GMT examples:

Plotting the ages of oceanic crust

Michael Grund
(Email: mgrund_info@gmx.de)

Karlsruhe Institute of Technology (KIT), Geophysical Institute, Karlsruhe, Germany

General information

If you make use of the content described in this manual please give reference to my dissertation in whose framework the presented map was developed:

> **Grund, M. (2019)**, *Exploring geodynamics at different depths with shear wave splitting*, Karlsruhe Institute of Technology (KIT), http://doi.org/10.5445/IR/1000091425.

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1 Plotting the map

In this manual I provide GMT (Generic Mapping Tools, e.g. Wessel et al., 2013) instructions to go from a raw map in a global Robinson projection to a publication-ready figure that displays the ages of oceanic lithosphere.

All content shown in the following is based on the bash-script `GMT_PLOT_ages.gmt` that can be downloaded together with all required files (colormaps etc.) from https://github.com/michaelgrund/GMT-plotting. The used seafloor age data of Müller et al. (2008) was downloaded from ftp://ftp.earthbyte.org/earthbyte/agegrid/2008/Grids/. Scientific colormaps are provided by Fabio Crameri (Crameri, 2018a,b) and were downloaded from http://www.fabiocrameri.ch/colourmaps.php. Matplotlib colormaps (originally developed by Nathaniel J. Smith, Stefan van der Walt, and (in the case of viridis) Eric Firing)

converted to GMT's cpt format were downloaded from http://soliton.vm.bytemark.co.uk/pub/cpt-city/mpl/index.html. Further information about these colormaps can be found at https://bids.github.io/colormap/.

If GMT 5.2.1 (or higher, Wessel et al., 2013) is installed on your (Linux) system you can directly reproduce the whole content shown in this manual by running `GMT_PLOT_ages.gmt` via command line. In the following the individual steps to get the final figure are lined out. Detailed comments on each step are included in the code blocks (gray boxes). Since the final GMT output is stored in a postscript file (`*.ps`), a pdf converter such as `ps2pdf` (see bottom of the last code block) should be installed on your system. Furthermore, to get a figure without white spaces around the plot, I recommend to install `pdfcrop` from Heiko Oberdiek (can be downloaded from https://ctan.org/pkg/pdfcrop?lang=de).

1.1 Basic settings

```
#!/bin/bash

gmtset  MAP_GRID_PEN_PRIMARY 0.3p,dimgrey \
        PROJ_LENGTH_UNIT c \
        MAP_ANNOT_OBLIQUE 30 \
        MAP_ANNOT_OFFSET 0.1i \
        MAP_ANNOT_OFFSET_PRIMARY 5p \
        MAP_ANNOT_OFFSET_SECONDARY 5p \
        COLOR_MODEL rgb \
        FONT_ANNOT_PRIMARY 8p,Helvetica \
        FONT_LABEL 8p \
        MAP_FRAME_WIDTH 2p \
        MAP_FRAME_PEN 1.2p \
        COLOR_BACKGROUND white \
        COLOR_FOREGROUND white \
        PS_CHAR_ENCODING Standard+ \
        MAP_TICK_LENGTH_PRIMARY 0i

################################################################################################
# GMT (5.2.1) script to plot the age of the oceanic crust in a global view
################################################################################################

# 2019, Michael Grund (KIT Karlsruhe, Geophysical Institute)

# Required files to run this script are included in the download directory.

################################################################################################
# If you use the content of this script or the accompanying files please acknowledge GMT
# and my PhD thesis (DOI: 10.5445/IR/1000091425).
################################################################################################

################################################################################################
# define output file name
outps=PLOT_GMT_age.ps

# viridis colormap file that is used to color-code the depths of the individual events
# (downloaded from http://soliton.vm.bytemark.co.uk/pub/cpt-city/mpl/tn/viridis.png.index.html)
# -M uses defined fore and background colors, -I reverses the colormap, define colormap
# between 0 and 180 millions of years (Ma) with increments of 10 years
makecpt -Cviridis.cpt -T0/180/10 -M -I > ageMG.cpt

# if you want to apply another colormap you can directly use the following ones
# which are included in the download package (just uncomment the corresponding line):

# makecpt -Cinferno.cpt -T0/180/10 -M -I > ageMG.cpt
# makecpt -Cdevon.cpt -T0/180/10 -M -I > ageMG.cpt
```

```
# makecpt -Clajolla.cpt -T0/180/10 -M > ageMG.cpt

###############################################################################################
# data containing the seafloor ages were downloaded from:
#
#       ftp://ftp.earthbyte.org/earthbyte/agegrid/2008/Grids/
#
# different formats are available, in the following we use the file <<< age.3.6.nc >>> that
# was unzipped from the downloaded <<< age.3.6.nc.bz2 >>>

###############################################################################################
```

