Magna Earthquake Project Proposal

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Basic Info

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- Project Repository - https://github.com/armstrong06/dataviscourse-pr-MagnaEarthquakeSequence

Background and Motivation

On 18 March 2020, an M5.7 earthquake occurred on the Salt Lake City segment of the Wasatch Fault. This is the largest earthquake to occur in Utah since a M5.0 in 1962 and damage estimates are greater than $150 million (Pang et al., 2020). Within the first hour of this earthquake occurring, ~21,000 individuals had submitted a felt report to the United States Geological Survey (USGS; 2020). As of 18 September 2020, 2,482 earthquakes have been catalogued by the University of Utah Seismograph Stations (UUSS; 2020) as part of the ongoing earthquake sequence relating to the main shock. There have been 6 notable and widely felt aftershocks greater than M4. Though earthquakes pose a significant safety risk to the densely populated Wasatch Front, earthquakes are a relatively foreign phenomenon to many of the individuals living here. Lack of information regarding earthquakes and circulated misinformation likely increased fear surrounding the Magna earthquake and its aftershocks. In our project, we would like to highlight important information specifically from the Magna earthquake sequence. In addition, we would also like to use the data to educate on earthquake properties and dispel some myths and misinformation surrounding earthquakes in general.

This project is mainly motivated by Alysha's involvement with the UUSS. Alysha has a degree in geophysics and currently a masters student with the UUSS. Guy and Andrew just think that the project and earthquakes are cool and would like to learn more over the course of completing the project.

References:

Pang, G., Koper, K. D., Mesimeri, M., Pankow, K. L., Baker, B., & Farrell, J., et al. (2020). Seismic analysis of the 2020 Magna, Utah, earthquake sequence: Evidence for a listric Wasatch fault. *Geophysical Research Letters*, 47, e2020GL089798. https://doi-org.ezproxy.lib.utah.edu/10.1029/2020GL089798

University of Utah Seismograph Stations, (2020). 2020 Magna Earthquake Sequence Catalog. Retrieved October 30, 2020, from https://quake.utah.edu/earthquake-information-products/earthquake-catalogs/2020-magna-earthquake-sequence-catalog

United States Geological Survey, (2020). M 5.7 - 4km NNW of Magna, Utah. Retrieved October 30, 2020, from https://earthquake.usgs.gov/earthquakes/eventpage/uu60363602/executive

Project Objectives

Primary questions:

- What was the sequence of events in the Magna earthquake?
- Which earthquakes and aftershocks were part of this earthquake?
- What can someone expect during/after an earthquake?
- Where did these earthquakes occur (regional setting and historic overview)?
- How did the sequence evolve with respect to space and time?

- What are the aftershocks, how many occurred, what are their depths

Learn & Accomplish:

- Learn more about the details of an earthquake
    - Most people just think of an earthquake as a single massive event, with possible aftershocks, but there is a lot going on beneath the surface.
- Explain details of earthquakes:
    - Focal mechanisms, aftershocks, main shocks, magnitudes, magnitude and time relationships, focal mechanism and types of faulting, what size is physically possible for the region, Wasatch Fault and recurrence intervals
    - Visualization of what different magnitudes would look like:
        - Energy of earthquakes.
- Make an interactive visualization of the earthquake data.
    - Intuitive interactivity of the visualization
    - Some storytelling that highlights key/interesting events and data points.

Benefits

- Learn about earthquakes
- Provide accessible, detailed information about the Magna earthquake

Data

We are collecting the bulk of our information from the University of Utah Seismograph Station (UUSS); this information has been made publicly available through the United States Geological Survey (USGS) at https://earthquake.usgs.gov/earthquakes/search/. The information can be downloaded as a CSV or GeoJSON file, which is helpful for visualisation purposes. This information will include the core pieces for most of our visualisations, i.e. location, depth, origin time, and magnitude. For some of the visualisations we plan on creating we will require station information, which is available from the UUSS. We will download waveform data for the mainshock from the Incorporated Research Institutions for Seismology. We will also be creating visualisations related to the felt intensity which will be derived from felt reports and hazard maps available from the USGS.

