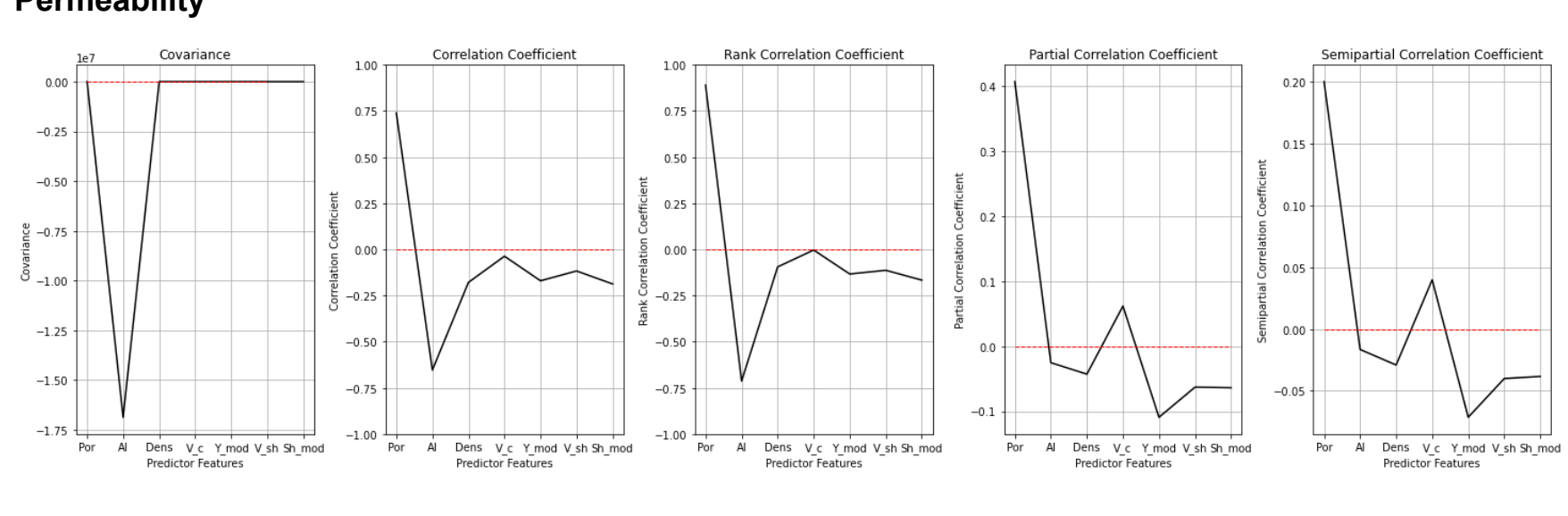
Feature ranking

Summary

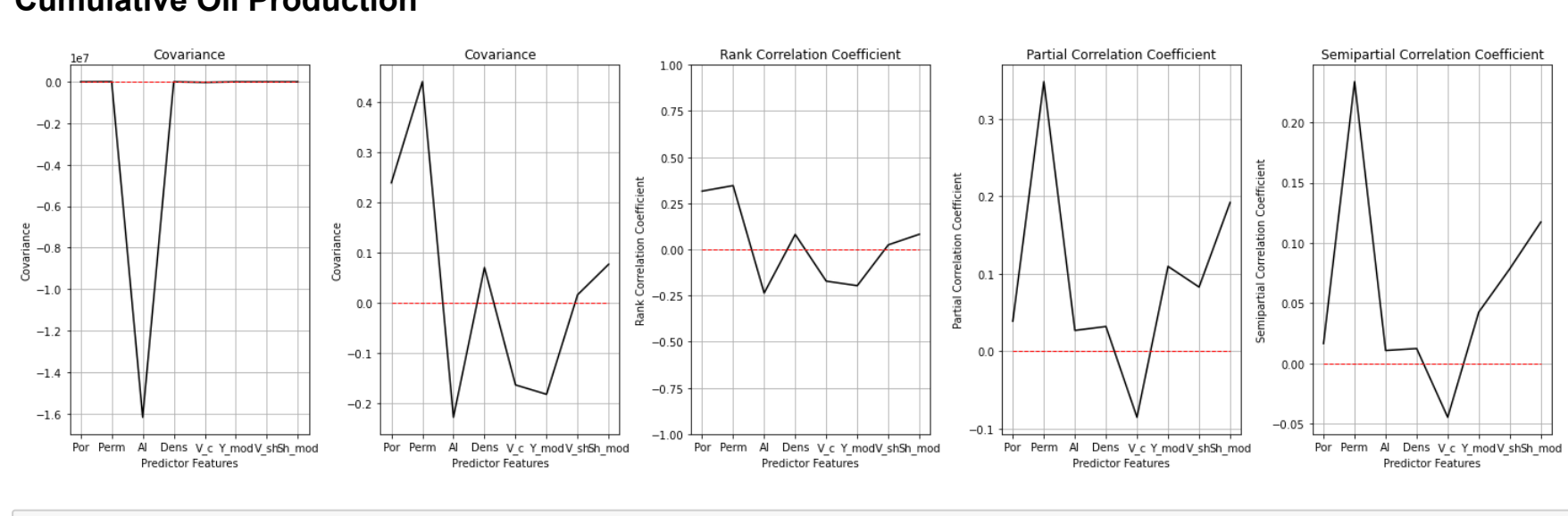
We rank features according to predict potential for cumulative oil production and permeability.

For permeability: Porosity, Young's modulus and Compression velocity may contain the most information.
For cumulative oil production (1 yr): Permeability, Shear Modulus, and Young's modulus contain much information.
Facies data not considered.

