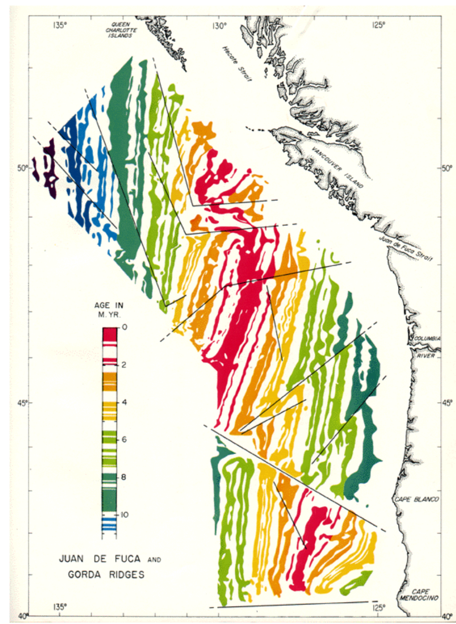
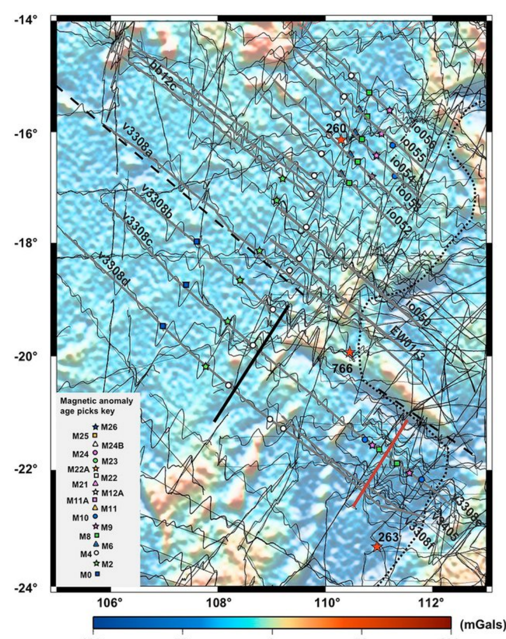
Seafloor Magnetic Anomaly Globe and Map

This globe plots the current data set of marine magnetic anomalies, which can be used to accomplish a variety of quantitative plate tectonic analyses. Each symbol plotted on the globe represents a location where a particular marine magnetic anomaly has been identified and thus we can assign a specific age to that location. As the data set of marine magnetic anomalies and their ages has grown it has required a more complex approach to representing the data. Here we describe the representation of the magnetic anomalies.

What are these magnetic anomalies and are they the same as the magnetic stripes?



The development of the theory of plate tectonics was driven by the discovery of magnetic lineations (or magnetic stripes)in the oceans that could be correlated with a magnetic reversal time scale that was being developed on land. Maps such as the one shown here helped demonstrate the patterns of symmetric seafloor spreading from the mid-ocean ridges. Sea floor ages were were assigned to these magnetic polarity intervals, allowing the age of the ocean crust to be determined. In general, in areas where the oceanic crust formed during magnetic polarity intervals similar to today, the magnitude of the magnetic field signal is enhanced (producing a 'positive' anomaly), and over areas of ocean crust that were produced during an interval when the magnetic poles were reversed will generate a diminished signal ('negative' anomaly). These are referenced to the background regional magnetic field intensity which varies with latitude.



Over time, since the 1960's, a substantial portion of the world's oceans were surveyed and the seafloor magnetic anomalies were identified and named, using a numeric naming schemes where present day is anomaly 1 (sometimes the anomaly number is preceded by a C or an M indicating whether they are younger than the Cretaceous (C- Cenozoic), or older (M - Mesozoic). Although initially these identified magnetic lineations were plotted as stripes, in most cases what was observed was the magnetic signal of this anomaly along a ship track (as shown in the figure to the right), where the grey lines indicate the path of the ship survey and the magnetic signal is plotted along the tracks. Specific, named anomalies are identified along those survey lines. Once a sufficient number of such anomaly identifications are made, then they could be correlated and as appropriate interpolated to estimate the age of the seafloor, in regions not directly observed. Such compilations led to maps such as the following (left), in which magnetic anomalies in the northeastern Pacific were assigned anomaly names, correlated and interpolated between observations. Such representations helped make it clear the expected coherency of the seafloor age (and magnetic polarity). At this time, anomalies were assigned a particular age (based on detailed analyses of both on-land and marine data sets).

