# A Neural Network Classification model to predict lithologies from geophysical logs of Kansas Oil field, USA

**Geophysical logs used**

1. Natural Gamma (API)
2. Neutron Porosity (%)
3. Density Porosity (%)
4. Photo electric cross-section (in barns/sec)

**Most common Lithologies present in the area**

1. Halite
2. Gypsum
3. Dolomite
4. Dolomitic Limestone
5. Cherty Dolomitic Limestone
6. Cherty Dolomite
7. Limestone
8. Cherty Limestone
9. Chert
10. Shale
11. Sand Stone
12. Ironstone
13. Coal

**Nature of Reservior** Carbonate reservior

In [1]:
```
import geopandas as gpd
```

In [2]:
```
import folium
m=folium.Map([38.7128,-98.0060],zoom_start=5)
display(m)
```


In [3]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import folium
```

In [4]:
```
data = pd.read_csv('DataSet.csv')
```

In [5]:
```
data.head()
```

Out[5]:

| | GR | NPHI | DPHI | PEF | PICK | TRUE |
|---|---|---|---|---|---|---|
| **0** | 18.4445 | 0.1263 | 0.0973 | 2.5341 | 7 | 7 |
| **1** | 18.4814 | 0.1138 | 0.0882 | 2.5683 | 7 | 7 |
| **2** | 17.9632 | 0.1100 | 0.0890 | 2.5396 | 7 | 7 |
| **3** | 16.0150 | 0.1213 | 0.1170 | 2.3682 | 7 | 7 |
| **4** | 14.6361 | 0.1112 | 0.1520 | 2.1106 | 10 | 10 |

In [6]:
```
data1 = data[['GR','NPHI', 'DPHI', 'PEF', 'TRUE']]
```

In [7]:
```
data1.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 5 columns):
 #   Column  Non-Null Count  Dtype  
---  ------  --------------  -----  
 0   GR      5000 non-null   float64
 1   NPHI    5000 non-null   float64
 2   DPHI    5000 non-null   float64
 3   PEF     5000 non-null   float64
 4   TRUE    5000 non-null   int64  
dtypes: float64(4), int64(1)
memory usage: 195.4 KB
```

In [8]:
```
import csv
input_file = csv.DictReader(open("Lithology.csv"))
```

In [9]:
```
import csv
with open('Lithology.csv') as f:
    d = dict(filter(None, csv.reader(f)))

print(d)
```

```
{'1': 'Unkown', '2': 'Halite', '3': 'Gypsum', '4': 'Dolomite', '5': 'Dolomitic Limestone', '6': 'Cherty Dolomitic L
imestone', '7': 'Cherty Dolomite', '8': 'Limestone', '9': 'Cherty Limestone', '10': 'Chert', '11': 'Shale', '12':
'Sand Stone', '13': 'Ironstone', '14': 'Coal'}
```

In [10]:
```
type(d)
```

Out[10]:
```
dict
```

In [11]:
```
print(d)
```

```
{'1': 'Unkown', '2': 'Halite', '3': 'Gypsum', '4': 'Dolomite', '5': 'Dolomitic Limestone', '6': 'Cherty Dolomitic L
imestone', '7': 'Cherty Dolomite', '8': 'Limestone', '9': 'Cherty Limestone', '10': 'Chert', '11': 'Shale', '12':
'Sand Stone', '13': 'Ironstone', '14': 'Coal'}
```

In [12]:
```
data1["TRUE"] = data1["TRUE"].astype(str)
```

```
C:\Users\DELL\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returni
ng-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-ver
sus-a-copy)
  """Entry point for launching an IPython kernel.
```

In [13]:
```
data1
```

Out[13]:

| | GR | NPHI | DPHI | PEF | TRUE |
|---|---|---|---|---|---|
| **0** | 18.4445 | 0.1263 | 0.0973 | 2.5341 | 7 |
| **1** | 18.4814 | 0.1138 | 0.0882 | 2.5683 | 7 |
| **2** | 17.9632 | 0.1100 | 0.0890 | 2.5396 | 7 |
| **3** | 16.0150 | 0.1213 | 0.1170 | 2.3682 | 7 |
| **4** | 14.6361 | 0.1112 | 0.1520 | 2.1106 | 10 |
| **...** | ... | ... | ... | ... | ... |
| **4995** | 13.0368 | 0.1183 | 0.0607 | 3.8356 | 5 |
| **4996** | 15.1915 | 0.1109 | 0.0523 | 3.8810 | 5 |
| **4997** | 17.0435 | 0.1029 | 0.0466 | 3.8576 | 5 |
| **4998** | 16.7579 | 0.1225 | 0.0658 | 3.8497 | 5 |
| **4999** | 18.9554 | 0.1439 | 0.0864 | 3.8989 | 5 |

5000 rows × 5 columns

In [14]:
```
data1['TRUE']
```

Out[14]:
```
0        7
1        7
2        7
3        7
4       10
        ..
4995     5
4996     5
4997     5
4998     5
4999     5
Name: TRUE, Length: 5000, dtype: object
```

In [15]:
```
data1.TRUE = [d[item] for item in data1.TRUE]
```

