Importing Libraries

In [41]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import warnings

warnings.filterwarnings("ignore")
plt.style.use("ggplot")
sns.set(style="dark")
sns.set_theme("talk")
```

Importing Dataset

In [6]:
```
data=pd.read_csv("C:\\Users\\PAWAN\\DS\\Python\\project\\earthquake_data_tsuna
```

Time-Based Analysis

Exploring Dataset

In [7]:
```
data.head()
```

Out[7]:

	magnitude	cdi	mmi	sig	nst	dmin	gap	depth	latitude	longitude	Year	Month	tsuna
0	7.0	8	7	768	117	0.509	17.0	14.000	-9.7963	159.596	2022	11	
1	6.9	4	4	735	99	2.229	34.0	25.000	-4.9559	100.738	2022	11	
2	7.0	3	3	755	147	3.125	18.0	579.000	-20.0508	-178.346	2022	11	
3	7.3	5	5	833	149	1.865	21.0	37.000	-19.2918	-172.129	2022	11	
4	6.6	0	2	670	131	4.998	27.0	624.464	-25.5948	178.278	2022	11	

In [17]:
```
data.columns
```

Out[17]:
```
Index(['magnitude', 'cdi', 'mmi', 'sig', 'nst', 'dmin', 'gap', 'depth',
       'latitude', 'longitude', 'Year', 'Month', 'tsunami'],
      dtype='object')
```

In [8]:
```
data.shape
```

Out[8]:
```
(782, 13)
```

In [9]:
```python
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 782 entries, 0 to 781
Data columns (total 13 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   magnitude  782 non-null    float64
 1   cdi        782 non-null    int64  
 2   mmi        782 non-null    int64  
 3   sig        782 non-null    int64  
 4   nst        782 non-null    int64  
 5   dmin       782 non-null    float64
 6   gap        782 non-null    float64
 7   depth      782 non-null    float64
 8   latitude   782 non-null    float64
 9   longitude  782 non-null    float64
 10  Year       782 non-null    int64  
 11  Month      782 non-null    int64  
 12  tsunami    782 non-null    int64  
dtypes: float64(6), int64(7)
memory usage: 79.6 KB
```

In [10]:
```python
data.describe()
```

Out[10]:

	magnitude	cdi	mmi	sig	nst	dmin	gap	
count	782.000000	782.000000	782.000000	782.000000	782.000000	782.000000	782.000000	78
mean	6.941125	4.333760	5.964194	870.108696	230.250639	1.325757	25.038990	7
std	0.445514	3.169939	1.462724	322.465367	250.188177	2.218805	24.225067	13
min	6.500000	0.000000	1.000000	650.000000	0.000000	0.000000	0.000000	
25%	6.600000	0.000000	5.000000	691.000000	0.000000	0.000000	14.625000	1
50%	6.800000	5.000000	6.000000	754.000000	140.000000	0.000000	20.000000	2
75%	7.100000	7.000000	7.000000	909.750000	445.000000	1.863000	30.000000	4
max	9.100000	9.000000	9.000000	2910.000000	934.000000	17.654000	239.000000	67

In [13]:
```
data.isnull().sum()
```

Out[13]:
```
magnitude    0
cdi          0
mmi          0
sig          0
nst          0
dmin         0
gap          0
depth        0
latitude     0
longitude    0
Year         0
Month        0
tsunami      0
dtype: int64
```

In [15]:
```
data["tsunami"].value_counts()
```

Out[15]:
```
tsunami
0    478
1    304
Name: count, dtype: int64
```

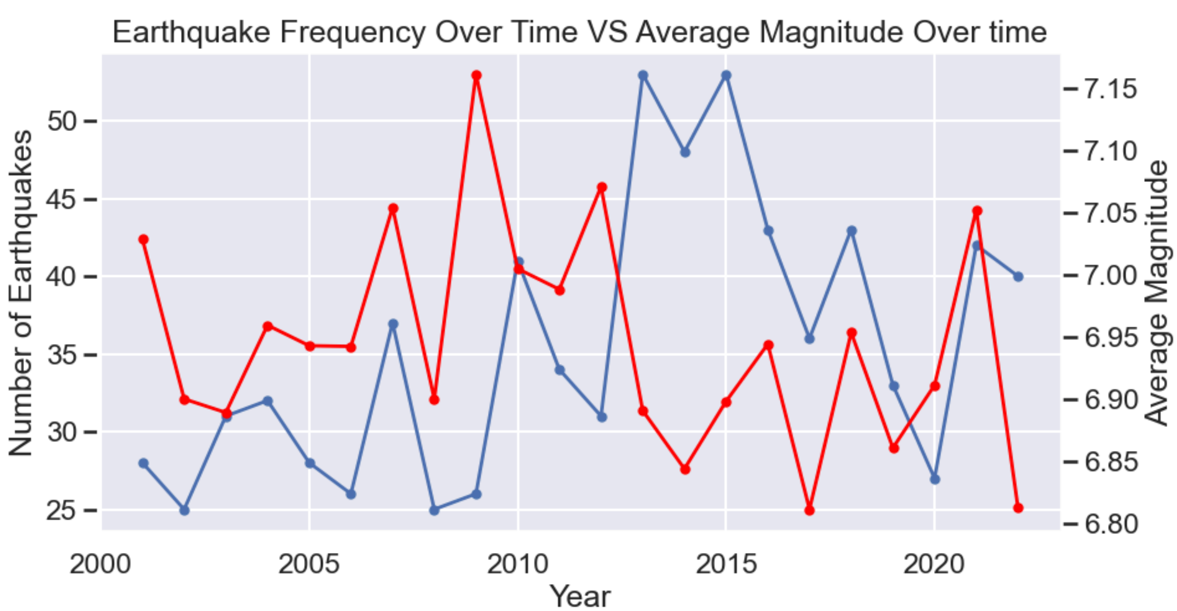
In [77]:
```
freq_per_year = data["Year"].value_counts().sort_index()
avg_magn_year = data.groupby("Year")["magnitude"].mean()
freq_per_year
```

Out[77]:
```
Year
2001    28
2002    25
2003    31
2004    32
2005    28
2006    26
2007    37
2008    25
2009    26
2010    41
2011    34
2012    31
2013    53
2014    48
2015    53
2016    43
2017    36
2018    43
2019    33
2020    27
2021    42
2022    40
Name: count, dtype: int64
```

Identify any trends in the frequency or magnitude of earthquakes over time.

1. Earthquake Frequency Over Time

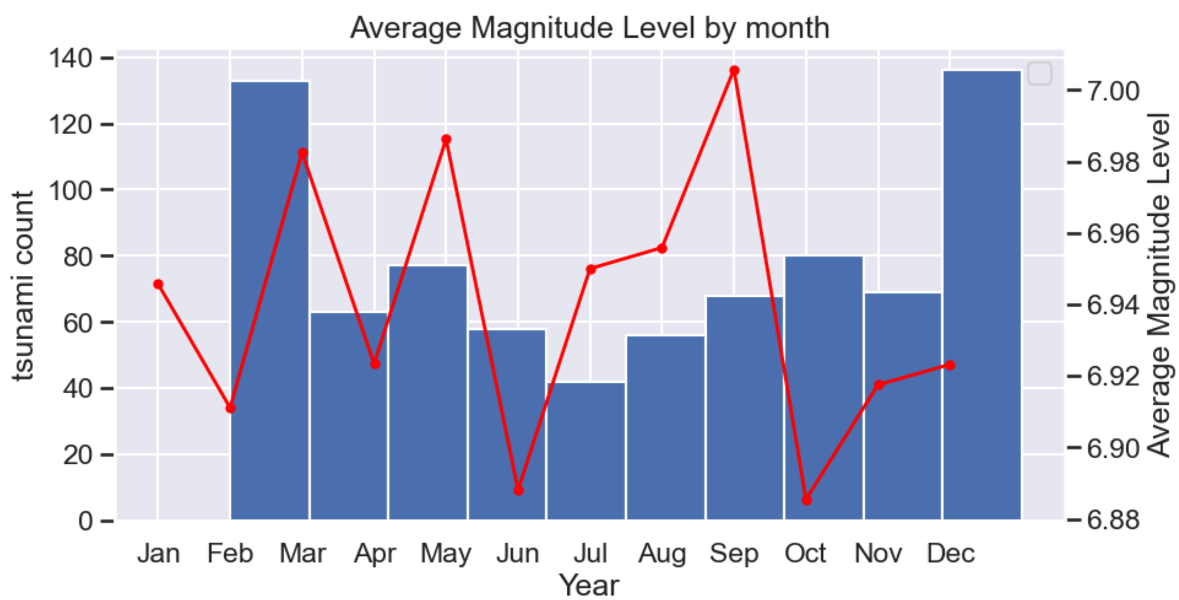
In [116]:
```
fig,ax1 = plt.subplots(figsize=(10,5))
ax1.plot(freq_per_year.index,freq_per_year.values,marker="o",linewidth=2,marke
ax1.set_xlabel('Year')
ax1.set_ylabel('Number of Earthquakes')
ax1.set_title("Earthquake Frequency Over Time VS Average Magnitude Over time")