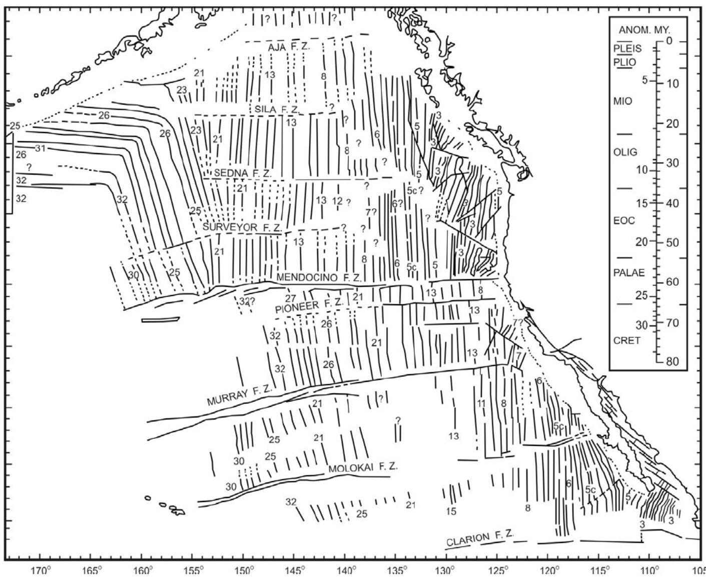
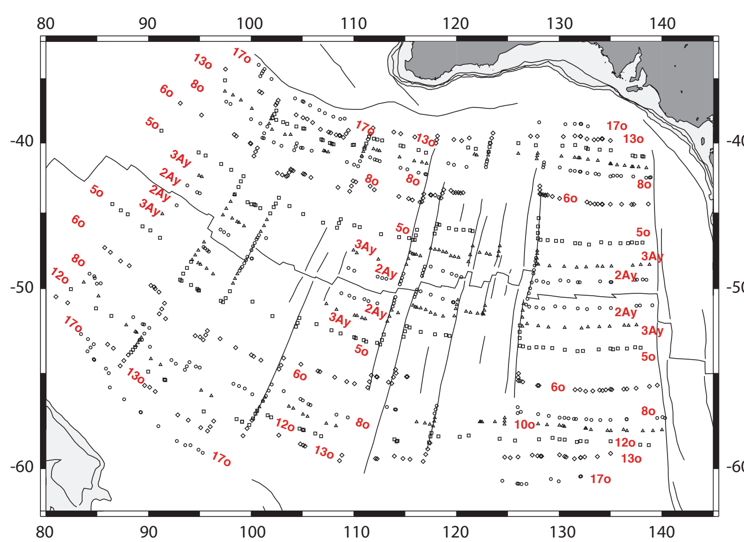


Figure 4. Magnetic anomalies in the North East Pacific (Atwater and Menard 1970), numbered according to the Heirtzler et al. (1968) time scale as calibrated by Berggren (1969).

As more data were collected and the age constraints on the data improved, two things happened. First numerous additional magnetic anomalies were observed and rather than totally revise the existing anomaly names, these new anomalies were fit into the existing magnetic anomaly time scale (with the names of these newly identified anomalies fitting between existing named anomalies - e.g. between named anomaly 2 and 3, new anomalies were given names such as 2An.1n or 2Ar), are identified as representing a normal polarity or reversed polarity time interval ("n" or "r" is appended to the name), and the magnetic anomaly was explicitly assigned a beginning (old -"o") and ending (young - "y") age. It also became clear that the interpolation between observations could be problematic. This led to the more common current practice of specifically identifying the anomaly position (and whether it is the young or old edge of the anomaly being plotted) - that is what is plotted is the actual location where the anomaly was observed on a particular geophysical survey. An example of such a representation is shown here (right). In this case (in the southern ocean between Australia and Antarctica) various anomalies have been identified and their old ("o") or young ("y") edges are plotted on the map. In this way the specific age for that location on the sea floor can be more precisely delineated.