Permeability



Cumulative Oil Production



In [116]:
```
import os                                                   # to set current working directory
import numpy as np                                          # ndarrays for gridded data
import pandas as pd                                         # DataFrames for tabular data
import matplotlib.pyplot as plt                             # for visualizing data
from sklearn.impute import KNNImputer
import seaborn as sns
from sklearn.preprocessing import StandardScaler
from scipy import stats
from sklearn.linear_model import LinearRegression
from scipy import linalg
```

In [74]:
```
# Read producer
prod = pd.read_csv("wellbore_data_producer_wells.csv")  # read a .csv file in as a DataFrame
# Read cumulative oil
cumoil = pd.read_csv('production_history.csv')
```

In [75]:
```
cumoil.head()
```

Out[75]:

	Well_ID	Cumulative oil production (1 yr), MSTB	Cumulative oil production (2 yr), MSTB	Cumulative oil production (3 yr), MSTB	Cumulative Water production (1 yr), MSTB	Cumulative Water production (2 yr), MSTB	Cumulative Water production (3 yr), MSTB
0	Well_no_1	450.98	684.20	847.33	494.89	1236.40	2108.7
1	Well_no_2	594.43	946.61	1201.20	226.97	646.50	1187.7
2	Well_no_3	381.75	611.38	781.40	393.17	948.18	1603.1
3	Well_no_4	795.82	1262.80	1573.20	253.25	782.38	1502.9
4	Well_no_5	259.90	426.42	548.68	523.66	1187.00	1932.5

In [76]:
```
prod.head()
```

Out[76]:

	Well_ID	X, m	Y, m	Depth, m	Porosity, fraction	Permeability, mD	Acoustic Impedance, kg*s/m^2	Rock facies	Density, g/cm3	Compressible velocity, m/s	Youngs modulus, GPa	Shear velocity, m/s	S mod
0	Well_no_1	7325	7175	3052.8	0.13330	NaN	6981171.853	Sandstone	2.280137	3106.544655	24.721555	1690.417133	7.30
1	Well_no_1	7325	7175	3053.3	0.13865	NaN	7234748.871	Sandstone	2.135061	4003.697087	23.360728	1573.847967	5.20
2	Well_no_1	7325	7175	3053.8	0.14638	NaN	7157383.755	Sandstone	1.991045	3462.569030	28.232152	1636.279139	
3	Well_no_1	7325	7175	3054.3	NaN	NaN	NaN	Sandstone	1.694242	3836.960702	29.220132	1613.043048	5.07
4	Well_no_1	7325	7175	3054.8	0.14993	NaN	NaN	Sandstone	1.664371	3919.585777	NaN	1636.846284	5.27

In [77]:
```
# Join on Well_ID (Left outer join)
df = pd.merge(prod, cumoil, on='Well_ID',how='left')
df.head()
```

Out[77]:

	Well_ID	X, m	Y, m	Depth, m	Porosity, fraction	Permeability, mD	Acoustic Impedance, kg*s/m^2	Rock facies	Density, g/cm3	Compressible velocity, m/s	Youngs modulus, GPa	Shear velocity, m/s	S mod
0	Well_no_1	7325	7175	3052.8	0.13330	NaN	6981171.853	Sandstone	2.280137	3106.544655	24.721555	1690.417133	7.30
1	Well_no_1	7325	7175	3053.3	0.13865	NaN	7234748.871	Sandstone	2.135061	4003.697087	23.360728	1573.847967	5.20
2	Well_no_1	7325	7175	3053.8	0.14638	NaN	7157383.755	Sandstone	1.991045	3462.569030	28.232152	1636.279139	
3	Well_no_1	7325	7175	3054.3	NaN	NaN	NaN	Sandstone	1.694242	3836.960702	29.220132	1613.043048	5.07
4	Well_no_1	7325	7175	3054.8	0.14993	NaN	NaN	Sandstone	1.664371	3919.585777	NaN	1636.846284	5.27

In [78]:
```
# One Hot Encode categorical attributes (Rock facies)
```

In [79]:
```
df2=df.drop(['Well_ID','Rock facies'],axis=1)
df2 = df2.iloc[:,3:-5]
df2.head()
```