Data Processing

The data retrieved from UUSS/USGS is mostly structured, but we'll have to combine and correlate the data ourselves in order to display it in the visualizations. We plan to extract earthquake information like location, depth, magnitude, and origin time. Other information we hope to work with includes station location, recorded peak ground accelerations and waveforms for the main shock at some stations. Waveform information may need to be processed using Obspy, a Python package for seismology.

Data processing will be a combination of pulling in the data we need and combining it into a pre-computed set that is loaded by the visualization. The main challenge will be taking data from multiple sources and collating them into a single data set.

Visualization Design

At the end of this document we have included all the steps we took to create the final design of the visualisation. These steps roughly follow the five design sheet methodology. It starts with the results of our brainstorming session, flows through three rough drafts, and finishes with a rough sketch of our final design.

Explanation of Final Design

We chose a design suited to a story-telling experience, where the user is presented with a long webpage that they scroll through, and in doing so, discover more about the topic presented. We will present various visualizations of different aspects of the Magna earthquake, starting with ones that show a broad overview, and diving deeper into more specific topics as the user scrolls deeper into the page. These visualizations will be accompanied by educational explanations. Our hope is to demystify earthquakes and their mechanisms, and to have a visitor leave with a deeper appreciation of the data collected from seismology stations that make analysis like this possible.

Features

Must-have Features

- Map - to show data
- Scrolling story-telling - visualization format
- Educational information - central purpose
- Linked views - enhances interactivity and brings the data to life
- Time, magnitude, and frequency relationships

Optional Features

- View at the end with full interactivity
    - This is very high up, but not having this wouldn’t cause the visualization to be worthless.
- Interactive educational ‘widgets’

- Having nice animations / transitions on scroll
  - This would make it look better, but it’s not critical
- Navigation - in other notable “scrolly-telling” visualisations we have viewed as part of this class, dots are arranged on the side which correspond to pages. The inclusion of this feature would be nice, but it’s an entirely aesthetic improvement and doesn’t affect the actual visualisation component. The efficacy of this addition is also dependent on our ability to add good transitions on scroll.

Project Schedule

Week of:	**Milestone to be achieved**
Nov. 1	Data processing/import. Build the structure of the website
Nov. 8	Educational content and important views.
Nov. 15	Build out views
Nov. 22	Interactivity and optional goals.
Nov. 29	Polish. Presentation prep

Exploratory Data Analysis:

We initially looked at a map of Utah with the different datasets plotted on it to explore the datasets. After getting the map of Utah to work, the earthquake sequence was plotted with lakes in Utah to ensure the placement of the earthquakes was correct with respect to the Great Salt Lake. Then, all the faults in Utah were plotted (Figure 1). There are quite a lot of faults, so we filtered the faults to only include the Wasatch Fault zone and the West Valley Fault zone. Next, we began exploring the data for the seismometers that recorded the mainshock (Figure 2). The data file we had include stations not maintained by the UUSS and some that were not in Utah, so we excluded these. Station coverage is very dense, especially in the Salt Lake Valley. So, we explored ways of filtering down the number of stations. This included looking at only using broadband or strong motion seismometers. However, most of the stations in the dataset are strong motion and this does not seem like the best way to reduce the data without reducing it too much. For the time being, we are just keeping all the stations as it is interesting to look at the different intensity values.

