GEOL 593P – Exercise 1

Goal-A: Plotting Data from GeoMapApp

Goal-B: Testing Klein and Langmuir (1987)

Due September 14th, 2017

Exercise Summary

It is amazing how much data is available online if you know where to look. In this exercise you will familiarize yourself with data available from GeoMapApp, which is linked to the IEDA and Marine Geoscience Data System. The overarching goal of this exercise is to test the findings of Klein and Langmuir (1987) firsthand. Does their hypothesis still hold with the larger geochemical data sets that are now available?

Group 1. Fast-spreading ridge

This exercise will walk you through creating maps and downloading data for a classic fast-spreading ridge. The East Pacific Rise (EPR) stretches all the way from the Gulf of California to the Antarctic Plate around ~ 60 °S.

Group 2. Intermediate-spreading ridges

This exercise will walk you through creating maps and downloading data for classic intermediate-spreading ridges. The Juan de Fuca Ridge (JdFR) and the Gorda Ridge (GR) are our neighborhood spreading centers, located just off of the coast of the western US.

Group 3. Slow-spreading ridge segment

This exercise will walk you through creating maps and downloading data for a classic slow-spreading ridge segment. The Mid-Atlantic Ridge stretches all the way from Iceland to the Bouvet triple junction south of Africa.

Learning Goals

1. Familiarize yourself with GeoMapApp, including bathymetric and geochemical data sets
2. Learn to plot a base map in GMT
3. Create several major elements vs. depth plots to investigate the relationship between spreading rate, mid-ocean ridge depth, and geochemical proxies for mantle melting processes

1. Creating a base map

The first step is to spend some time getting to know the mid-ocean ridge you are going to study (Group 1. East Pacific Rise (EPR); Group 2. Juan de Fuca Ridge (JdFR) and the Gorda Ridge (GR); Group 3. Mid-Atlantic Ridge (MAR)). To do this, you will need to download GeoMapApp, a powerful tool created to integrate geological, geochemical, and geophysical data in one location.

Install and run GeoMapApp

Step 1: Download GeoMapApp for your computer from: [http://www.geomapapp.org (http://www.geomapapp.org)](http://www.geomapapp.org)

Step 2: Open GeoMapApp and choose the Mercator projection. The initial base map provides satellite topography/bathymetry.

Step 3: Create a folder on the computer called “GEOL593P” and a subfolder called “P01”

Find your study area

A. Familiarize yourself with the mid-ocean ridge. Using the zoom tool

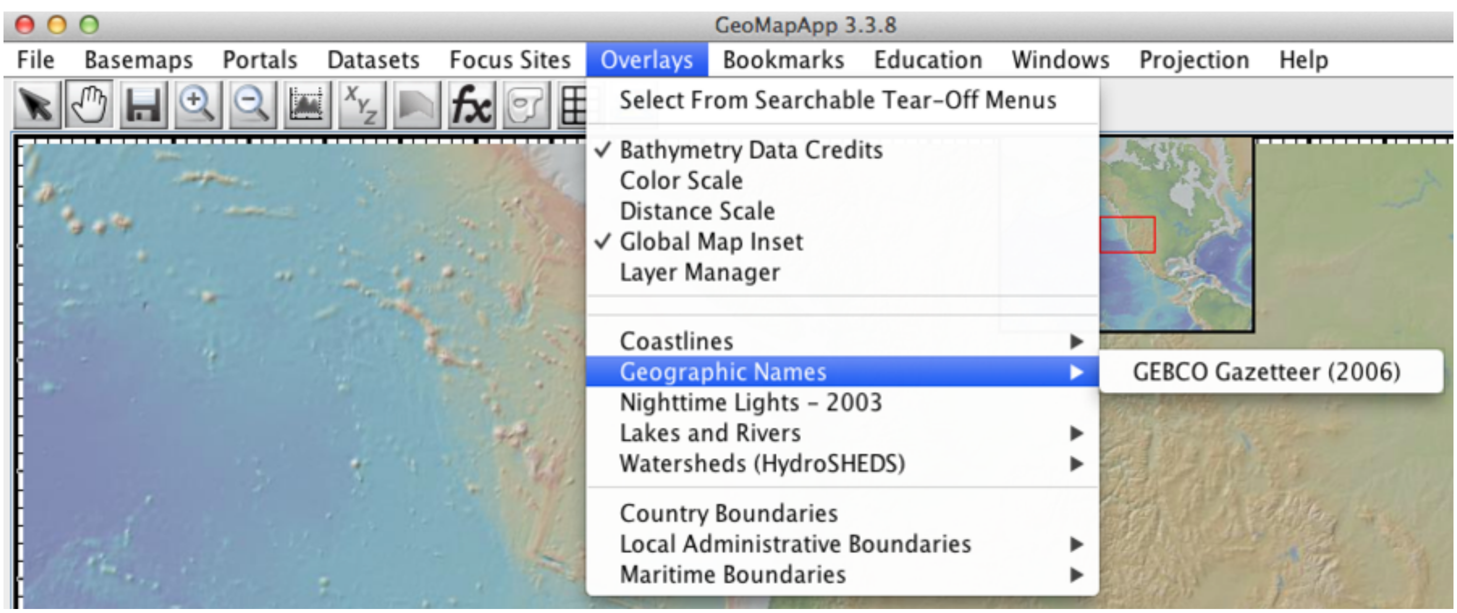
to zoom in on specific features along the mid-ocean ridge, and the profile tool

to create bathymetry profiles along and across the ridge axis.

i. How does the depth of the ridge axis vary from north to south?

ii. How does the morphology of the ridge axis vary from north to south?

