 16741.786661 |
| 7 | 3.0 | 1 | 0.00 | 179.66 | 13 | 220.05 | 16.926923 | 1.000 | 2457.208190 |
| 8 | 4.0 | 0 | 0.00 | 2126.13 | 1076 | 79050.36 | 73.466877 | 15.950 | 24416.863654 |
| 9 | 4.0 | 1 | 1.00 | 766.36 | 6 | 790.26 | 131.710000 | 3.860 | 96679.482040 |
| 10 | 5.0 | 0 | 0.00 | 1912.89 | 1670 | 75709.25 | 45.334880 | 11.850 | 15318.242592 |
| 11 | 5.0 | 1 | 1.00 | 1218.89 | 11 | 1416.67 | 128.788182 | 1.000 | 133888.936696 |
| 12 | 6.0 | 0 | 0.00 | 1986.92 | 1828 | 142299.38 | 77.844300 | 15.955 | 33492.739825 |
| 13 | 6.0 | 1 | 1.00 | 99.99 | 3 | 104.11 | 34.703333 | 3.120 | 3197.885233 |
| 14 | 7.0 | 0 | 0.00 | 6130.21 | 3345 | 270548.20 | 80.881375 | 21.950 | 53190.240240 |
| 15 | 7.0 | 1 | 3.76 | 730.86 | 23 | 2757.78 | 119.903478 | 99.990 | 18364.034296 |
| 16 | 8.0 | 0 | 0.00 | 7879.42 | 5174 | 469638.61 | 90.768962 | 27.860 | 66935.333965 |
| 17 | 8.0 | 1 | 0.68 | 104.81 | 5 | 137.15 | 27.430000 | 0.680 | 2035.647200 |
| 18 | 9.0 | 0 | 0.00 | 7429.15 | 7863 | 800360.93 | 101.788240 | 30.140 | 67488.645824 |
| 19 | 9.0 | 1 | 0.00 | 717.15 | 15 | 1110.79 | 74.052667 | 14.460 | 33239.610392 |

Total Transaction Amount by Hour - Not Fraud (Class 0)

Total Transaction Amount by Hour - Fraud (Class 1)

Proportion of Total Median Transaction Amount by Class

# Average Amount of Transactions by Hour



Average Transaction Amount - Not Fraud (Class 0)

Average Transaction Amount - Fraud (Class 1)
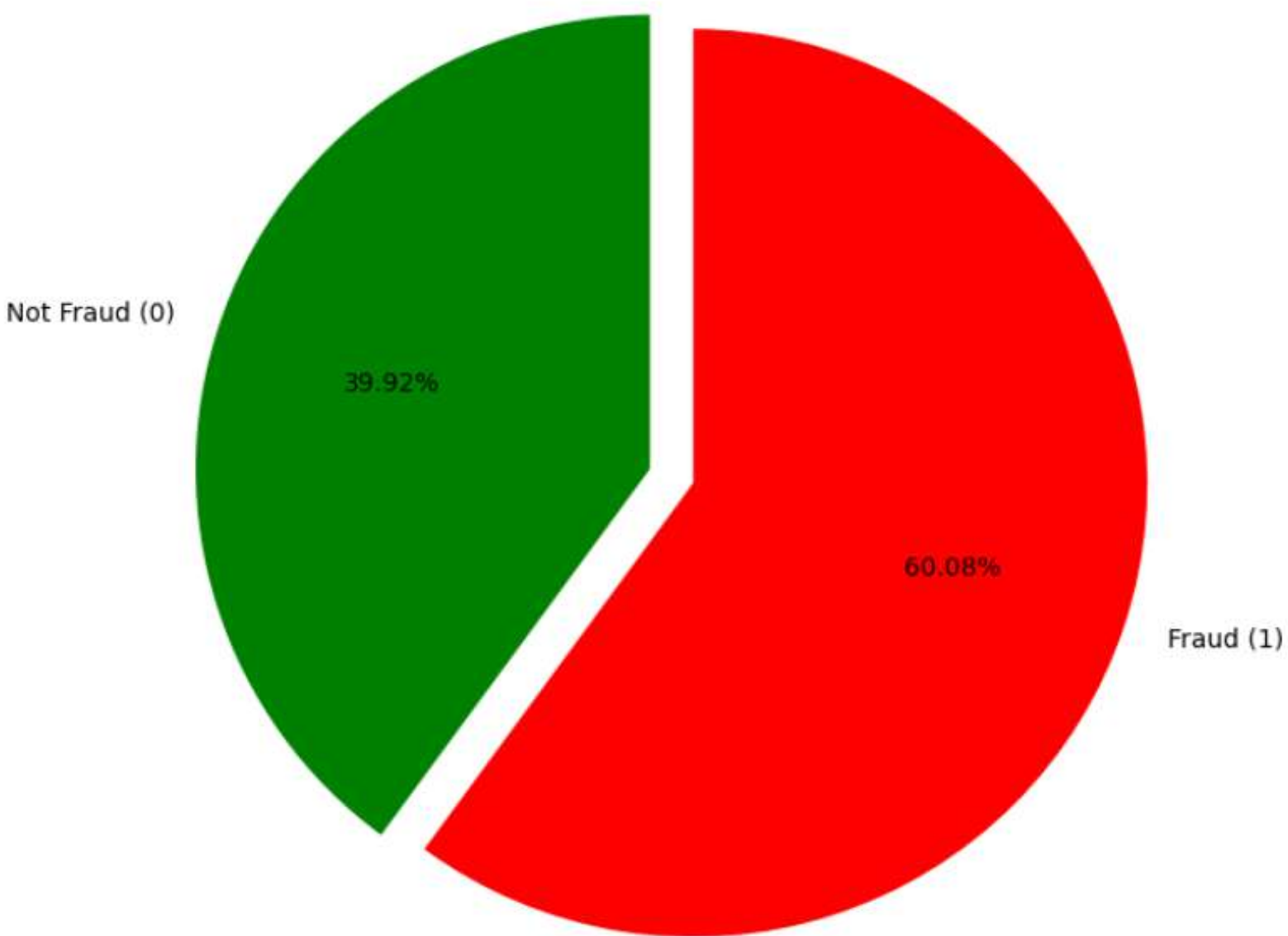
```
Descriptive Statistics - Class 0 (Not Fraud):
count      284315.000000
mean           88.291022
std           250.105092
min             0.000000
25%             5.650000
50%            22.000000
75%            77.050000
max         25691.160000
Name: Amount, dtype: float64

Descriptive Statistics - Class 1 (Fraud):
count         492.000000
mean          122.211321
std           256.683288
min             0.000000
25%             1.000000
50%             9.250000
75%           105.890000
max          2125.870000
Name: Amount, dtype: float64
```
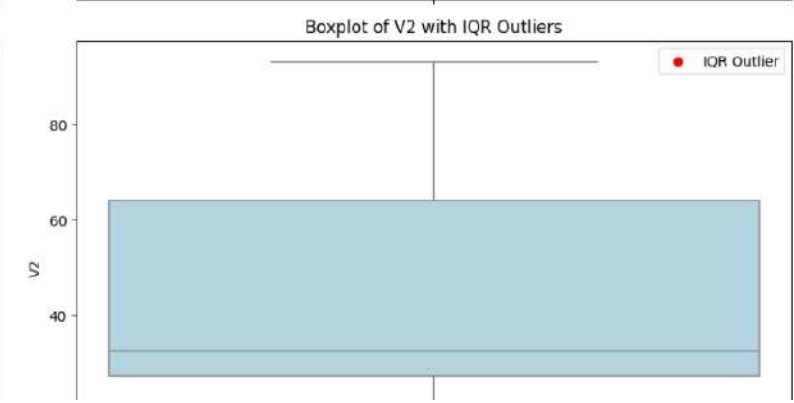
Boxplot of Time with IQR Outliers

