Text of Theme 2,

Practicing desktop study,
Expert Meeting on Technical Matters regarding the Outer Continental Shelf.

March 9, 2006

1. INTRODUCTION

1-1. Aim of the Theme

- ✓ Making some maps which could contribute desktop studies on the establishment of the outer limit of continental shelf beyond 200 NM using readily available bathymetric data.
- ✓ To make those maps, you will experience the Generic Mapping Tools (GMT) step by step. GMT is an open source collection, which manipulates geographic data sets and produces PostScript File of varies sort of maps.

1-2. Why Do We Use GMT ?

- ✓ GMT is free softoware.
- ✓ GMT ~~easily~~ installs on almost any computer; Windows, Lunux, Machintosh, ...
- ✓ Output of GMT is high quality PostScript.

1-3. Applications installed in your PC

In this theme, you will use following applications.

- ✓ **GMT ver. 3.4.5**: Map making tools (free software). Current version is 4.1.1
  http://gmt.soest.hawaii.edu/
- ✓ **GSview ver. 4.7** with **Ghostscript ver. 8.5.3**: Graphical interface for Ghostscript. Ghostscript is an interpreter for the PostScript page description language. (free software)
  http://www.cs.wisc.edu/~ghost/index.htm
- ✓ **Notepad** : Basic text editor (attached to MS Windows OS).
- ✓ **Command prompt window**: A window displayed on the desktop used to interface with the MS-DOS operating system (attached to MS Windows OS).

1-4. Documentation of GMT

GMT Online Services gives access to four sets of useful documentation of GMT ver.4 at the following web-page.

http://gmt.soest.hawaii.edu/
(When the GMT homepage opens, click "DOCS" in the left sub-window.)

The documentation of GMT ver. 3.4.5 is saved in '`C:\seminar\tools\GMT Manual`' (and in your CD-R distributed maybe.) You will find that GMT has so many functions to see the documentation. In

this seminar, we will overview only elementary functions of GMT in the interest of time.

2. How to Make Maps Using GMT?

In this section you will learn about workflow of making maps using GMT and go through a hands-on experience of it.

2-1. Workflow

The workflow of making maps by using GMT is as follow:

1. Preparing input data,
2. Writing a GMT batch script using a text-editor,
3. Executing the GMT batch script in the MS-DOS command prompt. And then it generates a map image described in PostScript format.
4. Displaying and printing out the map image (for example by using GSview).

2-2. Demonstration

(A demonstration will be done.)

2-3. Exercise 1:

To experience what has been demonstrated now, read and complete the following instructions:

1. Open the working folder which is located at C:\seminar\theme2\work. To do that, simply double-click the following folders in its order: **shortcut to seminar** > **theme2** > **work**, where the **shortcut to seminar** is located on the desktop.

2. Open the batch script file by **Notepad**. To do that, right-click on `go.bat` in the **work** folder window, and select **edit**. An edit display of `go.bat` appears. In the display, get a grasp of what GMT batch script is.

3. Open a MS-DOS command prompt. To do that, double-click on the **command prompt** icon located on the desktop. A command prompt window appears.

4. On the command prompt, change the current directory (or folder) to our working directory: `C:\seminar\theme2\work`. To do that, type

   ```
   cd c:\seminar\theme2\work
   ```

   and then press the enter key. Make certain that the last line of the command prompt becomes "`C:\seminar\theme2\work >`"

5. Execute GMT batch script. To do that, type `go.bat` on the command prompt and press the enter key. Some information flows in the command prompt. Make sure that `map.ps` which is a map image file is created in the work folder.

6. Display the map created. To do that, double-click the file `map.ps`. A GSview window displaying a map appears.

3. First Step of Using GMT –Making Base Map-

In this section, you will learn about each GMT commands one by one used in the above batch script.

3-1. Drawing a Basemap Frame –psbasemap-

3-1-1. Example of how psbasemap is used in go.bat.

```
psbasemap -V -K -R121/150.25/20/51.5 -JM18c -Ba1g1f0.2 > map.ps
```

3-1-2. Description

psbasemap creates a mapframe. You can specify the map region of interest, map projection, and separate tickmark intervals for boundary annotation, gridding, and ticking.
No space between the option flag and the associated arguments. Use upper case for the option flags.