```
C:\Users\DELL\Anaconda3\lib\site-packages\pandas\core\generic.py:5159: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)
  self[name] = value
```

In [16]:
```
data1
```

Out[16]:

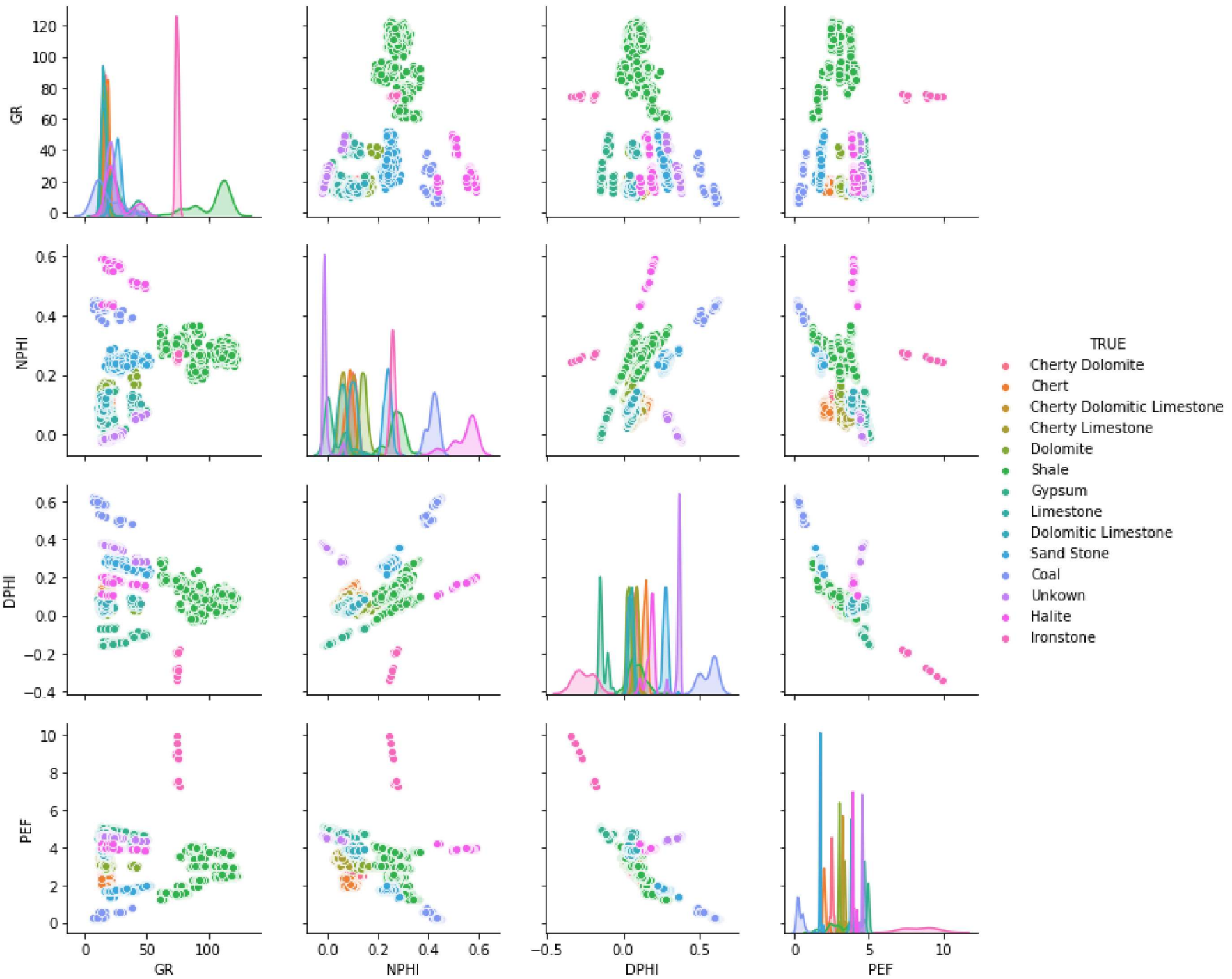
| | GR | NPHI | DPHI | PEF | TRUE |
|---|---|---|---|---|---|
| **0** | 18.4445 | 0.1263 | 0.0973 | 2.5341 | Cherty Dolomite |
| **1** | 18.4814 | 0.1138 | 0.0882 | 2.5683 | Cherty Dolomite |
| **2** | 17.9632 | 0.1100 | 0.0890 | 2.5396 | Cherty Dolomite |
| **3** | 16.0150 | 0.1213 | 0.1170 | 2.3682 | Cherty Dolomite |
| **4** | 14.6361 | 0.1112 | 0.1520 | 2.1106 | Chert |
| **...** | ... | ... | ... | ... | ... |
| **4995** | 13.0368 | 0.1183 | 0.0607 | 3.8356 | Dolomitic Limestone |
| **4996** | 15.1915 | 0.1109 | 0.0523 | 3.8810 | Dolomitic Limestone |