Boxplot of Amount with IQR Outliers

Boxplot of V1 with IQR Outliers

Boxplot of V2 with IQR Outliers
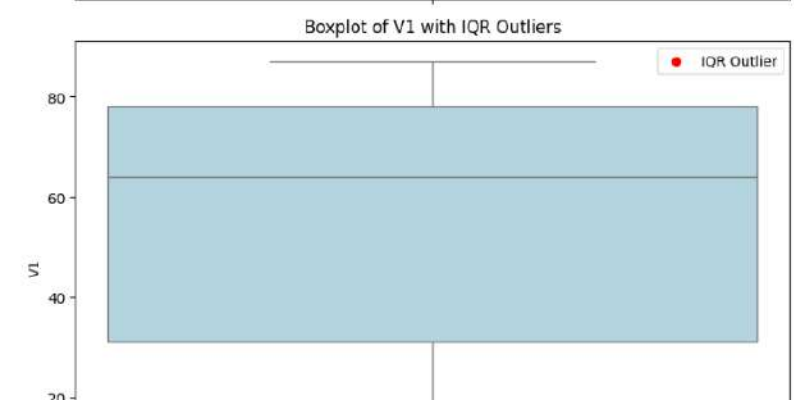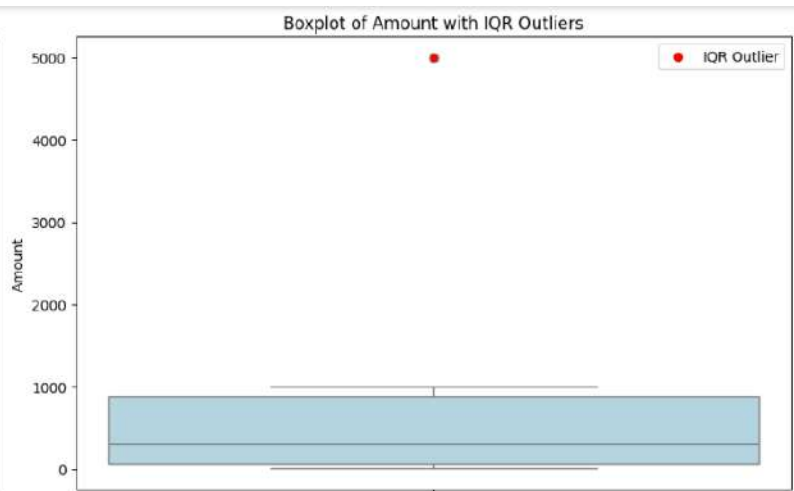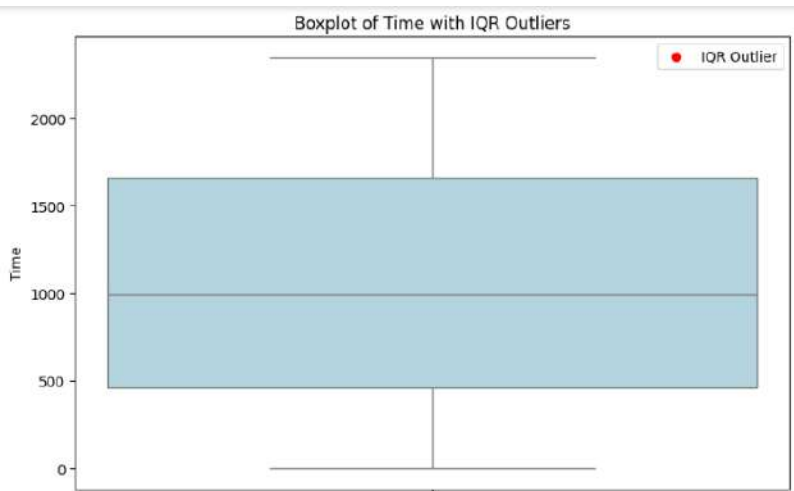
```
Feature: Amount
Q1: 62.5, Q3: 875.0
IQR: 812.5
Lower Bound: -1156.25, Upper Bound: 2093.75

Outliers detected:
   Time   Amount  V1  V2  V3  V4  V5  V6  V7  V8  V9  V10  V11  V12  V13  V14
5  2345     5000  21  34  54  66  43  78  97  89  70   68    3   73   11   51

   V15  V16  V17  V18  V19  V20  V21  V22  V23  V24  V25  V26  V27  V28  Hour
5   45   67   14   61   59   43    2   25   67   79   87   10   60   56     0

   Minute   Second  Part_of_day   Amount_log      V_mean       V_std  V_max  V_min
5      39        5        Night     8.517393   51.178571   27.149863     97      2
```

```
Normalized Data (first 5 rows):
       Time    Amount        V1       V2        V3        V4        V5  \
0  0.000000  0.000000  0.743902  1.00000  0.410714  0.000000  1.000000
1  0.153518  0.008016  0.695122  0.27907  0.000000  1.000000  0.119403
2  0.319829  0.018036  0.000000  0.22093  0.553571  0.516129  0.208955
3  0.524520  0.098196  0.939024  0.00000  0.357143  0.032258  0.477612
4  0.767591  0.198397  1.000000  0.77907  1.000000  0.064516  0.000000

         V6        V7        V8        V9       V10       V11       V12  \
0  0.058824  0.000000  0.322222  1.000000  0.572917  0.183908  0.376623
1  0.823529  0.476190  0.655556  0.824742  0.364583  0.896552  0.000000
2  0.000000  0.777778  0.000000  0.000000  0.791667  0.919540  0.935065
