Methane, too, may be warming the atmosphere

Methane, or marsh gas, is increasing in abundance in our atmosphere. With other trace gases, it is adding to the suggested warming effect of the steadily growing concentration of carbon dioxide.

Measurements by Dr Paul Fraser of the CSIRO Division of Atmospheric Physics, in conjunction with scientists from the Oregon Graduate Centre in the United States, show that air sampled at the Cape Grim atmospheric baseline station in Tasmania has increased its methane content by 1·2% per year over the last 3 years. This figure is in line with results being recorded at stations overseas where similar measurements are being made.

One computer model of atmospheric warming estimates that, during the last decade, carbon dioxide has caused an average global temperature rise of 0·14°C, and methane and other trace gases have caused a further increase of 0·10°C. These effects are small, but growing. Before the end of this century, the combined effect of these warming gases should begin to become apparent above the natural variability of climate (see 'When the air's carbon dioxide doubles', in *Ecos* 28).

As far as we can ascertain, the methane content of the atmosphere has increased by about 200 parts per billion over the last decade (from 1400 to 1600 p.p.b.). In assessing both the causes and effects of this rise, we must consider other trace gases because of methane's interactions with them.

In particular, methane is closely coupled with carbon monoxide, oxides of nitrogen, ozone, and hydroxyl radicals in the lower atmosphere and with chlorine radicals in the stratosphere. As a result of the burning of fossil fuels, emissions of carbon monoxide and oxides of nitrogen — as well as carbon dioxide — have been increasing. From models of atmospheric chemistry, scientists infer that an increase in these gases, and in methane, brings about an increase in ozone in the lower atmosphere.

Oil and natural-gas production adds some methane to the air.

Although only about 10% of the atmosphere's ozone is in this region (the troposphere), this amount contributes about half of the compound's total warming (or 'greenhouse') effect. Thus, methane not only contributes directly to a global warming, but also does so indirectly.

Each cow belches up about 300 litres of methane a day.

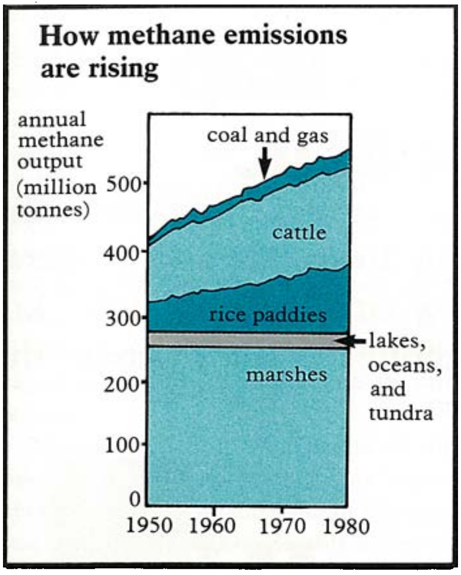
In another chemical interaction, methane reduces the number of chlorine radicals in the stratosphere by converting them to hydrochloric acid. As a consequence, it reduces the ozone-destroying potential of the chlorine-containing chlorofluorocarbons that have been building up in the atmosphere. (There is a possibility that chlorofluorocarbons themselves may be leading to unwelcome changes in our climate — see *Ecos* 14.)

The reaction of methane with the hydroxyl radical (OH) is the principal removal mechanism (or sink) for the gas in the atmosphere. The burning of fossil fuels is believed to have two effects that are relevant here. When carbon monoxide is added to the atmosphere, it reduces the concentration of the hydroxyl radical, and so less methane is destroyed, leading to higher methane levels. However, extra oxides of nitrogen (also liberated from fossil-fuel combustion) create more ozone, which leads to more hydroxyl radicals, and so to a decrease in methane levels.

