Magellan
Program to Model Marine Magnetic Anomalies

Version 0.4

May 5, 2010

1 General Things About Magellan

Magellan is intended to become a state of the art forward marine magnetic program. It runs on all platforms (Linux, Mac/Os, Windows, etc.) and is written in the Python programming language. There is still a lot of work that has to be done on Magellan, but this 0.3 version is able to do basic modeling with several good features, including the capability to vary the magnetization along the profile with time. For further information about Magellan, visit `http://www.magellan-project.net`.

2 How to Install Magellan

2.1 Linux/Unix

To install Magellan follow the steps mentioned below.

1. You will first need to download Python v. 2.5 (do not install Python 2.6 because numpy doesn't work with it).
2. Magellan uses the matplotlib library and matplotlib uses the numpy package. After installing python download these two packages (they can both be found at `http://sourceforge.net`).
3. Download the Magellan zip and unzip it to the location you want it.
4. CD into the location of the unzipped Magellan folder. Type 'python setup.py install'
5. Magellan should now be installed. Try just typing 'magellan'. You should get the message 'No track data file given'.
6. Try running magellan with the data files that come with Magellan.

2.2 Mac OSX

To install Magellan follow the steps mentioned below.

1. You will first need to download Python v. 2.5 (do not install Python 2.6 because numpy doesn't work with it). There are a fair amount of websites that offer instructions on that (google 'Mac Os install python').
2. Magellan uses the matplotlib library and matplotlib uses the numpy package. After installing python download these two packages (they can both be found at `http://sourceforge.net`).
3. Download the Magellan zip and unzip it to the location you want it.
4. Open the command line prompt and cd into the magellan directory (where the setup.py file is).
5. Write python setup.py install.
6. Magellan will be installed at /Library/Frameworks/Python.framework/Versions/Current/bin/magellan and /Library/Frameworks/Python.framework/Versions/2.5/bin/magellan. The Mag folder will be installed at Library/Frameworks/Python.framework/Versions/2.5/lib/python2.5/site-packages and Library/Frameworks/Python.framework/Versions/Current/lib/python2.5/site-packages.
7. NOTE: I ran into a problem with numpy, pylab and matplotlib when I tried running Magellan. I got the error "No module named matplotlib". The Mac OSX operating system sometimes comes with matplotlib and numpy built in. I re-installed numpy, pytz, dateutil, matplotlib and setuptools (removed the old ones first from Library/Frameworks/Python.framework/Versions/2.5/lib/python2.5/site-packages and Library/Frameworks/Python.framework/Versions/Current/lib/python2.5/site-packages using sudo). From sourceforge I downloaded the tar.gz, unzipped it, and ran 'sudo python setup.py install' for each of them.
8. Magellan should now be installed. Try just typing 'magellan'. You should get the message 'No track data file given'.
9. Try running magellan with the data files that come with magellan.

2.3 Windows

To install Magellan follow the steps mentioned below.

1. You will first need to download Python v. 2.5 (do not install Python 2.6 because numpy doesn't work with it). There are a fair amount of websites that offer instructions on that (google 'windows install python').
2. Magellan uses the matplotlib library and matplotlib uses the numpy package. After installing python download these two packages (they can both be found at `http://sourceforge.net`). Choose the packages that correspond to the bit size of your windows operating system.
3. Add the location of python to your path (Right click My Computer - Properties - Advanced - Environment Variables button - Highlight Path - Edit - Add the path, eg. C:\Python25).
4. Download the Magellan zip and unzip it to the location you want it.
5. Open the command line prompt and cd into the magellan directory (where the setup.py file is).
6. Write python setup.py install.
7. Magellan should now be installed. Try just typing 'magellan'. You should get the message 'No track data file given'.
8. Try running magellan with the data files that come with magellan.

Now you should be able to run Magellan by writing *magellan* along with the parameters you want in the command line prompt.

3 Functions in Magellan

Magellan can simulate normal and asymmetric seafloor spreading with ridge jumps and varying magnetization. Next subsections will describe the different parameter files that Magellan can take in. They can all be created in text editor and are plain ascii files. The % sign is used for comments.

