Earthquake_Capstone_Report

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The Problem

One of the biggest problems that exists in geology involves the prediction of significant earthquakes. Earthquakes can be measured in several ways, but a significant earthquake is a tremor that measures 5.5 or higher on the Richter scale. Predicting such earthquakes is important as significant earthquakes often cause significant damage to infrastructure and loss of life.Ideally, a solution could be found using data to predict the probability of occurance of a significant earthquake for a given location.

Data Sources

Two data sets were used in this analysis. The first data set, signif_earthquakes, was obtained from NOAA's Significant Earthquakes Database (https://www.ngdc.noaa.gov/nndc/struts/form?t=101650&s=1&d=1) and lists every recorded earthquake in history back to 2150 BC. The other data set used, USGS_df, was obtained from Kaggle (https://www.kaggle.com/usgs/earthquake-database#database.csv) and lists all recorded major earthquakes in the USGS data base from 1965 to 2016.

signif_earthquakes clean-up

This file, signif_earthquakes, presented several challenges. The file first needed to be reduced to only include relevant variables from the original original data set; these relevant columsn included date information, time, magnitude, and location information. Next, the data needed to be filtered to include observations that included reliable magnitude measurements. The chosen measurement scale for this analysis is the Richter scale as it has been shown to be reliable and provides substantial amounts of data; therefore, all data prior to the creation and regular use of the Richter scale (1935) was removed. Earthquakes that were documented without a measurement were also filtered and removed from the table. These processes left us with the table below:

```
head(signif_earthquakes)
```

```
##   year month day hour minute second focal_depth eq_mag_unk country
## 1 1965     2  10   16      9   <NA>          52        5.1    IRAN
## 2 1965     3  28   16     33   <NA>          61        7.3   CHILE
## 3 1965     3  31    9     47   <NA>          78        7.1  GREECE
## 4 1965     4  29   15     28   43.7          59        6.5     USA
## 5 1965     6  21    0     21   <NA>          40        6.0    IRAN
## 6 1966     3   7    1     16   <NA>          38        6.0  TURKEY
##                         location_name latitude longitude
```

```
## 1                              IRAN:  NW     37.6      47.1
## 2                       CHILE:  CENTRAL    -32.4     -71.2
## 3                                GREECE     38.6      22.4
## 4                    WASHINGTON:  SEATTLE     47.4    -122.3
## 5 IRAN:  HADJIABAD, SARKHUN, SARCHAHAN     28.1      55.9
## 6                     TURKEY:  VARTO, MUS     39.1      41.6
```

USGS_df Clean-up

The next step in the cleaning of data was to address the USGS data set from Kaggle. Like signif_earthquakes, the columns relevant to this analysis first had to be extracted. From USGS_df, selected columns were “Date”, “Time”, “Latitude”, “Longitude”, “Depth”, and “Magnitude”. The selection of these columns allows us to complete our data analysis as well as join the columns together. After selecting the relevant columns, the date column was reformatted to international date format and the “depth” column was renamed to “focal_depth” to better indicate what the values represent. The cleaned table for USGS_df appears below:

```
#Print head(USGS_df)
head(USGS_df)

##         date     time latitude longitude focal_depth magnitude
## 1 1965-01-02 13:44:18   19.246   145.616       131.6       6.0
## 2 1965-01-04 11:29:49    1.863   127.352        80.0       5.8
## 3 1965-01-05 18:05:58  -20.579  -173.972        20.0       6.2
## 4 1965-01-08 18:49:43  -59.076   -23.557        15.0       5.8
## 5 1965-01-09 13:32:50   11.938   126.427        15.0       5.8
## 6 1965-01-10 13:36:32  -13.405   166.629        35.0       6.7
```

Joining the data frames

To best join the data frames together without losing data, a full_join function was used. However, for the full_join function to work best, the data from signif_earthquakes needed to be slighly altered to match the format found in USGS_df. This alteration was done by assigning a zero value to time measurements, then by combining hours, minutes, and seconds into one column marked “time” in hh:mm:ss format. This zero value was assigned as some earthuakes were measured in hh:mm and some in hh:mm:ss.

Another set of columns that needed to be combined in the signif_earthquakes data frame were the date columns (month, day, year). These were united into one labelled “date” and put into international date format YYYY-MM-DD. These changes led to the new format of the signif_earthquake data frame:

Once the two tables were in the correct formats, full_join was used to consolidate the data into one data frame:

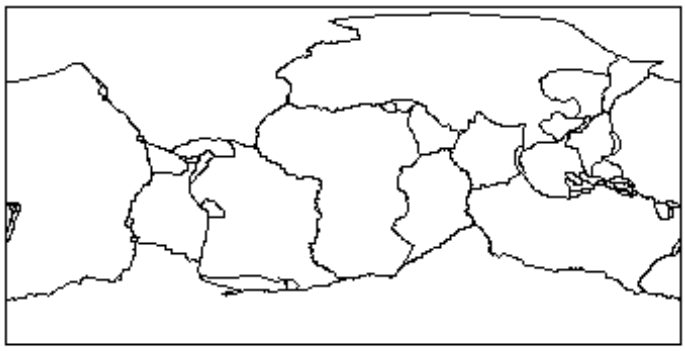
```
#Join tables together via date, time, latitude, and longitude
earthquakes <- full_join(signif_earthquakes, USGS_df, by = c("date", "time",
                                                             "latitude",
```

```
                                                        "longitude",
                                                        "magnitude",
                                                        "focal_depth"))

summary(earthquakes)
```

```
##      date               time           focal_depth       magnitude
##  Length:23579       Length:23579      Min.   : -1.10   Min.   :3.200
##  Class :character   Class1:hms        1st Qu.: 14.51   1st Qu.:5.600
##  Mode  :character   Class2:difftime   Median : 33.00   Median :5.700
##                     Mode  :numeric    Mean   : 70.52   Mean   :5.885
##                                       3rd Qu.: 54.00   3rd Qu.:6.000
##                                       Max.   :700.00   Max.   :9.100
##                                       NA's   :5
##    country           location_name         latitude         longitude
##  Length:23579       Length:23579       Min.   :-77.080   Min.   :-180.00
##  Class :character   Class :character   1st Qu.:-18.564   1st Qu.: -76.13
##  Mode  :character   Mode  :character   Median : -3.500   Median : 103.10
##                                        Mean   :  1.814   Mean   :  39.55
##                                        3rd Qu.: 26.816   3rd Qu.: 144.89
##                                        Max.   : 86.005   Max.   : 180.00
##
```

However, one more data set was needed to complete the analysis. Stored as a JSON file, this data set contained the plate bounddaries of each plate by connecting a series of coordinates. This file was uploaded and read using the geojsonio package. Once loaded, the earthquakes data set was overlaid onto the plate boundaries data set.

```
# Import data for tectonic plate boundaries
plate_data <- "PB2002_plates.json"
plates <- geojson_read(plate_data, what = "sp")

plot(plates)
```



```
# convert list of earthquake points into a SpatialPointsDataFrame
coordinates(earthquakes) <- ~ longitude + latitude

# convert earthquakes to use the same coordinate system as plates (for
overlay)
proj4string(earthquakes) <- proj4string(plates)

# Create overlay
earthquakes_plates <- over(earthquakes, plates)
```

The final step in tidying the data was to combine the columns from the two resulting tables and save the new result as a data frame. This gives us the following result:

```
# Attach the resulting columns that we got from over to the rows of eqs
earthquakes$LAYER <- earthquakes_plates$LAYER
earthquakes$Code <- earthquakes_plates$Code
earthquakes$PlateName <- earthquakes_plates$PlateName

earthquakes <- as.data.frame(earthquakes)


head(earthquakes)

##        date       time focal_depth magnitude country
## 1 1965-2-10 16:09:00.0          52       5.1    IRAN
## 2 1965-3-28 16:33:00.0          61       7.3   CHILE
## 3 1965-3-31 09:47:00.0          78       7.1  GREECE
```

```
## 4 1965-4-29 15:28:43.7          59       6.5     USA
## 5 1965-6-21 00:21:00.0          40       6.0    IRAN
## 6  1966-3-7 01:16:00.0          38       6.0  TURKEY
##                          location_name latitude longitude LAYER Code
## 1                            IRAN:  NW     37.6      47.1 plate   EU
## 2                       CHILE:  CENTRAL    -32.4     -71.2 plate   SA
## 3                                GREECE     38.6      22.4 plate   EU
## 4                  WASHINGTON:  SEATTLE     47.4    -122.3 plate   NA
## 5 IRAN:  HADJIABAD, SARKHUN, SARCHAHAN     28.1      55.9 plate   EU
## 6                   TURKEY:  VARTO, MUS     39.1      41.6 plate   EU
##       PlateName
## 1       Eurasia
## 2 South America
## 3       Eurasia
## 4 North America
## 5       Eurasia
## 6       Eurasia
```

To aid in analysis, the date column was separated into year, month, and day. The outliers were then filtered out of the data sets (incomplete data for 2017 and 2018).

```
#separate date column into year, month, and day
earthquakes <- separate(earthquakes, date, into = c("year", "month", "day"))

#Filter outliers (1 earthquake recorded in 2017, 2018)
earthquakes <- filter(earthquakes, year < 2017)
earthquakes <- filter(earthquakes, magnitude > 5.5)

head(earthquakes)
```

```
##   year month day       time focal_depth magnitude country
## 1 1965     3  28 16:33:00.0          61       7.3   CHILE
## 2 1965     3  31 09:47:00.0          78       7.1  GREECE
## 3 1965     4  29 15:28:43.7          59       6.5     USA
## 4 1965     6  21 00:21:00.0          40       6.0    IRAN
## 5 1966     3   7 01:16:00.0          38       6.0  TURKEY
## 6 1966     8  15 02:15:00.0          53       5.6   INDIA
##                          location_name latitude longitude LAYER Code
## 1                       CHILE:  CENTRAL    -32.4     -71.2 plate   SA
## 2                                GREECE     38.6      22.4 plate   EU
## 3                  WASHINGTON:  SEATTLE     47.4    -122.3 plate   NA
## 4 IRAN:  HADJIABAD, SARKHUN, SARCHAHAN     28.1      55.9 plate   EU
## 5                   TURKEY:  VARTO, MUS     39.1      41.6 plate   EU
## 6                             INDIA:  N     28.7      78.9 plate   IN
##       PlateName
## 1 South America
## 2       Eurasia
## 3 North America
## 4       Eurasia
```

```
## 5       Eurasia
## 6         India
```

Initial Exploration of Data

After combining the data sets, an initial exploration was completed to identify any possible trends. Using the earthquakes, data set, a bar graph was created for year vs # of major earthquakes from 1965 through 2016. The bar graph yielded the following results, with a trend of an increasing number of earthquakes worldwide. A peak number of earthquakes appears in 2011, which had nearly 100 more significant earthquakes than any other year in recorded seismic history.

To get more detail on the magnitude of earthquakes that occurred by year, a boxplot was created for year against magnitude. Major earthquake outliers above a 9.0 magnitude appeared in both 2004 and 2011. However, as the data reveals, although there were more earthquakes in 2011, the majority of the earthquakes were within the 5.5 to 6.5 magnitude range.

A boxplot of Plate name vs. magnitude was then created for all earthquakes in the data set. From this plot, it is easy to tell that the majority of significant earthquakes occuring on all plates register between a 5.5 and a 6.5 on the Richter scale. This tells us that the outlier events are above a 6.5. The plates that have extreme outliers (India, Burma, North America, Okhotsk) are plates that sit on top of convergent subduction zones, where pressure would built until one plate slips under the other, creating a large seismic event.

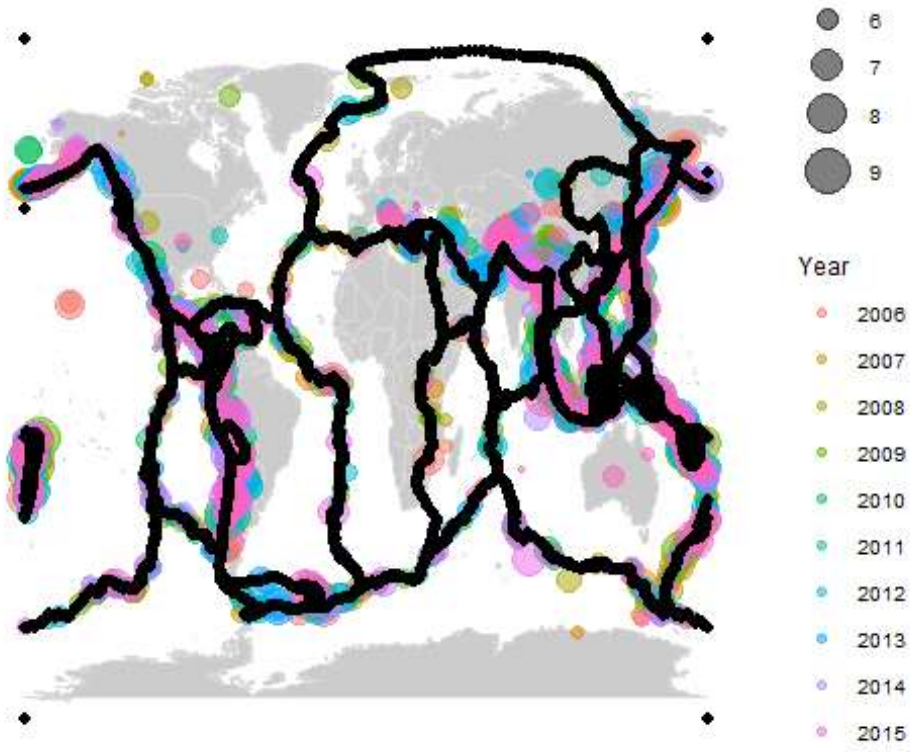
Using a map to plot data

The next step taken in the data exploration was to plot the earthquake occurences on a world map. Once the map of the tectonic plates was established, the earthquakes were then charted by year to see if there was a recognizable pattern.

As the year plate map revealed, there were many significant earthquakes within the last ten years of the data set. To get a better look at the data, the map was restricted to just the data from 2006 through 2016. When that data was charted, the results were mixed and not quite clear. It became obvious that the most recent major earthquakes were along subduction zones such as the western edge of the South American continent and along the Aleutian islands of Alaska. Places where multiple plates met along the ring of fire (the western, northern, and eastern edges of the Pacific plate) experienced strong annual seismic events.

Interestingly, the decade map also picked up increased seismic activity that was recorded in the middle of the tectonic plates. Some of this, such as the Hawaiian Islands, can be caused by ‘hot spots’ or thin, weak areas in the Earth’s crust that allow magma to push through, forming a volcano. However, other seismic events, such as the ones recorded in arkansas, virginia, and the gulf of mexico, may be caused by human activity. As a result, the focus is on major earthquakes occurring at plate boundaries.

```r
#Earthquakes from 2006-2016
earthquakes2006_2016 <- filter(earthquakes, year > 2005)

decade_map <- world +
  geom_point(aes(x = longitude, y = latitude, size = magnitude, color =
year),
             data = earthquakes2006_2016, alpha = .5) +
  geom_point(data = plates, aes(x = long, y = lat), fill = 'black', stroke =
1)+
  scale_size_continuous(range = c(1, 8), breaks = c(6, 7, 8, 9)) +
  labs(size = 'magnitude', color = 'Year') +
  theme(legend.position = "right")

## Regions defined for each Polygons

plot(decade_map)
```

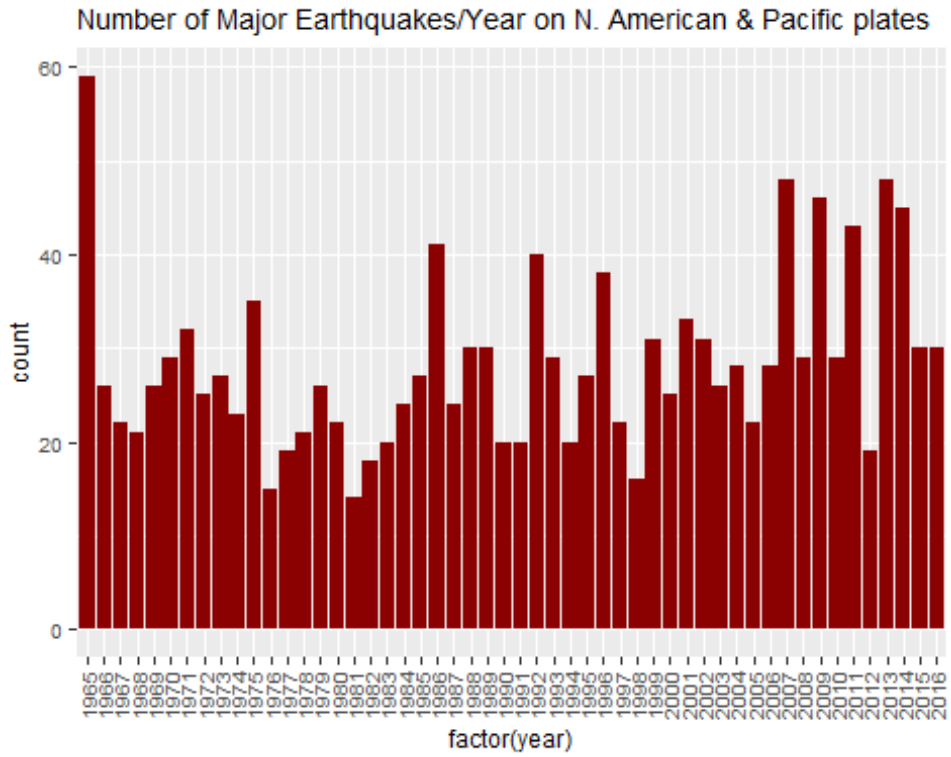


Narrowing the data

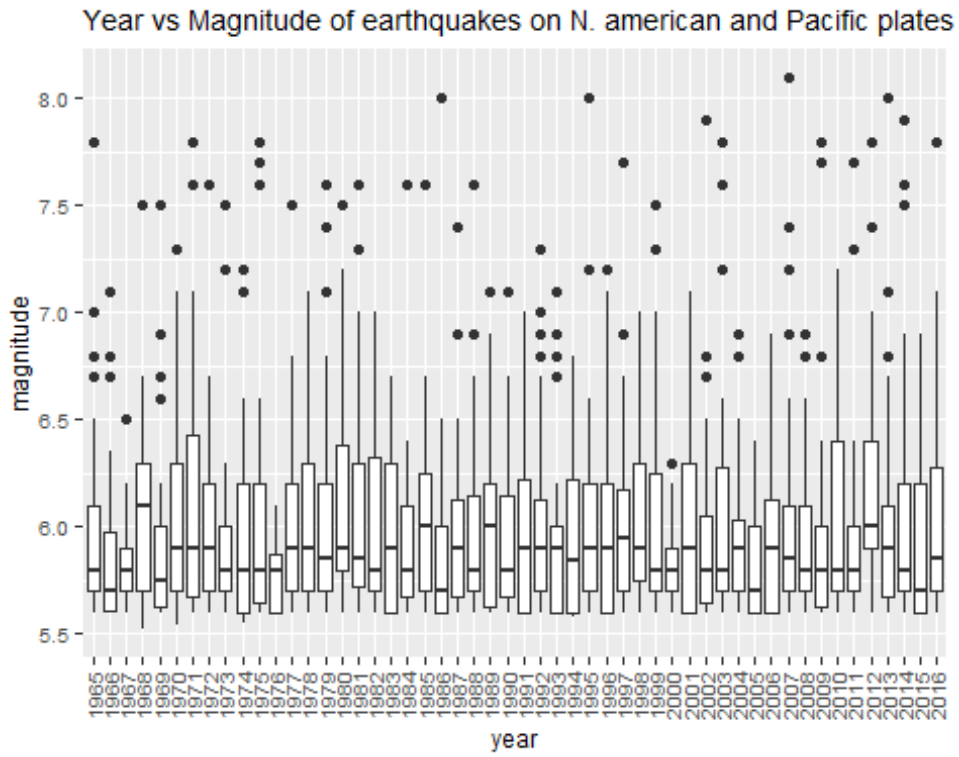
The next step in the data exploration was to narrow the data. This was done by restricting the data to just one or two plates and repeating the bar graph and the box plots. An animation was also added to better visualize the data. The plates that were tested individually were the Pacific plate, the North American Plate, the South American Plate, the Eurasian Plate, and the North American and Pacific Plates combined. Of these, the only restricted data to show a pattern was the North American and the Pacific plates. These two

plates were combined because as the Pacific plate subducts under the North American plate, the seismic events are recorded on the North American plate.

```
#Filter for North American and Pacific plate earthquakes
nap_earthquakes <- filter(earthquakes, PlateName == c("North America",
                                                      "Pacific"))

#Bar graph of year vs # of major earthquakes (1965-2016)
ggplot(nap_earthquakes, aes(factor(year))) +
  geom_bar(stat = "count", fill = "dark red") +
  theme(axis.text.x=element_text(angle=90, hjust=1, vjust=0.5),
        text=element_text(size=9)) +
  ggtitle("Number of Major Earthquakes/Year on N. American & Pacific plates")
```




```
#Boxplot of year vs magnitude on North American and Pacific plates
ggplot(nap_earthquakes, aes(x = year, y = magnitude)) +
  geom_boxplot() +
  theme(axis.text.x=element_text(angle=90, hjust=1, vjust=0.5),
        text=element_text(size=9)) +
  ggtitle("Year vs Magnitude of earthquakes on N. american and Pacific
plates")
```




```
#Unite month, day, year columns
nap_earthquakes <- unite(nap_earthquakes, quake_date, c("year", "month",
"day"),
                         sep = "-")

#Animate progression of earthquakes for North American and Pacific Plates
ghost_points_ini <- tibble(
  quake_date = as.Date('1965-01-01'),
  magnitude = 0, longitude = 0, latitude = 0)

ghost_points_fin <- tibble(
  quake_date = seq(as.Date('2017-01-01'),
                   as.Date('2017-01-02'),
                   by = 'days'),
  magnitude = 0, longitude = 0, latitude = 0)

nap_animated_map <- world +
  geom_point(data = plates, aes(x = long, y = lat), fill = 'black', stroke =
1)+
  geom_point(aes(x = longitude, y = latitude, size = magnitude,
                 color = PlateName, frame = as.Date(quake_date),
                 cumulative = FALSE), data = head(nap_earthquakes, n = 100L),
             alpha = .5) +
  geom_point(aes(x = longitude, y = latitude, size = magnitude,
                 frame = quake_date,
                 cumulative = FALSE),
```

```
              data = ghost_points_ini, alpha = 0) +
  geom_point(aes(x = longitude, y = latitude, size = magnitude,
                 frame = quake_date,
                 cumulative = FALSE),
             data = ghost_points_fin, alpha = 0) +
  scale_size_continuous(range = c(1, 8), breaks = c(6, 7, 8, 9)) +
  labs(size = 'magnitude', color = 'Plate Name') +
  theme(legend.position = "right")
```

```
## Regions defined for each Polygons
```

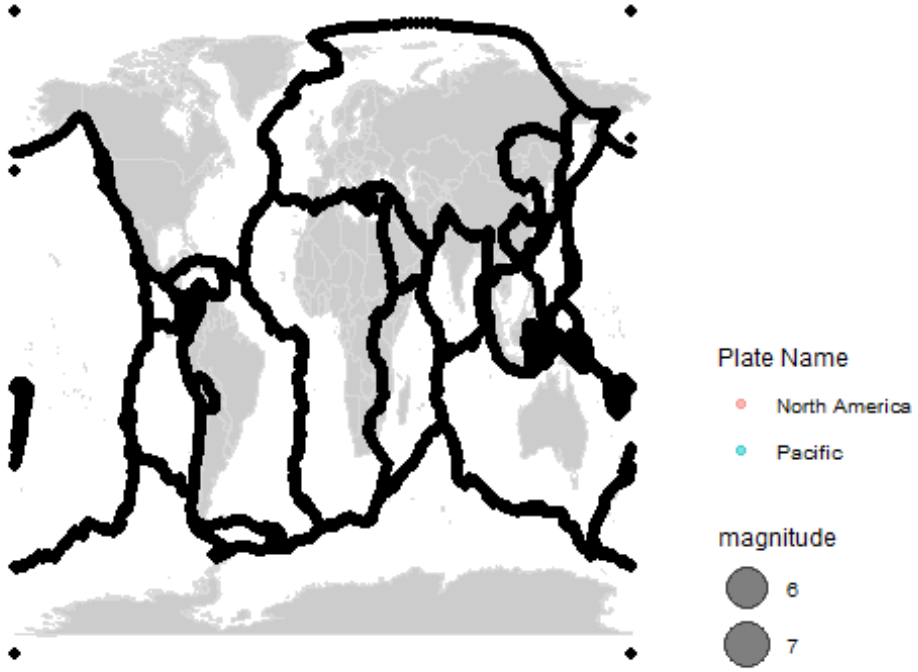
```
## Warning: Ignoring unknown aesthetics: frame, cumulative
```

```
## Warning: Ignoring unknown aesthetics: frame, cumulative
```

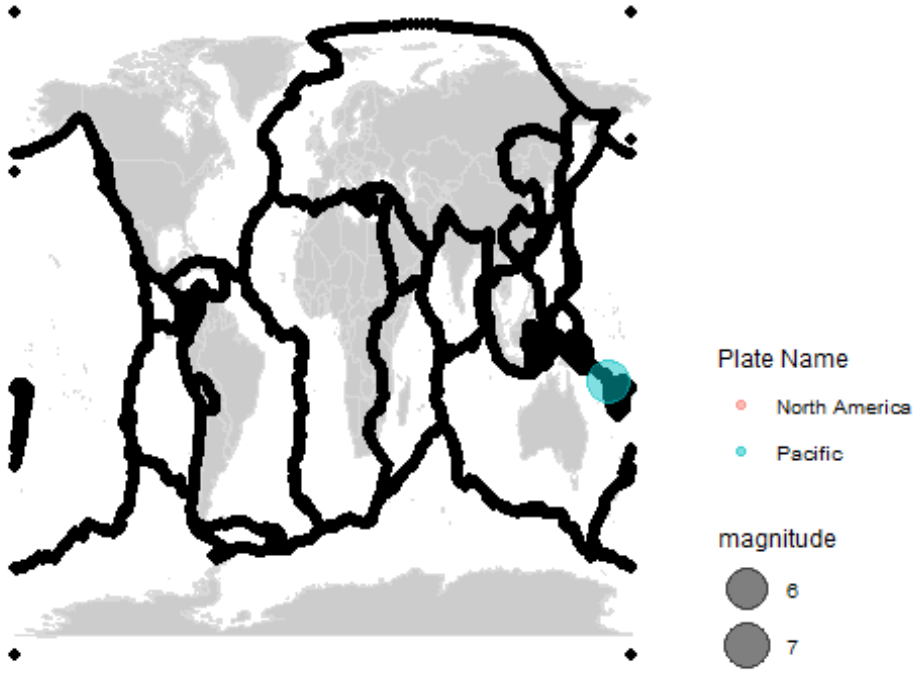
```
## Warning: Ignoring unknown aesthetics: frame, cumulative
```

```
gganimate::gg_animate(nap_animated_map)
```