-R	Specify the map region of interest by geographic coordinates. Its form is *-Rwest/east/south/north*. They are specified in decimal degrees in the above example. A longitude of the western hemisphere is set to a counterclockwise angle from the Greenwich meridian (ex 150W → 210, 161.4W → 198.6). A latitude of south hemisphere is a negative value of it (ex. 23S → -23).
-J	Select the map projection and set map width (or scale). In the above example -JM18c, M sets that the map projection is Mercator, and 18c that the map width is 18cm.
-B	Set boundary annotation, gridding and ticking intervals. In the above example '-Ba1g1f0.2', a1 sets that the annotation interval is 1 degree, g1 that the gridding interval is 1 degree, and f0.2 that the ticking interval is 0.2 degrees.
>	GMT programs write their output to the terminal. '>' makes a new file and redirects the output into the file. In the above example > map.ps, a file map.ps is created and the output stream produced by psbasemap is writen into map.ps. It is not a GMT function but MS-DOS. (Unix also has the same function.)

3-1-3. Exercise 2:

Make a new map whose annotation interval is 5 degrees, gridding interval 5 degrees, and ticking interval 1 degree, by editing the batch script go.bat. To do that you can refer the following instructions.

1. Open go.bat by Notepad.
   (It may already be open. If not, right-click on go.bat in the work folder window, and select edit.

An edit display of `go.bat` appears.)

2. In the line of **psbasemap**, change `-B` option so as to satisfy the above direction.

   Hint: `-Ba5g5f1`

3. Save the changed file.

4. Execute the changed batch script. To do that, in the command prompt, type `go.bat` and press the enter key.

   (If the command prompt has not been opened, double-click on **command prompt** located on the desktop, type `cd c:\seminar\theme2\work` in it, and then press the enter key. Make certain that the last line of the command prompt is `C:\seminar\theme2\work >`.)

5. Display the map. If '`map.ps`' has already been opened by GSview, simply click on the window and activate it. Then GSview automatically load the new data. If not, double-click the file '`map.ps`' located in our working folder.

3-2. Drawing Coastlines and Painting Land Areas -pscoast-

3-2-1. Example of how pscoast is used in go.bat.

```
pscoast  -V -K -O -R -JM -Dc -W >> map.ps
```

3-2-2. Description

pscoast draws coastlines and paint land areas by a color. GMT has built-in coastline data. The datafiles come in 5 different resolutions: (**f**)ull, (**h**)igh, (**i**)ntermediate, (**l**)ow, and (**c**)rude.

-R	Specify the map region of interest by geographic coordinates as described in the previous section. If attached parameters are not supplied like the above example, GMT program get them from the previous command lines using the same argument. In this case, **pscoast** uses `-R121/150.25/20/51.5`, because the `-R` argument is already used with parameters `121/150.25/20/51.5` in the previous **psbasemap** line.
-J	Select the map projection and set map width (or scale). If attached parameters are not supplied like the above example, GMT program get them from the previous command lines using the same argument. In this case, **pscoast** uses `-JM18c`, because the `-JM` argument is already used with parameters `18c` in the previous **psbasemap** line.
-D	Selects the resolution of the data set to use from (**f**)ull, (**h**)igh, (**i**)ntermediate,

	(l)ow, and (c)rude. In the above example `-Dc`, the crude resolution is selected.
-W	Draw coastlines.[Default is no coastlines.]
-G	Paint land areas by a color. The color is specified by the RGB system. Its form is `-Gred/green/blue`' Examples: `-G0/0/0` black `-G255/0/0` red
>>	GMT programs write their output to the terminal. >> redirects and append it to the existing file specified. (Notice the deference from >.) In the above example >> `map.ps`, the output stream produced by `pscoast` is writen after the end of `map.ps`. It is not a GMT function but MS-DOS. (Unix also has the same function.) If you use > but >>, the PostScript data created by the previous commands will be deleted.

3-2-3. Exercise 3:

Make a new map whose coast lines are highest resolution, by editing the batch script file `go.bat`. To do that you can refer the following instructions.