1.2 Plot raw ages grid

```


##########
# Fig. 1 # plot age grid
##########

# recalculate ages in Ma since in <<< age.3.6.nc >>> they are given in absolute millions with
# lots of zeros ;)
grdmath age.3.6.nc=ns 0.01 MUL = age.3.6.grd=nf -V
infile_age=age.3.6.grd

# plot grid using a Robinson projection, centered at 0 degrees longitude and a size of
# 3.5i (-JN0/3.5i) between -180/+180 in longitude (-Rd), grid is color-coded with the
# defined colormap <<< ageMG.cpt >>> (-CageMG.cpt)
grdimage $infile_age -Rd -JN0/3.5i -P -K -CageMG.cpt > $outps

###############################################################################################
```

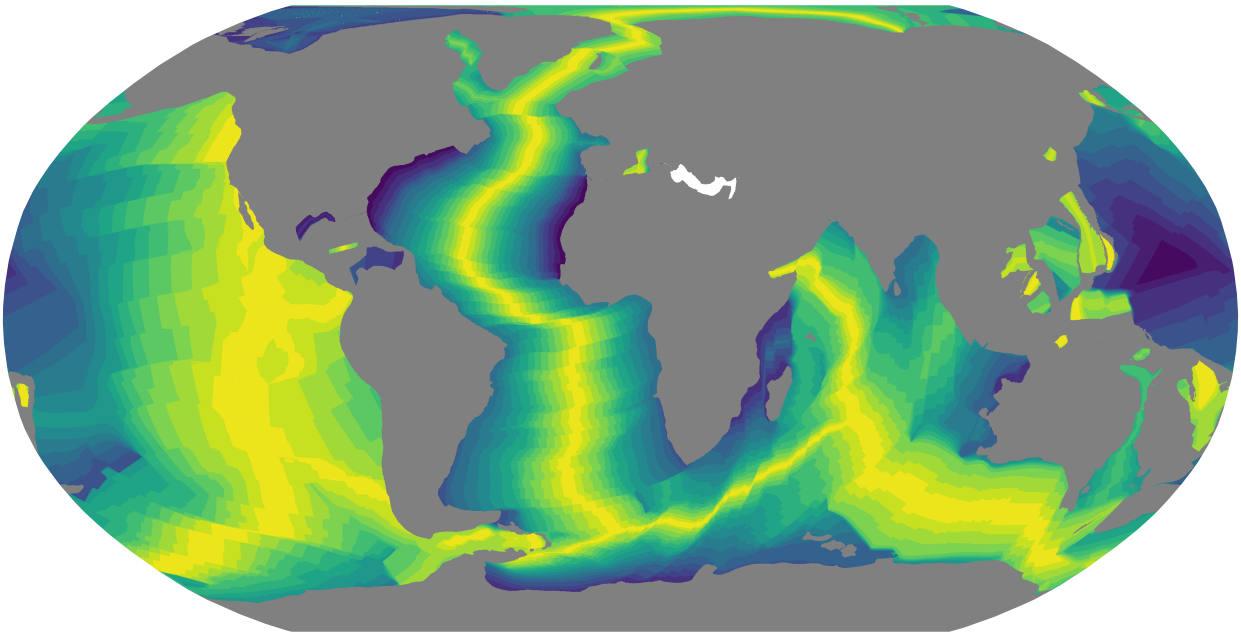

Figure 1: Plot grid of seafloor ages data (here colormap `viridis` is used) by Müller et al. (2008) on a global map in Robinson projection. Dark gray areas mark regions with not data points.