3  0.372549  0.428571  0.533333  0.103093  0.000000  0.287356  1.000000
4  0.196078  1.000000  1.000000  0.989691  1.000000  1.000000  0.597403

        V13       V14       V15       V16       V17       V18       V19  \
0  0.329545  0.000000  1.000000  0.017241  0.384615  0.980769  0.491525
1  0.363636  0.927711  0.533333  0.551724  1.000000  1.000000  0.254237
2  1.000000  1.000000  0.983333  0.000000  0.115385  0.326923  0.118644
3  0.636364  0.867470  0.616667  0.672414  0.000000  0.000000  0.983051
4  0.704545  0.108434  0.000000  1.000000  0.538462  0.942308  0.000000

        V20       V21       V22      V23       V24       V25       V26  \
0  0.633803  0.257732  1.000000  0.96875  0.117647  0.179487  0.352941
1  0.169014  0.773196  0.173077  0.87500  0.047059  0.730769  0.000000
2  1.000000  0.783505  0.538462  0.15625  0.317647  0.615385  0.691176
3  0.197183  0.154639  0.826923  1.00000  1.000000  0.064103  0.411765
4  0.000000  1.000000  0.134615  0.00000  0.000000  0.000000  1.000000

        V27       V28  Hour    Minute  Second  Amount_log    V_mean     V_std  \
0  0.500000  0.780488   0.0  0.000000     0.0    0.000000  0.239264  0.258381
1  0.250000  0.756098   0.0  0.153846     0.0    0.250663  0.404908  0.000000
2  1.000000  1.000000   0.0  0.307692     1.0    0.362321  0.570552  0.734541
3  0.821429  0.000000   0.0  0.512821     1.0    0.624024  0.000000  0.513640
4  0.000000  0.829268   0.0  0.769231     0.0    0.737129  1.000000  1.000000

      V_max     V_min
0  0.833333  0.333333
1  0.000000  1.000000
