SPQ Module 11 – Greenhouse Gases & Antarctic Ice

Ninety-eight percent of Antarctica is covered in ice, ice that is up to 15,000 feet thick. Fifteen thousand feet is deeper than most mountains in North America are high! What does this ice, over which Ray, Richard and Kevin are now running, have to do with our knowledge of greenhouse gases?

Let us first refresh our memories about greenhouse gases.

Greenhouse gases are molecules found in the earth's atmosphere. They can occur naturally or can be produced by man. The earth's most abundant greenhouse gases are:

- **Water vapor**
- **Carbon dioxide**
- **Methane**
- **Nitrous oxide**
- **Ozone**
- **CFC's (Chlorofluorocarbons)**

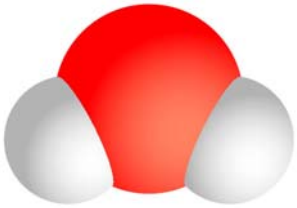

Figure 1: Water Molecule

Scientists are concerned about greenhouse gases because they are rapidly heating up the Earth's atmosphere in a manner that may cause cataclysmic changes to fragile ecosystems and lead to starvation and extinction. If this is so should mankind be focused on eliminating greenhouse gases from our atmosphere?

Absolutely not.

Greenhouse gases are essential for the survival of life on earth. This is because they absorb thermal energy (heat) thereby keeping the surface of the earth warm. Without greenhouse gases the planet would be so cold that it would be uninhabitable.

The current problem the Earth faces with global warming is due to the fact that levels of greenhouse gases have been rising for the last 250 years. As the level of greenhouse gases rise, more heat is absorbed by the atmosphere and the earth gets warmer. Prior to the last 250 years the level of greenhouse gases in the Earth's atmosphere had been relatively constant for the previous 10,000 years. The recent climb in greenhouse gases dates back to Industrial Revolution and has been caused by human activity.

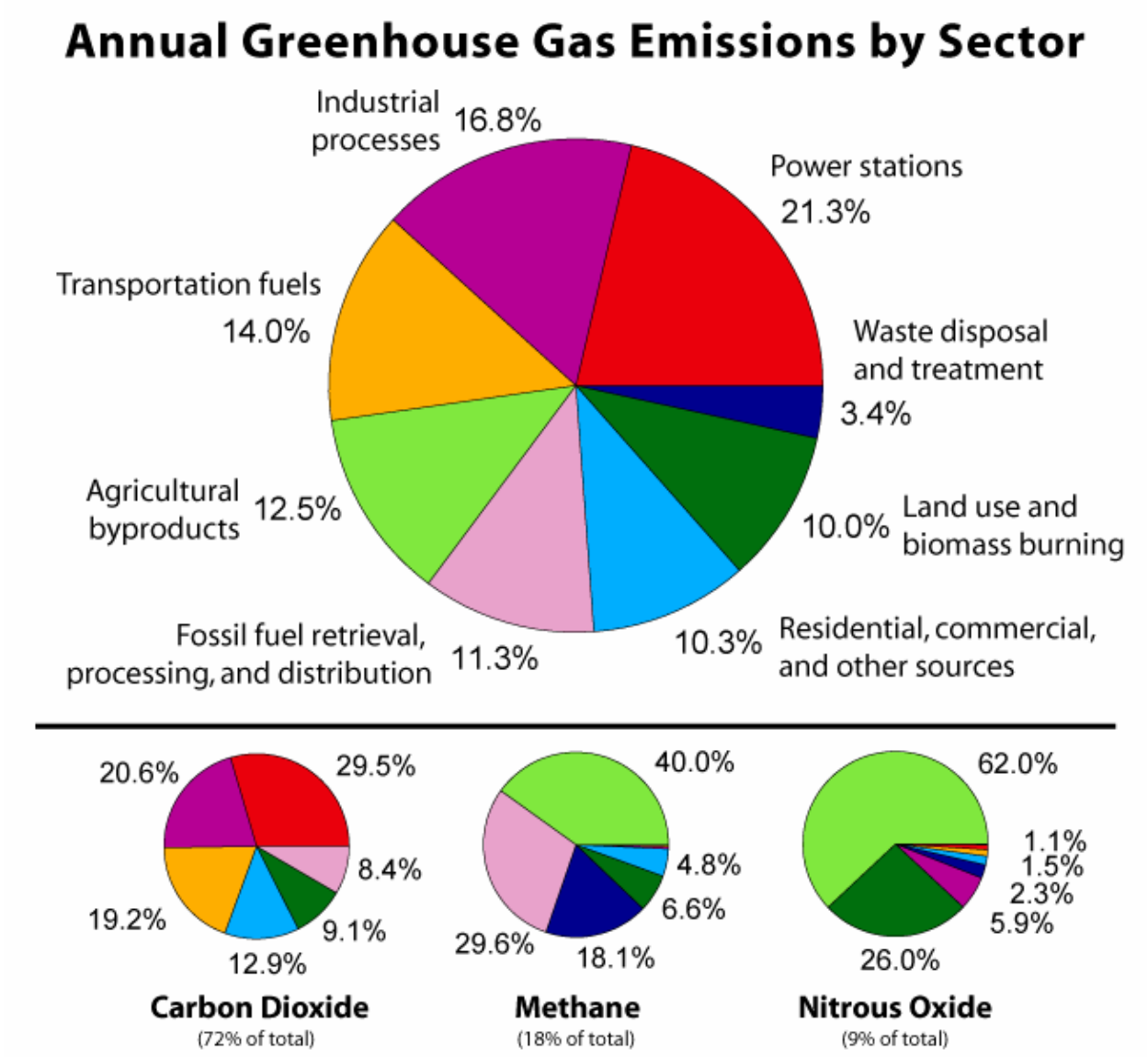

Figure 2: The relative fraction of man-made greenhouse gases produced by eight categories of sources for the year 2000 (source: The Emission Database for Global Atmospheric Research)

Today scientists can directly measure the amount of Carbon dioxide, or other greenhouse gases in the Earth's atmosphere. But how have scientists been able to establish what the levels of greenhouse gases were in the atmosphere thousands of years ago? The answer brings us back to the ice over which our expedition members are traveling.

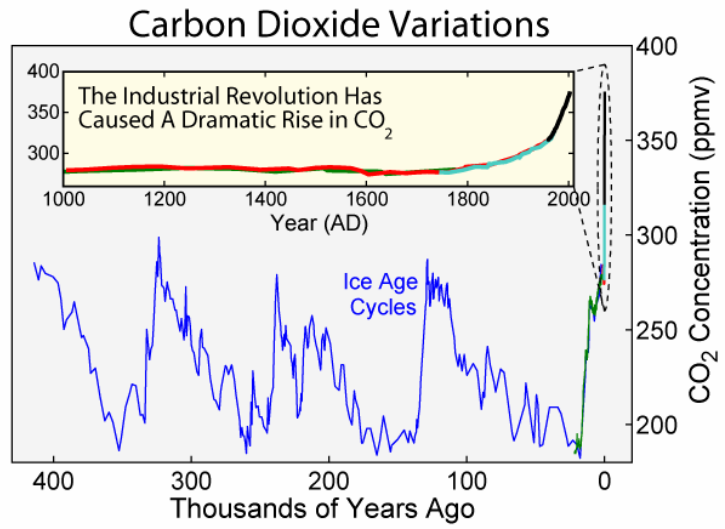

Figure 3: The variations in concentration of carbon dioxide (CO2) in the atmosphere during the last 400 thousand years. Since the Industrial Revolution, circa 1800, the burning of fossil fuels has caused a dramatic increase of CO2 in the atmosphere, reaching levels unprecedented in the last 400 thousand years. (sources: (blue) Vostok ice core, (green) EPICA ice core, (cyan) Siple Dome ice core, (black) Mauna Loa Observatory, Hawaii)

When ice freezes it can capture little pockets of air in it. The air that is captured reflects the constituents of the atmosphere at the time the ice froze. Recall that the ice in Antarctica is up to 15 thousand feet thick. It has taken over 700 thousand years to build ice this thick. By drilling down into the ice and analyzing the air pockets captured, a historical record of the atmospheric greenhouse gases can be established going back 700 thousand years. So the thick ice sheet that covers Antarctica has proven to be the richest source of historical greenhouse gas data.

Figure 4: Inside of the ice core storage area at the National Ice Core Laboratory in Denver Colorado. The typical tube contains a one meter section of ice core. (source: Eric Cravens, Assistant Curator, National Ice Core Lab)

Figure 5: Vostok station. The site was chosen by the Soviet Union for the deep coring possibilities it offered. French and, later, American scientists became interested in the Soviet research and began to participate in coring activities at the site. (source: Todd Sowers LDEO, Columbia University, Palisades, New York.)

So let us check in with our expedition. Are greenhouse gases having a direct impact on the expedition members? The answer is yes.

Antarctica is the highest and coldest continent on Earth. For much of their journey Ray, Richard and Kevin will be traveling at about 10,000 feet above sea level. Air becomes colder at higher levels. The reason for this is that at higher elevations the atmosphere, which is the layer of gases that surrounds the earth, becomes thinner (less dense). This means that there are fewer greenhouse gases at higher elevations and consequently the air is colder. So one of the reasons why Ray, Richard and Kevin will have to contend with very cold temperature in Antarctica (even in the summer months) is because Antarctica is so high and there are fewer greenhouse gases at high elevations.

I hope this does not change their mind about the importance of reducing greenhouse gas emissions!

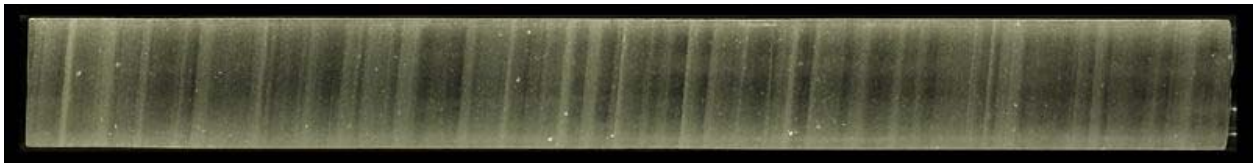

Figure 6: Section of an ice core sample. This ice was formed ~16250 years ago during the final stages of the last ice age and approximately 38 years are represented here. By analyzing the ice and the gases trapped within, scientists are able learn about past climate conditions. (source: National Ice Core Laboratory).

Did You Know?

Some planets have much higher levels of greenhouse gases in their atmosphere – such as Venus where the average surface temperature is 467degrees Celsius.