| **4997** | 17.0435 | 0.1029 | 0.0466 | 3.8576 | Dolomitic Limestone |
| **4998** | 16.7579 | 0.1225 | 0.0658 | 3.8497 | Dolomitic Limestone |
| **4999** | 18.9554 | 0.1439 | 0.0864 | 3.8989 | Dolomitic Limestone |

5000 rows × 5 columns

# Data Visualization

In [17]:
```
sns.pairplot(data1, hue="TRUE")
```

Out[17]: <seaborn.axisgrid.PairGrid at 0x13b6c5c69c8>




## Natural Gamma Value in different type of Lithology

In [33]:
```
dd1=data1[data1["TRUE"].isin(['Dolomite','Limestone','Sand Stone'])]
dd1
```

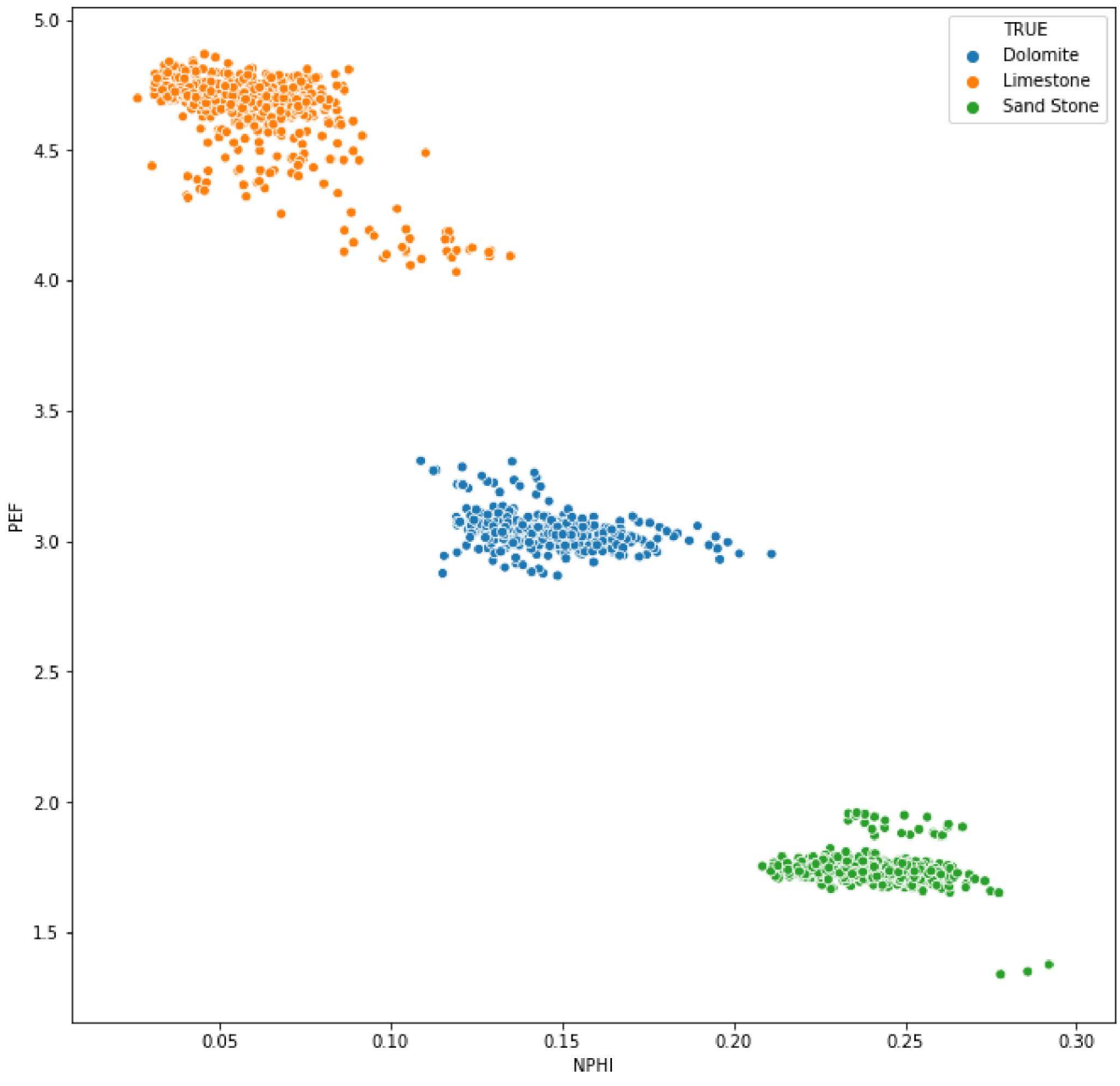
Out[33]:

| | GR | NPHI | DPHI | PEF | TRUE |
|---|---|---|---|---|---|
| **104** | 14.7541 | 0.1298 | 0.0438 | 2.9257 | Dolomite |
| **105** | 15.9558 | 0.1606 | 0.0589 | 2.9954 | Dolomite |
| **106** | 15.9973 | 0.1650 | 0.0600 | 2.9572 | Dolomite |