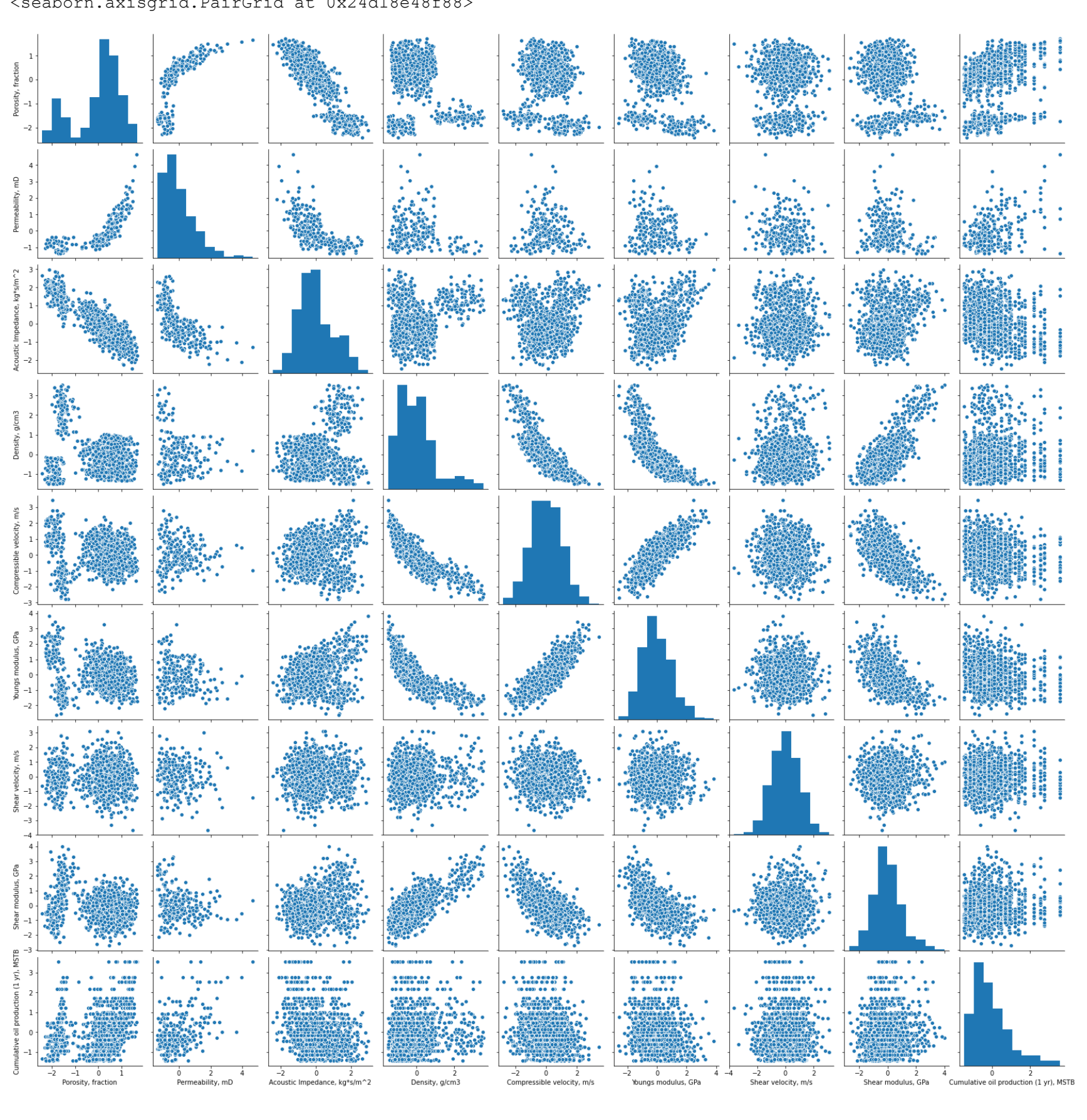
Out[79]:

	Porosity, fraction	Permeability, mD	Acoustic Impedance, kg*s/m^2	Density, g/cm3	Compressible velocity, m/s	Youngs modulus, GPa	Shear velocity, m/s	Shear modulus, GPa	Cumulative oil production (1 yr), MSTB
0	0.13330	NaN	6981171.853	2.280137	3106.544655	24.721555	1690.417133	7.304717	450.98
1	0.13865	NaN	7234748.871	2.135061	4003.697087	23.360728	1573.847967	5.202120	450.98
2	0.14638	NaN	7157383.755	1.991045	3462.569030	28.232152	1636.279139	NaN	450.98
3	NaN	NaN	NaN	1.694242	3836.960702	29.220132	1613.043048	5.074763	450.98
4	0.14993	NaN	NaN	1.664371	3919.585777	NaN	1636.846284	5.277834	450.98

In [80]:
```
# Instantiate scaler class
scaler = StandardScaler()
# Fit on data
df2_std = scaler.fit_transform(df2)
df2_std = pd.DataFrame(df2_std, columns=df2.columns)
```

In [59]:
```
sns.pairplot(df2_std, vars=df2_std.columns, markers = "o")
```

Out[59]: <seaborn.axisgrid.PairGrid at 0x24d18e48f88>



Feature Ranking

In [157]:
```
# Covariance
covariance = df2.cov().loc[:,['Permeability, mD','Cumulative oil production (1 yr), MSTB']]
covariance
```

Out[157]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Porosity, fraction	2.193064e+00	1.962994e+00
Permeability, mD	6.543910e+03	8.017265e+03
Acoustic Impedance, kg*s/m^2	-1.687387e+07	-1.618434e+07
Density, g/cm3	-6.152738e+00	6.599887e+00
Compressible velocity, m/s	-2.020291e+03	-2.678316e+04
Youngs modulus, GPa	-7.246919e+01	-2.241550e+02
Shear velocity, m/s	-9.649752e+02	3.643349e+02
Shear modulus, GPa	-2.345177e+01	2.625422e+01
Cumulative oil production (1 yr), MSTB	8.017265e+03	5.146955e+04

In [89]:
```
# Correlation (Measures linear relationship)
std_corr = df2_std.corr().loc[:,['Permeability, mD','Cumulative oil production (1 yr), MSTB']]
std_corr
```

Out[89]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Porosity, fraction	0.739573	0.238922
Permeability, mD	1.000000	0.440140
Acoustic Impedance, kg*s/m^2	-0.653252	-0.227484
Density, g/cm3	-0.178500	0.070356
Compressible velocity, m/s	-0.036582	-0.163101
Youngs modulus, GPa	-0.169565	-0.181783
Shear velocity, m/s	-0.116603	0.016193
Shear modulus, GPa	-0.186816	0.076836
Cumulative oil production (1 yr), MSTB	0.440140	1.000000

Permeability, Porosity and Acoustic Impedance best linear relationship with cumulative oil.
Porosity and Acoustic Impedance best linear relationship with permeability.