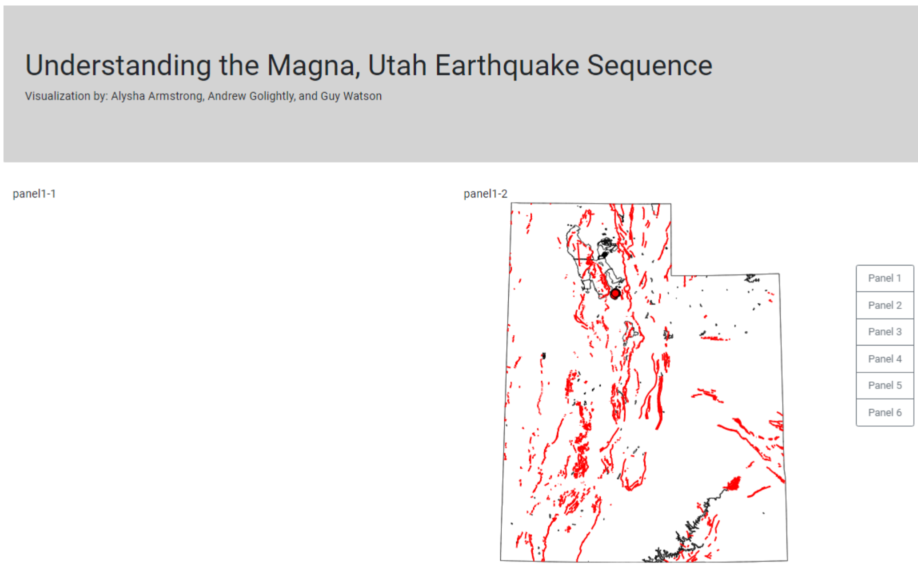


Figure 1. Map of Utah with all the faults plotted

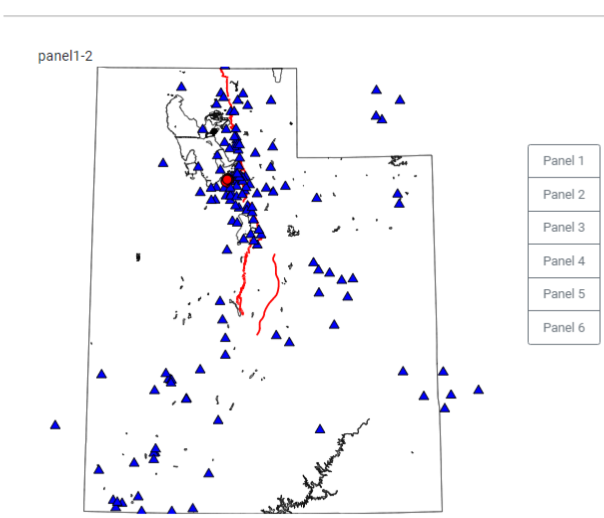


Figure 2. Map of Utah with only the Wasatch and West Valley faults and all seismometers from our dataset.

Design Evolution:

Initially, we had all the data plotted together, however to keep the maps from getting too cluttered, we did not put the faults and seismometers on the same map (Figure 3). Because the earthquake sequence is quite local with respect to the map of Utah, we decided to only plot the main shock as a large star on these maps (Figure 4; Figure 5). To be able to better see the details of the sequence, we created a street map using the Google Maps API and plotted the earthquakes as circles with the magnitude encoded in the radius (Figure 6). This is nice because we can scroll and pan around, but the tool-tip does not seem to be very sensitive in this map and we will have to explore this. So far, our time vs magnitude plot is only a simple scatter plot, but we plan to encode depth in color and to add tool-tips, brush-selection and a time-slider (Figure 7).