1.3 Plot the continents

```
##########
# Fig. 2 # plot continents
##########

# add continents, only plot objects with areas larger than 10000 km^2 (-A10000)
# add annotations and lat/lon gridlines (-Bx... and -By...), only annotate south axis (-BweSn)
col_cont=217.6/217.6/217.6
pscoast -R -J -Dc -G$col_cont -C$col_cont -K -O -P -A10000 -Bx90g30 -By30g15 -BweSn >> $outps

#########################################################################################################
```

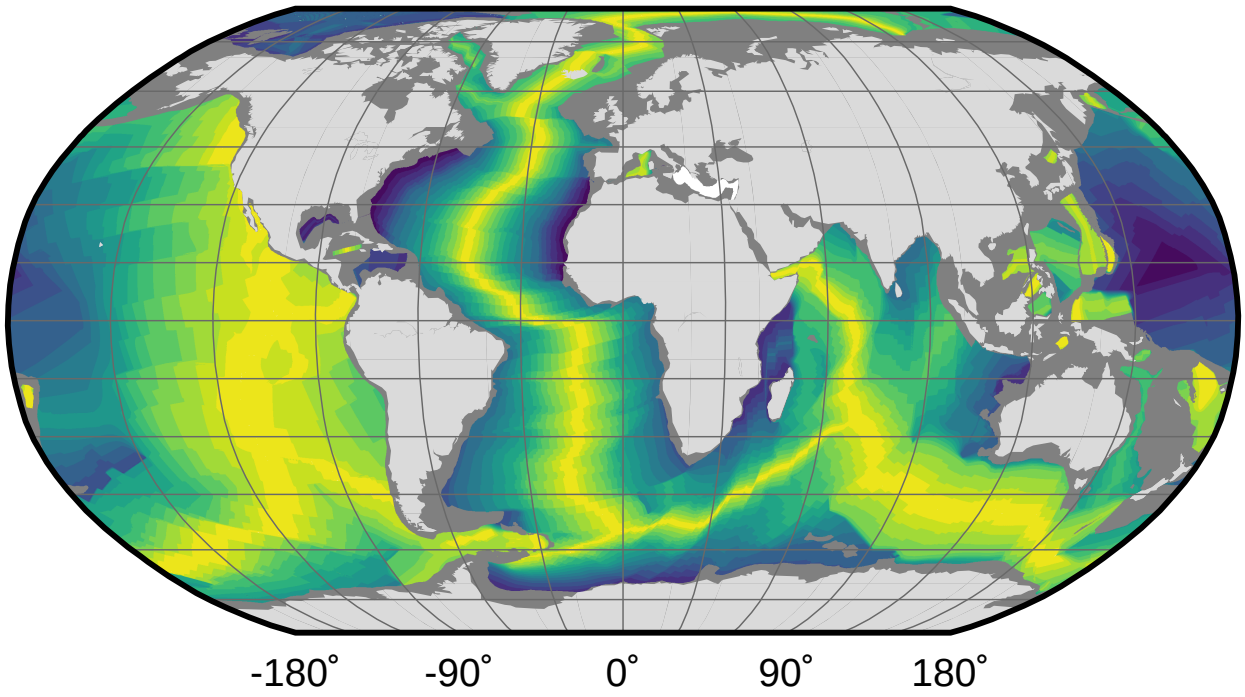

Figure 2: Plot the continents in light gray on top of the grid data. Add also annotations, gridlines and a map frame.

1.4 Plot the colorbar

```
##########
# Fig. 3 # plot the colorbar
##########

# adjust some settings for plotting the scale
gmtset MAP_ANNOT_OFFSET 0.14i
gmtset MAP_TICK_LENGTH_PRIMARY -0.1i
gmtset MAP_FRAME_PEN 1p

# plot the bar with annotation, foreground sidebar angle is added in white and specified
# in size (+ef0.06i), location and size of the bar is defined via -Dx, +h gives a horizontal bar
psscale -CageMG.cpt -Dx1.3/5.2+w2.5i/0.1i+ef0.06i+ml+h -Bxa20+l"Age of oceanic crust in Ma" \
    -O -K >> $outps

##########
ps2pdf $outps $outps.pdf
pdfcrop $outps.pdf $outps.pdf
```