| **107** | 16.7282 | 0.1657 | 0.0646 | 2.9598 | Dolomite |
| **108** | 15.3756 | 0.1670 | 0.0652 | 2.9600 | Dolomite |
| **...** | ... | ... | ... | ... | ... |
| **4967** | 13.1443 | 0.0476 | 0.0475 | 4.7253 | Limestone |
| **4968** | 11.8830 | 0.0584 | 0.0571 | 4.7876 | Limestone |
| **4969** | 13.8328 | 0.0757 | 0.0741 | 4.8097 | Limestone |
| **4970** | 17.1072 | 0.0652 | 0.0576 | 4.7773 | Limestone |
| **4971** | 17.1222 | 0.0734 | 0.0520 | 4.5640 | Limestone |

1448 rows × 5 columns

In [36]:
```
fig, ax = plt.subplots()
# the size of A4 paper
fig.set_size_inches(11, 11)
sns.scatterplot(x=dd1['NPHI'],y=dd1['PEF'],hue=dd1['TRUE'])
```

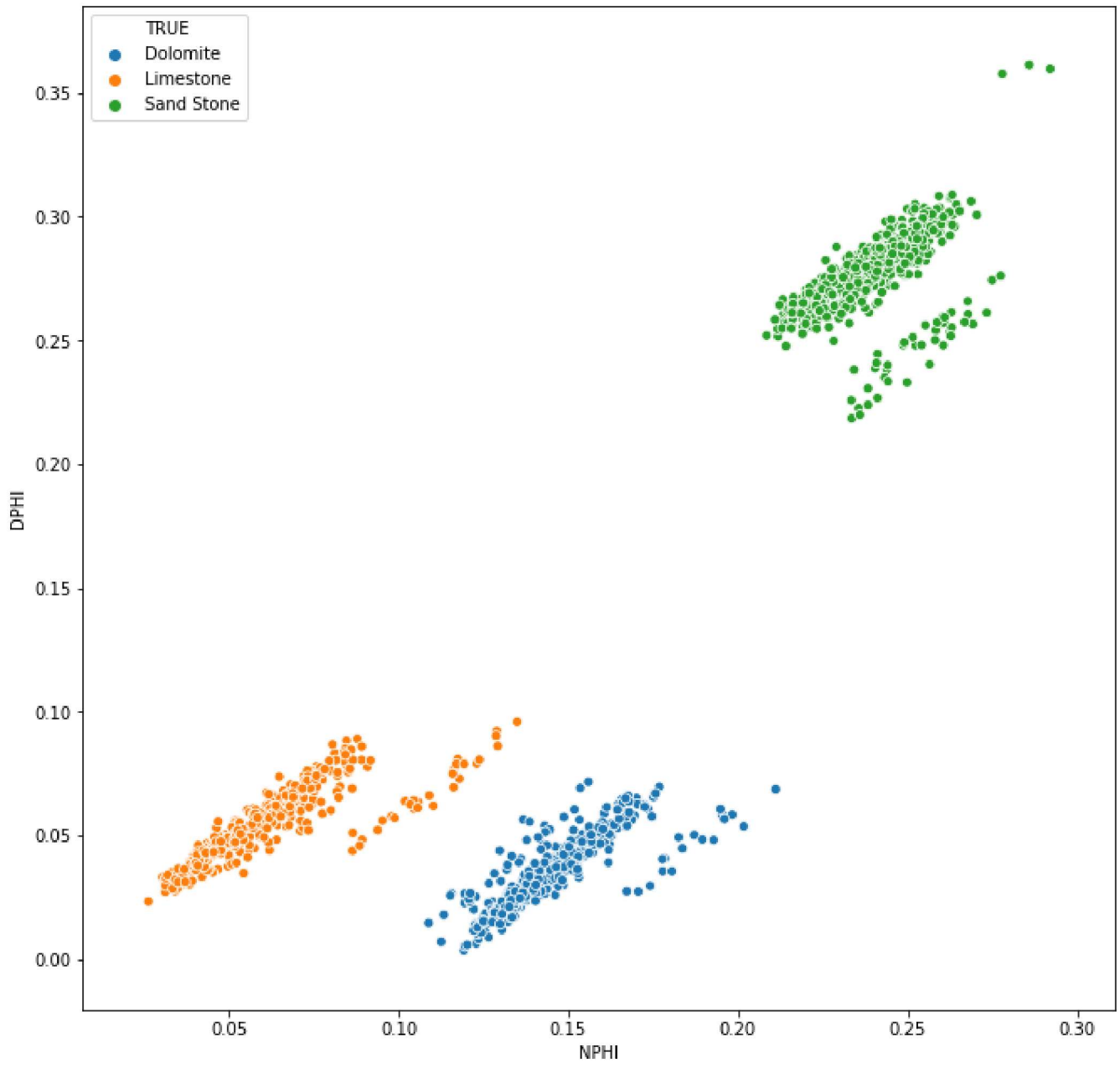
Out[36]: <matplotlib.axes._subplots.AxesSubplot at 0x13b70a30f08>



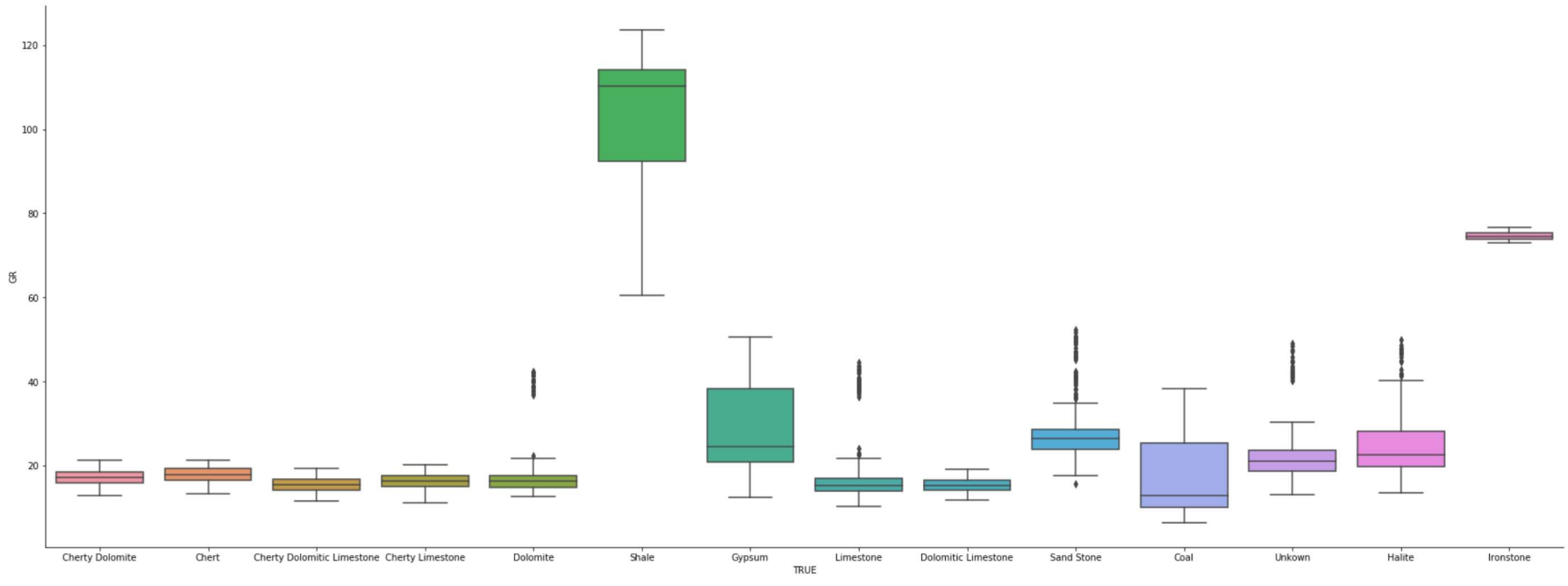