In [111]:
```
# Spearman Rank Coeff (Monotonic Relationship)
stand_rank_correlation, stand_rank_correlation_pval = stats.spearmanr(df2_std, nan_policy='omit')

stand_rank_correlation = pd.DataFrame(stand_rank_correlation, columns=df2_std.columns, index=df2_std.c
olumns)
tmp = stand_rank_correlation.loc[:,['Permeability, mD','Cumulative oil production (1 yr), MSTB']]
tmp.sort_values(by=['Cumulative oil production (1 yr), MSTB'], ascending=False)
#tmp.sort_values(by=['Permeability, mD'], ascending=False)
```

Out[111]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Cumulative oil production (1 yr), MSTB	0.346120	1.000000
Permeability, mD	1.000000	0.346120
Porosity, fraction	0.890404	0.315930
Shear modulus, GPa	-0.166004	0.082534
Density, g/cm3	-0.094427	0.081487
Shear velocity, m/s	-0.112821	0.025137
Compressible velocity, m/s	-0.003052	-0.171612
Youngs modulus, GPa	-0.132961	-0.195970
Acoustic Impedance, kg*s/m^2	-0.712823	-0.236079

Best monotonic relationship with Cumu Oil: Perm, Por, Youngs Modulus
Best monotonic relationship with Perm: Por, AI
Caution: Omit NaNs

In [112]:
```
# Credit to Dr. Michael Pyrcz, UT Austin
def partial_corr(C):
#     Returns the sample linear partial correlation coefficients between pairs of variables in C, contr
olling 
#     for the remaining variables in C.

#     Parameters
#     C : array-like, shape (n, p)
#         Array with the different variables. Each column of C is taken as a variable
#     Returns
#     P : array-like, shape (p, p)
#         P[i, j] contains the partial correlation of C[:, i] and C[:, j] controlling
#         for the remaining variables in C.

    C = np.asarray(C)
    p = C.shape[1]
    P_corr = np.zeros((p, p), dtype=np.float)
    for i in range(p):
        P_corr[i, i] = 1
        for j in range(i+1, p):
            idx = np.ones(p, dtype=np.bool)
            idx[i] = False
            idx[j] = False
            beta_i = linalg.lstsq(C[:, idx], C[:, j])[0]
            beta_j = linalg.lstsq(C[:, idx], C[:, i])[0]
            res_j = C[:, j] - C[:, idx].dot( beta_i)
            res_i = C[:, i] - C[:, idx].dot(beta_j)
            corr = stats.pearsonr(res_i, res_j)[0]
            P_corr[i, j] = corr
            P_corr[j, i] = corr
    return P_corr

def semipartial_corr(C): # Michael Pyrcz modified the function above by Fabian Pedregosa-Izquierdo, f8
bianp.net for semipartial correlation
    C = np.asarray(C)
    p = C.shape[1]
    P_corr = np.zeros((p, p), dtype=np.float)
    for i in range(p):
        P_corr[i, i] = 1
        for j in range(i+1, p):
            idx = np.ones(p, dtype=np.bool)
            idx[i] = False
            idx[j] = False
            beta_i = linalg.lstsq(C[:, idx], C[:, j])[0]
            res_j = C[:, j] - C[:, idx].dot( beta_i)
            res_i = C[:, i] # just use the value, not a residual
            corr = stats.pearsonr(res_i, res_j)[0]
            P_corr[i, j] = corr
            P_corr[j, i] = corr
    return P_corr
```

In [125]:
```
# Partial Correlation (Linear relationship of variable pairs, controlled for all other linear relation
ships)
std_partial_correlation = partial_corr(df2_std.dropna()) # calculate the partial correlation coefficie
nts
std_partial_correlation = pd.DataFrame(std_partial_correlation, columns=df2_std.columns, index=df2_std
.columns)
tmp = std_partial_correlation.loc[:,['Permeability, mD','Cumulative oil production (1 yr), MSTB']]
tmp.sort_values(by=['Cumulative oil production (1 yr), MSTB'], ascending=False)
#tmp.sort_values(by=['Permeability, mD'], ascending=False)
```

Out[125]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Cumulative oil production (1 yr), MSTB	0.347752	1.000000
Permeability, mD	1.000000	0.347752
Shear modulus, GPa	-0.063833	0.192000
Youngs modulus, GPa	-0.109186	0.109570
Shear velocity, m/s	-0.062882	0.082913
Porosity, fraction	0.406569	0.038917
Density, g/cm3	-0.042932	0.032057
Acoustic Impedance, kg*s/m^2	-0.025310	0.026997
Compressible velocity, m/s	0.061717	-0.085011

Best relationship for Cumulative: Perm, Shear, Youngs
Best relationship for Permeability: Por, Youngs
Caution: Drop NaN

In [129]:
```
# Semipartial correl
std_semipartial_correlation = semipartial_corr(df2_std.dropna()) # calculate the partial correlation c
oefficients
std_semipartial_correlation = pd.DataFrame(std_semipartial_correlation, columns=df2_std.columns, index
=df2_std.columns)
tmp = std_semipartial_correlation.loc[:,['Permeability, mD','Cumulative oil production (1 yr), MSTB']]
tmp.sort_values(by=['Cumulative oil production (1 yr), MSTB'], ascending=False)
#tmp.sort_values(by=['Permeability, mD'], ascending=False)
```

Out[129]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Cumulative oil production (1 yr), MSTB	0.233757	1.000000
Permeability, mD	1.000000	0.233757
Shear modulus, GPa	-0.038301	0.117284
Shear velocity, m/s	-0.040016	0.078532
Youngs modulus, GPa	-0.071379	0.042513
Porosity, fraction	0.200398	0.016493
Density, g/cm3	-0.029065	0.012323
Acoustic Impedance, kg*s/m^2	-0.016467	0.010727
Compressible velocity, m/s	0.039912	-0.044701