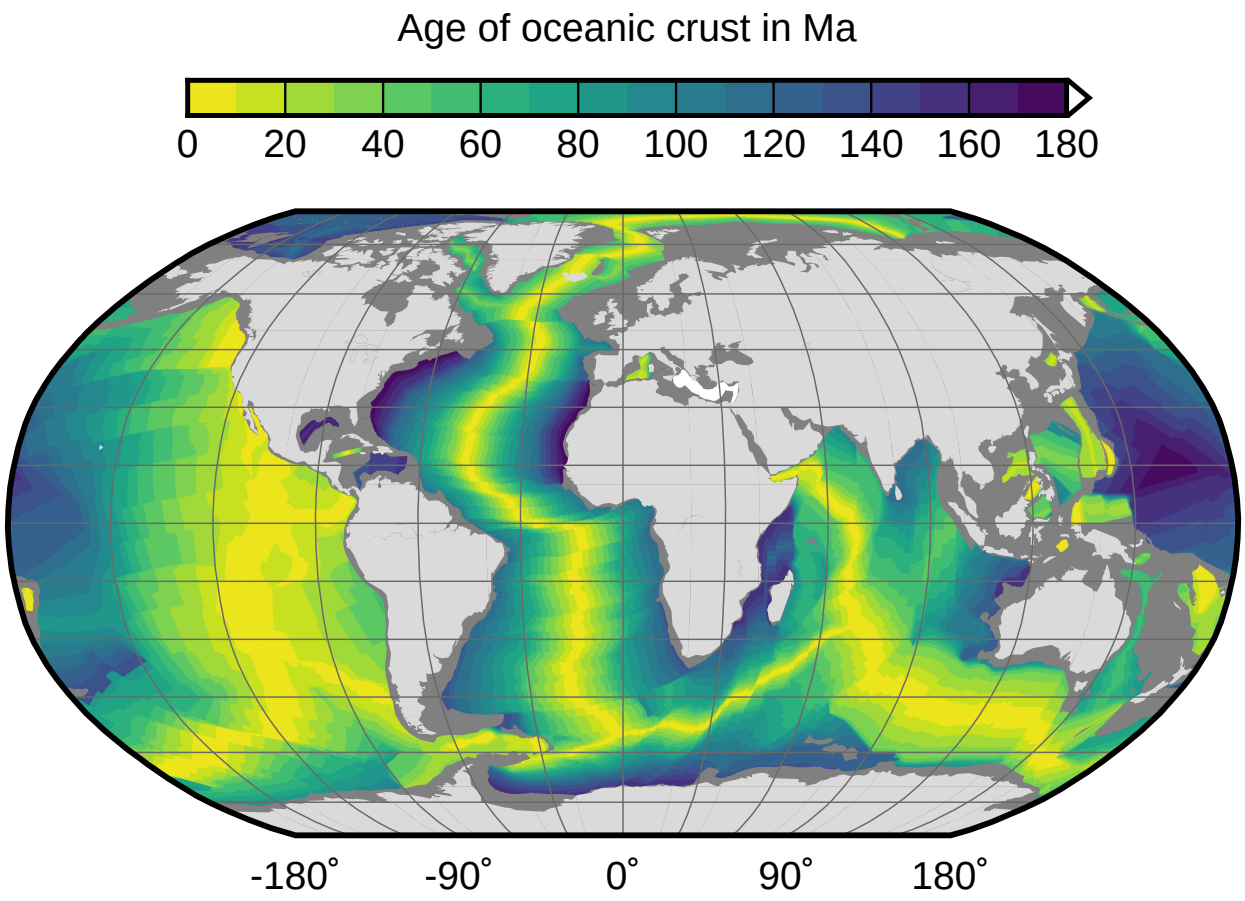

Figure 3: Plot the colorbar with annotations.

2 Using other colormaps

As mentioned in the beginning of this manual, of course you can also use other colormaps to plot the data. In principle each colormap available in (or converted to) GMT's cpt format can be used here. Fig. 4 displays four examples (including the one shown above) that can be easily reproduced by changing the `makecpt` command (see first code box, default is `viridis.cpt`). The corresponding colormap files for these four examples (`viridis.cpt`, `inferno.cpt`, `devon.cpt` and `lajolla.cpt`) are already included in the download package.