3.1 Data File

The data file contains five columns, distance from ridge (km), depth at that distance from the ridge (km)and the measured magnetic anomaly value (nT). (*NOTE:* it is assumed that the Earth's magnetic field, at the time when the measurement was done, has been subtracted from the recorded value so the anomaly value itself is only left. Magellan will do this for you in one of the future releases.) To use the data file *filename* when running Magellan it is specified after all the options (magellan [options] *filename*. Equivalently the data file can be specified in the configuration file, with the key *data=filename*. Here is an example of a data file, obtained from the Reykjanes Ridge (Hey et al., 2010)

```
% Everything written after the percentage sign is a comment
% This is a plain text file with the format below
% distance from ridge(km) depth(km) magnetic anomaly(nT)
-10.000000 0.76 14.91
-9.000000 0.831 358.37
-8.000000 0.744 1044.42
-7.000000 0.557 1745.77
-6.000000 0.528 1691.73
-5.000000 0.641 803.62
-4.000000 0.653 559.79
-3.000000 0.741 642.65
-2.000000 0.732 745.36
-1.000000 0.75 977.09
0.000000 0.86 639.72
1.000000 0.806 311.57
2.000000 0.703 496.94
```

```
3.000000 0.709 439.74
4.000000 0.723 351.59
5.000000 0.604 -19.61
6.000000 0.724 1066.69
7.000000 0.666 1695.18
8.000000 0.679 2128.43
9.000000 0.724 956.99
10.000000 0.722 494.87
```

The depth is always positive (due to the Cartesian coordinate system used, described in the section above). The distance between data points is up to the user and the resolution is never greater than the spacing of data points, i.e. if the spacing is 3 km then Magellan will arrange the magnetized blocks every 3 km so smaller reversal periods might not be detected (*NOTE*: This is a present defect in Magellan and will be fixed).

3.2 Spreading Rate File

The spreading rate file contains three columns, beginning of period (Myr), end of period (Myr) and full spreading rate (km/Myr). To use the spreading rate file *filename* when running Magellan the -s option can be used followed by the spreading rate file (magellan -s *filename*). Equivalently the spreading rate file can be specified in the configuration file, with the key *spreadingrate=filename*.

Here is an example of a spreading rate file

```
% Everything written after the percentage sign is a comment
% This is a plain text file
% start(Myr) end(Myr) full spreading rate(km/Myr)
0 50 20
50 89 25
89 118 15
```

3.3 Asymmetry File

The asymmetry file contains three columns, beginning of period (Myr), end of period (Myr) and asymmetry (%). To use the asymmetry file *filename* when running Magellan the -a option can be used followed by the asymmetry file (mageallan -a *filename*). Equivalently the asymmetry file can be specified in the configuration file, with the key *asymmetry=filename*. A negative asymmetry represents faster spreading to the westerly part of the profile and a positive asymmetry represents faster spreading to the easterly part of the profile (for a north-south striking profiles the north is negative and south positive). For instance if the asymmetry is 0.05 the spreading rate to the left of the ridge is (1 - 0.05) * 1/2 spreading rate and to the right of the ridge the spreading rate is (1 + 0.05) * 1/2 spreading rate. Thus, when the left and right spreading rates are added, the outcome is always the full spreading rate.

Here is an example of an asymmetry file

```
% Everything written after the percentage sign is a comment
% This is a plain text file with the format below
% start(Myr) end(Myr) asymmetry(%)
0 50 0.04
50 89 0.01
89 118 -0.02
```

3.4 Jump File

The jump file contains two columns, time of jump (Myr) and distance of jump (km). To use the jump file *filename* when running Magellan the -j option can be used followed by the jump file (magellan -j *filename*). Equivalently the jump file can be specified in the configuration file, with the key *jump=filename*. Negative and positive jumps represent ridge jumps where the new ridge forms left and right of the failing ridge, respectively.

Here is an example of a jump file

```
% Everything written after the percentage sign is a comment
% This is a plain text file with the format below
% time(Myr) distance(km)
3 4.3
23 -3.1
```

3.5 Magnetization File

The magnetization file contains three columns, beginning of period (Myr), end of period (Myr) and magnetization (A/m, amperes per meter). To use the magnetization file *filename* when running Magellan the -m option can be used followed by the magnetization file (magellan -m *filename*). Equivalently the magnetization file can be specified in the configuration file, with the key *magnetization=filename*. The magnetization used controls the amplitude of the magnetic wiggles.

Here is an example of a magnetization file

```
% Everything written after the percentage sign is a comment
% This is a plain text file with the format below
% start(Myr) end(Myr) magnetization(A/m)
0 0.78 20
0.78 10 10
10 118 5
```

3.6 Time Scale File

The time scale file contains two columns, beginning of period (Myr) and end of period (Myr). There is no need to specify the polarity of the period since the first reversal period is assumed to be normally polarized. To use the time scale file *filename* when running Magellan the -t option can be used followed by the time scale file (magellan -t *filename*). Equivalently the time scale file can be specified in the configuration file, with the key *timescale=filename*.

3.7 Other Parameters

There are several scalar parameters that can be specified in the configuration file or in the command line. These parameters are listed in alphabetical order below.