Best for Cumu Oil: Perm, Shear
Best for Perm: Por
Caution: Drop NaN

Feature Ranking Plot for Permeability

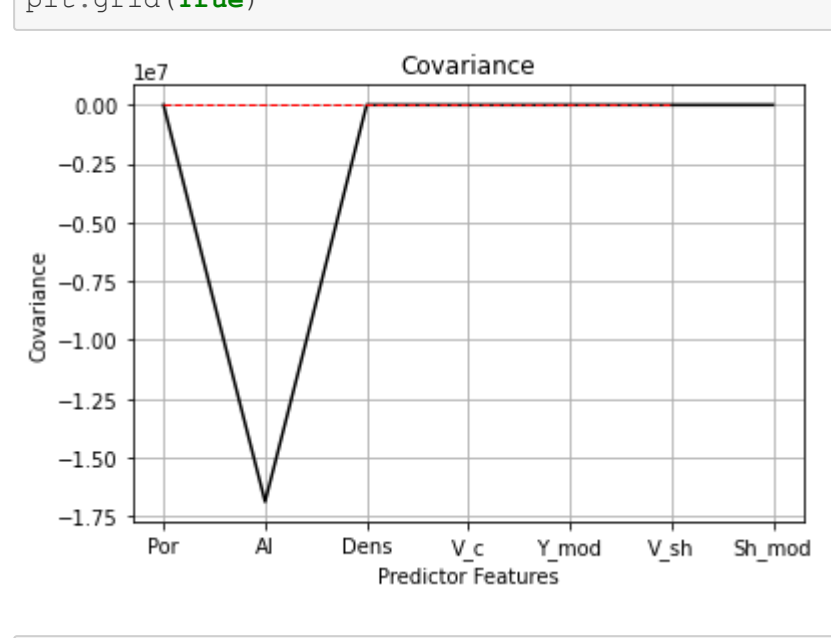
In [205]:
```
covariance
```

Out[205]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Porosity, fraction	2.193064e+00	1.962994e+00
Permeability, mD	6.543910e+03	8.017265e+03
Acoustic Impedance, kg*s/m^2	-1.687387e+07	-1.618434e+07
Density, g/cm3	-6.152738e+00	6.599887e+00
Compressible velocity, m/s	-2.020291e+03	-2.678316e+04
Youngs modulus, GPa	-7.246919e+01	-2.241550e+02
Shear velocity, m/s	-9.649752e+02	3.643349e+02
Shear modulus, GPa	-2.345177e+01	2.625422e+01
Cumulative oil production (1 yr), MSTB	8.017265e+03	5.146955e+04

In [217]:
```
covariance.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Permeabil
ity, mD']
features = ['Por','AI','Dens','V_c','Y_mod','V_sh','Sh_mod']
```

In [218]:
```
plt.plot(features,
         covariance.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,
'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Covariance')
t = plt.title('Covariance')
#plt.ylim(-5000,5000)
plt.grid(True)
```

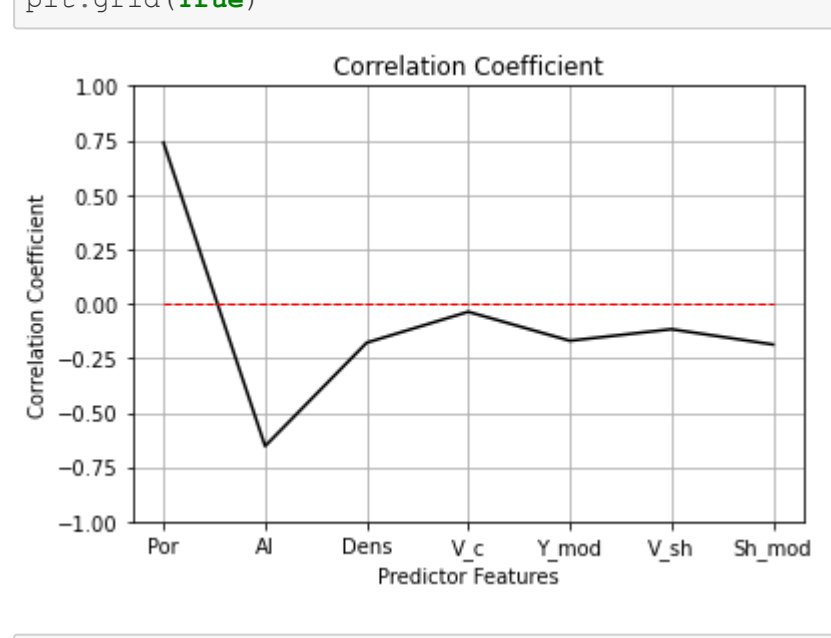


In [219]:
```
std_corr
```

Out[219]:

	Permeability, mD	Cumulative oil production (1 yr), MSTB
Porosity, fraction	0.739573	0.238922
Permeability, mD	1.000000	0.440140
Acoustic Impedance, kg*s/m^2	-0.653252	-0.227484
Density, g/cm3	-0.178500	0.070356
Compressible velocity, m/s	-0.036582	-0.163101
Youngs modulus, GPa	-0.169565	-0.181783
Shear velocity, m/s	-0.116603	0.016193
Shear modulus, GPa	-0.186816	0.076836
Cumulative oil production (1 yr), MSTB	0.440140	1.000000