2  1.000000  0.333333
3  0.666667  0.333333
```

```
Standardized Data (first 5 rows):
        Time    Amount        V1        V2        V3        V4        V5  \
0 -1.334664 -0.620272  0.399289  1.648854 -0.099034 -0.803913  2.001810
1 -0.890119 -0.597717  0.268016 -0.444572 -1.465706  1.965121 -0.692641
2 -0.408529 -0.569523 -1.602625 -0.613396  0.376330  0.625266 -0.418629
3  0.184198 -0.343969  0.924381 -1.254930 -0.277296 -0.714590  0.403407
4  0.888061 -0.062027  1.088472  1.007320  1.861842 -0.625266 -1.057991

         V6        V7        V8        V9       V10       V11       V12  \
0 -0.924857 -1.729995 -0.735580  0.977071  0.010846 -0.907772 -0.657439
1  1.097727 -0.387757  0.210166  0.543761 -0.639907  0.869550 -1.768065
2 -1.080440  0.462326 -1.649801 -1.495343  0.694137  0.926883  0.989351
3 -0.095079 -0.521981 -0.136608 -1.240455 -1.778725 -0.649774  1.180838
4 -0.561829  1.088704  1.187436  0.951582  1.344890  1.127549 -0.006383

        V13       V14       V15       V16       V17       V18       V19  \
0 -0.553366 -1.477005  1.139099 -1.273631 -0.118958  0.768698  0.042927
1 -0.446263  0.867931 -0.257752  0.216277  1.784366  0.818830 -0.558055
2  1.552994  1.050653  1.089211 -1.321693 -0.951662 -0.935806 -0.901473
3  0.410562  0.715662 -0.008315  0.552708 -1.308535 -1.788058  1.287819
4  0.624768 -1.202922 -1.854153  1.465878  0.356873  0.668433 -1.201964

        V20       V21       V22       V23       V24       V25       V26  \
0  0.768005 -0.636438  1.489996  0.892060 -0.681335 -0.677401 -0.216642