B. Find positions for the following geographical features in GeoMapApp. To add labels to your map select Overlays > Geographic Names > GEBCO Gazetteer (2006) as shown below.



Answer

Group 1:

i. Siqueiros Fracture Zone

Longitude = ?

Latitude = ?

ii. Garrett Fracture Zone

Longitude = ? (hint: 13.5˚ S)

Latitude = ?

Group 2:

i. Axial Seamount

Longitude = ?

Latitude = ?

ii. Blanco Fracture Zone

Longitude = ?

Latitude = ?

Group 3:

i. Charlie-Gibbs Fracture Zone

Longitude = ?

Latitude = ?

ii. Lucky Strike Hole

Longitude = ?

Latitude = ?

ii. Atlantis Fracture Zone

Longitude = ?

Latitude = ?

One thing that you will notice is that the geographical location names in GeoMapApp are woefully inadequate.

2. Relative Plate Motion Velocities

How much does the spreading rate vary along the your MOR? Find the spreading rates at the four latitudes below using the Morvel plate model (DeMets et al., 2010) to look up relative plate velocities: http://ofgs.aori.u-tokyo.ac.jp/~okino/platecalc_new.html (http://ofgs.aori.u-tokyo.ac.jp/~okino/platecalc_new.html)

Group 1: East Pacific Rise (EPR)

Latitude	Longitude	Plate velocity
50°S	?	?
30°S	?	?
5°N	?	?
25°N	?	?

Group 2: JdFR and GR

Latitude	Longitude	Plate velocity
42°N	?	?
45°N	?	?
47°N	?	?
49.5°N	?	?

Group 3: Mid-Atlantic Ridge (MAR)

Latitude	Longitude	Plate velocity
50°S	?	?
30°S	?	?
5°N	?	?
25°N	?	?

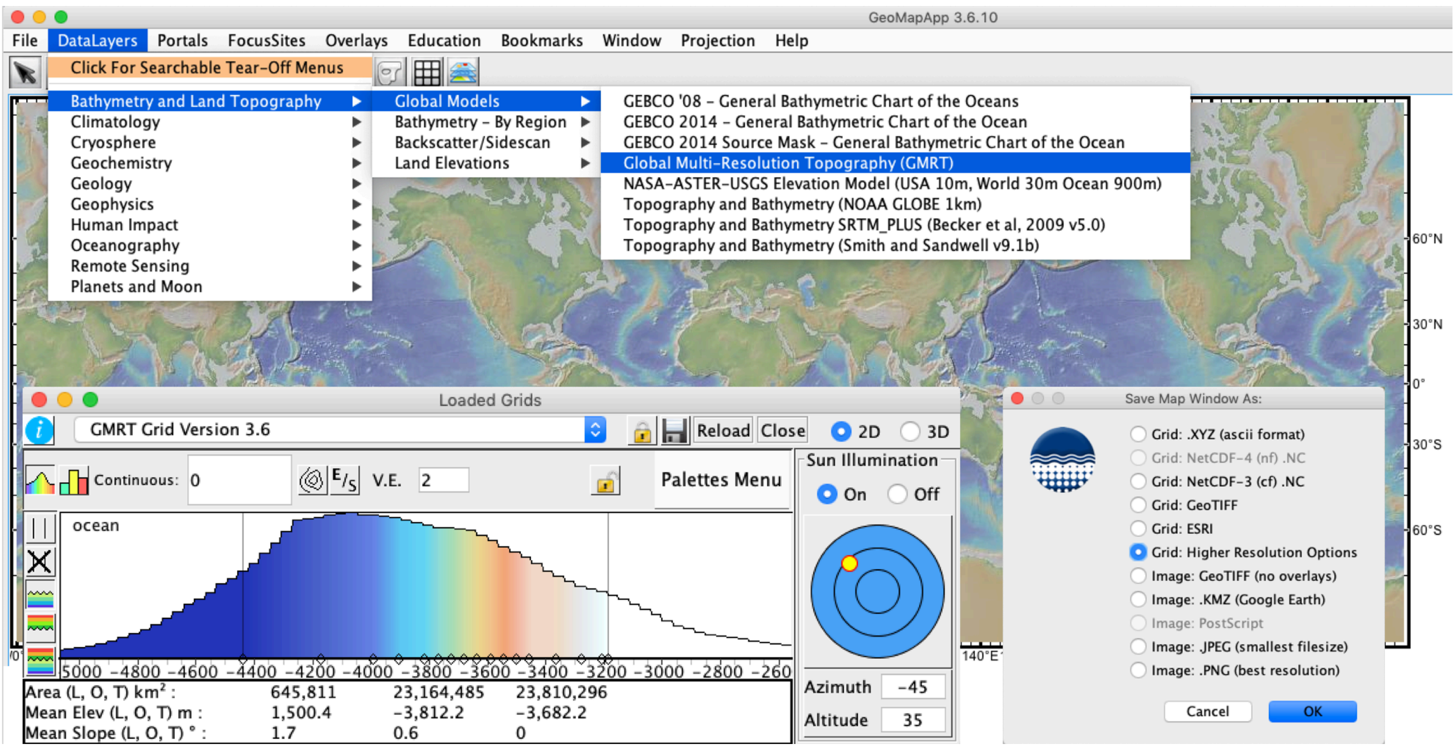
3. Downloading and Plotting Data from GeoMapApp

There are a number of powerful data portals in GeoMapApp, which allow you to plot available data on the map and choose datasets for exporting to Python, Excel or Matlab. This can be very useful if you are trying to determine what datasets are available at a given location.