**Cross-plot neutron porosity vs density porosity**

In [35]:
```
fig, ax = plt.subplots()
# the size of A4 paper
fig.set_size_inches(11, 11)
sns.scatterplot(x=dd1['NPHI'],y=dd1['DPHI'],hue=dd1['TRUE'])
```

Out[35]: <matplotlib.axes._subplots.AxesSubplot at 0x13b7048b048>

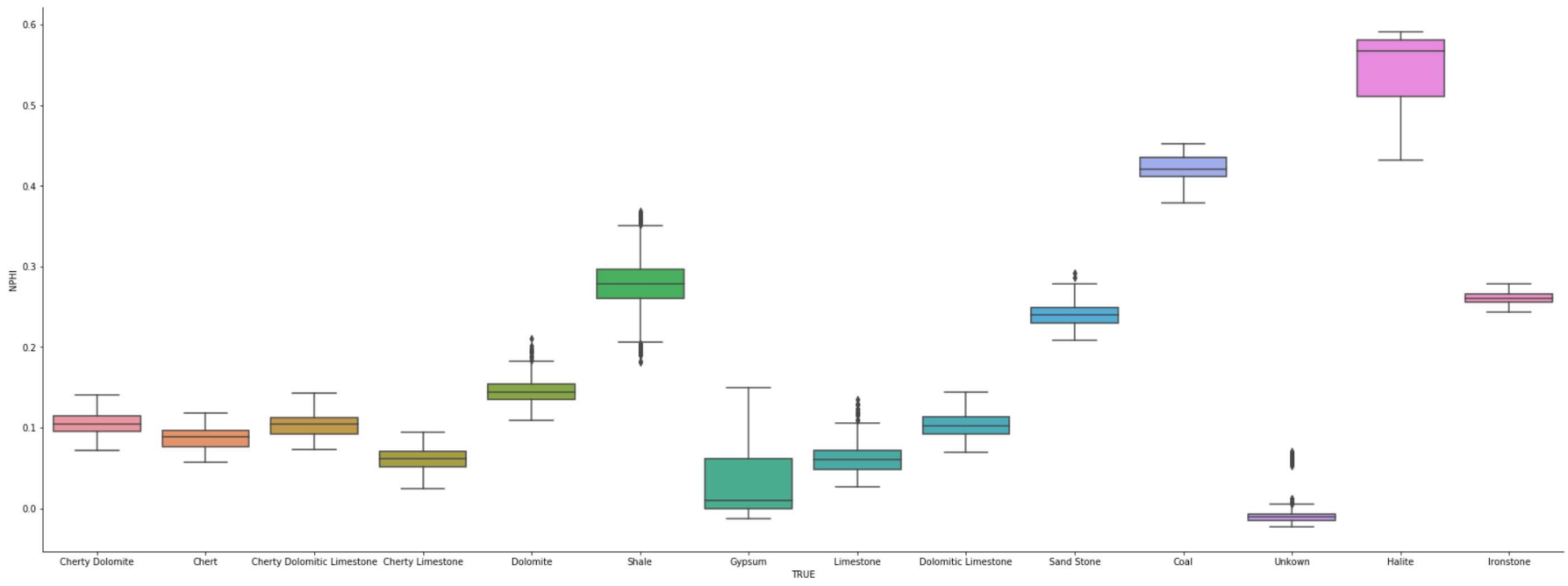


In [18]:
```
fig, ax = plt.subplots()
# the size of A4 paper
fig.set_size_inches(30, 11)
sns.boxplot(x=data1["TRUE"], y=data1["GR"], ax=ax)
sns.despine()
fig.savefig('Gamma.png')
```



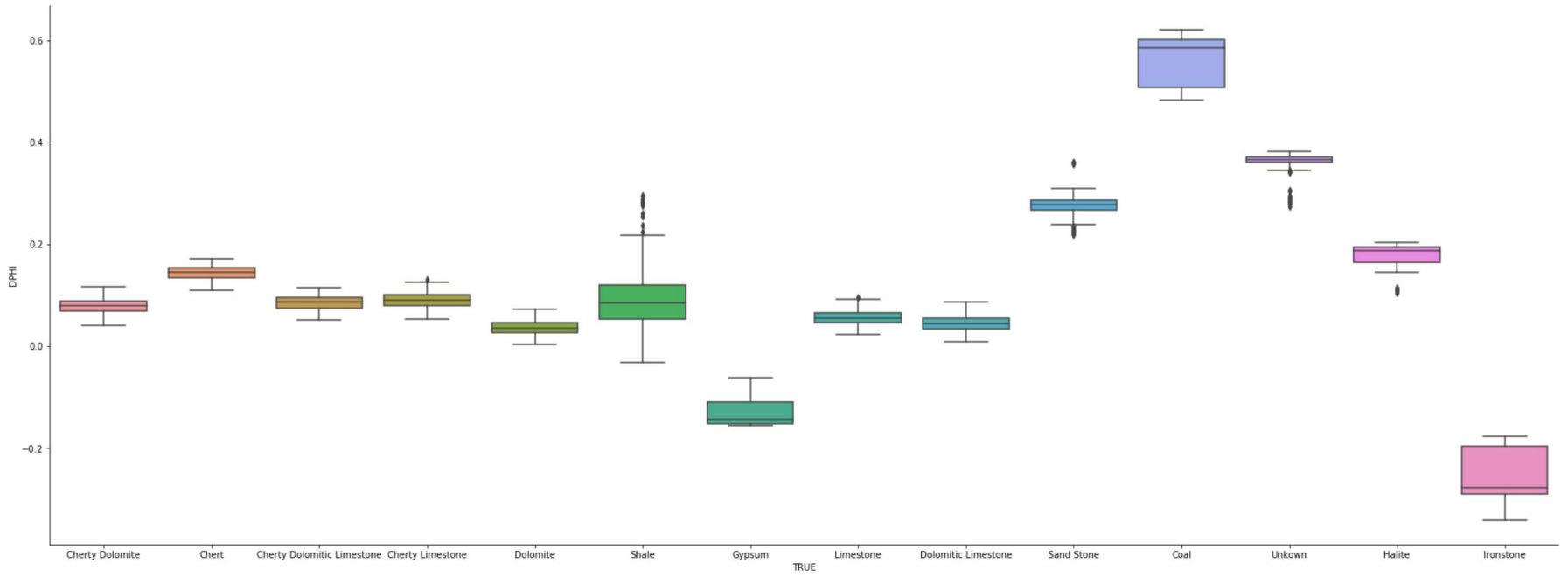

# Neutron Posoristy in various Lithologies

In [19]:
```
fig, ax = plt.subplots()
# the size of A4 paper
fig.set_size_inches(30, 11)
sns.boxplot(x=data1["TRUE"], y=data1["NPHI"], ax=ax)
sns.despine()
fig.savefig('Neutron.png')
```

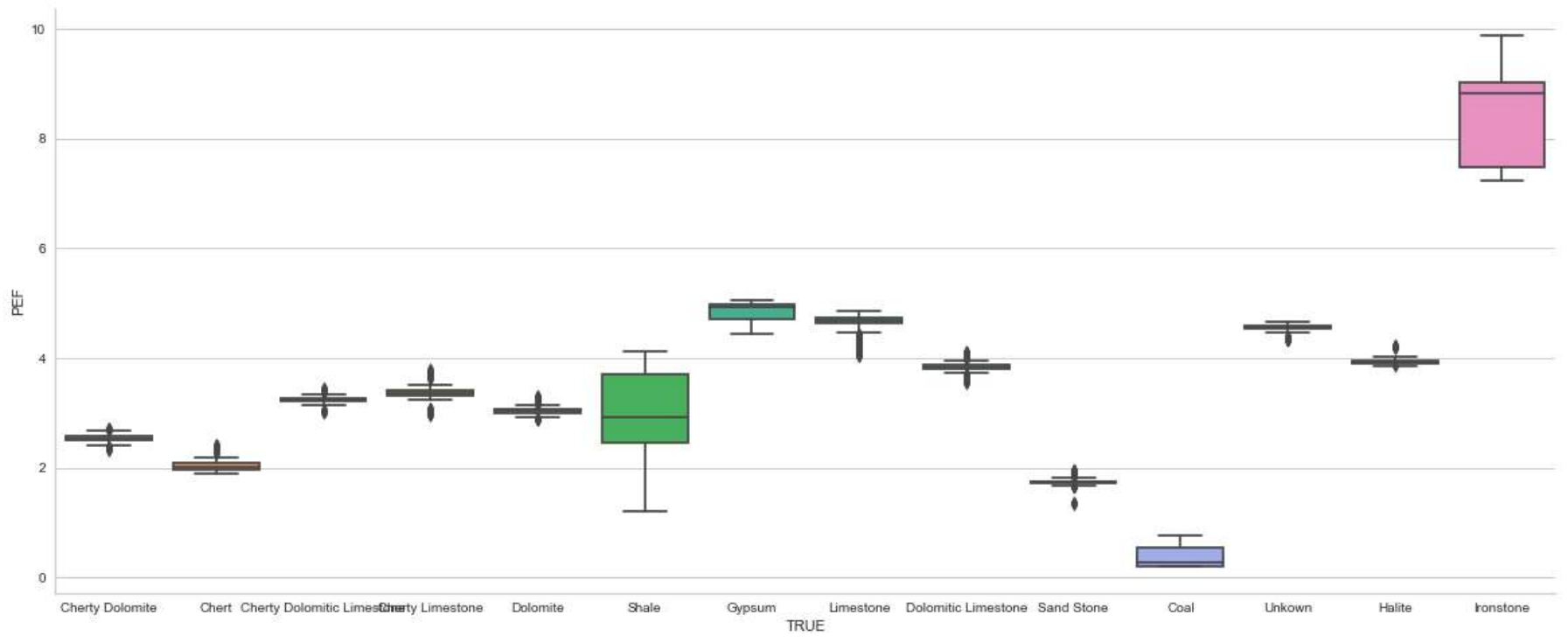



# Density porosity in various lithologies

In [20]:
```
fig, ax = plt.subplots()
# the size of A4 paper
fig.set_size_inches(30, 11)
sns.boxplot(x=data1["TRUE"], y=data1["DPHI"], ax=ax)
sns.despine()
fig.savefig('Density.png')
```




In [208]:
```
fig, ax = plt.subplots()
# the size of A4 paper
fig.set_size_inches(20, 8)
sns.boxplot(x=data1["TRUE"], y=data1["PEF"], ax=ax)
sns.despine()
fig.savefig('PEF.png')
```




In [209]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
data1["TRUE"]  = le.fit_transform(data1['TRUE'])
```

```
C:\Users\DELL\Anaconda3\lib\site-packages\ipykernel_launcher.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy (http://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy)
  This is separate from the ipykernel package so we can avoid doing imports until
```