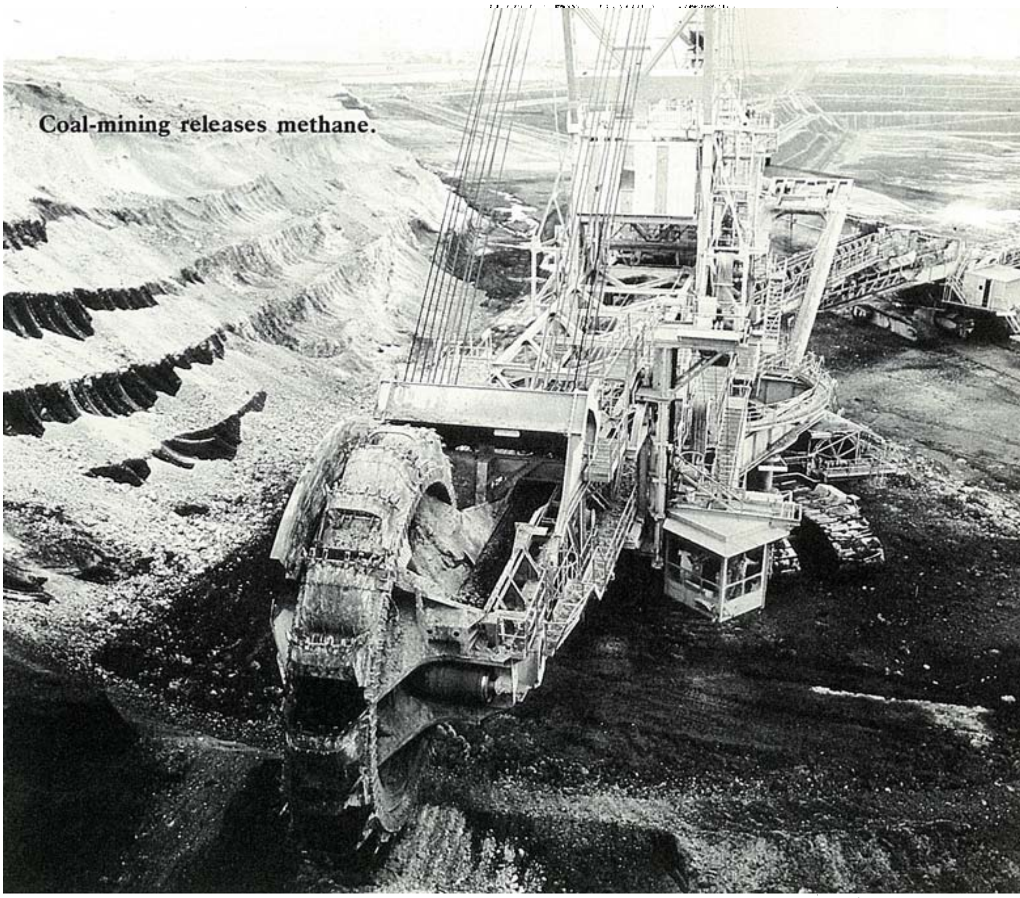
Sources and sinks

Scientists are as yet unable to say with certainty which effect predominates, but the inescapable fact is that methane's levels are rising. It has many sources, the main ones being: the decomposition of organic matter in soils and swamps by anaerobic bacteria; fermentation in the digestive systems of animals, particularly cattle and other ruminants; and leakage from commercial natural-gas fields and

Instruments for measuring the minute concentration of methane in the air. A gas chromatograph equipped with a flame ionization detector is the heart of the system.



These estimates of methane emissions indicate that increasing methane levels in the atmosphere are largely due to cattle and rice paddies.



Coal-mining releases methane.

coal mines. The gas may also seep from faults in the earth's crust.

The earth's atmosphere contains something like 4 to 5 billion tonnes of methane, with a current estimated yearly addition of 0·5 to 1 billion tonnes. The gas stays in the air for an average of about 5 years before breaking down, ultimately to carbon dioxide.

Isotope measurements lead scientists to suspect that the sources of more than 80% of the methane are biological. The ratio of carbon-14 to carbon-12 is higher in living systems than in long-dead organic material, because of the slow radioactive decay of carbon-14 (its half-life is 5700 years). Hence, methane from swamps and cattle, for example, has a higher ratio than that from natural-gas fields.