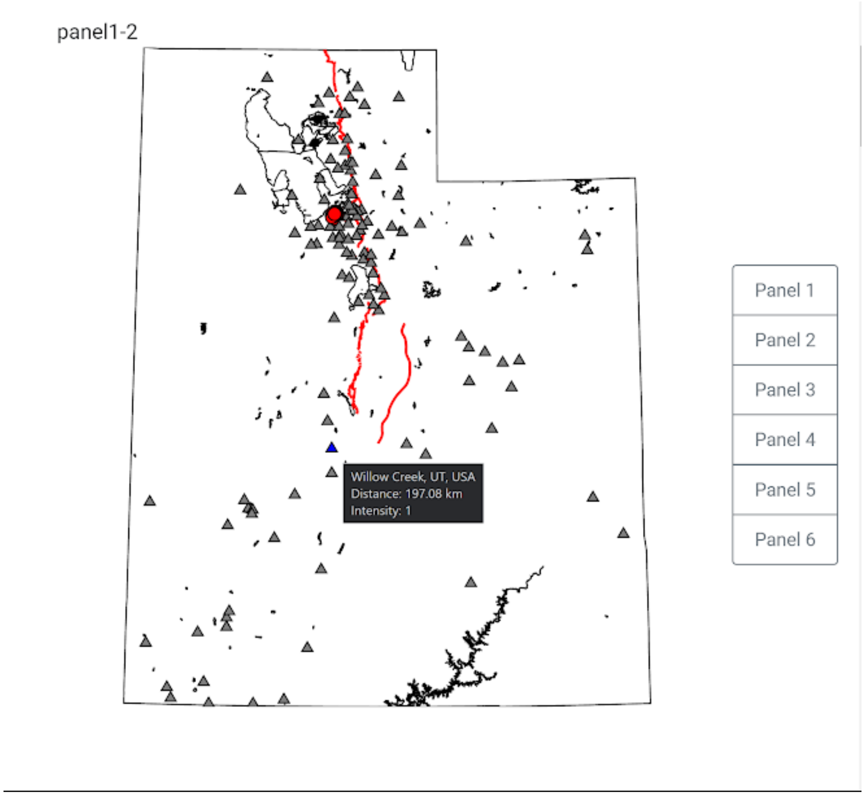


Figure 3. Map of select seismometers and faults with the earthquake sequence. Scrolly-telling navigation buttons clearly shown to the right, though they are not labeled yet.

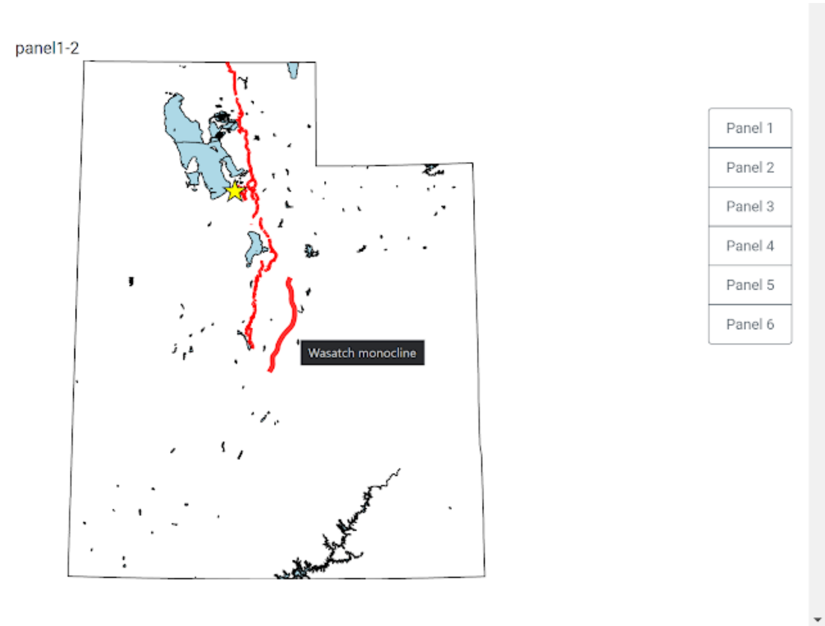


Figure 4. Map of Utah with select faults, Utah lakes, and the mainshock (star). Tool tip for on fault segment shown in the black text box.