1. Open Portals > Bathymetry, Gravity and Magnetic Anomaly Profiles for a view of all underway shiptrack data that is available in GeoMapApp. This will provide a very interesting view of where the majority of the ridge experiments on the EPR have taken place. Where, generally, has the majority of data been collected along the EPR? Why do you think that is?

1. Now we want to begin downloading data. For this first step you are going to create a map for the region around the Siqueiros fracture zone. The goal is to create the map view as well as along axis and across axis profiles.

Step 1: Go to Basemaps > Global Grids > Bathymetry > Global Multi-Resolution Topography



Step 2:

Group 1: East Pacific Rise (EPR): Find the 9N region of the EPR. Look for Siqueiros Transform fault Lat and Lon (that you listed above). Select a region that includes at least 1 degree north of the Clipperton and 1 degree south of the Siqueiros FZ.

Group 2: Blanco region of the JdFR and GR: Look for Blanco Transform fault Lat and Lon (that you listed above). Select a region that includes at least 1 degree north and 1 degree south of the Blanco FZ.

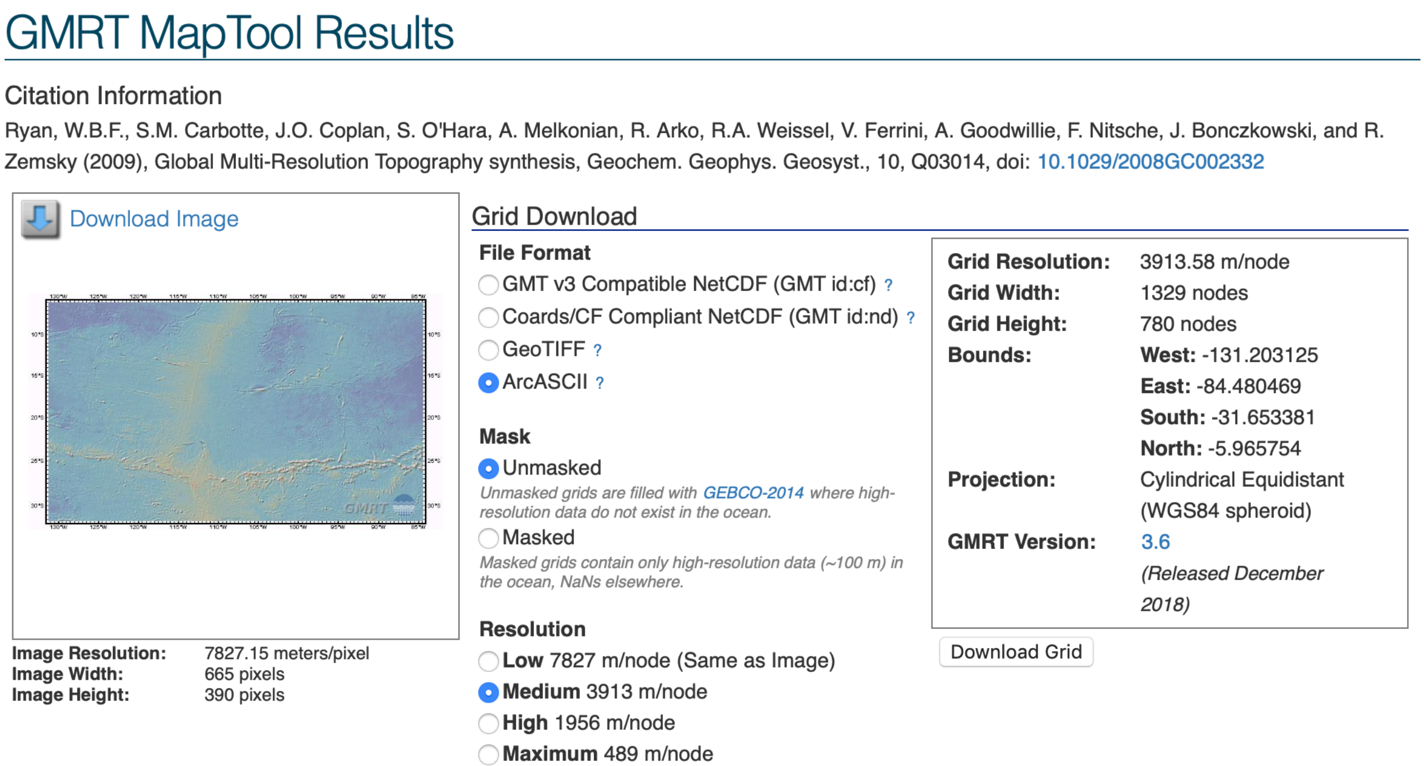
Group 3: Atlantis Fracture Zone: Find the Atlantis Fracture Zone's Lat and Lon (that you listed above). Select a region that includes at least 2 degrees north and south of the Atlantis FZ along the MAR.