- *Profile Azimuth* - The azimuth of the profile, measured clockwise from north in degrees. Range: 0 to 360.
- *Ridge Azimuth* - The azimuth of the ridge, measured clockwise from north in degrees. Range: 0 to 360.
- *Spreading Direction* - The azimuth of the current spreading direction, measured clockwise from north in degrees. Range: 0-360.
- *Declination* - The declination of the Earth's field at the time and position the measurement was taken. Range: -90 to 90.
- *Inclination* - The inclination of the Earth's field, in degrees, at the time and position the measurement was taken. Range: -90 to 90.
- *Thickness* - The thickness of the magnetized layer in kilometers.
- *Spacing between points* - Spacing between calculated points.

3.8 Configuration File

The configuration file can be used to avoid having to use many single letter options (-a, -j, etc.) and set the options in this file. If Magellan is run with the configuration file and any option, the resulting model will use the option(s) specified and ignore the one in the configuration file. To use the configuration file *filename* when running Magellan the -c option can be used followed by the configuration file (magellan -c *filename*). The parameters/files that can be specified in the configuration file are

- data file (as described above)
- asymmetry file (as described above)
- spreading rate file (as described above)
- jump file (as described above)
- magnetization file (as described above)
- timescale (as described above), default is the timescale of Cande and Kent (1995)
- inclination (inclination=degrees), default is 45
- declination (declination=degrees), default is 45
- profile azimuth (profile_azimuth=degrees), default is 90
- ridge azimuth (ridge_azimuth=degrees), default is 0
- spreading direction (spreading_direction=degrees), default is 0
- thickness of the magnetized layer (thickness=km), default is 0.5km
- spacing between the points where the model is calculated (pointspacing), default is 1km

Henceforth, Magellan can be run only with the configuration file specified. Here is an example of a configuration file

```
% Configuration file example
thickness=1
inclination=30
declination=10
spreadingrate=track.spr
asymmetry=track.as
magnetization=track.mag
jump=track.jump
data=track.xzd
timescale=mytimescale
pointspacing=0.5
profile_azimuth=30
spreading_direction=20
ridge_azimuth=130
```

4 The Graph

Magellan utilizes the matplotlib library to plot up the results from the modeling. Figure 1 shows data from the Reykjanes Ridge (Hey et al., 2009). The upper plot shows the data (blue) and the model (orange) from Magellan. The lower plot shows the bathymetry and magnetized blocks with normal (blue) and reversed (white) polarity, calculated from the Cande and Kent (1995) time scale. The bathymetry is considered the upper boundary of the magnetized layers and the lower boundary is the bathymetry duplicated (the thickness is 0.5 km). Two ridge jumps are present, one 5 km to the west (of the failing ridge) at 10 Ma and one 7 km to the east at 15 Ma. The jump file used looks like this

```
10 -5
15 7
```

Notice that the first jump has a negative sign (the new ridge forms to the west of the failing ridge). Pseudofaults and failing rifts are shown as vertical lines in the figure, pseudofaults are shown in green and failed rifts in red. Note that two pseudofaults and one failed rift are associated with one jump and the failing rift is always further away from the ridge axis than the pseudofaults.