1. Open `go.bat` by Notepad.
2. In the line of **`pscoast`**, change `-D` option so as to draw coastlines with highest resolution.

   Hint: `-Df`
3. Save the changed file.
4. Execute the changed batch script. To do that, in the command prompt, type `go.bat` and press the enter key.
5. Display the map. If '`map.ps`' has already been opened by GSView, simply click on the window and activate it. Then GSView automatically load the new data. If not, double-click the file '`map.ps`' located in our working folder.

3-2-4. Exercise 4:

Paint the land areas by magenta

Hint 1: Complete the same procedure as the exercise 3.

Hint 2: Append `-G` option in the line of **`pscoast`**. See above for details regarding `-G`.

Hint 3: The RGB code of magenta is 255/0/255.

3-3. Plotting Text on Maps -`pstext`-

3-3-1. Example of how pscoast is used in go.bat.

```
echo 0 0 14 0 0 LB write your name here | pstext -V -O -R0/100/0/100
-Jx1 -Y-1.6c >> map.ps
```

3-3-2. Description

You can plot text using **pstext**. I don't explain **pstext** in detail in the interest of time. But you can find the text string "*write your name here*" in the above line and you can also find that the same text string is plotted at the lower left of your map. (Check it now.) As you are aware, if you change this text string to one you want, it will be plotted at the same place of the map.

3-3-3. Exercise 5:

Plot your name at the lower left of the map. Check it in the GSview window.

Hint 1: Complete the same procedure as the exercise 3 or 4.

Hint 2: Rewrite "*write your name here*" to your name in the last line of `go.bat`.

3-4. Selecting Page Orientation etc -gmtset-

3-4-1. Example of how page orientation is changed in go.bat.

```
gmtset PAGE_ORIENTATION landscape
```

3-4-2. Description

gmtset changes individual GMT default parameters. Its form is **gmtset** *PARAMETER value*. You can change page orientation of your map by setting the parameter PAGE_ORIENTATION, where you can select one from landscape and portrait. There are 58 parameters which **gmtset** can change. See the **gmtdefaults** manual page for more information.
In the above example, the page orientation is set to landscape.

3-4-3. Exercise 6:

Change the page orientation of your map to portrait. Check it in the GSView display.

3-4-4. Exercise 7:

Adjust your map size to the display (or page) size.

Hint 1: Now '-JM18c' in the **psbasemap**'s line in `go.bat` sets your map width to 18cm. Change it so as to adjust your map size to the page size.

3-5. Misc – –K & –O options-

If more than two GMT commands make one map, you must put -K and/or –O options as below;

in the first command line,	set –K option,
in the last command line,	set –O option,
in the interim command lines	set both of –K and –O options.

3-5-1. Example of how –K and –O options are used in go.bat.

```
psbasemap -V -K -R121/150.25/20/51.5 -JM18c -Ba1g1f0.2 > map.ps

pscoast  -V -K -O -R -JM -Dc -W >> map.ps

echo 0 0 14 0 0 LB write your name here | pstext -V -O -R0/100/0/100
-Jx1 -Y-1.6c >> map.ps
```

4. Making Various Maps of Your Country

4-1 Making a Coastline Map of the Region of Your Country

4-1-1. Exercise 8:

Make a new map whose region includes your country by completing the following steps:

1. Decide the map borders of interest by geographic coordinates.
   You can refer the blank map on your desk. The borders should be at least 350 nautical miles (or about 6 degrees) away from territorial sea base lines of your country. A longitude of the western hemisphere is set to a counterclockwise angle from the Greenwich meridian (ex 150 degrees west → 210 = 360 – 150). A latitude of south hemisphere is a negative value of it (ex. 23 degrees south → –23).

2. Select the page orientation from landscape and portrait.

3. Specify the new map region and page orientation in your batch script `go.bat`.

   Hint: `-R` option specifies the map region of interest. Its form is `-Gwest/east/south/north`.

4. Execute the batch script and display the new map.

5. Adjust your map size to the display (or page) size

   Hint: `-J` option sets the map width. For example, `-JM18c` sets the map width in 18 cm.

4-1-2. Exercise 9:

Print out the map by GSView. To do that, click on **print** in **file** menu of GSview window. When the Print window opens, click on **OK** button.