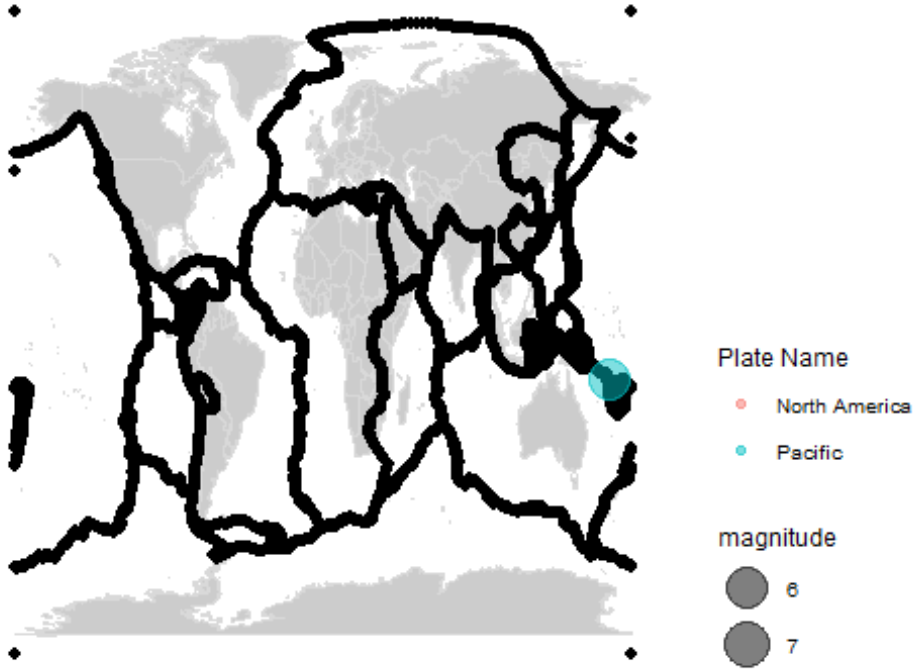
1965-01-01



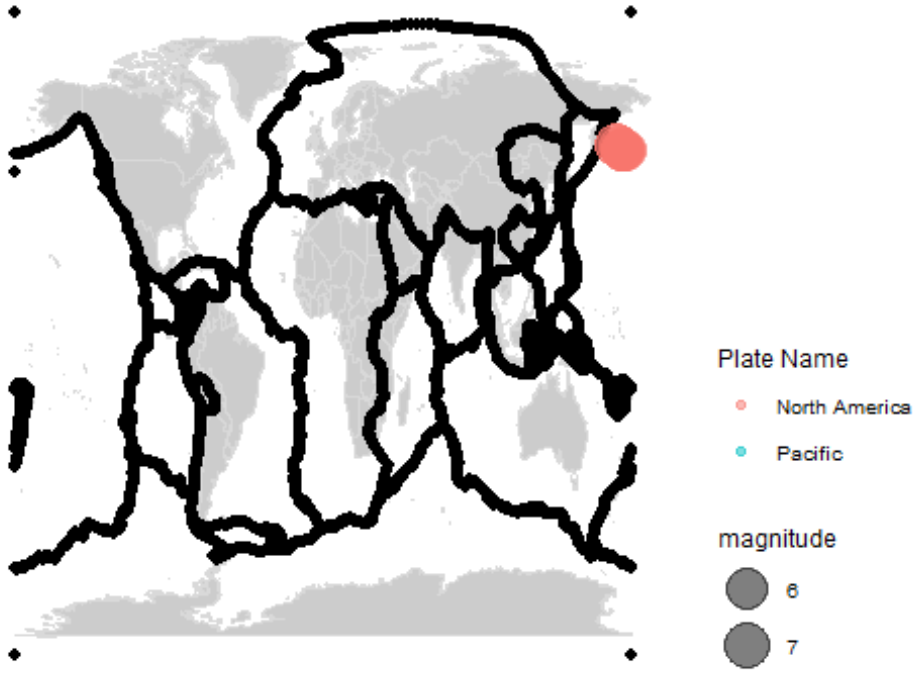
1965-01-10



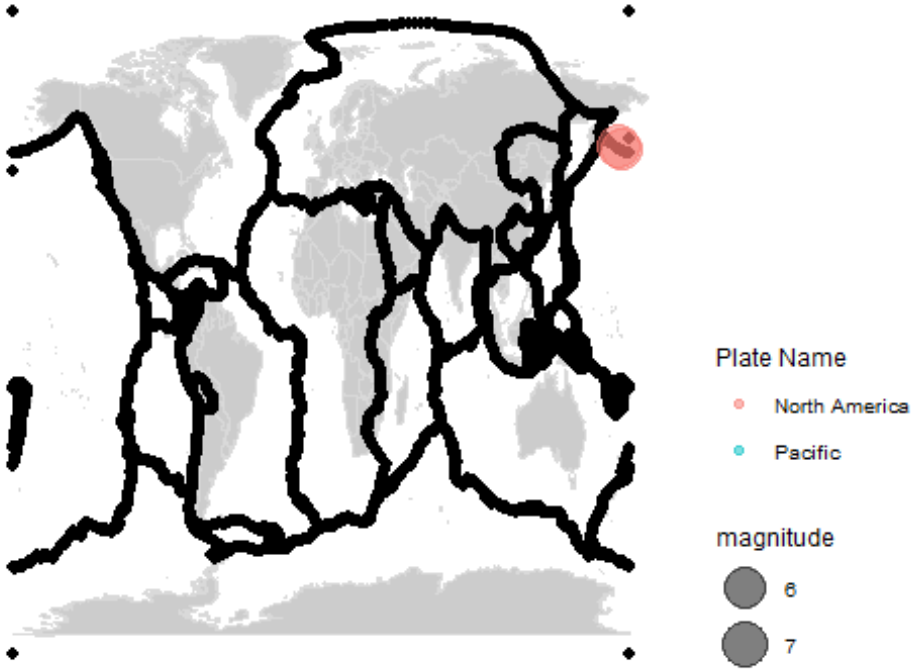
1965-01-15



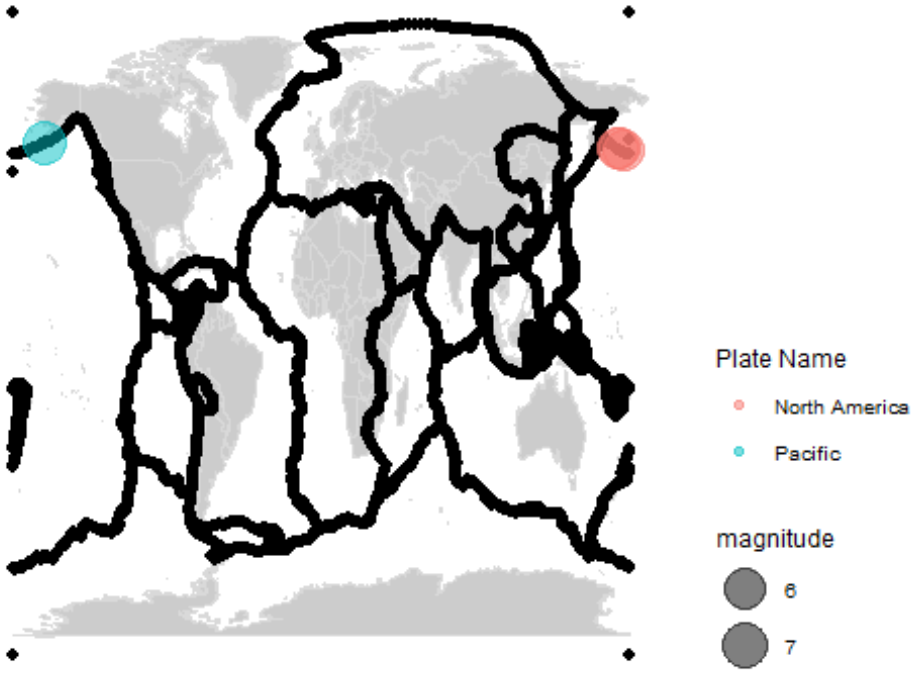
1965-02-04



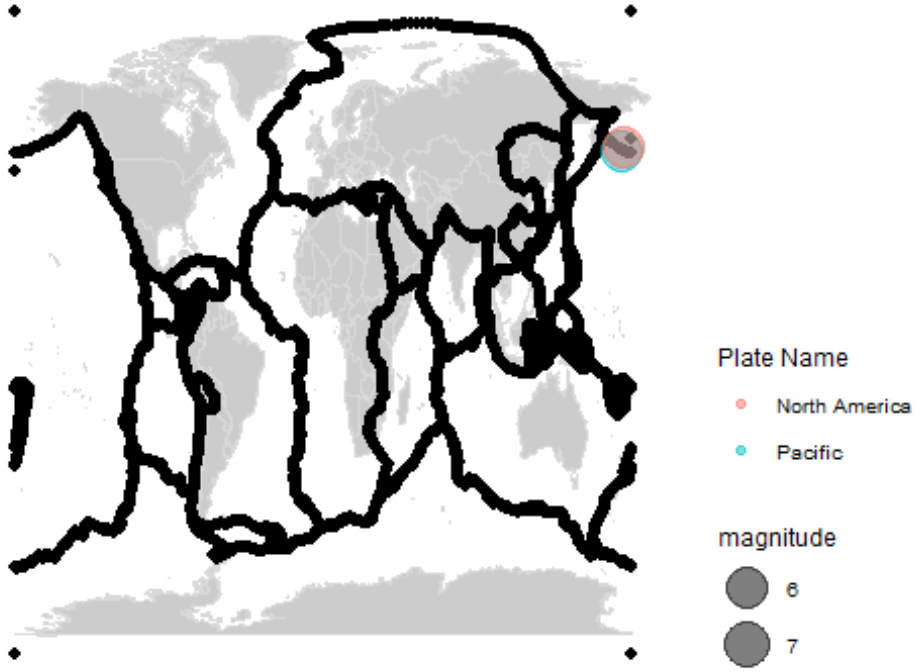
1965-02-05



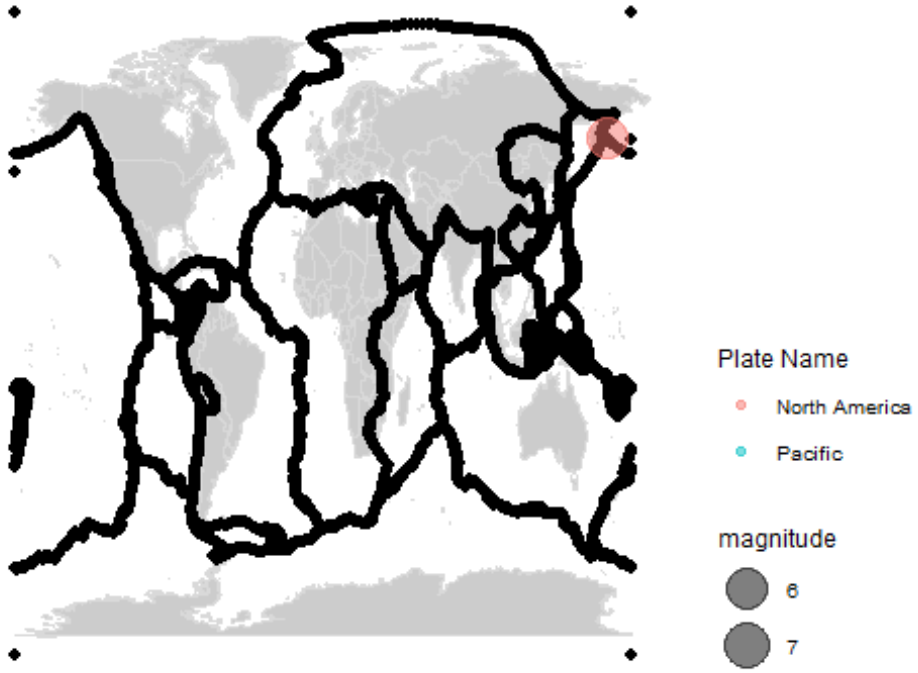
1965-02-06



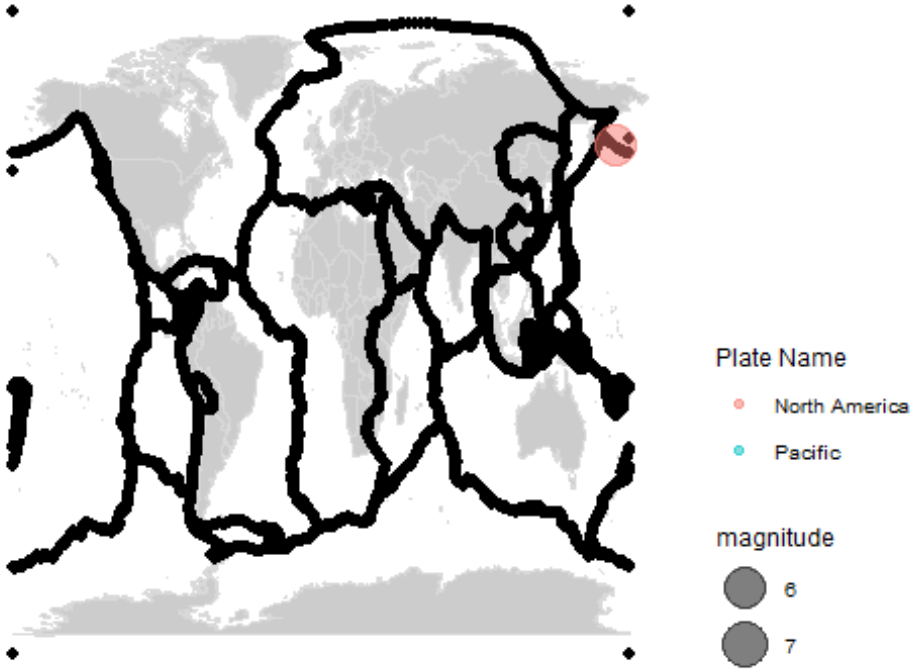
1965-02-07



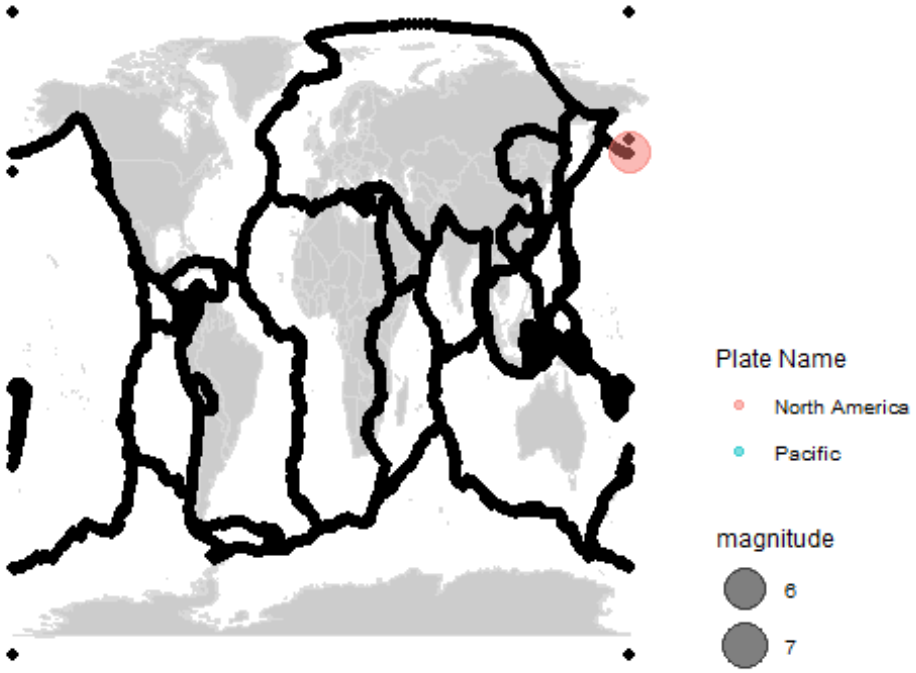
1965-02-08



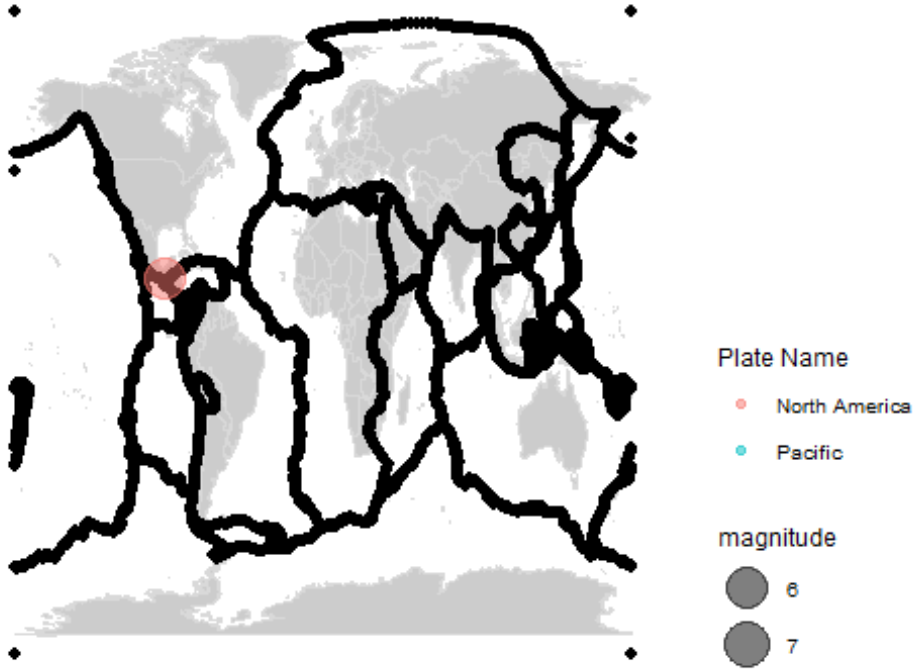
1965-02-09



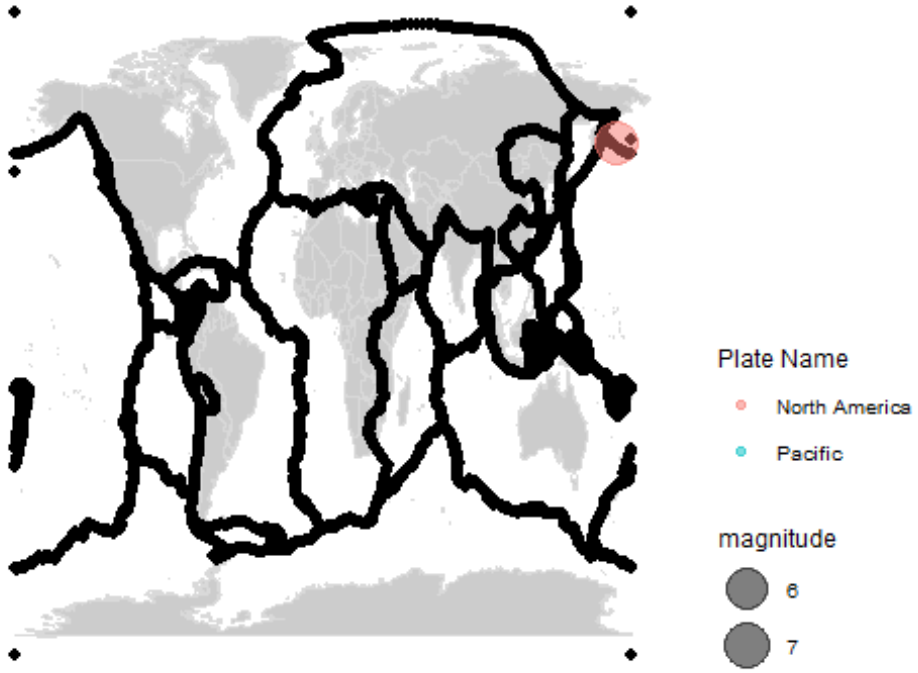
1965-02-15



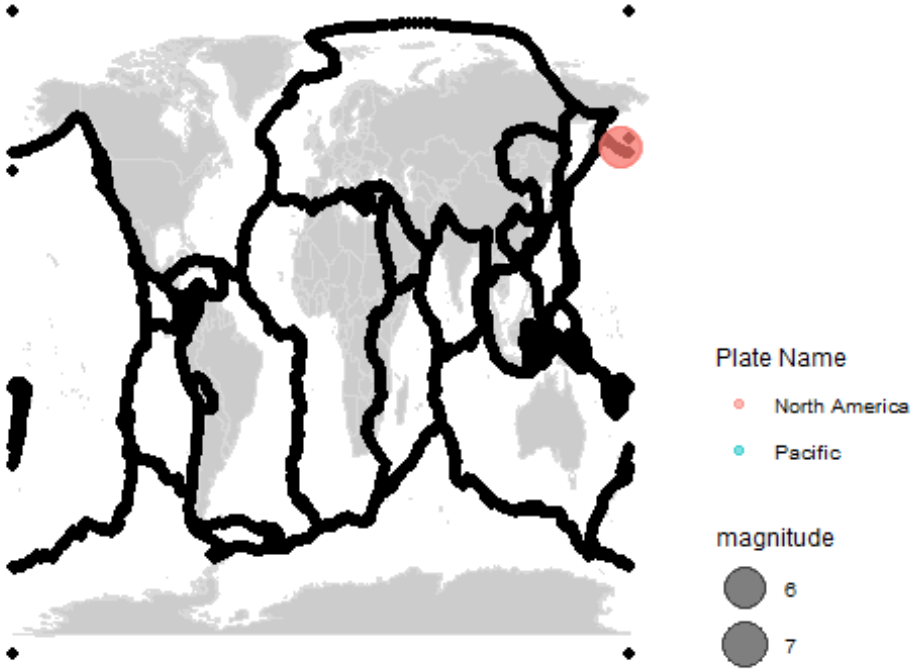
1965-03-01



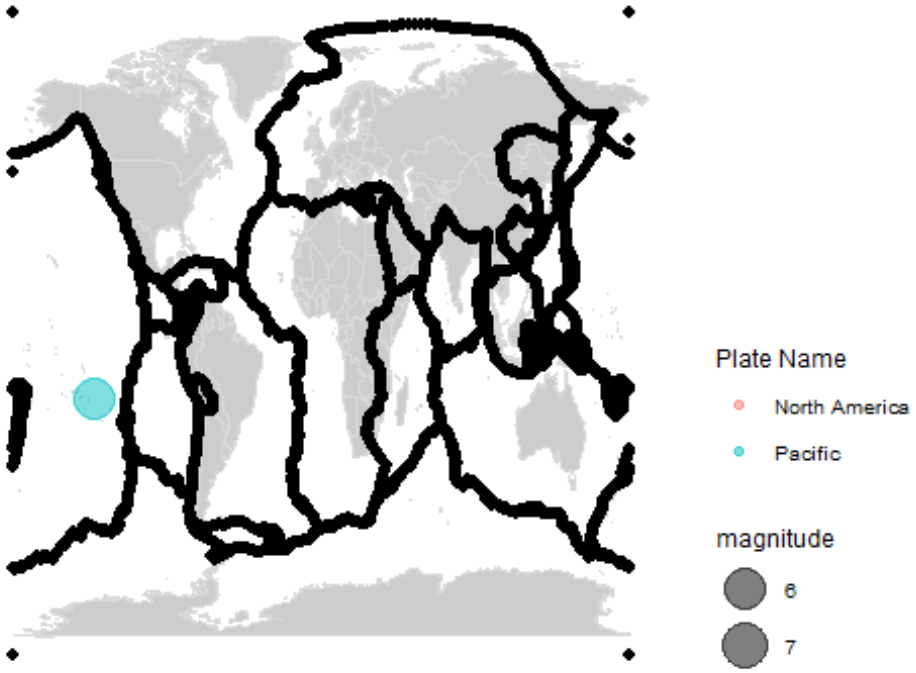
1965-03-03



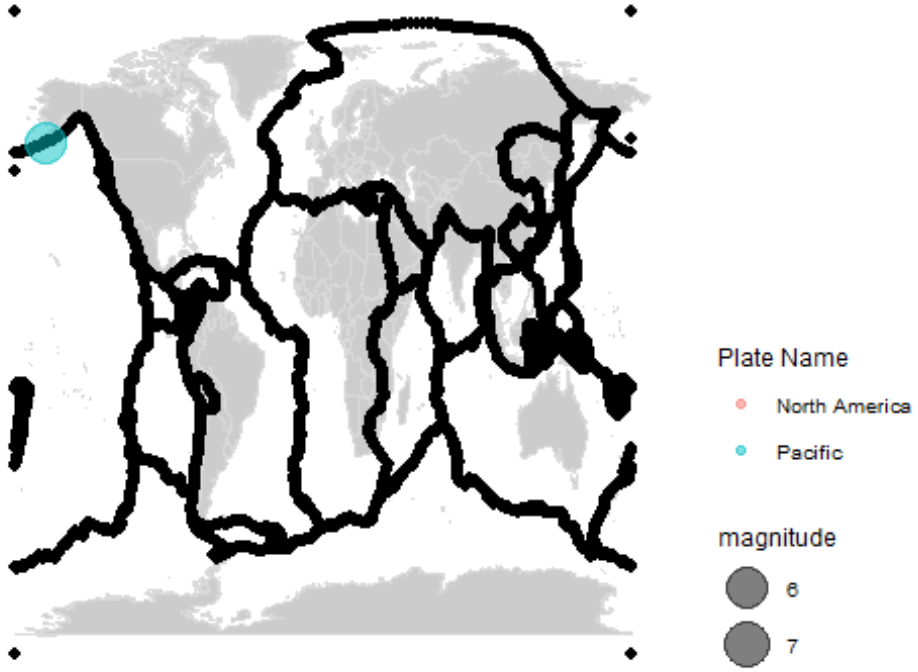
1965-03-05



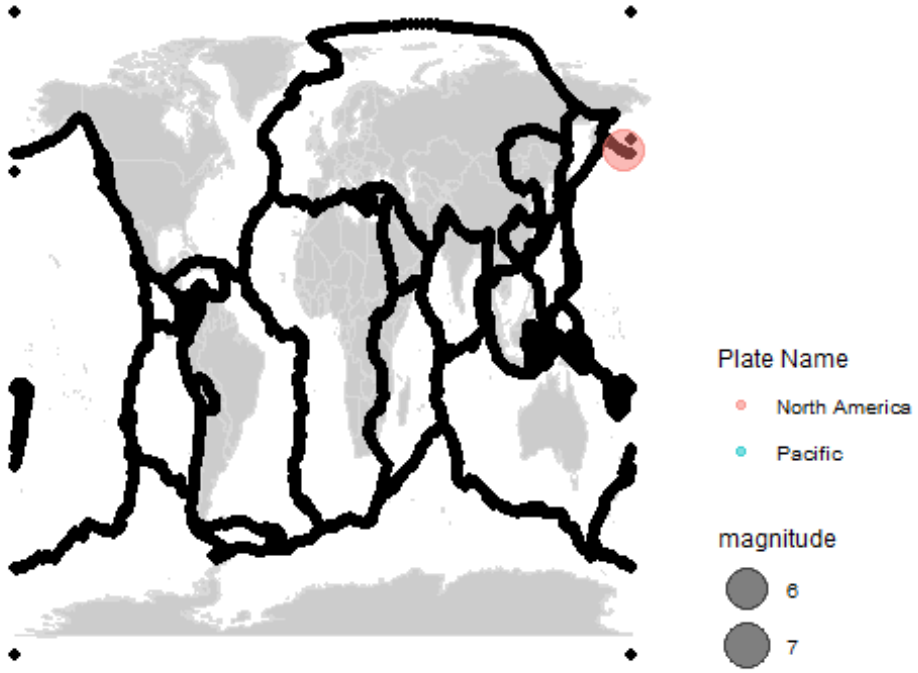
1965-03-06



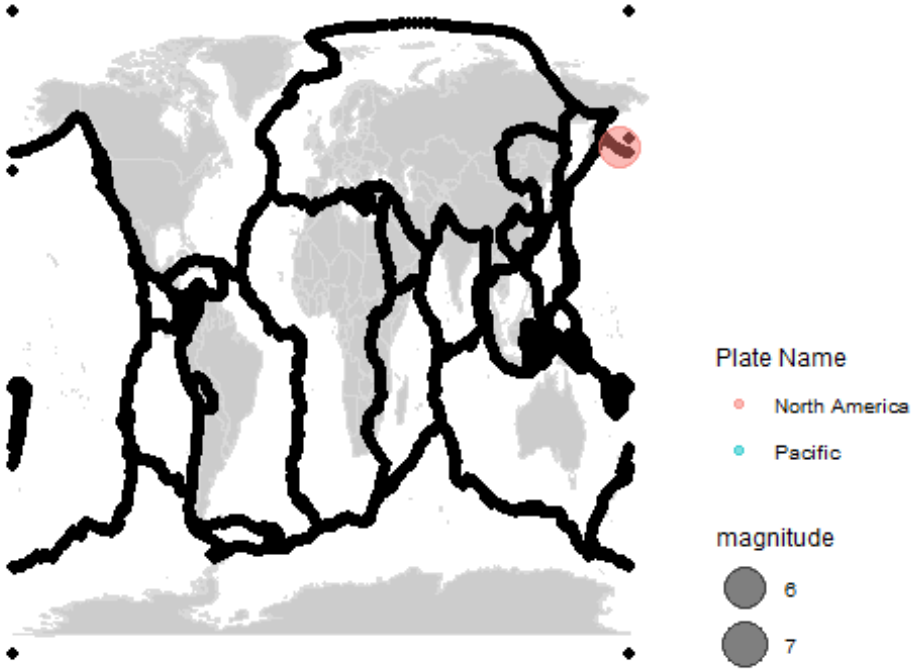
1965-03-13



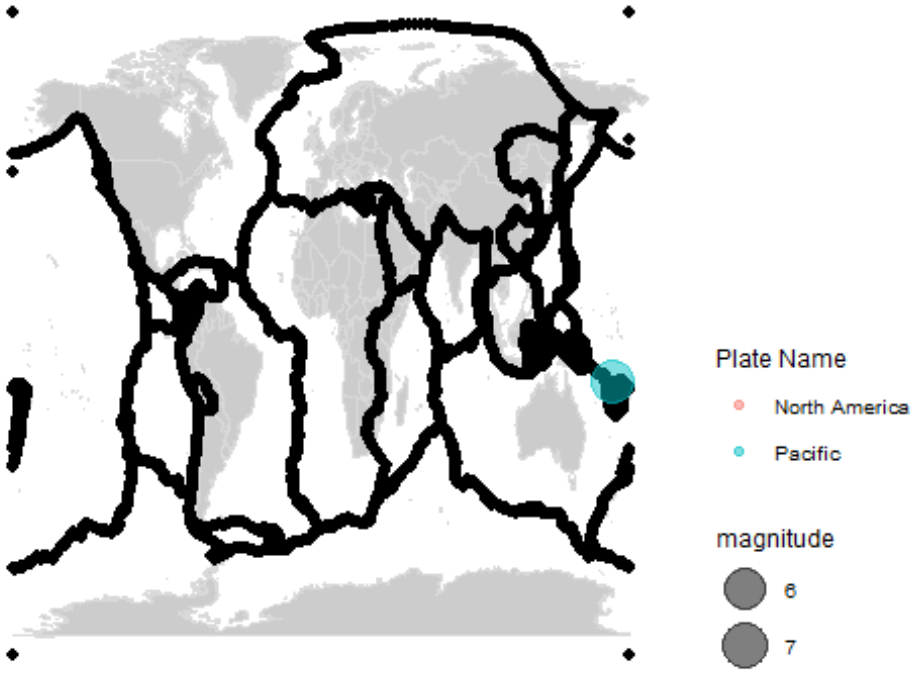
1965-04-04



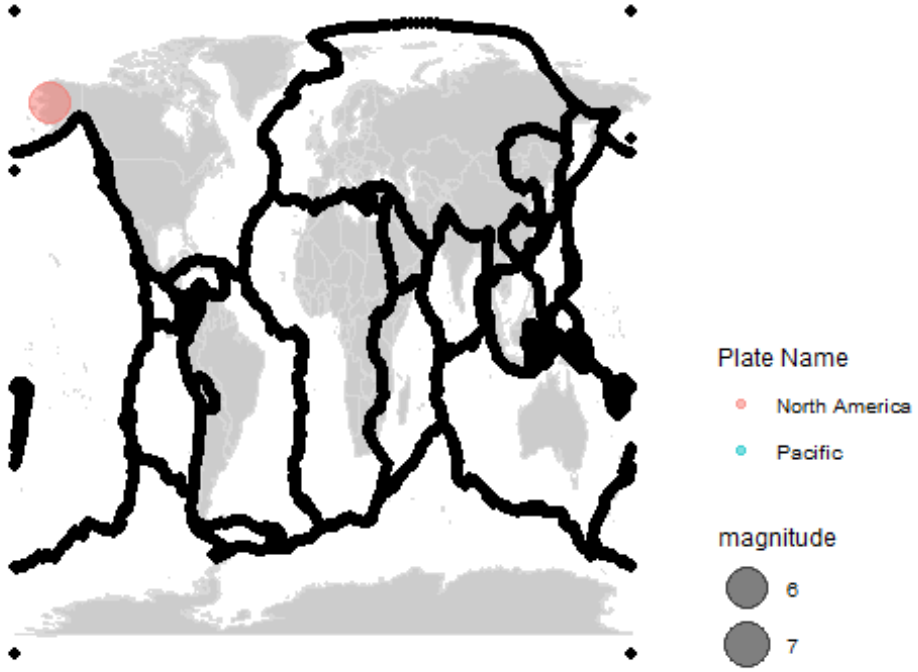
1965-04-08



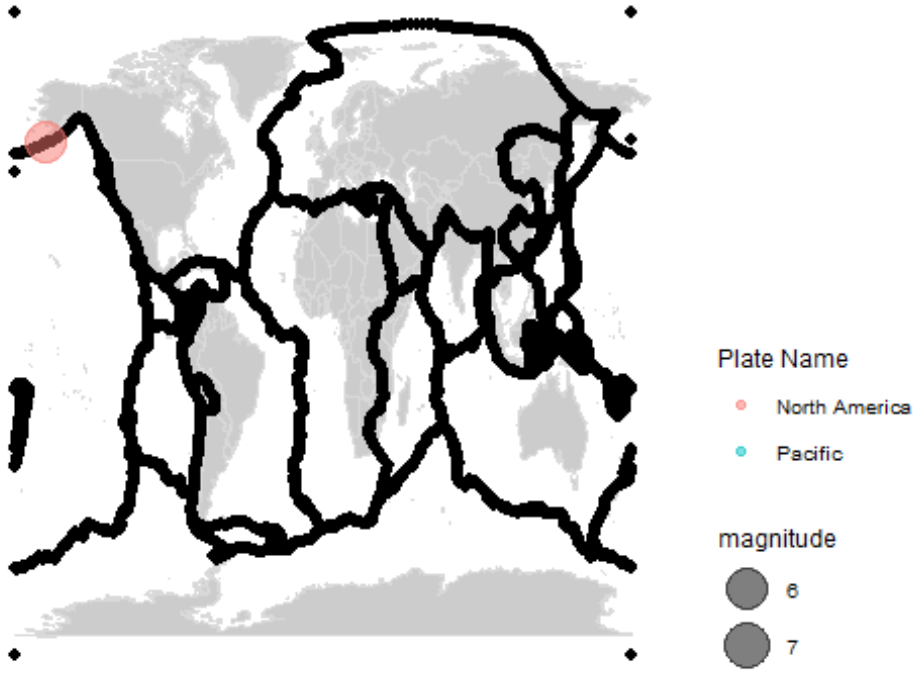
1965-04-10



1965-04-16



1965-04-26



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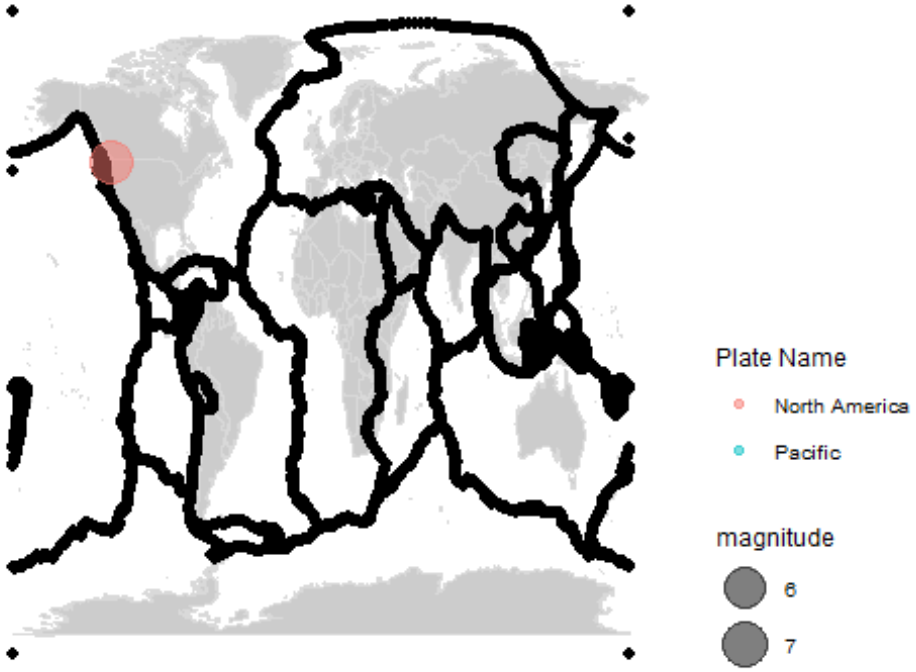

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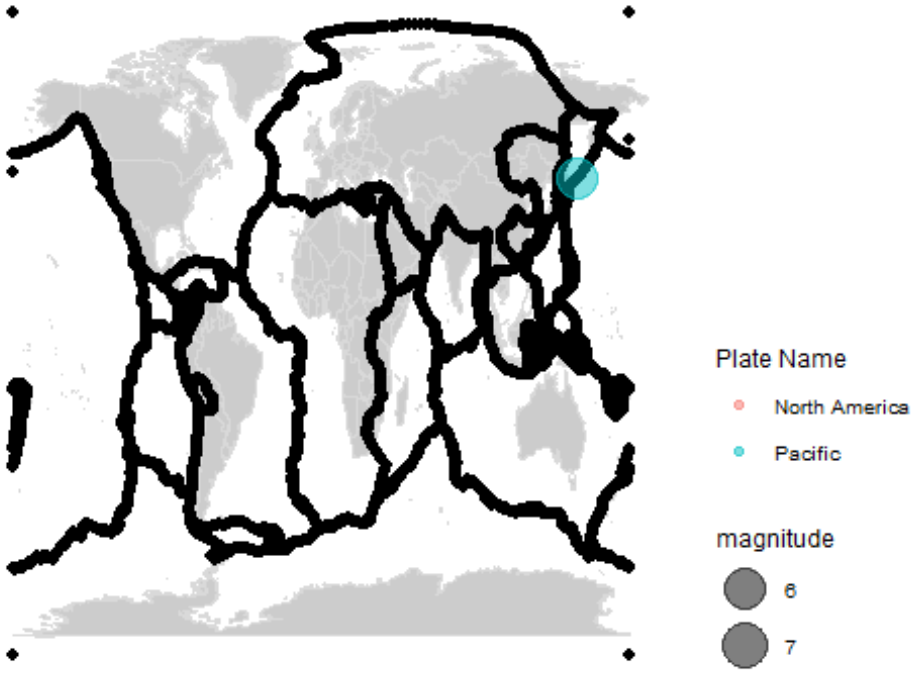

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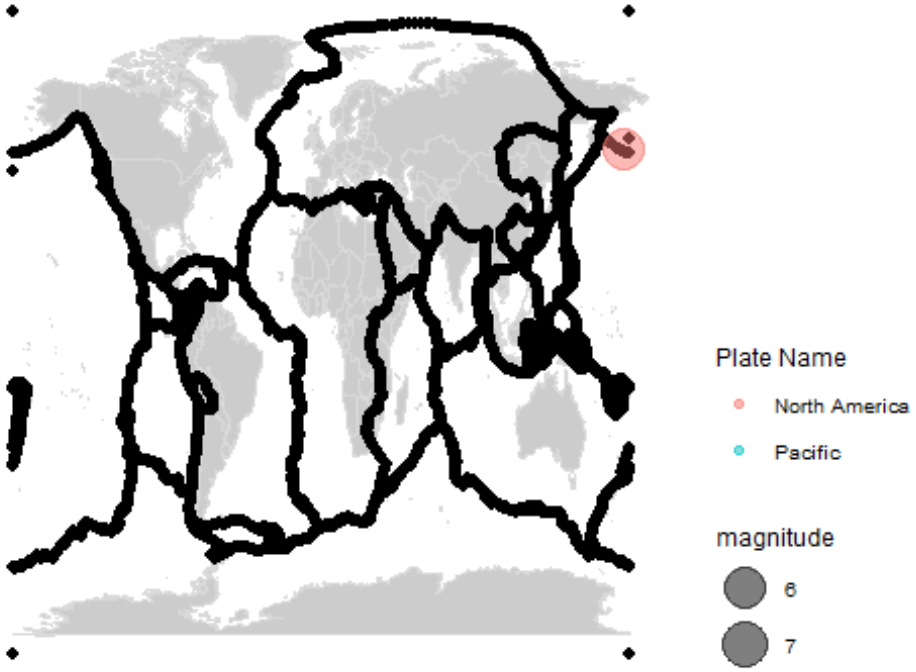

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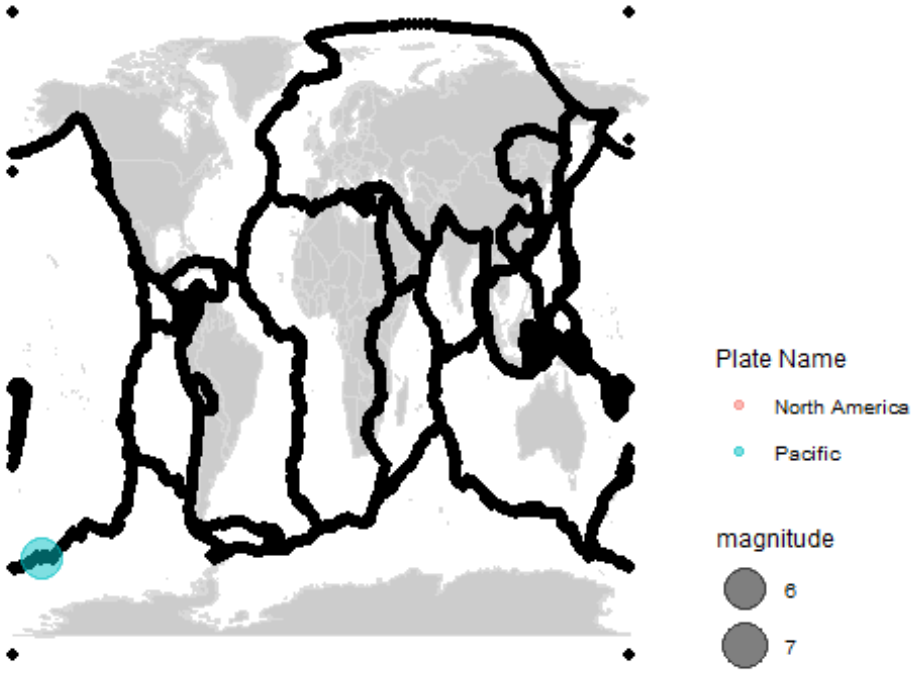

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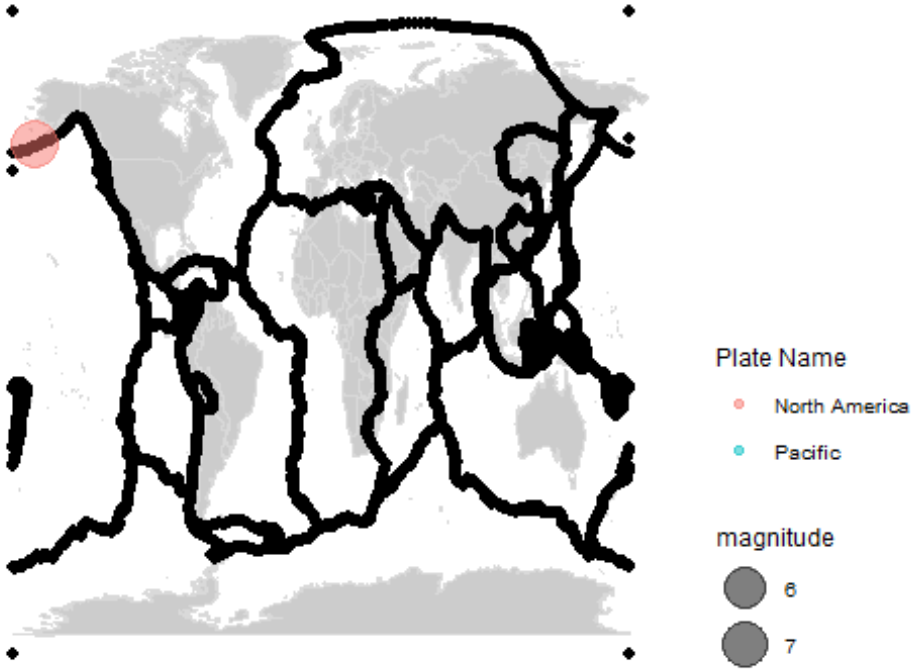

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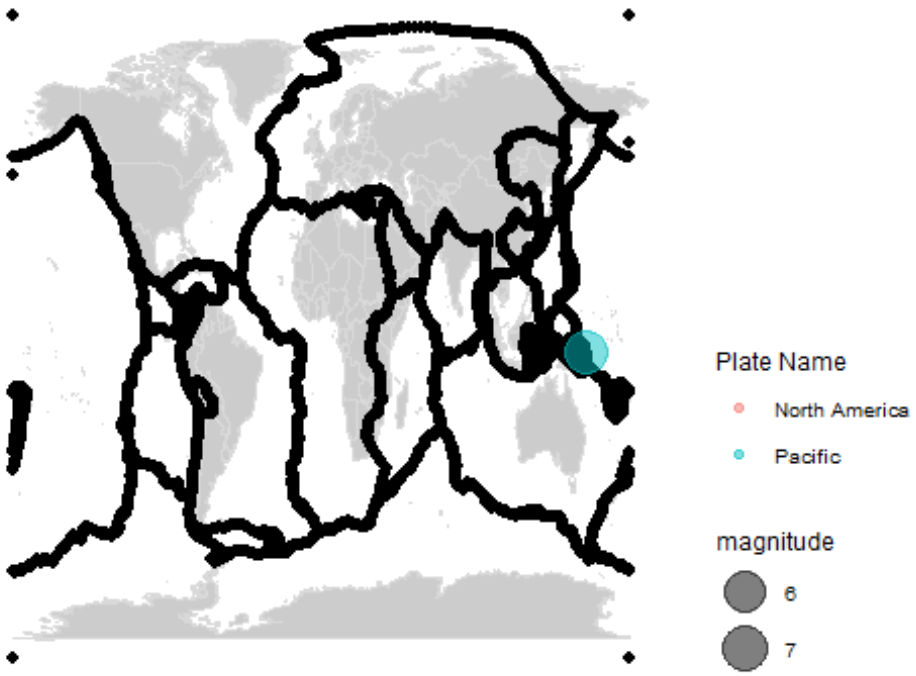

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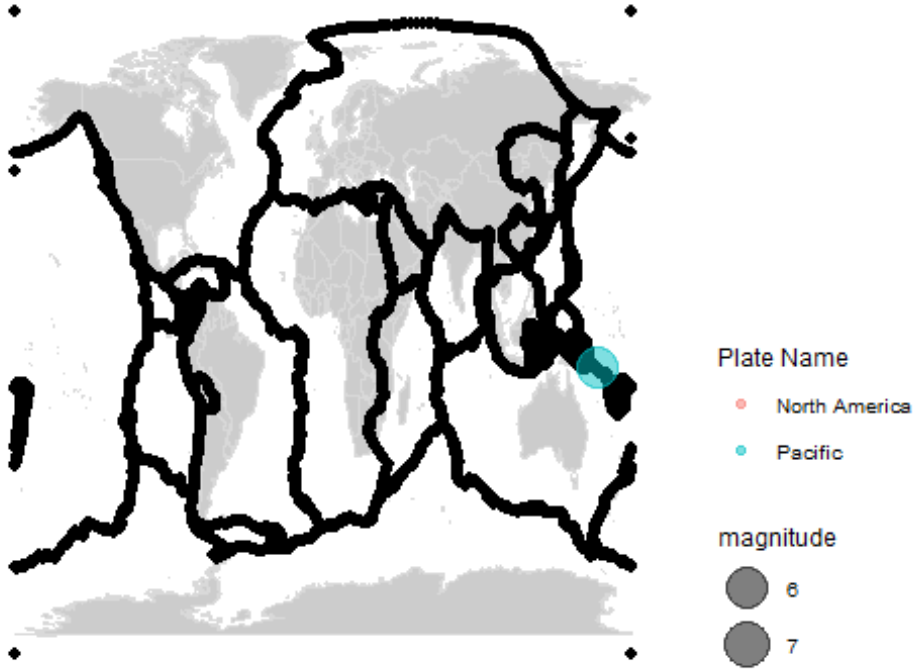

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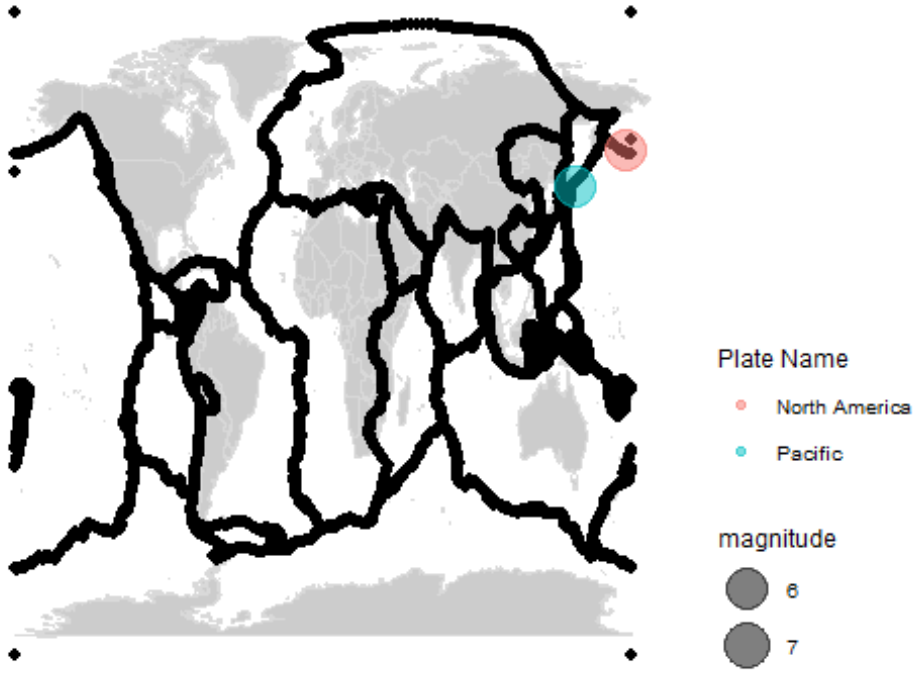

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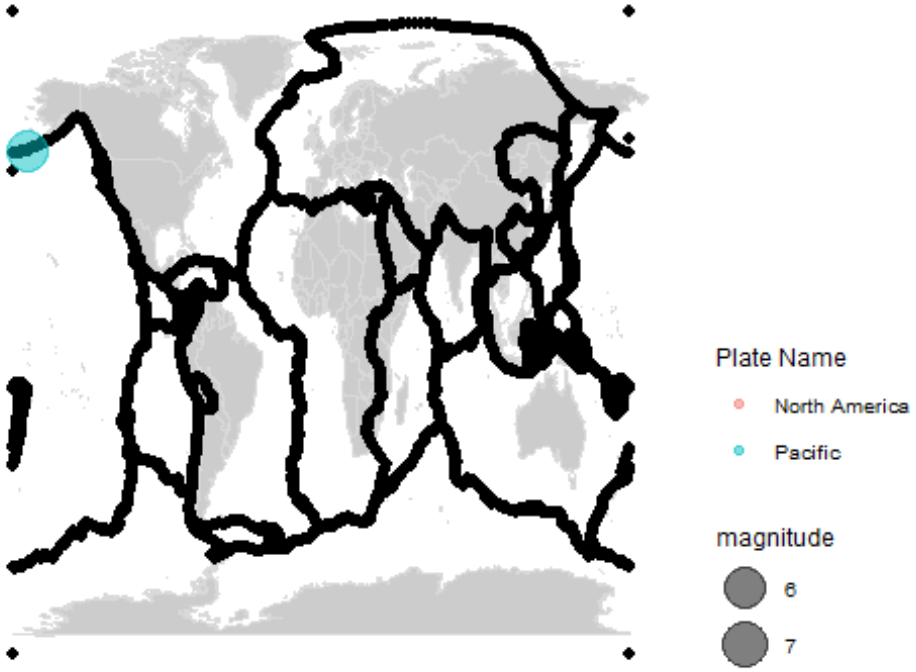

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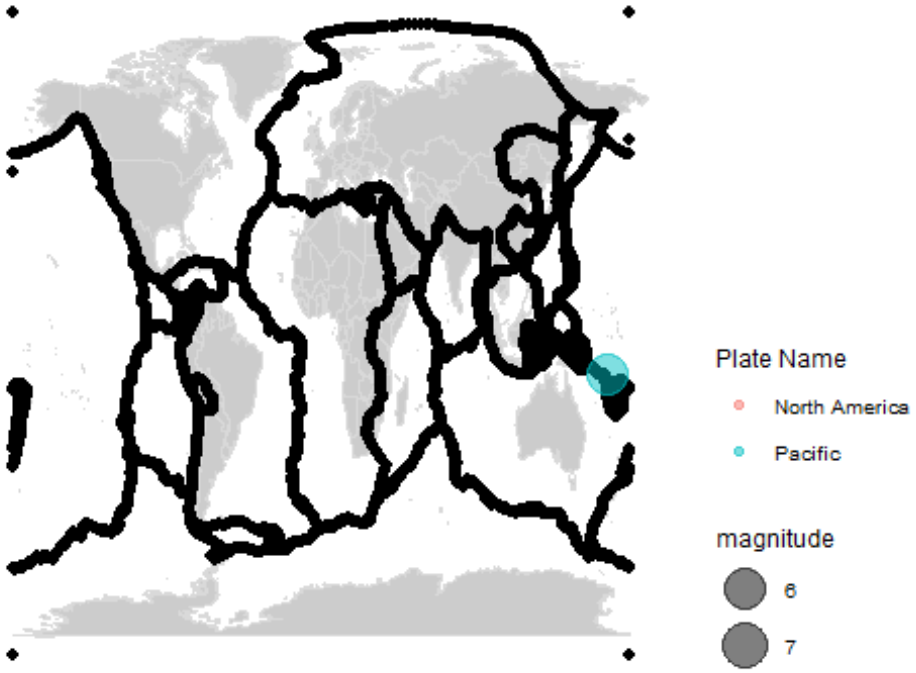

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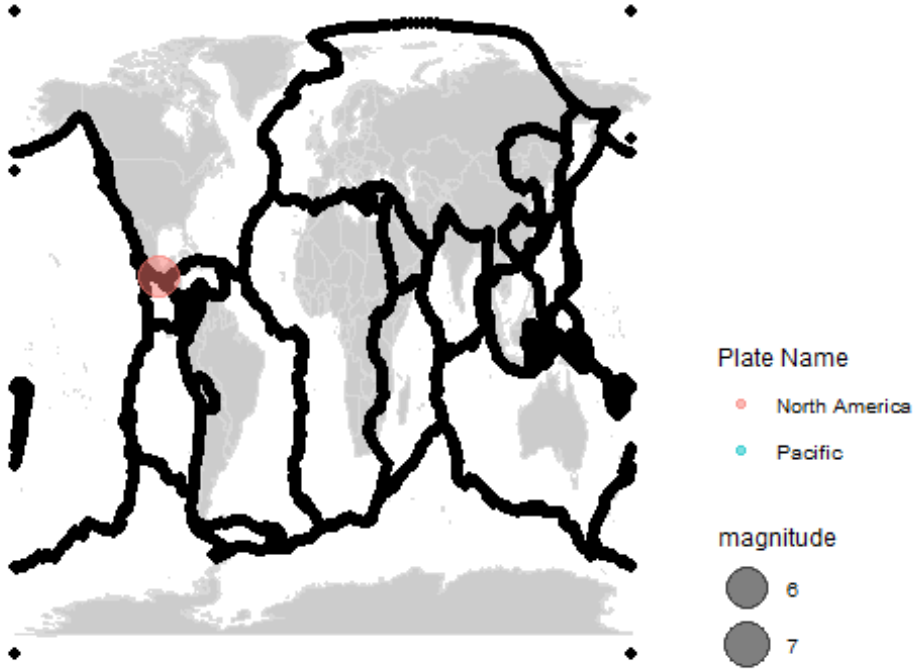

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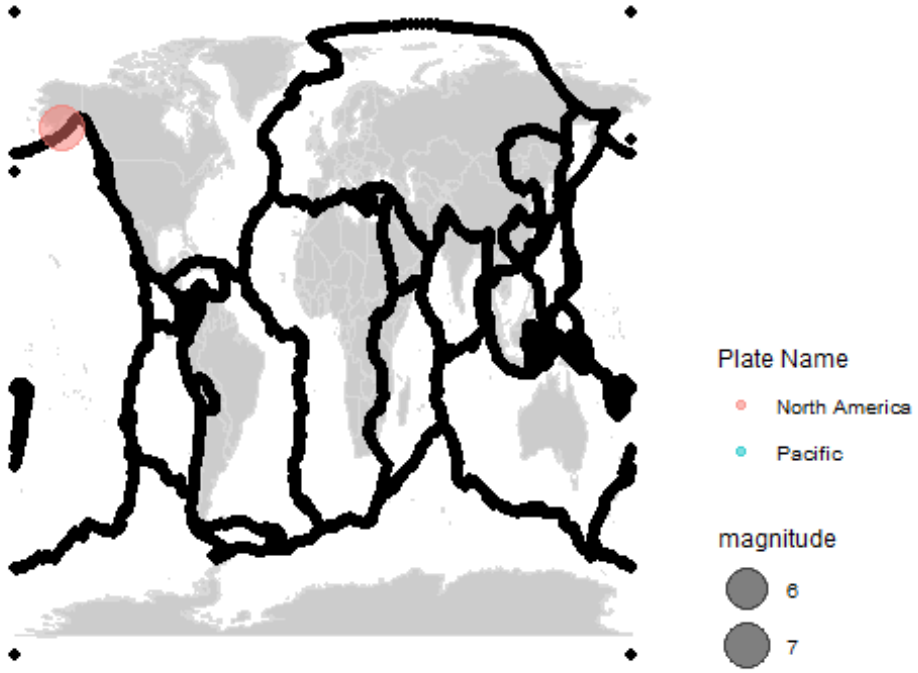

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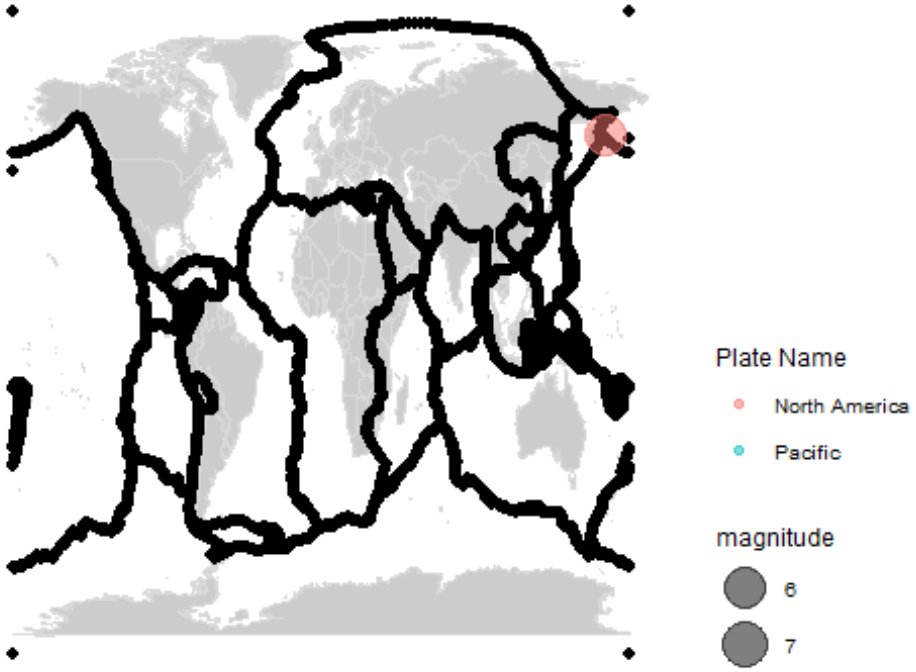

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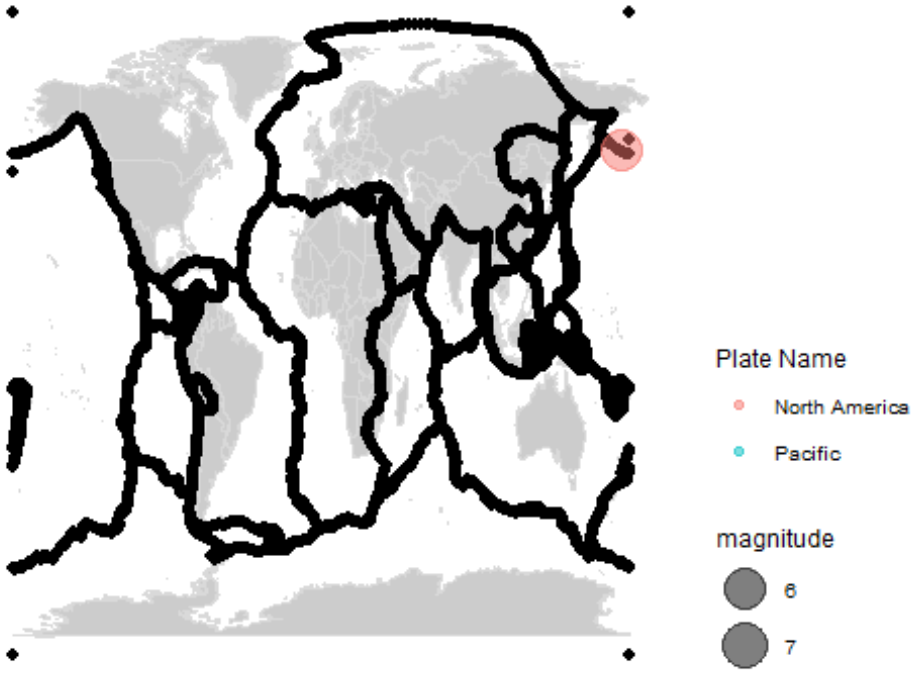

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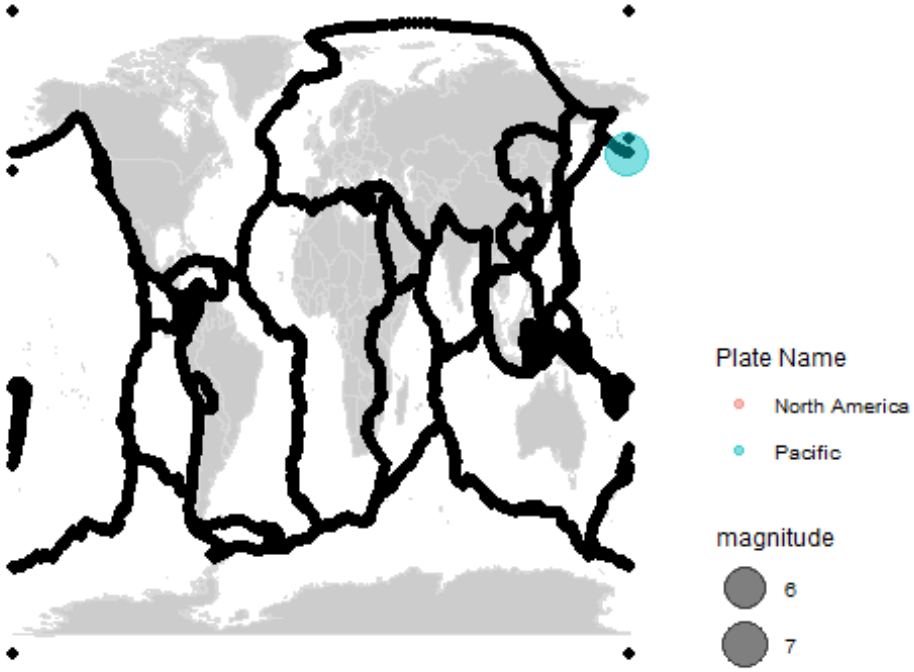

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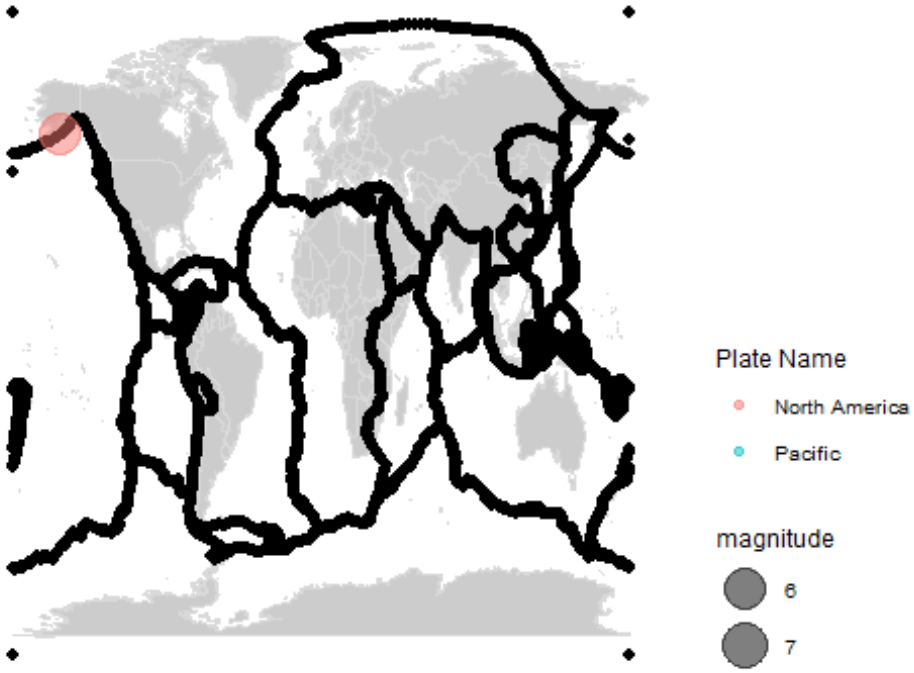

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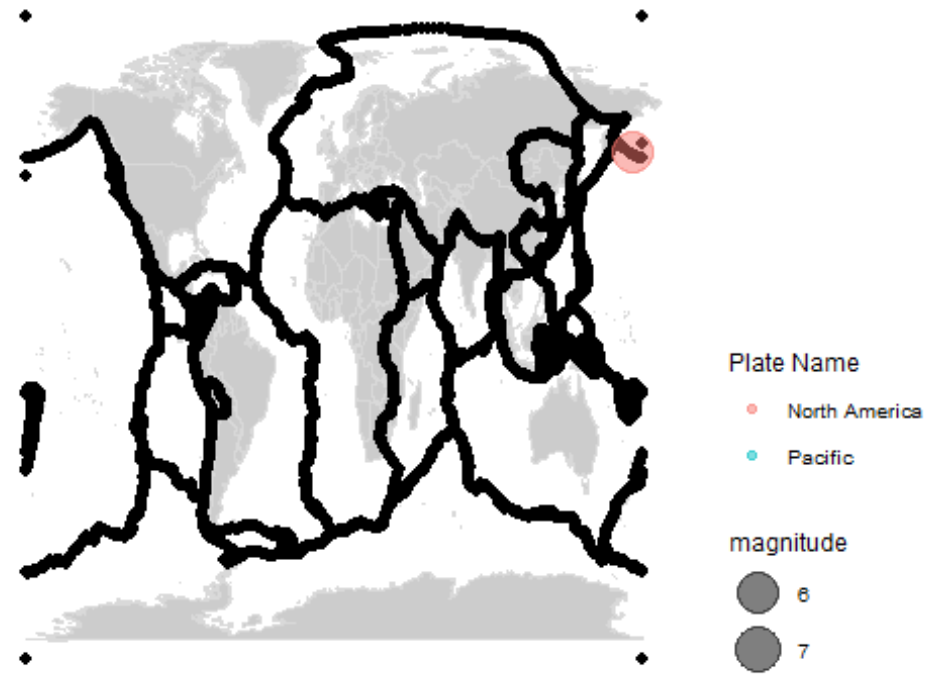

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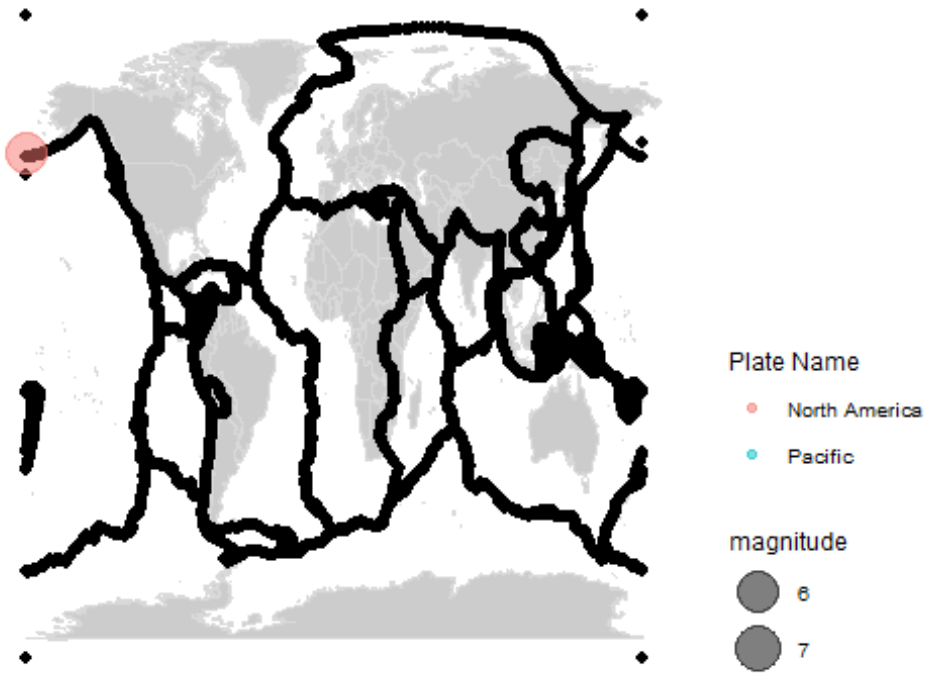

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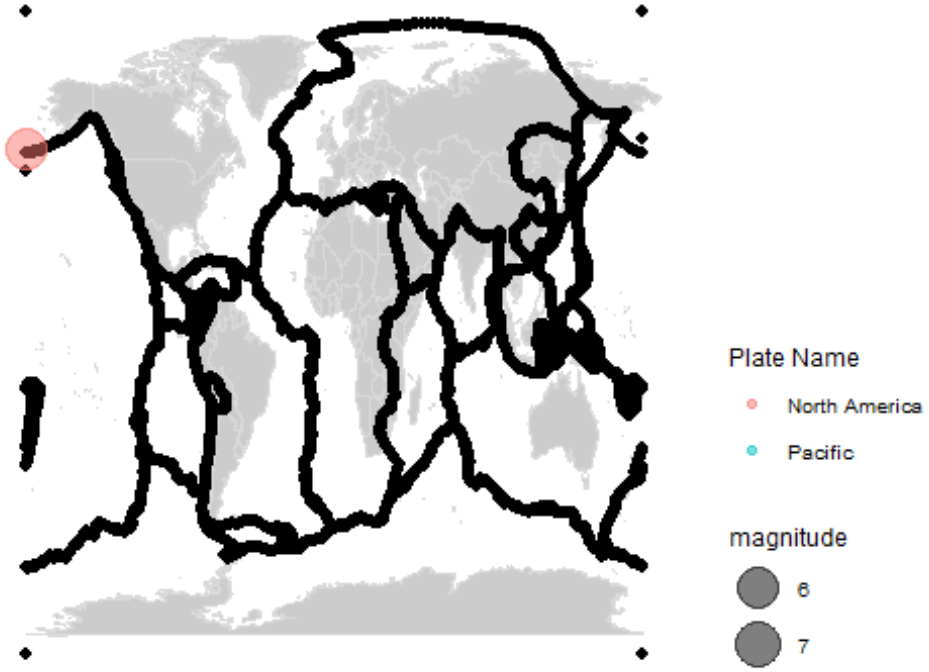

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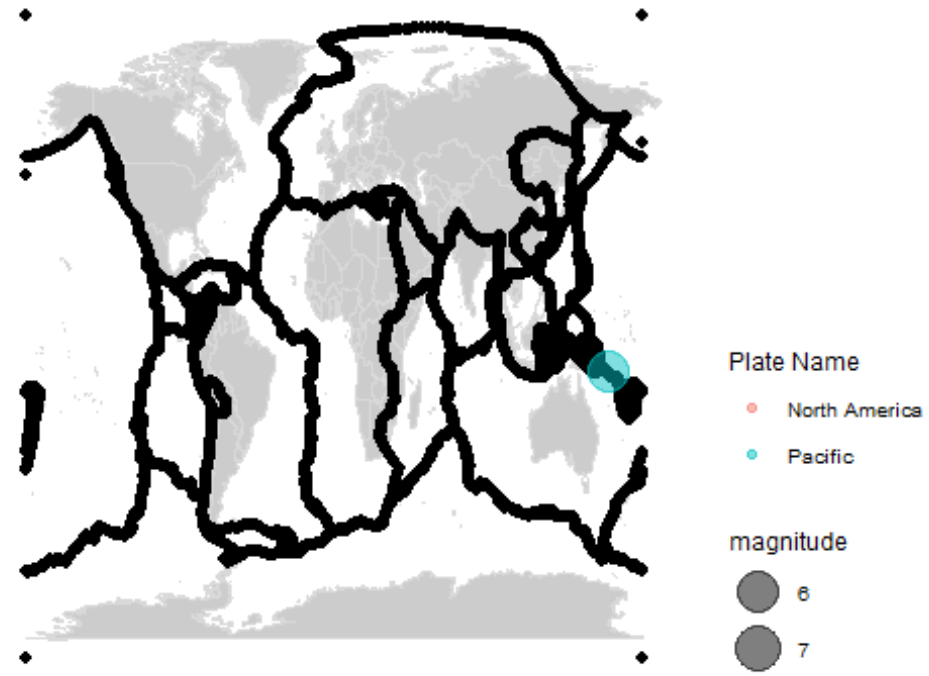

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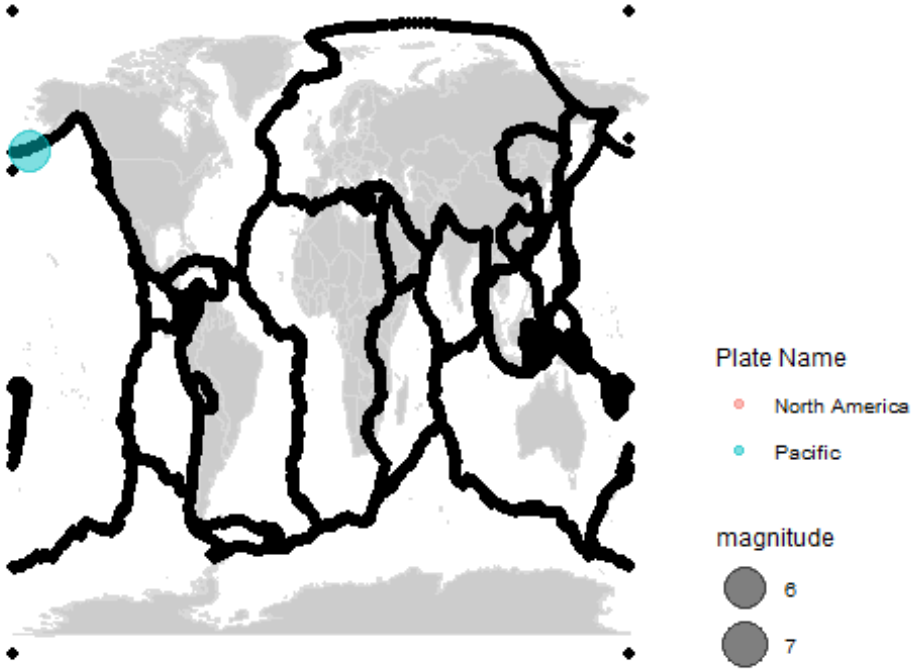

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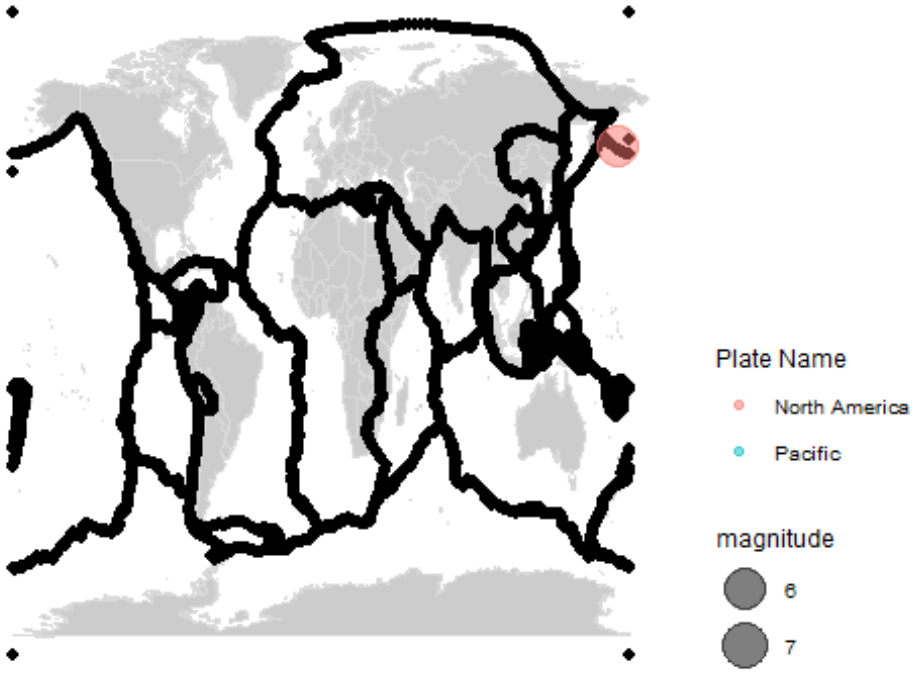