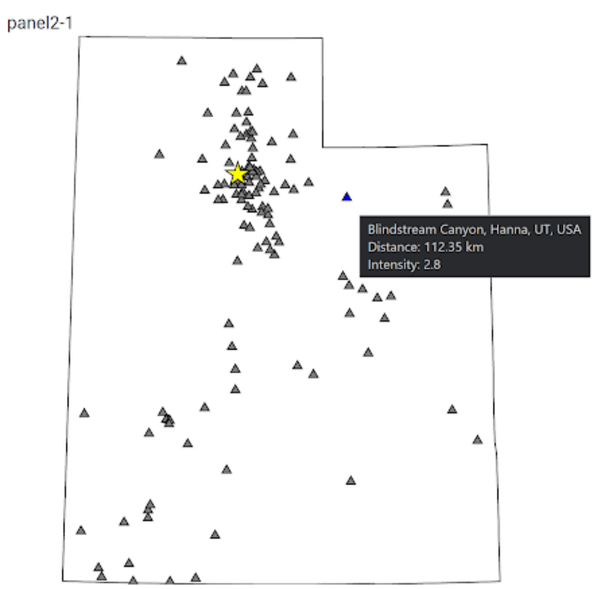


Figure 5. Map of Utah with just seismometers (triangles) and the mainshock (star). Tooltip with information regarding the blue seismometers shown in the black text box.

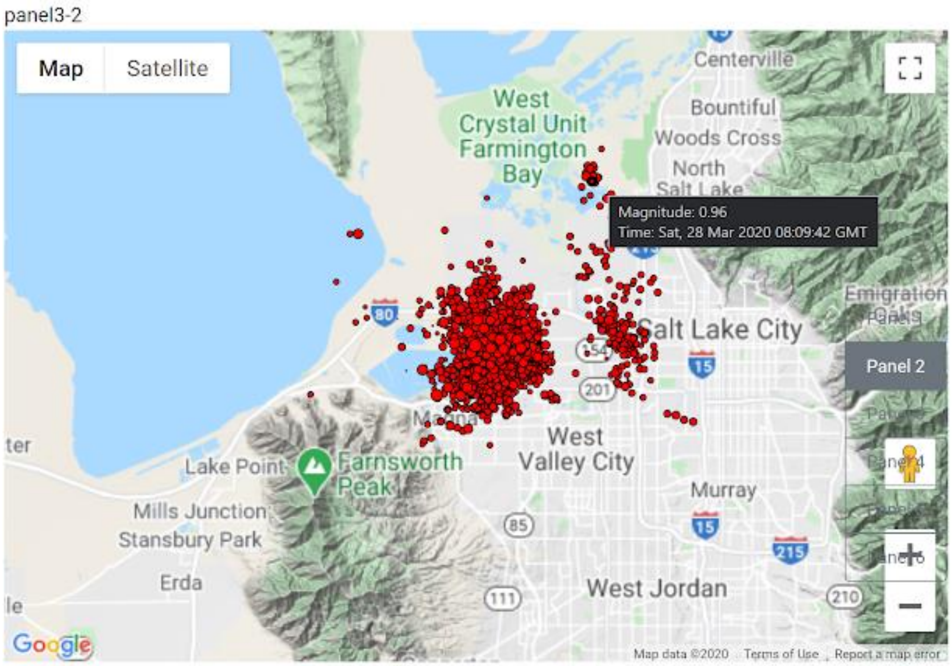


Figure 6. Google API street map view of the aftershock sequence. Tooltip for earthquake magnitude and date shown in the black textbox.