Once you have the region you want for your data, hit the save icon on the Global Grids window.

You will then be given the option to save in a variety of formats. There is no right answer here. You could save it as a JPG and have a nice map or as a .grd or .xyz file that you can manipulate in GMT and Matlab. Alternatively, you can save as a GeoTIFF and use Matlab or ArcGIS.

For today, we are going to play around with mapping in Jupyter Notebook with Python. So select “Grid: Higher Resolution Options”. This will take you to the MGDS GMRT website so that you can download the data. You have a number of options for resolution. As you can see the highest resolution option is > 100 m spacing.

Select **ArcASCII** & **Unmasked** & **Medium Resolution**



Step 3: Once you have downloaded the data, move it to the same folder as this Jupyter Notebook.

Python code for plotting bathymetry

More information and tutorial for Python see "[PythonIntroNotebooks (./PythonIntroNotebooks)]" by Prof. [Greg Waite (https://www.mtu.edu/geo/department/faculty/waite/)]

In [1]:
```
# import python modules
import matplotlib.pyplot as plt
import matplotlib.colors as cs
import numpy as np
```

A function for reading the ArcASCII file by Zhan (2017)

In [2]:
```
# TOPO = readTOPOasc(ascname = '*.asc')
# TOPO = {'x': x, 'y': y, 'data': datamat}
def readTOPOasc(ascname):
    # open the file
    f = open(ascname, 'r')
    # read by lines
    for i, line in enumerate(f):
        if i < 7:
            line = line.strip()
            columns = line.split()
            # read the head of the file
            if columns[0] == 'ncols':
                ncols = int(columns[1])
            if columns[0] == 'nrows':
                nrows = int(columns[1])
            if columns[0] == 'xllcorner':
                xllcorner = float(columns[1])
            if columns[0] == 'yllcorner':
                yllcorner = float(columns[1])
            if columns[0] == 'cellsize':
                cellsize = float(columns[1])
            if columns[0] == 'nodata_value':
                nodata_value = float(columns[1])

    # Create X,Y mesh
    x = cellsize * np.arange(ncols) + xllcorner
    y = cellsize * np.arange(nrows) + yllcorner
    y = y[::-1]

    # read by lines
    datamat = np.genfromtxt(ascname,
                            skip_header=6,
                            dtype=float
                            )

    # substitude the nodata value
    datamat[datamat == nodata_value] = 'nan'

    # storing all data into Topo
    TOPO = {'x': x, 'y': y,
            'data': datamat
            }

    return TOPO
```

Now, read the .asc file

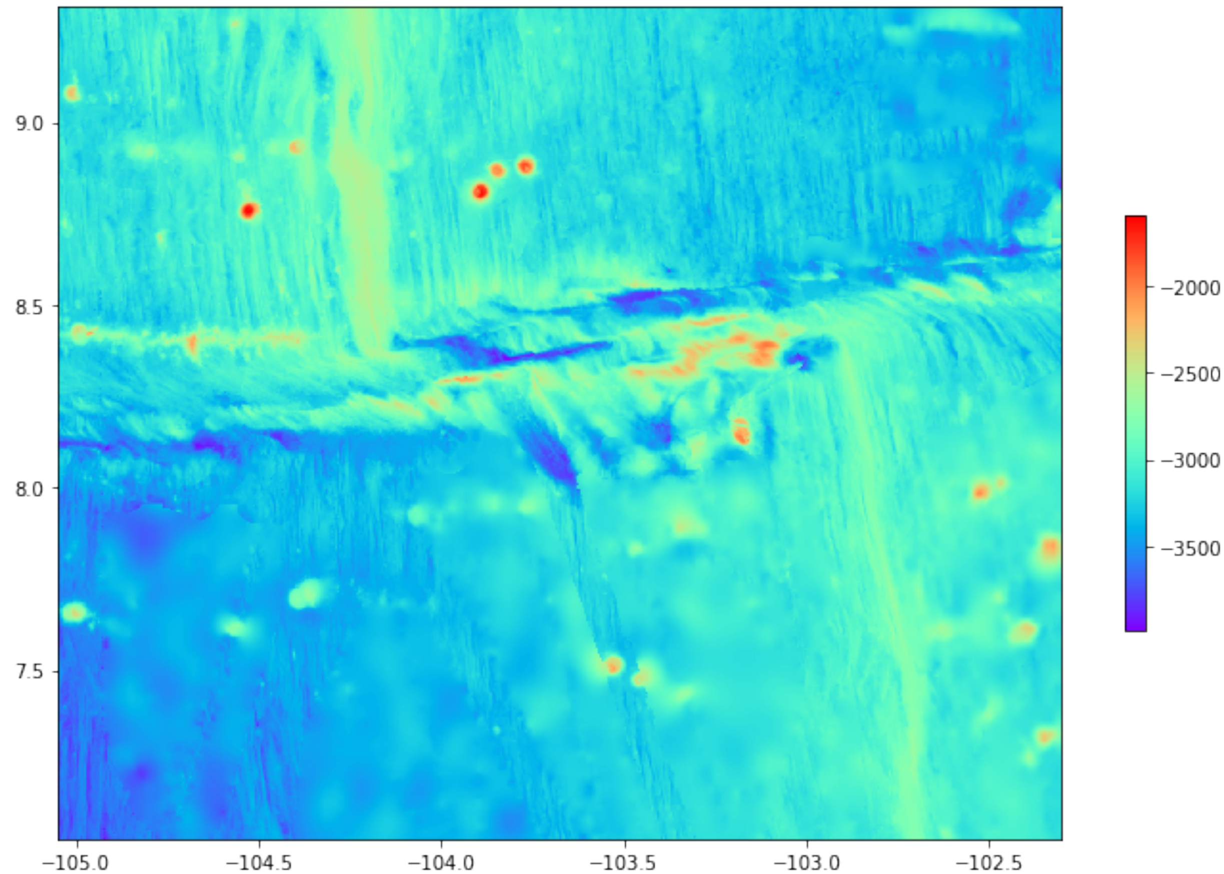
change the "ascname" to the file name of your asc file.