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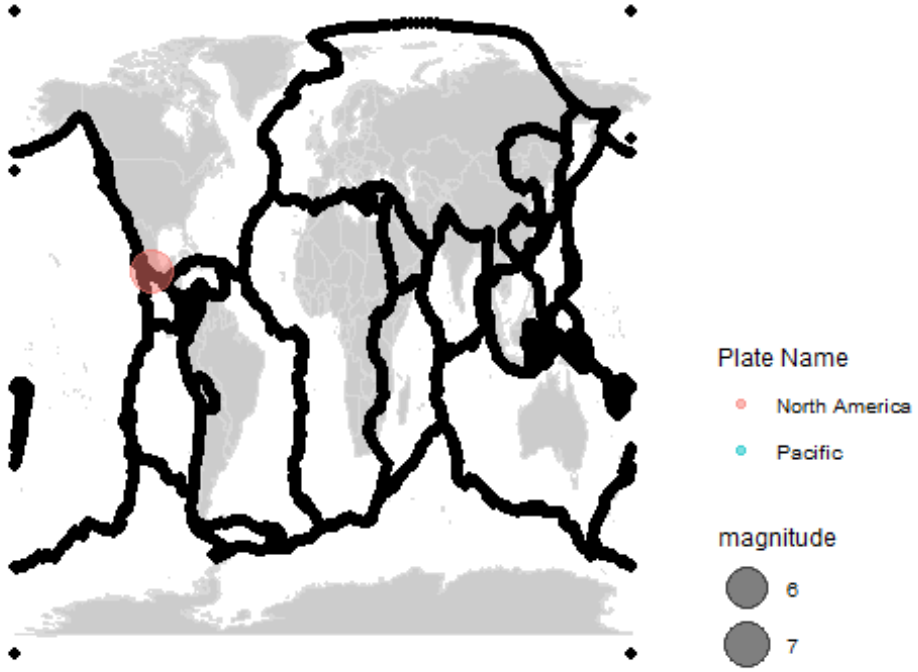

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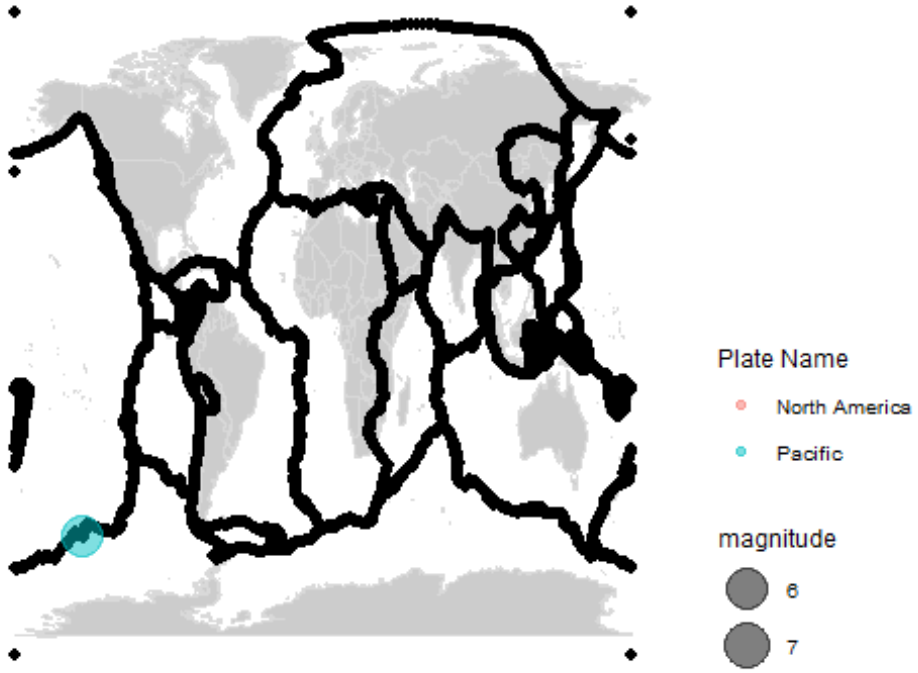

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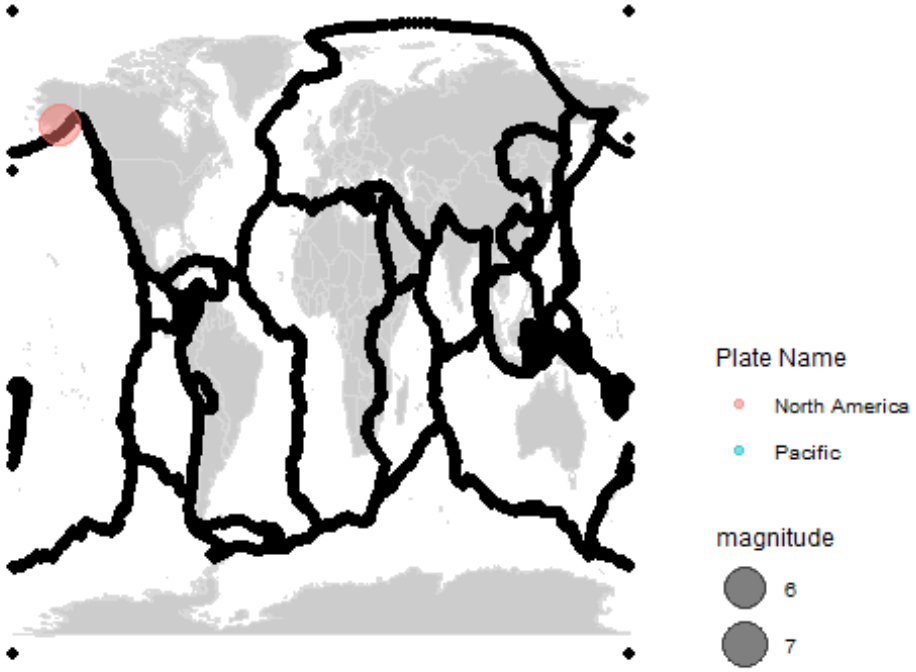

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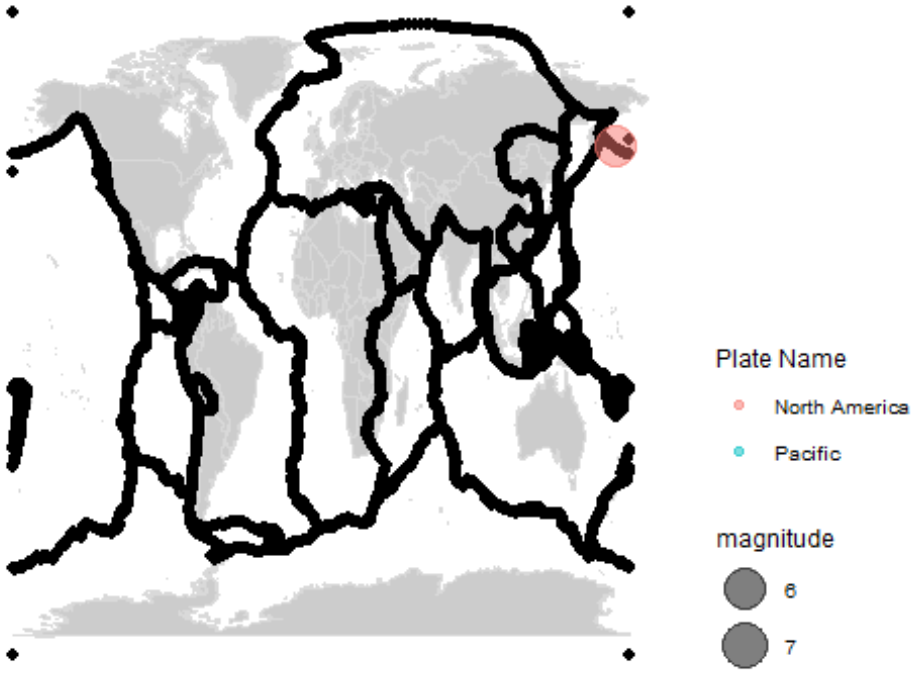

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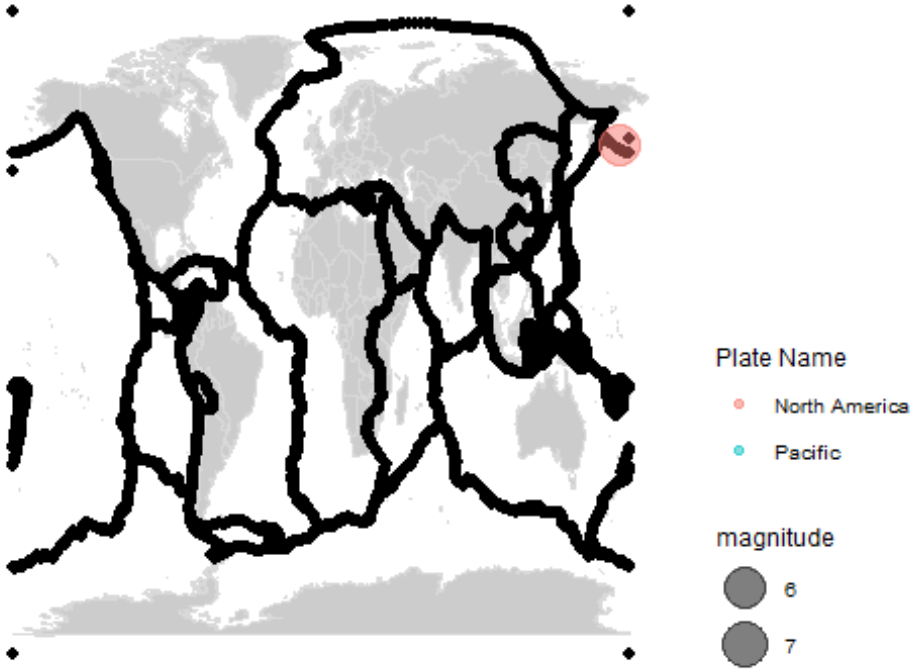

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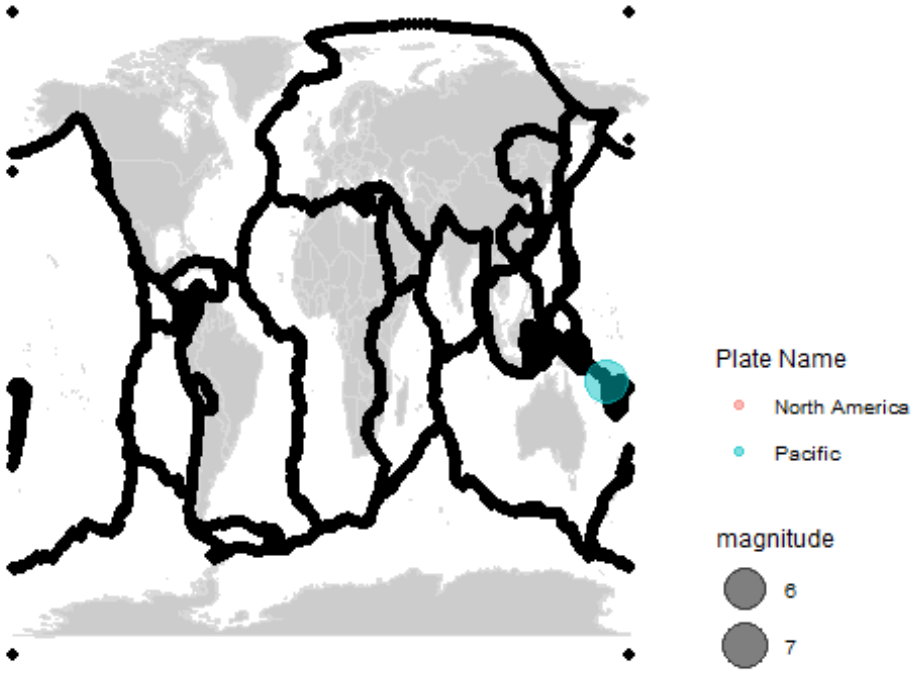

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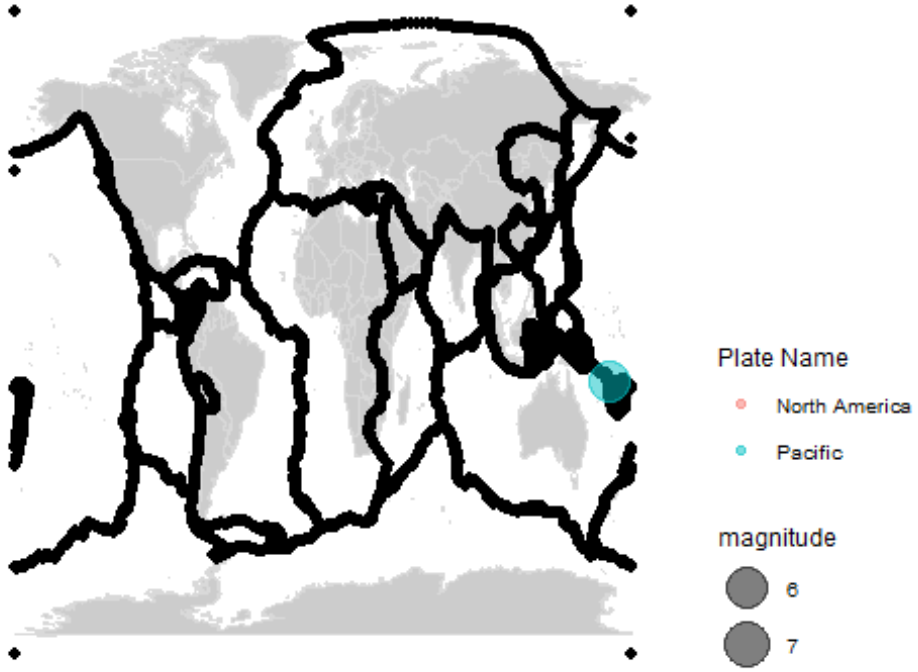

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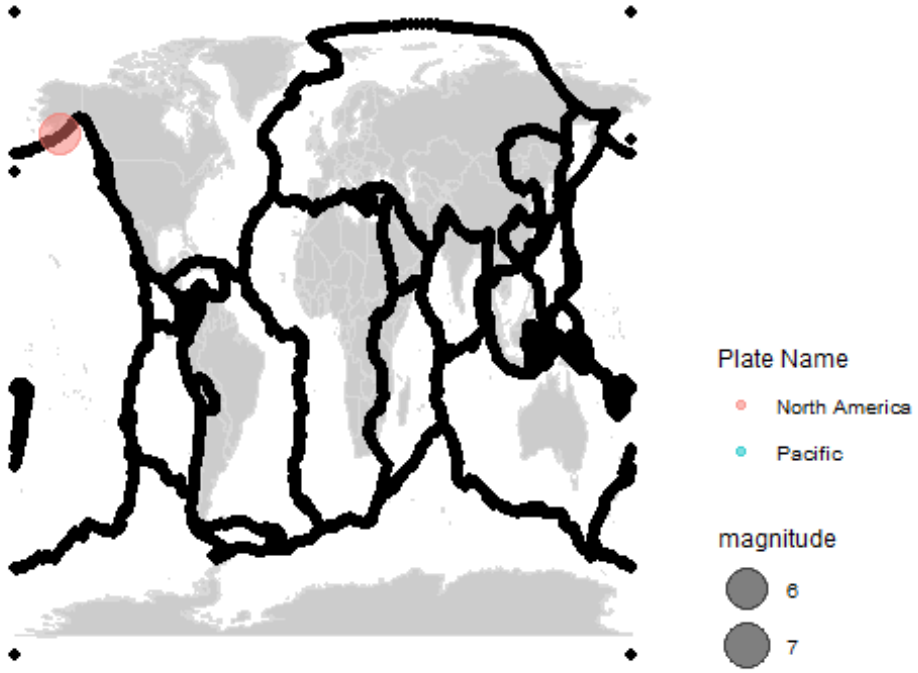

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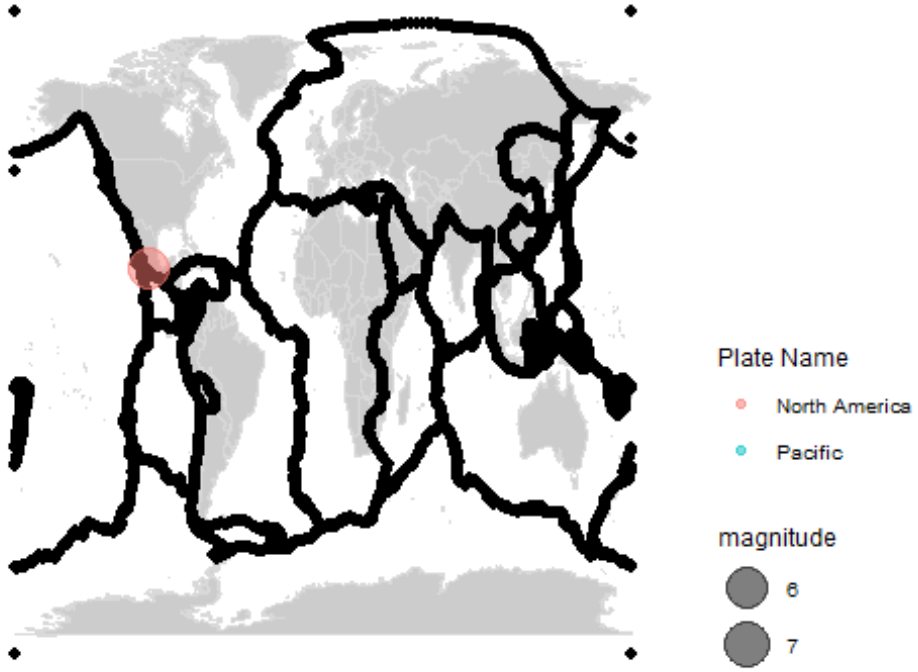

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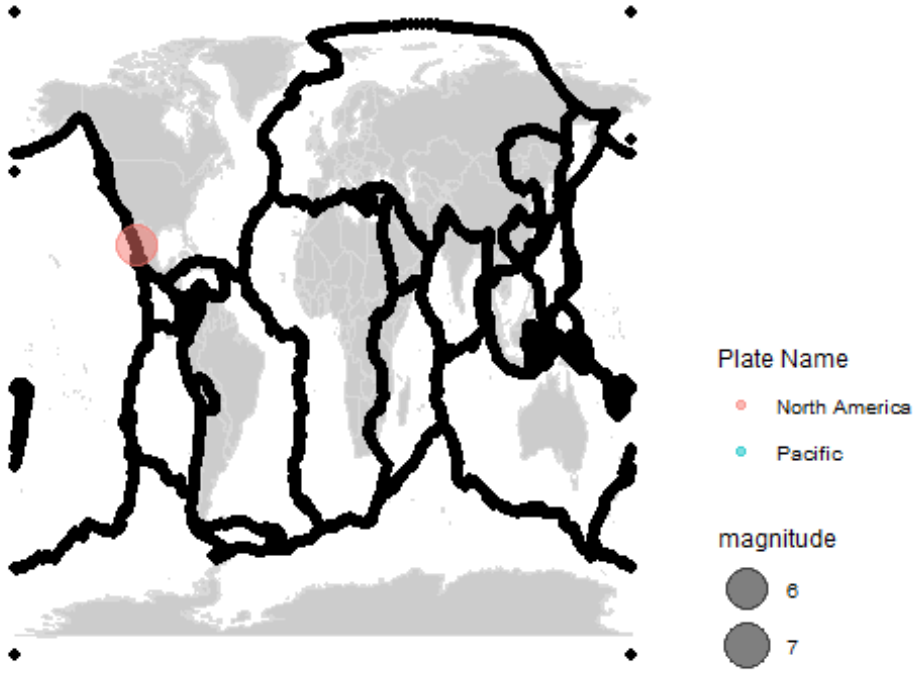

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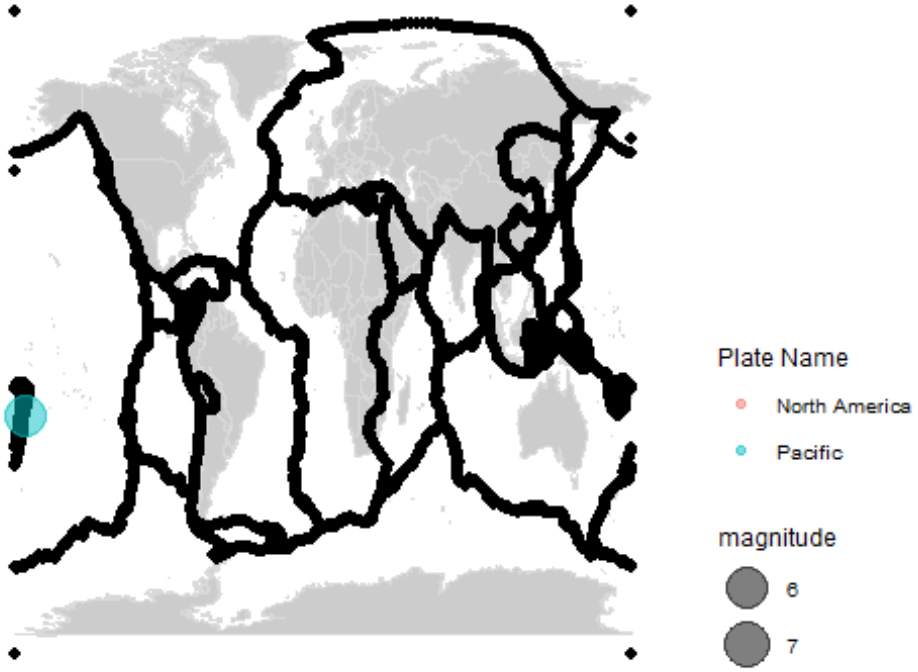

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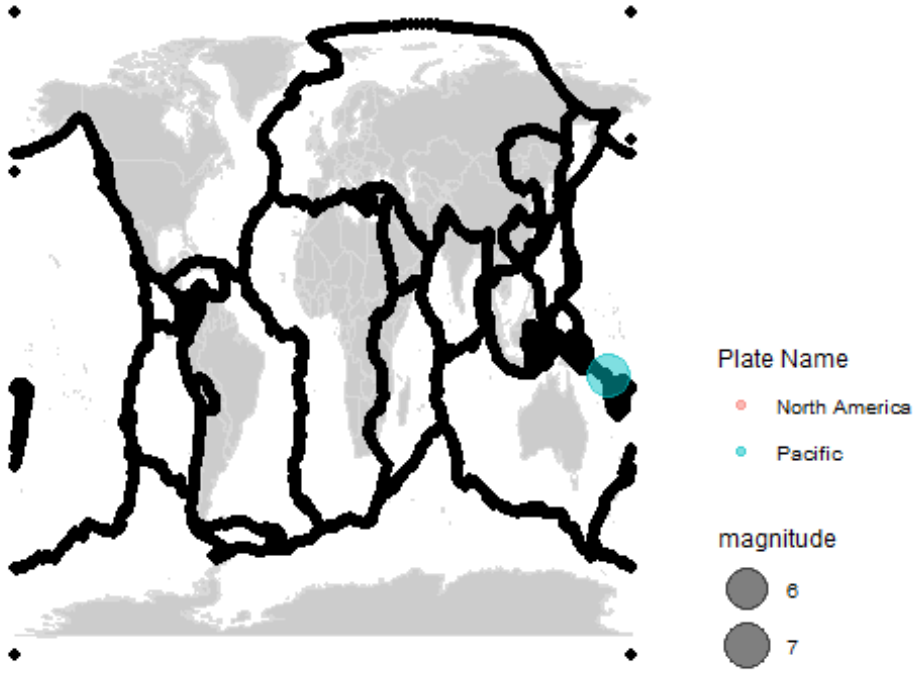

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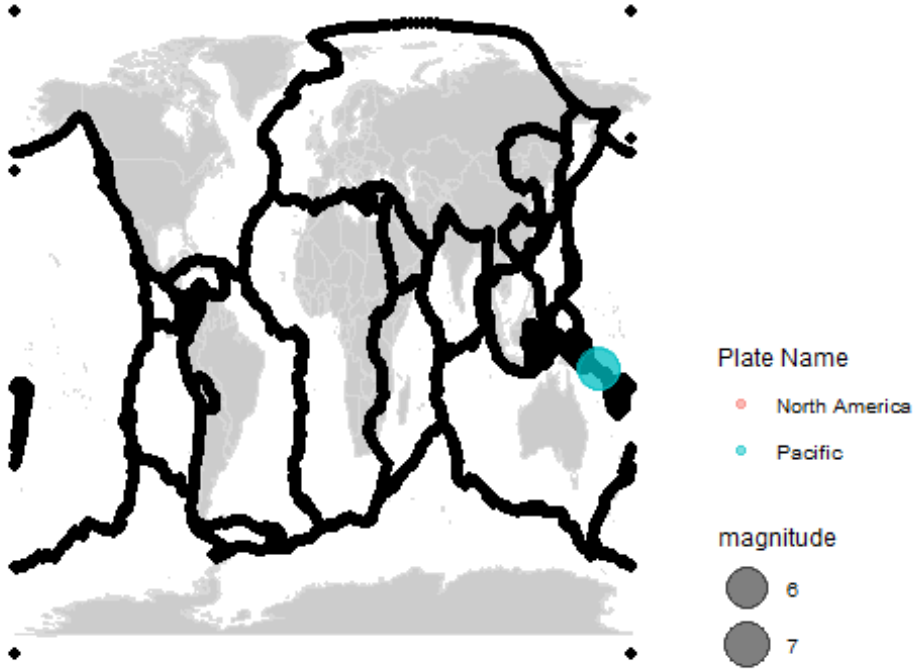

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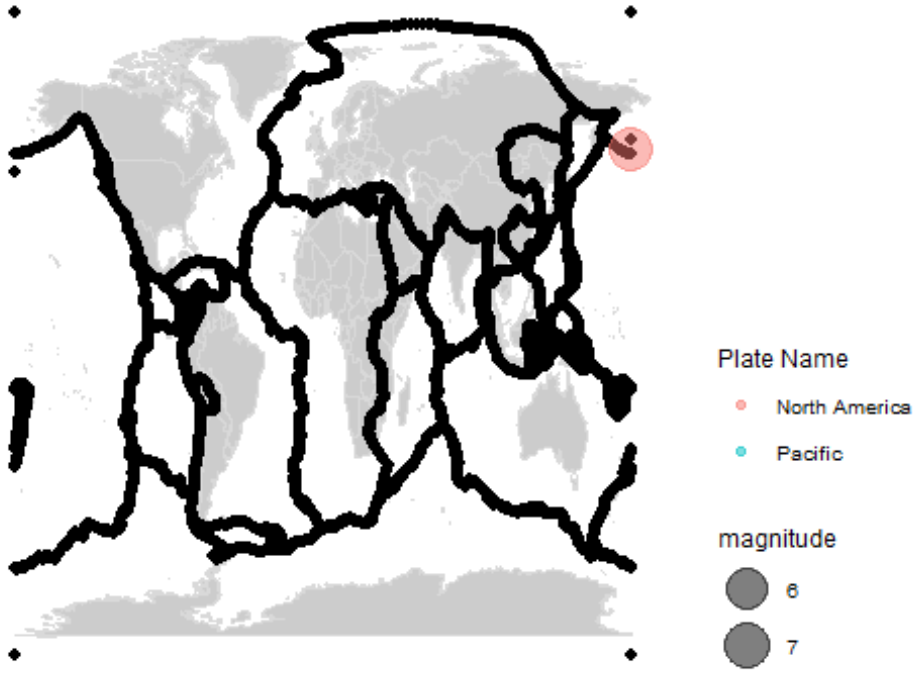

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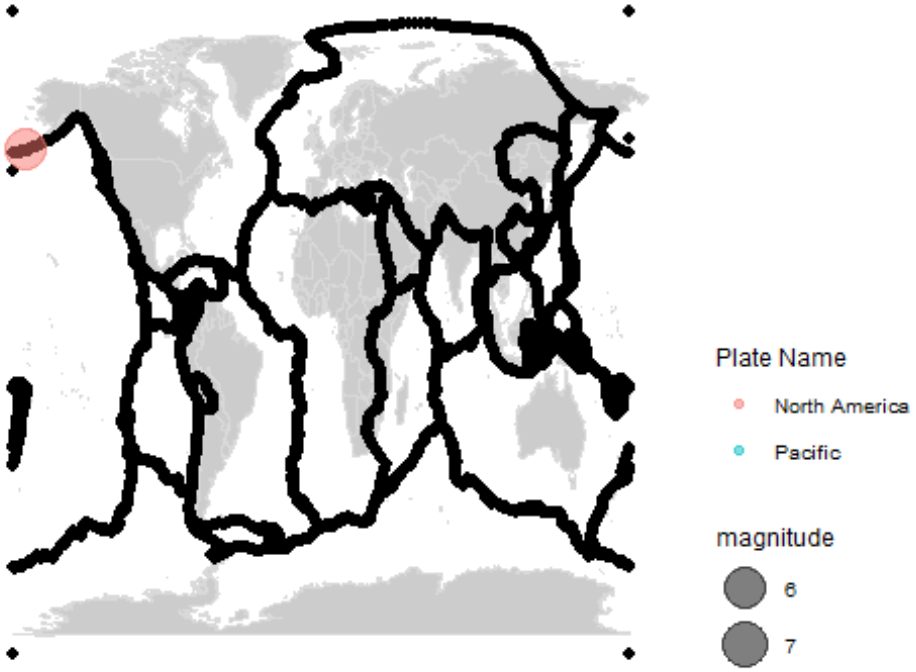

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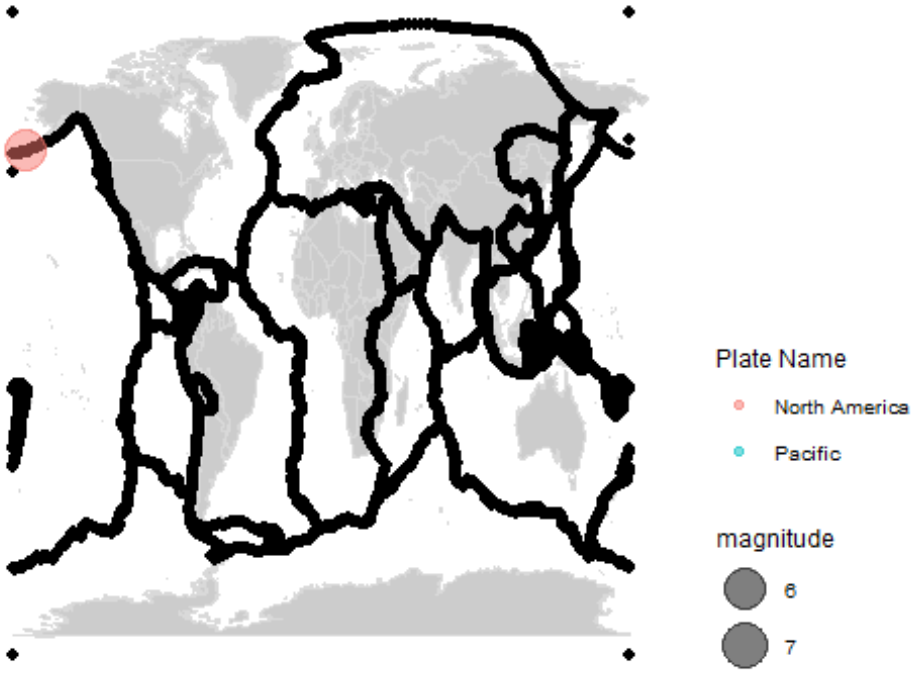

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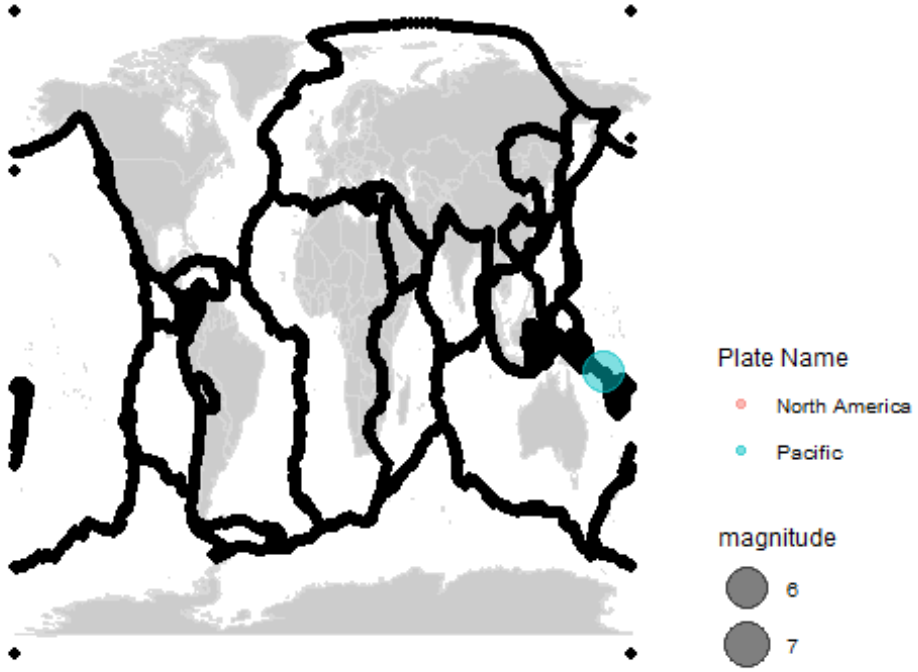

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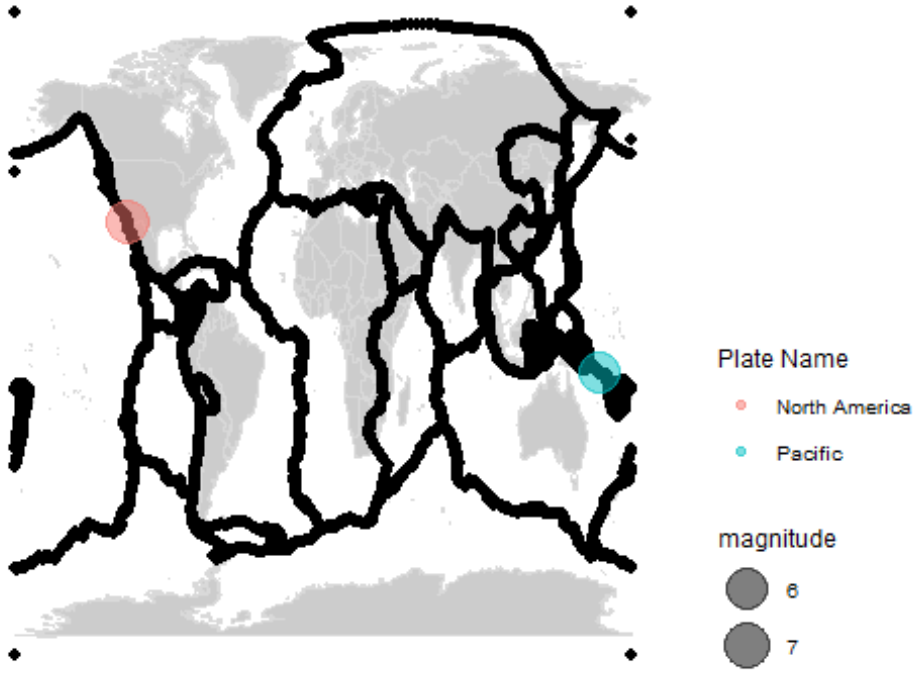

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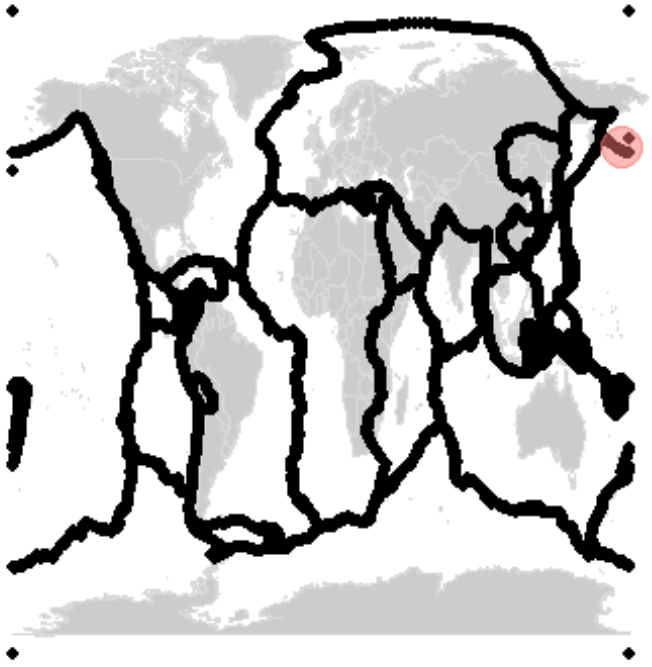

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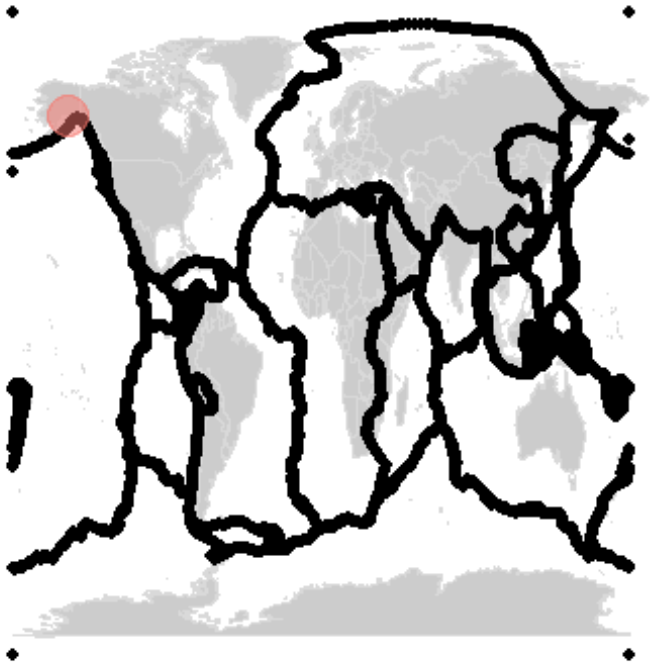
- North America
- Pacific

magnitude
- 6
- 7

1966-08-30



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magnitude
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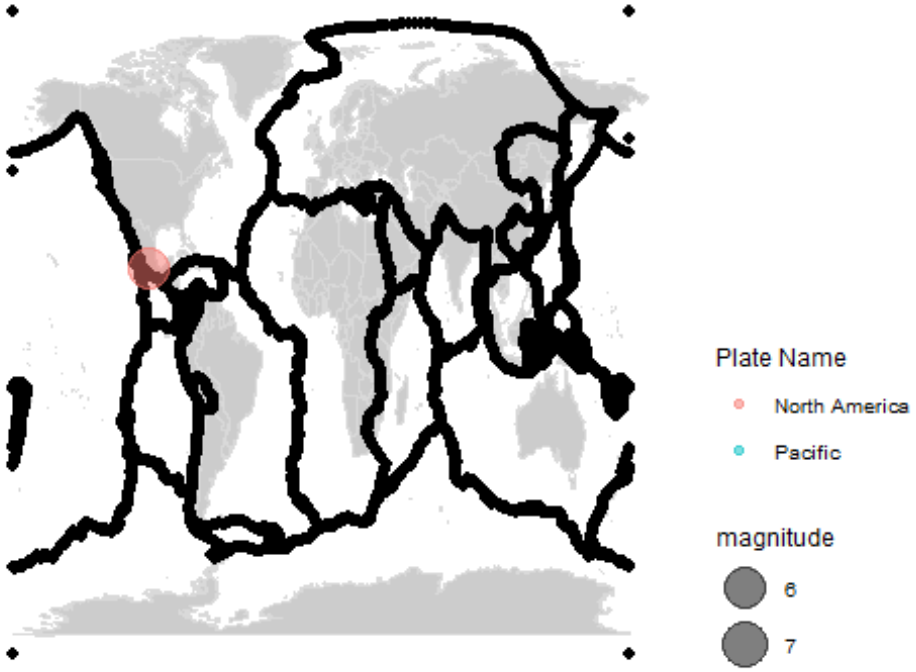

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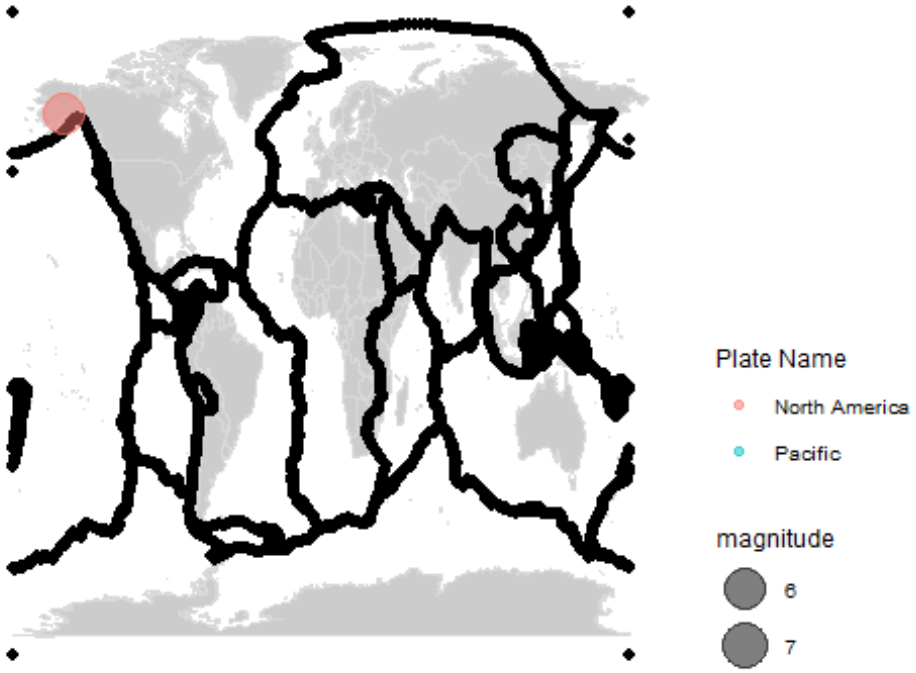

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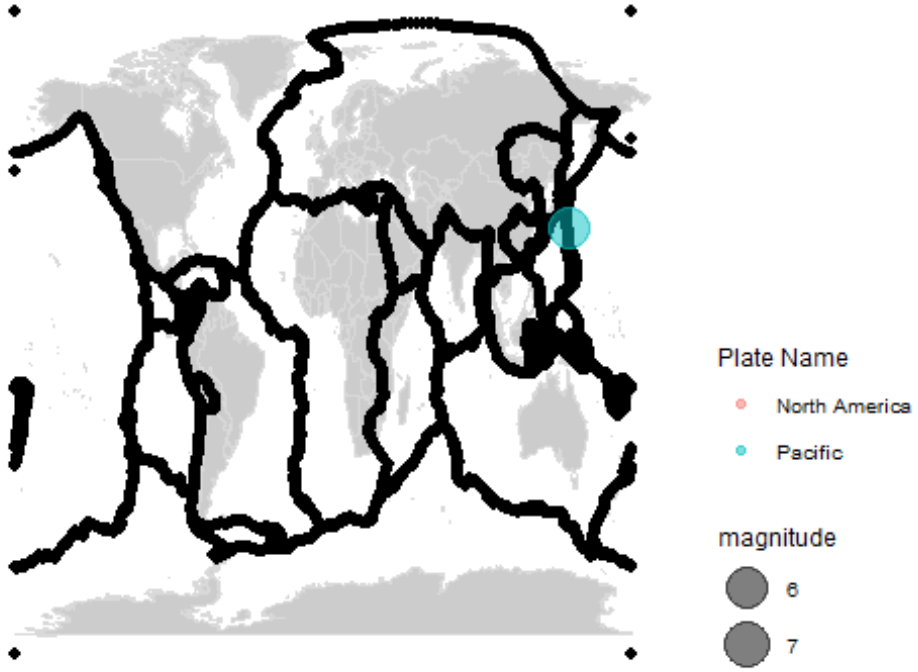

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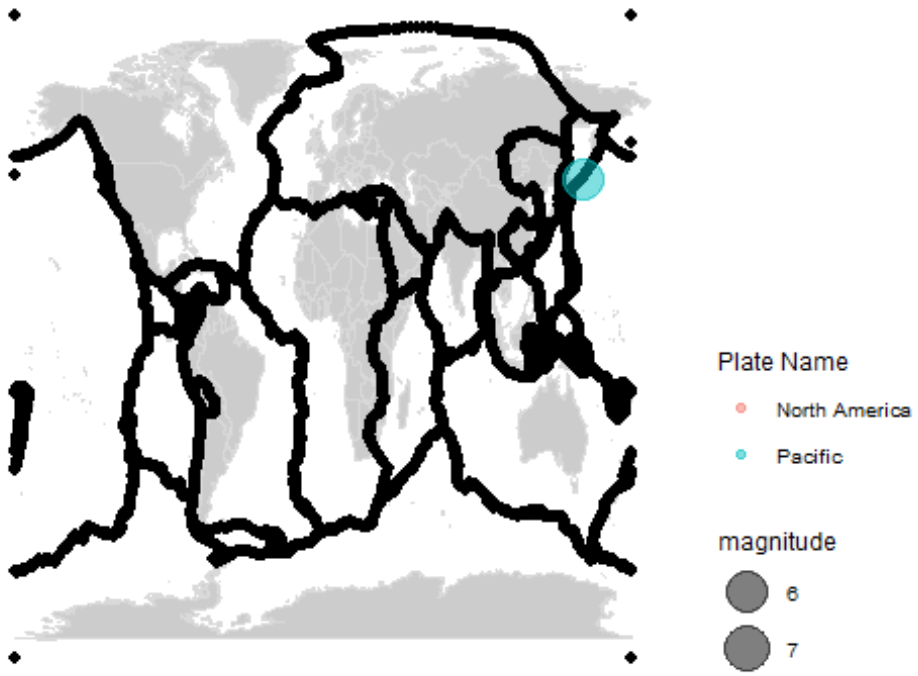

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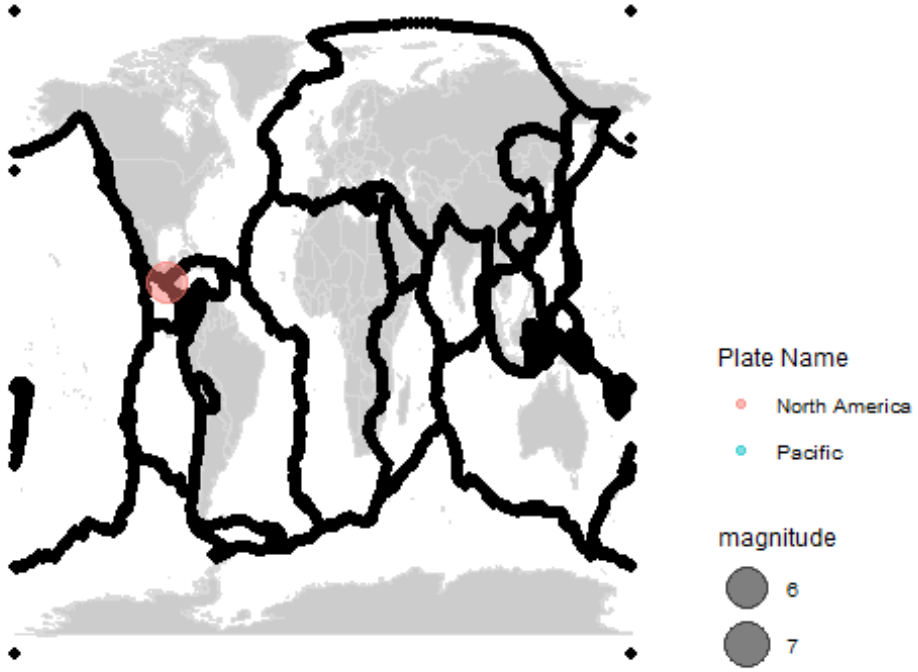

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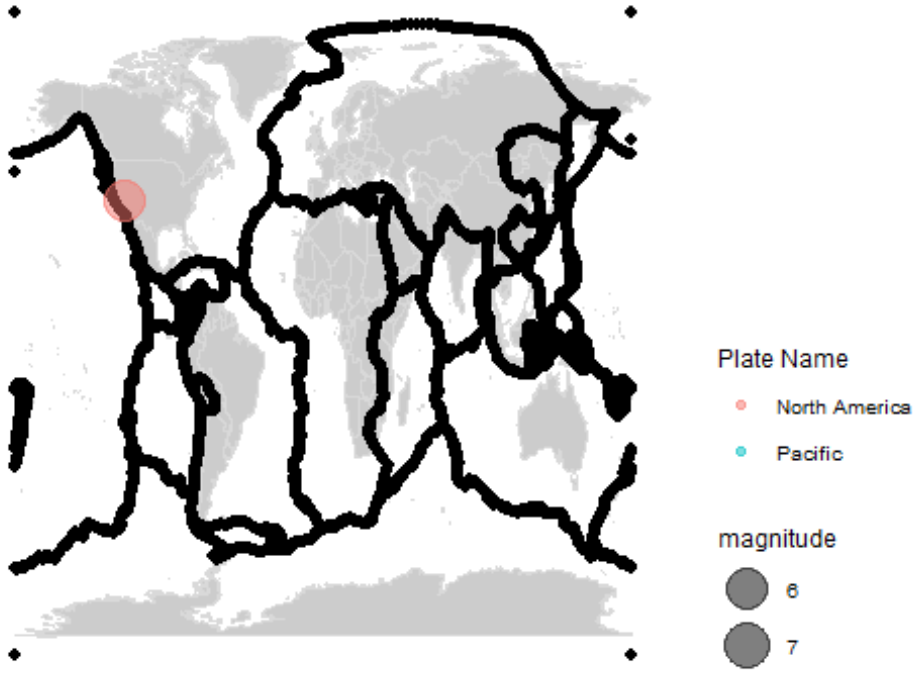

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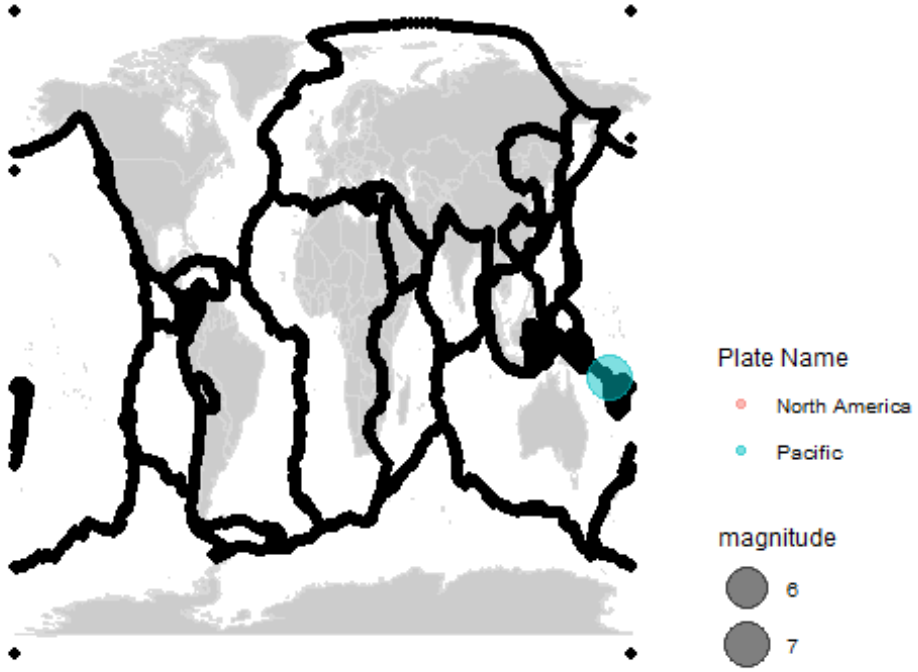