ax2 = ax1.twinx()
ax2.plot(avg_magn_year.index,avg_magn_year.values,marker="o",color="red",linew
ax2.set_xlabel('Year')
ax2.set_ylabel('Average Magnitude')
ax2.grid(False)

plt.show()
```



2. Magnitude Over Month

In [ ]:
```
import calendar

avg_magnitude_by_month= data.groupby("Month")["magnitude"].mean()
earthquakes_count_by_month= data.groupby("Month")["Month"].value_counts()

month_list=[calendar.month_abbr[m] for m in avg_magnitude_by_month.index]
```

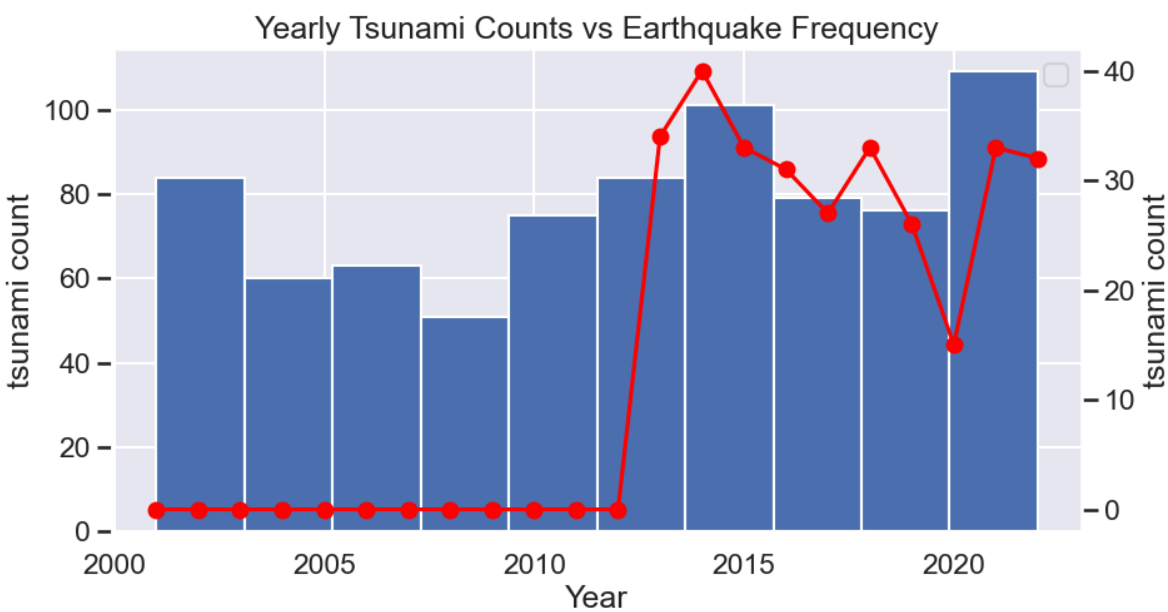
In [132]:
```
fig, ax1=plt.subplots(figsize=(10,5))
ax1.hist(data["Month"])
ax1.set_xlabel('Year')
ax1.set_ylabel('tsunami count')


ax2=ax1.twinx()
ax2.plot(month_list,avg_magnitude_by_month.values,marker="o",color="red",linew
ax2.set_xlabel('Month')
ax2.set_ylabel('Average Magnitude Level')

ax2.set_title('Average Magnitude Level by month')
ax2.grid(False)

plt.legend()
plt.show()
```



3. Yearly Tsunami Counts vs Earthquake Frequency

In [71]:
```
Tsunami_Count_Per_Year=data.groupby("Year")["tsunami"].sum()
```

In [131]:
```
fig, ax1=plt.subplots(figsize=(10,5))
ax1.hist(data["Year"])
ax1.set_xlabel('Year')
ax1.set_ylabel('tsunami count')


ax2=ax1.twinx()
ax2.plot(Tsunami_Count_Per_Year.index,Tsunami_Count_Per_Year.values,marker="o"
ax2.set_xlabel('Year')
ax2.set_ylabel('tsunami count')
ax2.set_title("Yearly Tsunami Counts vs Earthquake Frequency")
ax2.grid(False)