In [3]:
```
ascname = "./Example.asc"
Bath = readTOPOasc(ascname)
```

Use matplotlib.pyplot.imshow function to plot the bathymetry

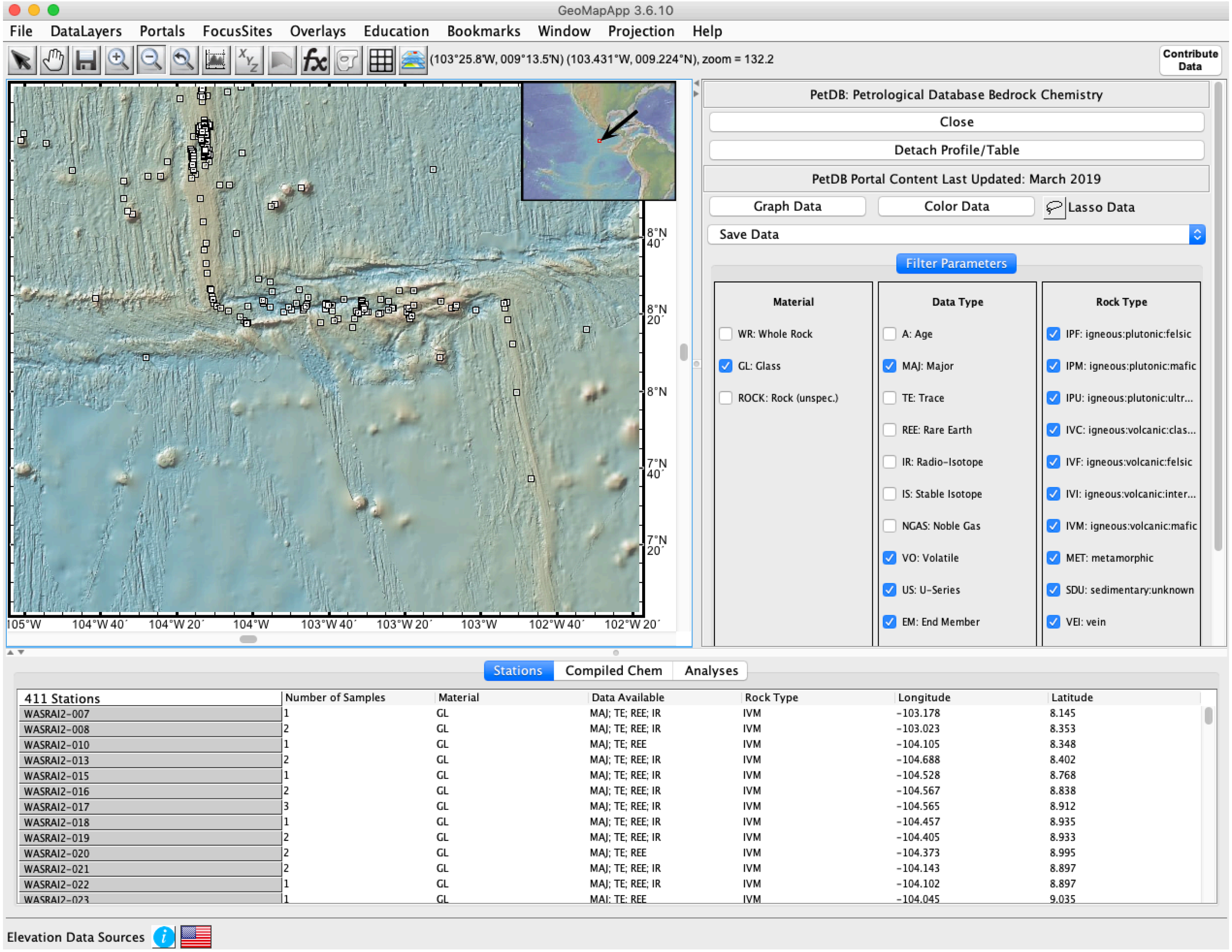
You can also change the colormap. See: https://matplotlib.org/3.1.0/tutorials/colors/colormaps.html (https://matplotlib.org/3.1.0/tutorials/colors/colormaps.html)