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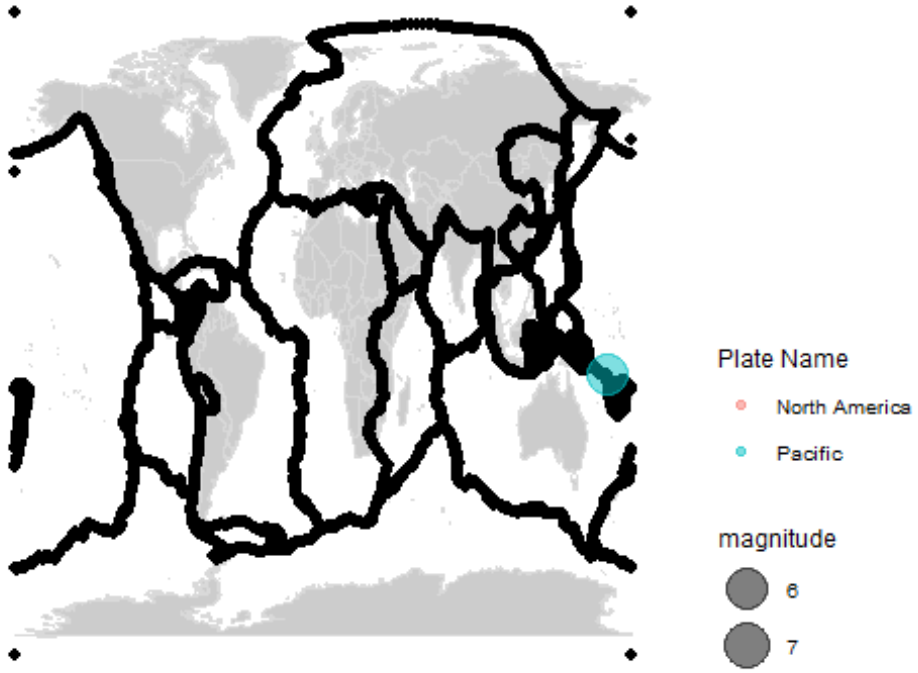

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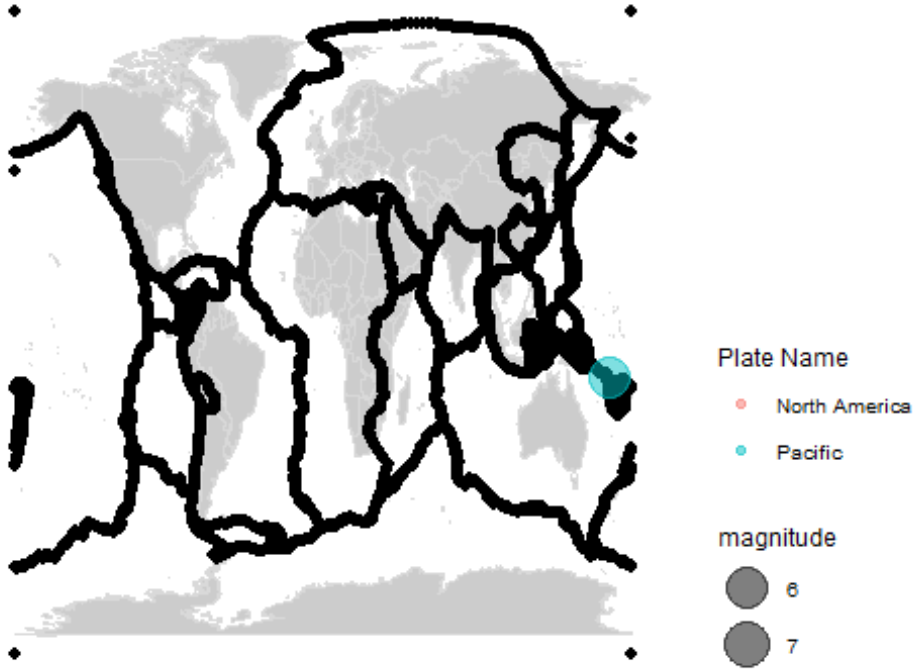

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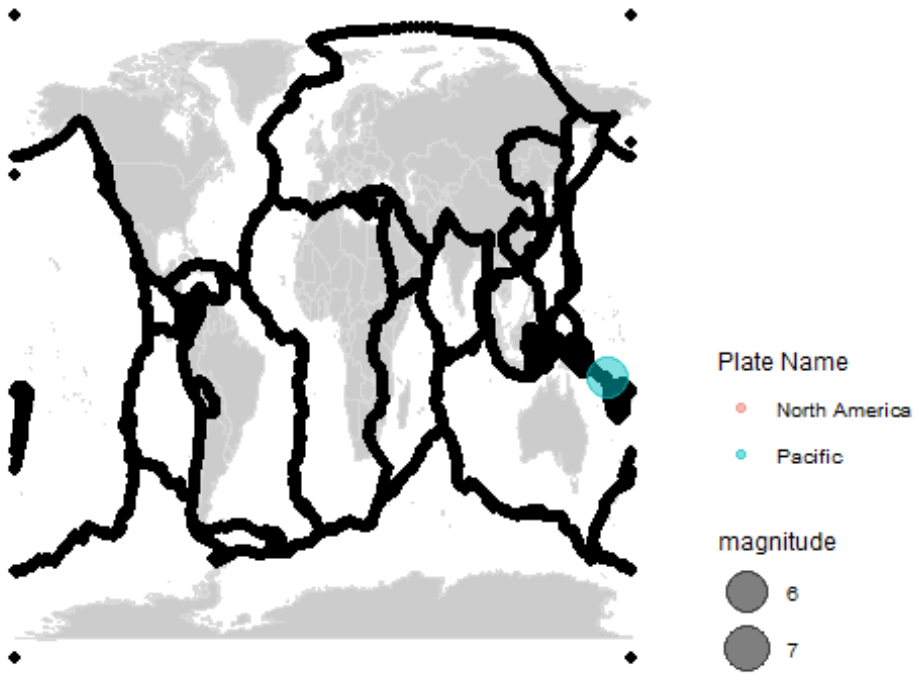

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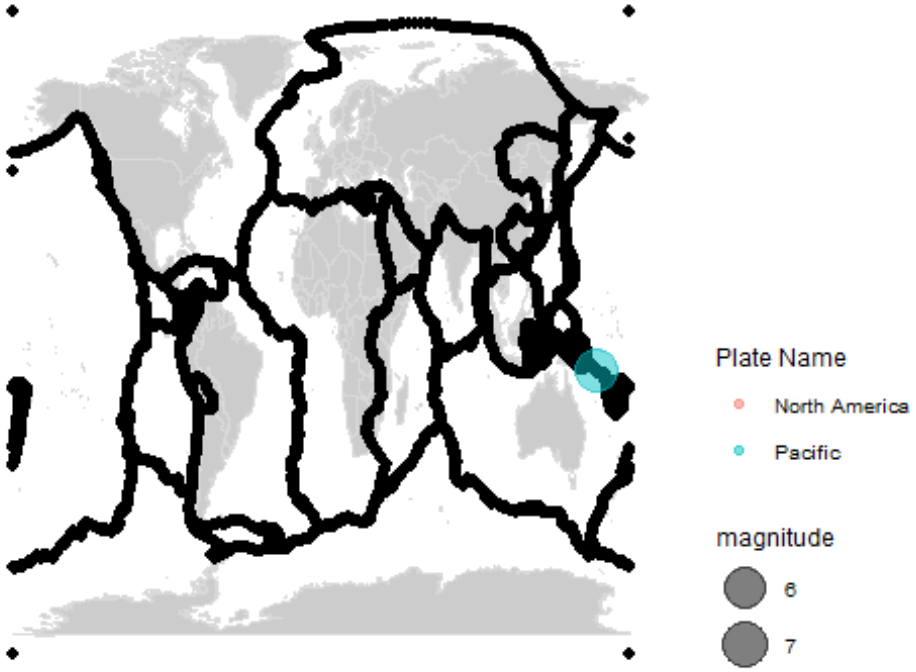

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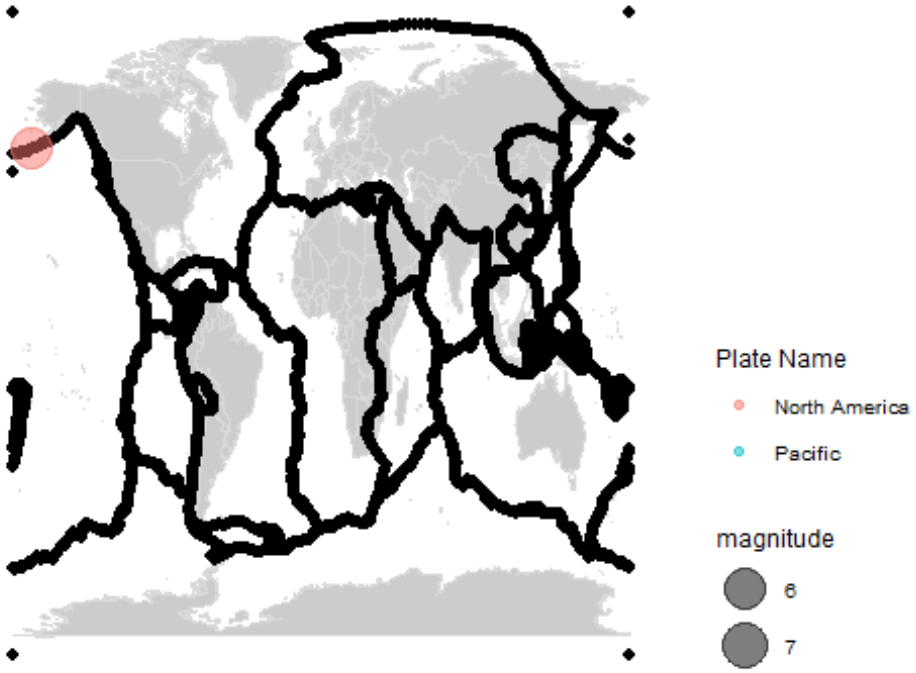
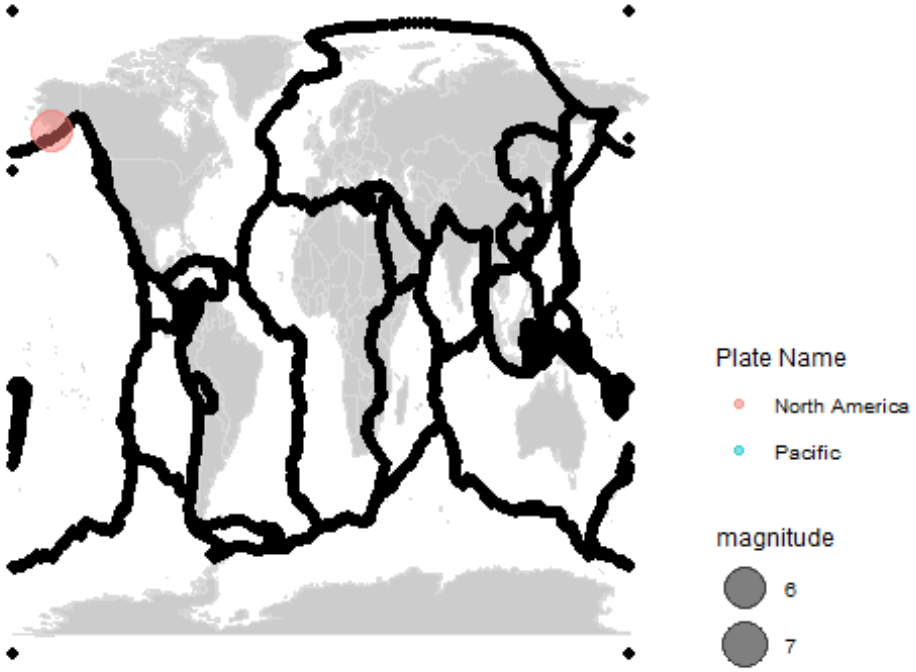
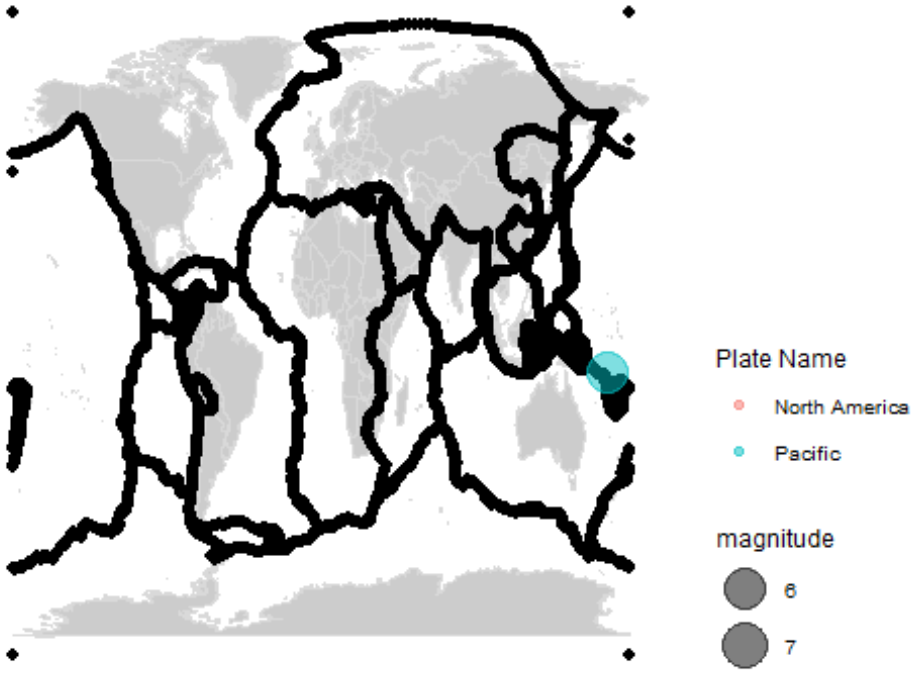


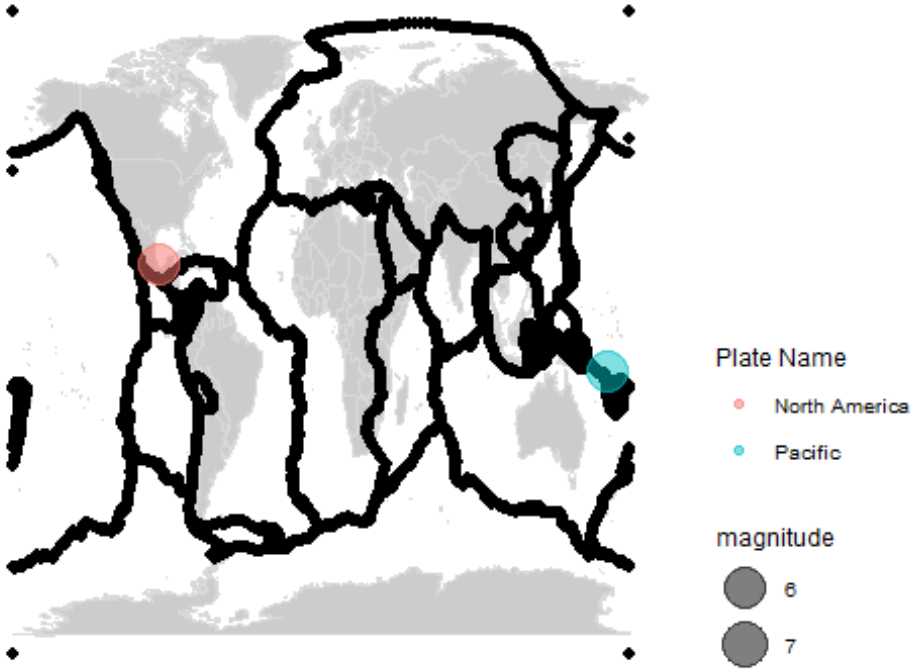
1967-02-07



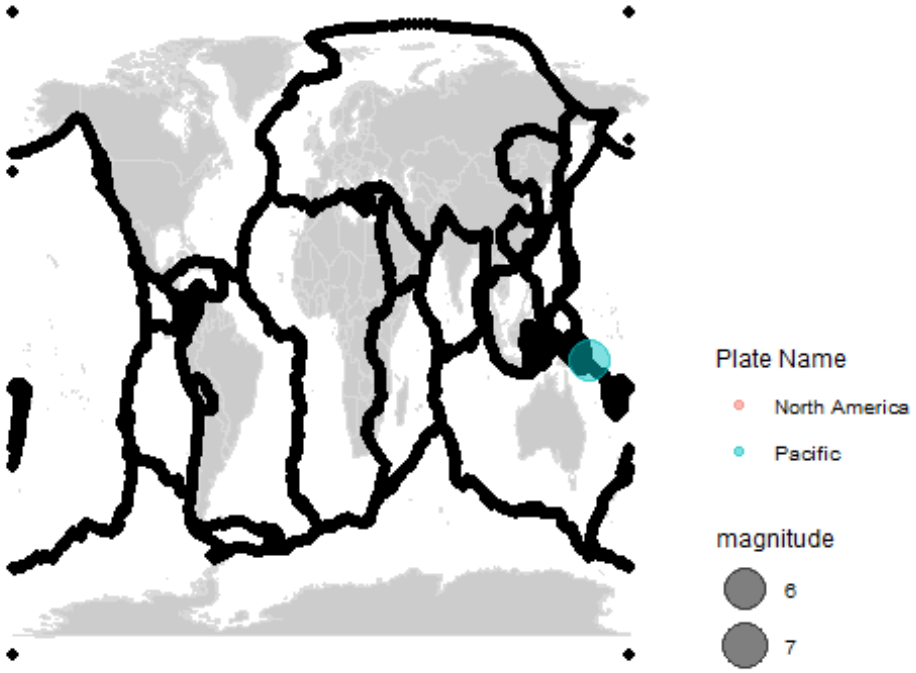
1967-03-09



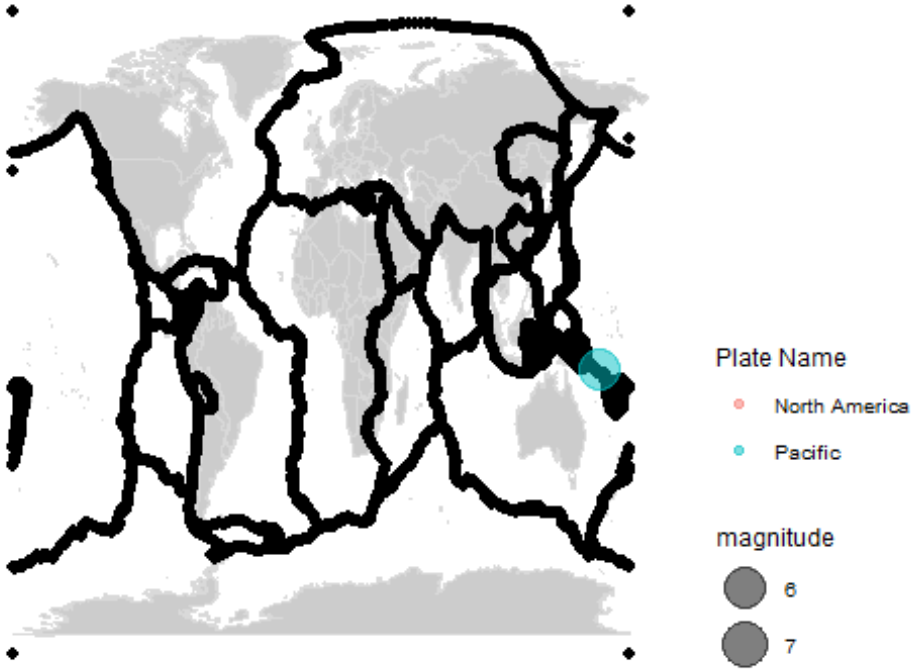
1967-03-11



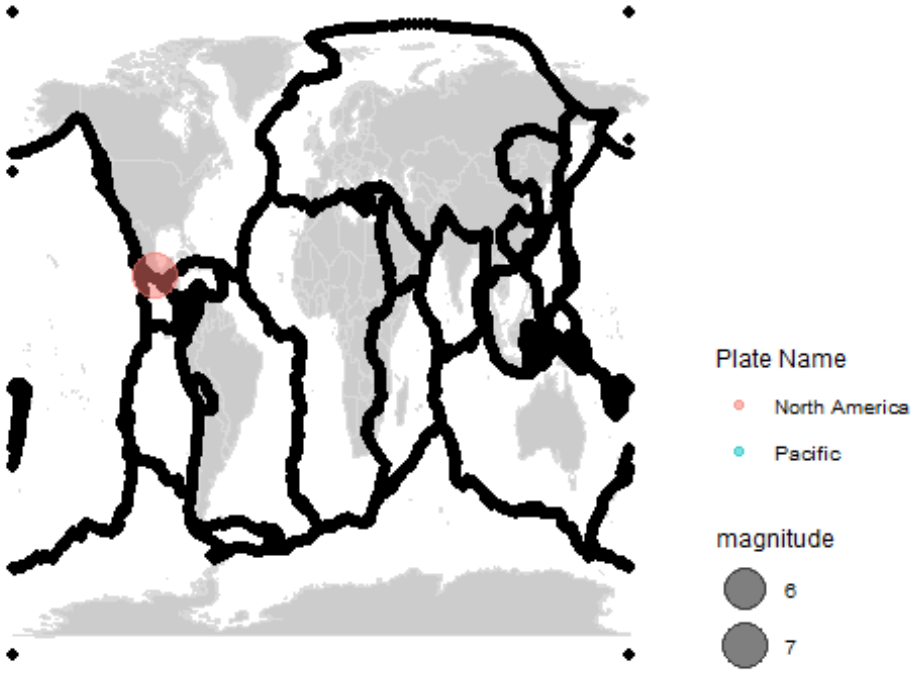
1967-04-10



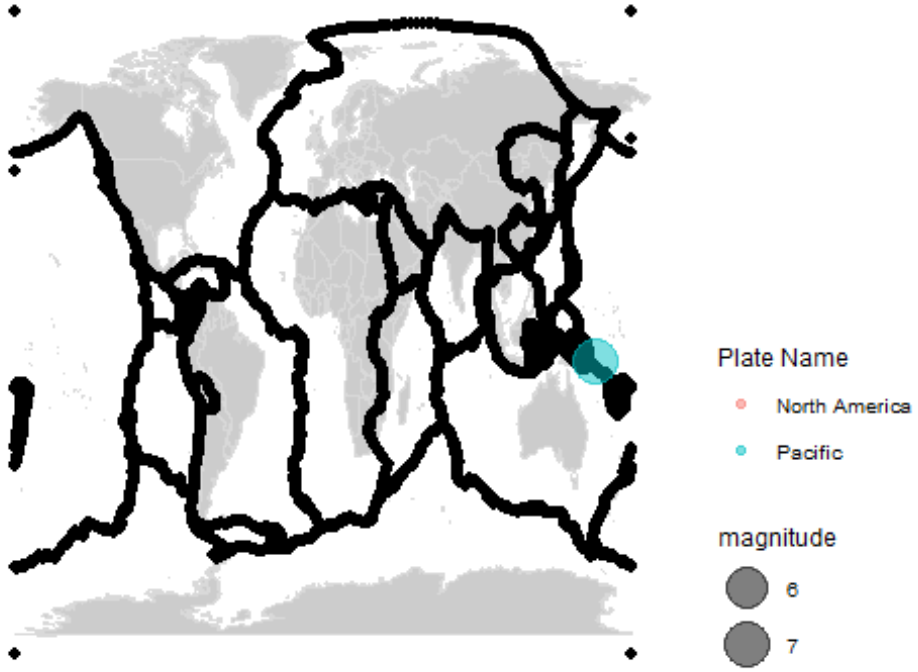
1967-05-05



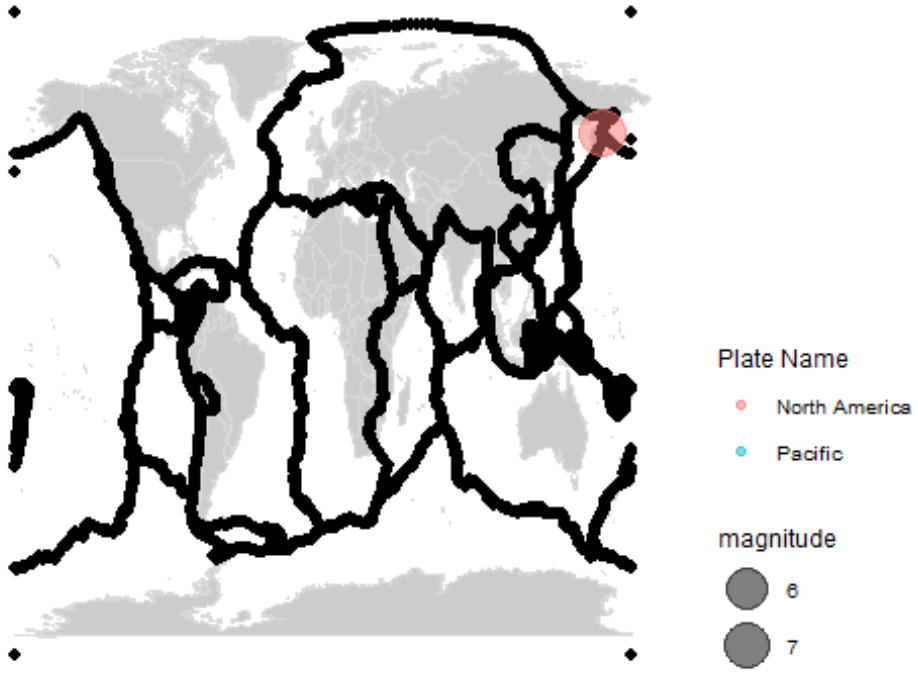
1968-08-02



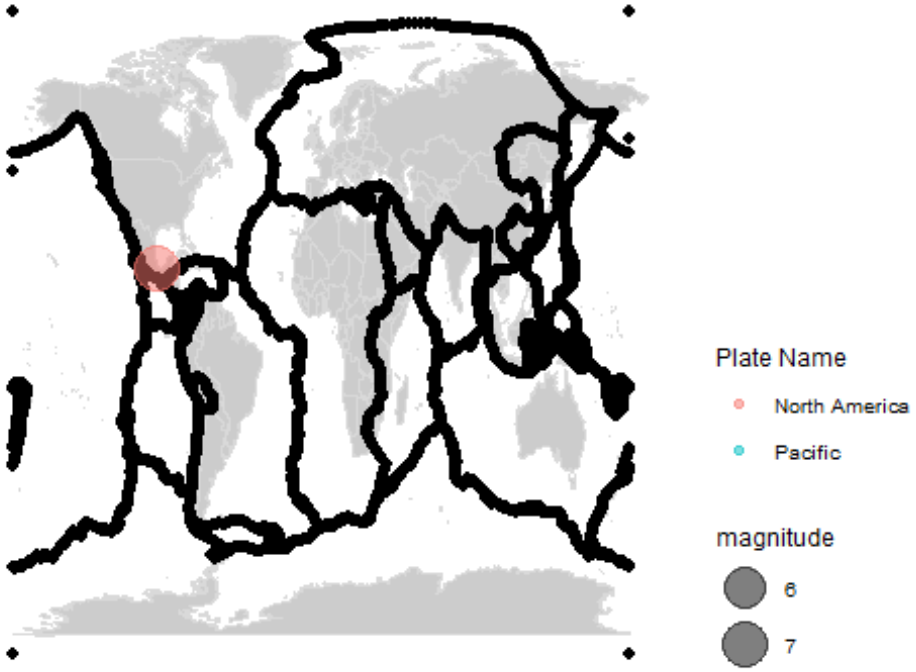
1969-01-05



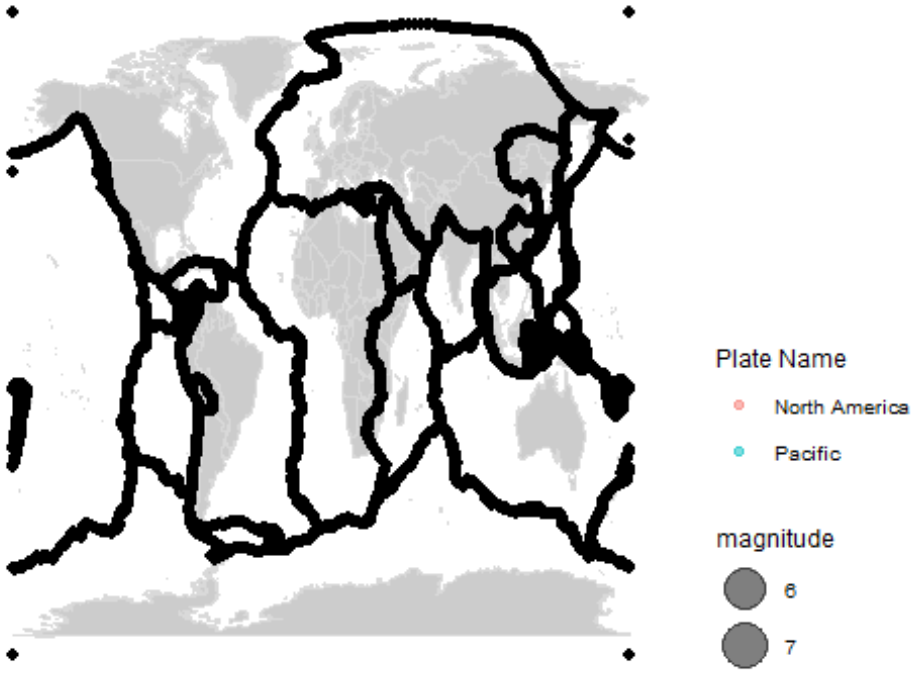
1971-12-15

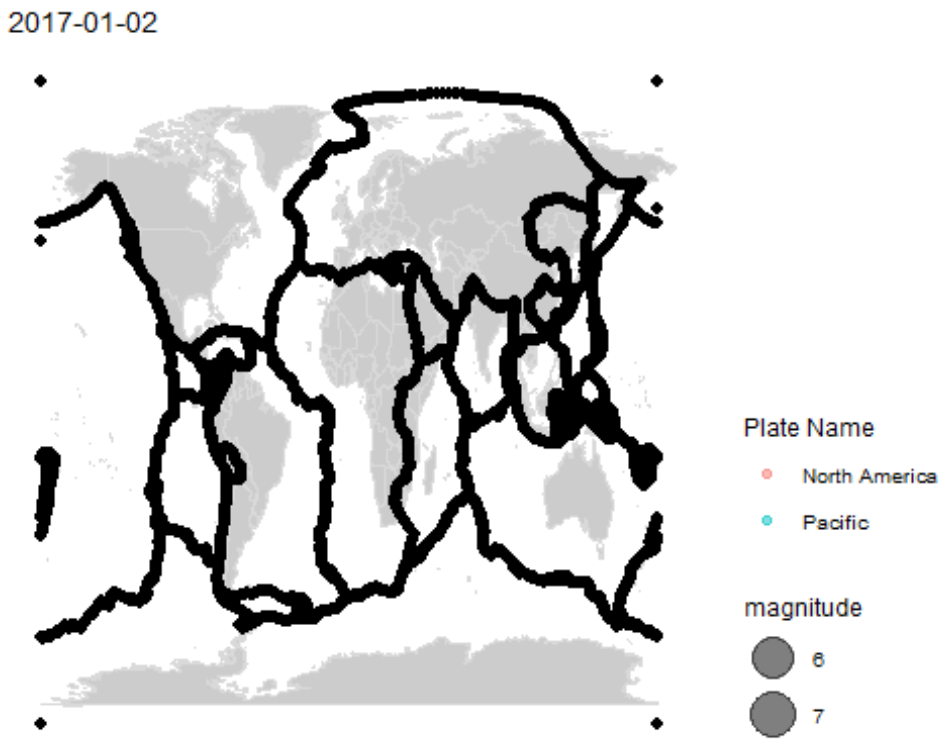


1973-08-28



2017-01-01

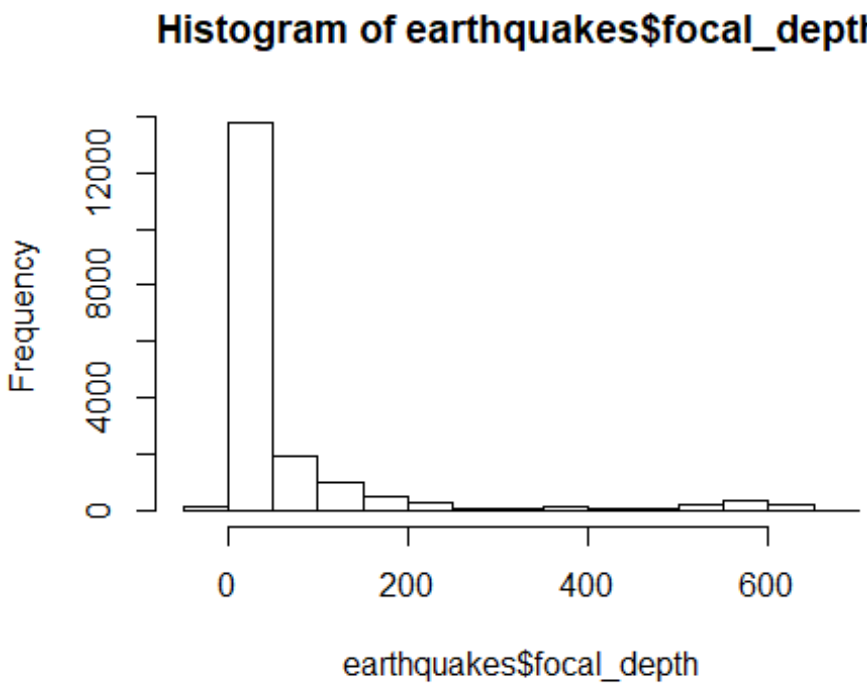




After looking at the data and narrowing down interactions to the Pacific and North American tectonic plates, the next step was to look for interactions between variables. This was done through the following code for both the earthquakes data set as well as the narrowed North American/Pacific (NAP) data set.

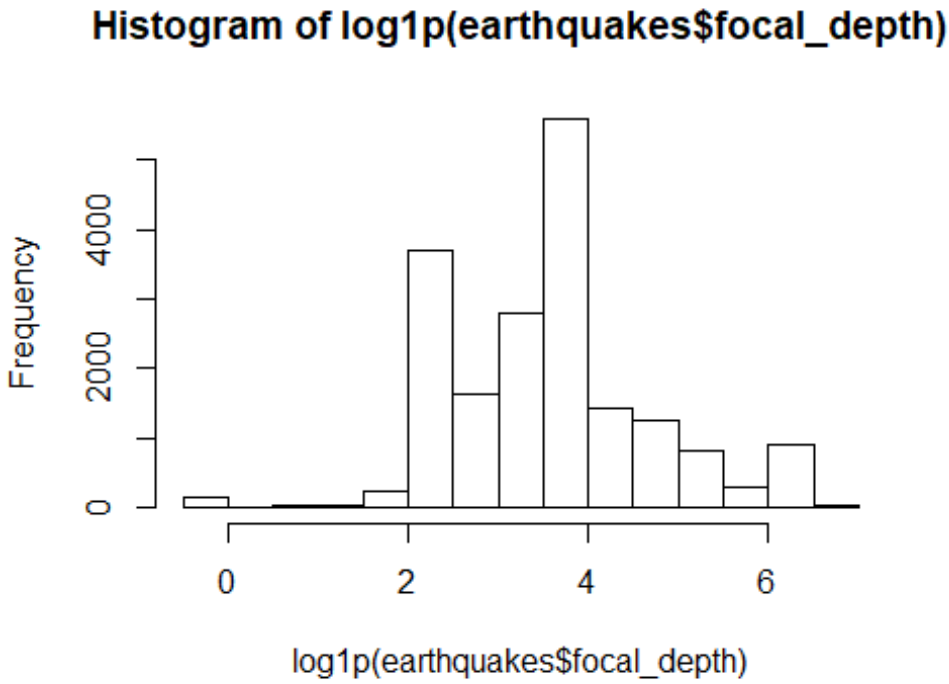
Checking for skew of variables

```
#Unite month, day, year columns
earthquakes1 <- unite(earthquakes, quake_date, c("year", "month", "day"),
                      sep = "-")

hist(earthquakes$focal_depth)
```

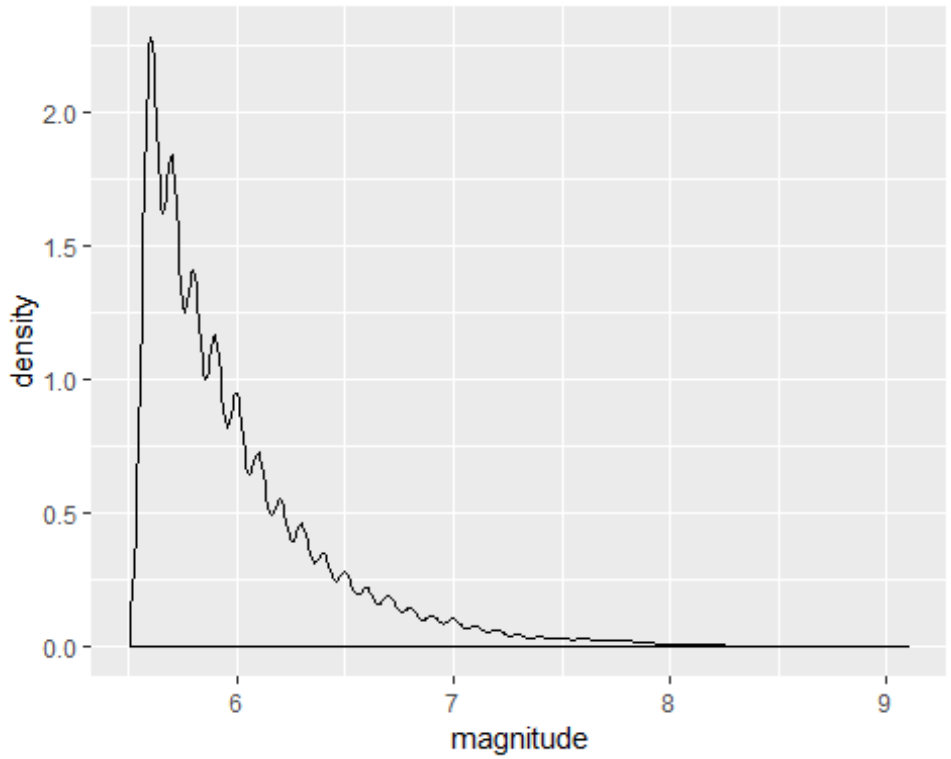



```r
hist(log1p(earthquakes$focal_depth))
```

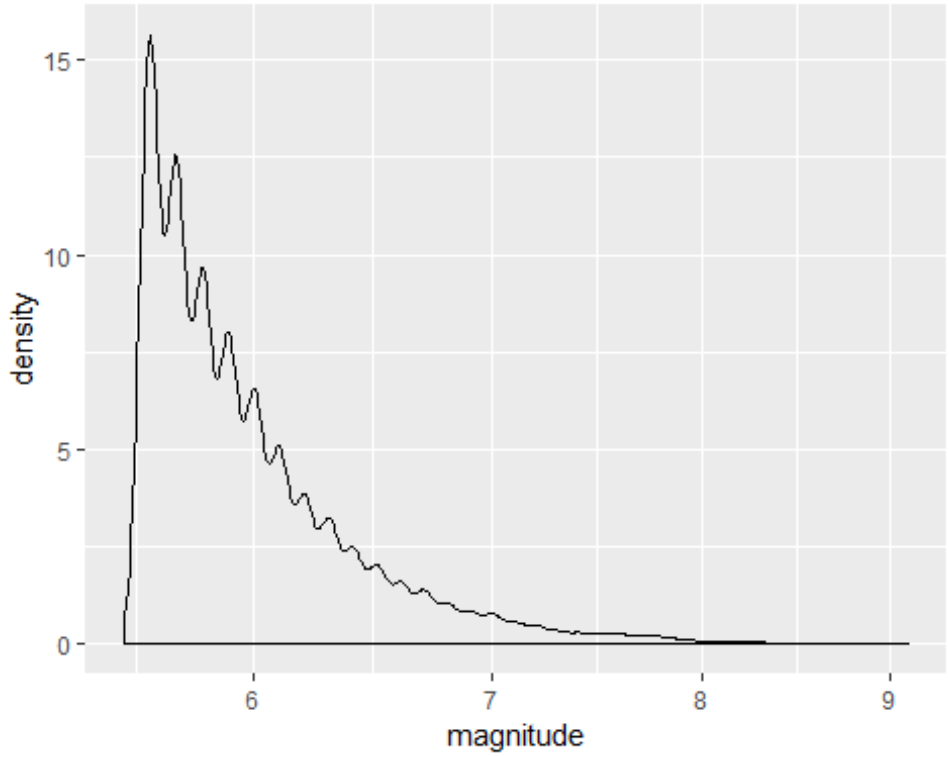
```
## Warning in log1p(earthquakes$focal_depth): NaNs produced
```



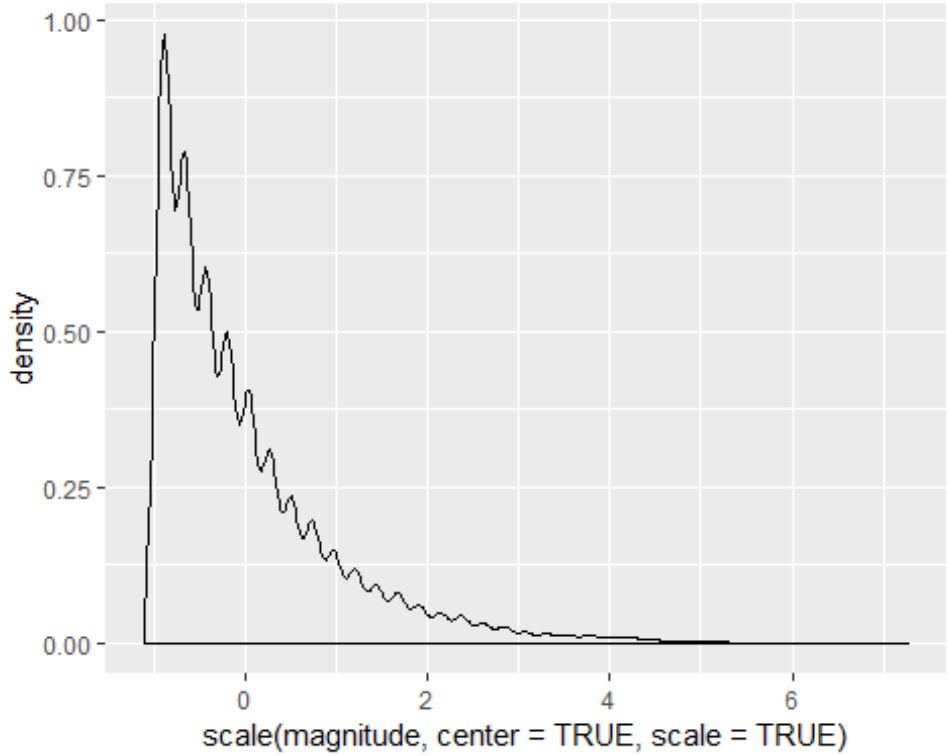
```
ggplot(earthquakes1, aes(x=magnitude)) + geom_density()
```




```
ggplot(earthquakes1, aes(x=magnitude)) + geom_density() +
  scale_x_continuous(trans="log1p")
```




```
ggplot(earthquakes1, aes(x=scale(magnitude, center=TRUE, scale=TRUE))) +
  geom_density()
```



```r
mean(earthquakes1$magnitude)
```

```
## [1] 5.982899
```

```r
median(earthquakes1$magnitude)
```

```
## [1] 5.8
```

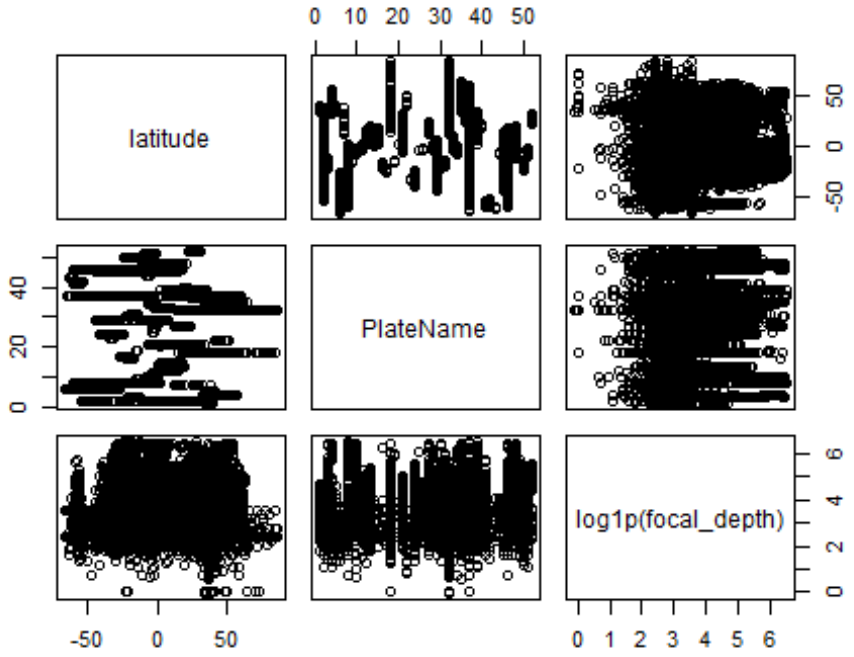
The next step in the analysis was to check for a skew in the variables; is the data skewed to the left or the right? In this case, it was discovered tha the focal depth was skewed to the right. The magnitude, although already measured on a log scale, was revealed to be minimally skewed to the right. To correct this, the focal depth measurements were adjusted by using log1p(focal_depth) in place of the direct value of the focal depth.

Interactions between variables

After checking for skews, interactions between variables were analyzed. Due to the above graphic exploration, the interactions were analyzed across the entire data set, earthquakes, and across the restricted North American & Pacific Plate earthquakes (nap_earthquakes).

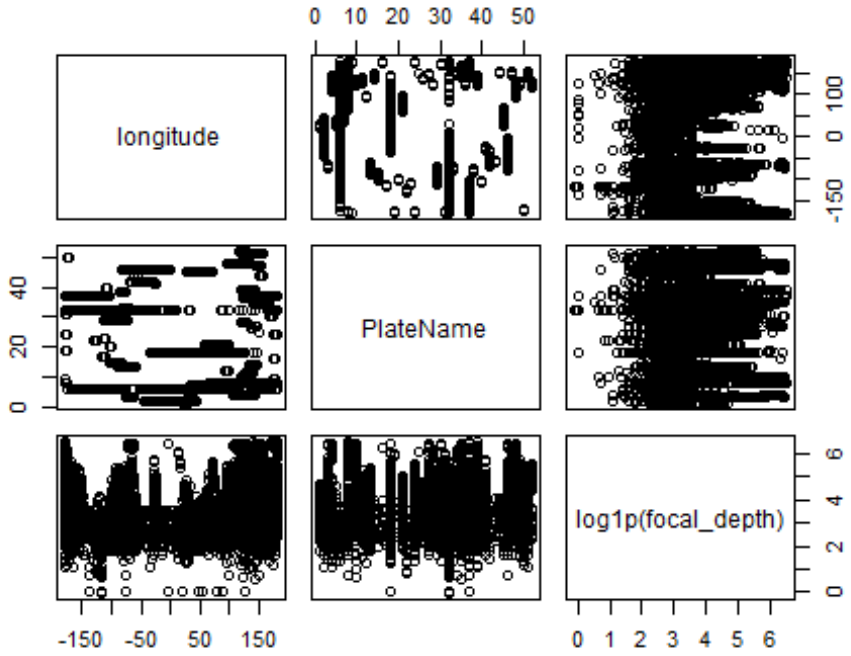
```r
##Interactions between variables


pairs(latitude ~ PlateName + log1p(focal_depth), data = earthquakes)
```

```
## Warning in log1p(focal_depth): NaNs produced
```



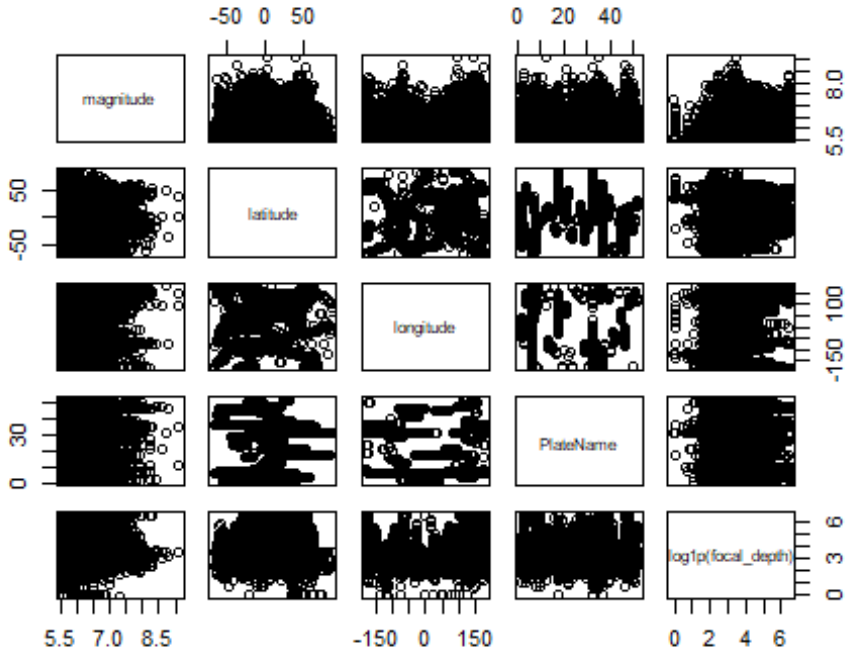
```
pairs(longitude ~ PlateName + log1p(focal_depth), data = earthquakes)
```

```
## Warning in log1p(focal_depth): NaNs produced
```

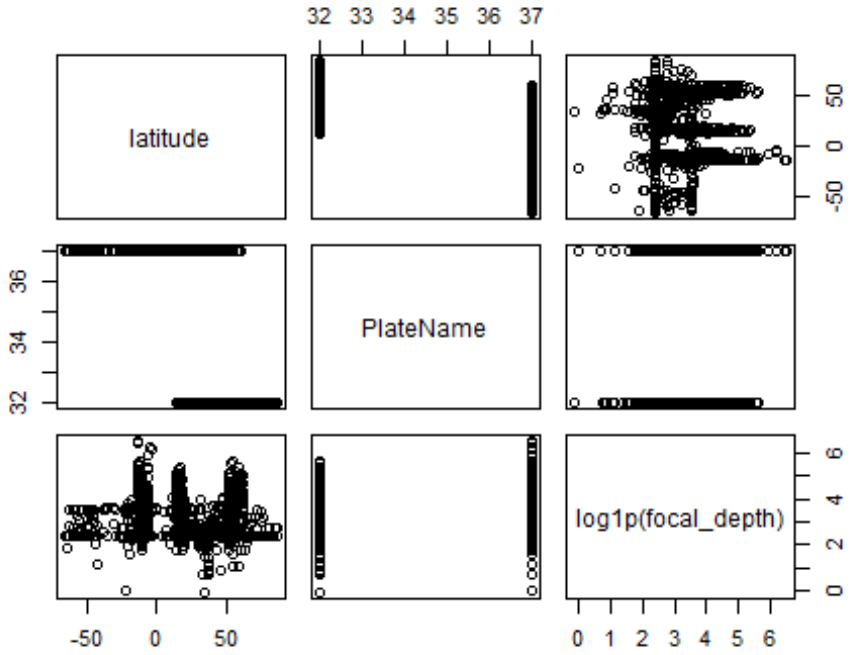



```
pairs(magnitude ~ latitude + longitude + PlateName + log1p(focal_depth),
      data = earthquakes)
```

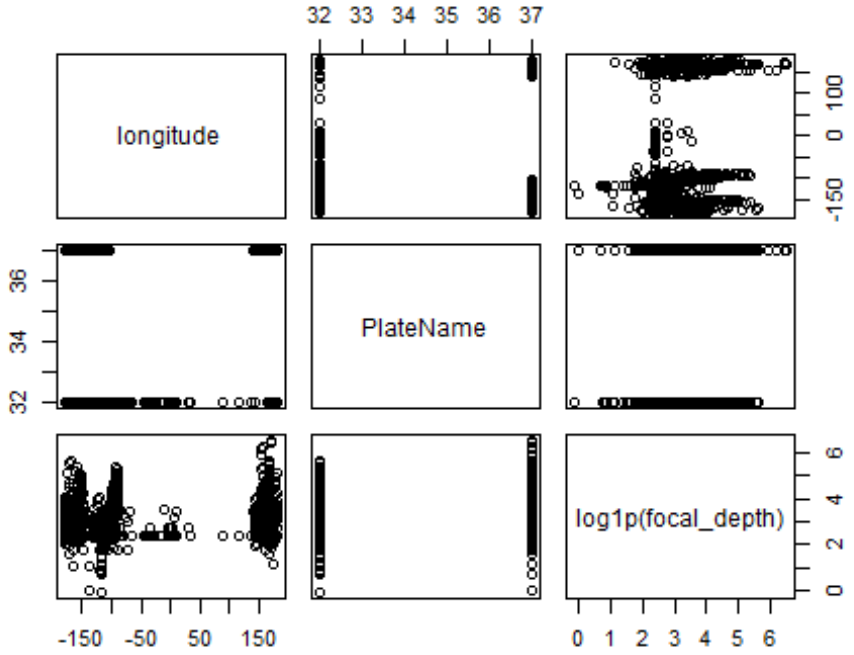
```
## Warning in log1p(focal_depth): NaNs produced
```



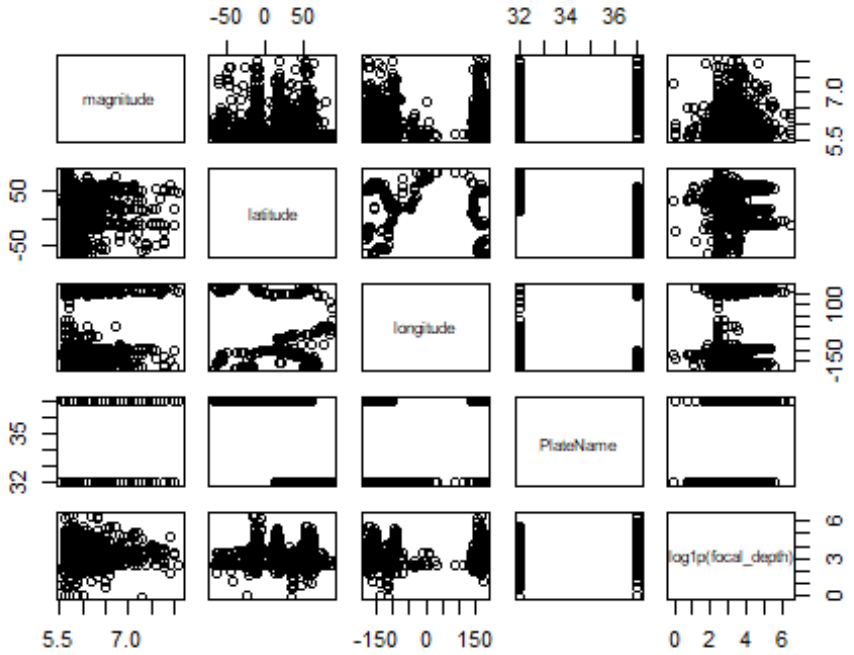

```
#Interactions between variables on North_American and Pacific plates


pairs(latitude ~ PlateName + log1p(focal_depth), data = nap_earthquakes)
```




```
pairs(longitude ~ PlateName + log1p(focal_depth), data = nap_earthquakes)
```



```
pairs(magnitude ~ latitude + longitude + PlateName + log1p(focal_depth),
      data = nap_earthquakes)
```



Given the above interactions, regardless of the data set, the best interaction seems to be between longitude and focal depth of the earthquake. Based on the data, these two variables have the most significant impact on the magnitude of a major earthquake. This does make sense as many subduction zones run along longitudinal lines and an earthquake close to the surface would have a stronger magnitude than one that is deep below the surface and has to travel through many layers of earth prior to reaching the seismographs.