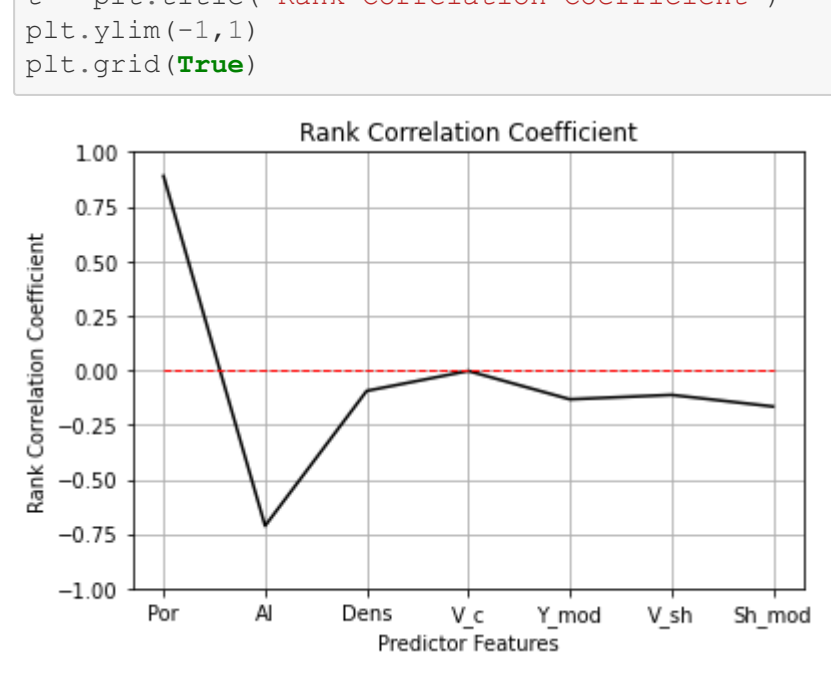
In [220]:
```
plt.plot(features,
         std_corr.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Pe
rmeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Correlation Coefficient')
t = plt.title('Correlation Coefficient')
plt.ylim(-1,1)
plt.grid(True)
```



In [221]:
```
stand_rank_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc
[:,'Permeability, mD']
```

Out[221]:
```
Porosity, fraction              0.890404
Acoustic Impedance, kg*s/m^2   -0.712823
Density, g/cm3                 -0.094427
Compressible velocity, m/s     -0.003052
Youngs modulus, GPa            -0.132961
Shear velocity, m/s            -0.112821
Shear modulus, GPa             -0.166004
Name: Permeability, mD, dtype: float64
```

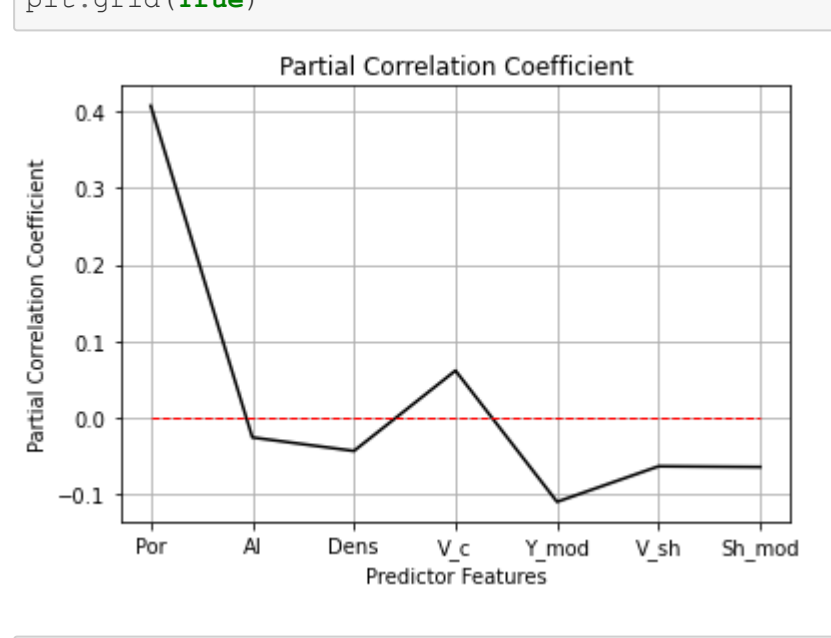
In [222]:
```
plt.plot(features,
         stand_rank_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axi
s=0).loc[:,'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Rank Correlation Coefficient')
t = plt.title('Rank Correlation Coefficient')
plt.ylim(-1,1)
plt.grid(True)
```



In [223]:
```
std_partial_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc
[:,'Permeability, mD']
```

Out[223]:
```
Porosity, fraction              0.406569
Acoustic Impedance, kg*s/m^2   -0.025310
Density, g/cm3                 -0.042932
Compressible velocity, m/s      0.061717
Youngs modulus, GPa            -0.109186
Shear velocity, m/s            -0.062882
Shear modulus, GPa             -0.063833
Name: Permeability, mD, dtype: float64
```

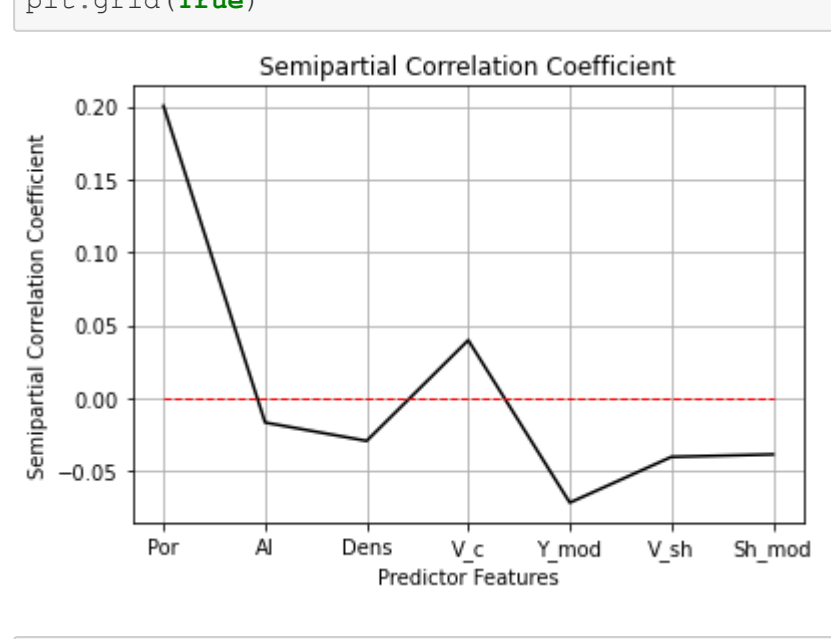
In [224]:
```
plt.plot(features,
         std_partial_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],ax
is=0).loc[:,'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Partial Correlation Coefficient')
t = plt.title('Partial Correlation Coefficient')
plt.grid(True)
```