1 -0.601950  0.747123 -0.732079  0.654763 -0.865756  0.803696 -1.256522
2  1.847364  0.774794  0.249768 -1.164512 -0.158807  0.493699  0.779910
3 -0.518922 -0.913150  1.024910  0.971159  1.623934 -0.987398 -0.043328
4 -1.100116  1.355890 -0.835431 -1.560006 -0.988704 -1.159618  1.689806

        V27       V28  Hour    Minute    Second  Amount_log    V_mean  \
0 -0.044705  0.169179   0.0 -1.321391 -0.792624   -1.502981 -0.702758
1 -0.795754  0.096674   0.0 -0.876811 -0.792624   -0.742946 -0.165745
2  1.457392  0.821726   0.0 -0.432231  1.402335   -0.404385  0.371268
3  0.920929 -2.150989   0.0  0.160543  1.402335    0.389122 -1.478443
4 -1.546802  0.314189   0.0  0.901509 -0.792624    0.732069  1.763524

      V_std     V_max     V_min
0 -0.622806  0.409616 -0.353553
1 -1.404831 -2.048080  1.767767
2  0.818356  0.901155 -0.353553
3  0.149771 -0.081923 -0.353553
```
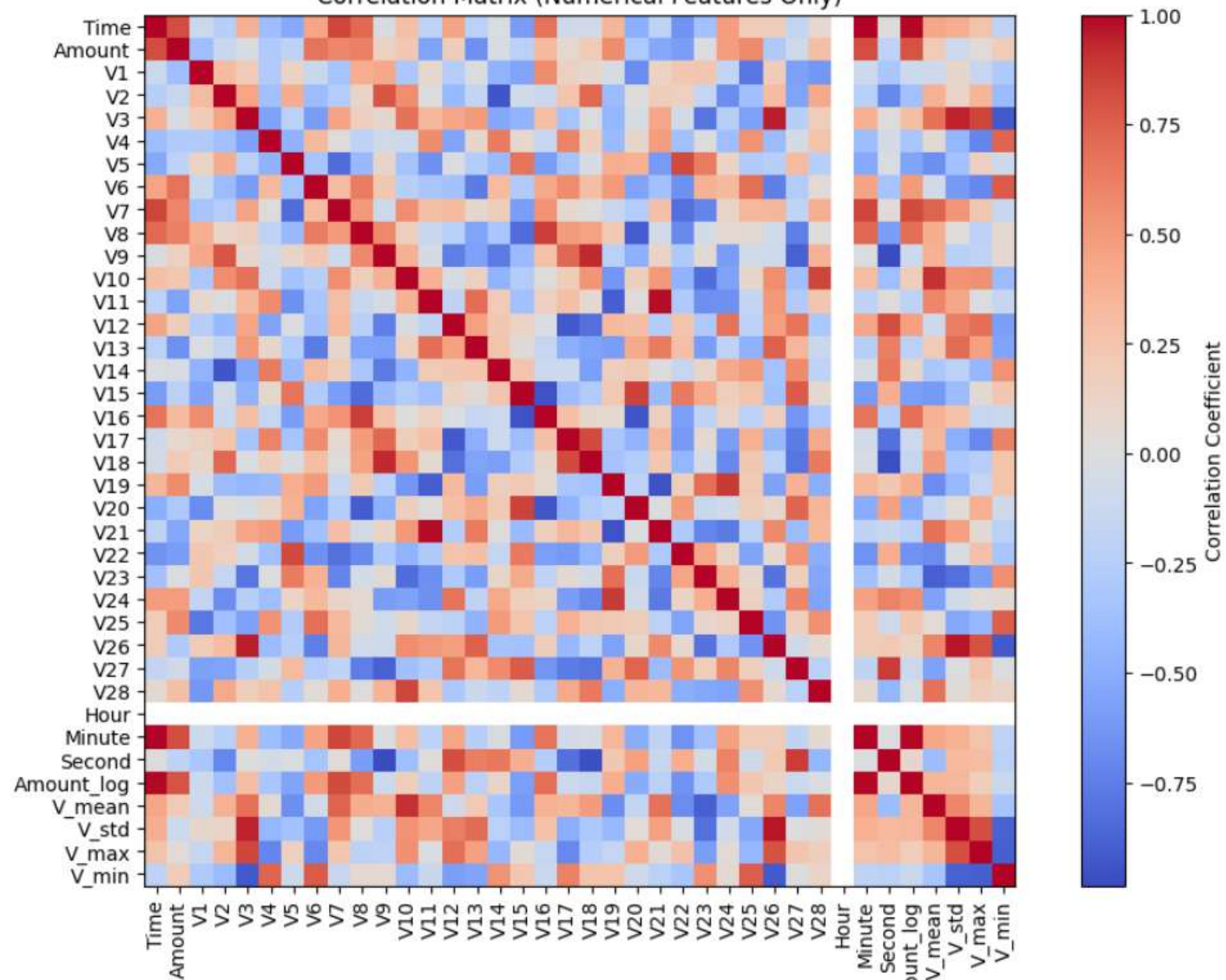
Correlation Matrix (Numerical Features Only)

```
Classification Report:
              precision    recall  f1-score   support

           0       1.00      0.98      0.99     56864
           1       0.06      0.92      0.11        98

    accuracy                           0.98     56962
   macro avg       0.53      0.95      0.55     56962
weighted avg       1.00      0.98      0.99     56962

Confusion Matrix:
[[55478  1386]
 [    8    90]]
ROC-AUC Score: 0.9720834996210077
```
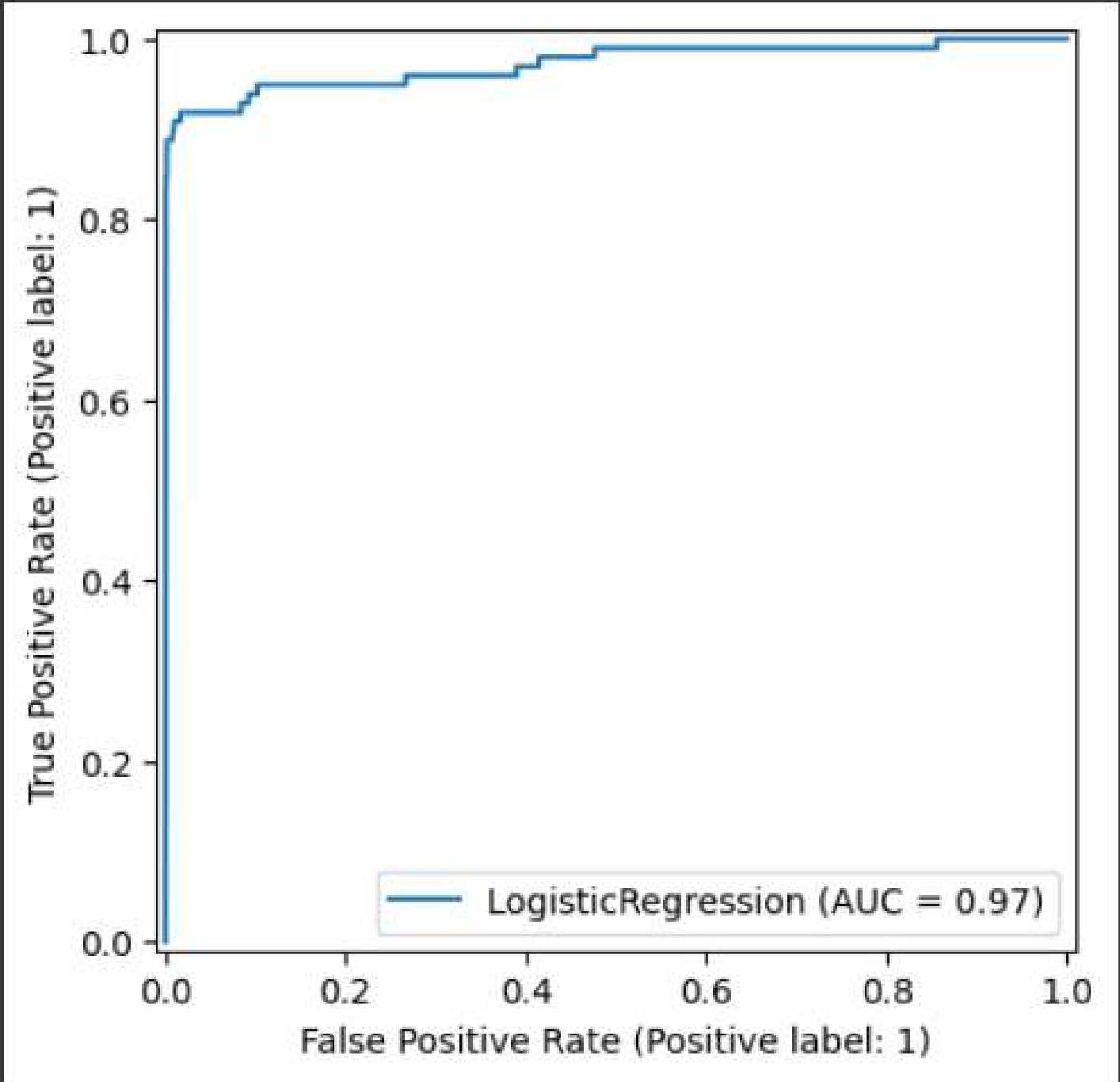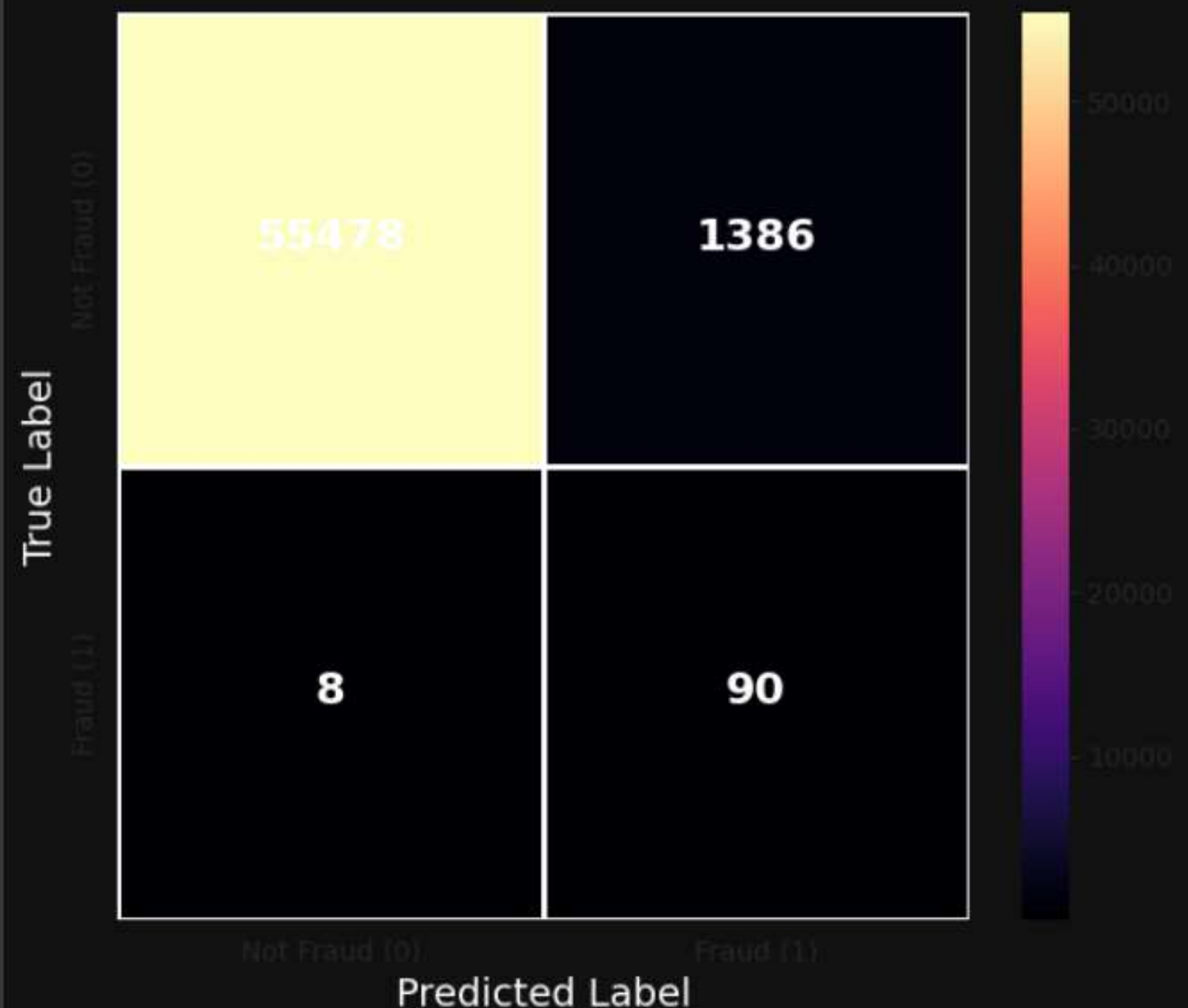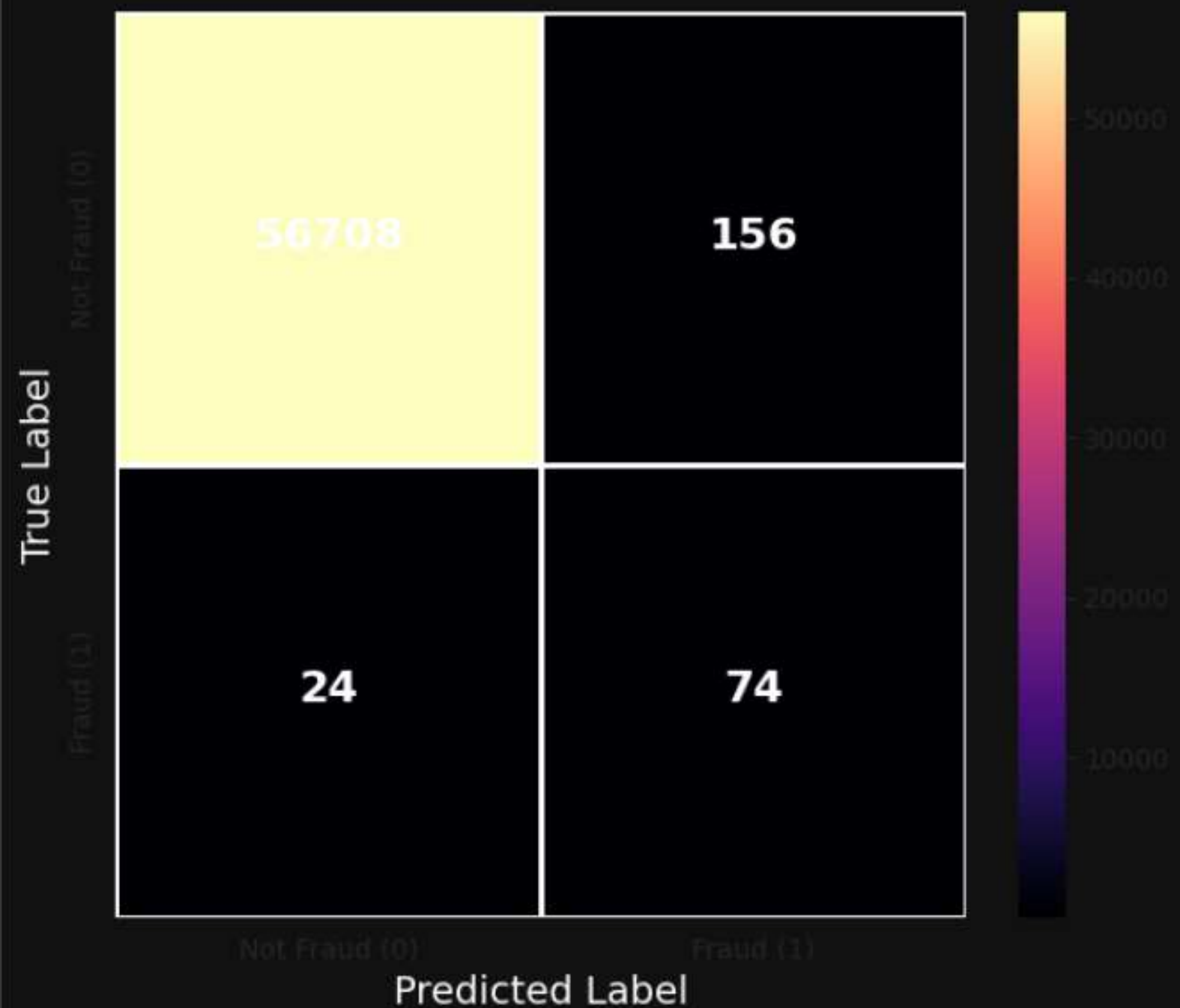
Confusion Matrix - Logistic Regression