Creating predictive models

After analyzing the above interactions, several predictive models were created to attempt to better predict the magnitude of major earthquakes. The models that were used included linear regression, logistic regression, binomial regressions, and the Poisson model.

Linear Regression

As was discovered earlier, there are multiple variables that can impact an earthquake's magnitude. Due to this, multiple linear regression was used to attempt to find if there is a linear relationship between the variables.

```
#Unite month, day, year columns
earthquakes1 <- unite(earthquakes, quake_date, c("year", "month", "day"),
                      sep = "-")
```

```r
# Linear Regression Models ------------------------------------------------


LRModel1 <-lm(magnitude ~ latitude + longitude, data = earthquakes1)
summary(LRModel1)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude + longitude, data = earthquakes1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.4707 -0.2960 -0.1392  0.1509  3.1110
##
## Coefficients:
##              Estimate Std. Error  t value Pr(>|t|)
## (Intercept) 5.978e+00  3.278e-03 1823.508  < 2e-16 ***
## latitude    4.302e-04  1.058e-04    4.067 4.79e-05 ***
## longitude   1.011e-04  2.541e-05    3.977 7.00e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4279 on 18843 degrees of freedom
## Multiple R-squared:  0.002124,   Adjusted R-squared:  0.002018
## F-statistic: 20.06 on 2 and 18843 DF,  p-value: 1.991e-09
```

```r
LRModel2 <-lm(magnitude ~ latitude * longitude, data = nap_earthquakes)
summary(LRModel2)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude, data = nap_earthquakes)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.4693 -0.3282 -0.1453  0.1708  2.0953
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)         5.990e+00  1.466e-02 408.716   <2e-16 ***
## latitude            1.929e-04  3.861e-04   0.500   0.6175
## longitude           2.089e-04  9.696e-05   2.155   0.0313 *
## latitude:longitude -3.737e-06  2.470e-06  -1.513   0.1305
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 0.4699 on 1475 degrees of freedom
## Multiple R-squared:  0.003459,   Adjusted R-squared:  0.001433
## F-statistic: 1.707 on 3 and 1475 DF,  p-value: 0.1637
```

```
LRModel3 <-lm(magnitude ~ latitude * longitude + log1p(focal_depth),
              data = earthquakes1)
```

```
## Warning in log1p(focal_depth): NaNs produced
```

```
summary(LRModel3)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude + log1p(focal_depth),
##     data = earthquakes1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.4735 -0.2974 -0.1187  0.1658  3.1106
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          5.955e+00  1.062e-02 560.862  < 2e-16 ***
## latitude             5.084e-04  1.076e-04   4.725 2.32e-06 ***
## longitude            9.512e-05  2.544e-05   3.739 0.000185 ***
## log1p(focal_depth)   7.094e-03  2.862e-03   2.478 0.013211 *
## latitude:longitude -2.954e-06  8.311e-07  -3.554 0.000381 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4276 on 18839 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.003039,   Adjusted R-squared:  0.002827
## F-statistic: 14.36 on 4 and 18839 DF,  p-value: 1.048e-11
```

```
LRModel4 <-lm(magnitude ~ latitude * longitude + log1p(focal_depth) +
PlateName,
              data = earthquakes1)
```

```
## Warning in log1p(focal_depth): NaNs produced
```

```
summary(LRModel4)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude + log1p(focal_depth) +
##     PlateName, data = earthquakes1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.5348 -0.2994 -0.1278  0.1654  3.1629
##
```

```
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)               5.958e+00  4.740e-02 125.696   <2e-16 ***
## latitude                  4.951e-04  2.567e-04   1.929   0.0538 .
## longitude                 1.013e-04  4.329e-05   2.341   0.0192 *
## log1p(focal_depth)        6.708e-03  3.210e-03   2.090   0.0366 *
## PlateNameAfrica          -7.279e-02  5.364e-02  -1.357   0.1748
## PlateNameAltiplano        3.454e-03  5.437e-02   0.064   0.9494
## PlateNameAmur             1.076e-01  5.808e-02   1.853   0.0638 .
## PlateNameAnatolia         2.048e-02  7.194e-02   0.285   0.7759
## PlateNameAntarctica      -6.378e-03  5.339e-02  -0.119   0.9049
## PlateNameArabia          -8.751e-02  7.930e-02  -1.103   0.2699
## PlateNameAustralia        3.246e-03  4.970e-02   0.065   0.9479
## PlateNameBalmoral Reef   -1.346e-01  1.497e-01  -0.899   0.3687
## PlateNameBanda Sea       -2.524e-02  5.293e-02  -0.477   0.6334
## PlateNameBirds Head      -7.102e-03  5.244e-02  -0.135   0.8923
## PlateNameBurma           -5.442e-02  5.338e-02  -1.019   0.3081
## PlateNameCaribbean       -5.195e-03  5.266e-02  -0.099   0.9214
## PlateNameCaroline        -3.629e-02  1.229e-01  -0.295   0.7678
## PlateNameCocos           -1.010e-01  7.856e-02  -1.286   0.1985
## PlateNameConway Reef      1.798e-02  8.403e-02   0.214   0.8306
## PlateNameEaster          -9.725e-02  8.865e-02  -1.097   0.2726
## PlateNameEurasia          3.544e-02  4.698e-02   0.754   0.4506
## PlateNameFutuna           1.286e-02  1.140e-01   0.113   0.9102
## PlateNameGalapagos       -6.461e-02  3.049e-01  -0.212   0.8322
## PlateNameIndia            6.261e-03  5.725e-02   0.109   0.9129
## PlateNameJuan de Fuca     2.179e-02  6.642e-02   0.328   0.7428
## PlateNameJuan Fernandez  -7.097e-02  1.281e-01  -0.554   0.5795
## PlateNameKermadec        -2.424e-03  5.169e-02  -0.047   0.9626
## PlateNameManus           -8.348e-04  9.303e-02  -0.009   0.9928
## PlateNameMaoke            2.248e-02  6.266e-02   0.359   0.7198
## PlateNameMariana         -8.505e-02  5.469e-02  -1.555   0.1199
## PlateNameMolucca Sea     -1.600e-02  5.566e-02  -0.287   0.7737
## PlateNameNazca           -7.468e-02  5.386e-02  -1.386   0.1656
## PlateNameNew Hebrides     4.183e-02  5.001e-02   0.836   0.4029
## PlateNameNiuafo'ou       -3.729e-02  5.980e-02  -0.624   0.5330
## PlateNameNorth America   -4.633e-03  4.707e-02  -0.098   0.9216
## PlateNameNorth Andes      1.306e-01  5.930e-02   2.203   0.0276 *
## PlateNameNorth Bismarck   3.697e-02  5.312e-02   0.696   0.4865
## PlateNameOkhotsk         -1.774e-02  4.728e-02  -0.375   0.7076
## PlateNameOkinawa         -6.085e-02  5.353e-02  -1.137   0.2556
## PlateNamePacific          1.573e-02  4.782e-02   0.329   0.7421
## PlateNamePanama           1.338e-01  6.454e-02   2.073   0.0381 *
## PlateNamePhilippine Sea  -1.563e-02  4.866e-02  -0.321   0.7480
## PlateNameRivera           3.440e-02  8.090e-02   0.425   0.6707
## PlateNameSandwich        -8.494e-02  5.715e-02  -1.486   0.1372
## PlateNameScotia           1.107e-01  8.355e-02   1.325   0.1853
## PlateNameShetland        -8.200e-03  1.387e-01  -0.059   0.9528
## PlateNameSolomon Sea      1.757e-03  7.187e-02   0.024   0.9805
## PlateNameSomalia         -1.015e-01  6.068e-02  -1.673   0.0944 .
```

```
## PlateNameSouth America   6.598e-02  4.939e-02   1.336   0.1816
## PlateNameSouth Bismarck  2.013e-02  4.970e-02   0.405   0.6854
## PlateNameSunda          -3.471e-02  4.737e-02  -0.733   0.4637
## PlateNameTimor          -4.312e-02  5.537e-02  -0.779   0.4362
## PlateNameTonga          -5.508e-02  5.131e-02  -1.073   0.2831
## PlateNameWoodlark       -2.040e-02  5.767e-02  -0.354   0.7236
## PlateNameYangtze        -7.505e-02  7.767e-02  -0.966   0.3340
## latitude:longitude      -1.738e-06  1.120e-06  -1.551   0.1208
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4262 on 18788 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.01217,    Adjusted R-squared:  0.009274
## F-statistic: 4.207 on 55 and 18788 DF,  p-value: < 2.2e-16

LRModel5 <-lm(magnitude ~ latitude * longitude + log1p(focal_depth) *
PlateName,
              data = earthquakes1)

## Warning in log1p(focal_depth): NaNs produced

summary(LRModel5)

##
## Call:
## lm(formula = magnitude ~ latitude * longitude + log1p(focal_depth) *
##     PlateName, data = earthquakes1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.7086 -0.2988 -0.1246  0.1631  3.1619
##
## Coefficients: (1 not defined because of singularities)
##                                          Estimate Std. Error t value
## (Intercept)                             6.021e+00  2.143e-01  28.090
## latitude                                5.340e-04  2.582e-04   2.068
## longitude                               6.297e-05  4.665e-05   1.350
## log1p(focal_depth)                     -1.283e-02  6.355e-02  -0.202
## PlateNameAfrica                        -1.992e-01  2.688e-01  -0.741
## PlateNameAltiplano                     -1.125e-01  2.464e-01  -0.456
## PlateNameAmur                           2.024e-02  2.356e-01   0.086
## PlateNameAnatolia                      -6.897e-02  3.392e-01  -0.203
## PlateNameAntarctica                    -1.344e-01  2.444e-01  -0.550
## PlateNameArabia                        -9.971e-01  5.194e-01  -1.920
## PlateNameAustralia                      4.447e-02  2.183e-01   0.204
## PlateNameBalmoral Reef                  1.719e-01  4.798e-01   0.358
## PlateNameBanda Sea                     -2.152e-01  2.318e-01  -0.928
## PlateNameBirds Head                     5.238e-01  2.476e-01   2.116
## PlateNameBurma                         -1.931e-01  2.764e-01  -0.699
## PlateNameCaribbean                      1.317e-01  2.442e-01   0.540
```

```
## PlateNameCaroline                              8.445e-01  6.567e-01   1.286
## PlateNameCocos                                -6.046e-01  4.289e-01  -1.410
## PlateNameConway Reef                          -1.920e-01  3.626e-01  -0.529
## PlateNameEaster                               -2.289e-01  5.996e-01  -0.382
## PlateNameEurasia                              -8.115e-02  2.162e-01  -0.375
## PlateNameFutuna                                1.379e-01  3.596e-01   0.383
## PlateNameGalapagos                            -8.499e-02  3.097e-01  -0.274
## PlateNameIndia                                -2.070e-01  2.544e-01  -0.814
## PlateNameJuan de Fuca                          2.660e-01  3.495e-01   0.761
## PlateNameJuan Fernandez                       -6.510e+00  2.323e+00  -2.803
## PlateNameKermadec                             -1.058e-01  2.290e-01  -0.462
## PlateNameManus                                 1.897e-01  3.548e-01   0.535
## PlateNameMaoke                                -7.996e-02  3.336e-01  -0.240
## PlateNameMariana                              -3.590e-01  2.419e-01  -1.484
## PlateNameMolucca Sea                           3.553e-01  2.626e-01   1.353
## PlateNameNazca                                -2.295e-01  2.682e-01  -0.856
## PlateNameNew Hebrides                         -7.354e-03  2.237e-01  -0.033
## PlateNameNiuafo'ou                            -8.782e-02  2.442e-01  -0.360
## PlateNameNorth America                        -1.003e-01  2.196e-01  -0.457
## PlateNameNorth Andes                           2.392e-01  2.564e-01   0.933
## PlateNameNorth Bismarck                       -2.516e-01  2.401e-01  -1.048
## PlateNameOkhotsk                              -4.869e-02  2.203e-01  -0.221
## PlateNameOkinawa                               1.321e-02  2.727e-01   0.048
## PlateNamePacific                              -5.498e-02  2.182e-01  -0.252
## PlateNamePanama                                7.478e-02  3.420e-01   0.219
## PlateNamePhilippine Sea                       -2.181e-01  2.213e-01  -0.985
## PlateNameRivera                                1.332e-01  4.460e-01   0.299
## PlateNameSandwich                             -1.845e-02  2.493e-01  -0.074
## PlateNameScotia                                4.838e-02  4.261e-01   0.114
## PlateNameShetland                              4.159e-01  6.675e-01   0.623
## PlateNameSolomon Sea                           1.012e+00  4.508e-01   2.245
## PlateNameSomalia                              -3.712e-01  3.243e-01  -1.145
## PlateNameSouth America                        -8.761e-02  2.188e-01  -0.400
## PlateNameSouth Bismarck                        8.175e-02  2.313e-01   0.353
## PlateNameSunda                                -3.372e-02  2.192e-01  -0.154
## PlateNameTimor                                 2.423e-01  2.529e-01   0.958
## PlateNameTonga                                -2.337e-01  2.276e-01  -1.027
## PlateNameWoodlark                             -3.554e-02  2.555e-01  -0.139
## PlateNameYangtze                              -3.340e-01  3.180e-01  -1.050
## latitude:longitude                            -1.198e-06  1.133e-06  -1.057
## log1p(focal_depth):PlateNameAfrica             4.353e-02  8.794e-02   0.495
## log1p(focal_depth):PlateNameAltiplano          3.143e-02  6.952e-02   0.452
## log1p(focal_depth):PlateNameAmur               2.541e-02  6.712e-02   0.379
## log1p(focal_depth):PlateNameAnatolia           2.840e-02  1.106e-01   0.257
## log1p(focal_depth):PlateNameAntarctica         4.606e-02  7.793e-02   0.591
## log1p(focal_depth):PlateNameArabia             3.599e-01  1.989e-01   1.810
## log1p(focal_depth):PlateNameAustralia         -2.744e-03  6.404e-02  -0.043
## log1p(focal_depth):PlateNameBalmoral Reef     -8.864e-02  1.364e-01  -0.650
## log1p(focal_depth):PlateNameBanda Sea          5.035e-02  6.655e-02   0.757
## log1p(focal_depth):PlateNameBirds Head        -1.496e-01  7.246e-02  -2.065
```

```
## log1p(focal_depth):PlateNameBurma            4.277e-02  8.156e-02   0.524
## log1p(focal_depth):PlateNameCaribbean       -3.624e-02  7.087e-02  -0.511
## log1p(focal_depth):PlateNameCaroline        -2.854e-01  2.081e-01  -1.371
## log1p(focal_depth):PlateNameCocos            1.819e-01  1.502e-01   1.211
## log1p(focal_depth):PlateNameConway Reef      6.982e-02  1.115e-01   0.626
## log1p(focal_depth):PlateNameEaster           4.450e-02  2.277e-01   0.195
## log1p(focal_depth):PlateNameEurasia          3.815e-02  6.426e-02   0.594
## log1p(focal_depth):PlateNameFutuna          -3.449e-02  9.770e-02  -0.353
## log1p(focal_depth):PlateNameGalapagos               NA         NA      NA
## log1p(focal_depth):PlateNameIndia            6.633e-02  7.554e-02   0.878
## log1p(focal_depth):PlateNameJuan de Fuca    -1.105e-01  1.303e-01  -0.848
## log1p(focal_depth):PlateNameJuan Fernandez   2.637e+00  9.511e-01   2.773
## log1p(focal_depth):PlateNameKermadec         2.927e-02  6.717e-02   0.436
## log1p(focal_depth):PlateNameManus           -5.744e-02  1.055e-01  -0.545
## log1p(focal_depth):PlateNameMaoke            3.251e-02  9.685e-02   0.336
## log1p(focal_depth):PlateNameMariana          7.156e-02  6.878e-02   1.040
## log1p(focal_depth):PlateNameMolucca Sea     -9.121e-02  7.418e-02  -1.230
## log1p(focal_depth):PlateNameNazca            5.362e-02  8.860e-02   0.605
## log1p(focal_depth):PlateNameNew Hebrides     1.809e-02  6.565e-02   0.276
## log1p(focal_depth):PlateNameNiuafo'ou        1.449e-02  6.916e-02   0.209
## log1p(focal_depth):PlateNameNorth America    2.842e-02  6.513e-02   0.436
## log1p(focal_depth):PlateNameNorth Andes     -3.110e-02  7.472e-02  -0.416
## log1p(focal_depth):PlateNameNorth Bismarck   8.150e-02  6.949e-02   1.173
## log1p(focal_depth):PlateNameOkhotsk          1.081e-02  6.501e-02   0.166
## log1p(focal_depth):PlateNameOkinawa         -1.812e-02  7.862e-02  -0.230
## log1p(focal_depth):PlateNamePacific          2.301e-02  6.474e-02   0.355
## log1p(focal_depth):PlateNamePanama           1.720e-02  1.041e-01   0.165
## log1p(focal_depth):PlateNamePhilippine Sea   5.762e-02  6.514e-02   0.885
## log1p(focal_depth):PlateNameRivera          -3.475e-02  1.412e-01  -0.246
## log1p(focal_depth):PlateNameSandwich        -1.479e-02  7.140e-02  -0.207
## log1p(focal_depth):PlateNameScotia           1.870e-02  1.552e-01   0.120
## log1p(focal_depth):PlateNameShetland        -1.442e-01  2.166e-01  -0.666
## log1p(focal_depth):PlateNameSolomon Sea     -3.104e-01  1.371e-01  -2.264
## log1p(focal_depth):PlateNameSomalia          1.029e-01  1.149e-01   0.896
## log1p(focal_depth):PlateNameSouth America    4.329e-02  6.447e-02   0.671
## log1p(focal_depth):PlateNameSouth Bismarck -1.160e-02  6.736e-02  -0.172
## log1p(focal_depth):PlateNameSunda            3.956e-03  6.462e-02   0.061
## log1p(focal_depth):PlateNameTimor           -6.389e-02  7.106e-02  -0.899
## log1p(focal_depth):PlateNameTonga            4.967e-02  6.676e-02   0.744
## log1p(focal_depth):PlateNameWoodlark         7.471e-03  7.438e-02   0.100
## log1p(focal_depth):PlateNameYangtze          6.726e-02  8.388e-02   0.802
##                                            Pr(>|t|)
## (Intercept)                                 < 2e-16 ***
## latitude                                    0.03867 *
## longitude                                   0.17711
## log1p(focal_depth)                          0.83999
## PlateNameAfrica                             0.45855
## PlateNameAltiplano                          0.64812
## PlateNameAmur                               0.93154
## PlateNameAnatolia                           0.83887
```

```
## PlateNameAntarctica                          0.58237
## PlateNameArabia                              0.05493 .
## PlateNameAustralia                           0.83857
## PlateNameBalmoral Reef                       0.72011
## PlateNameBanda Sea                           0.35334
## PlateNameBirds Head                          0.03437 *
## PlateNameBurma                               0.48470
## PlateNameCaribbean                           0.58952
## PlateNameCaroline                            0.19851
## PlateNameCocos                               0.15863
## PlateNameConway Reef                         0.59649
## PlateNameEaster                              0.70264
## PlateNameEurasia                             0.70736
## PlateNameFutuna                              0.70136
## PlateNameGalapagos                           0.78373
## PlateNameIndia                               0.41593
## PlateNameJuan de Fuca                        0.44669
## PlateNameJuan Fernandez                      0.00507 **
## PlateNameKermadec                            0.64416
## PlateNameManus                               0.59277
## PlateNameMaoke                               0.81060
## PlateNameMariana                             0.13785
## PlateNameMolucca Sea                         0.17606
## PlateNameNazca                               0.39219
## PlateNameNew Hebrides                        0.97377
## PlateNameNiuafo'ou                           0.71912
## PlateNameNorth America                       0.64778
## PlateNameNorth Andes                         0.35094
## PlateNameNorth Bismarck                      0.29478
## PlateNameOkhotsk                             0.82505
## PlateNameOkinawa                             0.96136
## PlateNamePacific                             0.80105
## PlateNamePanama                              0.82692
## PlateNamePhilippine Sea                      0.32441
## PlateNameRivera                              0.76514
## PlateNameSandwich                            0.94101
## PlateNameScotia                              0.90960
## PlateNameShetland                            0.53328
## PlateNameSolomon Sea                         0.02479 *
## PlateNameSomalia                             0.25235
## PlateNameSouth America                       0.68885
## PlateNameSouth Bismarck                      0.72377
## PlateNameSunda                               0.87777
## PlateNameTimor                               0.33809
## PlateNameTonga                               0.30440
## PlateNameWoodlark                            0.88936
## PlateNameYangtze                             0.29373
## latitude:longitude                           0.29055
## log1p(focal_depth):PlateNameAfrica           0.62058
## log1p(focal_depth):PlateNameAltiplano        0.65114
```

```
## log1p(focal_depth):PlateNameAmur            0.70501
## log1p(focal_depth):PlateNameAnatolia        0.79732
## log1p(focal_depth):PlateNameAntarctica      0.55451
## log1p(focal_depth):PlateNameArabia          0.07037 .
## log1p(focal_depth):PlateNameAustralia       0.96582
## log1p(focal_depth):PlateNameBalmoral Reef   0.51586
## log1p(focal_depth):PlateNameBanda Sea       0.44932
## log1p(focal_depth):PlateNameBirds Head      0.03894 *
## log1p(focal_depth):PlateNameBurma           0.60005
## log1p(focal_depth):PlateNameCaribbean       0.60908
## log1p(focal_depth):PlateNameCaroline        0.17025
## log1p(focal_depth):PlateNameCocos           0.22589
## log1p(focal_depth):PlateNameConway Reef     0.53125
## log1p(focal_depth):PlateNameEaster          0.84507
## log1p(focal_depth):PlateNameEurasia         0.55271
## log1p(focal_depth):PlateNameFutuna          0.72409
## log1p(focal_depth):PlateNameGalapagos            NA
## log1p(focal_depth):PlateNameIndia           0.37992
## log1p(focal_depth):PlateNameJuan de Fuca    0.39627
## log1p(focal_depth):PlateNameJuan Fernandez  0.00556 **
## log1p(focal_depth):PlateNameKermadec        0.66295
## log1p(focal_depth):PlateNameManus           0.58608
## log1p(focal_depth):PlateNameMaoke           0.73711
## log1p(focal_depth):PlateNameMariana         0.29821
## log1p(focal_depth):PlateNameMolucca Sea     0.21884
## log1p(focal_depth):PlateNameNazca           0.54505
## log1p(focal_depth):PlateNameNew Hebrides    0.78290
## log1p(focal_depth):PlateNameNiuafo'ou       0.83408
## log1p(focal_depth):PlateNameNorth America   0.66256
## log1p(focal_depth):PlateNameNorth Andes     0.67728
## log1p(focal_depth):PlateNameNorth Bismarck  0.24088
## log1p(focal_depth):PlateNameOkhotsk         0.86798
## log1p(focal_depth):PlateNameOkinawa         0.81774
## log1p(focal_depth):PlateNamePacific         0.72234
## log1p(focal_depth):PlateNamePanama          0.86876
## log1p(focal_depth):PlateNamePhilippine Sea  0.37642
## log1p(focal_depth):PlateNameRivera          0.80561
## log1p(focal_depth):PlateNameSandwich        0.83587
## log1p(focal_depth):PlateNameScotia          0.90412
## log1p(focal_depth):PlateNameShetland        0.50559
## log1p(focal_depth):PlateNameSolomon Sea     0.02356 *
## log1p(focal_depth):PlateNameSomalia         0.37039
## log1p(focal_depth):PlateNameSouth America   0.50197
## log1p(focal_depth):PlateNameSouth Bismarck  0.86326
## log1p(focal_depth):PlateNameSunda           0.95119
## log1p(focal_depth):PlateNameTimor           0.36859
## log1p(focal_depth):PlateNameTonga           0.45687
## log1p(focal_depth):PlateNameWoodlark        0.91999
## log1p(focal_depth):PlateNameYangtze         0.42266
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4254 on 18738 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.01837,    Adjusted R-squared:  0.01287
## F-statistic: 3.339 on 105 and 18738 DF,  p-value: < 2.2e-16
```

```
LRModel6 <-lm(magnitude ~ latitude * longitude * PlateName, data =
earthquakes1)
summary(LRModel6)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude * PlateName, data =
earthquakes1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.7898 -0.2996 -0.1247  0.1642  3.1422
##
## Coefficients: (2 not defined because of singularities)
##                                          Estimate Std. Error t value
## (Intercept)                             2.640e+01  1.705e+01   1.548
## latitude                               -5.391e-01  4.597e-01  -1.173
## longitude                              -8.997e-01  6.829e-01  -1.318
## PlateNameAfrica                        -2.047e+01  1.705e+01  -1.201
## PlateNameAltiplano                     -1.174e+01  1.898e+01  -0.619
## PlateNameAmur                          -1.090e+01  1.807e+01  -0.603
## PlateNameAnatolia                      -2.794e+01  2.542e+01  -1.099
## PlateNameAntarctica                    -2.058e+01  1.705e+01  -1.207
## PlateNameArabia                        -2.028e+01  1.711e+01  -1.186
## PlateNameAustralia                     -2.040e+01  1.705e+01  -1.197
## PlateNameBalmoral Reef                 -3.537e+01  2.354e+02  -0.150
## PlateNameBanda Sea                     -1.675e+01  1.722e+01  -0.973
## PlateNameBirds Head                    -2.148e+01  1.710e+01  -1.256
## PlateNameBurma                         -3.239e+01  1.783e+01  -1.817
## PlateNameCaribbean                     -1.861e+01  1.709e+01  -1.089
## PlateNameCaroline                      -2.403e+01  1.761e+01  -1.364
## PlateNameCocos                         -1.958e+01  1.714e+01  -1.143
## PlateNameConway Reef                   -1.901e+02  2.559e+02  -0.743
## PlateNameEaster                        -5.398e+00  2.140e+02  -0.025
## PlateNameEurasia                       -2.034e+01  1.705e+01  -1.193
## PlateNameFutuna                        -6.569e+01  1.484e+03  -0.044
## PlateNameGalapagos                     -8.858e+01  7.657e+01  -1.157
## PlateNameIndia                         -2.191e+01  1.705e+01  -1.285
## PlateNameJuan de Fuca                   9.105e+01  5.415e+01   1.681
## PlateNameJuan Fernandez                 1.688e+03  9.269e+02   1.821
## PlateNameKermadec                      -2.069e+01  1.705e+01  -1.213
## PlateNameManus                          2.550e+02  1.383e+03   0.184
## PlateNameMaoke                         -3.292e+01  4.480e+01  -0.735
```

```
## PlateNameMariana                          3.061e-01  2.602e+01   0.012
## PlateNameMolucca Sea                     -1.395e+01  1.726e+01  -0.809
## PlateNameNazca                           -1.982e+01  1.705e+01  -1.162
## PlateNameNew Hebrides                    -1.507e+01  2.014e+01  -0.748
## PlateNameNiuafo'ou                       -6.844e+01  1.397e+02  -0.490
## PlateNameNorth America                   -2.034e+01  1.705e+01  -1.193
## PlateNameNorth Andes                     -2.000e+01  1.727e+01  -1.158
## PlateNameNorth Bismarck                  -2.979e+01  1.784e+01  -1.670
## PlateNameOkhotsk                         -1.726e+01  1.717e+01  -1.005
## PlateNameOkinawa                         -1.029e+01  2.735e+01  -0.376
## PlateNamePacific                         -2.041e+01  1.705e+01  -1.197
## PlateNamePanama                          -2.174e+01  2.949e+01  -0.737
## PlateNamePhilippine Sea                  -2.230e+01  1.709e+01  -1.305
## PlateNameRivera                          -2.716e+02  1.798e+02  -1.510
## PlateNameSandwich                        -2.041e+01  2.937e+01  -0.695
## PlateNameScotia                          -1.069e+01  1.839e+01  -0.582
## PlateNameShetland                         4.254e+01  1.051e+03   0.040
## PlateNameSolomon Sea                      6.680e+01  1.045e+02   0.639
## PlateNameSomalia                         -2.023e+01  1.705e+01  -1.186
## PlateNameSouth America                   -2.046e+01  1.705e+01  -1.200
## PlateNameSouth Bismarck                  -9.764e+00  1.856e+01  -0.526
## PlateNameSunda                           -2.010e+01  1.705e+01  -1.179
## PlateNameTimor                           -1.454e+01  2.427e+01  -0.599
## PlateNameTonga                           -2.266e+01  3.123e+01  -0.726
## PlateNameWoodlark                        -4.241e+01  1.794e+01  -2.363
## PlateNameYangtze                         -1.901e+01  5.274e+01  -0.360
## latitude:longitude                        2.385e-02  1.844e-02   1.293
## latitude:PlateNameAfrica                  5.417e-01  4.597e-01   1.178
## latitude:PlateNameAltiplano               1.012e+00  6.603e-01   1.533
## latitude:PlateNameAmur                    3.574e-01  4.743e-01   0.753
## latitude:PlateNameAnatolia                7.244e-01  6.677e-01   1.085
## latitude:PlateNameAntarctica              5.366e-01  4.597e-01   1.167
## latitude:PlateNameArabia                  5.413e-01  4.635e-01   1.168
## latitude:PlateNameAustralia               5.396e-01  4.597e-01   1.174
## latitude:PlateNameBalmoral Reef          -4.168e-01  1.515e+01  -0.028
## latitude:PlateNameBanda Sea               8.427e-01  6.776e-01   1.244
## latitude:PlateNameBirds Head              4.056e-02  8.210e-01   0.049
## latitude:PlateNameBurma                   2.474e+00  7.909e-01   3.128
## latitude:PlateNameCaribbean               4.404e-01  4.680e-01   0.941
## latitude:PlateNameCaroline                1.549e-01  1.784e+00   0.087
## latitude:PlateNameCocos                   6.650e-01  4.939e-01   1.346
## latitude:PlateNameConway Reef            -9.595e+00  1.379e+01  -0.696
## latitude:PlateNameEaster                  9.602e-01  8.665e+00   0.111
## latitude:PlateNameEurasia                 5.386e-01  4.597e-01   1.172
## latitude:PlateNameFutuna                 -1.540e+00  9.774e+01  -0.016
## latitude:PlateNameGalapagos              -1.044e+01  6.619e+00  -1.577
## latitude:PlateNameIndia                   5.958e-01  4.602e-01   1.295
## latitude:PlateNameJuan de Fuca           -1.946e+00  1.260e+00  -1.544
## latitude:PlateNameJuan Fernandez          5.142e+01  2.782e+01   1.848
## latitude:PlateNameKermadec                5.330e-01  4.598e-01   1.159
```

```
## latitude:PlateNameManus                    7.613e+01  3.866e+02   0.197
## latitude:PlateNameMaoke                   -3.063e+00  1.048e+01  -0.292
## latitude:PlateNameMariana                 -6.250e-01  1.198e+00  -0.522
## latitude:PlateNameMolucca Sea              8.687e-01  1.642e+00   0.529
## latitude:PlateNameNazca                    5.561e-01  4.598e-01   1.209
## latitude:PlateNameNew Hebrides             6.907e-01  7.321e-01   0.943
## latitude:PlateNameNiuafo'ou               -3.092e+00  8.459e+00  -0.366
## latitude:PlateNameNorth America            5.376e-01  4.597e-01   1.170
## latitude:PlateNameNorth Andes              9.394e-02  5.462e-01   0.172
## latitude:PlateNameNorth Bismarck          -1.571e+00  1.498e+00  -1.049
## latitude:PlateNameOkhotsk                  5.441e-01  4.615e-01   1.179
## latitude:PlateNameOkinawa                  1.465e-01  9.925e-01   0.148
## latitude:PlateNamePacific                  5.402e-01  4.597e-01   1.175
## latitude:PlateNamePanama                   4.269e-01  2.656e+00   0.161
## latitude:PlateNamePhilippine Sea           6.439e-01  4.631e-01   1.390
## latitude:PlateNameRivera                   1.379e+01  9.591e+00   1.437
## latitude:PlateNameSandwich                 5.495e-01  6.210e-01   0.885
## latitude:PlateNameScotia                   7.076e-01  4.749e-01   1.490
## latitude:PlateNameShetland                 1.474e+00  1.683e+01   0.088
## latitude:PlateNameSolomon Sea              1.138e+01  1.463e+01   0.778
## latitude:PlateNameSomalia                  5.443e-01  4.598e-01   1.184
## latitude:PlateNameSouth America            5.381e-01  4.597e-01   1.171
## latitude:PlateNameSouth Bismarck           2.713e+00  1.497e+00   1.813
## latitude:PlateNameSunda                    5.526e-01  4.607e-01   1.200
## latitude:PlateNameTimor                    8.985e-01  2.256e+00   0.398
## latitude:PlateNameTonga                    6.862e-01  1.365e+00   0.503
## latitude:PlateNameWoodlark                -1.356e+00  7.743e-01  -1.752
## latitude:PlateNameYangtze                  4.656e-01  2.229e+00   0.209
## longitude:PlateNameAfrica                  9.011e-01  6.829e-01   1.320
## longitude:PlateNameAltiplano               1.022e+00  6.930e-01   1.475
## longitude:PlateNameAmur                    8.315e-01  6.844e-01   1.215
## longitude:PlateNameAnatolia                1.100e+00  9.013e-01   1.221
## longitude:PlateNameAntarctica              9.016e-01  6.829e-01   1.320
## longitude:PlateNameArabia                  8.958e-01  6.836e-01   1.310
## longitude:PlateNameAustralia               8.999e-01  6.829e-01   1.318
## longitude:PlateNameBalmoral Reef           9.791e-01  1.505e+00   0.651
## longitude:PlateNameBanda Sea               8.688e-01  6.832e-01   1.272
## longitude:PlateNameBirds Head              9.080e-01  6.829e-01   1.330
## longitude:PlateNameBurma                   1.026e+00  6.851e-01   1.498
## longitude:PlateNameCaribbean               9.204e-01  6.831e-01   1.347
## longitude:PlateNameCaroline                9.259e-01  6.836e-01   1.354
## longitude:PlateNameCocos                   9.116e-01  6.831e-01   1.335
## longitude:PlateNameConway Reef             1.873e+00  1.615e+00   1.160
## longitude:PlateNameEaster                  1.044e+00  1.991e+00   0.524
## longitude:PlateNameEurasia                 9.002e-01  6.829e-01   1.318
## longitude:PlateNameFutuna                  6.292e-01  8.366e+00   0.075
## longitude:PlateNameGalapagos                      NA         NA      NA
## longitude:PlateNameIndia                   9.193e-01  6.829e-01   1.346
## longitude:PlateNameJuan de Fuca            1.762e+00  7.913e-01   2.226
## longitude:PlateNameJuan Fernandez          1.618e+01  8.340e+00   1.941
```

```
## longitude:PlateNameKermadec                 8.982e-01  6.829e-01   1.315
## longitude:PlateNameManus                    -9.284e-01  9.207e+00  -0.101
## longitude:PlateNameMaoke                     9.891e-01  7.452e-01   1.327
## longitude:PlateNameMariana                   7.546e-01  6.963e-01   1.084
## longitude:PlateNameMolucca Sea               8.470e-01  6.832e-01   1.240
## longitude:PlateNameNazca                     9.074e-01  6.829e-01   1.329
## longitude:PlateNameNew Hebrides              8.682e-01  6.858e-01   1.266
## longitude:PlateNameNiuafo'ou                 6.256e-01  1.044e+00   0.599
## longitude:PlateNameNorth America             8.995e-01  6.829e-01   1.317
## longitude:PlateNameNorth Andes               9.035e-01  6.837e-01   1.321
## longitude:PlateNameNorth Bismarck            9.624e-01  6.838e-01   1.408
## longitude:PlateNameOkhotsk                   8.699e-01  6.830e-01   1.274
## longitude:PlateNameOkinawa                   8.220e-01  7.024e-01   1.170
## longitude:PlateNamePacific                   8.999e-01  6.829e-01   1.318
## longitude:PlateNamePanama                    8.939e-01  7.424e-01   1.204
## longitude:PlateNamePhilippine Sea            9.132e-01  6.829e-01   1.337
## longitude:PlateNameRivera                   -1.441e+00  1.789e+00  -0.805
## longitude:PlateNameSandwich                  9.649e-01  1.115e+00   0.865
## longitude:PlateNameScotia                    1.081e+00  6.989e-01   1.547
## longitude:PlateNameShetland                  2.142e+00  1.838e+01   0.117
## longitude:PlateNameSolomon Sea               3.204e-01  9.594e-01   0.334
## longitude:PlateNameSomalia                   8.944e-01  6.829e-01   1.310
## longitude:PlateNameSouth America             8.977e-01  6.829e-01   1.315
## longitude:PlateNameSouth Bismarck            8.284e-01  6.847e-01   1.210
## longitude:PlateNameSunda                     8.968e-01  6.829e-01   1.313
## longitude:PlateNameTimor                     8.557e-01  6.964e-01   1.229
## longitude:PlateNameTonga                     8.855e-01  6.993e-01   1.266
## longitude:PlateNameWoodlark                  1.057e+00  6.840e-01   1.545
## longitude:PlateNameYangtze                   8.932e-01  7.821e-01   1.142
## latitude:longitude:PlateNameAfrica          -2.385e-02  1.844e-02  -1.294
## latitude:longitude:PlateNameAltiplano       -1.716e-02  1.963e-02  -0.874
## latitude:longitude:PlateNameAmur            -2.253e-02  1.846e-02  -1.221
## latitude:longitude:PlateNameAnatolia        -2.871e-02  2.383e-02  -1.205
## latitude:longitude:PlateNameAntarctica      -2.381e-02  1.844e-02  -1.292
## latitude:longitude:PlateNameArabia          -2.394e-02  1.849e-02  -1.295
## latitude:longitude:PlateNameAustralia       -2.385e-02  1.844e-02  -1.294
## latitude:longitude:PlateNameBalmoral Reef   -1.874e-02  8.840e-02  -0.212
## latitude:longitude:PlateNameBanda Sea       -2.664e-02  1.886e-02  -1.412
## latitude:longitude:PlateNameBirds Head      -2.023e-02  1.916e-02  -1.056
## latitude:longitude:PlateNameBurma           -4.447e-02  1.966e-02  -2.262
## latitude:longitude:PlateNameCaribbean       -2.495e-02  1.847e-02  -1.351
## latitude:longitude:PlateNameCaroline        -2.130e-02  2.213e-02  -0.963
## latitude:longitude:PlateNameCocos           -2.279e-02  1.853e-02  -1.230
## latitude:longitude:PlateNameConway Reef      3.427e-02  8.114e-02   0.422
## latitude:longitude:PlateNameEaster          -1.969e-02  7.806e-02  -0.252
## latitude:longitude:PlateNameEurasia         -2.386e-02  1.844e-02  -1.294
## latitude:longitude:PlateNameFutuna          -3.659e-02  5.495e-01  -0.067
## latitude:longitude:PlateNameGalapagos               NA         NA      NA
## latitude:longitude:PlateNameIndia           -2.460e-02  1.844e-02  -1.334
## latitude:longitude:PlateNameJuan de Fuca    -4.305e-02  2.056e-02  -2.094
```

```
## latitude:longitude:PlateNameJuan Fernandez  4.313e-01  2.501e-01   1.724
## latitude:longitude:PlateNameKermadec       -2.389e-02  1.844e-02  -1.296
## latitude:longitude:PlateNameManus          -5.255e-01  2.568e+00  -0.205
## latitude:longitude:PlateNameMaoke           1.808e-03  7.761e-02   0.023
## latitude:longitude:PlateNameMariana        -1.571e-02  1.996e-02  -0.787
## latitude:longitude:PlateNameMolucca Sea    -2.702e-02  2.237e-02  -1.208
## latitude:longitude:PlateNameNazca          -2.365e-02  1.844e-02  -1.283
## latitude:longitude:PlateNameNew Hebrides   -2.475e-02  1.874e-02  -1.321
## latitude:longitude:PlateNameNiuafo'ou      -4.458e-02  5.152e-02  -0.865
## latitude:longitude:PlateNameNorth America  -2.384e-02  1.844e-02  -1.293
## latitude:longitude:PlateNameNorth Andes    -2.975e-02  1.880e-02  -1.582
## latitude:longitude:PlateNameNorth Bismarck -9.878e-03  2.067e-02  -0.478
## latitude:longitude:PlateNameOkhotsk        -2.369e-02  1.844e-02  -1.285
## latitude:longitude:PlateNameOkinawa        -2.085e-02  1.963e-02  -1.062
## latitude:longitude:PlateNamePacific        -2.385e-02  1.844e-02  -1.294
## latitude:longitude:PlateNamePanama         -2.653e-02  3.662e-02  -0.725
## latitude:longitude:PlateNamePhilippine Sea -2.460e-02  1.844e-02  -1.334
## latitude:longitude:PlateNameRivera          9.954e-02  9.030e-02   1.102
## latitude:longitude:PlateNameSandwich       -2.240e-02  2.403e-02  -0.932
## latitude:longitude:PlateNameScotia         -2.067e-02  1.862e-02  -1.110
## latitude:longitude:PlateNameShetland       -5.216e-03  2.943e-01  -0.018
## latitude:longitude:PlateNameSolomon Sea    -9.606e-02  9.728e-02  -0.988
## latitude:longitude:PlateNameSomalia        -2.391e-02  1.844e-02  -1.297
## latitude:longitude:PlateNameSouth America  -2.388e-02  1.844e-02  -1.295
## latitude:longitude:PlateNameSouth Bismarck -3.844e-02  2.078e-02  -1.850
## latitude:longitude:PlateNameSunda          -2.392e-02  1.844e-02  -1.297
## latitude:longitude:PlateNameTimor          -2.635e-02  2.544e-02  -1.036
## latitude:longitude:PlateNameTonga          -2.310e-02  1.986e-02  -1.163
## latitude:longitude:PlateNameWoodlark       -1.001e-02  1.894e-02  -0.529
## latitude:longitude:PlateNameYangtze        -2.345e-02  2.486e-02  -0.943
##                                           Pr(>|t|)
## (Intercept)                                0.12154
## latitude                                   0.24089
## longitude                                  0.18767
## PlateNameAfrica                            0.22976
## PlateNameAltiplano                         0.53599
## PlateNameAmur                              0.54618
## PlateNameAnatolia                          0.27172
## PlateNameAntarctica                        0.22740
## PlateNameArabia                            0.23577
## PlateNameAustralia                         0.23136
## PlateNameBalmoral Reef                     0.88053
## PlateNameBanda Sea                         0.33071
## PlateNameBirds Head                        0.20904
## PlateNameBurma                             0.06921 .
## PlateNameCaribbean                         0.27620
## PlateNameCaroline                          0.17256
## PlateNameCocos                             0.25317
## PlateNameConway Reef                       0.45751
## PlateNameEaster                            0.97987
```

```
## PlateNameEurasia                          0.23286
## PlateNameFutuna                           0.96469
## PlateNameGalapagos                        0.24734
## PlateNameIndia                            0.19878
## PlateNameJuan de Fuca                     0.09268 .
## PlateNameJuan Fernandez                   0.06861 .
## PlateNameKermadec                         0.22502
## PlateNameManus                            0.85366
## PlateNameMaoke                            0.46242
## PlateNameMariana                          0.99061
## PlateNameMolucca Sea                      0.41873
## PlateNameNazca                            0.24517
## PlateNameNew Hebrides                     0.45453
## PlateNameNiuafo'ou                        0.62425
## PlateNameNorth America                    0.23275
## PlateNameNorth Andes                      0.24683
## PlateNameNorth Bismarck                   0.09486 .
## PlateNameOkhotsk                          0.31483
## PlateNameOkinawa                          0.70664
## PlateNamePacific                          0.23131
## PlateNamePanama                           0.46090
## PlateNamePhilippine Sea                   0.19207
## PlateNameRivera                           0.13096
## PlateNameSandwich                         0.48709
## PlateNameScotia                           0.56085
## PlateNameShetland                         0.96772
## PlateNameSolomon Sea                      0.52276
## PlateNameSomalia                          0.23551
## PlateNameSouth America                    0.23011
## PlateNameSouth Bismarck                   0.59876
## PlateNameSunda                            0.23836
## PlateNameTimor                            0.54925
## PlateNameTonga                            0.46815
## PlateNameWoodlark                         0.01812 *
## PlateNameYangtze                          0.71848
## latitude:longitude                        0.19590
## latitude:PlateNameAfrica                  0.23861
## latitude:PlateNameAltiplano               0.12533
## latitude:PlateNameAmur                    0.45122
## latitude:PlateNameAnatolia                0.27797
## latitude:PlateNameAntarctica              0.24312
## latitude:PlateNameArabia                  0.24286
## latitude:PlateNameAustralia               0.24046
## latitude:PlateNameBalmoral Reef           0.97805
## latitude:PlateNameBanda Sea               0.21366
## latitude:PlateNameBirds Head              0.96060
## latitude:PlateNameBurma                   0.00176 **
## latitude:PlateNameCaribbean               0.34670
## latitude:PlateNameCaroline                0.93084
## latitude:PlateNameCocos                   0.17817
```

```
## latitude:PlateNameConway Reef               0.48668
## latitude:PlateNameEaster                    0.91177
## latitude:PlateNameEurasia                   0.24131
## latitude:PlateNameFutuna                    0.98743
## latitude:PlateNameGalapagos                 0.11470
## latitude:PlateNameIndia                     0.19549
## latitude:PlateNameJuan de Fuca              0.12253
## latitude:PlateNameJuan Fernandez            0.06456 .
## latitude:PlateNameKermadec                  0.24637
## latitude:PlateNameManus                     0.84390
## latitude:PlateNameMaoke                     0.77006
## latitude:PlateNameMariana                   0.60186
## latitude:PlateNameMolucca Sea               0.59682
## latitude:PlateNameNazca                     0.22655
## latitude:PlateNameNew Hebrides              0.34550
## latitude:PlateNameNiuafo'ou                 0.71469
## latitude:PlateNameNorth America             0.24221
## latitude:PlateNameNorth Andes               0.86344
## latitude:PlateNameNorth Bismarck            0.29422
## latitude:PlateNameOkhotsk                   0.23839
## latitude:PlateNameOkinawa                   0.88270
## latitude:PlateNamePacific                   0.23996
## latitude:PlateNamePanama                    0.87229
## latitude:PlateNamePhilippine Sea            0.16445
## latitude:PlateNameRivera                    0.15062
## latitude:PlateNameSandwich                  0.37621
## latitude:PlateNameScotia                    0.13626
## latitude:PlateNameShetland                  0.93020
## latitude:PlateNameSolomon Sea               0.43684
## latitude:PlateNameSomalia                   0.23653
## latitude:PlateNameSouth America             0.24176
## latitude:PlateNameSouth Bismarck            0.06989 .
## latitude:PlateNameSunda                     0.23029
## latitude:PlateNameTimor                     0.69039
## latitude:PlateNameTonga                     0.61508
## latitude:PlateNameWoodlark                  0.07985 .
## latitude:PlateNameYangtze                   0.83453
## longitude:PlateNameAfrica                   0.18699
## longitude:PlateNameAltiplano                0.14018
## longitude:PlateNameAmur                     0.22438
## longitude:PlateNameAnatolia                 0.22211
## longitude:PlateNameAntarctica               0.18675
## longitude:PlateNameArabia                   0.19009
## longitude:PlateNameAustralia                0.18760
## longitude:PlateNameBalmoral Reef            0.51525
## longitude:PlateNameBanda Sea                0.20348
## longitude:PlateNameBirds Head               0.18369
## longitude:PlateNameBurma                    0.13410
## longitude:PlateNameCaribbean                0.17787
## longitude:PlateNameCaroline                 0.17564
```

```
## longitude:PlateNameCocos                       0.18205
## longitude:PlateNameConway Reef                 0.24603
## longitude:PlateNameEaster                      0.60004
## longitude:PlateNameEurasia                     0.18745
## longitude:PlateNameFutuna                      0.94005
## longitude:PlateNameGalapagos                       NA
## longitude:PlateNameIndia                       0.17828
## longitude:PlateNameJuan de Fuca                0.02600 *
## longitude:PlateNameJuan Fernandez              0.05233 .
## longitude:PlateNameKermadec                    0.18843
## longitude:PlateNameManus                       0.91969
## longitude:PlateNameMaoke                       0.18443
## longitude:PlateNameMariana                     0.27849
## longitude:PlateNameMolucca Sea                 0.21507
## longitude:PlateNameNazca                       0.18393
## longitude:PlateNameNew Hebrides                0.20559
## longitude:PlateNameNiuafo'ou                   0.54905
## longitude:PlateNameNorth America               0.18777
## longitude:PlateNameNorth Andes                 0.18639
## longitude:PlateNameNorth Bismarck              0.15929
## longitude:PlateNameOkhotsk                     0.20283
## longitude:PlateNameOkinawa                     0.24187
## longitude:PlateNamePacific                     0.18759
## longitude:PlateNamePanama                      0.22859
## longitude:PlateNamePhilippine Sea              0.18118
## longitude:PlateNameRivera                      0.42065
## longitude:PlateNameSandwich                    0.38705
## longitude:PlateNameScotia                      0.12182
## longitude:PlateNameShetland                    0.90724
## longitude:PlateNameSolomon Sea                 0.73839
## longitude:PlateNameSomalia                     0.19031
## longitude:PlateNameSouth America               0.18865
## longitude:PlateNameSouth Bismarck              0.22629
## longitude:PlateNameSunda                       0.18910
## longitude:PlateNameTimor                       0.21917
## longitude:PlateNameTonga                       0.20544
## longitude:PlateNameWoodlark                    0.12247
## longitude:PlateNameYangtze                     0.25343
## latitude:longitude:PlateNameAfrica             0.19579
## latitude:longitude:PlateNameAltiplano          0.38209
## latitude:longitude:PlateNameAmur               0.22217
## latitude:longitude:PlateNameAnatolia           0.22836
## latitude:longitude:PlateNameAntarctica         0.19652
## latitude:longitude:PlateNameArabia             0.19544
## latitude:longitude:PlateNameAustralia          0.19584
## latitude:longitude:PlateNameBalmoral Reef      0.83208
## latitude:longitude:PlateNameBanda Sea          0.15787
## latitude:longitude:PlateNameBirds Head         0.29106
## latitude:longitude:PlateNameBurma              0.02373 *
## latitude:longitude:PlateNameCaribbean          0.17681
```

```
## latitude:longitude:PlateNameCaroline        0.33578
## latitude:longitude:PlateNameCocos           0.21874
## latitude:longitude:PlateNameConway Reef     0.67274
## latitude:longitude:PlateNameEaster          0.80083
## latitude:longitude:PlateNameEurasia         0.19562
## latitude:longitude:PlateNameFutuna          0.94691
## latitude:longitude:PlateNameGalapagos            NA
## latitude:longitude:PlateNameIndia           0.18225
## latitude:longitude:PlateNameJuan de Fuca    0.03625 *
## latitude:longitude:PlateNameJuan Fernandez  0.08469 .
## latitude:longitude:PlateNameKermadec        0.19515
## latitude:longitude:PlateNameManus           0.83783
## latitude:longitude:PlateNameMaoke           0.98141
## latitude:longitude:PlateNameMariana         0.43124
## latitude:longitude:PlateNameMolucca Sea     0.22709
## latitude:longitude:PlateNameNazca           0.19951
## latitude:longitude:PlateNameNew Hebrides    0.18663
## latitude:longitude:PlateNameNiuafo'ou       0.38682
## latitude:longitude:PlateNameNorth America   0.19596
## latitude:longitude:PlateNameNorth Andes     0.11371
## latitude:longitude:PlateNameNorth Bismarck  0.63272
## latitude:longitude:PlateNameOkhotsk         0.19898
## latitude:longitude:PlateNameOkinawa         0.28812
## latitude:longitude:PlateNamePacific         0.19580
## latitude:longitude:PlateNamePanama          0.46876
## latitude:longitude:PlateNamePhilippine Sea  0.18227
## latitude:longitude:PlateNameRivera          0.27032
## latitude:longitude:PlateNameSandwich        0.35143
## latitude:longitude:PlateNameScotia          0.26694
## latitude:longitude:PlateNameShetland        0.98586
## latitude:longitude:PlateNameSolomon Sea     0.32340
## latitude:longitude:PlateNameSomalia         0.19471
## latitude:longitude:PlateNameSouth America   0.19517
## latitude:longitude:PlateNameSouth Bismarck  0.06437 .
## latitude:longitude:PlateNameSunda           0.19451
## latitude:longitude:PlateNameTimor           0.30031
## latitude:longitude:PlateNameTonga           0.24479
## latitude:longitude:PlateNameWoodlark        0.59711
## latitude:longitude:PlateNameYangtze         0.34560
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4251 on 18640 degrees of freedom
## Multiple R-squared:  0.02578,    Adjusted R-squared:  0.01507
## F-statistic: 2.406 on 205 and 18640 DF,  p-value: < 2.2e-16

LRModel7 <-lm(magnitude ~ latitude * longitude + log1p(focal_depth),
              data = nap_earthquakes)
summary(LRModel7)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude + log1p(focal_depth),
##     data = nap_earthquakes)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.4741 -0.3299 -0.1459  0.1691  2.1117
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          5.934e+00  4.779e-02 124.171   <2e-16 ***
## latitude             1.277e-04  3.897e-04   0.328    0.743
## longitude            1.736e-04  1.011e-04   1.718    0.086 .
## log1p(focal_depth)   1.814e-02  1.471e-02   1.234    0.218
## latitude:longitude  -3.091e-06  2.525e-06  -1.224    0.221
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4698 on 1474 degrees of freedom
## Multiple R-squared:  0.004487,   Adjusted R-squared:  0.001786
## F-statistic: 1.661 on 4 and 1474 DF,  p-value: 0.1566
```

```
LRModel8 <-lm(magnitude ~ latitude * longitude * log1p(focal_depth) *
PlateName,
              data = earthquakes1)
```

```
## Warning in log1p(focal_depth): NaNs produced
```

```
summary(LRModel8)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude * log1p(focal_depth) *
##     PlateName, data = earthquakes1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.9250 -0.2901 -0.1218  0.1632  3.1394
##
## Coefficients: (9 not defined because of singularities)
##                                                                  Estimate
## (Intercept)                                                    -7.235e+00
## latitude                                                        2.879e-01
## longitude                                                       2.919e-01
## log1p(focal_depth)                                              7.380e+00
## PlateNameAfrica                                                 1.311e+01
## PlateNameAltiplano                                              6.546e+01
## PlateNameAmur                                                   1.431e+01
## PlateNameAnatolia                                               3.248e+01
## PlateNameAntarctica                                             1.395e+01
```

```
## PlateNameArabia                                  1.424e+01
## PlateNameAustralia                               1.351e+01
## PlateNameBalmoral Reef                          -2.631e+03
## PlateNameBanda Sea                               2.648e+01
## PlateNameBirds Head                              1.305e+01
## PlateNameBurma                                   7.616e+01
## PlateNameCaribbean                               1.652e+01
## PlateNameCaroline                                3.200e+00
## PlateNameCocos                                   3.492e+00
## PlateNameConway Reef                            -4.624e+02
## PlateNameEaster                                  1.602e+03
## PlateNameEurasia                                 1.305e+01
## PlateNameFutuna                                 -4.905e+01
## PlateNameGalapagos                              -2.100e+01
## PlateNameIndia                                   1.138e+01
## PlateNameJuan de Fuca                           -1.355e+02
## PlateNameJuan Fernandez                          1.167e+03
## PlateNameKermadec                                1.009e+01
## PlateNameManus                                  -8.449e+02
## PlateNameMaoke                                   8.083e+01
## PlateNameMariana                                -5.906e+01
## PlateNameMolucca Sea                             5.429e+01
## PlateNameNazca                                   1.638e+01
## PlateNameNew Hebrides                            4.873e+01
## PlateNameNiuafo'ou                               6.320e+02
## PlateNameNorth America                           1.406e+01
## PlateNameNorth Andes                            -4.808e+00
## PlateNameNorth Bismarck                          5.003e+01
## PlateNameOkhotsk                                -1.058e+01
## PlateNameOkinawa                                 5.799e+01
## PlateNamePacific                                 1.322e+01
## PlateNamePanama                                 -4.888e+01
## PlateNamePhilippine Sea                          2.079e+01
## PlateNameRivera                                 -9.908e+02
## PlateNameSandwich                               -1.173e+02
## PlateNameScotia                                  1.436e+01
## PlateNameShetland                               -8.989e+03
## PlateNameSolomon Sea                            -7.592e+01
## PlateNameSomalia                                 1.294e+01
## PlateNameSouth America                           1.206e+01
## PlateNameSouth Bismarck                          1.701e+01
## PlateNameSunda                                   1.419e+01
## PlateNameTimor                                  -1.187e+01
## PlateNameTonga                                   2.093e+02
## PlateNameWoodlark                               -2.010e+01
## PlateNameYangtze                                 5.198e+02
## latitude:longitude                              -5.168e-03
## latitude:log1p(focal_depth)                     -1.731e-01
## longitude:log1p(focal_depth)                    -2.473e-01
## latitude:PlateNameAfrica                        -2.862e-01
```

```
## latitude:PlateNameAltiplano                                  2.720e+00
## latitude:PlateNameAmur                                      -2.983e-01
## latitude:PlateNameAnatolia                                  -8.343e-01
## latitude:PlateNameAntarctica                                -2.707e-01
## latitude:PlateNameArabia                                    -4.397e-01
## latitude:PlateNameAustralia                                 -2.751e-01
## latitude:PlateNameBalmoral Reef                             -1.978e+02
## latitude:PlateNameBanda Sea                                  3.188e+00
## latitude:PlateNameBirds Head                                -5.837e+00
## latitude:PlateNameBurma                                     -7.117e+00
## latitude:PlateNameCaribbean                                 -5.096e-01
## latitude:PlateNameCaroline                                  -8.907e-01
## latitude:PlateNameCocos                                      7.602e-01
## latitude:PlateNameConway Reef                               -2.115e+01
## latitude:PlateNameEaster                                     6.045e+01
## latitude:PlateNameEurasia                                   -2.806e-01
## latitude:PlateNameFutuna                                     1.878e+00
## latitude:PlateNameGalapagos                                 -7.163e+00
## latitude:PlateNameIndia                                     -2.317e-01
## latitude:PlateNameJuan de Fuca                               3.394e+00
## latitude:PlateNameJuan Fernandez                             3.084e+01
## latitude:PlateNameKermadec                                  -3.706e-01
## latitude:PlateNameManus                                     -1.069e+02
## latitude:PlateNameMaoke                                      1.777e+01
## latitude:PlateNameMariana                                    2.559e+00
## latitude:PlateNameMolucca Sea                                9.625e+00
## latitude:PlateNameNazca                                     -1.420e-01
## latitude:PlateNameNew Hebrides                               1.854e+00
## latitude:PlateNameNiuafo'ou                                  3.645e+01
## latitude:PlateNameNorth America                             -3.037e-01
## latitude:PlateNameNorth Andes                                1.273e-01
## latitude:PlateNameNorth Bismarck                             5.404e+00
## latitude:PlateNameOkhotsk                                    2.110e-01
## latitude:PlateNameOkinawa                                   -3.280e+00
## latitude:PlateNamePacific                                   -2.819e-01
## latitude:PlateNamePanama                                     7.031e+00
## latitude:PlateNamePhilippine Sea                            -5.240e-01
## latitude:PlateNameRivera                                     5.410e+01
## latitude:PlateNameSandwich                                  -2.561e+00
## latitude:PlateNameScotia                                    -2.611e-01
## latitude:PlateNameShetland                                  -1.458e+02
## latitude:PlateNameSolomon Sea                               -1.905e+01
## latitude:PlateNameSomalia                                   -3.252e-01
## latitude:PlateNameSouth America                             -3.008e-01
## latitude:PlateNameSouth Bismarck                            -1.780e-01
## latitude:PlateNameSunda                                     -2.312e-01
## latitude:PlateNameTimor                                     -6.808e+00
## latitude:PlateNameTonga                                      8.132e+00
## latitude:PlateNameWoodlark                                  -4.384e+00
## latitude:PlateNameYangtze                                   -2.216e+01
```