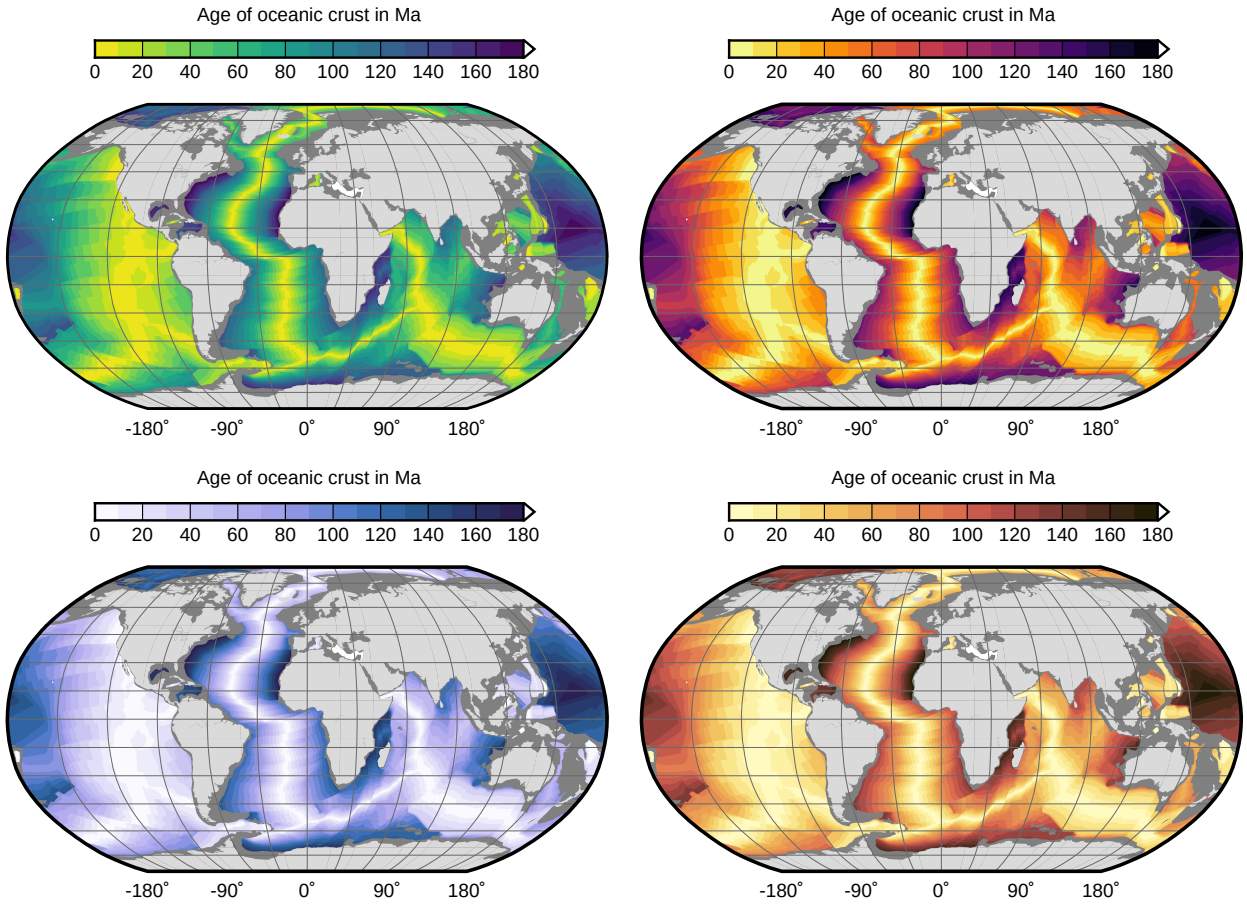

Figure 4: Using the Matplotlib colormaps (`viridis` and `inferno`), developed by Nathaniel J. Smith, Stefan van der Walt, and (in the case of viridis) Eric Firing, and the scientific colormaps (`devon` and `lajolla`) of Fabio Crameri (Crameri, 2018a,b) to plot the seafloor age data.

References

Crameri, F., 2018a. Scientific colour-maps, http://doi.org/10.5281/zenodo.1243862.

Crameri, F., 2018b. Geodynamic diagnostics, scientific visualisation and StagLab 3.0, *Geosci. Model Dev.*, **11**, 2541–2562, doi:10.5194/gmd–11–2541–2018.

Müller, R. D., Sdrolias, M., Gaina, C., & Roest, W. R., 2008. Age, spreading rates, and spreading asymmetry of the world's ocean crust, *Geochem. Geophys. Geosyst.*, **9**(4).

Wessel, P., Smith, W. H. F., Scharroo, R., Luis, J., & Wobbe, F., 2013. Generic Mapping Tools: Improved version released, *Eos Trans. AGU*, **94(45)**, 409–420.