plt.legend()
plt.show()
```

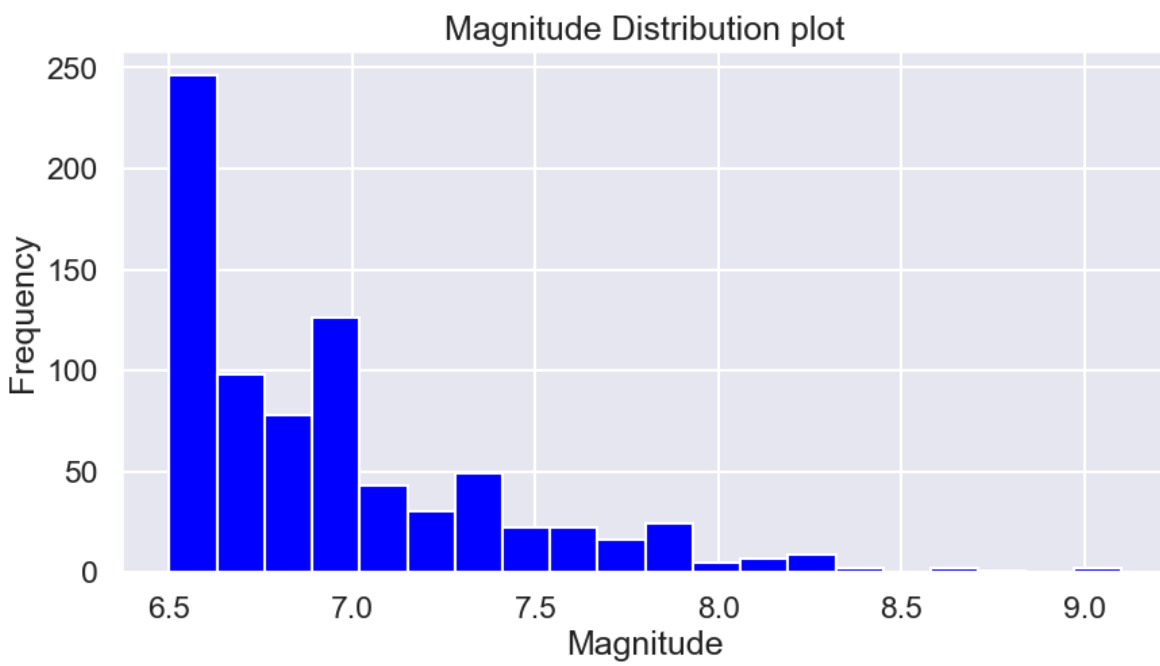


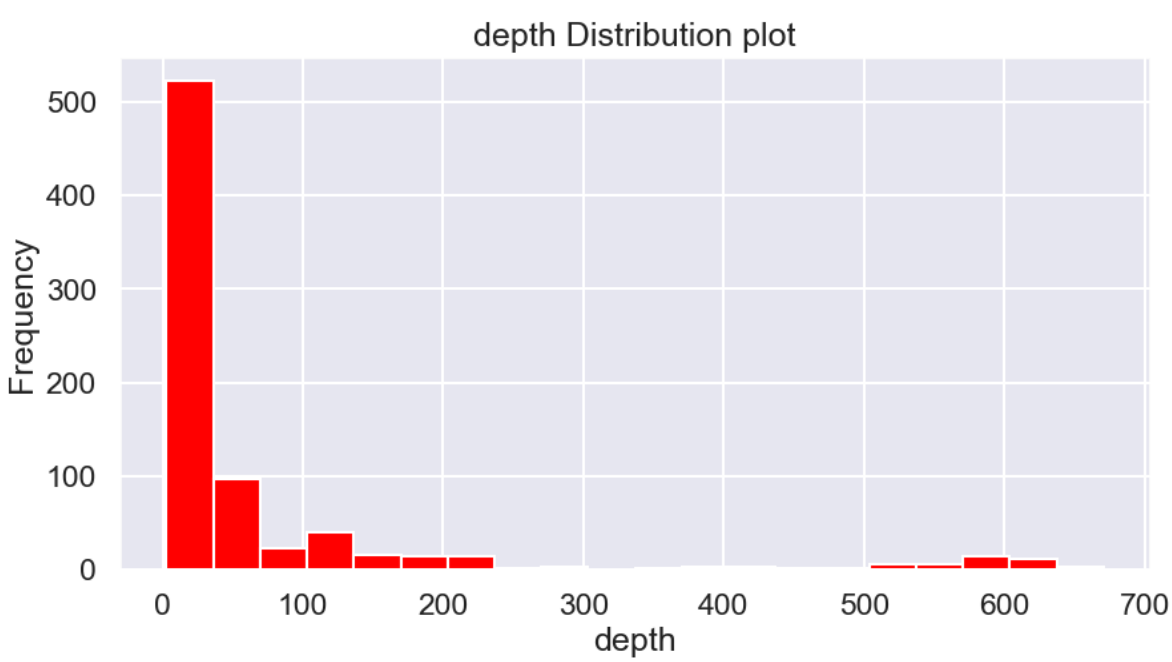
2. Magnitude and Depth Analysis:

2.2 Analyze the distribution of earthquake magnitudes and depths.

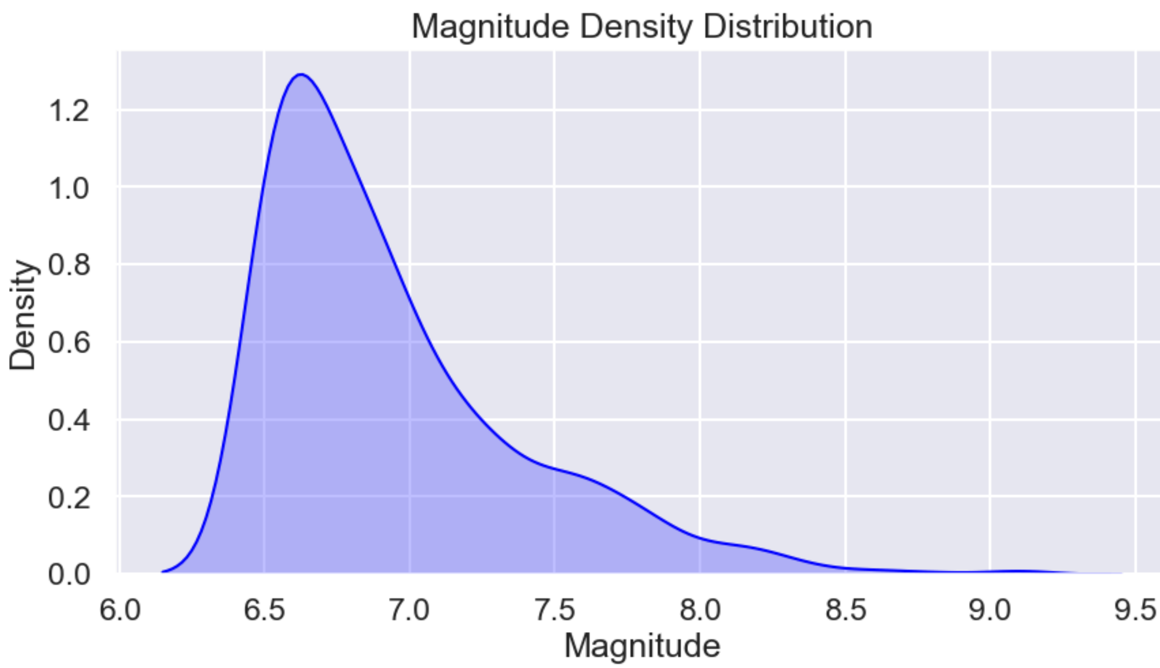
In [130]:
```
plt.figure(figsize=(10,5))
plt.hist(data["magnitude"],bins=20,color="blue")
plt.xlabel("Magnitude")
plt.ylabel("Frequency")
plt.title("Magnitude Distribution plot")