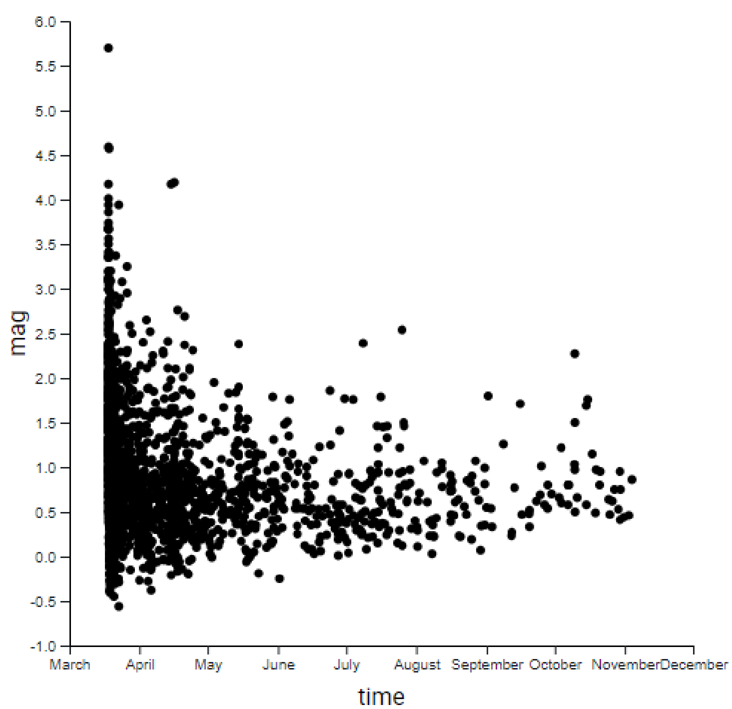


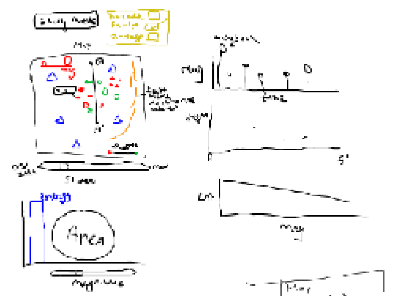
Figure 7. Initial time vs magnitude plot.

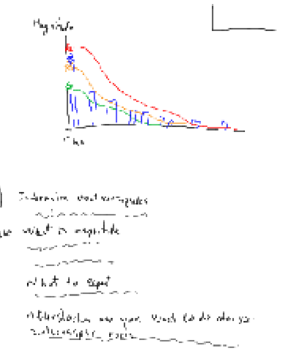
Implementation:

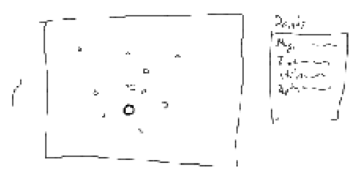
So far, the only interactive elements we have implemented are scolly-telling and tool-tips. Scrolly-telling is used to highlight various educational topics and various panels can be navigated to through the bubbles on the right of the screen (Figure 3). For our first map, there are tool-tips for the name of the various fault segments and the tool-tips for the information for the mainshock (Figure 4). In the second map, we added tool-tips to show the name, distance from the mainshock, and recorded shaking intensity for the various seismometers (Figure 5). The third map has tool-tips to show the date, time, and magnitude of the aftershocks (Figure 6).

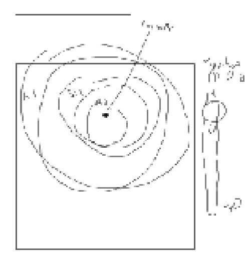
Evaluation:

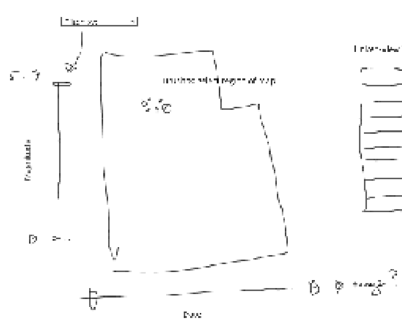
The visualization is starting to come together. The data has been working quite nicely and so far there have been no major issues. We have learned how to access and filter the relevant information from the data files to best suit our needs. We still have much to do.