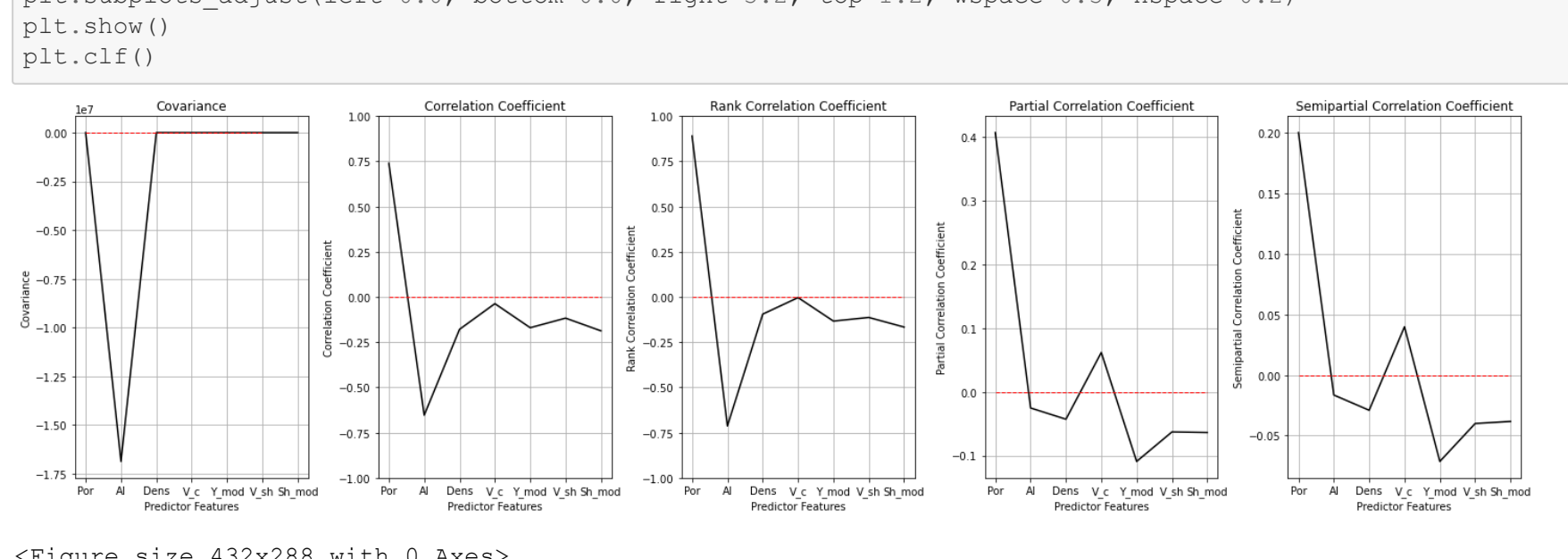
In [225]:
```
std_semipartial_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0)
.loc[:,'Permeability, mD']
```

Out[225]:
```
Porosity, fraction              0.200398
Acoustic Impedance, kg*s/m^2   -0.016467
Density, g/cm3                 -0.029065
Compressible velocity, m/s      0.039912
Youngs modulus, GPa            -0.071379
Shear velocity, m/s            -0.040016
Shear modulus, GPa             -0.038301
Name: Permeability, mD, dtype: float64
```

In [226]:
```
plt.plot(features,
         std_semipartial_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'
],axis=0).loc[:,'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Semipartial Correlation Coefficient')
t = plt.title('Semipartial Correlation Coefficient')
plt.grid(True)
```



In [229]:
```
plt.subplot(151)
plt.plot(features,
         covariance.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,
'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Covariance')
t = plt.title('Covariance')
#plt.ylim(-5000,5000)
plt.grid(True)

plt.subplot(152)
plt.plot(features,
         std_corr.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Pe
rmeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Correlation Coefficient')
t = plt.title('Correlation Coefficient')
plt.ylim(-1,1)
plt.grid(True)

plt.subplot(153)
plt.plot(features,
         stand_rank_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],axi
s=0).loc[:,'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Rank Correlation Coefficient')
t = plt.title('Rank Correlation Coefficient')
plt.ylim(-1,1)
plt.grid(True)


plt.subplot(154)
plt.plot(features,
         std_partial_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'],ax
is=0).loc[:,'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Partial Correlation Coefficient')
t = plt.title('Partial Correlation Coefficient')
plt.grid(True)

plt.subplot(155)
plt.plot(features,
         std_semipartial_correlation.drop(['Permeability, mD','Cumulative oil production (1 yr), MSTB'
],axis=0).loc[:,'Permeability, mD'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Semipartial Correlation Coefficient')
t = plt.title('Semipartial Correlation Coefficient')
plt.grid(True)

plt.subplots_adjust(left=0.0, bottom=0.0, right=3.2, top=1.2, wspace=0.3, hspace=0.2)
plt.show()
plt.clf()
```