Contamination of atmospheric methane by carbon-14 from nuclear explosions complicates the picture. Measurements made before the explosions began, although unambiguous, are of limited precision. So scientists attempt to compensate for the effect of atomic bomb tests when interpreting their measurements.

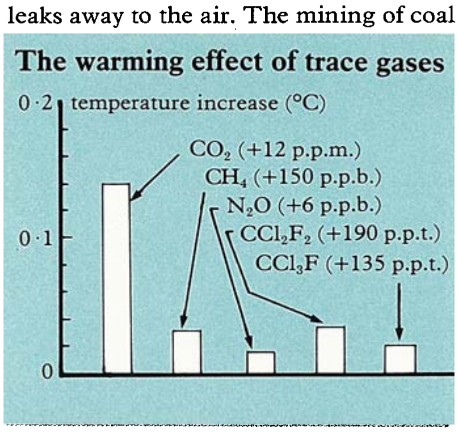
Some scientists are taking measurements on air bubbles trapped in Antarctic ice that is at least 100 years old. This work indicates that the concentration of methane last century may have been about 600 p.p.b., less than half today's figure.

Effects of rice and cattle

The annual input of methane to the atmosphere is not known accurately. Using one published estimate of 550 million tonnes per year, Dr Fraser calculates that about half of this comes from natural marshes and one-quarter from artificial marshes, particularly rice paddies. The remaining quarter comes from ruminant animals, mainly cattle, and coal and gas fields.

It is significant that cattle numbers and rice paddies are steadily increasing. Cattle are among the fastest-growing methane sources. Since 1940 their numbers have doubled to 1210 million, according to United Nations sources. Each cow belches up about 300 litres of methane a day.

Also, in the 30 years from 1950, the area under rice has more than doubled. Industrial growth over the same period has meant that coal and gas use has grown too. Quantities of natural gas (which is mainly methane) are deliberately vented to the atmosphere; and some inevitably leaks away to the air. The mining of coal releases pockets of methane trapped in coal seams.



A modelling study suggests that trace gases added to the atmosphere between 1970 and 1980 caused a global warming of 0·1°C — nearly as much as that brought about by carbon dioxide (0·14°C).

The diagram shows the combined effect of all these sources. It shows a rise in methane emissions of 0·9% per year, corresponding to a rise in atmospheric concentration of about 0·7%. The contribution of marshes is assumed to be constant, although the area of wetlands, swamps, bogs, flood-plains, and the like is no doubt being altered, and the amount of methane they emit varies a lot depending on temperature, nutrient supply, and other factors.

The influence of added carbon monoxide and oxides of nitrogen also has to be considered when relating the increase in methane emissions to the changing methane level in the atmosphere. The results of calculations with one model of atmospheric chemistry suggest a rise of 0·6% per year from such sources, giving a total rise in methane level of 1·3% per year. This is in reasonable (although possibly fortuitous) agreement with actual measurements, suggesting that scientists may be on the right track.

Detailed measurements at Cape Grim show that, superimposed on a steady increase, the concentration of methane varies throughout the year, probably in response to seasonal biological activity. Intriguingly, maximum methane concentrations are found in autumn in the Northern Hemisphere, whereas the Southern Hemisphere's maximum occurs in spring, that is, around the same time (September–October).

Experience in modelling Southern Hemispheric annual cycles of carbon dioxide has shown that a significant, if not the major, part of the variation in carbon dioxide levels in this hemisphere is due to biological activity in the other hemisphere. The impact of this activity on the composition of the Southern Hemisphere's atmosphere is delayed by the time it takes for air masses to exchange between the hemispheres (of the order of 1 year).

The same phenomenon could be occurring with methane. In other words, this year's minimum in Australia's methane concentration could be last year's minimum from the Northern Hemisphere.

A net transfer of methane from the Northern Hemisphere to the Southern Hemisphere occurs because methane sources are largely land-based and land is concentrated in the Northern Hemisphere. On average, concentrations in the Northern Hemisphere are higher than those in the Southern Hemisphere. Dr Fraser calculates that this gradient is maintained by an annual flux of 80 million tonnes of methane from the Northern into the Southern Hemisphere.

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More about the topic

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