A Guide to

Soil / Ground Gas Risk

Natural ground gases such as methane and carbon dioxide are found widely in soils and rocks, as they are an integral component of the geochemical cycle of the Earth. Methane and carbon dioxide can also occur due to the activities of man such as landfilling waste (landfill gas) and by mining (mine gas[5]) .

Distributed by:
Air-Met Scientific Pty Ltd

Air-Met Sales/Service
P: 1800 000 744
F: 1800 000 774
E: sales@airmet.com.au

Air-Met Rental
P: 1300 137 067
E: hire@airmet.com.au
W: www.airmet.com.au

Soil / Gas Risks

Uncontrolled subsurface gas migration and emission poses a number of risks to the environment and human health & safety from anthropogenic sources (the general term for gases originating in human activity) such as:-

- landfill waste
- abandoned coal mining
- shale gas production
- contaminated land from past industrial use (some dating as far back as Victorian times)
- pipeline leaks from current industrial processes such as oil refining & chemical manufacture
- Coal bed methane

And depending on the type of gas present, there is the potential for:-

- an explosion
- acute health effects e.g. headaches, dizziness, unconsciousness or even asphyxiation and death
- chronic, long term health effects e.g. cancers.
- Global warming

The effects are most dangerous when gases and vapours enter buildings because they become more concentrated rather than dispersing to the ambient atmosphere.

Ground Gases

In addition to methane (CH_4) and carbon dioxide (CO_2) from landfill, numerous trace gases may be present in ground gas, depending on the nature of the contamination or underground activities. Other constituents principally may include carbon monoxide (CO) and hydrogen sulphide (H_2S) as well as a cocktail of other hydrocarbons and volatile organic compounds (VOCs).

Migration Pathways

Migration pathways include pore spaces (e.g. in sands or gravels), fractures, joints, bedding planes and fault lines. Anthropogenic influences can increase permeability, for example, by activities such as mine grouting, air blast rotary drilling, blasting and mining. All of these can have potentially catastrophic effects on pathways and ground gas movements. In addition, anthropogenic influences include sewers, granular backfill around services, cable ducts, pipes, service ducts, drains and voids such as inspection pits, under floor spaces and basements, all of which may provide preferential ground gas migration pathways.

Hazards associated with methane and carbon dioxide gases

It is well known that the presence of methane gas can be highly hazardous to human health. However, the fact that methane is a colourless, odourless gas means that there is no simple indicator of its presence until such a time as explosive limits are reached and an incident occurs. For this reason, it is vital that sources of methane are identified prior to any work on a (construction) site commencing, and that measures are put in place to prevent a dangerous build-up of gas within buildings. In March 1986 a house at Loscoe in Derbyshire was completely destroyed by a methane gas explosion, badly injuring the three occupants. Eight months later at a Public Inquiry, the sequence of events leading up to the incident was established and evidence produced to ascertain the origin of the methane [1]. During the proceedings, it became apparent that signs of ground heating had been detected approximately 100 m beyond the boundary of a near-by landfill some years before the explosion but that the phenomenon had been misinterpreted as a shallow burning coal seam. Had the geology been known to the investigators at that time, it is possible that the landfill would have been identified as the source of methane and the Loscoe area protected from the dangers of uncontrolled gas migration.

Carbon dioxide is also a colourless, odourless gas, which, although non-flammable, is both toxic and an asphyxiant because it displaces oxygen. As carbon dioxide is denser than air, it will collect in low points and depressions, which can be an extreme hazard during foundation construction and earth movements on development sites or in finished buildings and structures. One such case was reported by *Inside Housing* [2] following the development of 64 council houses in Gorebridge, West Lothian. Instead of being “a dream destination, they (the houses) exposed families to such serious health risks that the homes are now being demolished".

Local health professionals first noted a cluster of health complaints which eventually lead to Midlothian Council calling in consulting and structural engineers (Fairhurst) to carry out an investigation, which resulted in a 195 page report [3].

Fairhurst demonstrated the migration of CO_2 from former coal mine workings and as can be seen in figure 1, the pathways are dependent upon the localised geology, in this case predominantly sandstone, clay and sand.