Confusion Matrix - SVM

```
Classification Report (SVM):
              precision    recall  f1-score   support

           0       1.00      1.00      1.00     56864
           1       0.32      0.76      0.45        98

    accuracy                           1.00     56962
   macro avg       0.66      0.88      0.72     56962
weighted avg       1.00      1.00      1.00     56962


Confusion Matrix (SVM):
[[56708    156]
 [   24     74]]
ROC-AUC Score (SVM): 0.9731908678637465
```
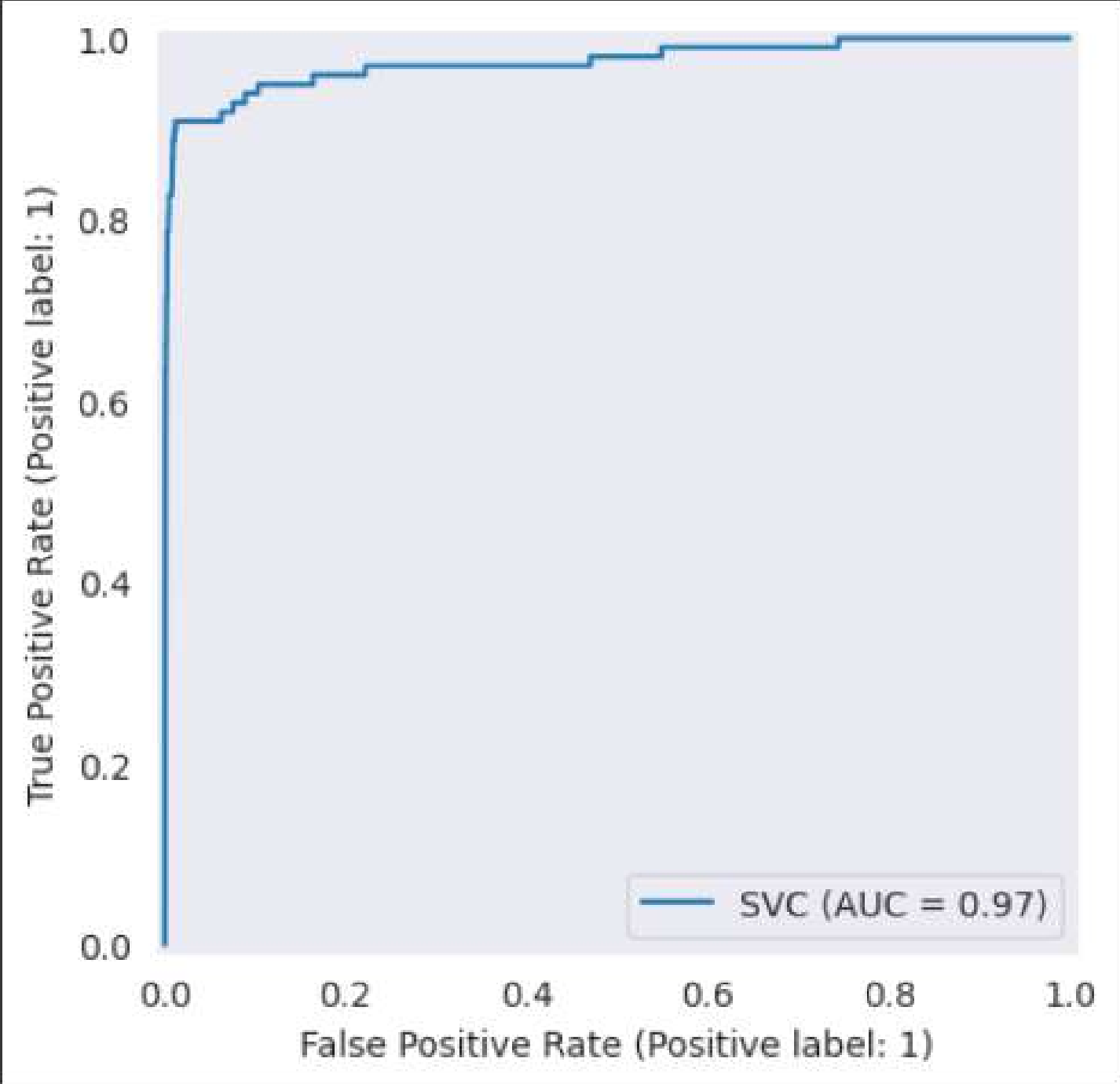
```
Classification Report (LinearSVC):
