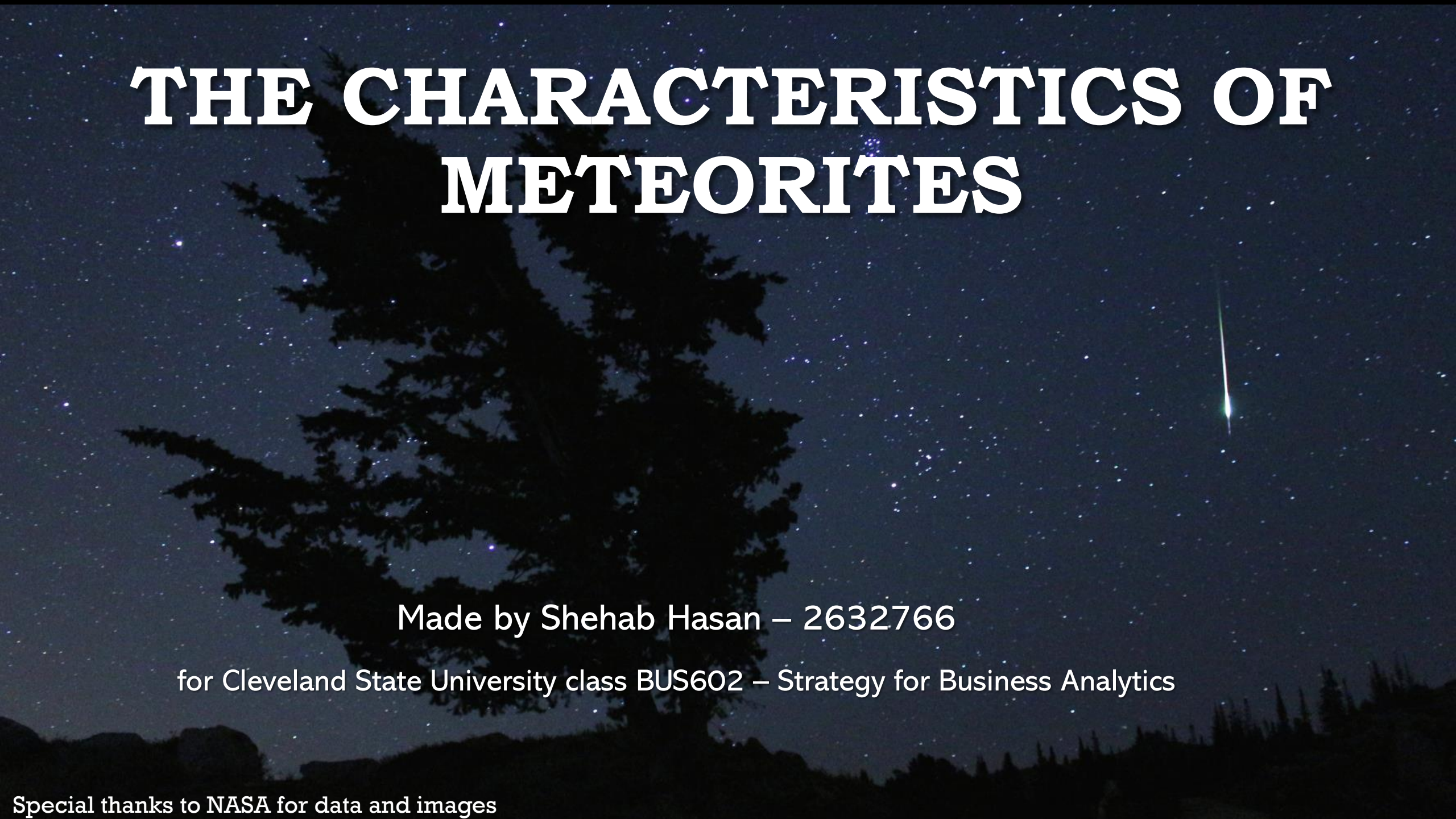


THE CHARACTERISTICS OF METEORITES

Made by Shehab Hasan – 2632766

for Cleveland State University class BUS602 – Strategy for Business Analytics

Special thanks to NASA for data and images

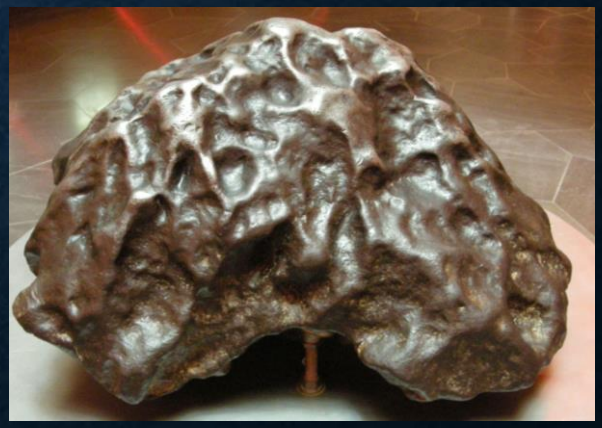
METEORITES: BACKGROUND & PROJECT SUMMARY

- A meteorite is any piece of space debris that has **survived** its entry through the atmosphere and landed on the surface.
- In space, it is a *meteoroid*; on the way down, a *meteor*
- There are 3 main categories – stony, iron, and stony iron. Stony is further broken down into achondrite and chondrites.

Chondrite with visible chondrules

- My project was to analyze a database of recorded meteorites to learn descriptive and statistic characteristics of meteorites.
- Where's the best place to find a meteorite?
  Wherever they stick out!

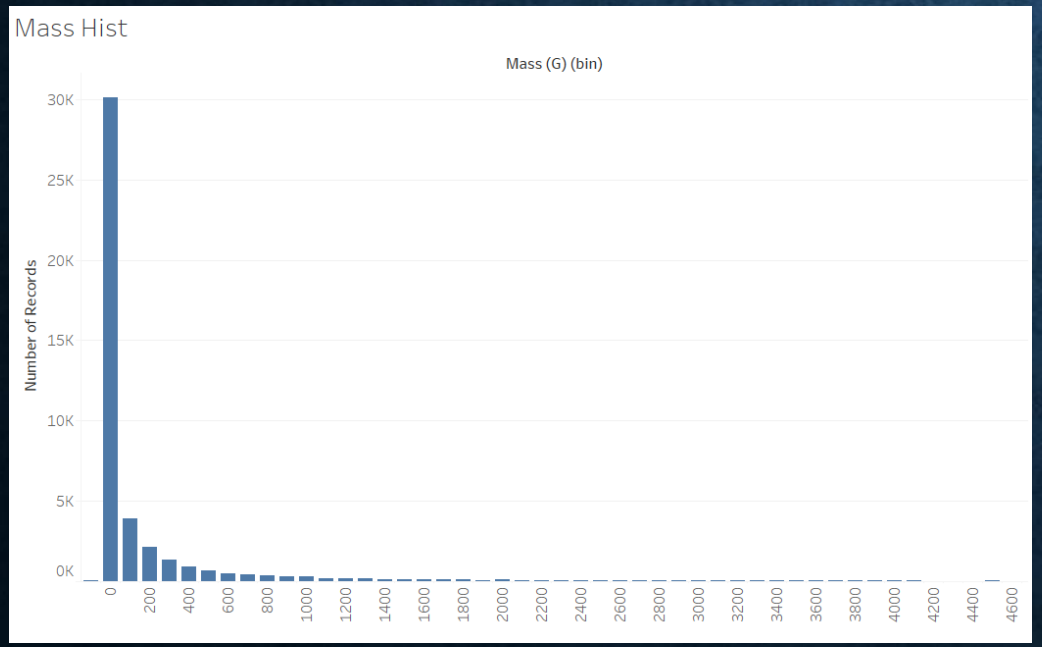
Iron Meteorite in museum display

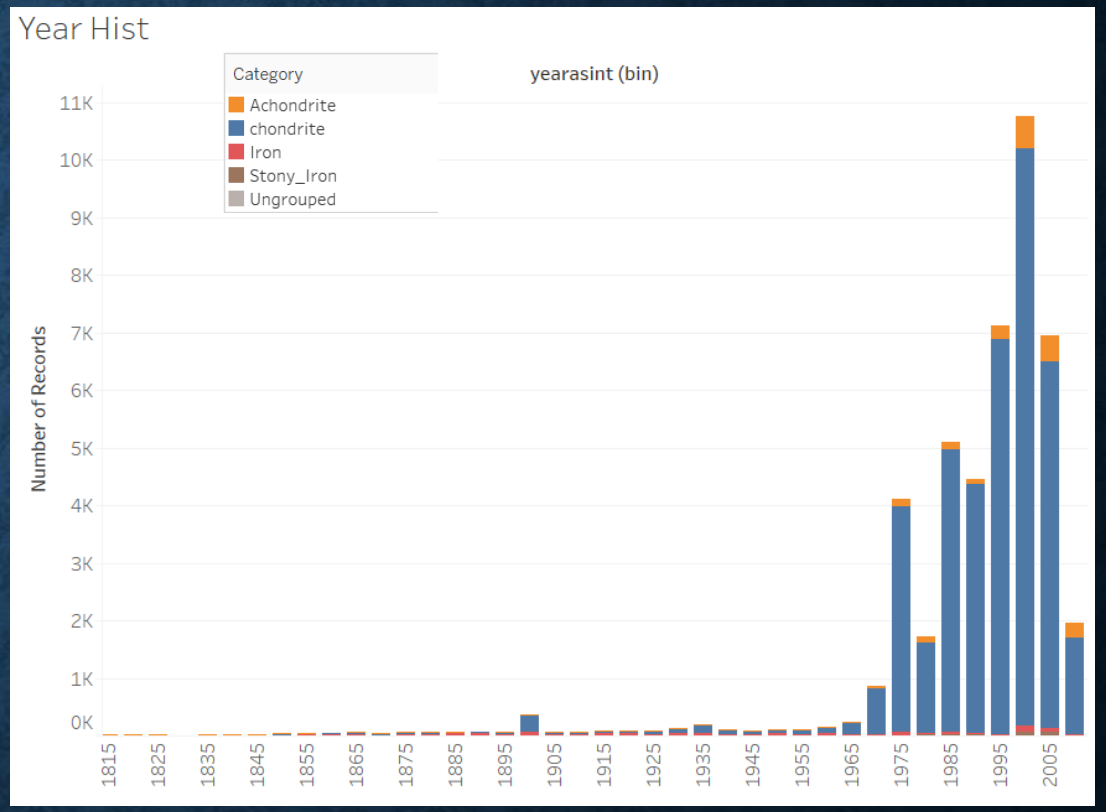


DATA SOURCE

Data was obtained from NASA in a spreadsheet with 45641 records.

Each record has a sitename, fell/found status, a classification code, mass, date of find, and latitude and longitude.





Although the data goes as far back as 860AD, most recordings were taken after the start of the space race in the 1960s.

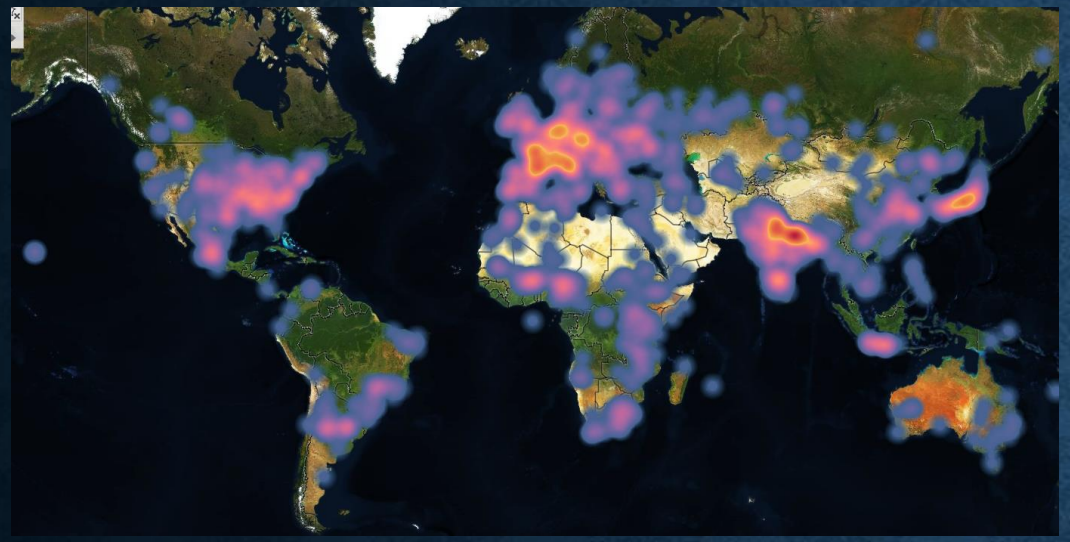
DATA ADJUSTMENTS

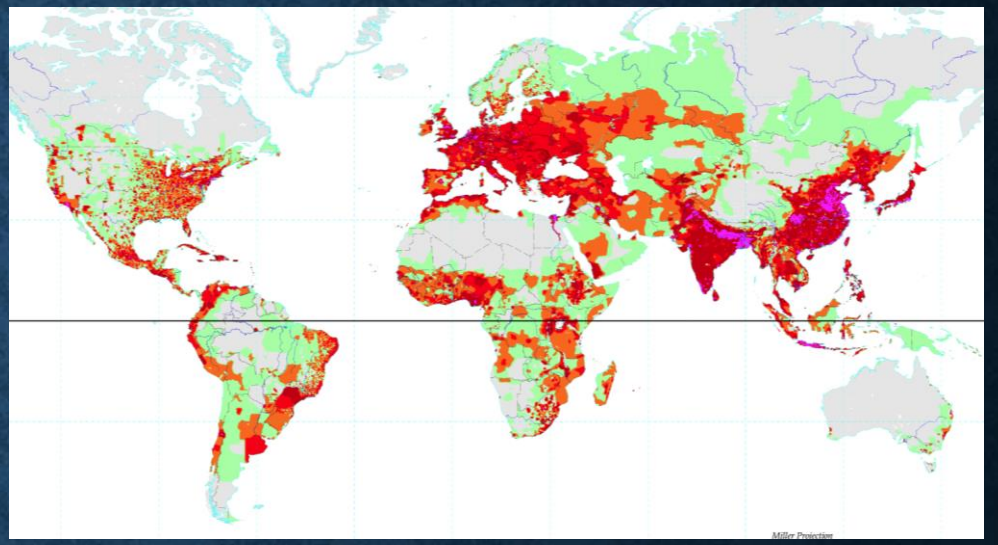
The following adjustments were done in python:

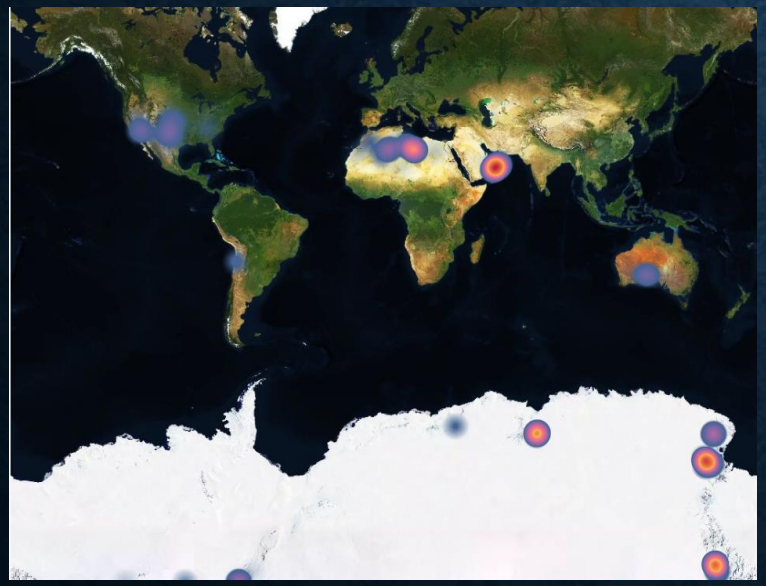
- The classification code was broken down into separate columns; category, class, group and chondrite type. There were over 450 unique classification codes.
- Example: EH4 -> Cat.: Chondrite, Class: Enstatite, Group: EH, Chon Type: 4
- Ex2: Iron, IAB-ung -> Cat.: Iron, Class: Non-Magmatic, Group: IAB
- Over 12000 geocoordinates had to be imputed, this was done by calculating the average lat/long for each sitename.

In Tableau, the mass histogram led me to create a logarithmic measure of mass, LogMass, which is in base 10. 1=1g, 3=1kg, 6=1000kg

INTERESTING INSIGHTS AND VISUALIZATIONS







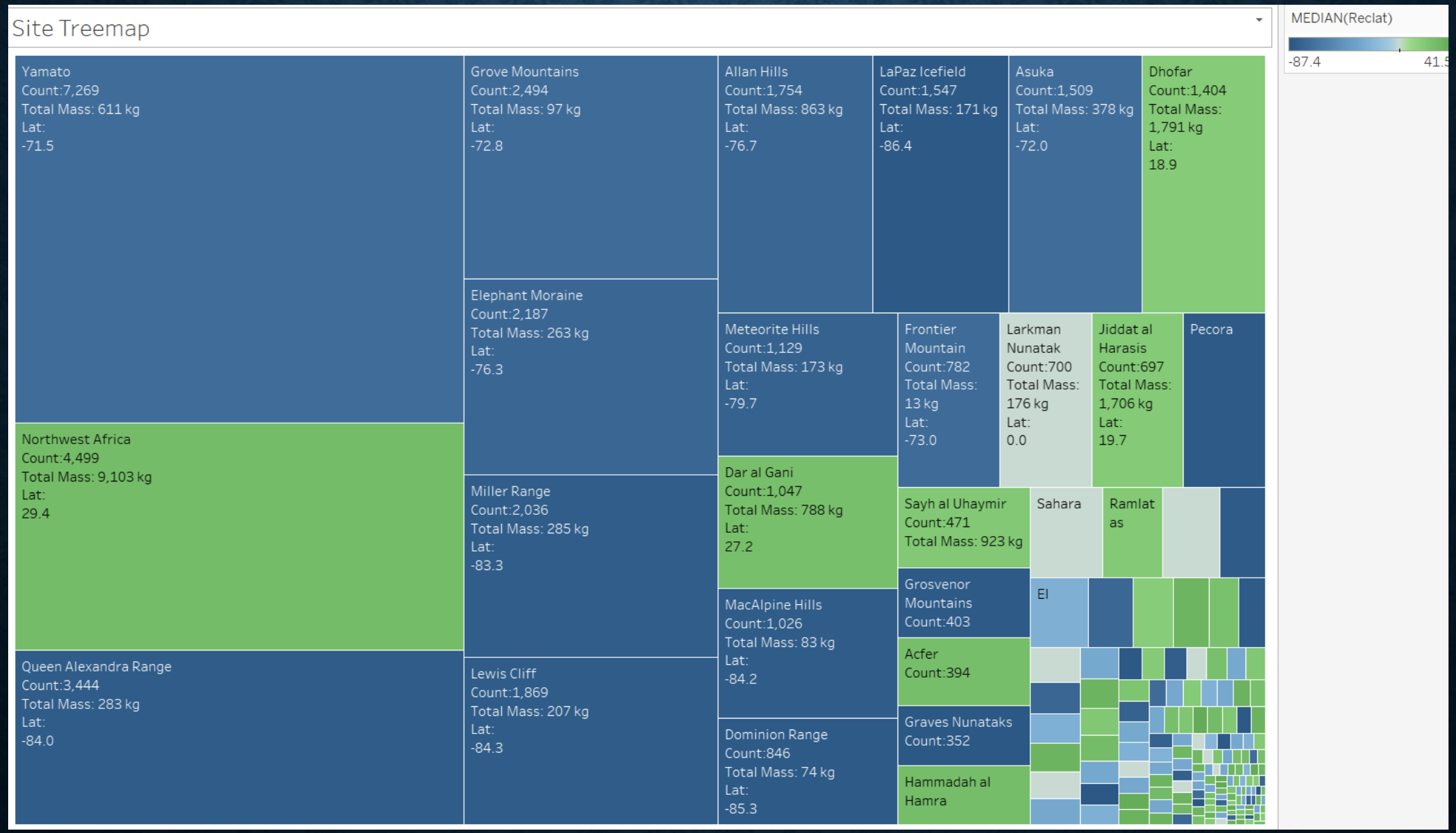
Top left is a heatmap of all “Fell” meteorites

Top right is a population heat map from wikipedia

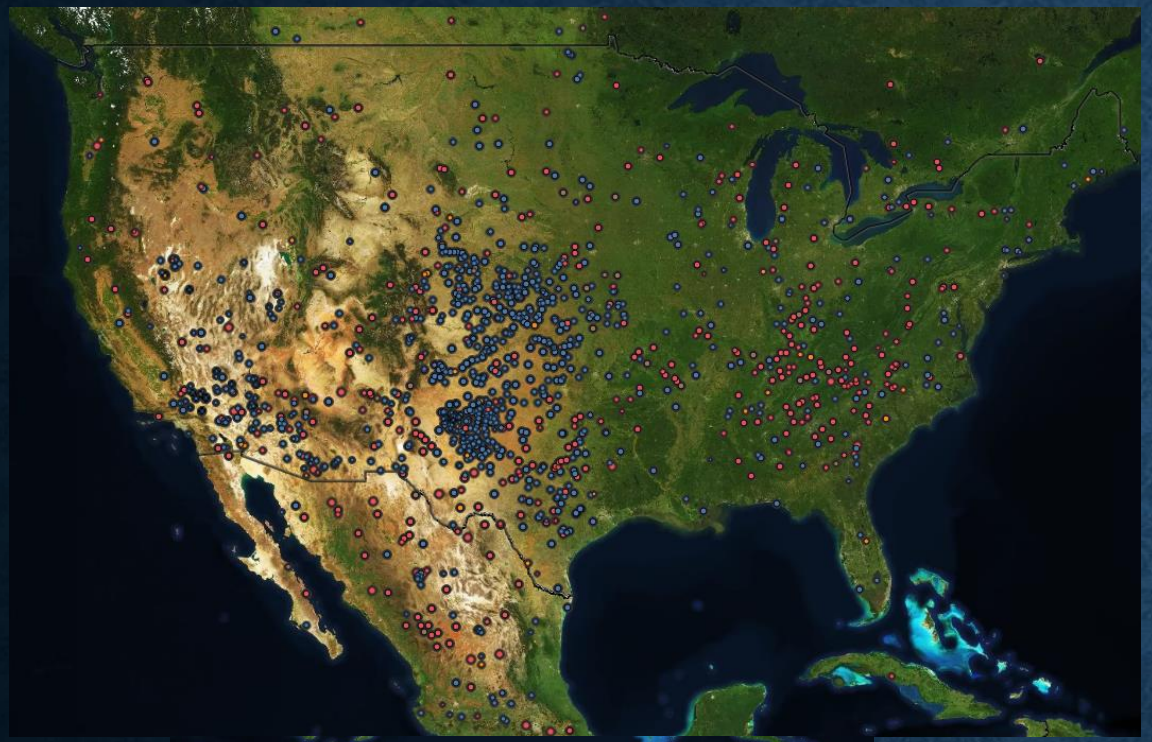
Bottom left is heatmap of all “Found” meteorites

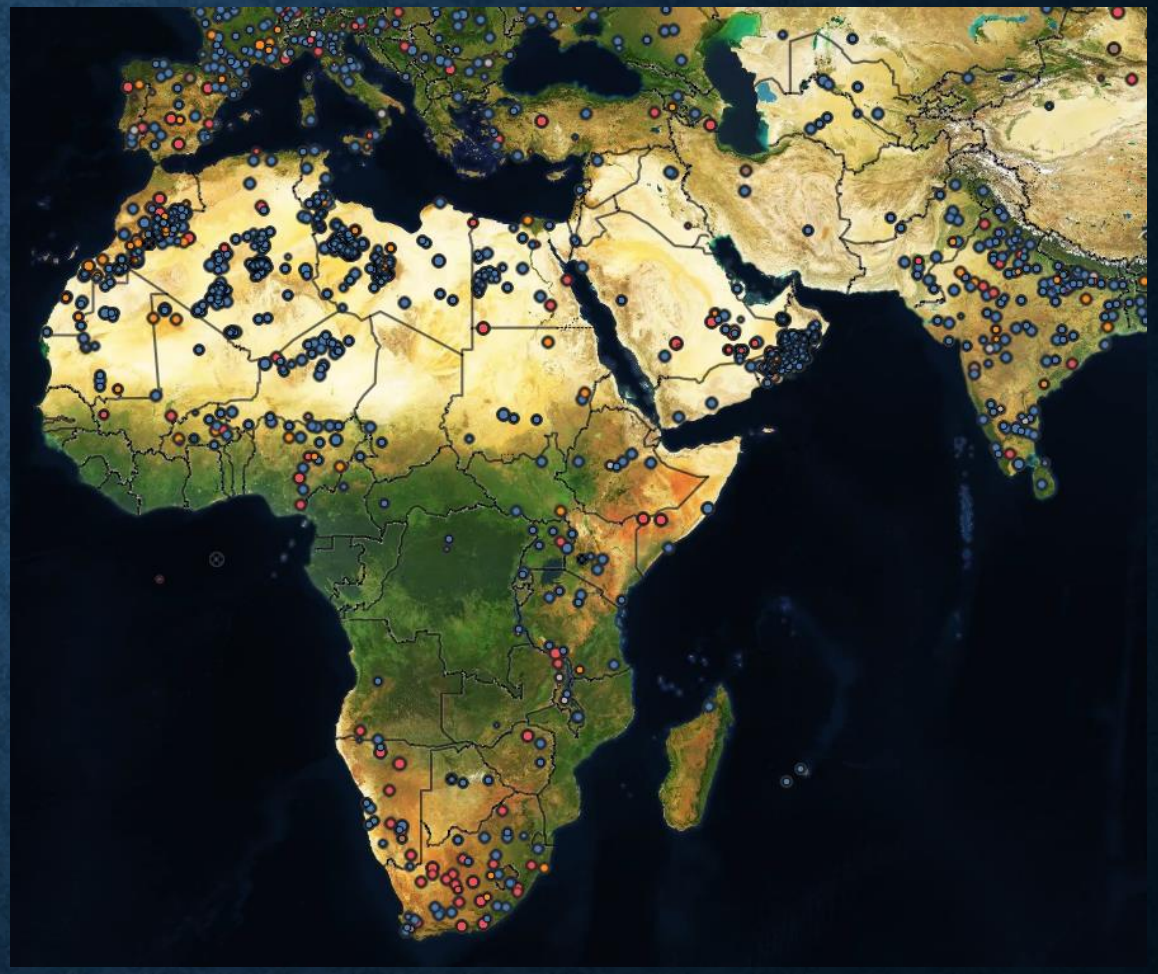
What makes anartica such a good meteorite site?

MOST FINDINGS ARE IN ANTARCTICA



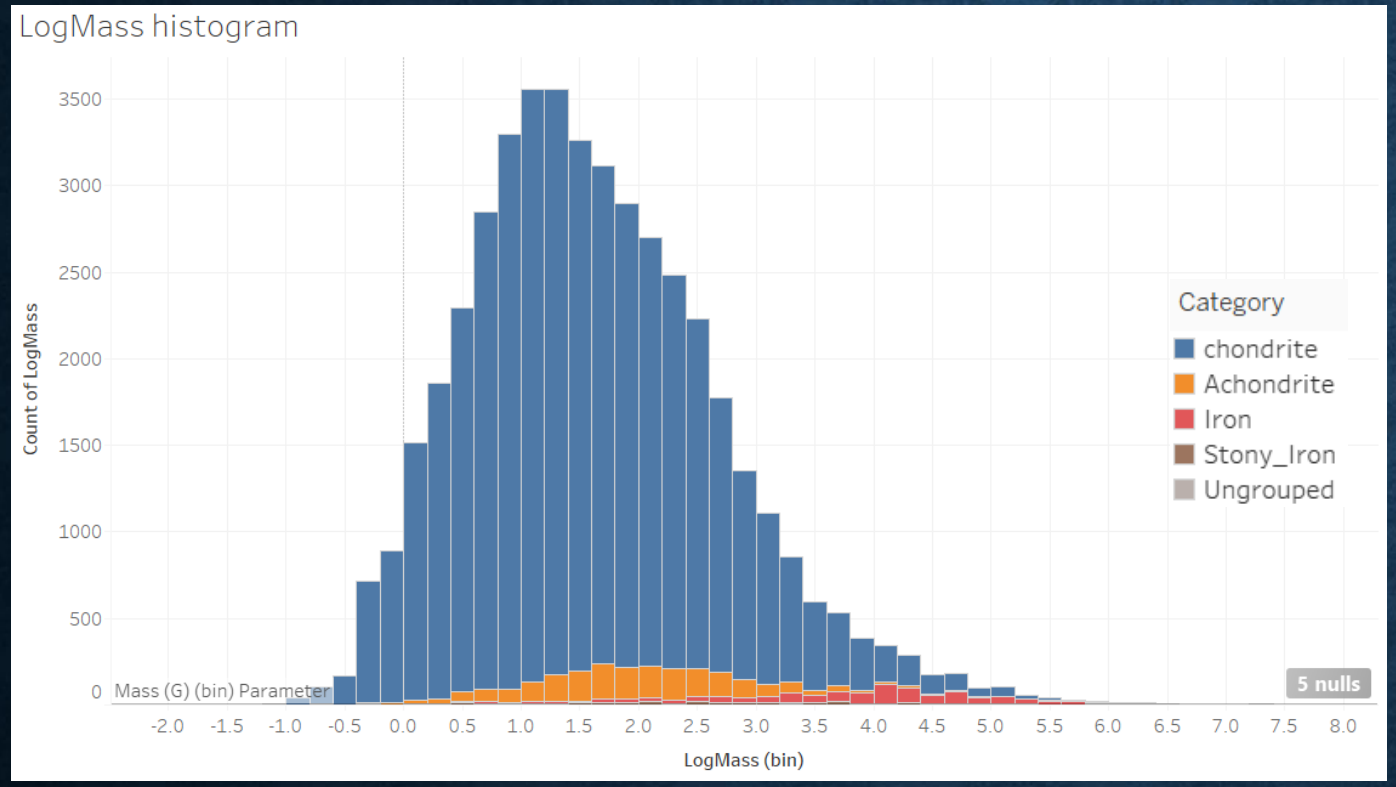
DESERTS ARE GOOD TOO

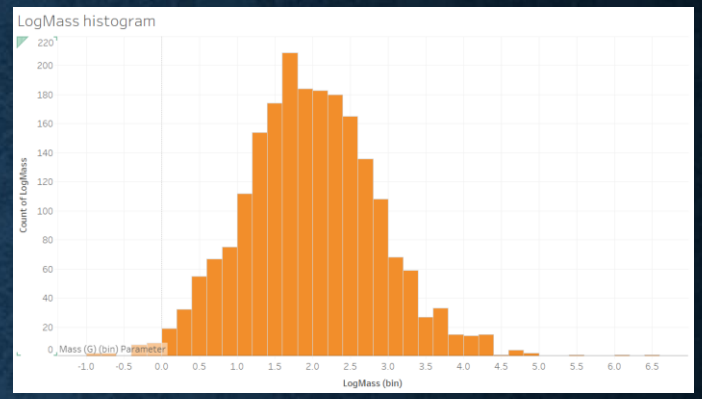


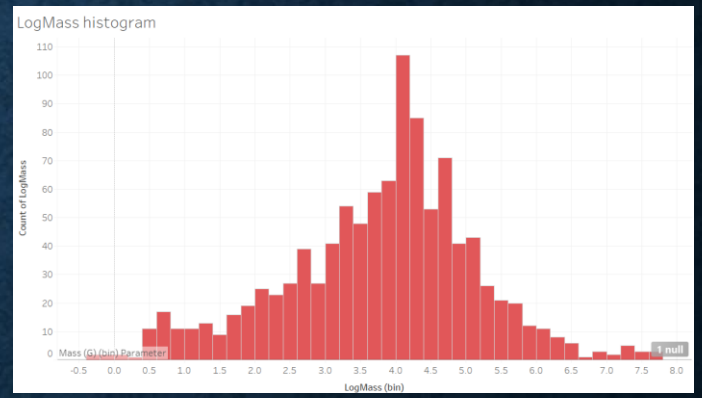


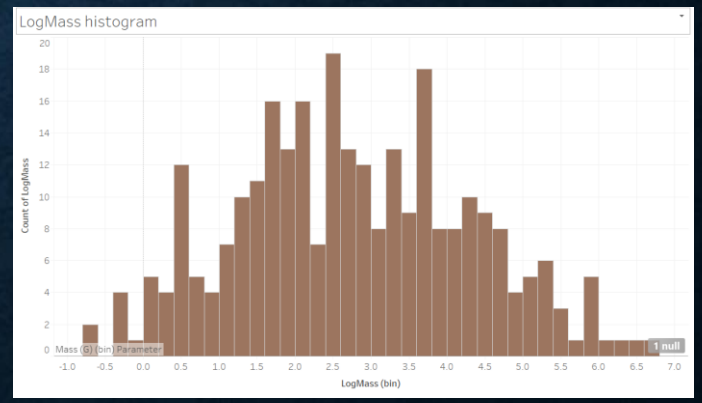
Because meteors break on impact, we see meteorites of the same type in large clusters. These clusters are easy to find and excavate in desert regions.

LOGMASS IS NORMALLY DISTRUBTED





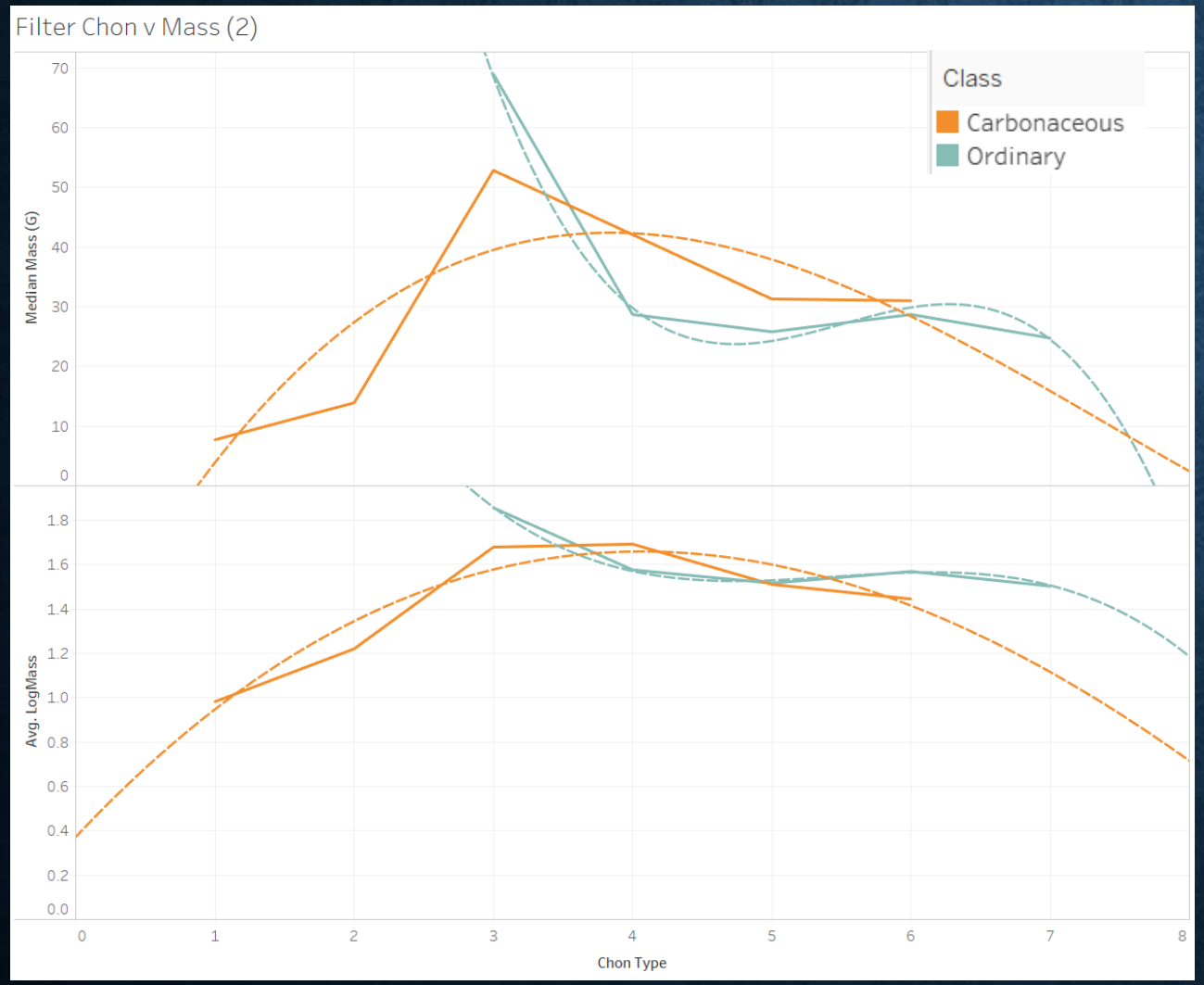




Mass Chart

Category	Number of Recor..	Avg. Mass (G)	Std. dev. of Mass ..	Median Mass (G)	Max. Mass (G)	Avg. LogMass	Std. dev. of LogM..
Achondrite	2,115	2,902.39	69,916.00	89.56	3,000,000	1.9773	0.8882
chondrite	42,117	1,520.69	29,365.75	28.40	4,000,000	1.5568	1.0268
Iron	1,069	494,262.89	3,763,929.66	10,000.00	60,000,000	3.7830	1.3659
Stony_Iron	281	72,445.58	389,152.32	496.16	4,300,000	2.7647	1.5460
Ungrouped	59	10,084.02	30,715.25	1,570.50	173,000	2.8228	1.4443
Grand Total	45,641	13,285.66	575,152.84	32.70	60,000,000	1.6355	1.0930

REGRESSION MODELING: CHONDRITE TYPE VS MASS



3rd degree polynomial regression, using median mass and avg. logmass

15110 records for Ordinary Chondrites
1177 records for Carbonaceous Chondrites

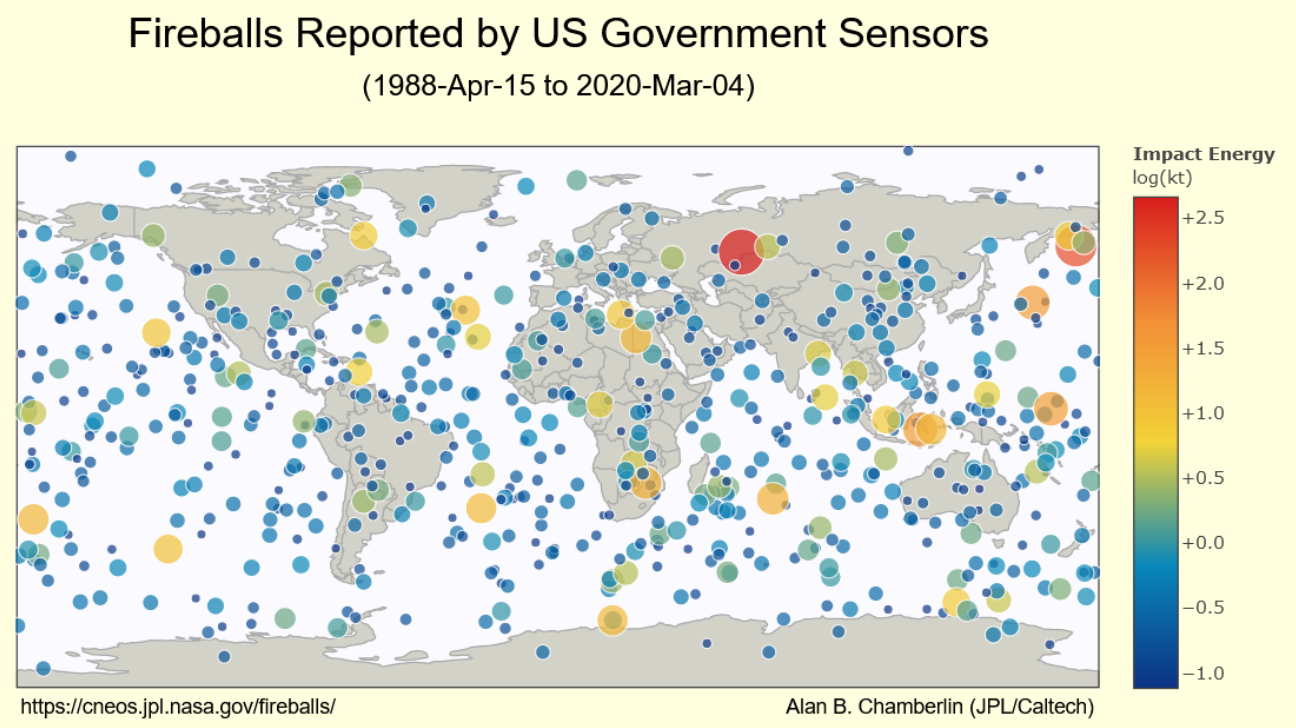
A polynomial trend model of degree 3 is computed for median of Mass (G) given Chon Type.

Model formula: Class*(Chon Type^3 + Chon Type^2 + Chon Type + intercept)

Individual trend lines:

Panes		Color	Line		Coefficients				
Row	Column	Class	p-value	DF	Term	Value	StdErr	t-value	p-value
Median Mass (G)	Chon Type	Ordinary	0.0763669	1	Chon Type^3	-3.6875	0.596869	-6.17807	0.102159
					Chon Type^2	60.9196	8.97347	6.78886	0.0931047
					Chon Type	-328.946	43.1683	-7.62008	0.0830703
					intercept	606.854	66.0532	9.18736	0.0690213
Median Mass (G)	Chon Type	Carbonaceous	0.411755	2	Chon Type^3	0.34963	1.81133	0.193024	0.864765
					Chon Type^2	-7.80397	19.168	-0.407134	0.723349
					Chon Type	44.5257	59.901	0.743321	0.534745
					intercept	-33.3717	52.5722	-0.634778	0.590503
LogMass	Chon Type	Ordinary	0.0664454	1	Chon Type^3	-0.0282458	0.0039748	-7.10617	0.0890025
					Chon Type^2	0.462235	0.0597585	7.73506	0.0818492
					Chon Type	-2.47926	0.287478	-8.62418	0.0734898
					intercept	5.89772	0.439878	13.4076	0.0473942
LogMass	Chon Type	Carbonaceous	0.141557	2	Chon Type^3	0.0021195	0.0168805	0.12556	0.911563
					Chon Type^2	-0.0951181	0.178635	-0.532472	0.647634
					Chon Type	0.668656	0.558242	1.19779	0.353698
					intercept	0.367692	0.489941	0.750482	0.531244

CONCLUSIONS



Fireballs – meteors in the atmosphere with the potential to yield meteorites – are randomly scattered around the earth

The data confirms what makes intuitive sense

- Chondrite type 3, which indicates lowly damaged meteorites, are the largest
- Meteors fall randomly, but are more likely to be sighted in population dense areas
- Otherwise, meteorites are more likely to be found where they're distinct and preserved

CONSIDERATIONS FOR IMPROVEMENTS AND FURTHER STUDY

- Create meteorite simulator based on combination of fireball and meteorite database.
- See if this simulation suggests there would be a region of the earth where meteorites might be preserved but not yet collected and recorded.
- More detailed breakdown of *reclass* that includes material composition estimates.

APPENDIX TABLE OF CONTENTS

A1: CHONDRITE TYPE # VS LOGMASS

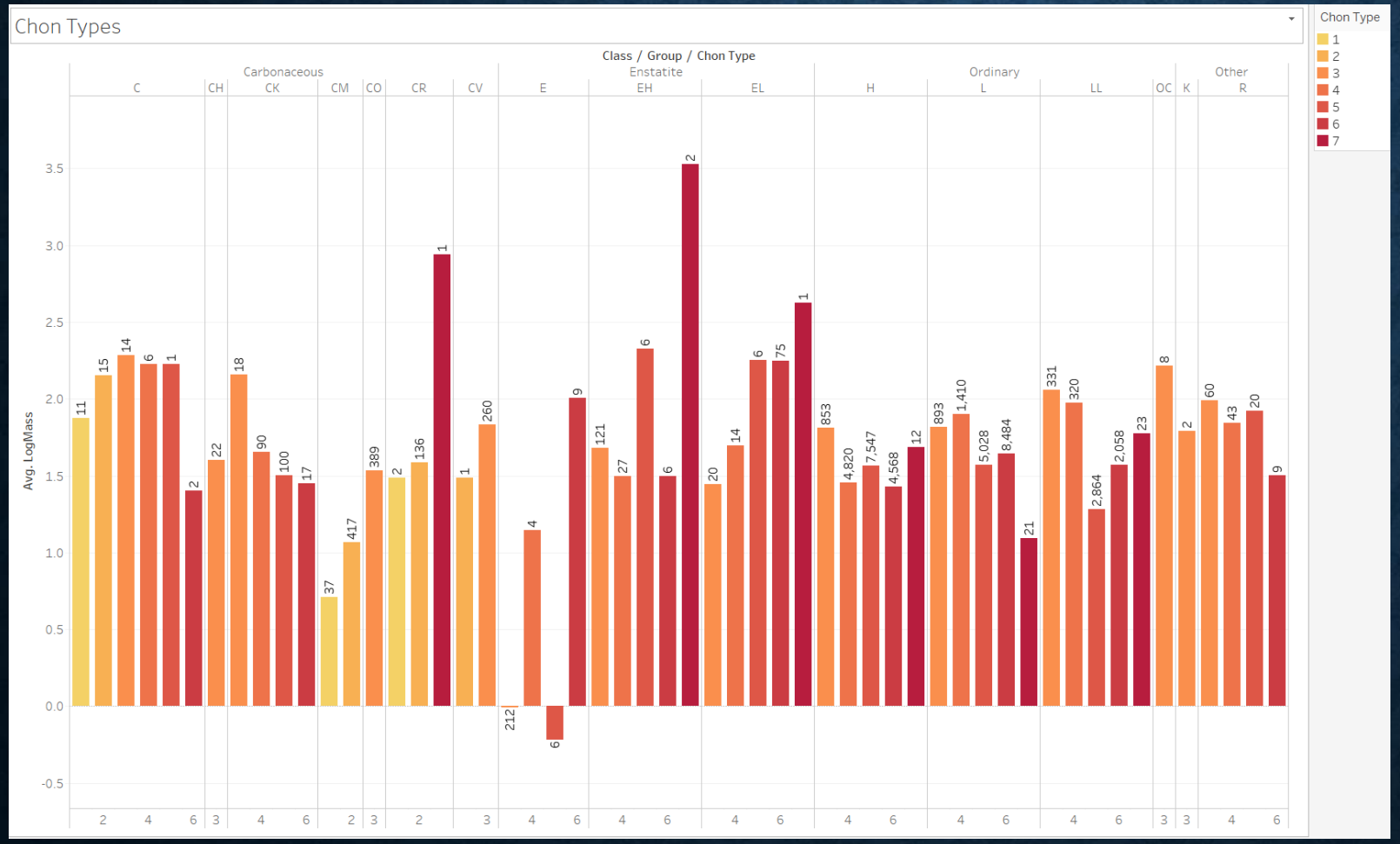
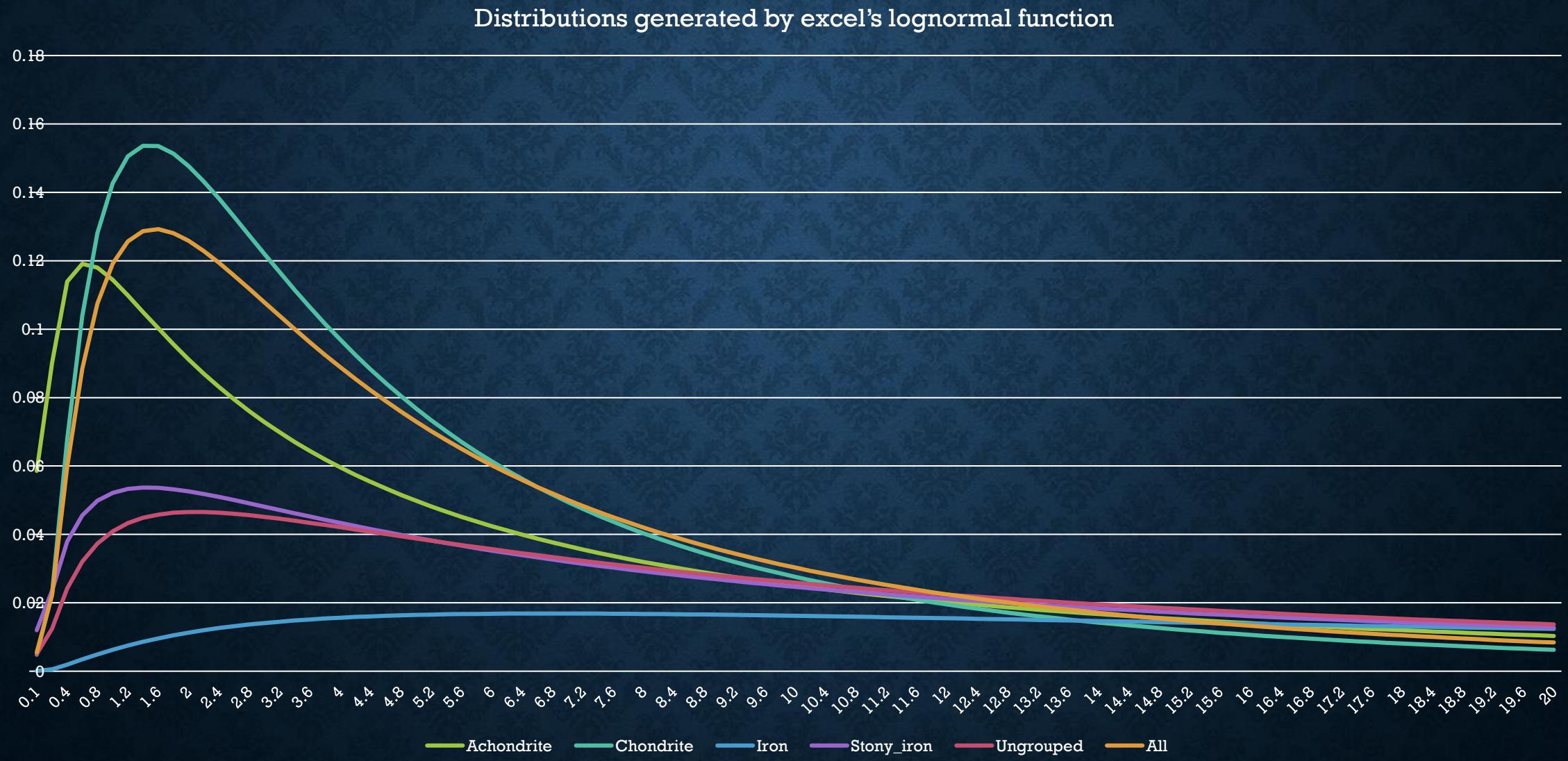


Table is organized by Class, Group and chondrite type. The numbers above the bar are the total # of records for that classification.

A2: PROBABILITY DISTRIBUTION FUNCTION FOR METEORITE MASS



A3: FULL REGRESSION LINE DETAILS

Trend Lines Model

A polynomial trend model of degree 3 is computed for average of LogMass given Chon Type.

Model formula:	Class*(Chon Type^3 + Chon Type^2 + Chon Type + intercept)
Number of modeled observations:	11
Number of filtered observations:	0
Model degrees of freedom:	8
Residual degrees of freedom (DF):	3
SSE (sum squared error):	0.0371571
MSE (mean squared error):	0.0123857
R-Squared:	0.933175
Standard error:	0.111291
p-value (significance):	0.0847719

Analysis of Variance:

Field	DF	SSE	MSE	F	p-value
Class	4	0.08017443	0.0200436	1.61829	0.360878

A polynomial trend model of degree 3 is computed for median of Mass (G) given Chon Type.

Model formula:	Class*(Chon Type^3 + Chon Type^2 + Chon Type + intercept)
Number of modeled observations:	11
Number of filtered observations:	0
Model degrees of freedom:	8
Residual degrees of freedom (DF):	3
SSE (sum squared error):	430.335
MSE (mean squared error):	143.445
R-Squared:	0.853453
Standard error:	11.9769
p-value (significance):	0.242929

Analysis of Variance:

Field	DF	SSE	MSE	F	p-value
Class	4	928.49106	232.123	1.6182	0.360894

Individual trend lines:

Panes		Color	Line		Coefficients				
Row	Column	Class	p-value	DF	Term	Value	StdErr	t-value	p-value
Median Mass (G)	Chon Type	Ordinary	0.0763669	1	Chon Type^3	-3.6875	0.596869	-6.17807	0.102159
					Chon Type^2	60.9196	8.97347	6.78886	0.0931047
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A4: STACKED BAR CHART FOR NON-ORDINARY METEORITES