plt.figure(figsize=(10,5))
plt.hist(data["depth"],bins=20,color="red")
plt.xlabel("depth")
plt.ylabel("Frequency")
plt.title("depth Distribution plot")
```

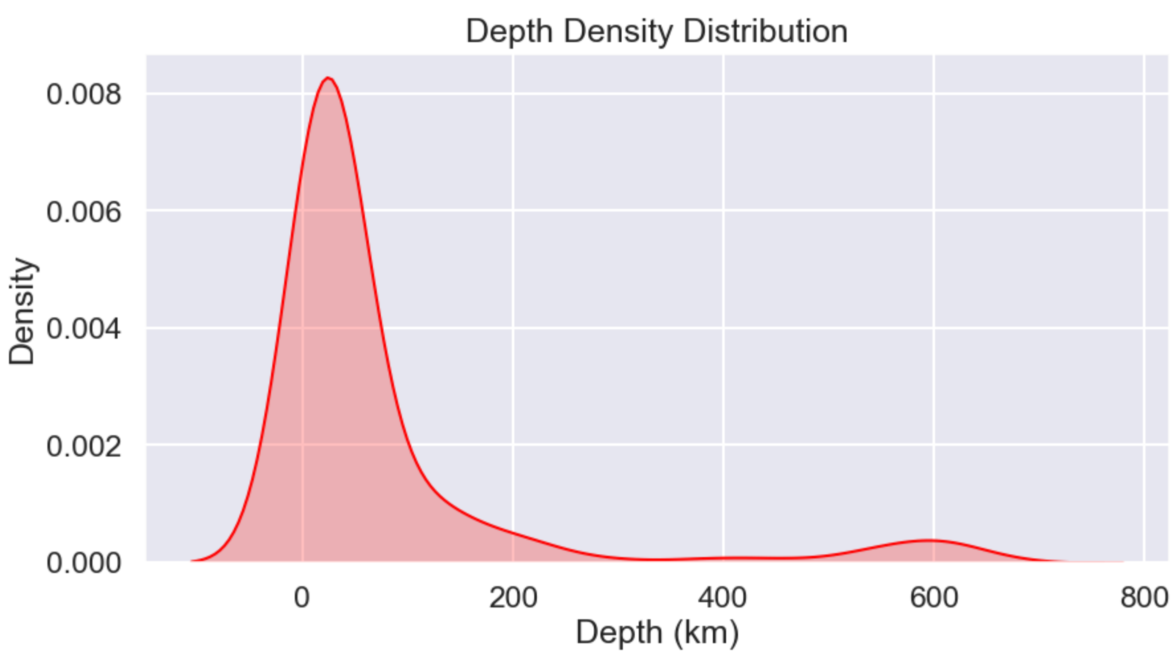
Out[130]:
```
Text(0.5, 1.0, 'depth Distribution plot')
```





In [133]:
```
plt.figure(figsize=(10,5))
sns.kdeplot(data['magnitude'], shade=True, color='blue')
plt.title('Magnitude Density Distribution')
plt.xlabel('Magnitude')
plt.show()

plt.figure(figsize=(10,5))
sns.kdeplot(data['depth'], shade=True, color='red')
plt.title('Depth Density Distribution')
plt.xlabel('Depth (km)')
plt.show()
```





Compare the average magnitude and depth of tsunami vs. non-tsunami events.

In [140]:
```
avg_magnitude=data["magnitude"][data["tsunami"]==1].mean()
avg_magnitude_non=data["magnitude"][data["tsunami"]==0].mean()

avg_depth=data["depth"][data["tsunami"]==1].mean()
avg_depth_non=data["depth"][data["tsunami"]==0].mean()
```

In [141]:
```
print("Average Magnitude:")
print(f"Tsunami: {avg_magnitude:.2f}, Non-Tsunami: {avg_magnitude_non:.2f}")

print("\nAverage Depth (km):")
print(f"Tsunami: {avg_depth:.2f}, Non-Tsunami: {avg_depth_non:.2f}")
```

```
Average Magnitude:
Tsunami: 6.94, Non-Tsunami: 6.94

Average Depth (km):
Tsunami: 85.66, Non-Tsunami: 69.67
```

Highlight major earthquakes (≥8.0) and their characteristics.

In [143]:
```
major_eq=data[data["magnitude"]>=0.8]
major_eq[['Year', 'Month', 'magnitude', 'depth', 'latitude', 'longitude', 'tsu
```

Out[143]:

	Year	Month	magnitude	depth	latitude	longitude	tsunami
0	2022	11	7.0	14.000	-9.7963	159.596	1
1	2022	11	6.9	25.000	-4.9559	100.738	0
2	2022	11	7.0	579.000	-20.0508	-178.346	1
3	2022	11	7.3	37.000	-19.2918	-172.129	1
4	2022	11	6.6	624.464	-25.5948	178.278	1

In [144]:
```
print("Major Earthquake Statistics:")
print(major_eq[['magnitude', 'depth']].describe())
```