```
## longitude:PlateNameAfrica                                -2.928e-01
## longitude:PlateNameAltiplano                              4.465e-01
## longitude:PlateNameAmur                                  -2.882e-01
## longitude:PlateNameAnatolia                              -7.383e-01
## longitude:PlateNameAntarctica                            -2.942e-01
## longitude:PlateNameArabia                                -3.223e-01
## longitude:PlateNameAustralia                             -2.937e-01
## longitude:PlateNameBalmoral Reef                          1.458e+01
## longitude:PlateNameBanda Sea                             -3.961e-01
## longitude:PlateNameBirds Head                            -2.848e-01
## longitude:PlateNameBurma                                 -9.609e-01
## longitude:PlateNameCaribbean                             -2.500e-01
## longitude:PlateNameCaroline                              -2.137e-01
## longitude:PlateNameCocos                                 -3.860e-01
## longitude:PlateNameConway Reef                            2.451e+00
## longitude:PlateNameEaster                                 1.390e+01
## longitude:PlateNameEurasia                               -2.876e-01
## longitude:PlateNameFutuna                                -6.583e-01
## longitude:PlateNameGalapagos                                     NA
## longitude:PlateNameIndia                                 -2.729e-01
## longitude:PlateNameJuan de Fuca                          -1.470e+00
## longitude:PlateNameJuan Fernandez                         9.525e+00
## longitude:PlateNameKermadec                              -3.124e-01
## longitude:PlateNameManus                                  5.507e+00
## longitude:PlateNameMaoke                                 -7.898e-01
## longitude:PlateNameMariana                                2.012e-01
## longitude:PlateNameMolucca Sea                           -6.234e-01
## longitude:PlateNameNazca                                 -2.543e-01
## longitude:PlateNameNew Hebrides                          -4.983e-01
## longitude:PlateNameNiuafo'ou                              3.229e+00
## longitude:PlateNameNorth America                         -2.825e-01
## longitude:PlateNameNorth Andes                           -5.193e-01
## longitude:PlateNameNorth Bismarck                        -5.416e-01
## longitude:PlateNameOkhotsk                               -1.225e-01
## longitude:PlateNameOkinawa                               -5.667e-01
## longitude:PlateNamePacific                               -2.907e-01
## longitude:PlateNamePanama                                -1.017e+00
## longitude:PlateNamePhilippine Sea                        -3.469e-01
## longitude:PlateNameRivera                                -9.570e+00
## longitude:PlateNameSandwich                              -4.906e+00
## longitude:PlateNameScotia                                 9.333e-03
## longitude:PlateNameShetland                              -1.537e+02
## longitude:PlateNameSolomon Sea                            3.163e-01
## longitude:PlateNameSomalia                               -2.874e-01
## longitude:PlateNameSouth America                         -3.040e-01
## longitude:PlateNameSouth Bismarck                        -3.180e-01
## longitude:PlateNameSunda                                 -3.002e-01
## longitude:PlateNameTimor                                 -5.988e-02
## longitude:PlateNameTonga                                  8.400e-01
## longitude:PlateNameWoodlark                              -5.543e-02
```

```
## longitude:PlateNameYangtze                                -4.087e+00
## log1p(focal_depth):PlateNameAfrica                         -7.365e+00
## log1p(focal_depth):PlateNameAltiplano                      -1.597e+01
## log1p(focal_depth):PlateNameAmur                           -6.219e+00
## log1p(focal_depth):PlateNameAnatolia                       -1.773e+01
## log1p(focal_depth):PlateNameAntarctica                     -7.734e+00
## log1p(focal_depth):PlateNameArabia                         -7.873e+00
## log1p(focal_depth):PlateNameAustralia                      -7.438e+00
## log1p(focal_depth):PlateNameBalmoral Reef                   8.715e+02
## log1p(focal_depth):PlateNameBanda Sea                      -9.586e+00
## log1p(focal_depth):PlateNameBirds Head                     -7.352e+00
## log1p(focal_depth):PlateNameBurma                          -3.038e+01
## log1p(focal_depth):PlateNameCaribbean                      -7.958e+00
## log1p(focal_depth):PlateNameCaroline                       -5.363e+00
## log1p(focal_depth):PlateNameCocos                          -3.592e+00
## log1p(focal_depth):PlateNameConway Reef                     6.602e+01
## log1p(focal_depth):PlateNameEaster                         -6.374e+02
## log1p(focal_depth):PlateNameEurasia                        -7.299e+00
## log1p(focal_depth):PlateNameFutuna                         -7.996e+01
## log1p(focal_depth):PlateNameGalapagos                             NA
## log1p(focal_depth):PlateNameIndia                          -7.192e+00
## log1p(focal_depth):PlateNameJuan de Fuca                    9.695e+01
## log1p(focal_depth):PlateNameJuan Fernandez                 -5.837e+01
## log1p(focal_depth):PlateNameKermadec                       -6.598e+00
## log1p(focal_depth):PlateNameManus                           1.736e+02
## log1p(focal_depth):PlateNameMaoke                          -2.822e+01
## log1p(focal_depth):PlateNameMariana                         2.248e+01
## log1p(focal_depth):PlateNameMolucca Sea                    -1.721e+01
## log1p(focal_depth):PlateNameNazca                          -8.400e+00
## log1p(focal_depth):PlateNameNew Hebrides                   -1.593e+01
## log1p(focal_depth):PlateNameNiuafo'ou                      -1.797e+02
## log1p(focal_depth):PlateNameNorth America                  -7.669e+00
## log1p(focal_depth):PlateNameNorth Andes                    -1.448e+00
## log1p(focal_depth):PlateNameNorth Bismarck                 -1.995e+01
## log1p(focal_depth):PlateNameOkhotsk                         7.489e-01
## log1p(focal_depth):PlateNameOkinawa                        -2.016e+01
## log1p(focal_depth):PlateNamePacific                        -7.370e+00
## log1p(focal_depth):PlateNamePanama                          1.141e+01
## log1p(focal_depth):PlateNamePhilippine Sea                 -1.008e+01
## log1p(focal_depth):PlateNameRivera                          2.317e+02
## log1p(focal_depth):PlateNameSandwich                        3.107e+01
## log1p(focal_depth):PlateNameScotia                         -3.403e+00
## log1p(focal_depth):PlateNameShetland                        2.650e+03
## log1p(focal_depth):PlateNameSolomon Sea                     4.972e+01
## log1p(focal_depth):PlateNameSomalia                        -7.199e+00
## log1p(focal_depth):PlateNameSouth America                  -6.919e+00
## log1p(focal_depth):PlateNameSouth Bismarck                 -5.859e+00
## log1p(focal_depth):PlateNameSunda                          -7.563e+00
## log1p(focal_depth):PlateNameTimor                          -3.772e-01
## log1p(focal_depth):PlateNameTonga                          -5.427e+01
```

```
## log1p(focal_depth):PlateNameWoodlark                    -4.373e+00
## log1p(focal_depth):PlateNameYangtze                     -1.699e+02
## latitude:longitude:log1p(focal_depth)                    5.652e-03
## latitude:longitude:PlateNameAfrica                       5.195e-03
## latitude:longitude:PlateNameAltiplano                    4.758e-02
## latitude:longitude:PlateNameAmur                         4.961e-03
## latitude:longitude:PlateNameAnatolia                     1.796e-02
## latitude:longitude:PlateNameAntarctica                   5.086e-03
## latitude:longitude:PlateNameArabia                       8.003e-03
## latitude:longitude:PlateNameAustralia                    5.067e-03
## latitude:longitude:PlateNameBalmoral Reef                1.116e+00
## latitude:longitude:PlateNameBanda Sea                   -2.220e-02
## latitude:longitude:PlateNameBirds Head                   4.639e-02
## latitude:longitude:PlateNameBurma                        7.760e-02
## latitude:longitude:PlateNameCaribbean                    2.153e-03
## latitude:longitude:PlateNameCaroline                     9.243e-03
## latitude:longitude:PlateNameCocos                        1.553e-02
## latitude:longitude:PlateNameConway Reef                  1.257e-01
## latitude:longitude:PlateNameEaster                       5.476e-01
## latitude:longitude:PlateNameEurasia                      5.018e-03
## latitude:longitude:PlateNameFutuna                       1.635e-02
## latitude:longitude:PlateNameGalapagos                           NA
## latitude:longitude:PlateNameIndia                        4.532e-03
## latitude:longitude:PlateNameJuan de Fuca                 3.427e-02
## latitude:longitude:PlateNameJuan Fernandez               2.663e-01
## latitude:longitude:PlateNameKermadec                     4.570e-03
## latitude:longitude:PlateNameManus                        7.420e-01
## latitude:longitude:PlateNameMaoke                       -1.281e-01
## latitude:longitude:PlateNameMariana                     -1.428e-02
## latitude:longitude:PlateNameMolucca Sea                 -7.583e-02
## latitude:longitude:PlateNameNazca                        6.817e-03
## latitude:longitude:PlateNameNew Hebrides                -7.302e-03
## latitude:longitude:PlateNameNiuafo'ou                    2.141e-01
## latitude:longitude:PlateNameNorth America                4.996e-03
## latitude:longitude:PlateNameNorth Andes                  7.933e-03
## latitude:longitude:PlateNameNorth Bismarck              -3.363e-02
## latitude:longitude:PlateNameOkhotsk                      1.664e-03
## latitude:longitude:PlateNameOkinawa                      2.590e-02
## latitude:longitude:PlateNamePacific                      5.167e-03
## latitude:longitude:PlateNamePanama                       9.012e-02
## latitude:longitude:PlateNamePhilippine Sea               6.821e-03
## latitude:longitude:PlateNameRivera                       5.074e-01
## latitude:longitude:PlateNameSandwich                    -7.517e-02
## latitude:longitude:PlateNameScotia                       1.045e-02
## latitude:longitude:PlateNameShetland                    -2.474e+00
## latitude:longitude:PlateNameSolomon Sea                  1.304e-01
## latitude:longitude:PlateNameSomalia                      6.245e-03
## latitude:longitude:PlateNameSouth America                5.221e-03
## latitude:longitude:PlateNameSouth Bismarck               4.153e-03
## latitude:longitude:PlateNameSunda                        4.741e-03
```

```
## latitude:longitude:PlateNameTimor                          6.080e-02
## latitude:longitude:PlateNameTonga                          5.375e-02
## latitude:longitude:PlateNameWoodlark                       3.420e-02
## latitude:longitude:PlateNameYangtze                        1.702e-01
## latitude:log1p(focal_depth):PlateNameAfrica                1.734e-01
## latitude:log1p(focal_depth):PlateNameAltiplano            -3.105e-01
## latitude:log1p(focal_depth):PlateNameAmur                  1.511e-01
## latitude:log1p(focal_depth):PlateNameAnatolia              4.554e-01
## latitude:log1p(focal_depth):PlateNameAntarctica            1.653e-01
## latitude:log1p(focal_depth):PlateNameArabia                2.431e-01
## latitude:log1p(focal_depth):PlateNameAustralia             1.706e-01
## latitude:log1p(focal_depth):PlateNameBalmoral Reef         6.450e+01
## latitude:log1p(focal_depth):PlateNameBanda Sea            -5.037e-01
## latitude:log1p(focal_depth):PlateNameBirds Head            1.731e+00
## latitude:log1p(focal_depth):PlateNameBurma                 2.934e+00
## latitude:log1p(focal_depth):PlateNameCaribbean             2.195e-01
## latitude:log1p(focal_depth):PlateNameCaroline              4.353e-01
## latitude:log1p(focal_depth):PlateNameCocos                -1.597e-01
## latitude:log1p(focal_depth):PlateNameConway Reef           2.345e+00
## latitude:log1p(focal_depth):PlateNameEaster               -2.392e+01
## latitude:log1p(focal_depth):PlateNameEurasia               1.704e-01
## latitude:log1p(focal_depth):PlateNameFutuna               -6.252e+00
## latitude:log1p(focal_depth):PlateNameGalapagos                    NA
## latitude:log1p(focal_depth):PlateNameIndia                 1.719e-01
## latitude:log1p(focal_depth):PlateNameJuan de Fuca         -2.298e+00
## latitude:log1p(focal_depth):PlateNameJuan Fernandez               NA
## latitude:log1p(focal_depth):PlateNameKermadec              1.941e-01
## latitude:log1p(focal_depth):PlateNameManus                 3.330e+00
## latitude:log1p(focal_depth):PlateNameMaoke                -5.471e+00
## latitude:log1p(focal_depth):PlateNameMariana              -1.162e+00
## latitude:log1p(focal_depth):PlateNameMolucca Sea          -2.557e+00
## latitude:log1p(focal_depth):PlateNameNazca                 1.230e-01
## latitude:log1p(focal_depth):PlateNameNew Hebrides         -3.985e-01
## latitude:log1p(focal_depth):PlateNameNiuafo'ou            -1.019e+01
## latitude:log1p(focal_depth):PlateNameNorth America         1.786e-01
## latitude:log1p(focal_depth):PlateNameNorth Andes          -9.148e-02
## latitude:log1p(focal_depth):PlateNameNorth Bismarck       -1.949e+00
## latitude:log1p(focal_depth):PlateNameOkhotsk               2.796e-02
## latitude:log1p(focal_depth):PlateNameOkinawa               1.049e+00
## latitude:log1p(focal_depth):PlateNamePacific               1.713e-01
## latitude:log1p(focal_depth):PlateNamePanama               -2.086e+00
## latitude:log1p(focal_depth):PlateNamePhilippine Sea        2.721e-01
## latitude:log1p(focal_depth):PlateNameRivera               -1.293e+01
## latitude:log1p(focal_depth):PlateNameSandwich              8.453e-01
## latitude:log1p(focal_depth):PlateNameScotia                2.384e-01
## latitude:log1p(focal_depth):PlateNameShetland              4.310e+01
## latitude:log1p(focal_depth):PlateNameSolomon Sea           9.660e+00
## latitude:log1p(focal_depth):PlateNameSomalia               1.907e-01
## latitude:log1p(focal_depth):PlateNameSouth America         1.786e-01
## latitude:log1p(focal_depth):PlateNameSouth Bismarck        6.499e-01
```

```
## latitude:log1p(focal_depth):PlateNameSunda                    1.608e-01
## latitude:log1p(focal_depth):PlateNameTimor                     1.864e+00
## latitude:log1p(focal_depth):PlateNameTonga                    -1.818e+00
## latitude:log1p(focal_depth):PlateNameWoodlark                  7.789e-01
## latitude:log1p(focal_depth):PlateNameYangtze                   7.169e+00
## longitude:log1p(focal_depth):PlateNameAfrica                   2.482e-01
## longitude:log1p(focal_depth):PlateNameAltiplano                1.264e-01
## longitude:log1p(focal_depth):PlateNameAmur                     2.363e-01
## longitude:log1p(focal_depth):PlateNameAnatolia                 5.030e-01
## longitude:log1p(focal_depth):PlateNameAntarctica               2.490e-01
## longitude:log1p(focal_depth):PlateNameArabia                   2.608e-01
## longitude:log1p(focal_depth):PlateNameAustralia                2.477e-01
## longitude:log1p(focal_depth):PlateNameBalmoral Reef           -4.706e+00
## longitude:log1p(focal_depth):PlateNameBanda Sea                2.641e-01
## longitude:log1p(focal_depth):PlateNameBirds Head               2.454e-01
## longitude:log1p(focal_depth):PlateNameBurma                    4.916e-01
## longitude:log1p(focal_depth):PlateNameCaribbean                2.389e-01
## longitude:log1p(focal_depth):PlateNameCaroline                 2.310e-01
## longitude:log1p(focal_depth):PlateNameCocos                    2.855e-01
## longitude:log1p(focal_depth):PlateNameConway Reef             -1.786e-01
## longitude:log1p(focal_depth):PlateNameEaster                  -5.374e+00
## longitude:log1p(focal_depth):PlateNameEurasia                  2.457e-01
## longitude:log1p(focal_depth):PlateNameFutuna                  -1.628e-01
## longitude:log1p(focal_depth):PlateNameGalapagos                       NA
## longitude:log1p(focal_depth):PlateNameIndia                    2.467e-01
## longitude:log1p(focal_depth):PlateNameJuan de Fuca             1.066e+00
## longitude:log1p(focal_depth):PlateNameJuan Fernandez                  NA
## longitude:log1p(focal_depth):PlateNameKermadec                 2.526e-01
## longitude:log1p(focal_depth):PlateNameManus                   -9.922e-01
## longitude:log1p(focal_depth):PlateNameMaoke                    4.004e-01
## longitude:log1p(focal_depth):PlateNameMariana                  4.229e-02
## longitude:log1p(focal_depth):PlateNameMolucca Sea              3.266e-01
## longitude:log1p(focal_depth):PlateNameNazca                    2.354e-01
## longitude:log1p(focal_depth):PlateNameNew Hebrides             2.969e-01
## longitude:log1p(focal_depth):PlateNameNiuafo'ou               -7.334e-01
## longitude:log1p(focal_depth):PlateNameNorth America            2.439e-01
## longitude:log1p(focal_depth):PlateNameNorth Andes              3.218e-01
## longitude:log1p(focal_depth):PlateNameNorth Bismarck           3.321e-01
## longitude:log1p(focal_depth):PlateNameOkhotsk                  1.868e-01
## longitude:log1p(focal_depth):PlateNameOkinawa                  3.247e-01
## longitude:log1p(focal_depth):PlateNamePacific                  2.470e-01
## longitude:log1p(focal_depth):PlateNamePanama                   4.701e-01
## longitude:log1p(focal_depth):PlateNamePhilippine Sea           2.669e-01
## longitude:log1p(focal_depth):PlateNameRivera                   2.448e+00
## longitude:log1p(focal_depth):PlateNameSandwich                 1.627e+00
## longitude:log1p(focal_depth):PlateNameScotia                   2.118e-01
## longitude:log1p(focal_depth):PlateNameShetland                 4.568e+01
## longitude:log1p(focal_depth):PlateNameSolomon Sea             -1.363e-01
## longitude:log1p(focal_depth):PlateNameSomalia                  2.435e-01
## longitude:log1p(focal_depth):PlateNameSouth America            2.522e-01
```

```
## longitude:log1p(focal_depth):PlateNameSouth Bismarck           2.374e-01
## longitude:log1p(focal_depth):PlateNameSunda                    2.488e-01
## longitude:log1p(focal_depth):PlateNameTimor                    1.838e-01
## longitude:log1p(focal_depth):PlateNameTonga                   -2.358e-02
## longitude:log1p(focal_depth):PlateNameWoodlark                 2.261e-01
## longitude:log1p(focal_depth):PlateNameYangtze                  1.468e+00
## latitude:longitude:log1p(focal_depth):PlateNameAfrica         -5.661e-03
## latitude:longitude:log1p(focal_depth):PlateNameAltiplano      -1.244e-02
## latitude:longitude:log1p(focal_depth):PlateNameAmur           -5.426e-03
## latitude:longitude:log1p(focal_depth):PlateNameAnatolia       -1.261e-02
## latitude:longitude:log1p(focal_depth):PlateNameAntarctica     -5.606e-03
## latitude:longitude:log1p(focal_depth):PlateNameArabia         -7.003e-03
## latitude:longitude:log1p(focal_depth):PlateNameAustralia      -5.631e-03
## latitude:longitude:log1p(focal_depth):PlateNameBalmoral Reef  -3.681e-01
## latitude:longitude:log1p(focal_depth):PlateNameBanda Sea      -4.194e-04
## latitude:longitude:log1p(focal_depth):PlateNameBirds Head     -1.723e-02
## latitude:longitude:log1p(focal_depth):PlateNameBurma          -3.498e-02
## latitude:longitude:log1p(focal_depth):PlateNameCaribbean      -4.931e-03
## latitude:longitude:log1p(focal_depth):PlateNameCaroline       -7.529e-03
## latitude:longitude:log1p(focal_depth):PlateNameCocos          -9.022e-03
## latitude:longitude:log1p(focal_depth):PlateNameConway Reef    -1.840e-02
## latitude:longitude:log1p(focal_depth):PlateNameEaster         -2.206e-01
## latitude:longitude:log1p(focal_depth):PlateNameEurasia        -5.594e-03
## latitude:longitude:log1p(focal_depth):PlateNameFutuna         -4.194e-02
## latitude:longitude:log1p(focal_depth):PlateNameGalapagos              NA
## latitude:longitude:log1p(focal_depth):PlateNameIndia          -5.681e-03
## latitude:longitude:log1p(focal_depth):PlateNameJuan de Fuca   -2.503e-02
## latitude:longitude:log1p(focal_depth):PlateNameJuan Fernandez         NA
## latitude:longitude:log1p(focal_depth):PlateNameKermadec       -5.496e-03
## latitude:longitude:log1p(focal_depth):PlateNameManus          -3.764e-02
## latitude:longitude:log1p(focal_depth):PlateNameMaoke           3.585e-02
## latitude:longitude:log1p(focal_depth):PlateNameMariana         3.527e-03
## latitude:longitude:log1p(focal_depth):PlateNameMolucca Sea     1.651e-02
## latitude:longitude:log1p(focal_depth):PlateNameNazca          -6.223e-03
## latitude:longitude:log1p(focal_depth):PlateNameNew Hebrides   -2.331e-03
## latitude:longitude:log1p(focal_depth):PlateNameNiuafo'ou      -6.465e-02
## latitude:longitude:log1p(focal_depth):PlateNameNorth America  -5.588e-03
## latitude:longitude:log1p(focal_depth):PlateNameNorth Andes    -8.281e-03
## latitude:longitude:log1p(focal_depth):PlateNameNorth Bismarck  8.671e-03
## latitude:longitude:log1p(focal_depth):PlateNameOkhotsk        -4.562e-03
## latitude:longitude:log1p(focal_depth):PlateNameOkinawa        -1.171e-02
## latitude:longitude:log1p(focal_depth):PlateNamePacific        -5.653e-03
## latitude:longitude:log1p(focal_depth):PlateNamePanama         -3.236e-02
## latitude:longitude:log1p(focal_depth):PlateNamePhilippine Sea -6.354e-03
## latitude:longitude:log1p(focal_depth):PlateNameRivera         -1.262e-01
## latitude:longitude:log1p(focal_depth):PlateNameSandwich        1.846e-02
## latitude:longitude:log1p(focal_depth):PlateNameScotia         -6.297e-03
## latitude:longitude:log1p(focal_depth):PlateNameShetland        7.274e-01
## latitude:longitude:log1p(focal_depth):PlateNameSolomon Sea    -6.886e-02
## latitude:longitude:log1p(focal_depth):PlateNameSomalia        -6.125e-03
```

```
## latitude:longitude:log1p(focal_depth):PlateNameSouth America  -5.652e-03
## latitude:longitude:log1p(focal_depth):PlateNameSouth Bismarck -8.780e-03
## latitude:longitude:log1p(focal_depth):PlateNameSunda          -5.553e-03
## latitude:longitude:log1p(focal_depth):PlateNameTimor          -2.000e-02
## latitude:longitude:log1p(focal_depth):PlateNameTonga          -1.716e-02
## latitude:longitude:log1p(focal_depth):PlateNameWoodlark       -9.842e-03
## latitude:longitude:log1p(focal_depth):PlateNameYangtze        -5.856e-02
##                                                              Std. Error
## (Intercept)                                                   9.340e+01
## latitude                                                      2.516e+00
## longitude                                                     3.840e+00
## log1p(focal_depth)                                            2.902e+01
## PlateNameAfrica                                               9.340e+01
## PlateNameAltiplano                                            1.032e+02
## PlateNameAmur                                                 9.552e+01
## PlateNameAnatolia                                             1.468e+02
## PlateNameAntarctica                                           9.341e+01
## PlateNameArabia                                               9.440e+01
## PlateNameAustralia                                            9.340e+01
## PlateNameBalmoral Reef                                        2.883e+03
## PlateNameBanda Sea                                            9.427e+01
## PlateNameBirds Head                                           9.377e+01
## PlateNameBurma                                                1.041e+02
## PlateNameCaribbean                                            9.357e+01
## PlateNameCaroline                                             1.097e+02
## PlateNameCocos                                                9.437e+01
## PlateNameConway Reef                                          1.605e+03
## PlateNameEaster                                               6.073e+03
## PlateNameEurasia                                              9.341e+01
## PlateNameFutuna                                               6.895e+03
## PlateNameGalapagos                                            1.327e+02
## PlateNameIndia                                                9.344e+01
## PlateNameJuan de Fuca                                         4.015e+02
## PlateNameJuan Fernandez                                       1.236e+03
## PlateNameKermadec                                             9.343e+01
## PlateNameManus                                                7.926e+03
## PlateNameMaoke                                                2.687e+02
## PlateNameMariana                                              1.330e+02
## PlateNameMolucca Sea                                          9.555e+01
## PlateNameNazca                                                9.343e+01
## PlateNameNew Hebrides                                         1.033e+02
## PlateNameNiuafo'ou                                            5.219e+02
## PlateNameNorth America                                        9.341e+01
## PlateNameNorth Andes                                          9.416e+01
## PlateNameNorth Bismarck                                       9.748e+01
## PlateNameOkhotsk                                              9.390e+01
## PlateNameOkinawa                                              1.643e+02
## PlateNamePacific                                              9.340e+01
## PlateNamePanama                                               1.942e+02
## PlateNamePhilippine Sea                                       9.367e+01
```

```
## PlateNameRivera                                          1.082e+03
## PlateNameSandwich                                        1.629e+02
## PlateNameScotia                                          1.071e+02
## PlateNameShetland                                        1.877e+04
## PlateNameSolomon Sea                                     6.619e+02
## PlateNameSomalia                                         9.342e+01
## PlateNameSouth America                                   9.340e+01
## PlateNameSouth Bismarck                                  1.005e+02
## PlateNameSunda                                           9.341e+01
## PlateNameTimor                                           1.293e+02
## PlateNameTonga                                           1.543e+02
## PlateNameWoodlark                                        9.707e+01
## PlateNameYangtze                                         2.143e+02
## latitude:longitude                                       1.036e-01
## latitude:log1p(focal_depth)                              7.873e-01
## longitude:log1p(focal_depth)                             1.200e+00
## latitude:PlateNameAfrica                                 2.516e+00
## latitude:PlateNameAltiplano                              3.558e+00
## latitude:PlateNameAmur                                   2.551e+00
## latitude:PlateNameAnatolia                               3.870e+00
## latitude:PlateNameAntarctica                             2.516e+00
## latitude:PlateNameArabia                                 2.618e+00
## latitude:PlateNameAustralia                              2.516e+00
## latitude:PlateNameBalmoral Reef                          2.074e+02
## latitude:PlateNameBanda Sea                              3.494e+00
## latitude:PlateNameBirds Head                             5.003e+00
## latitude:PlateNameBurma                                  6.312e+00
## latitude:PlateNameCaribbean                              2.546e+00
## latitude:PlateNameCaroline                               5.866e+01
## latitude:PlateNameCocos                                  2.822e+00
## latitude:PlateNameConway Reef                            8.646e+01
## latitude:PlateNameEaster                                 2.399e+02
## latitude:PlateNameEurasia                                2.516e+00
## latitude:PlateNameFutuna                                 4.559e+02
## latitude:PlateNameGalapagos                              8.482e+00
## latitude:PlateNameIndia                                  2.521e+00
## latitude:PlateNameJuan de Fuca                           8.824e+00
## latitude:PlateNameJuan Fernandez                         2.950e+01
## latitude:PlateNameKermadec                               2.517e+00
## latitude:PlateNameManus                                  2.220e+03
## latitude:PlateNameMaoke                                  6.562e+01
## latitude:PlateNameMariana                                6.064e+00
## latitude:PlateNameMolucca Sea                            8.933e+00
## latitude:PlateNameNazca                                  2.518e+00
## latitude:PlateNameNew Hebrides                           3.537e+00
## latitude:PlateNameNiuafo'ou                              3.179e+01
## latitude:PlateNameNorth America                          2.516e+00
## latitude:PlateNameNorth Andes                            2.848e+00
## latitude:PlateNameNorth Bismarck                         8.274e+00
## latitude:PlateNameOkhotsk                                2.523e+00
```

```
## latitude:PlateNameOkinawa                                  6.010e+00
## latitude:PlateNamePacific                                  2.516e+00
## latitude:PlateNamePanama                                   1.974e+01
## latitude:PlateNamePhilippine Sea                           2.537e+00
## latitude:PlateNameRivera                                   5.726e+01
## latitude:PlateNameSandwich                                 3.429e+00
## latitude:PlateNameScotia                                   2.674e+00
## latitude:PlateNameShetland                                 2.982e+02
## latitude:PlateNameSolomon Sea                              9.287e+01
## latitude:PlateNameSomalia                                  2.517e+00
## latitude:PlateNameSouth America                            2.516e+00
## latitude:PlateNameSouth Bismarck                           7.888e+00
## latitude:PlateNameSunda                                    2.522e+00
## latitude:PlateNameTimor                                    1.169e+01
## latitude:PlateNameTonga                                    6.623e+00
## latitude:PlateNameWoodlark                                 3.988e+00
## latitude:PlateNameYangtze                                  8.507e+00
## longitude:PlateNameAfrica                                  3.840e+00
## longitude:PlateNameAltiplano                               3.889e+00
## longitude:PlateNameAmur                                    3.843e+00
## longitude:PlateNameAnatolia                                5.189e+00
## longitude:PlateNameAntarctica                              3.840e+00
## longitude:PlateNameArabia                                  3.853e+00
## longitude:PlateNameAustralia                               3.840e+00
## longitude:PlateNameBalmoral Reef                           1.675e+01
## longitude:PlateNameBanda Sea                               3.841e+00
## longitude:PlateNameBirds Head                              3.840e+00
## longitude:PlateNameBurma                                   3.871e+00
## longitude:PlateNameCaribbean                               3.841e+00
## longitude:PlateNameCaroline                                3.862e+00
## longitude:PlateNameCocos                                   3.843e+00
## longitude:PlateNameConway Reef                             9.944e+00
## longitude:PlateNameEaster                                  5.339e+01
## longitude:PlateNameEurasia                                 3.840e+00
## longitude:PlateNameFutuna                                  3.895e+01
## longitude:PlateNameGalapagos                                      NA
## longitude:PlateNameIndia                                   3.840e+00
## longitude:PlateNameJuan de Fuca                            4.915e+00
## longitude:PlateNameJuan Fernandez                          8.899e+00
## longitude:PlateNameKermadec                                3.840e+00
## longitude:PlateNameManus                                   5.277e+01
## longitude:PlateNameMaoke                                   4.247e+00
## longitude:PlateNameMariana                                 3.895e+00
## longitude:PlateNameMolucca Sea                             3.843e+00
## longitude:PlateNameNazca                                   3.840e+00
## longitude:PlateNameNew Hebrides                            3.849e+00
## longitude:PlateNameNiuafo'ou                               4.826e+00
## longitude:PlateNameNorth America                           3.840e+00
## longitude:PlateNameNorth Andes                             3.843e+00
## longitude:PlateNameNorth Bismarck                          3.844e+00
```

```
## longitude:PlateNameOkhotsk                                  3.841e+00
## longitude:PlateNameOkinawa                                  3.980e+00
## longitude:PlateNamePacific                                  3.840e+00
## longitude:PlateNamePanama                                   4.355e+00
## longitude:PlateNamePhilippine Sea                           3.840e+00
## longitude:PlateNameRivera                                   1.071e+01
## longitude:PlateNameSandwich                                 6.151e+00
## longitude:PlateNameScotia                                   4.027e+00
## longitude:PlateNameShetland                                 3.370e+02
## longitude:PlateNameSolomon Sea                              5.757e+00
## longitude:PlateNameSomalia                                  3.840e+00
## longitude:PlateNameSouth America                            3.840e+00
## longitude:PlateNameSouth Bismarck                           3.848e+00
## longitude:PlateNameSunda                                    3.840e+00
## longitude:PlateNameTimor                                    3.904e+00
## longitude:PlateNameTonga                                    3.904e+00
## longitude:PlateNameWoodlark                                 3.844e+00
## longitude:PlateNameYangtze                                  4.121e+00
## log1p(focal_depth):PlateNameAfrica                          2.902e+01
## log1p(focal_depth):PlateNameAltiplano                       3.039e+01
## log1p(focal_depth):PlateNameAmur                            2.960e+01
## log1p(focal_depth):PlateNameAnatolia                        4.964e+01
## log1p(focal_depth):PlateNameAntarctica                      2.902e+01
## log1p(focal_depth):PlateNameArabia                          2.951e+01
## log1p(focal_depth):PlateNameAustralia                       2.902e+01
## log1p(focal_depth):PlateNameBalmoral Reef                   8.933e+02
## log1p(focal_depth):PlateNameBanda Sea                       2.924e+01
## log1p(focal_depth):PlateNameBirds Head                      2.913e+01
## log1p(focal_depth):PlateNameBurma                           3.224e+01
## log1p(focal_depth):PlateNameCaribbean                       2.906e+01
## log1p(focal_depth):PlateNameCaroline                        3.633e+01
## log1p(focal_depth):PlateNameCocos                           2.947e+01
## log1p(focal_depth):PlateNameConway Reef                     4.816e+02
## log1p(focal_depth):PlateNameEaster                          2.512e+03
## log1p(focal_depth):PlateNameEurasia                         2.902e+01
## log1p(focal_depth):PlateNameFutuna                          2.250e+03
## log1p(focal_depth):PlateNameGalapagos                              NA
## log1p(focal_depth):PlateNameIndia                           2.903e+01
## log1p(focal_depth):PlateNameJuan de Fuca                    1.603e+02
## log1p(focal_depth):PlateNameJuan Fernandez                  3.031e+02
## log1p(focal_depth):PlateNameKermadec                        2.902e+01
## log1p(focal_depth):PlateNameManus                           2.909e+03
## log1p(focal_depth):PlateNameMaoke                           7.782e+01
## log1p(focal_depth):PlateNameMariana                         4.040e+01
## log1p(focal_depth):PlateNameMolucca Sea                     2.955e+01
## log1p(focal_depth):PlateNameNazca                           2.903e+01
## log1p(focal_depth):PlateNameNew Hebrides                    3.135e+01
## log1p(focal_depth):PlateNameNiuafo'ou                       1.304e+02
## log1p(focal_depth):PlateNameNorth America                   2.902e+01
## log1p(focal_depth):PlateNameNorth Andes                     2.921e+01
```

```
## log1p(focal_depth):PlateNameNorth Bismarck                    3.028e+01
## log1p(focal_depth):PlateNameOkhotsk                           2.915e+01
## log1p(focal_depth):PlateNameOkinawa                           4.742e+01
## log1p(focal_depth):PlateNamePacific                           2.902e+01
## log1p(focal_depth):PlateNamePanama                            5.986e+01
## log1p(focal_depth):PlateNamePhilippine Sea                    2.909e+01
## log1p(focal_depth):PlateNameRivera                            3.556e+02
## log1p(focal_depth):PlateNameSandwich                          4.749e+01
## log1p(focal_depth):PlateNameScotia                            3.618e+01
## log1p(focal_depth):PlateNameShetland                          5.708e+03
## log1p(focal_depth):PlateNameSolomon Sea                       2.044e+02
## log1p(focal_depth):PlateNameSomalia                           2.902e+01
## log1p(focal_depth):PlateNameSouth America                     2.902e+01
## log1p(focal_depth):PlateNameSouth Bismarck                    3.105e+01
## log1p(focal_depth):PlateNameSunda                             2.902e+01
## log1p(focal_depth):PlateNameTimor                             3.683e+01
## log1p(focal_depth):PlateNameTonga                             4.293e+01
## log1p(focal_depth):PlateNameWoodlark                          2.999e+01
## log1p(focal_depth):PlateNameYangtze                           6.768e+01
## latitude:longitude:log1p(focal_depth)                         3.262e-02
## latitude:longitude:PlateNameAfrica                            1.036e-01
## latitude:longitude:PlateNameAltiplano                         1.095e-01
## latitude:longitude:PlateNameAmur                              1.037e-01
## latitude:longitude:PlateNameAnatolia                          1.376e-01
## latitude:longitude:PlateNameAntarctica                        1.036e-01
## latitude:longitude:PlateNameArabia                            1.051e-01
## latitude:longitude:PlateNameAustralia                         1.036e-01
## latitude:longitude:PlateNameBalmoral Reef                     1.177e+00
## latitude:longitude:PlateNameBanda Sea                         1.054e-01
## latitude:longitude:PlateNameBirds Head                        1.088e-01
## latitude:longitude:PlateNameBurma                             1.205e-01
## latitude:longitude:PlateNameCaribbean                         1.038e-01
## latitude:longitude:PlateNameCaroline                          4.290e-01
## latitude:longitude:PlateNameCocos                             1.045e-01
## latitude:longitude:PlateNameConway Reef                       5.057e-01
## latitude:longitude:PlateNameEaster                            2.106e+00
## latitude:longitude:PlateNameEurasia                           1.036e-01
## latitude:longitude:PlateNameFutuna                            2.565e+00
## latitude:longitude:PlateNameGalapagos                                NA
## latitude:longitude:PlateNameIndia                             1.037e-01
## latitude:longitude:PlateNameJuan de Fuca                      1.229e-01
## latitude:longitude:PlateNameJuan Fernandez                    2.663e-01
## latitude:longitude:PlateNameKermadec                          1.036e-01
## latitude:longitude:PlateNameManus                             1.474e+01
## latitude:longitude:PlateNameMaoke                             4.835e-01
## latitude:longitude:PlateNameMariana                           1.104e-01
## latitude:longitude:PlateNameMolucca Sea                       1.244e-01
## latitude:longitude:PlateNameNazca                             1.036e-01
## latitude:longitude:PlateNameNew Hebrides                      1.047e-01
## latitude:longitude:PlateNameNiuafo'ou                         2.080e-01
```

```
## latitude:longitude:PlateNameNorth America                    1.036e-01
## latitude:longitude:PlateNameNorth Andes                       1.050e-01
## latitude:longitude:PlateNameNorth Bismarck                    1.157e-01
## latitude:longitude:PlateNameOkhotsk                           1.036e-01
## latitude:longitude:PlateNameOkinawa                           1.118e-01
## latitude:longitude:PlateNamePacific                           1.036e-01
## latitude:longitude:PlateNamePanama                            2.577e-01
## latitude:longitude:PlateNamePhilippine Sea                    1.037e-01
## latitude:longitude:PlateNameRivera                            5.392e-01
## latitude:longitude:PlateNameSandwich                          1.334e-01
## latitude:longitude:PlateNameScotia                            1.058e-01
## latitude:longitude:PlateNameShetland                          5.352e+00
## latitude:longitude:PlateNameSolomon Sea                       6.163e-01
## latitude:longitude:PlateNameSomalia                           1.036e-01
## latitude:longitude:PlateNameSouth America                     1.036e-01
## latitude:longitude:PlateNameSouth Bismarck                    1.151e-01
## latitude:longitude:PlateNameSunda                             1.036e-01
## latitude:longitude:PlateNameTimor                             1.374e-01
## latitude:longitude:PlateNameTonga                             1.095e-01
## latitude:longitude:PlateNameWoodlark                          1.059e-01
## latitude:longitude:PlateNameYangtze                           1.211e-01
## latitude:log1p(focal_depth):PlateNameAfrica                   7.873e-01
## latitude:log1p(focal_depth):PlateNameAltiplano                9.369e-01
## latitude:log1p(focal_depth):PlateNameAmur                     7.977e-01
## latitude:log1p(focal_depth):PlateNameAnatolia                 1.310e+00
## latitude:log1p(focal_depth):PlateNameAntarctica               7.873e-01
## latitude:log1p(focal_depth):PlateNameArabia                   8.378e-01
## latitude:log1p(focal_depth):PlateNameAustralia                7.873e-01
## latitude:log1p(focal_depth):PlateNameBalmoral Reef            6.355e+01
## latitude:log1p(focal_depth):PlateNameBanda Sea                1.014e+00
## latitude:log1p(focal_depth):PlateNameBirds Head               1.520e+00
## latitude:log1p(focal_depth):PlateNameBurma                    1.984e+00
## latitude:log1p(focal_depth):PlateNameCaribbean                7.952e-01
## latitude:log1p(focal_depth):PlateNameCaroline                 2.401e+01
## latitude:log1p(focal_depth):PlateNameCocos                    9.225e-01
## latitude:log1p(focal_depth):PlateNameConway Reef              2.608e+01
## latitude:log1p(focal_depth):PlateNameEaster                   9.924e+01
## latitude:log1p(focal_depth):PlateNameEurasia                  7.873e-01
## latitude:log1p(focal_depth):PlateNameFutuna                   1.489e+02
## latitude:log1p(focal_depth):PlateNameGalapagos                       NA
## latitude:log1p(focal_depth):PlateNameIndia                    7.889e-01
## latitude:log1p(focal_depth):PlateNameJuan de Fuca             3.480e+00
## latitude:log1p(focal_depth):PlateNameJuan Fernandez                  NA
## latitude:log1p(focal_depth):PlateNameKermadec                 7.874e-01
## latitude:log1p(focal_depth):PlateNameManus                    8.161e+02
## latitude:log1p(focal_depth):PlateNameMaoke                    1.881e+01
## latitude:log1p(focal_depth):PlateNameMariana                  1.776e+00
## latitude:log1p(focal_depth):PlateNameMolucca Sea              2.439e+00
## latitude:log1p(focal_depth):PlateNameNazca                    7.879e-01
## latitude:log1p(focal_depth):PlateNameNew Hebrides             1.045e+00
```

```
## latitude:log1p(focal_depth):PlateNameNiuafo'ou                 7.798e+00
## latitude:log1p(focal_depth):PlateNameNorth America             7.873e-01
## latitude:log1p(focal_depth):PlateNameNorth Andes               8.796e-01
## latitude:log1p(focal_depth):PlateNameNorth Bismarck            2.631e+00
## latitude:log1p(focal_depth):PlateNameOkhotsk                   7.892e-01
## latitude:log1p(focal_depth):PlateNameOkinawa                   1.715e+00
## latitude:log1p(focal_depth):PlateNamePacific                   7.873e-01
## latitude:log1p(focal_depth):PlateNamePanama                    6.005e+00
## latitude:log1p(focal_depth):PlateNamePhilippine Sea            7.931e-01
## latitude:log1p(focal_depth):PlateNameRivera                    1.878e+01
## latitude:log1p(focal_depth):PlateNameSandwich                  1.024e+00
## latitude:log1p(focal_depth):PlateNameScotia                    8.707e-01
## latitude:log1p(focal_depth):PlateNameShetland                  9.055e+01
## latitude:log1p(focal_depth):PlateNameSolomon Sea               2.872e+01
## latitude:log1p(focal_depth):PlateNameSomalia                   7.878e-01
## latitude:log1p(focal_depth):PlateNameSouth America             7.873e-01
## latitude:log1p(focal_depth):PlateNameSouth Bismarck            2.324e+00
## latitude:log1p(focal_depth):PlateNameSunda                     7.885e-01
## latitude:log1p(focal_depth):PlateNameTimor                     2.992e+00
## latitude:log1p(focal_depth):PlateNameTonga                     1.782e+00
## latitude:log1p(focal_depth):PlateNameWoodlark                  1.186e+00
## latitude:log1p(focal_depth):PlateNameYangtze                   2.575e+00
## longitude:log1p(focal_depth):PlateNameAfrica                   1.200e+00
## longitude:log1p(focal_depth):PlateNameAltiplano                1.206e+00
## longitude:log1p(focal_depth):PlateNameAmur                     1.200e+00
## longitude:log1p(focal_depth):PlateNameAnatolia                 1.726e+00
## longitude:log1p(focal_depth):PlateNameAntarctica               1.200e+00
## longitude:log1p(focal_depth):PlateNameArabia                   1.206e+00
## longitude:log1p(focal_depth):PlateNameAustralia                1.200e+00
## longitude:log1p(focal_depth):PlateNameBalmoral Reef            5.203e+00
## longitude:log1p(focal_depth):PlateNameBanda Sea                1.200e+00
## longitude:log1p(focal_depth):PlateNameBirds Head               1.200e+00
## longitude:log1p(focal_depth):PlateNameBurma                    1.209e+00
## longitude:log1p(focal_depth):PlateNameCaribbean                1.200e+00
## longitude:log1p(focal_depth):PlateNameCaroline                 1.210e+00
## longitude:log1p(focal_depth):PlateNameCocos                    1.201e+00
## longitude:log1p(focal_depth):PlateNameConway Reef              3.003e+00
## longitude:log1p(focal_depth):PlateNameEaster                   2.206e+01
## longitude:log1p(focal_depth):PlateNameEurasia                  1.200e+00
## longitude:log1p(focal_depth):PlateNameFutuna                   1.271e+01
## longitude:log1p(focal_depth):PlateNameGalapagos                       NA
## longitude:log1p(focal_depth):PlateNameIndia                    1.200e+00
## longitude:log1p(focal_depth):PlateNameJuan de Fuca             1.725e+00
## longitude:log1p(focal_depth):PlateNameJuan Fernandez                  NA
## longitude:log1p(focal_depth):PlateNameKermadec                 1.200e+00
## longitude:log1p(focal_depth):PlateNameManus                    1.935e+01
## longitude:log1p(focal_depth):PlateNameMaoke                    1.307e+00
## longitude:log1p(focal_depth):PlateNameMariana                  1.215e+00
## longitude:log1p(focal_depth):PlateNameMolucca Sea              1.200e+00
## longitude:log1p(focal_depth):PlateNameNazca                    1.200e+00
```

```
## longitude:log1p(focal_depth):PlateNameNew Hebrides             1.202e+00
## longitude:log1p(focal_depth):PlateNameNiuafo'ou                1.401e+00
## longitude:log1p(focal_depth):PlateNameNorth America            1.200e+00
## longitude:log1p(focal_depth):PlateNameNorth Andes              1.200e+00
## longitude:log1p(focal_depth):PlateNameNorth Bismarck           1.201e+00
## longitude:log1p(focal_depth):PlateNameOkhotsk                  1.200e+00
## longitude:log1p(focal_depth):PlateNameOkinawa                  1.234e+00
## longitude:log1p(focal_depth):PlateNamePacific                  1.200e+00
## longitude:log1p(focal_depth):PlateNamePanama                   1.356e+00
## longitude:log1p(focal_depth):PlateNamePhilippine Sea           1.200e+00
## longitude:log1p(focal_depth):PlateNameRivera                   3.502e+00
## longitude:log1p(focal_depth):PlateNameSandwich                 1.808e+00
## longitude:log1p(focal_depth):PlateNameScotia                   1.299e+00
## longitude:log1p(focal_depth):PlateNameShetland                 1.027e+02
## longitude:log1p(focal_depth):PlateNameSolomon Sea              1.786e+00
## longitude:log1p(focal_depth):PlateNameSomalia                  1.200e+00
## longitude:log1p(focal_depth):PlateNameSouth America            1.200e+00
## longitude:log1p(focal_depth):PlateNameSouth Bismarck           1.202e+00
## longitude:log1p(focal_depth):PlateNameSunda                    1.200e+00
## longitude:log1p(focal_depth):PlateNameTimor                    1.213e+00
## longitude:log1p(focal_depth):PlateNameTonga                    1.213e+00
## longitude:log1p(focal_depth):PlateNameWoodlark                 1.201e+00
## longitude:log1p(focal_depth):PlateNameYangtze                  1.291e+00
## latitude:longitude:log1p(focal_depth):PlateNameAfrica          3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameAltiplano       3.340e-02
## latitude:longitude:log1p(focal_depth):PlateNameAmur            3.263e-02
## latitude:longitude:log1p(focal_depth):PlateNameAnatolia        4.584e-02
## latitude:longitude:log1p(focal_depth):PlateNameAntarctica      3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameArabia          3.334e-02
## latitude:longitude:log1p(focal_depth):PlateNameAustralia       3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameBalmoral Reef   3.613e-01
## latitude:longitude:log1p(focal_depth):PlateNameBanda Sea       3.302e-02
## latitude:longitude:log1p(focal_depth):PlateNameBirds Head      3.411e-02
## latitude:longitude:log1p(focal_depth):PlateNameBurma           3.794e-02
## latitude:longitude:log1p(focal_depth):PlateNameCaribbean       3.265e-02
## latitude:longitude:log1p(focal_depth):PlateNameCaroline        1.735e-01
## latitude:longitude:log1p(focal_depth):PlateNameCocos           3.302e-02
## latitude:longitude:log1p(focal_depth):PlateNameConway Reef     1.528e-01
## latitude:longitude:log1p(focal_depth):PlateNameEaster          8.706e-01
## latitude:longitude:log1p(focal_depth):PlateNameEurasia         3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameFutuna          8.380e-01
## latitude:longitude:log1p(focal_depth):PlateNameGalapagos              NA
## latitude:longitude:log1p(focal_depth):PlateNameIndia           3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameJuan de Fuca    4.203e-02
## latitude:longitude:log1p(focal_depth):PlateNameJuan Fernandez         NA
## latitude:longitude:log1p(focal_depth):PlateNameKermadec        3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameManus           5.419e+00
## latitude:longitude:log1p(focal_depth):PlateNameMaoke           1.392e-01
## latitude:longitude:log1p(focal_depth):PlateNameMariana         3.442e-02
## latitude:longitude:log1p(focal_depth):PlateNameMolucca Sea     3.751e-02
```

```
## latitude:longitude:log1p(focal_depth):PlateNameNazca           3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameNew Hebrides    3.287e-02
## latitude:longitude:log1p(focal_depth):PlateNameNiuafo'ou       5.491e-02
## latitude:longitude:log1p(focal_depth):PlateNameNorth America   3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameNorth Andes     3.300e-02
## latitude:longitude:log1p(focal_depth):PlateNameNorth Bismarck  3.647e-02
## latitude:longitude:log1p(focal_depth):PlateNameOkhotsk         3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameOkinawa         3.465e-02
## latitude:longitude:log1p(focal_depth):PlateNamePacific         3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNamePanama          7.879e-02
## latitude:longitude:log1p(focal_depth):PlateNamePhilippine Sea  3.263e-02
## latitude:longitude:log1p(focal_depth):PlateNameRivera          1.768e-01
## latitude:longitude:log1p(focal_depth):PlateNameSandwich        4.025e-02
## latitude:longitude:log1p(focal_depth):PlateNameScotia          3.374e-02
## latitude:longitude:log1p(focal_depth):PlateNameShetland        1.629e+00
## latitude:longitude:log1p(focal_depth):PlateNameSolomon Sea     1.906e-01
## latitude:longitude:log1p(focal_depth):PlateNameSomalia         3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameSouth America   3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameSouth Bismarck  3.576e-02
## latitude:longitude:log1p(focal_depth):PlateNameSunda           3.262e-02
## latitude:longitude:log1p(focal_depth):PlateNameTimor           3.977e-02
## latitude:longitude:log1p(focal_depth):PlateNameTonga           3.388e-02
## latitude:longitude:log1p(focal_depth):PlateNameWoodlark        3.320e-02
## latitude:longitude:log1p(focal_depth):PlateNameYangtze         3.777e-02
##                                                               t value
## (Intercept)                                                    -0.077
## latitude                                                        0.114
## longitude                                                       0.076
## log1p(focal_depth)                                              0.254
## PlateNameAfrica                                                 0.140
## PlateNameAltiplano                                              0.634
## PlateNameAmur                                                   0.150
## PlateNameAnatolia                                               0.221
## PlateNameAntarctica                                             0.149
## PlateNameArabia                                                 0.151
## PlateNameAustralia                                              0.145
## PlateNameBalmoral Reef                                         -0.913
## PlateNameBanda Sea                                              0.281
## PlateNameBirds Head                                             0.139
## PlateNameBurma                                                  0.731
## PlateNameCaribbean                                              0.176
## PlateNameCaroline                                               0.029
## PlateNameCocos                                                  0.037
## PlateNameConway Reef                                           -0.288
## PlateNameEaster                                                 0.264
## PlateNameEurasia                                                0.140
## PlateNameFutuna                                                -0.007
## PlateNameGalapagos                                             -0.158
## PlateNameIndia                                                  0.122
## PlateNameJuan de Fuca                                          -0.337
```

```
## PlateNameJuan Fernandez                                  0.943
## PlateNameKermadec                                        0.108
## PlateNameManus                                          -0.107
## PlateNameMaoke                                           0.301
## PlateNameMariana                                        -0.444
## PlateNameMolucca Sea                                     0.568
## PlateNameNazca                                           0.175
## PlateNameNew Hebrides                                    0.472
## PlateNameNiuafo'ou                                       1.211
## PlateNameNorth America                                   0.151
## PlateNameNorth Andes                                    -0.051
## PlateNameNorth Bismarck                                  0.513
## PlateNameOkhotsk                                        -0.113
## PlateNameOkinawa                                         0.353
## PlateNamePacific                                         0.142
## PlateNamePanama                                         -0.252
## PlateNamePhilippine Sea                                  0.222
## PlateNameRivera                                         -0.915
## PlateNameSandwich                                       -0.720
## PlateNameScotia                                          0.134
## PlateNameShetland                                       -0.479
## PlateNameSolomon Sea                                    -0.115
## PlateNameSomalia                                         0.139
## PlateNameSouth America                                   0.129
## PlateNameSouth Bismarck                                  0.169
## PlateNameSunda                                           0.152
## PlateNameTimor                                          -0.092
## PlateNameTonga                                           1.356
## PlateNameWoodlark                                       -0.207
## PlateNameYangtze                                         2.426
## latitude:longitude                                      -0.050
## latitude:log1p(focal_depth)                             -0.220
## longitude:log1p(focal_depth)                            -0.206
## latitude:PlateNameAfrica                                -0.114
## latitude:PlateNameAltiplano                              0.765
## latitude:PlateNameAmur                                  -0.117
## latitude:PlateNameAnatolia                              -0.216
## latitude:PlateNameAntarctica                            -0.108
## latitude:PlateNameArabia                                -0.168
## latitude:PlateNameAustralia                             -0.109
## latitude:PlateNameBalmoral Reef                         -0.953
## latitude:PlateNameBanda Sea                              0.912
## latitude:PlateNameBirds Head                            -1.167
## latitude:PlateNameBurma                                 -1.128
## latitude:PlateNameCaribbean                             -0.200
## latitude:PlateNameCaroline                              -0.015
## latitude:PlateNameCocos                                  0.269
## latitude:PlateNameConway Reef                           -0.245
## latitude:PlateNameEaster                                 0.252
## latitude:PlateNameEurasia                               -0.111
```