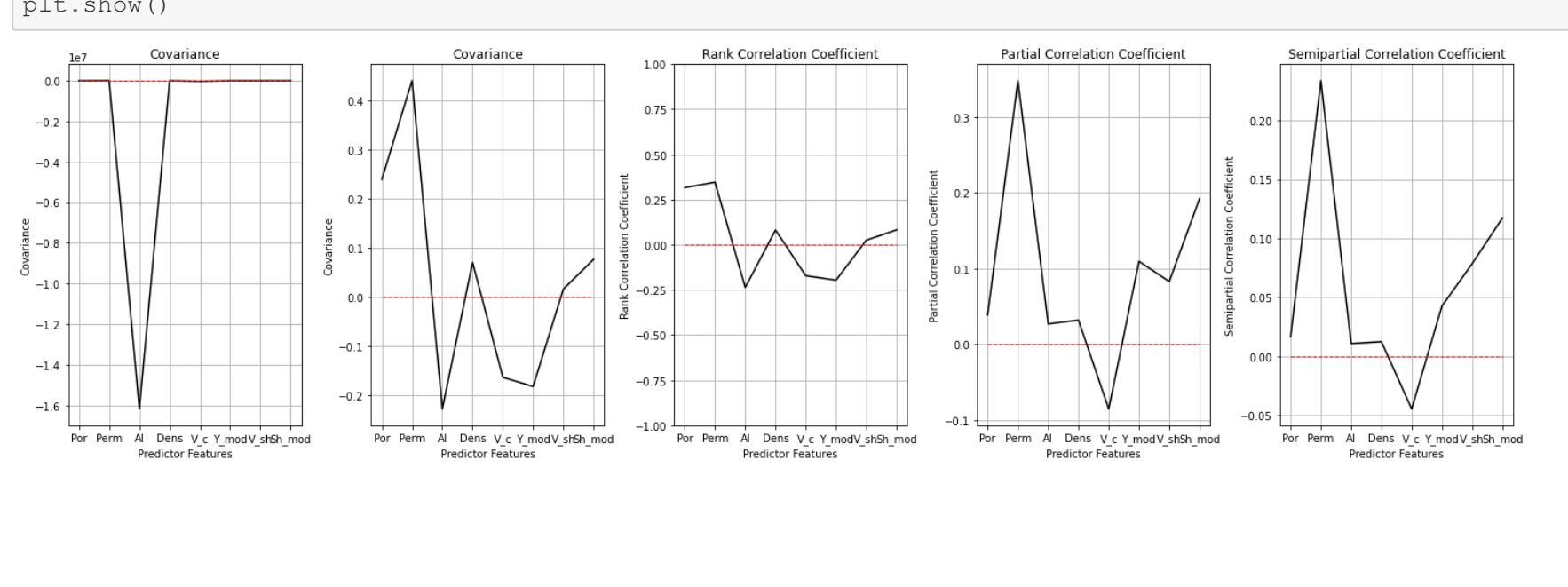


<Figure size 432x288 with 0 Axes>

In [230]:
```
covariance.drop(['Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Cumulative oil production (1
 yr), MSTB'],
```

Out[230]:
```
(Porosity, fraction              1.962994e+00
 Permeability, mD                8.017265e+03
 Acoustic Impedance, kg*s/m^2   -1.618434e+07
 Density, g/cm3                  6.599887e+00
 Compressible velocity, m/s     -2.678316e+04
 Youngs modulus, GPa            -2.241550e+02
 Shear velocity, m/s             3.643349e+02
 Shear modulus, GPa              2.625422e+01
 Name: Cumulative oil production (1 yr), MSTB, dtype: float64,)
```

```
In [232]: t='Cumulative oil production (1 yr), MSTB'
features = ['Por','Perm','AI','Dens','V_c','Y_mod','V_sh','Sh_mod']
plt.subplot(151)
plt.plot(features,
         covariance.drop(['Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Cumulative oil prod
uction (1 yr), MSTB'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Covariance')
t = plt.title('Covariance')
#plt.ylim(-5000,5000)
plt.grid(True)

plt.subplot(152)
plt.plot(features,
         std_corr.drop(['Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Cumulative oil produc
tion (1 yr), MSTB'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Covariance')
t = plt.title('Covariance')
#plt.ylim(-5000,5000)
plt.grid(True)

plt.subplot(153)
plt.plot(features,
         stand_rank_correlation.drop(['Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Cumulat
ive oil production (1 yr), MSTB'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Rank Correlation Coefficient')
t = plt.title('Rank Correlation Coefficient')
plt.ylim(-1,1)
plt.grid(True)


plt.subplot(154)
plt.plot(features,
         std_partial_correlation.drop(['Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Cumula
tive oil production (1 yr), MSTB'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Partial Correlation Coefficient')
t = plt.title('Partial Correlation Coefficient')
plt.grid(True)

plt.subplot(155)
plt.plot(features,
         std_semipartial_correlation.drop(['Cumulative oil production (1 yr), MSTB'],axis=0).loc[:,'Cu
mulative oil production (1 yr), MSTB'],
         color='black')
plt.plot([0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0],'r--',color='red',linewidth = 1.0)
plt.xlabel('Predictor Features')
plt.ylabel('Semipartial Correlation Coefficient')
t = plt.title('Semipartial Correlation Coefficient')
plt.grid(True)

plt.subplots_adjust(left=0.0, bottom=0.0, right=3.2, top=1.2, wspace=0.3, hspace=0.2)
plt.show()
```




```
In [ ]:
```

```
In [ ]:
```