```
Major Earthquake Statistics:
        magnitude       depth
count  782.000000  782.000000
mean     6.941125   75.883199
std      0.445514  137.277078
min      6.500000    2.700000
25%      6.600000   14.000000
50%      6.800000   26.295000
75%      7.100000   49.750000
max      9.100000  670.810000
```

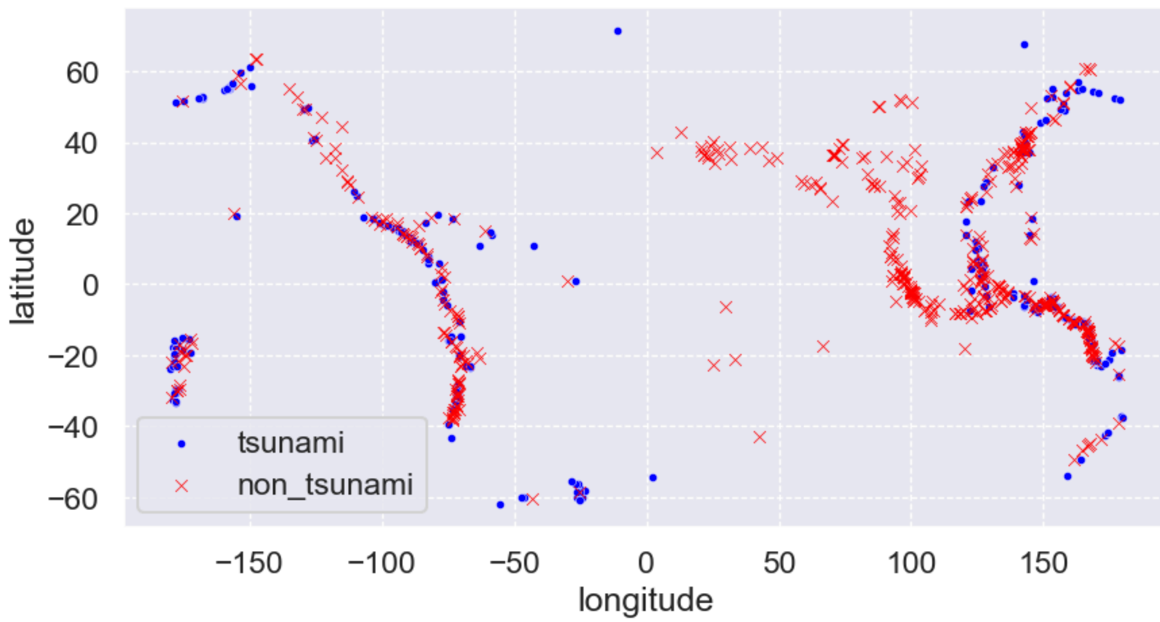
3. Geographic Distribution Using 2D Plotting:

Plot earthquake locations using latitude and longitude on a 2D scatter plot.

In [180]:
```
tsunami=data[["latitude","longitude"]][data["tsunami"]==1]
non_tsunami=data[["latitude","longitude"]][data["tsunami"]==0]