```
## latitude:PlateNameFutuna                                  0.004
## latitude:PlateNameGalapagos                               -0.844
## latitude:PlateNameIndia                                   -0.092
## latitude:PlateNameJuan de Fuca                             0.385
## latitude:PlateNameJuan Fernandez                           1.046
## latitude:PlateNameKermadec                                -0.147
## latitude:PlateNameManus                                   -0.048
## latitude:PlateNameMaoke                                    0.271
## latitude:PlateNameMariana                                  0.422
## latitude:PlateNameMolucca Sea                              1.078
## latitude:PlateNameNazca                                   -0.056
## latitude:PlateNameNew Hebrides                             0.524
## latitude:PlateNameNiuafo'ou                                1.147
## latitude:PlateNameNorth America                           -0.121
## latitude:PlateNameNorth Andes                              0.045
## latitude:PlateNameNorth Bismarck                           0.653
## latitude:PlateNameOkhotsk                                  0.084
## latitude:PlateNameOkinawa                                 -0.546
## latitude:PlateNamePacific                                 -0.112
## latitude:PlateNamePanama                                   0.356
## latitude:PlateNamePhilippine Sea                          -0.207
## latitude:PlateNameRivera                                   0.945
## latitude:PlateNameSandwich                                -0.747
## latitude:PlateNameScotia                                  -0.098
## latitude:PlateNameShetland                                -0.489
## latitude:PlateNameSolomon Sea                             -0.205
## latitude:PlateNameSomalia                                 -0.129
## latitude:PlateNameSouth America                           -0.120
## latitude:PlateNameSouth Bismarck                          -0.023
## latitude:PlateNameSunda                                   -0.092
## latitude:PlateNameTimor                                   -0.583
## latitude:PlateNameTonga                                    1.228
## latitude:PlateNameWoodlark                                -1.099
## latitude:PlateNameYangtze                                 -2.605
## longitude:PlateNameAfrica                                 -0.076
## longitude:PlateNameAltiplano                               0.115
## longitude:PlateNameAmur                                   -0.075
## longitude:PlateNameAnatolia                               -0.142
## longitude:PlateNameAntarctica                             -0.077
## longitude:PlateNameArabia                                 -0.084
## longitude:PlateNameAustralia                              -0.076
## longitude:PlateNameBalmoral Reef                           0.870
## longitude:PlateNameBanda Sea                              -0.103
## longitude:PlateNameBirds Head                             -0.074
## longitude:PlateNameBurma                                  -0.248
## longitude:PlateNameCaribbean                              -0.065
## longitude:PlateNameCaroline                               -0.055
## longitude:PlateNameCocos                                  -0.100
## longitude:PlateNameConway Reef                             0.246
## longitude:PlateNameEaster                                  0.260
```

```
## longitude:PlateNameEurasia                                  -0.075
## longitude:PlateNameFutuna                                   -0.017
## longitude:PlateNameGalapagos                                    NA
## longitude:PlateNameIndia                                    -0.071
## longitude:PlateNameJuan de Fuca                             -0.299
## longitude:PlateNameJuan Fernandez                            1.070
## longitude:PlateNameKermadec                                 -0.081
## longitude:PlateNameManus                                     0.104
## longitude:PlateNameMaoke                                    -0.186
## longitude:PlateNameMariana                                   0.052
## longitude:PlateNameMolucca Sea                              -0.162
## longitude:PlateNameNazca                                    -0.066
## longitude:PlateNameNew Hebrides                             -0.129
## longitude:PlateNameNiuafo'ou                                 0.669
## longitude:PlateNameNorth America                            -0.074
## longitude:PlateNameNorth Andes                              -0.135
## longitude:PlateNameNorth Bismarck                           -0.141
## longitude:PlateNameOkhotsk                                  -0.032
## longitude:PlateNameOkinawa                                  -0.142
## longitude:PlateNamePacific                                  -0.076
## longitude:PlateNamePanama                                   -0.233
## longitude:PlateNamePhilippine Sea                           -0.090
## longitude:PlateNameRivera                                   -0.894
## longitude:PlateNameSandwich                                 -0.798
## longitude:PlateNameScotia                                    0.002
## longitude:PlateNameShetland                                 -0.456
## longitude:PlateNameSolomon Sea                               0.055
## longitude:PlateNameSomalia                                  -0.075
## longitude:PlateNameSouth America                            -0.079
## longitude:PlateNameSouth Bismarck                           -0.083
## longitude:PlateNameSunda                                    -0.078
## longitude:PlateNameTimor                                    -0.015
## longitude:PlateNameTonga                                     0.215
## longitude:PlateNameWoodlark                                 -0.014
## longitude:PlateNameYangtze                                  -0.992
## log1p(focal_depth):PlateNameAfrica                          -0.254
## log1p(focal_depth):PlateNameAltiplano                       -0.525
## log1p(focal_depth):PlateNameAmur                            -0.210
## log1p(focal_depth):PlateNameAnatolia                        -0.357
## log1p(focal_depth):PlateNameAntarctica                      -0.267
## log1p(focal_depth):PlateNameArabia                          -0.267
## log1p(focal_depth):PlateNameAustralia                       -0.256
## log1p(focal_depth):PlateNameBalmoral Reef                    0.976
## log1p(focal_depth):PlateNameBanda Sea                       -0.328
## log1p(focal_depth):PlateNameBirds Head                      -0.252
## log1p(focal_depth):PlateNameBurma                           -0.942
## log1p(focal_depth):PlateNameCaribbean                       -0.274
## log1p(focal_depth):PlateNameCaroline                        -0.148
## log1p(focal_depth):PlateNameCocos                           -0.122
## log1p(focal_depth):PlateNameConway Reef                      0.137
```

```
## log1p(focal_depth):PlateNameEaster                          -0.254
## log1p(focal_depth):PlateNameEurasia                         -0.252
## log1p(focal_depth):PlateNameFutuna                          -0.036
## log1p(focal_depth):PlateNameGalapagos                           NA
## log1p(focal_depth):PlateNameIndia                           -0.248
## log1p(focal_depth):PlateNameJuan de Fuca                     0.605
## log1p(focal_depth):PlateNameJuan Fernandez                  -0.193
## log1p(focal_depth):PlateNameKermadec                        -0.227
## log1p(focal_depth):PlateNameManus                            0.060
## log1p(focal_depth):PlateNameMaoke                           -0.363
## log1p(focal_depth):PlateNameMariana                          0.557
## log1p(focal_depth):PlateNameMolucca Sea                     -0.582
## log1p(focal_depth):PlateNameNazca                           -0.289
## log1p(focal_depth):PlateNameNew Hebrides                    -0.508
## log1p(focal_depth):PlateNameNiuafo'ou                       -1.378
## log1p(focal_depth):PlateNameNorth America                   -0.264
## log1p(focal_depth):PlateNameNorth Andes                     -0.050
## log1p(focal_depth):PlateNameNorth Bismarck                  -0.659
## log1p(focal_depth):PlateNameOkhotsk                          0.026
## log1p(focal_depth):PlateNameOkinawa                         -0.425
## log1p(focal_depth):PlateNamePacific                         -0.254
## log1p(focal_depth):PlateNamePanama                           0.191
## log1p(focal_depth):PlateNamePhilippine Sea                  -0.347
## log1p(focal_depth):PlateNameRivera                           0.652
## log1p(focal_depth):PlateNameSandwich                         0.654
## log1p(focal_depth):PlateNameScotia                          -0.094
## log1p(focal_depth):PlateNameShetland                         0.464
## log1p(focal_depth):PlateNameSolomon Sea                      0.243
## log1p(focal_depth):PlateNameSomalia                         -0.248
## log1p(focal_depth):PlateNameSouth America                   -0.238
## log1p(focal_depth):PlateNameSouth Bismarck                  -0.189
## log1p(focal_depth):PlateNameSunda                           -0.261
## log1p(focal_depth):PlateNameTimor                           -0.010
## log1p(focal_depth):PlateNameTonga                           -1.264
## log1p(focal_depth):PlateNameWoodlark                        -0.146
## log1p(focal_depth):PlateNameYangtze                         -2.510
## latitude:longitude:log1p(focal_depth)                        0.173
## latitude:longitude:PlateNameAfrica                           0.050
## latitude:longitude:PlateNameAltiplano                        0.434
## latitude:longitude:PlateNameAmur                             0.048
## latitude:longitude:PlateNameAnatolia                         0.131
## latitude:longitude:PlateNameAntarctica                       0.049
## latitude:longitude:PlateNameArabia                           0.076
## latitude:longitude:PlateNameAustralia                        0.049
## latitude:longitude:PlateNameBalmoral Reef                    0.948
## latitude:longitude:PlateNameBanda Sea                       -0.211
## latitude:longitude:PlateNameBirds Head                       0.426
## latitude:longitude:PlateNameBurma                            0.644
## latitude:longitude:PlateNameCaribbean                        0.021
## latitude:longitude:PlateNameCaroline                         0.022
```

```
## latitude:longitude:PlateNameCocos                          0.149
## latitude:longitude:PlateNameConway Reef                    0.249
## latitude:longitude:PlateNameEaster                         0.260
## latitude:longitude:PlateNameEurasia                        0.048
## latitude:longitude:PlateNameFutuna                         0.006
## latitude:longitude:PlateNameGalapagos                         NA
## latitude:longitude:PlateNameIndia                          0.044
## latitude:longitude:PlateNameJuan de Fuca                   0.279
## latitude:longitude:PlateNameJuan Fernandez                 1.000
## latitude:longitude:PlateNameKermadec                       0.044
## latitude:longitude:PlateNameManus                          0.050
## latitude:longitude:PlateNameMaoke                         -0.265
## latitude:longitude:PlateNameMariana                       -0.129
## latitude:longitude:PlateNameMolucca Sea                   -0.610
## latitude:longitude:PlateNameNazca                          0.066
## latitude:longitude:PlateNameNew Hebrides                  -0.070
## latitude:longitude:PlateNameNiuafo'ou                      1.029
## latitude:longitude:PlateNameNorth America                  0.048
## latitude:longitude:PlateNameNorth Andes                    0.076
## latitude:longitude:PlateNameNorth Bismarck                -0.291
## latitude:longitude:PlateNameOkhotsk                        0.016
## latitude:longitude:PlateNameOkinawa                        0.232
## latitude:longitude:PlateNamePacific                        0.050
## latitude:longitude:PlateNamePanama                         0.350
## latitude:longitude:PlateNamePhilippine Sea                 0.066
## latitude:longitude:PlateNameRivera                         0.941
## latitude:longitude:PlateNameSandwich                      -0.564
## latitude:longitude:PlateNameScotia                         0.099
## latitude:longitude:PlateNameShetland                      -0.462
## latitude:longitude:PlateNameSolomon Sea                    0.212
## latitude:longitude:PlateNameSomalia                        0.060
## latitude:longitude:PlateNameSouth America                  0.050
## latitude:longitude:PlateNameSouth Bismarck                 0.036
## latitude:longitude:PlateNameSunda                          0.046
## latitude:longitude:PlateNameTimor                          0.443
## latitude:longitude:PlateNameTonga                          0.491
## latitude:longitude:PlateNameWoodlark                       0.323
## latitude:longitude:PlateNameYangtze                        1.406
## latitude:log1p(focal_depth):PlateNameAfrica                0.220
## latitude:log1p(focal_depth):PlateNameAltiplano            -0.331
## latitude:log1p(focal_depth):PlateNameAmur                  0.189
## latitude:log1p(focal_depth):PlateNameAnatolia              0.348
## latitude:log1p(focal_depth):PlateNameAntarctica            0.210
## latitude:log1p(focal_depth):PlateNameArabia                0.290
## latitude:log1p(focal_depth):PlateNameAustralia             0.217
## latitude:log1p(focal_depth):PlateNameBalmoral Reef         1.015
## latitude:log1p(focal_depth):PlateNameBanda Sea            -0.497
## latitude:log1p(focal_depth):PlateNameBirds Head            1.138
## latitude:log1p(focal_depth):PlateNameBurma                 1.479
## latitude:log1p(focal_depth):PlateNameCaribbean             0.276
```

```
## latitude:log1p(focal_depth):PlateNameCaroline                    0.018
## latitude:log1p(focal_depth):PlateNameCocos                      -0.173
## latitude:log1p(focal_depth):PlateNameConway Reef                 0.090
## latitude:log1p(focal_depth):PlateNameEaster                     -0.241
## latitude:log1p(focal_depth):PlateNameEurasia                     0.216
## latitude:log1p(focal_depth):PlateNameFutuna                     -0.042
## latitude:log1p(focal_depth):PlateNameGalapagos                      NA
## latitude:log1p(focal_depth):PlateNameIndia                       0.218
## latitude:log1p(focal_depth):PlateNameJuan de Fuca               -0.660
## latitude:log1p(focal_depth):PlateNameJuan Fernandez                 NA
## latitude:log1p(focal_depth):PlateNameKermadec                    0.246
## latitude:log1p(focal_depth):PlateNameManus                       0.004
## latitude:log1p(focal_depth):PlateNameMaoke                      -0.291
## latitude:log1p(focal_depth):PlateNameMariana                    -0.654
## latitude:log1p(focal_depth):PlateNameMolucca Sea                -1.048
## latitude:log1p(focal_depth):PlateNameNazca                       0.156
## latitude:log1p(focal_depth):PlateNameNew Hebrides               -0.381
## latitude:log1p(focal_depth):PlateNameNiuafo'ou                  -1.307
## latitude:log1p(focal_depth):PlateNameNorth America               0.227
## latitude:log1p(focal_depth):PlateNameNorth Andes                -0.104
## latitude:log1p(focal_depth):PlateNameNorth Bismarck             -0.741
## latitude:log1p(focal_depth):PlateNameOkhotsk                     0.035
## latitude:log1p(focal_depth):PlateNameOkinawa                     0.612
## latitude:log1p(focal_depth):PlateNamePacific                     0.218
## latitude:log1p(focal_depth):PlateNamePanama                     -0.347
## latitude:log1p(focal_depth):PlateNamePhilippine Sea              0.343
## latitude:log1p(focal_depth):PlateNameRivera                     -0.689
## latitude:log1p(focal_depth):PlateNameSandwich                    0.825
## latitude:log1p(focal_depth):PlateNameScotia                      0.274
## latitude:log1p(focal_depth):PlateNameShetland                    0.476
## latitude:log1p(focal_depth):PlateNameSolomon Sea                 0.336
## latitude:log1p(focal_depth):PlateNameSomalia                     0.242
## latitude:log1p(focal_depth):PlateNameSouth America               0.227
## latitude:log1p(focal_depth):PlateNameSouth Bismarck              0.280
## latitude:log1p(focal_depth):PlateNameSunda                       0.204
## latitude:log1p(focal_depth):PlateNameTimor                       0.623
## latitude:log1p(focal_depth):PlateNameTonga                      -1.020
## latitude:log1p(focal_depth):PlateNameWoodlark                    0.656
## latitude:log1p(focal_depth):PlateNameYangtze                     2.784
## longitude:log1p(focal_depth):PlateNameAfrica                     0.207
## longitude:log1p(focal_depth):PlateNameAltiplano                  0.105
## longitude:log1p(focal_depth):PlateNameAmur                       0.197
## longitude:log1p(focal_depth):PlateNameAnatolia                   0.291
## longitude:log1p(focal_depth):PlateNameAntarctica                 0.208
## longitude:log1p(focal_depth):PlateNameArabia                     0.216
## longitude:log1p(focal_depth):PlateNameAustralia                  0.207
## longitude:log1p(focal_depth):PlateNameBalmoral Reef             -0.905
## longitude:log1p(focal_depth):PlateNameBanda Sea                  0.220
## longitude:log1p(focal_depth):PlateNameBirds Head                 0.205
## longitude:log1p(focal_depth):PlateNameBurma                      0.407
```

```
## longitude:log1p(focal_depth):PlateNameCaribbean                 0.199
## longitude:log1p(focal_depth):PlateNameCaroline                  0.191
## longitude:log1p(focal_depth):PlateNameCocos                     0.238
## longitude:log1p(focal_depth):PlateNameConway Reef              -0.059
## longitude:log1p(focal_depth):PlateNameEaster                   -0.244
## longitude:log1p(focal_depth):PlateNameEurasia                   0.205
## longitude:log1p(focal_depth):PlateNameFutuna                   -0.013
## longitude:log1p(focal_depth):PlateNameGalapagos                    NA
## longitude:log1p(focal_depth):PlateNameIndia                     0.206
## longitude:log1p(focal_depth):PlateNameJuan de Fuca              0.618
## longitude:log1p(focal_depth):PlateNameJuan Fernandez               NA
## longitude:log1p(focal_depth):PlateNameKermadec                  0.211
## longitude:log1p(focal_depth):PlateNameManus                    -0.051
## longitude:log1p(focal_depth):PlateNameMaoke                     0.306
## longitude:log1p(focal_depth):PlateNameMariana                   0.035
## longitude:log1p(focal_depth):PlateNameMolucca Sea               0.272
## longitude:log1p(focal_depth):PlateNameNazca                     0.196
## longitude:log1p(focal_depth):PlateNameNew Hebrides              0.247
## longitude:log1p(focal_depth):PlateNameNiuafo'ou                -0.523
## longitude:log1p(focal_depth):PlateNameNorth America             0.203
## longitude:log1p(focal_depth):PlateNameNorth Andes               0.268
## longitude:log1p(focal_depth):PlateNameNorth Bismarck            0.277
## longitude:log1p(focal_depth):PlateNameOkhotsk                   0.156
## longitude:log1p(focal_depth):PlateNameOkinawa                   0.263
## longitude:log1p(focal_depth):PlateNamePacific                   0.206
## longitude:log1p(focal_depth):PlateNamePanama                    0.347
## longitude:log1p(focal_depth):PlateNamePhilippine Sea            0.222
## longitude:log1p(focal_depth):PlateNameRivera                    0.699
## longitude:log1p(focal_depth):PlateNameSandwich                  0.900
## longitude:log1p(focal_depth):PlateNameScotia                    0.163
## longitude:log1p(focal_depth):PlateNameShetland                  0.445
## longitude:log1p(focal_depth):PlateNameSolomon Sea              -0.076
## longitude:log1p(focal_depth):PlateNameSomalia                   0.203
## longitude:log1p(focal_depth):PlateNameSouth America             0.210
## longitude:log1p(focal_depth):PlateNameSouth Bismarck            0.197
## longitude:log1p(focal_depth):PlateNameSunda                     0.207
## longitude:log1p(focal_depth):PlateNameTimor                     0.152
## longitude:log1p(focal_depth):PlateNameTonga                    -0.019
## longitude:log1p(focal_depth):PlateNameWoodlark                  0.188
## longitude:log1p(focal_depth):PlateNameYangtze                   1.137
## latitude:longitude:log1p(focal_depth):PlateNameAfrica          -0.174
## latitude:longitude:log1p(focal_depth):PlateNameAltiplano       -0.372
## latitude:longitude:log1p(focal_depth):PlateNameAmur            -0.166
## latitude:longitude:log1p(focal_depth):PlateNameAnatolia        -0.275
## latitude:longitude:log1p(focal_depth):PlateNameAntarctica      -0.172
## latitude:longitude:log1p(focal_depth):PlateNameArabia          -0.210
## latitude:longitude:log1p(focal_depth):PlateNameAustralia       -0.173
## latitude:longitude:log1p(focal_depth):PlateNameBalmoral Reef   -1.019
## latitude:longitude:log1p(focal_depth):PlateNameBanda Sea       -0.013
## latitude:longitude:log1p(focal_depth):PlateNameBirds Head      -0.505
```

```
## latitude:longitude:log1p(focal_depth):PlateNameBurma           -0.922
## latitude:longitude:log1p(focal_depth):PlateNameCaribbean       -0.151
## latitude:longitude:log1p(focal_depth):PlateNameCaroline        -0.043
## latitude:longitude:log1p(focal_depth):PlateNameCocos           -0.273
## latitude:longitude:log1p(focal_depth):PlateNameConway Reef     -0.120
## latitude:longitude:log1p(focal_depth):PlateNameEaster          -0.253
## latitude:longitude:log1p(focal_depth):PlateNameEurasia         -0.171
## latitude:longitude:log1p(focal_depth):PlateNameFutuna          -0.050
## latitude:longitude:log1p(focal_depth):PlateNameGalapagos           NA
## latitude:longitude:log1p(focal_depth):PlateNameIndia           -0.174
## latitude:longitude:log1p(focal_depth):PlateNameJuan de Fuca    -0.595
## latitude:longitude:log1p(focal_depth):PlateNameJuan Fernandez      NA
## latitude:longitude:log1p(focal_depth):PlateNameKermadec        -0.168
## latitude:longitude:log1p(focal_depth):PlateNameManus           -0.007
## latitude:longitude:log1p(focal_depth):PlateNameMaoke            0.258
## latitude:longitude:log1p(focal_depth):PlateNameMariana          0.102
## latitude:longitude:log1p(focal_depth):PlateNameMolucca Sea      0.440
## latitude:longitude:log1p(focal_depth):PlateNameNazca           -0.191
## latitude:longitude:log1p(focal_depth):PlateNameNew Hebrides    -0.071
## latitude:longitude:log1p(focal_depth):PlateNameNiuafo'ou       -1.177
## latitude:longitude:log1p(focal_depth):PlateNameNorth America   -0.171
## latitude:longitude:log1p(focal_depth):PlateNameNorth Andes     -0.251
## latitude:longitude:log1p(focal_depth):PlateNameNorth Bismarck   0.238
## latitude:longitude:log1p(focal_depth):PlateNameOkhotsk         -0.140
## latitude:longitude:log1p(focal_depth):PlateNameOkinawa         -0.338
## latitude:longitude:log1p(focal_depth):PlateNamePacific         -0.173
## latitude:longitude:log1p(focal_depth):PlateNamePanama          -0.411
## latitude:longitude:log1p(focal_depth):PlateNamePhilippine Sea  -0.195
## latitude:longitude:log1p(focal_depth):PlateNameRivera          -0.714
## latitude:longitude:log1p(focal_depth):PlateNameSandwich         0.459
## latitude:longitude:log1p(focal_depth):PlateNameScotia          -0.187
## latitude:longitude:log1p(focal_depth):PlateNameShetland         0.447
## latitude:longitude:log1p(focal_depth):PlateNameSolomon Sea     -0.361
## latitude:longitude:log1p(focal_depth):PlateNameSomalia         -0.188
## latitude:longitude:log1p(focal_depth):PlateNameSouth America   -0.173
## latitude:longitude:log1p(focal_depth):PlateNameSouth Bismarck  -0.246
## latitude:longitude:log1p(focal_depth):PlateNameSunda           -0.170
## latitude:longitude:log1p(focal_depth):PlateNameTimor           -0.503
## latitude:longitude:log1p(focal_depth):PlateNameTonga           -0.506
## latitude:longitude:log1p(focal_depth):PlateNameWoodlark        -0.296
## latitude:longitude:log1p(focal_depth):PlateNameYangtze         -1.550
##                                                               Pr(>|t|)
## (Intercept)                                                    0.93826
## latitude                                                       0.90892
## longitude                                                      0.93942
## log1p(focal_depth)                                             0.79924
## PlateNameAfrica                                                0.88836
## PlateNameAltiplano                                             0.52585
## PlateNameAmur                                                  0.88088
## PlateNameAnatolia                                              0.82485
```

```
## PlateNameAntarctica                                    0.88131
## PlateNameArabia                                        0.88008
## PlateNameAustralia                                     0.88500
## PlateNameBalmoral Reef                                 0.36151
## PlateNameBanda Sea                                     0.77880
## PlateNameBirds Head                                    0.88928
## PlateNameBurma                                         0.46449
## PlateNameCaribbean                                     0.85990
## PlateNameCaroline                                      0.97672
## PlateNameCocos                                         0.97048
## PlateNameConway Reef                                   0.77326
## PlateNameEaster                                        0.79190
## PlateNameEurasia                                       0.88892
## PlateNameFutuna                                        0.99432
## PlateNameGalapagos                                     0.87425
## PlateNameIndia                                         0.90302
## PlateNameJuan de Fuca                                  0.73582
## PlateNameJuan Fernandez                                0.34547
## PlateNameKermadec                                      0.91402
## PlateNameManus                                         0.91511
## PlateNameMaoke                                         0.76354
## PlateNameMariana                                       0.65708
## PlateNameMolucca Sea                                   0.56988
## PlateNameNazca                                         0.86086
## PlateNameNew Hebrides                                  0.63708
## PlateNameNiuafo'ou                                     0.22586
## PlateNameNorth America                                 0.88036
## PlateNameNorth Andes                                   0.95927
## PlateNameNorth Bismarck                                0.60776
## PlateNameOkhotsk                                       0.91030
## PlateNameOkinawa                                       0.72414
## PlateNamePacific                                       0.88746
## PlateNamePanama                                        0.80128
## PlateNamePhilippine Sea                                0.82437
## PlateNameRivera                                        0.36005
## PlateNameSandwich                                      0.47134
## PlateNameScotia                                        0.89333
## PlateNameShetland                                      0.63207
## PlateNameSolomon Sea                                   0.90868
## PlateNameSomalia                                       0.88982
## PlateNameSouth America                                 0.89723
## PlateNameSouth Bismarck                                0.86562
## PlateNameSunda                                         0.87924
## PlateNameTimor                                         0.92687
## PlateNameTonga                                         0.17516
## PlateNameWoodlark                                      0.83598
## PlateNameYangtze                                       0.01528 *
## latitude:longitude                                     0.96023
## latitude:log1p(focal_depth)                            0.82595
## longitude:log1p(focal_depth)                           0.83665
```

```
## latitude:PlateNameAfrica                                0.90944
## latitude:PlateNameAltiplano                             0.44457
## latitude:PlateNameAmur                                  0.90689
## latitude:PlateNameAnatolia                              0.82930
## latitude:PlateNameAntarctica                            0.91434
## latitude:PlateNameArabia                                0.86665
## latitude:PlateNameAustralia                             0.91294
## latitude:PlateNameBalmoral Reef                         0.34043
## latitude:PlateNameBanda Sea                             0.36156
## latitude:PlateNameBirds Head                            0.24337
## latitude:PlateNameBurma                                 0.25953
## latitude:PlateNameCaribbean                             0.84135
## latitude:PlateNameCaroline                              0.98789
## latitude:PlateNameCocos                                 0.78766
## latitude:PlateNameConway Reef                           0.80674
## latitude:PlateNameEaster                                0.80110
## latitude:PlateNameEurasia                               0.91122
## latitude:PlateNameFutuna                                0.99671
## latitude:PlateNameGalapagos                             0.39843
## latitude:PlateNameIndia                                 0.92677
## latitude:PlateNameJuan de Fuca                          0.70050
## latitude:PlateNameJuan Fernandez                        0.29575
## latitude:PlateNameKermadec                              0.88295
## latitude:PlateNameManus                                 0.96161
## latitude:PlateNameMaoke                                 0.78654
## latitude:PlateNameMariana                               0.67304
## latitude:PlateNameMolucca Sea                           0.28125
## latitude:PlateNameNazca                                 0.95501
## latitude:PlateNameNew Hebrides                          0.60009
## latitude:PlateNameNiuafo'ou                             0.25146
## latitude:PlateNameNorth America                         0.90392
## latitude:PlateNameNorth Andes                           0.96435
## latitude:PlateNameNorth Bismarck                        0.51368
## latitude:PlateNameOkhotsk                               0.93335
## latitude:PlateNameOkinawa                               0.58522
## latitude:PlateNamePacific                               0.91080
## latitude:PlateNamePanama                                0.72172
## latitude:PlateNamePhilippine Sea                        0.83637
## latitude:PlateNameRivera                                0.34482
## latitude:PlateNameSandwich                              0.45513
## latitude:PlateNameScotia                                0.92220
## latitude:PlateNameShetland                              0.62477
## latitude:PlateNameSolomon Sea                           0.83751
## latitude:PlateNameSomalia                               0.89720
## latitude:PlateNameSouth America                         0.90485
## latitude:PlateNameSouth Bismarck                        0.98199
## latitude:PlateNameSunda                                 0.92693
## latitude:PlateNameTimor                                 0.56017
## latitude:PlateNameTonga                                 0.21955
## latitude:PlateNameWoodlark                              0.27164
```

```
## latitude:PlateNameYangtze                                  0.00921 **
## longitude:PlateNameAfrica                                  0.93923
## longitude:PlateNameAltiplano                               0.90861
## longitude:PlateNameAmur                                    0.94022
## longitude:PlateNameAnatolia                                0.88687
## longitude:PlateNameAntarctica                              0.93893
## longitude:PlateNameArabia                                  0.93334
## longitude:PlateNameAustralia                               0.93904
## longitude:PlateNameBalmoral Reef                           0.38406
## longitude:PlateNameBanda Sea                               0.91787
## longitude:PlateNameBirds Head                              0.94088
## longitude:PlateNameBurma                                   0.80394
## longitude:PlateNameCaribbean                               0.94809
## longitude:PlateNameCaroline                                0.95587
## longitude:PlateNameCocos                                   0.91998
## longitude:PlateNameConway Reef                             0.80532
## longitude:PlateNameEaster                                  0.79457
## longitude:PlateNameEurasia                                 0.94029
## longitude:PlateNameFutuna                                  0.98652
## longitude:PlateNameGalapagos                                    NA
## longitude:PlateNameIndia                                   0.94334
## longitude:PlateNameJuan de Fuca                            0.76486
## longitude:PlateNameJuan Fernandez                          0.28447
## longitude:PlateNameKermadec                                0.93515
## longitude:PlateNameManus                                   0.91688
## longitude:PlateNameMaoke                                   0.85247
## longitude:PlateNameMariana                                 0.95881
## longitude:PlateNameMolucca Sea                             0.87115
## longitude:PlateNameNazca                                   0.94719
## longitude:PlateNameNew Hebrides                            0.89699
## longitude:PlateNameNiuafo'ou                               0.50349
## longitude:PlateNameNorth America                           0.94135
## longitude:PlateNameNorth Andes                             0.89251
## longitude:PlateNameNorth Bismarck                          0.88796
## longitude:PlateNameOkhotsk                                 0.97455
## longitude:PlateNameOkinawa                                 0.88677
## longitude:PlateNamePacific                                 0.93966
## longitude:PlateNamePanama                                  0.81544
## longitude:PlateNamePhilippine Sea                          0.92802
## longitude:PlateNameRivera                                  0.37144
## longitude:PlateNameSandwich                                0.42511
## longitude:PlateNameScotia                                  0.99815
## longitude:PlateNameShetland                                0.64823
## longitude:PlateNameSolomon Sea                             0.95618
## longitude:PlateNameSomalia                                 0.94033
## longitude:PlateNameSouth America                           0.93690
## longitude:PlateNameSouth Bismarck                          0.93414
## longitude:PlateNameSunda                                   0.93769
## longitude:PlateNameTimor                                   0.98776
## longitude:PlateNameTonga                                   0.82965
```

```
## longitude:PlateNameWoodlark                                0.98850
## longitude:PlateNameYangtze                                 0.32124
## log1p(focal_depth):PlateNameAfrica                         0.79964
## log1p(focal_depth):PlateNameAltiplano                      0.59932
## log1p(focal_depth):PlateNameAmur                           0.83360
## log1p(focal_depth):PlateNameAnatolia                       0.72099
## log1p(focal_depth):PlateNameAntarctica                     0.78983
## log1p(focal_depth):PlateNameArabia                         0.78966
## log1p(focal_depth):PlateNameAustralia                      0.79769
## log1p(focal_depth):PlateNameBalmoral Reef                  0.32927
## log1p(focal_depth):PlateNameBanda Sea                      0.74307
## log1p(focal_depth):PlateNameBirds Head                     0.80071
## log1p(focal_depth):PlateNameBurma                          0.34617
## log1p(focal_depth):PlateNameCaribbean                      0.78421
## log1p(focal_depth):PlateNameCaroline                       0.88265
## log1p(focal_depth):PlateNameCocos                          0.90298
## log1p(focal_depth):PlateNameConway Reef                    0.89097
## log1p(focal_depth):PlateNameEaster                         0.79972
## log1p(focal_depth):PlateNameEurasia                        0.80139
## log1p(focal_depth):PlateNameFutuna                         0.97165
## log1p(focal_depth):PlateNameGalapagos                           NA
## log1p(focal_depth):PlateNameIndia                          0.80433
## log1p(focal_depth):PlateNameJuan de Fuca                   0.54522
## log1p(focal_depth):PlateNameJuan Fernandez                 0.84728
## log1p(focal_depth):PlateNameKermadec                       0.82016
## log1p(focal_depth):PlateNameManus                          0.95243
## log1p(focal_depth):PlateNameMaoke                          0.71687
## log1p(focal_depth):PlateNameMariana                        0.57785
## log1p(focal_depth):PlateNameMolucca Sea                    0.56037
## log1p(focal_depth):PlateNameNazca                          0.77229
## log1p(focal_depth):PlateNameNew Hebrides                   0.61141
## log1p(focal_depth):PlateNameNiuafo'ou                      0.16816
## log1p(focal_depth):PlateNameNorth America                  0.79154
## log1p(focal_depth):PlateNameNorth Andes                    0.96045
## log1p(focal_depth):PlateNameNorth Bismarck                 0.51008
## log1p(focal_depth):PlateNameOkhotsk                        0.97951
## log1p(focal_depth):PlateNameOkinawa                        0.67067
## log1p(focal_depth):PlateNamePacific                        0.79949
## log1p(focal_depth):PlateNamePanama                         0.84887
## log1p(focal_depth):PlateNamePhilippine Sea                 0.72897
## log1p(focal_depth):PlateNameRivera                         0.51467
## log1p(focal_depth):PlateNameSandwich                       0.51298
## log1p(focal_depth):PlateNameScotia                         0.92505
## log1p(focal_depth):PlateNameShetland                       0.64242
## log1p(focal_depth):PlateNameSolomon Sea                    0.80785
## log1p(focal_depth):PlateNameSomalia                        0.80409
## log1p(focal_depth):PlateNameSouth America                  0.81153
## log1p(focal_depth):PlateNameSouth Bismarck                 0.85037
## log1p(focal_depth):PlateNameSunda                          0.79438
## log1p(focal_depth):PlateNameTimor                          0.99183
```

```
## log1p(focal_depth):PlateNameTonga                                0.20614
## log1p(focal_depth):PlateNameWoodlark                             0.88409
## log1p(focal_depth):PlateNameYangtze                              0.01209 *
## latitude:longitude:log1p(focal_depth)                            0.86242
## latitude:longitude:PlateNameAfrica                               0.96002
## latitude:longitude:PlateNameAltiplano                            0.66397
## latitude:longitude:PlateNameAmur                                 0.96184
## latitude:longitude:PlateNameAnatolia                             0.89613
## latitude:longitude:PlateNameAntarctica                           0.96086
## latitude:longitude:PlateNameArabia                               0.93930
## latitude:longitude:PlateNameAustralia                            0.96100
## latitude:longitude:PlateNameBalmoral Reef                        0.34319
## latitude:longitude:PlateNameBanda Sea                            0.83324
## latitude:longitude:PlateNameBirds Head                           0.66987
## latitude:longitude:PlateNameBurma                                0.51975
## latitude:longitude:PlateNameCaribbean                            0.98345
## latitude:longitude:PlateNameCaroline                             0.98281
## latitude:longitude:PlateNameCocos                                0.88189
## latitude:longitude:PlateNameConway Reef                          0.80367
## latitude:longitude:PlateNameEaster                               0.79484
## latitude:longitude:PlateNameEurasia                              0.96138
## latitude:longitude:PlateNameFutuna                               0.99492
## latitude:longitude:PlateNameGalapagos                                 NA
## latitude:longitude:PlateNameIndia                                0.96513
## latitude:longitude:PlateNameJuan de Fuca                         0.78036
## latitude:longitude:PlateNameJuan Fernandez                       0.31727
## latitude:longitude:PlateNameKermadec                             0.96483
## latitude:longitude:PlateNameManus                                0.95985
## latitude:longitude:PlateNameMaoke                                0.79109
## latitude:longitude:PlateNameMariana                              0.89706
## latitude:longitude:PlateNameMolucca Sea                          0.54218
## latitude:longitude:PlateNameNazca                                0.94756
## latitude:longitude:PlateNameNew Hebrides                         0.94438
## latitude:longitude:PlateNameNiuafo'ou                            0.30327
## latitude:longitude:PlateNameNorth America                        0.96155
## latitude:longitude:PlateNameNorth Andes                          0.93978
## latitude:longitude:PlateNameNorth Bismarck                       0.77125
## latitude:longitude:PlateNameOkhotsk                              0.98719
## latitude:longitude:PlateNameOkinawa                              0.81683
## latitude:longitude:PlateNamePacific                              0.96024
## latitude:longitude:PlateNamePanama                               0.72654
## latitude:longitude:PlateNamePhilippine Sea                       0.94754
## latitude:longitude:PlateNameRivera                               0.34667
## latitude:longitude:PlateNameSandwich                             0.57296
## latitude:longitude:PlateNameScotia                               0.92126
## latitude:longitude:PlateNameShetland                             0.64396
## latitude:longitude:PlateNameSolomon Sea                          0.83240
## latitude:longitude:PlateNameSomalia                              0.95195
## latitude:longitude:PlateNameSouth America                        0.95982
## latitude:longitude:PlateNameSouth Bismarck                       0.97122
```

```
## latitude:longitude:PlateNameSunda                          0.96352
## latitude:longitude:PlateNameTimor                          0.65805
## latitude:longitude:PlateNameTonga                          0.62336
## latitude:longitude:PlateNameWoodlark                       0.74669
## latitude:longitude:PlateNameYangtze                        0.15979
## latitude:log1p(focal_depth):PlateNameAfrica                0.82572
## latitude:log1p(focal_depth):PlateNameAltiplano             0.74039
## latitude:log1p(focal_depth):PlateNameAmur                  0.84979
## latitude:log1p(focal_depth):PlateNameAnatolia              0.72808
## latitude:log1p(focal_depth):PlateNameAntarctica            0.83372
## latitude:log1p(focal_depth):PlateNameArabia                0.77170
## latitude:log1p(focal_depth):PlateNameAustralia             0.82843
## latitude:log1p(focal_depth):PlateNameBalmoral Reef         0.31010
## latitude:log1p(focal_depth):PlateNameBanda Sea             0.61921
## latitude:log1p(focal_depth):PlateNameBirds Head            0.25497
## latitude:log1p(focal_depth):PlateNameBurma                 0.13915
## latitude:log1p(focal_depth):PlateNameCaribbean             0.78254
## latitude:log1p(focal_depth):PlateNameCaroline              0.98553
## latitude:log1p(focal_depth):PlateNameCocos                 0.86253
## latitude:log1p(focal_depth):PlateNameConway Reef           0.92834
## latitude:log1p(focal_depth):PlateNameEaster                0.80958
## latitude:log1p(focal_depth):PlateNameEurasia               0.82863
## latitude:log1p(focal_depth):PlateNameFutuna                0.96650
## latitude:log1p(focal_depth):PlateNameGalapagos                  NA
## latitude:log1p(focal_depth):PlateNameIndia                 0.82753
## latitude:log1p(focal_depth):PlateNameJuan de Fuca          0.50903
## latitude:log1p(focal_depth):PlateNameJuan Fernandez             NA
## latitude:log1p(focal_depth):PlateNameKermadec              0.80531
## latitude:log1p(focal_depth):PlateNameManus                 0.99674
## latitude:log1p(focal_depth):PlateNameMaoke                 0.77117
## latitude:log1p(focal_depth):PlateNameMariana               0.51313
## latitude:log1p(focal_depth):PlateNameMolucca Sea           0.29452
## latitude:log1p(focal_depth):PlateNameNazca                 0.87598
## latitude:log1p(focal_depth):PlateNameNew Hebrides          0.70298
## latitude:log1p(focal_depth):PlateNameNiuafo'ou             0.19110
## latitude:log1p(focal_depth):PlateNameNorth America         0.82057
## latitude:log1p(focal_depth):PlateNameNorth Andes           0.91717
## latitude:log1p(focal_depth):PlateNameNorth Bismarck        0.45875
## latitude:log1p(focal_depth):PlateNameOkhotsk               0.97174
## latitude:log1p(focal_depth):PlateNameOkinawa               0.54065
## latitude:log1p(focal_depth):PlateNamePacific               0.82777
## latitude:log1p(focal_depth):PlateNamePanama                0.72826
## latitude:log1p(focal_depth):PlateNamePhilippine Sea        0.73156
## latitude:log1p(focal_depth):PlateNameRivera                0.49105
## latitude:log1p(focal_depth):PlateNameSandwich              0.40919
## latitude:log1p(focal_depth):PlateNameScotia                0.78423
## latitude:log1p(focal_depth):PlateNameShetland              0.63413
## latitude:log1p(focal_depth):PlateNameSolomon Sea           0.73659
## latitude:log1p(focal_depth):PlateNameSomalia               0.80869
## latitude:log1p(focal_depth):PlateNameSouth America         0.82051
```

```
## latitude:log1p(focal_depth):PlateNameSouth Bismarck            0.77974
## latitude:log1p(focal_depth):PlateNameSunda                     0.83837
## latitude:log1p(focal_depth):PlateNameTimor                     0.53335
## latitude:log1p(focal_depth):PlateNameTonga                     0.30771
## latitude:log1p(focal_depth):PlateNameWoodlark                  0.51151
## latitude:log1p(focal_depth):PlateNameYangtze                   0.00537 **
## longitude:log1p(focal_depth):PlateNameAfrica                   0.83608
## longitude:log1p(focal_depth):PlateNameAltiplano                0.91657
## longitude:log1p(focal_depth):PlateNameAmur                     0.84394
## longitude:log1p(focal_depth):PlateNameAnatolia                 0.77075
## longitude:log1p(focal_depth):PlateNameAntarctica               0.83554
## longitude:log1p(focal_depth):PlateNameArabia                   0.82877
## longitude:log1p(focal_depth):PlateNameAustralia                0.83638
## longitude:log1p(focal_depth):PlateNameBalmoral Reef            0.36568
## longitude:log1p(focal_depth):PlateNameBanda Sea                0.82581
## longitude:log1p(focal_depth):PlateNameBirds Head               0.83792
## longitude:log1p(focal_depth):PlateNameBurma                    0.68423
## longitude:log1p(focal_depth):PlateNameCaribbean                0.84216
## longitude:log1p(focal_depth):PlateNameCaroline                 0.84859
## longitude:log1p(focal_depth):PlateNameCocos                    0.81208
## longitude:log1p(focal_depth):PlateNameConway Reef              0.95258
## longitude:log1p(focal_depth):PlateNameEaster                   0.80754
## longitude:log1p(focal_depth):PlateNameEurasia                  0.83772
## longitude:log1p(focal_depth):PlateNameFutuna                   0.98978
## longitude:log1p(focal_depth):PlateNameGalapagos                     NA
## longitude:log1p(focal_depth):PlateNameIndia                    0.83705
## longitude:log1p(focal_depth):PlateNameJuan de Fuca             0.53643
## longitude:log1p(focal_depth):PlateNameJuan Fernandez                NA
## longitude:log1p(focal_depth):PlateNameKermadec                 0.83319
## longitude:log1p(focal_depth):PlateNameManus                    0.95911
## longitude:log1p(focal_depth):PlateNameMaoke                    0.75938
## longitude:log1p(focal_depth):PlateNameMariana                  0.97224
## longitude:log1p(focal_depth):PlateNameMolucca Sea              0.78557
## longitude:log1p(focal_depth):PlateNameNazca                    0.84442
## longitude:log1p(focal_depth):PlateNameNew Hebrides             0.80485
## longitude:log1p(focal_depth):PlateNameNiuafo'ou                0.60067
## longitude:log1p(focal_depth):PlateNameNorth America            0.83890
## longitude:log1p(focal_depth):PlateNameNorth Andes              0.78865
## longitude:log1p(focal_depth):PlateNameNorth Bismarck           0.78211
## longitude:log1p(focal_depth):PlateNameOkhotsk                  0.87625
## longitude:log1p(focal_depth):PlateNameOkinawa                  0.79245
## longitude:log1p(focal_depth):PlateNamePacific                  0.83688
## longitude:log1p(focal_depth):PlateNamePanama                   0.72877
## longitude:log1p(focal_depth):PlateNamePhilippine Sea           0.82393
## longitude:log1p(focal_depth):PlateNameRivera                   0.48450
## longitude:log1p(focal_depth):PlateNameSandwich                 0.36817
## longitude:log1p(focal_depth):PlateNameScotia                   0.87047
## longitude:log1p(focal_depth):PlateNameShetland                 0.65639
## longitude:log1p(focal_depth):PlateNameSolomon Sea              0.93918
## longitude:log1p(focal_depth):PlateNameSomalia                  0.83916
```

```
## longitude:log1p(focal_depth):PlateNameSouth America            0.83347
## longitude:log1p(focal_depth):PlateNameSouth Bismarck           0.84344
## longitude:log1p(focal_depth):PlateNameSunda                    0.83567
## longitude:log1p(focal_depth):PlateNameTimor                    0.87952
## longitude:log1p(focal_depth):PlateNameTonga                    0.98449
## longitude:log1p(focal_depth):PlateNameWoodlark                 0.85062
## longitude:log1p(focal_depth):PlateNameYangtze                  0.25563
## latitude:longitude:log1p(focal_depth):PlateNameAfrica          0.86221
## latitude:longitude:log1p(focal_depth):PlateNameAltiplano       0.70966
## latitude:longitude:log1p(focal_depth):PlateNameAmur            0.86793
## latitude:longitude:log1p(focal_depth):PlateNameAnatolia        0.78327
## latitude:longitude:log1p(focal_depth):PlateNameAntarctica      0.86354
## latitude:longitude:log1p(focal_depth):PlateNameArabia          0.83364
## latitude:longitude:log1p(focal_depth):PlateNameAustralia       0.86294
## latitude:longitude:log1p(focal_depth):PlateNameBalmoral Reef   0.30838
## latitude:longitude:log1p(focal_depth):PlateNameBanda Sea       0.98987
## latitude:longitude:log1p(focal_depth):PlateNameBirds Head      0.61348
## latitude:longitude:log1p(focal_depth):PlateNameBurma           0.35656
## latitude:longitude:log1p(focal_depth):PlateNameCaribbean       0.87997
## latitude:longitude:log1p(focal_depth):PlateNameCaroline        0.96538
## latitude:longitude:log1p(focal_depth):PlateNameCocos           0.78468
## latitude:longitude:log1p(focal_depth):PlateNameConway Reef     0.90417
## latitude:longitude:log1p(focal_depth):PlateNameEaster          0.79999
## latitude:longitude:log1p(focal_depth):PlateNameEurasia         0.86384
## latitude:longitude:log1p(focal_depth):PlateNameFutuna          0.96009
## latitude:longitude:log1p(focal_depth):PlateNameGalapagos            NA
## latitude:longitude:log1p(focal_depth):PlateNameIndia           0.86175
## latitude:longitude:log1p(focal_depth):PlateNameJuan de Fuca    0.55155
## latitude:longitude:log1p(focal_depth):PlateNameJuan Fernandez       NA
## latitude:longitude:log1p(focal_depth):PlateNameKermadec        0.86620
## latitude:longitude:log1p(focal_depth):PlateNameManus           0.99446
## latitude:longitude:log1p(focal_depth):PlateNameMaoke           0.79676
## latitude:longitude:log1p(focal_depth):PlateNameMariana         0.91838
## latitude:longitude:log1p(focal_depth):PlateNameMolucca Sea     0.65985
## latitude:longitude:log1p(focal_depth):PlateNameNazca           0.84870
## latitude:longitude:log1p(focal_depth):PlateNameNew Hebrides    0.94345
## latitude:longitude:log1p(focal_depth):PlateNameNiuafo'ou       0.23904
## latitude:longitude:log1p(focal_depth):PlateNameNorth America   0.86396
## latitude:longitude:log1p(focal_depth):PlateNameNorth Andes     0.80185
## latitude:longitude:log1p(focal_depth):PlateNameNorth Bismarck  0.81206
## latitude:longitude:log1p(focal_depth):PlateNameOkhotsk         0.88877
## latitude:longitude:log1p(focal_depth):PlateNameOkinawa         0.73551
## latitude:longitude:log1p(focal_depth):PlateNamePacific         0.86241
## latitude:longitude:log1p(focal_depth):PlateNamePanama          0.68131
## latitude:longitude:log1p(focal_depth):PlateNamePhilippine Sea  0.84559
## latitude:longitude:log1p(focal_depth):PlateNameRivera          0.47522
## latitude:longitude:log1p(focal_depth):PlateNameSandwich        0.64658
## latitude:longitude:log1p(focal_depth):PlateNameScotia          0.85195
## latitude:longitude:log1p(focal_depth):PlateNameShetland        0.65520
## latitude:longitude:log1p(focal_depth):PlateNameSolomon Sea     0.71784
```

```
## latitude:longitude:log1p(focal_depth):PlateNameSomalia         0.85109
## latitude:longitude:log1p(focal_depth):PlateNameSouth America   0.86244
## latitude:longitude:log1p(focal_depth):PlateNameSouth Bismarck  0.80606
## latitude:longitude:log1p(focal_depth):PlateNameSunda           0.86483
## latitude:longitude:log1p(focal_depth):PlateNameTimor           0.61512
## latitude:longitude:log1p(focal_depth):PlateNameTonga           0.61263
## latitude:longitude:log1p(focal_depth):PlateNameWoodlark        0.76691
## latitude:longitude:log1p(focal_depth):PlateNameYangtze         0.12105
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4237 on 18437 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.04176,    Adjusted R-squared:  0.02066
## F-statistic: 1.979 on 406 and 18437 DF,  p-value: < 2.2e-16
```

```
LRModel9 <-lm(magnitude ~ latitude * longitude * log1p(focal_depth) *
PlateName,
              data = nap_earthquakes)
summary(LRModel9)
```

```
##
## Call:
## lm(formula = magnitude ~ latitude * longitude * log1p(focal_depth) *
##     PlateName, data = nap_earthquakes)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.5624 -0.3241 -0.1393  0.1789  1.9991
##
## Coefficients:
##                                                          Estimate
## (Intercept)                                             7.377e+00
## latitude                                               -2.634e-02
## longitude                                               1.473e-02
## log1p(focal_depth)                                     -4.732e-01
## PlateNamePacific                                       -1.401e+00
## latitude:longitude                                     -2.724e-04
## latitude:log1p(focal_depth)                             9.050e-03
## longitude:log1p(focal_depth)                           -5.256e-03
## latitude:PlateNamePacific                               3.362e-02
## longitude:PlateNamePacific                             -1.327e-02
## log1p(focal_depth):PlateNamePacific                     4.830e-01
## latitude:longitude:log1p(focal_depth)                   9.800e-05
## latitude:longitude:PlateNamePacific                     2.823e-04
## latitude:log1p(focal_depth):PlateNamePacific           -1.160e-02
## longitude:log1p(focal_depth):PlateNamePacific           4.818e-03
## latitude:longitude:log1p(focal_depth):PlateNamePacific -1.024e-04
##                                                        Std. Error t value
## (Intercept)                                             7.984e-01   9.239
```

```
## latitude                                                 1.512e-02  -1.743
## longitude                                                8.279e-03   1.780
## log1p(focal_depth)                                       2.941e-01  -1.609
## PlateNamePacific                                         8.023e-01  -1.746
## latitude:longitude                                       1.542e-04  -1.766
## latitude:log1p(focal_depth)                              5.632e-03   1.607
## longitude:log1p(focal_depth)                             3.039e-03  -1.730
## latitude:PlateNamePacific                                1.550e-02   2.169
## longitude:PlateNamePacific                               8.296e-03  -1.599
## log1p(focal_depth):PlateNamePacific                      2.954e-01   1.635
## latitude:longitude:log1p(focal_depth)                    5.701e-05   1.719
## latitude:longitude:PlateNamePacific                      1.560e-04   1.810
## latitude:log1p(focal_depth):PlateNamePacific             5.769e-03  -2.011
## longitude:log1p(focal_depth):PlateNamePacific            3.045e-03   1.582
## latitude:longitude:log1p(focal_depth):PlateNamePacific   5.762e-05  -1.777
##                                                         Pr(>|t|)
## (Intercept)                                               <2e-16 ***
## latitude                                                  0.0816 .
## longitude                                                 0.0754 .
## log1p(focal_depth)                                        0.1078
## PlateNamePacific                                          0.0810 .
## latitude:longitude                                        0.0776 .
## latitude:log1p(focal_depth)                               0.1083
## longitude:log1p(focal_depth)                              0.0839 .
## latitude:PlateNamePacific                                 0.0303 *
## longitude:PlateNamePacific                                0.1100
## log1p(focal_depth):PlateNamePacific                       0.1022
## latitude:longitude:log1p(focal_depth)                     0.0858 .
## latitude:longitude:PlateNamePacific                       0.0706 .
## latitude:log1p(focal_depth):PlateNamePacific              0.0446 *
## longitude:log1p(focal_depth):PlateNamePacific             0.1138
## latitude:longitude:log1p(focal_depth):PlateNamePacific    0.0758 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4683 on 1463 degrees of freedom
## Multiple R-squared:  0.01829,    Adjusted R-squared:  0.008226
## F-statistic: 1.817 on 15 and 1463 DF,  p-value: 0.02771
```