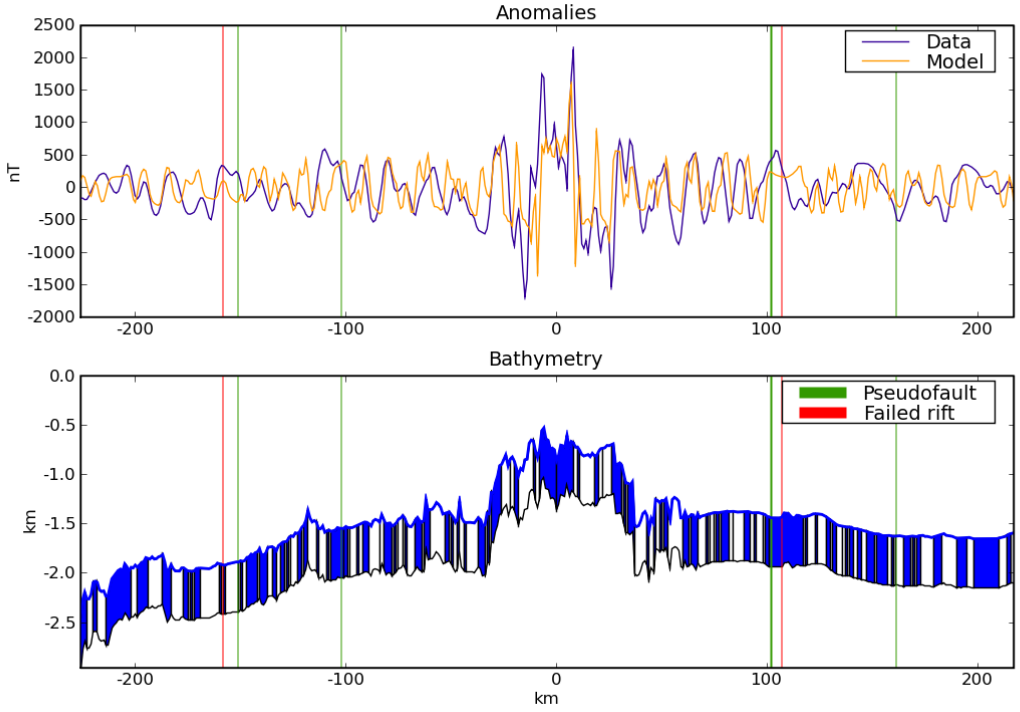

Figure 1: *The output from Magellan.*

5 Examples

All the examples below are obtained from the Reykjanes Ridge which spreads 30° obliquely from the general perpendicular spreading (that is the angle between the strike of the ridge and the flowline is 60° rather than 90°). Note that the timescale used is from Lourens 2004.

5.1 Track22 from the R/V Knorr 2007 Reykjanes Ridge Expedition

The files and parameters we use for this example are from Hey et al. 2010.

```
Jump file: track22.jump
1.2 -2
3.7 1
6.7 2
8.8 2
13.6 6

Spreading rate file: track22.spr
0 6.5 18.8
6.5 23.03 22.7

Magnetization file: track22.mag
0 0.78 25
0.78 15 8
15 23.03 6

Configuration file: track22.config
timescale=Lourens2004.dat
profile_azimuth=100
ridge_azimuth=220
```

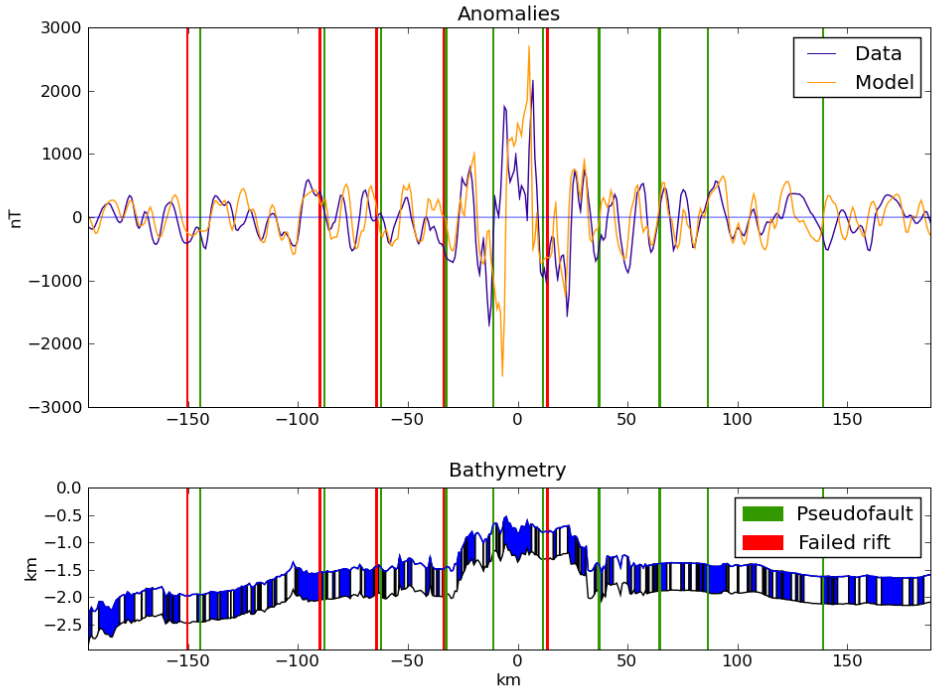

Figure 2: *The output from Magellan for track22.*

```
spreading_direction=100
inclination=75
declination=-18
spreadingrate=track22.spr
magnetization=track22.mag
jump=track22.jump
data=track22.xzm
contam=0.7
```

There are several ways to run Magellan with these parameters. Firstly, just by specifying the configuration file

```
magellan -c track22.config
```

If parameters are specified in the command line then Magellan will use those parameters and ignore the ones in the configuration file, i.e.

```
magellan -c track22.config -j track22v2.jump --azimuth=40
```

will use the azimuth=40 and track22v2.jump file instead of using the azimuth=100 and track22.jump file found in the configuration file. Figure 2 shows the output from Magellan for the first run.