print(data["tsunami"].value_counts())
```

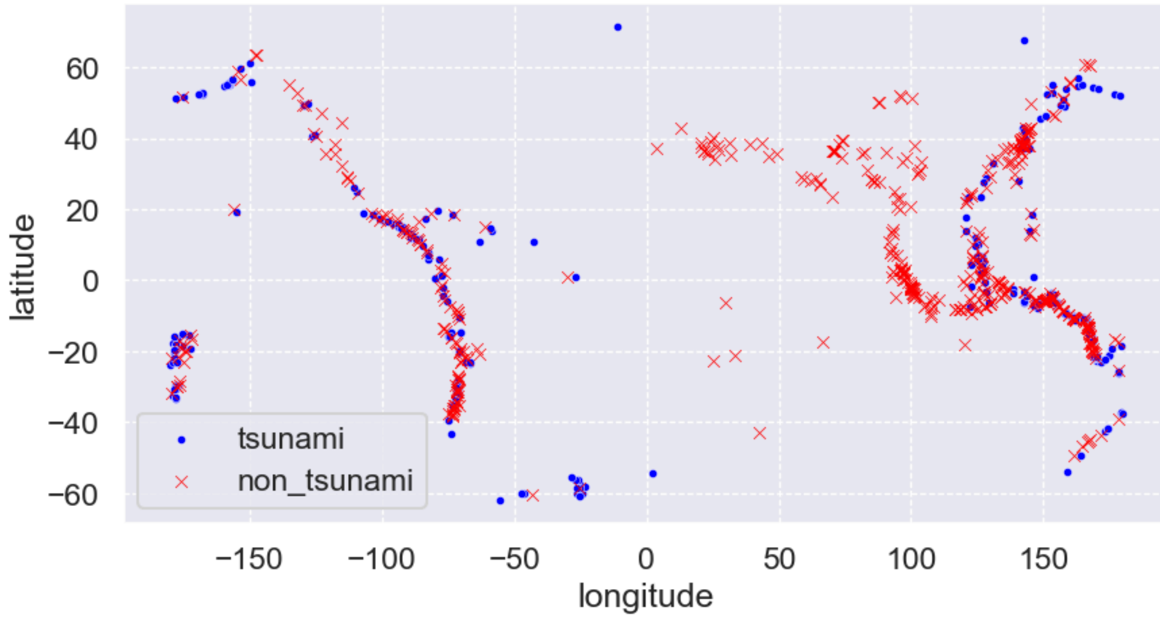
```
tsunami
0    478
1    304
Name: count, dtype: int64
```

In [178]:
```
plt.figure(figsize=(10,5))
sns.scatterplot(data=tsunami,y="latitude",x="longitude",marker="o",s=20,color=
sns.scatterplot(data=non_tsunami,y="latitude",x="longitude",marker="x",s=40,co
plt.legend(["tsunami","non_tsunami"])
plt.grid(linestyle="--",linewidth=0.9)
```



Visually distinguish between tsunami and non-tsunami events.

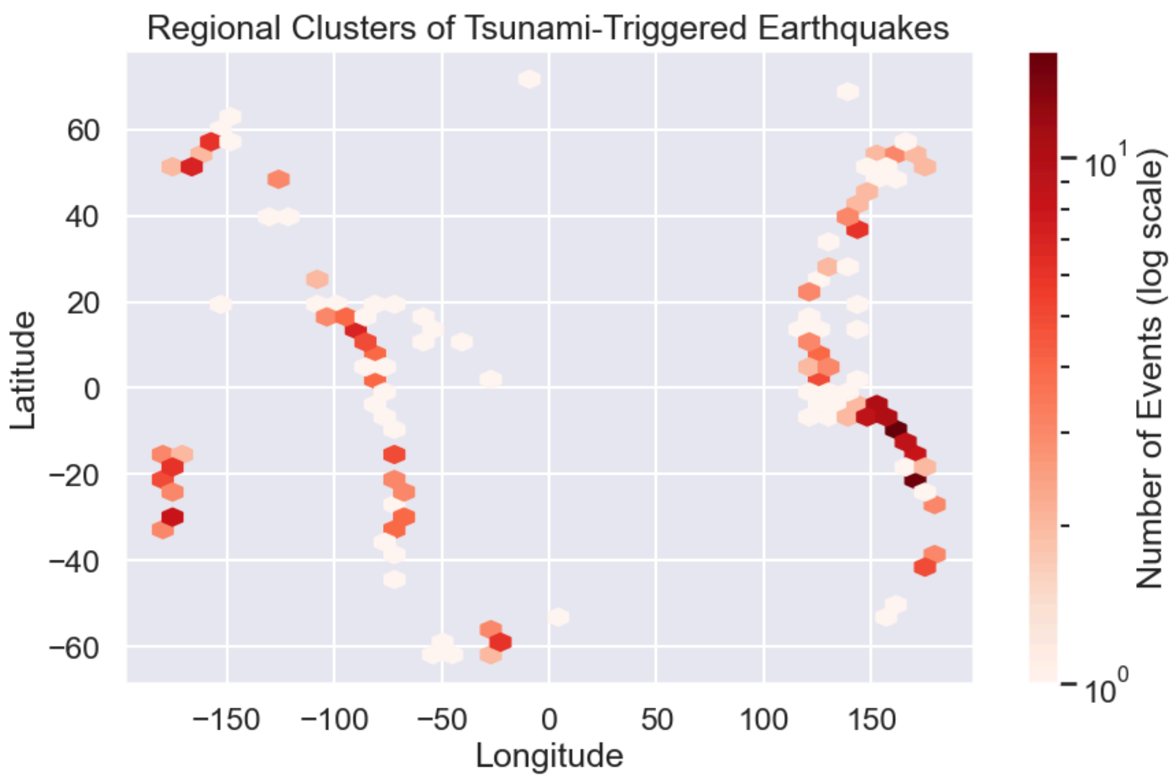
In [181]:
```
plt.figure(figsize=(10,5))
sns.scatterplot(data=tsunami,y="latitude",x="longitude",marker="o",s=20,color=
sns.scatterplot(data=non_tsunami,y="latitude",x="longitude",marker="x",s=40,co
plt.legend(["tsunami","non_tsunami"])
plt.grid(linestyle="--",linewidth=0.9)
```