In [210]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(data1.drop(['TRUE'], axis=1),
                                                    data1['TRUE'], train_size=0.7, random_state=122)
```

In [211]:
```
from sklearn.preprocessing import MinMaxScaler
min_max_scaler = MinMaxScaler()
X_train_minmax = min_max_scaler.fit_transform(X_train)
X_test_minmax = min_max_scaler.fit_transform(X_test)
```

In [212]:
```
print(X_train_minmax.shape)
print(X_test_minmax.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(3500, 4)
(1500, 4)
(3500,)
(1500,)
```

In [213]:
```
import keras.utils as ut
dummy_y_train = ut.to_categorical(y_train)
dummy_y_test = ut.to_categorical(y_test)
```

In [214]:
```
dummy_y_train
```

Out[214]:
```
array([[0., 0., 0., ..., 0., 1., 0.],
       [0., 0., 0., ..., 0., 0., 0.],
       ...,
       [0., 0., 0., ..., 0., 0., 0.],
       [0., 0., 1., ..., 0., 0., 0.],
       [0., 0., 0., ..., 0., 0., 0.]], dtype=float32)
```

In [215]:
```
import tensorflow as tf
```

In [216]:
```
from tensorflow import keras
from tensorflow.keras import layers
```

In [217]:
```
model = keras.Sequential()
model.add(layers.Dense(8, input_dim=4, activation='relu'))
model.add(layers.Dense(4, activation='relu'))
model.add(layers.Dense(14, activation='softmax'))
```

In [218]:
```
model.summary()
```