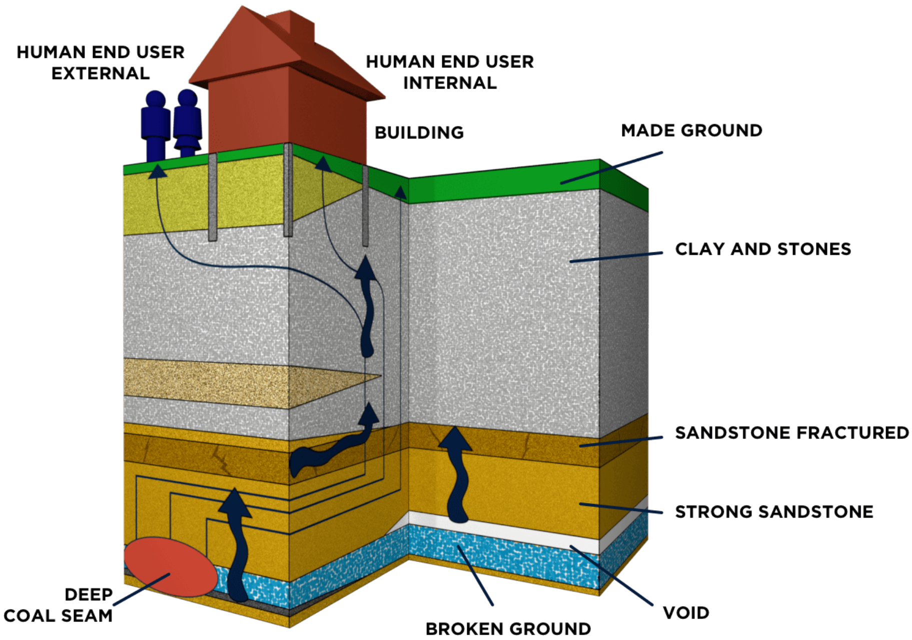

Figure 1: This diagram is based on Fairhurst material showing the potential CO_2 migration pathways

Environmental factors that can influence gas migration

Rapid changes in atmospheric pressure influence the risk of gas entry into properties. As atmospheric pressure decreases the likelihood of gas entry into the properties on the site increases. This relationship was evident from early monitoring in a vacated Gorgebridge property (see figure 2). The highest concentration of CO_2 represented by the blue line, were recorded when the atmospheric pressure, represented by the dotted red line, was lowest and had fallen rapidly.

However, there are several other factors that can come into play that influence migration in addition to changes in barometric pressure namely:

- porosity and permeability of soil and bedrock
- temperature differentials
- rain or snow.

It is known that groundwater levels influence the migration of gasses through abandoned coal mines for example and that if water levels rise, seepage can occur at the surface through natural fault-lines or artificial pathways connecting to the surface e.g. tunnels, adits, shafts etc.