Identify clusters or regions with higher concentration of tsunami events (without using map tiles or interactive maps).

In [183]:
```
tsunami_data=data[data["tsunami"]==1]
```

In [184]:
```
plt.figure(figsize=(10,6))
plt.hexbin(
    tsunami_data["longitude"],
    tsunami_data["latitude"],
    gridsize=40,
    cmap="Reds",
    bins="log"
)
plt.colorbar(label="Number of Events (log scale)")
plt.title("Regional Clusters of Tsunami-Triggered Earthquakes")
plt.xlabel("Longitude")
plt.ylabel("Latitude")
plt.show()
```

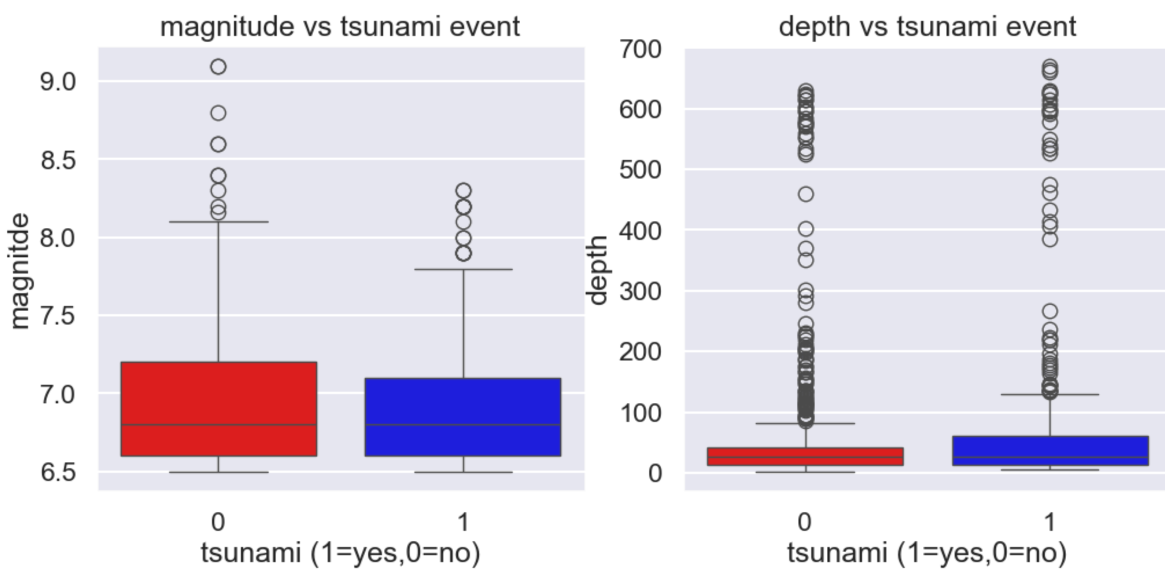


4. Statistical and Comparative Analysis:

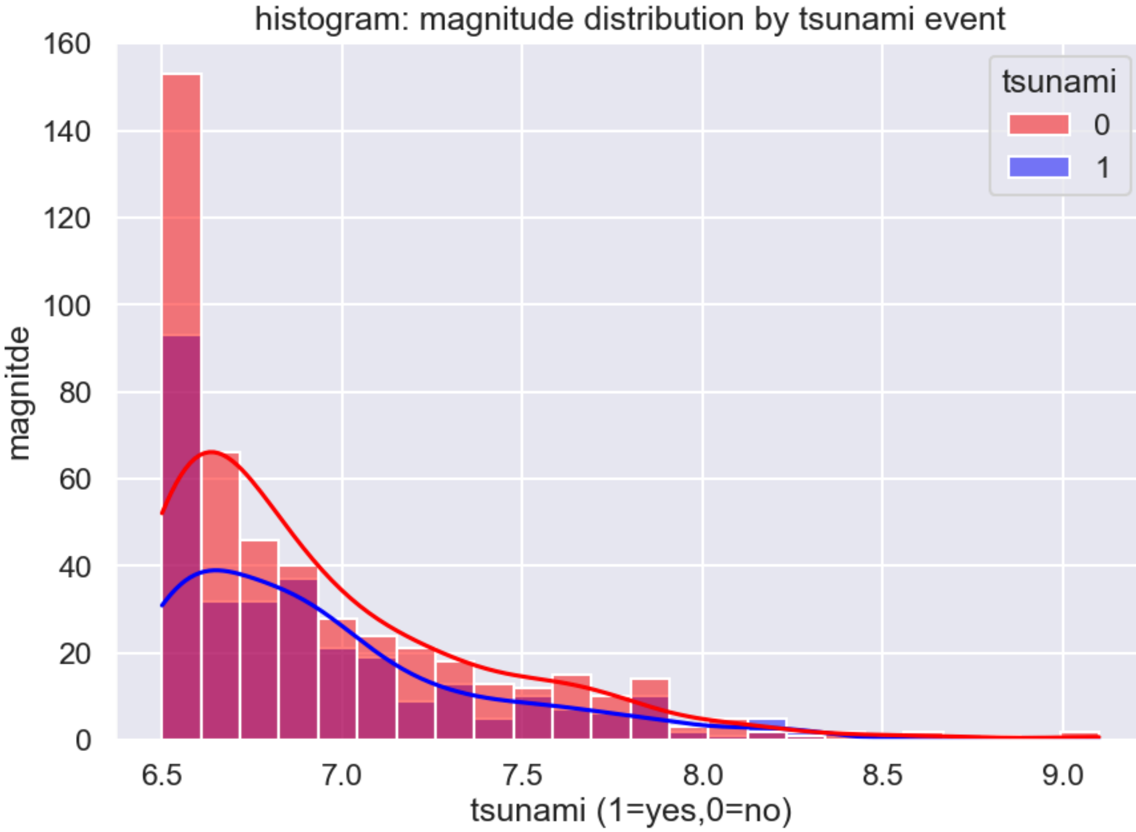
Use box plots, histograms, and bar charts to compare seismic features between tsunami and non-tsunami events.

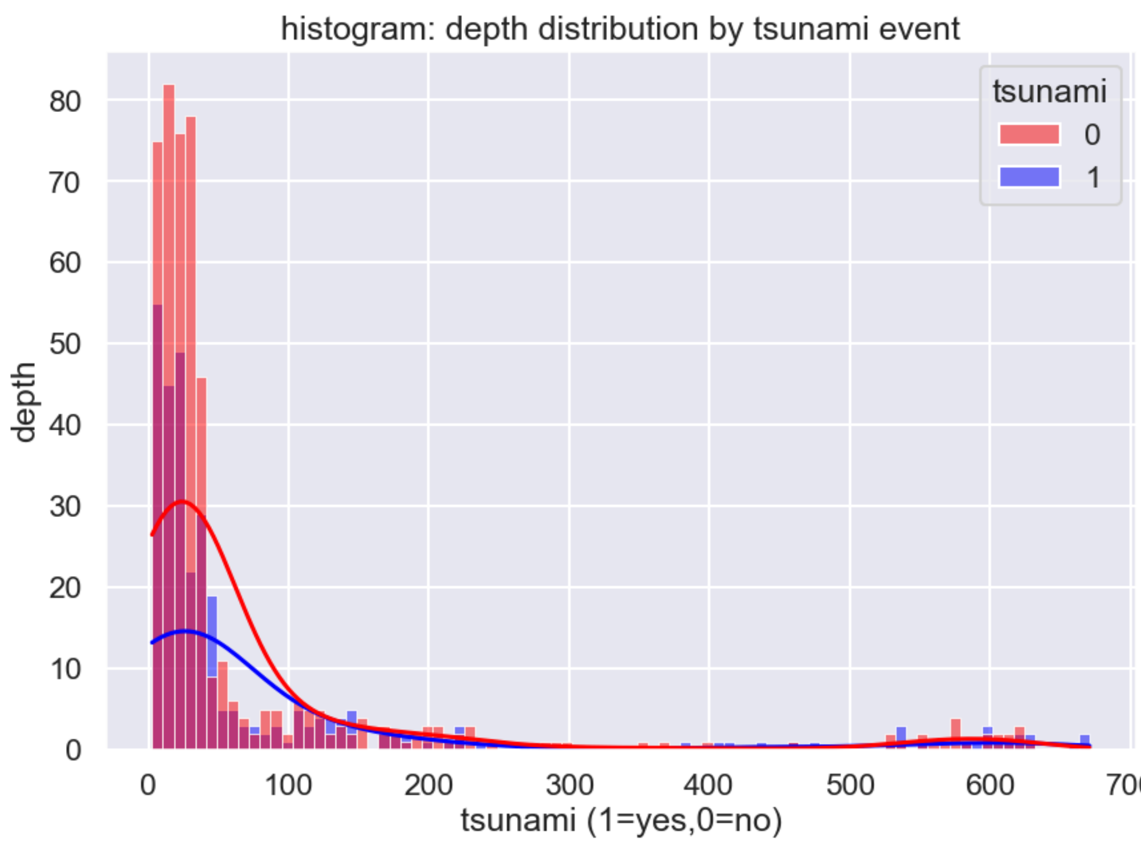
In [205]:
```
fig, axi = plt.subplots(1,2,figsize=(12,5))

