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http://www.global-warming-geo-engineering.org/DOE-Meeting/Catastrophic-Methane-Hydrate-Release/ag14.html

Catastrophic Methane Hydrate Release Mitigation

This topic falls under the category of abrupt climate change as will be clear shortly. Methane hydrates or clathrates are combinations of water and methane in the form of an ice-like matrix. The methane is the result of the action of methanogenic bacteria on sediment over thousands of years. The methane is kept in an ice form where appropriate combinations of temperature and pressure exist.

Methane hydrates are widespread in sea sediments hundreds of meters below the sea floor along the outer continental margins and are also found in Arctic permafrost. Some deposits are close to the ocean floor and at water depths as shallow as 150 m, although at low latitudes they are generally only found below 500 m. The deposits can be 300-600 m thick and cover large horizontal areas. A nearby deposit nearly 500 km in length is found along the Blake Ridge off the coast of N.C. at depths of 2000-4000 m.

The total quantity of methane hydrates in the ocean sediment is estimated to be around 10,000 GtC. The methane hydrates in sediment considered part of U.S. territory alone could supply U.S. natural gas needs for 1000 years. Because of this enormous quantity, methane hydrates are being investigated as an energy source to replace petroleum and conventional sources of natural gas, although an extraction technology for ocean sediments does not presently exist.

There is some evidence that massive releases of methane from ocean sediment hydrate deposits may have been indirectly responsible for ending some of the ice ages. Were such releases to occur today because of warming of the oceans or as a

result of seismic events, the result could be a sudden rise in atmospheric temperature, triggering feedback mechanisms that might lead to rapid melting of polar ice.

In the slides, the example of a 1 GtC release was used. That represents 0.01% of the total methane hydrates in the ocean. The quantity degassed to the atmosphere 15,000 years ago, at the end of the last ice age is now believed to be around 4 GtC as methane or 0.04%. The average temperature of the Earth increased from 30°F to 60°F within a few decades. The radiative forcing from the methane alone would have been insufficient to cause more than a 3°F increase. It is thought that feedback effects from additional methane released from melting permafrost, carbon dioxide and water vapor contributed to the rest of the warming. But the initial methane hydrate release from the ocean may have been the catalyst.

All of the conditions that may have led to the methane hydrate release 15,000 years ago do not exist today. Sea levels were much lower and thus, the pressure on the sediments was less. However, there is some evidence that ocean currents that impinge on ocean sediments are getting warmer, especially in the Arctic. Global warming is thus a possible triggering mechanism for massive methane hydrate release in today's climate.

What causes release of methane hydrates is still poorly understood. Warm waters may destabilize the hydrate zone. Hydrates on the surface of the ocean floor on a ridge may then degass. The sediment may then become unstable and slide down the ridge, exposing other layers of methane hydrate, accelerating the release. As an example, the Storegga slump off the coast of Norway 8000 years ago could have released between 1 and 4 GtC as methane.

Alternatively, an undersea earthquake today, say off the Blake Ridge or the coast of Japan or California might loosen and cause some of the sediment to slide down the ridge or slump, exposing the hydrate layer to the warmer water. That in turn could cause a chain reaction of events, leading to the release of massive quantities of methane.

Another possibility is drilling and other activities related to exploration and recovery of methane hydrates as an energy resource. The hydrates tend to occur in the pores of sediment and help to bind it together. Attempting to remove the hydrates may cause the sediment to collapse and release the hydrates. So, it may not

take thousands of years to warm the ocean and the sediments enough to cause massive releases, only lots of drilling rigs.

Returning to the 4 GtC release scenario, assume such a release occurs over a one-year period sometime in the next 50 years as result of slope failure. According to the Report of the Methane Hydrate Advisory Committee, "Catastrophic slope failure appears to be necessary to release a sufficiently large quantity of methane rapidly enough to be transported to the atmosphere without significant oxidation or dissolution."

In this event, methane will enter the atmosphere as methane gas. It will have a residence time of several decades and a global warming potential of 62 times that of carbon dioxide over a 20-year period.

This would be the equivalent of 248 GtC as carbon dioxide or 31 times the annual man-made GHG emissions of today. Put another way, this would have the impact of nearly 30 years worth of GHG warming all at once. The result would almost certainly be a rapid rise in the average air temperature, perhaps as much as 3°F immediately. This might be tolerable if that's as far as things go. But, just like 15,000 years ago, if the feedback mechanisms kick in, we can expect rapid melting of Greenland and Antarctic ice and an overall temperature increase of 30°F.

For point of reference, the average temperature of the Earth (atmosphere, land and top layer of the ocean) in 2004 is around 60°F. The methane hydrate release projected here would raise the temperature to around 90°F or more. Such high temperatures would undoubtedly destabilize all of the other methane hydrates in the ocean and arctic permafrost, some 10,000 GtC or 620,000 GtC equivalent as carbon dioxide. This would have the impact of 78,000 years worth of GHG warming over a few decades. The temperatures reached and sustained would most likely cause a rapid die off in ocean phytoplankton and other sea life as well as most land plants and animals, including humans. The result would be a mass extinction and mark a major transition point in the Earth's geological history.

Although a 1000 or 10,000 GtC methane release in one year or over several decades is very unlikely, a 4 GtC release is entirely plausible. Even if the feedback mechanisms that were operative 15,000 years ago became partly active, the outcome could be just as disastrous as the scenario outlined above.

Gaskill said that if any massive releases of methane from methane hydrates were to occur, attempts should be made to ignite and burn the methane gas at the ocean's surface. By converting the methane to carbon dioxide, the threat of abrupt climate change is reduced by a factor of 62, to less than one-years worth of GHG emissions. Even if the mitigation effort is only partly successful, say 75% is converted to carbon dioxide, the remaining methane, equivalent to an 8-year pulse of all present day GHG emissions in a single year might still spell trouble, but it would be far preferable to the nightmare scenarios outlined above.

Combustion could be accomplished by aerial release and ignition of distillate fuel over the area where the methane is entering the atmosphere. There are several potential problems with this approach. The area to be covered may be too large to effectively treat in this way. Advection may also make continuous burning difficult. Dr. MacCracken pointed out that the methane level in the air at the surface might be too low to ignite. This would, of course depend on how fast the gas is being released.

Regardless, the potential for massive methane release from sediments represents such a significant threat that emergency mitigation plans like the one suggested here need to be prepared. The Methane Hydrate Research and Development Act of 2000, Public Law 106-193 does not address such catastrophic scenarios and we are unaware of anyone working on such plans.