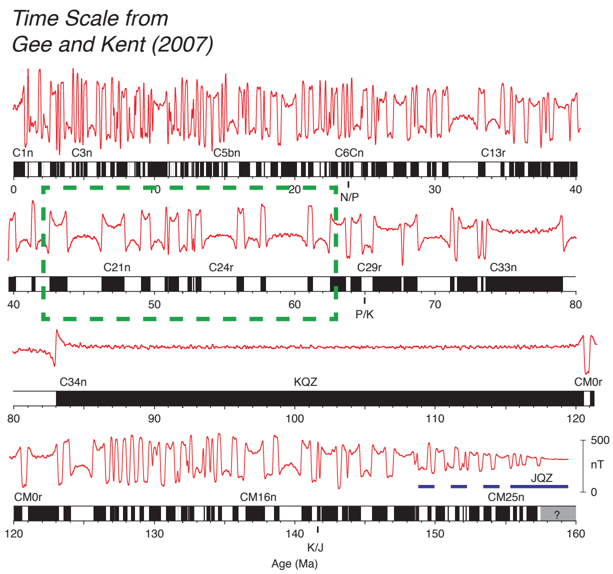


What is plotted on the globe and accompanying map?

In the globe and map provided here, we plot the current global catalog of magnetic anomalies. Not all anomalies are observed in all locations and so the sequence varies depending on the location (which ocean, what is the plate spreading rate, what is the location latitude, and and what was orientation of the mid-ocean ridge at the time of crust formation). The complete set of anomalies and their assigned ages (that is plotted on the accompanying Mercator map) is given in the *"Globe/Map Legend and Magnetic Anomaly Time Scale."* We do not plot the ages directly, since they are assigned to each anomaly and as research progresses that age assigned to a particular anomaly can change. The table provided with the kit allows the user to convert any anomaly to its equivalent age. Because of the scale of the globe, we have plotted a subset of the entire catalog for clarity. We use a combination of symbol type, symbol color, and symbol size to represent the data. Solid symbols represent the young age of each anomaly and open symbols are the old age of the anomaly (i.e. when it started). Those anomalies that more commonly occur are shown with the larger symbols. On the following page examples of the correlations between observed anomalies and the symbols plotted on the globe/map are shown.

In the upper left of they figure, the magnetic anomaly time series that would be observed in a complete ocean crust section is shown by the red lines. The underlying white/black striped bar represents the specific normal and reversed magnetic polarity time intervals inferred from the time-series data. Each of those time intervals is assigned an anomaly name (e.g. C21n) which represents the same age everywhere on Earth. A section from the complete anomaly names and ages table is shown in the upper right, along with the symbols used to plot those data on the globe/map. In the center figure, a section of the time series is plotted and annotated with anomaly names, and the symbols used in the globe/map. As you can see, the open symbols are at the old edge of the anomaly and closed symbols are at the young edge. Below that the specific locations where some of those anomalies are plotted on the globe (off the west coast of California) are indicated. Note that for some anomalies, such as Anomaly C21n, both the old and young edge of the anomaly are plotted, but more typically only the young (e.g. C25n) or old (e.g. C24n.3n) edge of an anomaly is plotted.

At various locations on the globe/map the anomaly plotted is labeled with its name, allowing one to easily find themselves on the time scale. Different colors are used to make the specific assignment of anomaly to symbol easier. In areas of slower spreading rates, less ocean crust is produced and thus the anomalies will be closer together. In some of those cases, (e.g. the north Atlantic Ocean) we could not plot all of the identified anomalies because of overlap.



Anomaly #	Age (Ma)
18n.1n	**38.426-39.552**
18n.2n	**39.631-40.130**
19n	41.257-41.521
19r	41.521-42.536
20n	**42.536-43.789**
21n	**46.264-47.906**
22n	49.037-49.714
23n.1n	50.778-50.946
23n.2n	51.047-51.743
24n.1n	52.364-52.663
24n.2n	52.757-52.801
24n.3n	**52.903-53.347**
25n	**55.904-56.391**
26n	57.554-57.911
27n	**60.920-61.276**