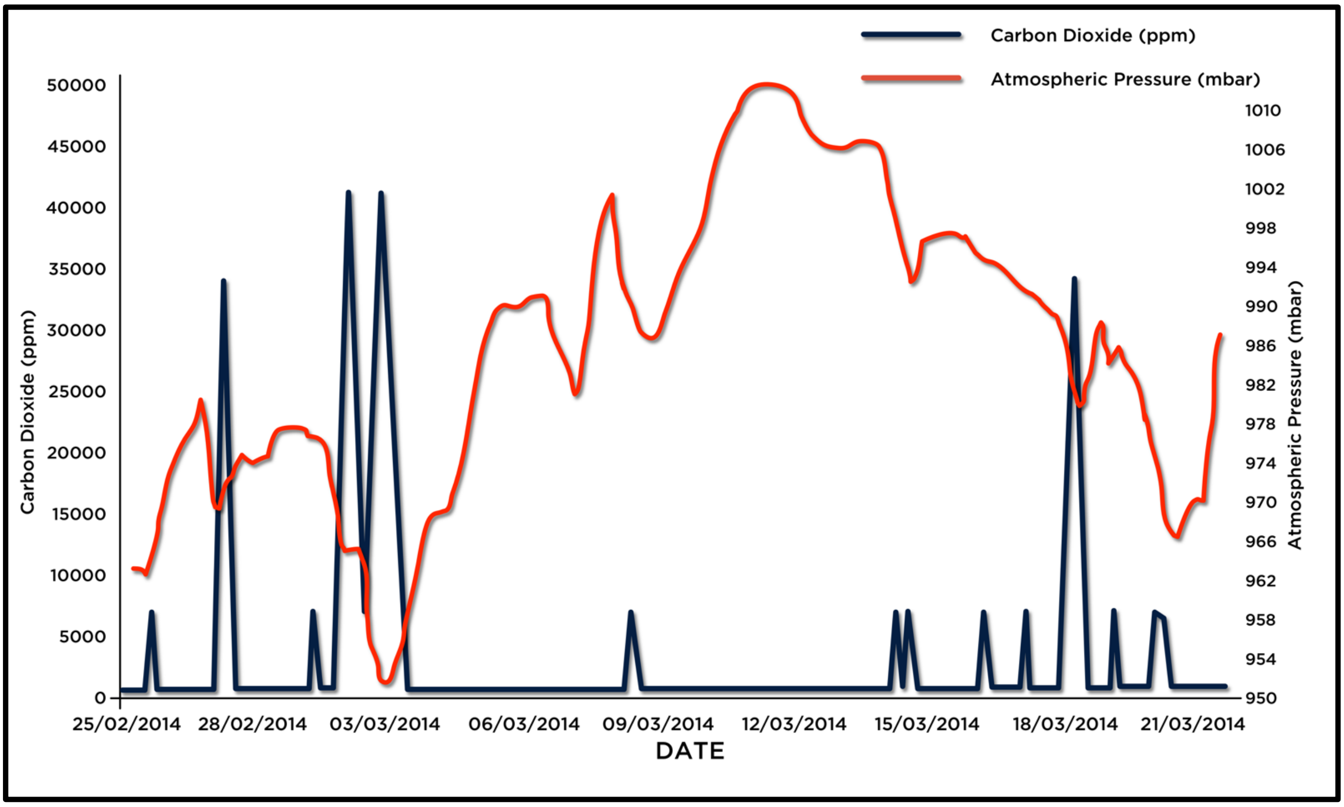

Figure 2: CO_2 versus atmospheric pressure in an affected house (data source Fairhurst)

Subsurface gas monitoring

So, what can be done to mitigate the potential drastic effects? Whether a landowner, developer or regulator the objective is identical; namely to ensure that any existing or proposed development remains or takes place safely [4].

But because of the temporal or seasonal effects on ground gas migration, monitoring has to be undertaken over a potentially wide geographic area, lasting several months. Sampling techniques like soil probes, for example, which require subsequent laboratory analysis (using thermal desorption and gas chromatography) are clearly labour intensive and costly.

However, there is the possibility to undertake long-term, un-manned, continuous, monitoring using especially designed borehole devices that are battery powered, record multiple gases and make the data available for download to a laptop for later analysis, or, via telemetry. A subsequent guide will look into the considerations when specifying and buying such instrumentation.

Disclaimer

The information provided in this guide is for informational purposes only. The materials are general in nature; they are not offered as advice on a particular matter and should not be relied on as such. Use of this guide does not constitute a legal contract. While we make every effort to ensure that the material in this guide is accurate and up-to-date when we publish it, you should exercise your own independent skill and judgment before you rely on it. In any important matter, you should seek professional advice relevant to your own circumstances.

References

1. *Lessons from Loscoe: the uncontrolled migration of landfill gas*. G. M. Williams & N. Aitkenhead, Quarterly Journal of Engineering Geology and Hydrogeology (1991) 24 (2): 191-207. Published: May 01, 1991
2. https://www.insidehousing.co.uk/insight/insight/what-lies-beneath3-44230
3. http://www.nhslothian.scot.nhs.uk/MediaCentre/PressReleases/2017/Documents/Gorebridge%20Report.pdf
4. http://www.nhbc.co.uk/NHBCpublications/LiteratureLibrary/Technical/filedownload,29440,en.pdf
5. CL:AIRE research bulletin – A Pragmatic Approach to Ground Gas Risk Assessment
   Card G, Wilson S, Mortimer S. 2012. A Pragmatic Approach to Ground Gas Risk Assessment. CL:AIRE Research Bulletin RB17. CL:AIRE, London, UK. ISSN 2047- 6450 (Online)

About ION Science

ION Science provide a portfolio of handheld, fixed and portable photoionization (PID) detection instruments for the rapid, accurate detection of volatile organic compounds (VOCs). Find out more about our industry leading range of VOC detection solutions by visiting: www.ionscience.com

For long term monitoring Ion Science recommends the

GASCLAM 2

Ground gas monitor

UK (head office)
USA
China
India
Germany
Italy
France