              precision    recall  f1-score   support

           0       1.00      1.00      1.00     56864
           1       0.80      0.58      0.67        98

    accuracy                           1.00     56962
   macro avg       0.90      0.79      0.84     56962
weighted avg       1.00      1.00      1.00     56962

Confusion Matrix (LinearSVC):
[[56850    14]
 [   41    57]]
ROC-AUC Score (LinearSVC): 0.9752619569212042
```
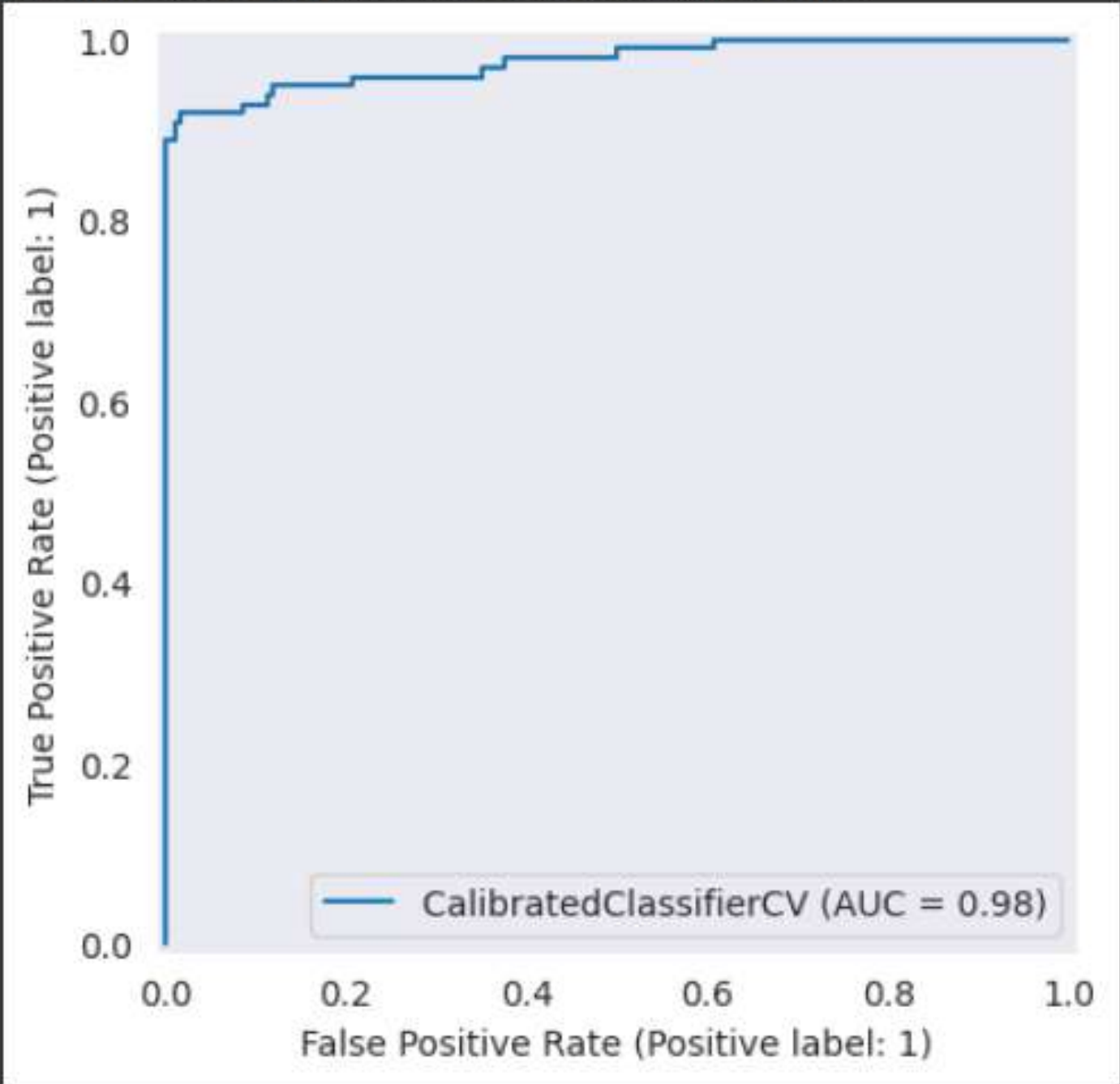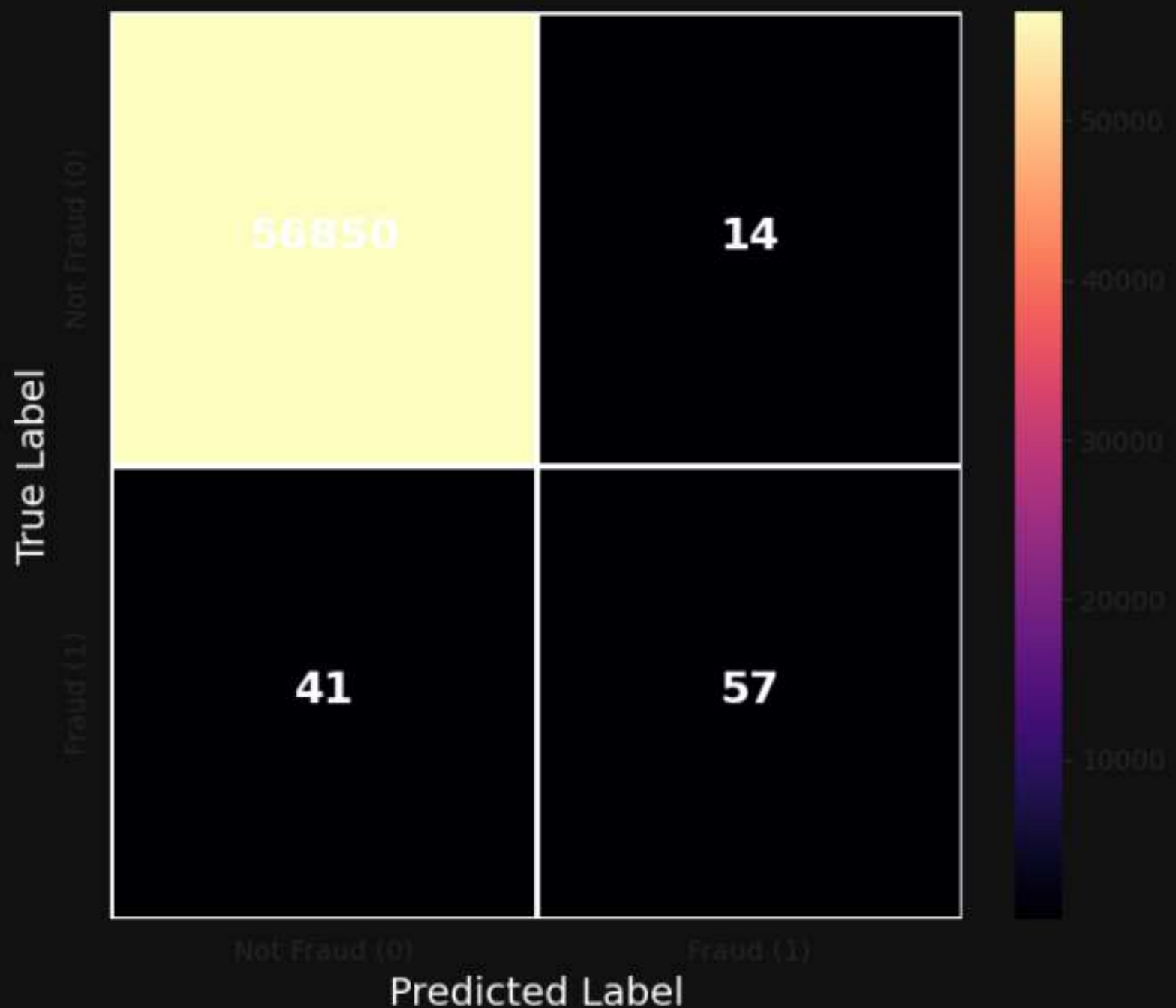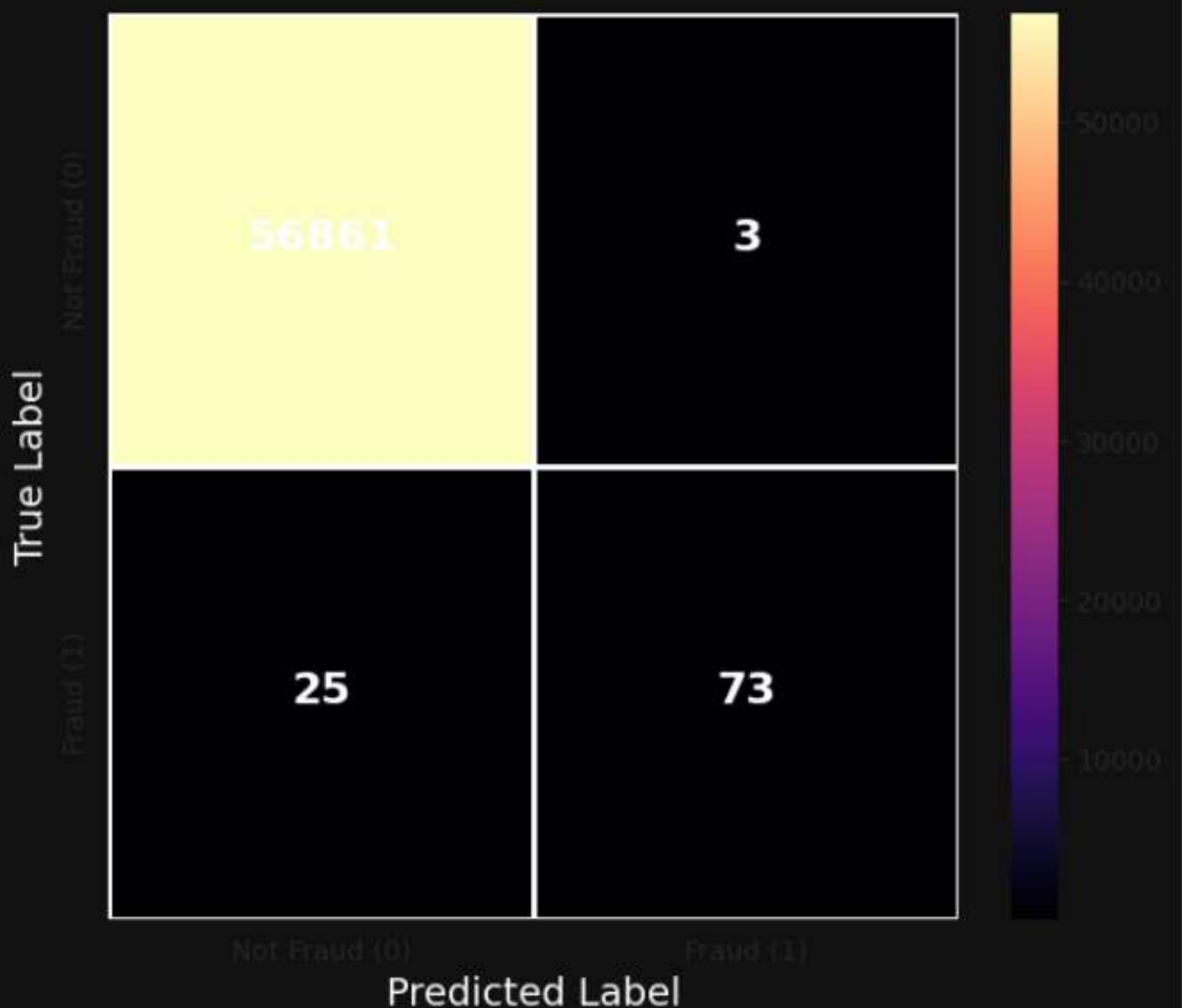
Confusion Matrix - LinearSVC

Confusion Matrix - Random Forest

```
Random Forest - Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00     56864
           1       0.96      0.74      0.84        98

    accuracy                           1.00     56962
   macro avg       0.98      0.87      0.92     56962
weighted avg       1.00      1.00      1.00     56962


Confusion Matrix:
[[56861     3]
 [   25    73]]
ROC-AUC Score: 0.952908497036969
```

ROC Curve - Random Forest

True Positive Rate (Positive label: 1)

RandomForestClassifier (AUC = 0.95)

False Positive Rate (Positive label: 1)