4-2. Drawing a Topographic Colored Image onto Your Map Using the ETOPO2 Gridded Global Elevation/Bathymetry Data -grdimage-

To draw a topographic map, you must prepare some 2-D gridded elevation/bathymetric data. In this section, we use ETOPO2 which is 2-minute gridded data for both ocean and land areas provided by the National Geographical Data Center (NGDC), NOAA.

4-2-1. Example of the usage of grdimage

```
grdimage gridfile -V -K -O -R -JM -B -Ccptfile -Iintensfile >> map.ps
```

4-2-2. Description

grdimage reads one 2-D grid file and produces a topographic colored image. A color palette table specifies the correspondence between elevation (or depth) and color. **grdimage** creates a shade map if an intensity file is provided.

gridfile	2-D gridded data set to be imaged.
-C	specify the file name of the color pallet table
-I	specify the file name of the intensity file to make a shade map.

4-2-3. Exercise 10

Draw a topographic image on your map. Input data are already prepared in **data** folder and its file-names are listed below.

list of the file-names of input data

File Type	for the eastern hemisphere	for the western hemisphere
2-D gridded data (*gridfile*)	`data\etopo2e.grd`	`data\etopo2w.grd`
intensity data (*intensfile*)	`data\etopo2e.int`	`data\etopo2w.int`
color palette table (*cptfile*)	`data\world.cpt`	

Hint: Add the following 2 lines just below the line of **psbasemap** in `go.bat`. (If all your map region is contained within the eastern hemisphere, you just have to add only the first line, and vice versa.)

```
grdimage data\etopo2e.grd -V -K -O -R -JM -B -Cdata\world.cpt
-Idata\etopo2e.int >> map.ps

grdimage data\etopo2w.grd -V -K -O -R -JM -B -Cdata\world.cpt
-Idata\etopo2w.int >> map.ps
```

4-2-4. Exercise 11

Change the name of cptfile to '`data\dpt.cpt`'.

Hint: `-Cdata\dpt.cpt`

4-3. Drawing Counter Lines –grdcontour—

You can draw counter lines from a 2-D gridded file using GMT program **grdcounter**.

4-3-1. Example of the usage of grdcontour

grdcontour *gridfile* -V -K -O -R -JM -C100 -L-10000/0 -A500f3 >> map.ps

4-3-2. Description

grdcontour reads a 2-D gridded file and produces a contour map by tracing each contour through the grid.

gridfile	2-D gridded data set ot by contoured.
-C	Specify a contour interval. In the above example, '-C100' set the contour interval to 100 m.
-L	Specify the limit range. In the above example, '-L-10000/0' specifies to draw contours only between -10000 m and 0 m.
-A	Specify the annotation interval. In the above example, '-A500f3' set that the annotation interval is 500m and the font size of annotations is 3 pt.

4-3-3. Exercise 12

Draw contour lines every 500m between -10000 m and 0 m, annotate every 2000m (using fontsize = 3), using grid files data\etopo2e.grd and data\etopo2e.grd. When you have finished, print out the map.

Hint: Add the following 2 lines just below the line of **grdimage** in go.bat. (If your entire map region is contained within the eastern hemisphere, you just have to add only the first line, and vice versa.)

```
grdcontour data\etopo2e.grd -V -K -O -R -JM -C500 -L-10000/0
-A2000f3 >> map.ps
grdcontour data\etopo2w.grd -V -K -O -R -JM -C500 -L-10000/0
-A2000f3 >> map.ps
```

4-4. Drawing Counter Lines of Sediment Thickness

There are prepared a 2-D grid data of sediment thickness distributed by NGDC. Its data structure is same as ETOPO2 elevation/bathymetric grid. So you can draw contour lines of sediment thickness just like in case of ETOPO2.

4-4-1. Exercise 13

There is a 2-D gridded file of sediment thickness in **data** folder whose name is data\sedthick_world.grd. Draw white contour lines of the sediment thickness every 200m between 0 m and 10000 m, annotate every 1000 m (using fontsize = 3). When you have finished, print out the map.