sns.boxplot(data=data,x="tsunami",y="magnitude",ax=axi[0],palette=["red","blue
axi[0].set_title("magnitude vs tsunami event")
axi[0].set_xlabel("tsunami (1=yes,0=no)")
axi[0].set_ylabel("magnitde")


sns.boxplot(data=data,x="tsunami",y="depth",ax=axi[1],palette=["red","blue"])
axi[1].set_title("depth vs tsunami event")
axi[1].set_xlabel("tsunami (1=yes,0=no)")
axi[1].set_ylabel("depth")
```

Out[205]:
```
Text(0, 0.5, 'depth')
```



In [229]:
```
fig, axi = plt.subplots(2,1,figsize=(10,15))

sns.histplot(data=data,x="magnitude",ax=axi[0],palette=["red","blue"],kde=True
axi[0].set_title("histogram: magnitude distribution by tsunami event")
axi[0].set_xlabel("tsunami (1=yes,0=no)")
axi[0].set_ylabel("magnitde")


sns.histplot(data=data,x="depth",ax=axi[1],palette=["red","blue"],kde=True,hue
axi[1].set_title("histogram: depth distribution by tsunami event")
axi[1].set_xlabel("tsunami (1=yes,0=no)")
axi[1].set_ylabel("depth")

plt.show()
```





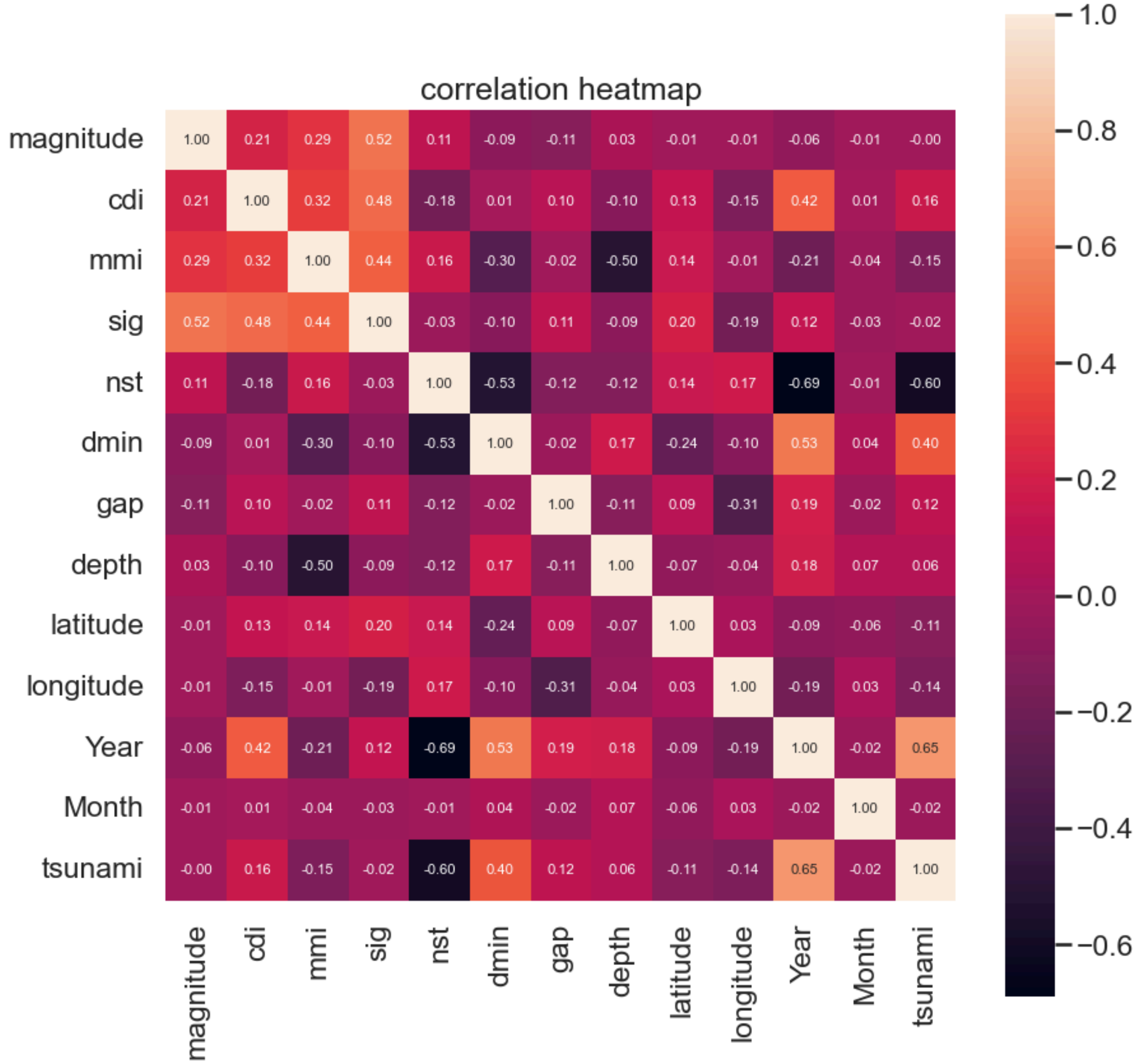
Analyze correlations between variables using heatmaps.

In [230]:
```
corr=data.corr()
corr
```

Out[230]:

	magnitude	cdi	mmi	sig	nst	dmin	gap	depth
magnitude	1.000000	0.209549	0.285552	0.515871	0.113114	-0.091403	-0.110626	0.030644
cdi	0.209549	1.000000	0.317937	0.479788	-0.175417	0.006554	0.098143	-0.097891
mmi	0.285552	0.317937	1.000000	0.442423	0.160417	-0.299074	-0.015723	-0.504439
sig	0.515871	0.479788	0.442423	1.000000	-0.030100	-0.095318	0.114285	-0.088667
nst	0.113114	-0.175417	0.160417	-0.030100	1.000000	-0.529371	-0.118812	-0.121982
dmin	-0.091403	0.006554	-0.299074	-0.095318	-0.529371	1.000000	-0.021933	0.168546
gap	-0.110626	0.098143	-0.015723	0.114285	-0.118812	-0.021933	1.000000	-0.111912
depth	0.030644	-0.097891	-0.504439	-0.088667	-0.121982	0.168546	-0.111912	1.000000
latitude	-0.008552	0.129003	0.144883	0.204306	0.144204	-0.238377	0.087756	-0.069492
longitude	-0.013911	-0.149048	-0.005803	-0.190132	0.173665	-0.097875	-0.313623	-0.036986
Year	-0.057083	0.423158	-0.212855	0.124439	-0.688602	0.529449	0.194002	0.178220
Month	-0.011926	0.007002	-0.035238	-0.029189	-0.014021	0.037502	-0.024953	0.069213
tsunami	-0.004726	0.160266	-0.147363	-0.015500	-0.600231	0.400752	0.116360	0.056814

In [243]:
```
plt.figure(figsize=(10,10))
sns.heatmap(corr,annot=True,square=True,fmt=".2f",annot_kws={"size": 8})
plt.title("correlation heatmap")
plt.show()
```



5. Insights and Observations:

Summarize key differences in seismic behavior between tsunami and non-tsunami earthquakes.

In [234]:
```
print(f"total events: {len(data)}")
print(f"tsunami events: {len(tsunami)}")
print(f"non tsunami events: {len(non_tsunami)}")
```

```
total events: 782
tsunami events: 304
non tsunami events: 478
```

In [235]:
```
ts_mean=data["magnitude"][data["tsunami"]==1].mean()
non_ts_mean=data["magnitude"][data["tsunami"]==0].mean()

print(f"mean magnitude of tsunami events: {ts_mean}")
print(f"mean magnitude of tsunami events: {non_ts_mean}")
```

```
mean magnitude of tsunami events: 6.938486842105264
mean magnitude of tsunami events: 6.942803347280335
```

A. Key Differences in Seismic Behavior

1.Magnitude Differences

1.1 Tsunami-triggering earthquakes generally show higher magnitudes, often ≥6.5, compared to non-tsunami events which mostly cluster between 4.0–6.0.

1.2 Boxplots and histograms reveal a right-skewed distribution for tsunami magnitudes — indicating more powerful events in that group.

2.Depth Differences

2.1 Tsunami events are typically shallower, commonly occurring at depths <50 km.

2.2 Non-tsunami earthquakes occur across a wider depth range, including many deep-focus (>300 km) events that rarely generate tsunamis.

3.Frequency and Distribution

3.1 Non-tsunami events are far more frequent overall.

3.2 Tsunami events are clustered geographically around subduction zones (e.g., Japan Trench, Indonesian Arc, Chile–Peru region), suggesting tectonic setting is a key factor.

4.Variability

4.1 Tsunami-related quakes show less variability in both depth and magnitude compared to non-tsunami quakes — indicating they occur within a more specific seismic profile (large and shallow).

In [ ]: