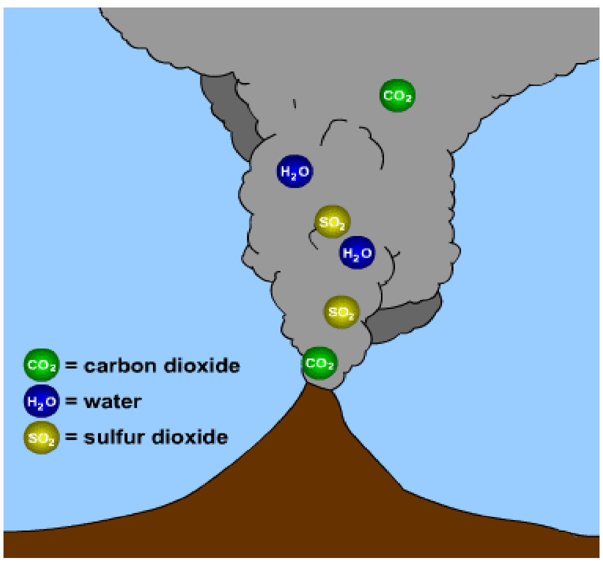
Student Sheet 1

PROBLEM SOLVING ACTIVITY: VOLCANOES AND CLIMATE CHANGE

As volcanoes erupt, they blast huge clouds into the atmosphere. These clouds are made up of particles and gases that were previously trapped in the geosphere, including sulfur dioxide, carbon dioxide, chlorine, argon, carbon monoxide, and water vapor. Millions of tons of harmful sulfur dioxide and carbon dioxide gas can reach the stratosphere from a major volcano. While all these gases play a small part in volcanic-induced climate change, sulfur dioxide aerosols are by far the largest contributors to global cooling.

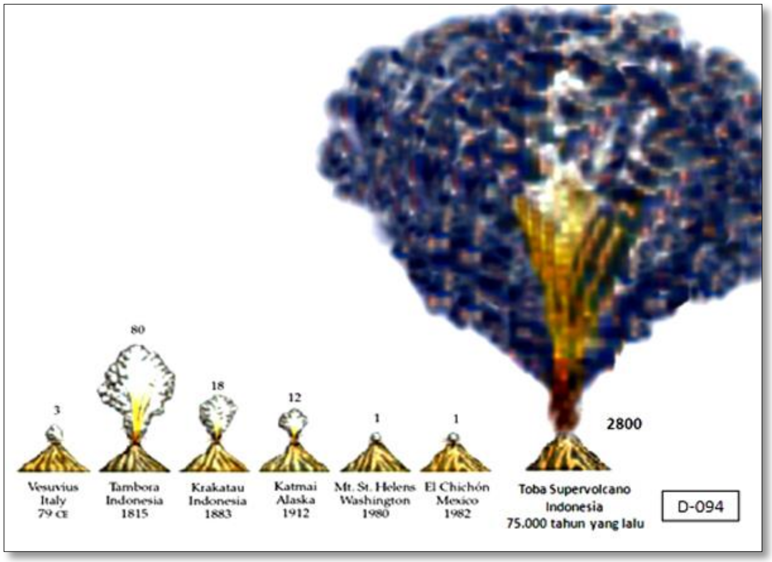


Sulfur dioxide has the most adverse effect on the atmosphere of any of the volcanic gases. Sulfur dioxide combines with water molecules to produce sulfuric acid within months of the eruption. Winds then spread these newly formed ***aerosols*** over the majority of the globe, where they stay in the atmosphere for upwards of two years. Not only do these aerosols cool the earth's surface by reflecting sunlight back into space, but the sulfuric acid also plays a role in the increased depletion of ozone.

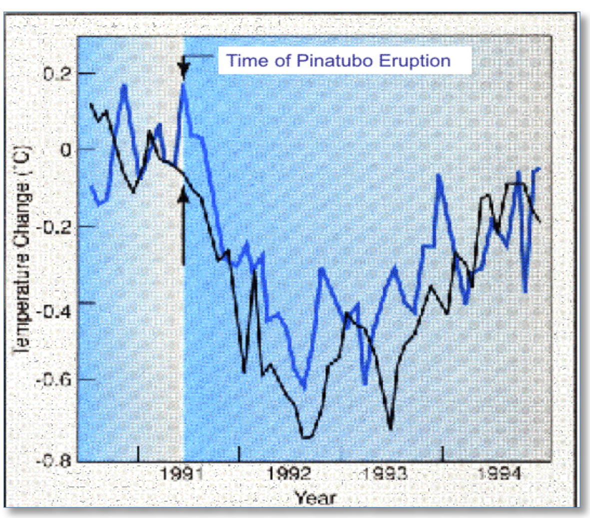
One of the greatest examples of the global cooling caused by volcanic eruptions occurred in 1816, known as "The Year without a Summer". One year after ***Mt. Tambora*** erupted in Indonesia its effects were already being felt globally. In New England snow fell in July of 1816, and temperatures reached the 30's.

Student Sheet 2

Both Europe and North America faced economic hardships from early frosts destroying large amounts of crops.



Some scientists also believe that the eruption of ***Mt. Toba*** in Indonesia may have actually cooled the planet by 3-5 degrees Celsius, resulting in a ***'volcanic winter'***. This ***super-eruption*** occurred sometime between 69,000 and 77,000 years ago at Lake Toba (Sumatra, Indonesia). It is recognized as one of the Earth's largest known eruptions. The related catastrophe hypothesis is that this event caused a global volcanic winter of 6–10 years and possibly a 1,000-year-long cooling episode. It had an estimated ***Volcanic Explosivity Index*** of 8- described as "mega-colossal" Its erupted mass was 100 times greater than that of the largest volcanic eruption in recent history, the 1815 eruption of Mt. Tambora in Indonesia, which caused the 1816 "Year Without a Summer" in the northern hemisphere.

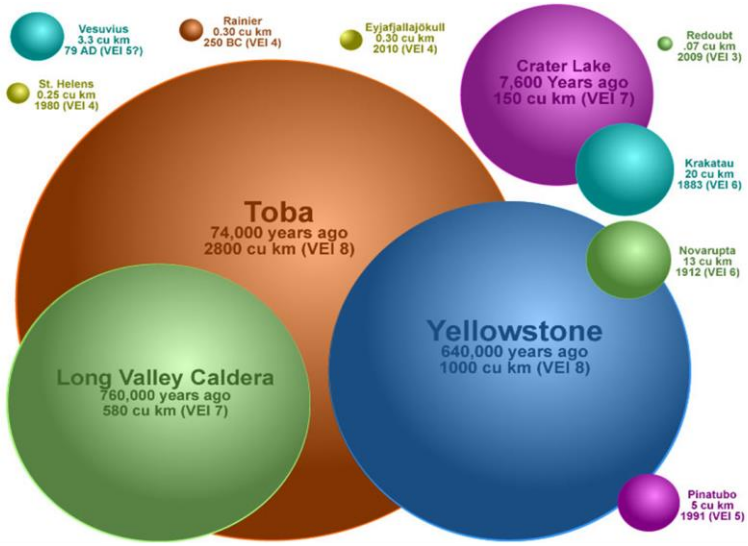


The eruption of Mt. Pinatubo in the Philippines in 1991 was one of the largest volcanic eruptions in the past century. The injection of between 14-26 million tons of sulfur into the stratosphere resulted in a global surface cooling of 0.5 degrees Celsius one year after the eruption. The climatic impact of this eruption was greater than El Nino or human-induced GHG changes from 1991-1993.

Student Sheet 3

In most cases, however, volcanic eruptions do not have such an extreme effect on the atmosphere. Eruptions of the magnitude of Pinatubo only happen around once every 100 years. The overall impact of a volcanic eruption on the atmosphere is dependent on the size of the volcano, its overall emissions, and the height of the volcano. No substantial climate change due to a volcano, however, has ever been witnessed for more than 10 years after the initial eruption.

The magnitude of eruptions differ tremendously; they are unpredictable; they differ in size; and ash and gases vary in composition. All of these factors make it difficult for scientists to separate volcanic effects from other influences on the global climate. While there is a definite short-term global cooling process brought about by volcanic eruptions, there have been no noticeable long-term effects, other than the depletion of ozone due to the release of aerosols. The relatively small amount of harm done to the atmosphere by volcanoesextensive damage done by humans.



Volcanic Explosivity Index (VEI)

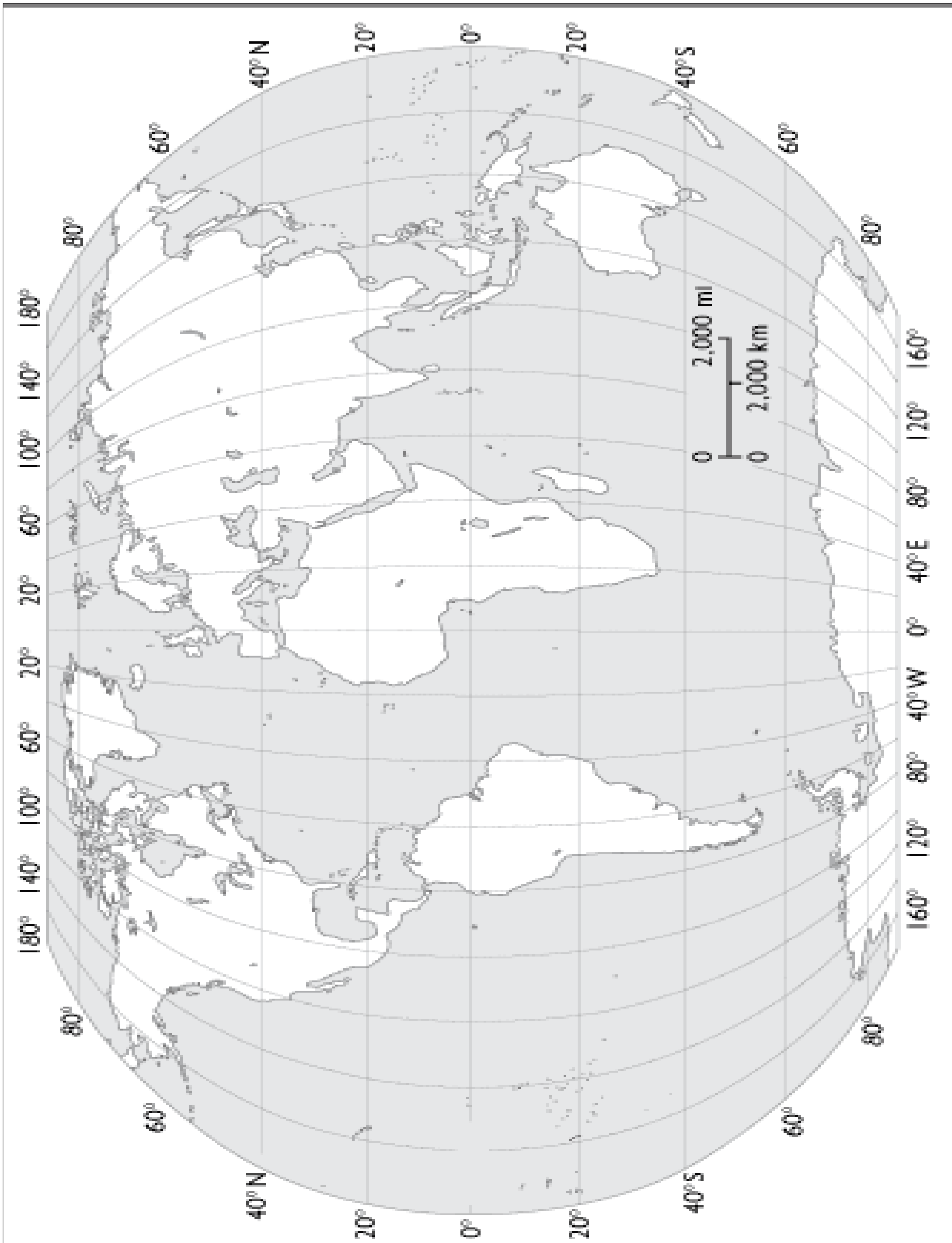
The impact of an eruption is the power of the volcanic eruption and the direction of the blast. Some eruptions are extremely explosive and inject material high into the atratosphere. While the Richter scale measures earthquake strength, volcanoes are evaluated by a scale called the ***Volcanic Explosivity Index (VEI).*** The V.E.I. gives us a way to measure the relative explosiveness of volcanic eruptions. It measures how much volcanic material is ejected, the height of the material thrown into the atmosphere, and how long the eruptions last. The scale is ***logarithmic***, or based on 10; therefore, an increase of "1" on the scale indicates an eruption 10 times more powerful than the number before it on the scale. Volcanoes are rated from 0-8, where 0 is the least eruption and 8 is the most explosive.

Student Sheet 4

TABLE 1:DATA FROM 11 MAJOR EXPLOSIVE VOLCANIC ERUPTIONS

LOCATION	ELEVATION (M)	LATITUDE	LONGITUDE	DATE	VEI
Krakatau, Indonesia	0813	6.1 S	105.42 E	8/1883	6
Pelee, W. Indies	1397	14.8 N	61.17 W	5/1902	4
Santa María, Guatemala	3772	14.8 N	91.55 W	10/1902	6
Ksudach, Kamchatka	1079	51.8 N	157.52 E	3/1907	5
Katmai, AK	0841	58.3 N	155.16 W	6/1912	6
Katla, Iceland	1363	63.6 N	19.03 W	10/1918	4
Komaga-take Japan	1140	42.7 N	140.68 E	6/1929	4
Agung, Indonesia	3142	8.3 S	115.51 E	3/1963	4
Taal, Philippines	0400	14.0 N	121.00 E	9/1965	5
Mt. St. Helens, USA	2549	46.2 N	122.18 W	5/1980	5
El Chichón,Mexico	1060	17.3 N	93.2 W	3/1982	5

Student Sheet 5



Students Sheet 6

DATA SHEET: BACKSCATTER/ALTITUDE 1991-1992

Aug-91		Jan-92	
Altitude(km)	Backscatter	Altitude (km)	Backscatter
4	18900	4	201
5.5	3100	5.5	44
7	333	7	34
8.5	130	8.5	42
10	97	10	63
11.5	101	11.5	250
13	272	13	425
14.5	636	14.5	485
16	971	16	682
17.5	482	17.5	1140
19	217	19	1790
20.5	340	20.5	1340
22	116	22	215
23.5	38	23.5	151
Oct-91		**Mar-92**	
Altitude(km)	Backscatter	Altitude (km)	Backscatter
4	10900	4	9650
5.5	505	5.5	3580
7	129	7	11
8.5	120	8.5	426
10	176	10	412
11.5	339	11.5	845
13	506	13	972
14.5	864	14.5	999
16	1020	16	1180
17.5	975	17.5	1420
19	901	19	1660
20.5	830	20.5	1230
22	416	22	395
23.5	150	23.5	136

TITLE____

Legend

Backscatter units

Altitude (km)

Student Sheet 7

ANALYSIS:

1. Which gas combines with water from a volcanic eruption to form sulfuric acid?

2. At what altitude above the troposphere, is the most backscatter from aerosols located?

3. Which layer of the Earth's atmosphere above 10 km has the most aerosol backscatter?

4. From January to August 1991 what happened to the amount of backscatter above an altitude of 10 km? Why?

5. What is the maximum amount of backscatter in the stratosphere for August 1991? For January 1992?

6. In which layer of the Earth's atmosphere, above the troposphere, is the largest amount of backscatter located for January 1992 and March 1992?

7. Between August 1991 and January 1992, what change in attitude, above the troposphere, occurred for the maximum amount of backscatter?

8. Why is the change in altitude significant for the amount of backscatter between August 1991 and January 1992?

9. Why does the maximum amount of backscatter occur in January 1992, when the eruption of Mt. Pinatubo occurred in June 1991, six months earlier? (Hint: Think about our location on the globe compared to Mt. Pinatubo.)

10. Why is the change in altitude significant for the maximum amount of backscatter between August 1991 and January 1992?

Student Sheet 8

CONCLUSION:

- Review the problem stated for **PART B** and write your conclusions here.