Hint: Add the following line just below the line of **grdcontour** in go.bat.

```
grdcontour data\sedthick_world.grd -V -K -O -R -JM -C200 -L0/10000
-A1000f3 -Wa9/255/255/255 -Wf3/255/255/255 >> map.ps
```

Hint: In the above line, `-W` argument set the width and color of the contour lines.

4-5. Drawing GEODAS Tracklines –psxy—

You downloaded GEODAS trackline data from the web-page of NGDC in Theme 1. You will draw the track lines on your map using GMT program **psxy**. There are three columns in a trackline data file but **psxy** uses only the first two columns, that is, longitude and latitude.

4-5-2. Exercise 15

Draw the trackline you have downloaded on your map, by going through the following steps.

1. Make a folder **track** in your working folder.
2. Copy the trackline data files into the folder **track**.
3. Copy the batch script `go.bat` to `track.bat`.
4. Add the following line just below the line of **grdcontour** in `track.bat`.

```
psxy track\*.xyz -V -K -O -R -JM -W3/255/0/0 -M -A >> map.ps
```

5. Execute `track.bat` and display `map.ps`.

5. About Other Bathymetric Data Sources

In the previous section, you have made bathymetric images using ETOPO2 data. In this section, you will make bathymetric images using other data sources, the GEBCO 1-minute global bathymetric grid and the trackline bathymetric navigation data provided by GEODAS of NGDC.

5.1 Making a Gridded File from GEODAS Trackline Data and Drawing Its Bathymetric Image.

Trackline bathymetric data obtained from GEODAS consists of arbitrary located (longitude, latitude, depth) points. You can make a 2-D gridded file from such (x, y, z)-format data executing a prepared batch script `makegrid.bat`, which is a combination of some GMT programs. The explanation will be skipped to save time. If you are interested, it would be good fun analyzing the batch script referring the GMT manual.

5-1-1. Exercise 15

Make 2-D gridded files from GEODAS trackline bathymetric data, by going through the following steps.

1. Confirm that the files of GEODAS trackline bathymetric data which you have downloaded are saved in **track** folder under **work** folder. If not, copy them to **work** folder.
2. Execute makegrid.bat in the command prompt (type makegrid.bat and press the enter key.). Then following 4 files are made in **data** folder.
    - `geodas-e.grd` and `geodas-e.int` for the east hemispher,
    - `geodas-w.grd` and `geodas-w.int` for the west hemispher

5-1-2. Exercise 16

Draw a bathymetric image using the GEODAS grid files you have just made. You have already drawn the same sort of images using the ETOPO2 grid file. So all you have to do is to change arguments of grid-file name and intensity-file name in the patch script used then.

1. Open `go.bat` by Notepad. (Right-click `go.bat` and select **edit**.)
2. In the lines of **grdimage**, change the arguments of grid-file and intensity-file to `data\geodas-e.grd` and `data\geodas-e.int` and/or `data\geodas-w.grd` and data\geodas-e.int like the below lines

```
grdimage data\geodas-e.grd -V -K -O -R -JM -B -Cdata\dpt.cpt
-Idata\geodas-e.int >> map.ps

grdimage data\geodas-w.grd -V -K -O -R -JM -B -Cdata\dpt.cpt
-Idata\geodas-w.int >> map.ps
```

3. In the lines of **grdcontour**, change the argument of grid-file to `data\geodas-e.grd` and/or `data\geodas-w.grd` like below line.

```
grdcontour data\geodas-e.grd -V -K -O -R -JM -C500 -L-10000/0
-A2000f3 >> map.ps

grdcontour data\geodas-w.grd -V -K -O -R -JM -C500 -L-10000/0
-A2000f3 >> map.ps
```

4. Execute `go.bat`.

5. Display `map.ps` and print out it.

5-2 Drawing a Bathymetric Image of GEBCO Grid Data

In this section you make a bathymetric image using "The GEBCO Digital Atlas published by the British Oceanographic Data Centre on behalf of IOC and IHO, 2003."

5-2-1. Exercise 17

Specify map region of interest in a new batch file `gebco.bat`, execute it on the command prompt, display `man.ps`, and print out it.

5-3 Comparing Characteristics of Bathymetric Images Made from Different Data Sources.

(Discussion)