In [4]:
```
fig1 = plt.figure(1,figsize=(12,8))
# plot bathymetry
plt.imshow(Bath["data"],
           extent=[Bath["x"].min(),
                   Bath["x"].max(),
                   Bath["y"].min(),
                   Bath["y"].max()],
           cmap="rainbow"
          )

# the range of the plot
plt.xlim([Bath["x"].min(), Bath["x"].max()])
plt.ylim([Bath["y"].min(), Bath["y"].max()])

# add a colorbar
plt.colorbar(shrink=0.5)
plt.show()
```



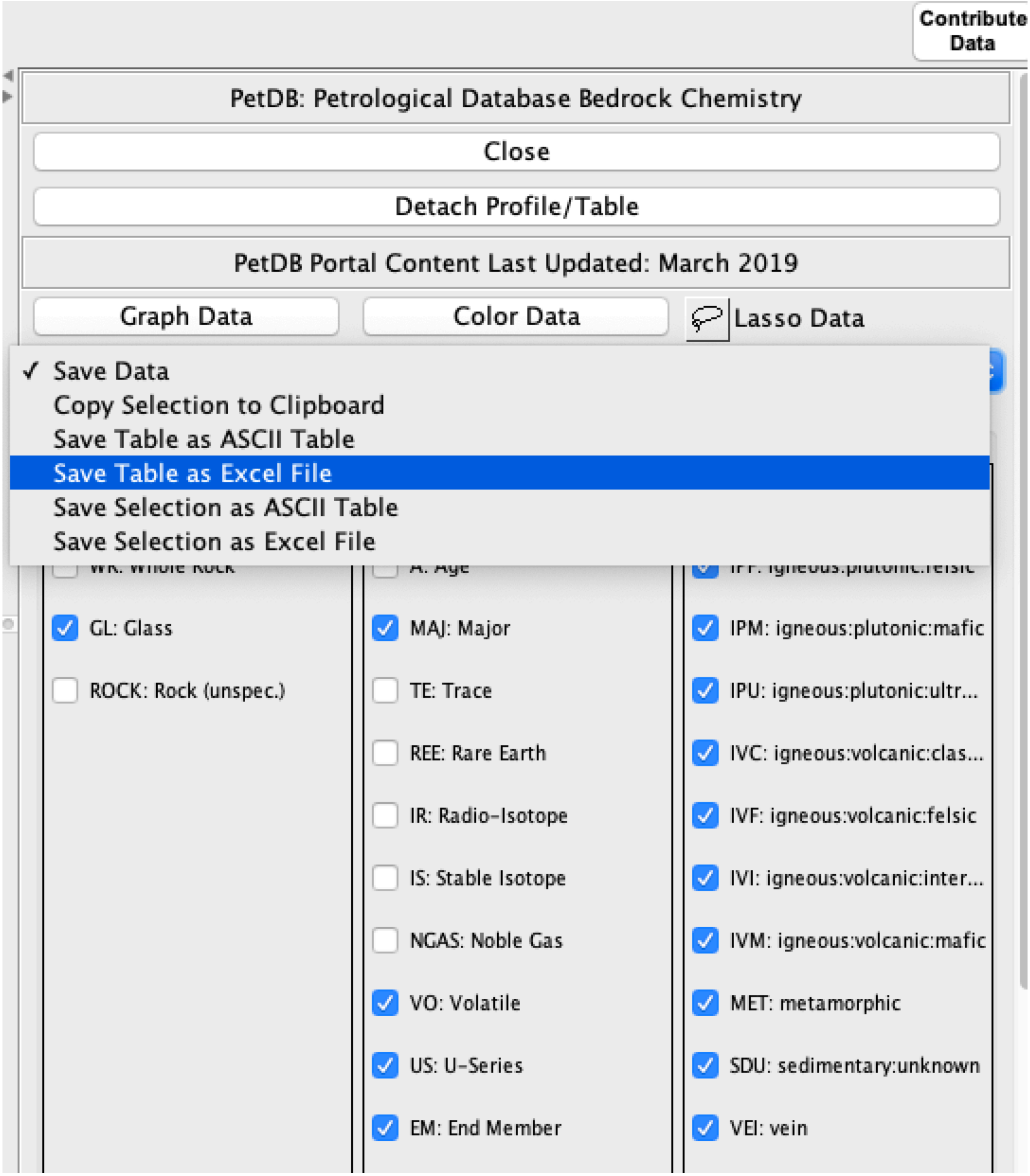
4. Testing Klein and Langmuir (1987)

Step 1: Open the PetDB portal (Portals > PetDB (Composition of the Oceanic Volcanic Crust)) this will plot a list of the PetDB sample analyses currently available along the mid-ocean ridge you are going to study (Group 1. East Pacific Rise (EPR); Group 2. Juan de Fuca Ridge (JdFR) and the Gorda Ridge (GR); Group 3. Mid-Atlantic Ridge (MAR)) into the GeoMapApp Window. Are there regions of the EPR that are more densely sampled than others? Where do there appear to be major gaps in sample collection, if anywhere?



Step 2: Now zoom back in on the study area so that you have ~ 1° of distance on either side of the transform faults. You will see circles throughout the area. These are locations where samples have been collected. We don't want all of the samples. Today we are going to make a plot similar to the depth vs composition plots from Klein and Langmuir. To this, we want only glass analyses and major element data.