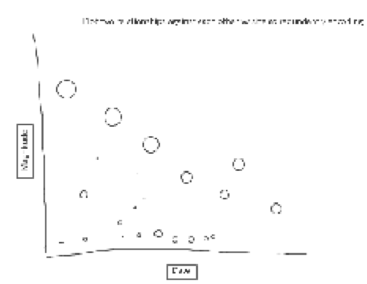


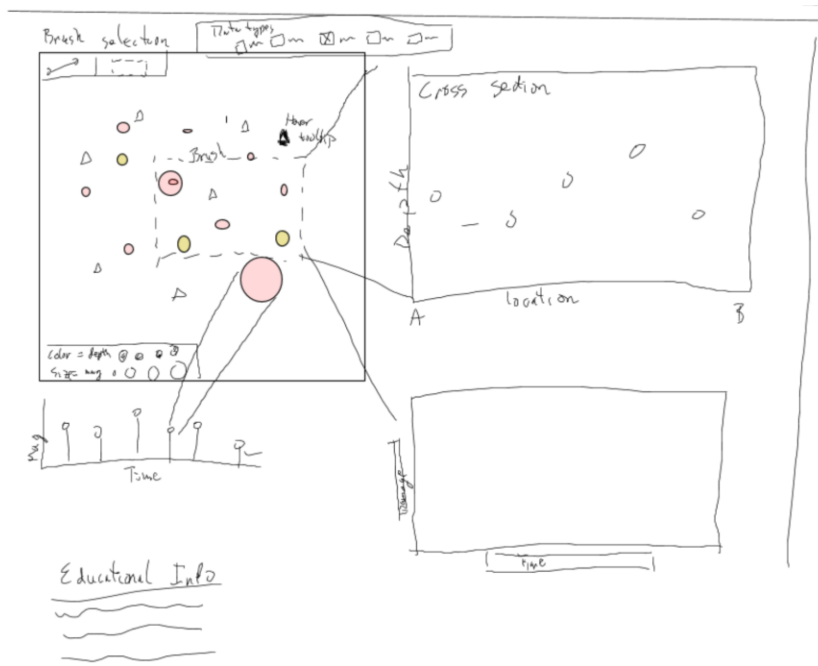









Magnitude
Date

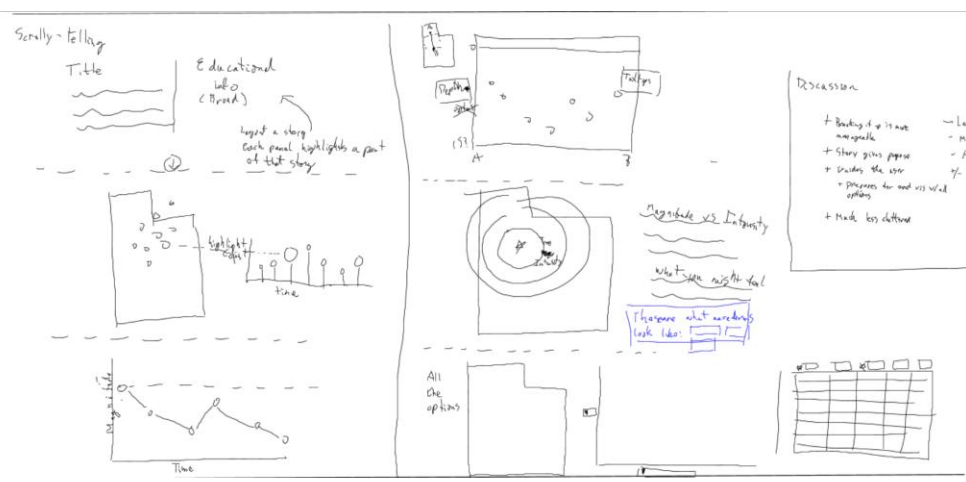


Discussion

+ Lot of info
  + Lot of drilling / views
+ Central map
  every thing relates back
+ Lots of interactivity

– Data overload

- Different views
- rerepresent map w/ different interactivity
- Scrolly telling
  - more education



Discussion

+ Breaking it up is more manageable
+ Story gives purpose
+ Guides the user
  + prepares for end vis w/ all options
+ Much less cluttered

– Less drilling
- More limited in views
- A lot of panels
+/- Less technical

- Highlight some important technical aspect
- Draw on scientific visualizations
- "Pretty" eye grabbing

FINAL DESIGN

Majority of scrolly-telling design