```
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_9 (Dense)              (None, 8)                 40
_________________________________________________________________
dense_10 (Dense)             (None, 4)                 36
_________________________________________________________________
dense_11 (Dense)             (None, 14)                70
=================================================================
Total params: 146
Trainable params: 146
Non-trainable params: 0
_________________________________________________________________
```

In [219]:
```
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy', 'accuracy'])
```

In [220]:
```
history = model.fit(X_train_minmax, dummy_y_train, epochs=50, batch_size=10, validation_data=(X_test_minmax, dummy_y
```

```
Train on 3500 samples, validate on 1500 samples
Epoch 1/50
3500/3500 [==============================] - 4s 1ms/sample - loss: 2.5715 - accuracy: 0.2500 - val_loss: 2.5173 -
val_accuracy: 0.2333
Epoch 2/50
3500/3500 [==============================] - 2s 535us/sample - loss: 2.4406 - accuracy: 0.2531 - val_loss: 2.2616
- val_accuracy: 0.2333
Epoch 3/50
3500/3500 [==============================] - 2s 431us/sample - loss: 1.8967 - accuracy: 0.3194 - val_loss: 1.6563
- val_accuracy: 0.3633
Epoch 4/50
3500/3500 [==============================] - 2s 441us/sample - loss: 1.4820 - accuracy: 0.5043 - val_loss: 1.3638
- val_accuracy: 0.6153
Epoch 5/50
3500/3500 [==============================] - 2s 437us/sample - loss: 1.2423 - accuracy: 0.6354 - val_loss: 1.1499
- val_accuracy: 0.7073
Epoch 6/50
3500/3500 [==============================] - 1s 396us/sample - loss: 1.0625 - accuracy: 0.7197 - val_loss: 0.9961
- val_accuracy: 0.7173
```

In [226]:
```
y_pred = model.predict(X_test)
```

In [222]:
```
y_p = np.argmax(y_pred, axis=-1)
y_p.max()
```

Out[222]: 12

In [223]:
```
from yellowbrick.classifier import ConfusionMatrix
```

In [224]:
```
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import OneHotEncoder
```

In [225]:
```
import matplotlib.pyplot as plt
def plot_graphs(history, string):
  plt.plot(history.history[string])
  plt.plot(history.history['val_'+string])
  plt.xlabel("Epochs")
  plt.ylabel(string)
  plt.legend([string, 'val_'+string])
  plt.show()

plot_graphs(history, "loss")
plot_graphs(history, "accuracy")
```