Step 3: To view the available data, click on "Compiled Chem" in the window below the map. Save the data as excel spreadsheet.


Contribute Data
PetDB: Petrological Database Bedrock Chemistry
Close
Detach Profile/Table
PetDB Portal Content Last Updated: March 2019
Graph Data
Color Data
Lasso Data
✓ Save Data
Copy Selection to Clipboard
Save Table as ASCII Table
Save Table as Excel File
Save Selection as ASCII Table
Save Selection as Excel File
GL: Glass
ROCK: Rock (unspec.)
MAJ: Major
TE: Trace
REE: Rare Earth
IR: Radio-Isotope
IS: Stable Isotope
NGAS: Noble Gas
VO: Volatile
US: U-Series
EM: End Member
IPM: igneous:plutonic:mafic
IPU: igneous:plutonic:ultr...
IVC: igneous:volcanic:clas...
IVF: igneous:volcanic:felsic
IVI: igneous:volcanic:inter...
IVM: igneous:volcanic:mafic
MET: metamorphic
SDU: sedimentary:unknown
VEI: vein

Use Pandas to read spreadsheet

pandas is an easy-to-use data structures and data analysis tools.

10 minutes to pandas(https://pandas.pydata.org/pandas-docs/stable/getting_started/10min.html (https://pandas.pydata.org/pandas-docs/stable/getting_started/10min.html))

In [5]:
```
import pandas as pd
Chem = pd.read_excel("PetDB_Export.xls")
Chem.head(3)
```

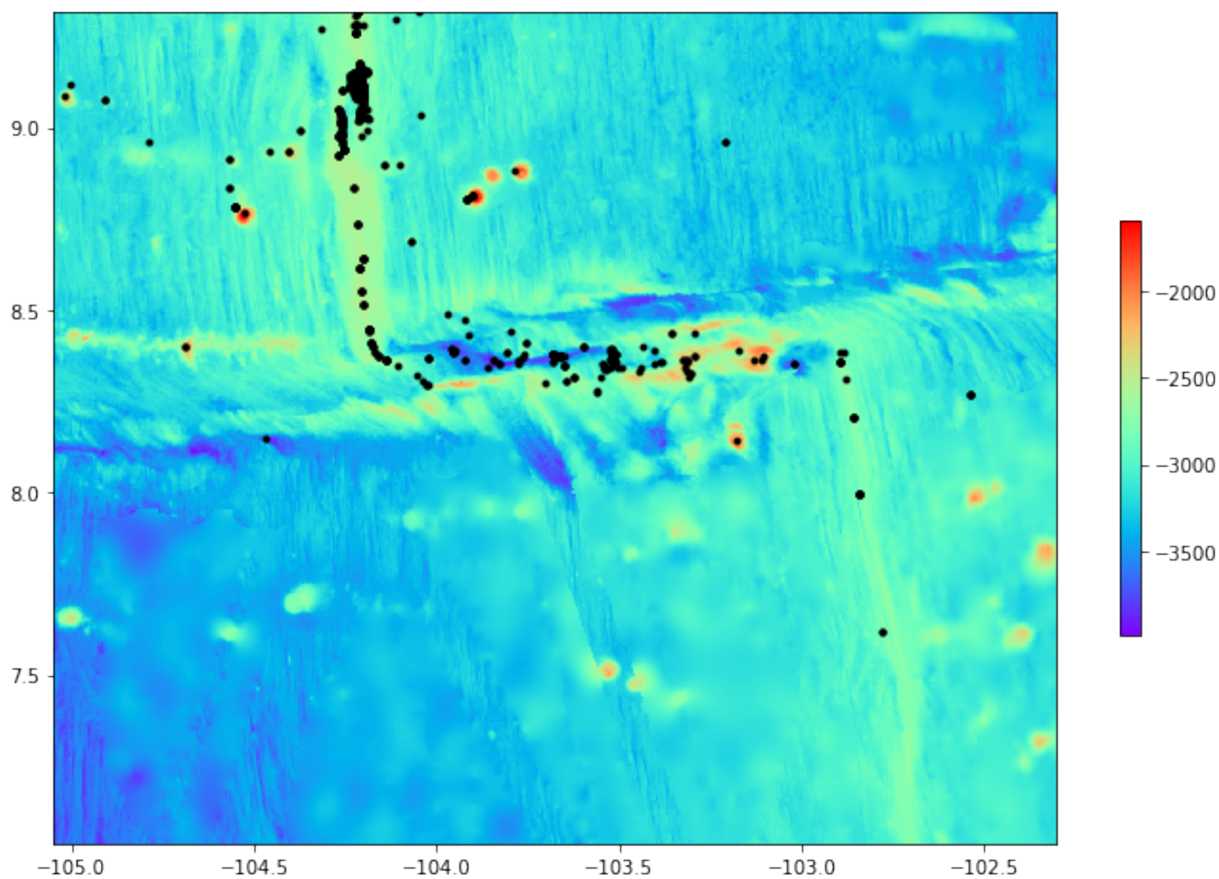
Out[5]:

	Sample ID	Latitude	Longitude	SiO2 (wt%)	TiO2 (wt%)	Al2O3 (wt%)	Cr2O3 (wt%)	Fe2O3 (wt%)	Fe2O3T (wt%)	FeO (wt%)	...	T
0	WASRAI2-007-013	8.145	-103.178	50.45	1.05	14.96					...	
1	WASRAI2-008-002	8.353	-103.023	51.42	1.51	14.19					...	
2	WASRAI2-008-008	8.353	-103.023	50.81	1.51	14.18					...	