Going through the results of the linear regressions, the first thing that is noticed is that the data does not follow a normal distribution. The next thing that draws attention from this model is the coeffictients vary substantially in value, particularly in the models that include individual tectonic plates (PlateName). Next, it is clear that for many of the models, the variables produce a t-value that is close to zero, demonstrating that the linear regression model does not show a linear relationship between the variables. Lastly, when looking at the R-squared values, it is clear that as all models are close to zero, this method of machine learning is not the best option for this data set.

Logistic Regression

```
#Create binomial column for major earthquake classification

earthquakes1$MajorEarthquakes = ifelse(earthquakes1$magnitude >= 7.0, 1, 0)
head(earthquakes1)
```

```
##   quake_date       time focal_depth magnitude country
## 1  1965-3-28 16:33:00.0          61       7.3   CHILE
## 2  1965-3-31 09:47:00.0          78       7.1  GREECE
## 3  1965-4-29 15:28:43.7          59       6.5     USA
## 4  1965-6-21 00:21:00.0          40       6.0    IRAN
## 5   1966-3-7 01:16:00.0          38       6.0  TURKEY
## 6  1966-8-15 02:15:00.0          53       5.6   INDIA
##                          location_name latitude longitude LAYER Code
## 1                     CHILE:  CENTRAL     -32.4     -71.2 plate   SA
## 2                              GREECE     38.6      22.4 plate   EU
## 3                  WASHINGTON:  SEATTLE     47.4    -122.3 plate   NA
## 4 IRAN:  HADJIABAD, SARKHUN, SARCHAHAN     28.1      55.9 plate   EU
## 5                   TURKEY:  VARTO, MUS     39.1      41.6 plate   EU
## 6                             INDIA:  N     28.7      78.9 plate   IN
##       PlateName MajorEarthquakes
## 1 South America                1
## 2       Eurasia                1
## 3 North America                0
## 4       Eurasia                0
## 5       Eurasia                0
## 6         India                0
```

```
table(earthquakes1$MajorEarthquakes)
```

```
##
##     0     1
## 18059   787
```

```
#Null model for earthquakes1

787/18846
```

```
## [1] 0.04175952
```

```
#null model is 0.04175952


# Logistic Regression Models ------------------------------------------


QuakeLog1 <- glm(MajorEarthquakes ~ latitude + longitude + log1p(focal_depth)
,
                 data = earthquakes1, family = binomial)
```

```
## Warning in log1p(focal_depth): NaNs produced
```

```
summary(QuakeLog1)
```

```
##
## Call:
## glm(formula = MajorEarthquakes ~ latitude + longitude +
log1p(focal_depth),
##     family = binomial, data = earthquakes1)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.3996  -0.3084  -0.2903  -0.2625   2.7541
##
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -3.7390578  0.1270568 -29.428  < 2e-16 ***
## latitude            0.0023936  0.0012732   1.880  0.06012 .
## longitude           0.0008313  0.0003059   2.717  0.00658 **
## log1p(focal_depth)  0.1536043  0.0324247   4.737 2.17e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6533.0  on 18843  degrees of freedom
## Residual deviance: 6498.2  on 18840  degrees of freedom
##   (2 observations deleted due to missingness)
## AIC: 6506.2
##
## Number of Fisher Scoring iterations: 6
```

```
car::Anova(QuakeLog1)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                     LR Chisq Df Pr(>Chisq)
## latitude              3.5269  1   0.060381 .
## longitude             7.5557  1   0.005982 **
## log1p(focal_depth)   21.8522  1  2.945e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
QuakeLog2 <- glm(MajorEarthquakes ~ longitude * log1p(focal_depth),
                 data = earthquakes1, family = binomial)
```

```
## Warning in log1p(focal_depth): NaNs produced
```

```
summary(QuakeLog2)
```

```
##
## Call:
## glm(formula = MajorEarthquakes ~ longitude * log1p(focal_depth),
##     family = binomial, data = earthquakes1)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.3828  -0.3063  -0.2898  -0.2647   2.7821
##
## Coefficients:
##                                Estimate Std. Error z value Pr(>|z|)
## (Intercept)                  -3.722e+00  1.296e-01 -28.717  < 2e-16 ***
## longitude                     9.550e-04  9.936e-04   0.961    0.337
## log1p(focal_depth)            1.496e-01  3.305e-02   4.527 5.99e-06 ***
## longitude:log1p(focal_depth) -2.770e-06  2.442e-04  -0.011    0.991
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6533.0  on 18843  degrees of freedom
## Residual deviance: 6501.7  on 18840  degrees of freedom
##   (2 observations deleted due to missingness)
## AIC: 6509.7
##
## Number of Fisher Scoring iterations: 6

car::Anova(QuakeLog2)

## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                              LR Chisq Df Pr(>Chisq)
## longitude                     10.1898  1   0.001412 **
## log1p(focal_depth)            20.8375  1  4.999e-06 ***
## longitude:log1p(focal_depth)   0.0001  1   0.990949
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

QuakeLog3 <- glm(MajorEarthquakes ~ log1p(focal_depth), data = earthquakes1,
                 family = binomial)

## Warning in log1p(focal_depth): NaNs produced

summary(QuakeLog3)

##
## Call:
## glm(formula = MajorEarthquakes ~ log1p(focal_depth), family = binomial,
##     data = earthquakes1)
##
```

```
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.3604  -0.2984  -0.2897  -0.2686   2.7253
##
## Coefficients:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -3.67383    0.12416 -29.591  < 2e-16 ***
## log1p(focal_depth)  0.14862    0.03195   4.652 3.28e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6533.0  on 18843  degrees of freedom
## Residual deviance: 6511.9  on 18842  degrees of freedom
##   (2 observations deleted due to missingness)
## AIC: 6515.9
##
## Number of Fisher Scoring iterations: 6

car::Anova(QuakeLog3)

## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                    LR Chisq Df Pr(>Chisq)
## log1p(focal_depth)    21.06  1  4.452e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

QuakeLog4 <- glm(MajorEarthquakes ~ latitude * longitude, data =
earthquakes1,
                 family = binomial)
summary(QuakeLog4)

##
## Call:
## glm(formula = MajorEarthquakes ~ latitude * longitude, family = binomial,
##     data = earthquakes1)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.3175  -0.3057  -0.3017  -0.2707   2.6577
##
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -3.173e+00  4.039e-02 -78.556  < 2e-16 ***
## latitude            2.438e-03  1.271e-03   1.918  0.05511 .
## longitude           8.689e-04  3.057e-04   2.842  0.00448 **
## latitude:longitude -1.264e-05  9.683e-06  -1.305  0.19190
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6539.4  on 18845  degrees of freedom
## Residual deviance: 6524.8  on 18842  degrees of freedom
## AIC: 6532.8
##
## Number of Fisher Scoring iterations: 6
```

```
car::Anova(QuakeLog4)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                    LR Chisq Df Pr(>Chisq)
## latitude             2.6521  1   0.103416
## longitude            8.1282  1   0.004358 **
## latitude:longitude   1.6865  1   0.194061
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Reviewing the models for logistic regression for all earthquakes, it becomes clear that a logistic regression does not accurately predict magnitude for earthquakes. However, from comparing the outcomes of each Anova test, we find longitude to be highly significant in determining whether an earthquakes will have a magnitude of 7.0 or above. The tests also reveal focal depth and plate name to be fairly significant predictors. These results again make sense as the plate location of a quake would determine the magnitude of the tremor; for example,a quake that occurs on the Pacific plate is more likely to be a major quake than a tremor on the eurasian plate as the Pacific plate is prone to sudden, sharp movements found only in subduction zones.

This process was then repeated by restricting the plates to the NAP plate data.

```
#Create binomial column for major earthquake classification for NAP data

nap_earthquakes$MajorEarthquakes =
  ifelse(nap_earthquakes$magnitude >= 7.0, 1, 0)
head(nap_earthquakes)
```

```
##   quake_date       time focal_depth magnitude         country
## 1  1965-4-29 15:28:43.7          59       6.5             USA
## 2   1968-8-2 14:06:00.0          36       7.5          MEXICO
## 3   1969-1-5 13:26:00.0          47       7.5 SOLOMON ISLANDS
## 4 1971-12-15 08:29:55.3          33       7.8          RUSSIA
## 5  1973-8-28 09:50:40.0          84       7.2          MEXICO
## 6 1965-01-10 13:36:32.0          35       6.7            <NA>
##                          location_name latitude longitude LAYER Code
## 1                   WASHINGTON:  SEATTLE   47.400  -122.300 plate   NA
## 2              MEXICO:  OAXACA, GUERRERO   16.500   -97.800 plate   NA
```

```
## 3 SOLOMON ISLANDS:  SANTA ISABEL ISLAND   -7.900   158.900 plate   PA
## 4  RUSSIA:  OFF KAMCHATKA, SHEMYA, ATTU   56.000   163.300 plate   NA
## 5        MEXICO:  VERACRUZ, MEXICO CITY   18.270   -96.600 plate   NA
## 6                                  <NA>  -13.405   166.629 plate   PA
##       PlateName MajorEarthquakes
## 1 North America                0
## 2 North America                1
## 3       Pacific                1
## 4 North America                1
## 5 North America                1
## 6       Pacific                0

table(nap_earthquakes$MajorEarthquakes)

##
##    0    1
## 1395   84

#Null model for nap_earthquakes

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## [1] 0.05679513

#null model is 0.05679513

NapQuakeLog1 <- glm(MajorEarthquakes ~ latitude * longitude,
                    data = nap_earthquakes, family = binomial)
summary(NapQuakeLog1)

##
## Call:
## glm(formula = MajorEarthquakes ~ latitude * longitude, family = binomial,
##     data = nap_earthquakes)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5135  -0.3784  -0.3258  -0.3085   2.5485
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -2.859e+00  1.444e-01 -19.802   <2e-16 ***
## latitude           -3.412e-03  3.816e-03  -0.894    0.371
## longitude           1.222e-03  9.452e-04   1.292    0.196
## latitude:longitude -3.861e-05  2.394e-05  -1.613    0.107
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 645.01  on 1478  degrees of freedom
```

```
## Residual deviance: 639.23  on 1475  degrees of freedom
## AIC: 647.23
##
## Number of Fisher Scoring iterations: 5
```

```
car::Anova(NapQuakeLog1)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                    LR Chisq Df Pr(>Chisq)
## latitude            1.24608  1    0.26430
## longitude           0.72474  1    0.39459
## latitude:longitude  2.72826  1    0.09859 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
NapQuakeLog2 <-glm(MajorEarthquakes ~ latitude * longitude *
log1p(focal_depth),
                   data = nap_earthquakes, family = binomial)
summary(NapQuakeLog2)
```

```
##
## Call:
## glm(formula = MajorEarthquakes ~ latitude * longitude *
log1p(focal_depth),
##     family = binomial, data = nap_earthquakes)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.6042  -0.3840  -0.3180  -0.2811   2.8802
##
## Coefficients:
##                                       Estimate Std. Error z value
## (Intercept)                         -4.419e+00  6.691e-01  -6.604
## latitude                             2.230e-02  2.024e-02   1.102
## longitude                            1.040e-02  4.632e-03   2.246
## log1p(focal_depth)                   5.237e-01  1.981e-01   2.644
## latitude:longitude                  -1.940e-04  1.254e-04  -1.547
## latitude:log1p(focal_depth)         -9.082e-03  6.404e-03  -1.418
## longitude:log1p(focal_depth)        -3.122e-03  1.383e-03  -2.257
## latitude:longitude:log1p(focal_depth)  5.424e-05  3.849e-05   1.409
##                                     Pr(>|z|)
## (Intercept)                         3.99e-11 ***
## latitude                              0.2706
## longitude                             0.0247 *
## log1p(focal_depth)                    0.0082 **
## latitude:longitude                    0.1218
## latitude:log1p(focal_depth)           0.1562
## longitude:log1p(focal_depth)          0.0240 *
## latitude:longitude:log1p(focal_depth)   0.1588
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 645.01  on 1478  degrees of freedom
## Residual deviance: 629.69  on 1471  degrees of freedom
## AIC: 645.69
##
## Number of Fisher Scoring iterations: 6
```

```
car::Anova(NapQuakeLog2)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                                       LR Chisq Df Pr(>Chisq)
## latitude                                2.5502  1    0.11028
## longitude                               0.0607  1    0.80541
## log1p(focal_depth)                      2.8731  1    0.09007 .
## latitude:longitude                      0.8196  1    0.36529
## latitude:log1p(focal_depth)             2.3995  1    0.12137
## longitude:log1p(focal_depth)            4.5915  1    0.03213 *
## latitude:longitude:log1p(focal_depth)   2.0016  1    0.15713
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
NapQuakeLog3 <-glm(MajorEarthquakes ~ latitude + longitude +
log1p(focal_depth),
                   data = nap_earthquakes, family = binomial)
summary(NapQuakeLog3)
```

```
##
## Call:
## glm(formula = MajorEarthquakes ~ latitude + longitude +
log1p(focal_depth),
##     family = binomial, data = nap_earthquakes)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5515  -0.3719  -0.3288  -0.2974   2.7758
##
## Coefficients:
##                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -3.6023225  0.4562750  -7.895  2.9e-15 ***
## latitude           -0.0048551  0.0036646  -1.325   0.1852
## longitude           0.0003129  0.0008427   0.371   0.7104
## log1p(focal_depth)  0.2584137  0.1319410   1.959   0.0502 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 645.01  on 1478  degrees of freedom
## Residual deviance: 638.14  on 1475  degrees of freedom
## AIC: 646.14
##
## Number of Fisher Scoring iterations: 5
```

```
car::Anova(NapQuakeLog3)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                    LR Chisq Df Pr(>Chisq)
## latitude             1.7466  1    0.18630
## longitude            0.1379  1    0.71036
## log1p(focal_depth)   3.8169  1    0.05074 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
NapQuakeLog4 <-glm(MajorEarthquakes ~ longitude * log1p(focal_depth),
                   data = nap_earthquakes, family = binomial)
summary(NapQuakeLog4)
```

```
##
## Call:
## glm(formula = MajorEarthquakes ~ longitude * log1p(focal_depth),
##     family = binomial, data = nap_earthquakes)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5494  -0.3702  -0.3591  -0.2893   2.9578
##
## Coefficients:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   -3.6670062  0.4837771  -7.580 3.46e-14 ***
## longitude                      0.0055953  0.0033538   1.668   0.0952 .
## log1p(focal_depth)             0.2596796  0.1383545   1.877   0.0605 .
## longitude:log1p(focal_depth) -0.0014087  0.0009525  -1.479   0.1392
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 645.01  on 1478  degrees of freedom
## Residual deviance: 637.64  on 1475  degrees of freedom
## AIC: 645.64
##
## Number of Fisher Scoring iterations: 6
```

```
car::Anova(NapQuakeLog4)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                               LR Chisq Df Pr(>Chisq)
## longitude                       1.0177  1    0.31306
## log1p(focal_depth)              3.3164  1    0.06859 .
## longitude:log1p(focal_depth)    2.2437  1    0.13416
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
NapQuakeLog5 <-glm(MajorEarthquakes ~ log1p(focal_depth),
                   data = nap_earthquakes, family = binomial)
summary(NapQuakeLog5)
```

```
##
## Call:
## glm(formula = MajorEarthquakes ~ log1p(focal_depth), family = binomial,
##     data = nap_earthquakes)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.5115  -0.3540  -0.3396  -0.3040   2.7333
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)          -3.6843     0.4574  -8.056 7.91e-16 ***
## log1p(focal_depth)    0.2639     0.1304   2.024    0.043 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 645.01  on 1478  degrees of freedom
## Residual deviance: 640.90  on 1477  degrees of freedom
## AIC: 644.9
##
## Number of Fisher Scoring iterations: 5
```

```
car::Anova(NapQuakeLog5)
```

```
## Analysis of Deviance Table (Type II tests)
##
## Response: MajorEarthquakes
##                     LR Chisq Df Pr(>Chisq)
## log1p(focal_depth)    4.1106  1    0.04261 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#Predicting using the best model(NapQuakeLog4)
```

```
predictTrain = predict(NapQuakeLog4, type = "response")
summary(predictTrain)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.01160 0.04487 0.06375 0.05680 0.06627 0.14006
```

```
#Are we predicting higher probabilities for Major Earthquakes (>7.0
magnitude?)

tapply(predictTrain, nap_earthquakes$MajorEarthquakes, mean)
```

```
##          0          1
## 0.05652912 0.06121290
```

Looking at the results of the logistic regression for the North American and Pacific plates, it is clear that a logistic regression model better fits this restricted data set rather than the entire earthquakes set. The deviances are 1/10 of the values found in the larger set: deviances hover around 600 as do AIC values, indicating that this is a better fit than when the model is applied to all earthquake data.

Interestingly, when Anova is run across each of the NAP models, we find that focal depth of the earthquake becomes the most significant predictor of when an earthquake's magnitude will exceed 7.0 on the Richter scale. This may be due to the earth settling after a large subduction event, leading to a shallower focal point.

Binomial distributions

```
#binomial distribution for earthquakes1
eq_agg_df <- earthquakes1 %>% group_by(PlateName) %>%
  summarize(TotalMajor = sum(MajorEarthquakes), TotalEarthquakes = n())

bd_model <- glm(cbind(TotalMajor, TotalEarthquakes - TotalMajor) ~ PlateName,
    family=binomial("logit"), data=eq_agg_df)

summary(bd_model)
```

```
##
## Call:
## glm(formula = cbind(TotalMajor, TotalEarthquakes - TotalMajor) ~
##     PlateName, family = binomial("logit"), data = eq_agg_df)
##
## Deviance Residuals:
##  [1]  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
## [24]  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
## [47]  0  0  0  0  0  0
##
## Coefficients:
##                           Estimate Std. Error z value Pr(>|z|)
## (Intercept)            -3.773e+00  7.152e-01  -5.275 1.33e-07 ***
## PlateNameAfrica         5.919e-02  8.260e-01   0.072   0.9429
## PlateNameAltiplano      5.341e-01  7.845e-01   0.681   0.4960
```

```
## PlateNameAmur            1.288e+00  7.810e-01   1.649   0.0992 .
## PlateNameAnatolia       -2.703e-01  1.237e+00  -0.219   0.8270
## PlateNameAntarctica     -2.022e-01  7.723e-01  -0.262   0.7934
## PlateNameArabia          3.509e-02  1.239e+00   0.028   0.9774
## PlateNameAustralia       5.294e-01  7.323e-01   0.723   0.4697
## PlateNameBalmoral Reef  -2.325e+01  1.494e+05   0.000   0.9999
## PlateNameBanda Sea       7.029e-01  7.694e-01   0.914   0.3609
## PlateNameBirds Head      6.747e-01  7.693e-01   0.877   0.3805
## PlateNameBurma           5.104e-01  7.917e-01   0.645   0.5192
## PlateNameCaribbean       7.770e-01  7.696e-01   1.010   0.3127
## PlateNameCaroline       -2.365e+01  1.459e+05   0.000   0.9999
## PlateNameCocos          -2.476e+01  1.416e+05   0.000   0.9999
## PlateNameConway Reef     1.618e-01  1.240e+00   0.130   0.8962
## PlateNameEaster         -2.446e+01  1.423e+05   0.000   0.9999
## PlateNameEurasia         8.833e-01  7.272e-01   1.215   0.2245
## PlateNameFutuna         -2.383e+01  1.448e+05   0.000   0.9999
## PlateNameGalapagos      -2.213e+01  1.807e+05   0.000   0.9999
## PlateNameIndia           1.120e+00  7.865e-01   1.423   0.1546
## PlateNameJuan de Fuca    5.147e-01  9.261e-01   0.556   0.5784
## PlateNameJuan Fernandez  1.288e+00  1.263e+00   1.020   0.3078
## PlateNameKermadec        5.024e-01  7.437e-01   0.676   0.4993
## PlateNameManus          -2.430e+01  1.428e+05   0.000   0.9999
## PlateNameMaoke           1.154e+00  8.153e-01   1.416   0.1568
## PlateNameMariana         4.304e-01  8.120e-01   0.530   0.5961
## PlateNameMolucca Sea     1.236e+00  7.672e-01   1.611   0.1073
## PlateNameNazca          -1.158e+00  1.008e+00  -1.149   0.2504
## PlateNameNew Hebrides    9.435e-01  7.315e-01   1.290   0.1971
## PlateNameNiuafo'ou      -1.197e+00  1.232e+00  -0.971   0.3313
## PlateNameNorth America   7.185e-01  7.267e-01   0.989   0.3228
## PlateNameNorth Andes     1.271e+00  7.872e-01   1.615   0.1063
## PlateNameNorth Bismarck  8.208e-01  7.659e-01   1.072   0.2839
## PlateNameOkhotsk         7.015e-01  7.253e-01   0.967   0.3334
## PlateNameOkinawa        -2.659e-01  8.752e-01  -0.304   0.7613
## PlateNamePacific         9.038e-01  7.239e-01   1.248   0.2119
## PlateNamePanama          1.146e+00  8.308e-01   1.379   0.1679
## PlateNamePhilippine Sea  6.470e-01  7.417e-01   0.872   0.3831
## PlateNameRivera         -2.467e+01  1.418e+05   0.000   0.9999
## PlateNameSandwich       -1.194e+00  1.007e+00  -1.185   0.2361
## PlateNameScotia          1.208e+00  9.330e-01   1.295   0.1955
## PlateNameShetland       -2.343e+01  1.476e+05   0.000   0.9999
## PlateNameSolomon Sea     1.357e+00  8.540e-01   1.589   0.1121
## PlateNameSomalia        -3.299e-01  1.010e+00  -0.327   0.7439
## PlateNameSouth America   1.036e+00  7.248e-01   1.429   0.1530
## PlateNameSouth Bismarck  4.503e-01  7.474e-01   0.603   0.5468
## PlateNameSunda           5.394e-01  7.266e-01   0.742   0.4579
## PlateNameTimor           2.562e-01  8.265e-01   0.310   0.7565
## PlateNameTonga          -4.303e-01  7.901e-01  -0.545   0.5860
## PlateNameWoodlark        8.416e-01  8.020e-01   1.049   0.2940
## PlateNameYangtze        -2.478e+01  1.416e+05   0.000   0.9999
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 1.3748e+02  on 51  degrees of freedom
## Residual deviance: 3.4186e-10  on  0  degrees of freedom
## AIC: 272.14
##
## Number of Fisher Scoring iterations: 24
```

```
#measuring relative & absolute effects of binomial distributions

exp(coef(bd_model))  #relative effects
```

```
##             (Intercept)         PlateNameAfrica      PlateNameAltiplano
##            2.298851e-02            1.060976e+00            1.705882e+00
##           PlateNameAmur       PlateNameAnatolia     PlateNameAntarctica
##            3.625000e+00            7.631579e-01            8.169014e-01
##         PlateNameArabia      PlateNameAustralia  PlateNameBalmoral Reef
##            1.035714e+00            1.697955e+00            7.966861e-11
##      PlateNameBanda Sea     PlateNameBirds Head          PlateNameBurma
##            2.019643e+00            1.963542e+00            1.665957e+00
##      PlateNameCaribbean       PlateNameCaroline          PlateNameCocos
##            2.175000e+00            5.366257e-11            1.773640e-11
##    PlateNameConway Reef         PlateNameEaster        PlateNameEurasia
##            1.175676e+00            2.394181e-11            2.418870e+00
##         PlateNameFutuna      PlateNameGalapagos          PlateNameIndia
##            4.487015e-11            2.450312e-10            3.063380e+00
##   PlateNameJuan de Fuca PlateNameJuan Fernandez       PlateNameKermadec
##            1.673077e+00            3.625000e+00            1.652736e+00
##          PlateNameManus          PlateNameMaoke        PlateNameMariana
##            2.802736e-11            3.171875e+00            1.537879e+00
##    PlateNameMolucca Sea          PlateNameNazca   PlateNameNew Hebrides
##            3.440678e+00            3.140794e-01            2.568898e+00
##      PlateNameNiuafo'ou  PlateNameNorth America    PlateNameNorth Andes
##            3.020833e-01            2.051272e+00            3.565574e+00
## PlateNameNorth Bismarck        PlateNameOkhotsk        PlateNameOkinawa
##            2.272388e+00            2.016742e+00            7.665198e-01
##        PlateNamePacific         PlateNamePanama PlateNamePhilippine Sea
##            2.468919e+00            3.144578e+00            1.909756e+00
##         PlateNameRivera       PlateNameSandwich         PlateNameScotia
##            1.941369e-11            3.031359e-01            3.346154e+00
##       PlateNameShetland    PlateNameSolomon Sea        PlateNameSomalia
##            6.673562e-11            3.883929e+00            7.190083e-01
##  PlateNameSouth America PlateNameSouth Bismarck          PlateNameSunda
##            2.817073e+00            1.568852e+00            1.714956e+00
##          PlateNameTimor          PlateNameTonga       PlateNameWoodlark
##            1.292079e+00            6.503322e-01            2.320000e+00
##        PlateNameYangtze
##            1.736140e-11
```

```r
plogis(-3.773)
```

```
## [1] 0.02246666
```

```r
plogis(-3.773 + coef(bd_model)) #absolute effects
```

```
##             (Intercept)         PlateNameAfrica      PlateNameAltiplano
##            5.280661e-04            2.380397e-02            3.772717e-02
##           PlateNameAmur       PlateNameAnatolia     PlateNameAntarctica
##            7.690610e-02            1.723733e-02            1.842885e-02
##         PlateNameArabia      PlateNameAustralia  PlateNameBalmoral Reef
##            2.325038e-02            3.755844e-02            1.831024e-12
##      PlateNameBanda Sea     PlateNameBirds Head          PlateNameBurma
##            4.435847e-02            4.317949e-02            3.687675e-02
##      PlateNameCaribbean       PlateNameCaroline          PlateNameCocos
##            4.760821e-02            1.233327e-12            4.076358e-13
##    PlateNameConway Reef         PlateNameEaster        PlateNameEurasia
##            2.630966e-02            5.502548e-13            5.266510e-02
##         PlateNameFutuna      PlateNameGalapagos          PlateNameIndia
##            1.031251e-12            5.631556e-12            6.577478e-02
##   PlateNameJuan de Fuca PlateNameJuan Fernandez       PlateNameKermadec
##            3.702851e-02            7.690610e-02            3.659479e-02
##          PlateNameManus          PlateNameMaoke        PlateNameMariana
##            6.441532e-13            6.794602e-02            3.413846e-02
##    PlateNameMolucca Sea          PlateNameNazca   PlateNameNew Hebrides
##            7.328219e-02            7.166758e-03            5.574950e-02
##      PlateNameNiuafo'ou  PlateNameNorth America    PlateNameNorth Andes
##            6.894915e-03            4.502189e-02            7.574084e-02
## PlateNameNorth Bismarck        PlateNameOkhotsk        PlateNameOkinawa
##            4.963411e-02            4.429757e-02            1.731195e-02
##        PlateNamePacific         PlateNamePanama PlateNamePhilippine Sea
##            5.369629e-02            6.740070e-02            4.204644e-02
##         PlateNameRivera       PlateNameSandwich         PlateNameScotia
##            4.461850e-13            6.918772e-03            7.141272e-02
##       PlateNameShetland    PlateNameSolomon Sea        PlateNameSomalia
##            1.533786e-12            8.194923e-02            1.625634e-02
##  PlateNameSouth America PlateNameSouth Bismarck          PlateNameSunda
##            6.080783e-02            3.480210e-02            3.792024e-02
##          PlateNameTimor          PlateNameTonga       PlateNameWoodlark
##            2.883946e-02            1.472648e-02            5.062142e-02
##        PlateNameYangtze
##            3.990172e-13
```

```r
#binomial distribution for nap_earthquakes
eq_agg_df_nap <- nap_earthquakes %>% group_by(PlateName) %>%
  summarize(TotalMajor = sum(MajorEarthquakes), TotalEarthquakes = n())

nap_model <- glm(cbind(TotalMajor, TotalEarthquakes - TotalMajor) ~
PlateName,
    family = binomial("logit"), data = eq_agg_df_nap)
```

```r
summary(nap_model)
```

```
##
## Call:
## glm(formula = cbind(TotalMajor, TotalEarthquakes - TotalMajor) ~
##     PlateName, family = binomial("logit"), data = eq_agg_df_nap)
##
## Deviance Residuals:
## [1]  0  0
##
## Coefficients:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)      -2.82138    0.16275 -17.335   <2e-16 ***
## PlateNamePacific  0.02216    0.22494   0.099    0.922
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance:  9.7074e-03  on 1  degrees of freedom
## Residual deviance: -2.1561e-13  on 0  degrees of freedom
## AIC: 15.04
##
## Number of Fisher Scoring iterations: 3
```

```r
#measuring relative & absolute effects of binomial distributions for nap data

exp(coef(nap_model))  #relative effects
```

```
##      (Intercept) PlateNamePacific
##       0.05952381       1.02240664
```

```r
plogis(-2.82138)
```

```
## [1] 0.05617972
```

```r
plogis(-2.82138 + coef(nap_model)) #absolute effects
```

```
##      (Intercept) PlateNamePacific
##      0.003530571      0.057366302
```

From the binomial regression of all earthquakes, it is clear to see that this model is a better fit than either the linear reression or the logistic regression. Plates that have subduction boundaries have coefficients closest to zero while plates with little movement or smaller, transverse boundaries have large coefficients, indicating their lower likelihood of experiencing a major tremor. Additionally, we find that the relative and absolute effects of each plate in this distribution are minimal, with the majority of values very close to zero. This data again makes sense as the effect each plate would have on the total of major earthquakes would be minimal given the number of tectonic plates.

However, things get more interesting when applying the binomial distribution to the North American/Pacific plates. In this model, the residual deviance is extremely low, indicating that this model is a good fit for the data (as opposed to the binomial regression for the full earthquake data, which had a high deviance). When the relative and absolute effects of this model were calculated, they were shown to be more significant than the model for all earthquakes; the relative effects returned a coefficient of 1.02 while the absolute effect returned a coefficient of 0.06. These values reinforce the concept that a more active plate, such as the Pacific plate, would have a higher impact on the total of major earthquakes than a less active plate, such as the North American plate (which usually only experiences major tremors as a result of the Pacific plate subducting under it, causing the North American plate to be pushed up).

Poisson Models

```
#Poisson distribution for earthquakes1

p_model <- glm(TotalMajor ~ PlateName, family=poisson("log"), data=eq_agg_df)

summary(p_model)

##
## Call:
## glm(formula = TotalMajor ~ PlateName, family = poisson("log"),
##     data = eq_agg_df)
##
## Deviance Residuals:
##  [1]  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
## [24]  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
## [47]  0  0  0  0  0  0
##
## Coefficients:
##                            Estimate Std. Error z value Pr(>|z|)
## (Intercept)              6.931e-01  7.071e-01   0.980 0.326959
## PlateNameAfrica          1.099e+00  8.165e-01   1.346 0.178457
## PlateNameAltiplano       1.609e+00  7.746e-01   2.078 0.037730 *
## PlateNameAmur            1.705e+00  7.687e-01   2.218 0.026576 *
## PlateNameAnatolia       -6.931e-01  1.225e+00  -0.566 0.571426
## PlateNameAntarctica      1.792e+00  7.638e-01   2.346 0.018978 *
## PlateNameArabia         -6.931e-01  1.225e+00  -0.566 0.571426
## PlateNameAustralia       3.045e+00  7.237e-01   4.207 2.59e-05 ***
## PlateNameBalmoral Reef  -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameBanda Sea       1.872e+00  7.596e-01   2.464 0.013727 *
## PlateNameBirds Head      1.872e+00  7.596e-01   2.464 0.013727 *
## PlateNameBurma           1.504e+00  7.817e-01   1.924 0.054352 .
## PlateNameCaribbean       1.872e+00  7.596e-01   2.464 0.013727 *
## PlateNameCaroline       -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameCocos          -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameConway Reef    -6.931e-01  1.225e+00  -0.566 0.571426
## PlateNameEaster         -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameEurasia         3.418e+00  7.186e-01   4.756 1.97e-06 ***
```

```
## PlateNameFutuna          -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameGalapagos       -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameIndia            1.609e+00  7.746e-01   2.078 0.037730 *
## PlateNameJuan de Fuca     4.055e-01  9.129e-01   0.444 0.656923
## PlateNameJuan Fernandez -6.931e-01  1.225e+00  -0.566 0.571426
## PlateNameKermadec         2.526e+00  7.348e-01   3.437 0.000588 ***
## PlateNameManus           -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameMaoke            1.253e+00  8.018e-01   1.562 0.118177
## PlateNameMariana          1.253e+00  8.018e-01   1.562 0.118177
## PlateNameMolucca Sea      1.946e+00  7.559e-01   2.574 0.010047 *
## PlateNameNazca           -1.636e-14  1.000e+00   0.000 1.000000
## PlateNameNew Hebrides     3.114e+00  7.226e-01   4.308 1.64e-05 ***
## PlateNameNiuafo'ou       -6.931e-01  1.225e+00  -0.566 0.571426
## PlateNameNorth America    3.450e+00  7.182e-01   4.803 1.56e-06 ***
## PlateNameNorth Andes      1.609e+00  7.746e-01   2.078 0.037730 *
## PlateNameNorth Bismarck   1.946e+00  7.559e-01   2.574 0.010047 *
## PlateNameOkhotsk          3.584e+00  7.169e-01   4.999 5.77e-07 ***
## PlateNameOkinawa          6.931e-01  8.660e-01   0.800 0.423492
## PlateNamePacific          3.738e+00  7.155e-01   5.224 1.75e-07 ***
## PlateNamePanama           1.099e+00  8.165e-01   1.346 0.178457
## PlateNamePhilippine Sea   2.603e+00  7.328e-01   3.552 0.000383 ***
## PlateNameRivera          -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameSandwich        -1.440e-14  1.000e+00   0.000 1.000000
## PlateNameScotia           4.055e-01  9.129e-01   0.444 0.656923
## PlateNameShetland        -2.500e+01  1.148e+05   0.000 0.999826
## PlateNameSolomon Sea      9.163e-01  8.367e-01   1.095 0.273439
## PlateNameSomalia         -1.168e-14  1.000e+00   0.000 1.000000
## PlateNameSouth America    3.651e+00  7.162e-01   5.097 3.45e-07 ***
## PlateNameSouth Bismarck   2.398e+00  7.385e-01   3.247 0.001167 **
## PlateNameSunda            3.450e+00  7.182e-01   4.803 1.56e-06 ***
## PlateNameTimor            1.099e+00  8.165e-01   1.346 0.178457
## PlateNameTonga            1.504e+00  7.817e-01   1.924 0.054352 .
## PlateNameWoodlark         1.386e+00  7.906e-01   1.754 0.079510 .
## PlateNameYangtze         -2.500e+01  1.148e+05   0.000 0.999826
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 1.3109e+03  on 51  degrees of freedom
## Residual deviance: 5.5789e-10  on  0  degrees of freedom
## AIC: 273.96
##
## Number of Fisher Scoring iterations: 22

exp(coef(p_model))

##             (Intercept)         PlateNameAfrica      PlateNameAltiplano
##            2.000000e+00            3.000000e+00            5.000000e+00
##           PlateNameAmur       PlateNameAnatolia     PlateNameAntarctica
```

```
##            5.500000e+00            5.000000e-01            6.000000e+00
##         PlateNameArabia      PlateNameAustralia  PlateNameBalmoral Reef
##            5.000000e-01            2.100000e+01            1.394734e-11
##      PlateNameBanda Sea     PlateNameBirds Head          PlateNameBurma
##            6.500000e+00            6.500000e+00            4.500000e+00
##      PlateNameCaribbean       PlateNameCaroline          PlateNameCocos
##            6.500000e+00            1.394734e-11            1.394734e-11
##    PlateNameConway Reef         PlateNameEaster        PlateNameEurasia
##            5.000000e-01            1.394734e-11            3.050000e+01
##         PlateNameFutuna      PlateNameGalapagos          PlateNameIndia
##            1.394734e-11            1.394734e-11            5.000000e+00
##   PlateNameJuan de Fuca PlateNameJuan Fernandez       PlateNameKermadec
##            1.500000e+00            5.000000e-01            1.250000e+01
##          PlateNameManus          PlateNameMaoke        PlateNameMariana
##            1.394734e-11            3.500000e+00            3.500000e+00
##    PlateNameMolucca Sea          PlateNameNazca   PlateNameNew Hebrides
##            7.000000e+00            1.000000e+00            2.250000e+01
##      PlateNameNiuafo'ou  PlateNameNorth America    PlateNameNorth Andes
##            5.000000e-01            3.150000e+01            5.000000e+00
## PlateNameNorth Bismarck        PlateNameOkhotsk        PlateNameOkinawa
##            7.000000e+00            3.600000e+01            2.000000e+00
##        PlateNamePacific         PlateNamePanama PlateNamePhilippine Sea
##            4.200000e+01            3.000000e+00            1.350000e+01
##         PlateNameRivera       PlateNameSandwich         PlateNameScotia
##            1.394734e-11            1.000000e+00            1.500000e+00
##       PlateNameShetland    PlateNameSolomon Sea        PlateNameSomalia
##            1.394734e-11            2.500000e+00            1.000000e+00
##  PlateNameSouth America PlateNameSouth Bismarck          PlateNameSunda
##            3.850000e+01            1.100000e+01            3.150000e+01
##          PlateNameTimor          PlateNameTonga       PlateNameWoodlark
##            3.000000e+00            4.500000e+00            4.000000e+00
##        PlateNameYangtze
##            1.394734e-11
```

```
#Poisson distribution for nap_earthquakes

nap_p_model <- glm(TotalMajor ~ PlateName, family = poisson("log"),
                   data = eq_agg_df_nap)

summary(nap_p_model)
```

```
##
## Call:
## glm(formula = TotalMajor ~ PlateName, family = poisson("log"),
##     data = eq_agg_df_nap)
##
## Deviance Residuals:
## [1]  0  0
##
## Coefficients:
```

```
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)        3.68888    0.15811  23.331   <2e-16 ***
## PlateNamePacific   0.09531    0.21847   0.436    0.663
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##     Null deviance: 1.9055e-01  on 1  degrees of freedom
## Residual deviance: 4.4409e-15  on 0  degrees of freedom
## AIC: 15.157
##
## Number of Fisher Scoring iterations: 2
```

```
exp(coef(nap_p_model))
```

```
##      (Intercept) PlateNamePacific
##             40.0              1.1
```

Since the Poisson model works better for data that does not follow a normal distribution, it is clear from the deviance (close to zero) that this is the best model for the world earthquake data. Looking at the results of the Poisson models, we see there is a very slight increase in the probability of a major earthquake on each plate using this prediction model.

In applying the model to the restricted NAP data set, we again find a very low deviance, indicating that this would be a good model for this data set as well. The coefficient for the Pacific plate in this model gives a 10% probability of a major earthquake occurring on this plate.

Conclusion

After gathering and analyzing two data sets covering global earthquakes with a magnitude of 5.5 or higher (as measured by the Richter scale), a relationship was found to exist between magnitude and longitude as well as magnitude and focal depth. Given what is known about earthquakes, this information is not surprising as subduction zones often occur along the longitudinal lines that create a border along the Pacifc tectonic plate, a part of the Ring of Fire.

Out of the four types of models created, the best model was the Poisson model. The Poisson model gave the probability of occurance of a tremor with a magnitude of 7.0 or greater, depending on the tectonic plate location. However, even with this probability, there is significant room to improve the possibility of earthquake prediction, as the Poisson model does not indicate where the quake may occur.

For future analysis, I would propose a few additions. The first modification to this analysis would be to analyze the data using a time series model as this may show a relationship between the time different earthquakes occurred on a given plate, as well as their locations. This type of analysis would likely work best on a plate that has similar to characteristics the Pacific plate: large numbers of significant quakes (magnitude 5.5 or larger), constantly

moving, a variety of types of fault zones. Another addition would include adding a data set that classifies the type of fault zone and to run an analysis on how fault zone impacts magnitude. Current geologic knowledge indicates that subduction zones cause the largest quakes; however, the amount of time that earthquakes have been able to be accurately measured is small when compared to the geologic timeline and it is possible that a strike-slip fault may also trigger less-frequent major quakes. The last addition would be a mixed effects model where the data would be analyzed to attempt to establish any possible patterns that may exist between subgroups of data (such as plate location).