3 rows × 52 columns

Plot geochemical sample location

In [6]:
```
fig2 = plt.figure(2,figsize=(12,8))
# plot bathymetry
plt.imshow(Bath["data"],
           extent=[Bath["x"].min(),
                  Bath["x"].max(),
                  Bath["y"].min(),
                  Bath["y"].max()],
           cmap="rainbow"
          )

# plot sample points
plt.plot(Chem.Longitude.values,
         Chem.Latitude.values,
         'k.')

# the range of the plot
plt.xlim([Bath["x"].min(), Bath["x"].max()])
plt.ylim([Bath["y"].min(), Bath["y"].max()])

# add a colorbar
plt.colorbar(shrink=0.5)
plt.show()
```



Interpolate the bathymetry to get the depth of the samples

Using interpolate from scipy

SciPy (pronounced “Sigh Pie”) is a Python-based ecosystem of open-source software for mathematics, science, and engineering. [https://www.scipy.org (https://www.scipy.org)](https://www.scipy.org)

In [7]:
```
from scipy import interpolate
f = interpolate.interp2d(Bath["x"], Bath["y"], Bath["data"])
Depth = np.diag(f(Chem.Longitude.values, Chem.Latitude.values))
```

Get the geochemical data

Note: in the Excel, the geochemical data is stored as text, not numbers. Use pandas.to_numeric to convert the texts to numbers for calculation and plots.

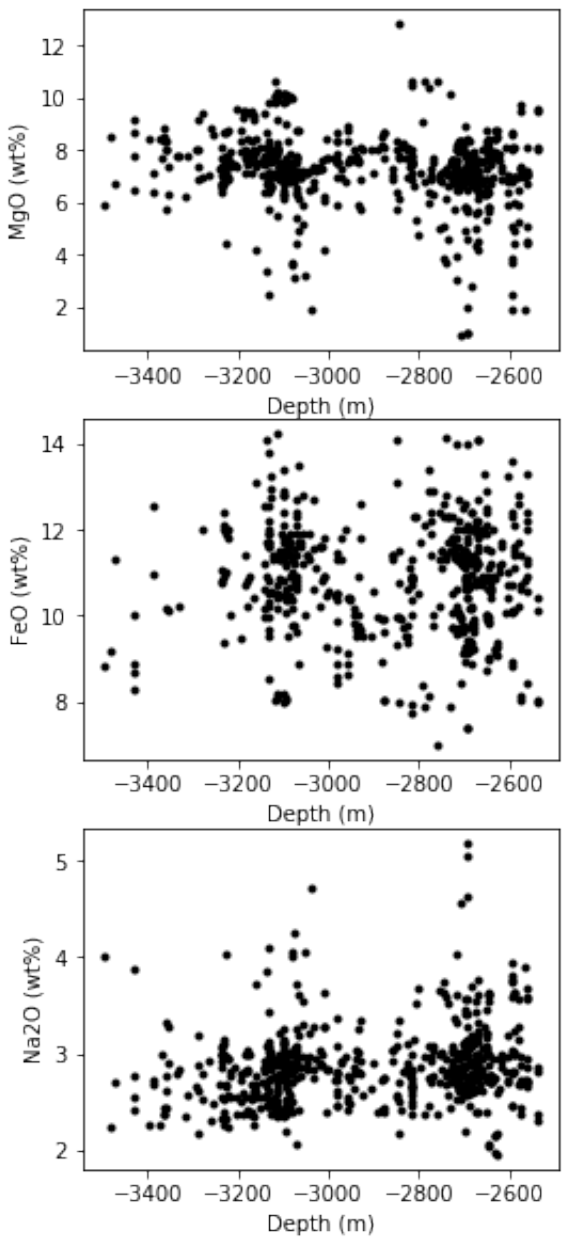
In [8]:
```
MgO = pd.to_numeric(Chem["MgO (wt%)"].values, errors='coerce')
FeO = pd.to_numeric(Chem["FeOT (wt%)"].values, errors='coerce')
Na2O = pd.to_numeric(Chem["Na2O (wt%)"].values, errors='coerce')
```

Plot the Geochemical data vs. Depth

Answer the question:

How do these plots compare to Klein and Langmuir? What did you expect to see?

In [9]:
```
fig3 = plt.figure(3, figsize=(4,10))

plt.subplot(311)
plt.plot(Depth, MgO, 'k.')
plt.xlabel("Depth (m)")
plt.ylabel("MgO (wt%)")

plt.subplot(312)
plt.plot(Depth, FeO, 'k.')
plt.xlabel("Depth (m)")
plt.ylabel("FeO (wt%)")

plt.subplot(313)
plt.plot(Depth, Na2O, 'k.')
plt.xlabel("Depth (m)")
plt.ylabel("Na2O (wt%)")

plt.show()
```



In [ ]: