

Quarry with a gas problem

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Introduction

The site comprises a former chalk quarry located in Kent, South East England. It has history of use as a field with no changes from the earliest historical mapping until 1931, where it was mapped as a sports ground. Active quarrying was first indicated on 1947 aerial imagery.

The site was backfilled with imported inert soils, placed to an earthworks specification, under an environmental permit in line with Environmental Permitting Regulations. It holds a deposit for recovery permit, whereby it can take in waste and place it to enable recovery. The site has technically become a landfill; however, imported waste had to fit a certain criteria, defined by the permit, in order to be accepted, i.e. inert material with no elevated levels of organic content.

Prior to raising levels, the site lay at an estimated elevation of around 1.5–2 m above ordnance datum (mAOD). The site was backfilled with material sourced from various ongoing building projects; it is understood that approximately 511,500 m³ of inert material was imported. Post-import levels identified a maximum depth of fill up to 25 m in thickness on the northern site boundary.



View of site while filling operations were underway (left), and view of completed operations (right).

The site was mapped (British Geological Society website) as being underlain by Head deposits in the southernmost corner, over the Lewes Nodular Chalk Formation, with the remainder of the site mapped as being underlain by Undifferentiated White Chalk Subgroup, and has been the subject of numerous investigations by LEAP and others.

Investigations were undertaken to verify the filling operations. During these investigations, unacceptably elevated levels of methane (in excess of 37%) and carbon dioxide (>5%) were identified.

Methodology

LEAP was instructed to undertake a geotechnical site investigation and verification of the filling operations, including dynamic probing tests (DPT) and windowless and cable percussive boreholes. The site was subject to planning permission for the construction of up to 130 residential dwellings, with associated gardens and access roads.

The investigation was designed to assess how well the site had been compacted following fill operations, to assess the make-up of the fill material and to understand the gas regime of the site. To aid compliance with the associated environmental permit for the infilling of the former quarry, a number of gas monitoring wells were installed across the site.

Cable percussive boreholes reached depths of between 25 and 30 m below ground level (mbgl) to identify the base of the fill material. DPTs reached depths of 6 mbgl, and gas monitoring wells were installed by LEAP to 3 mbgl, alongside additional boreholes installed by the landowner. These works also provided an insight into potential future works that may be required following permit surrender.

Ground conditions

Made ground: off-white and grey sandy silty clay and chalk with inclusions of brick, concrete, crystalline rock, flint, charcoal and organic matter.

Results

DPT results

- Low-strength soils were present across the site
- Depths of soft zones or voids varied between 1 m and 5.4 m
- These were mainly located toward the northeastern cliff boundary

Gas monitoring results

Six rounds of gas monitoring were undertaken over a period of nine weeks. Elevated levels of methane (in excess of 37%) and carbon dioxide (>5%) were recorded during spot monitoring.

Table 1: Summary of land gas monitoring results

Monitoring Visit Date	Maximum Recorded Concentration*						
	CO ₂ (%)	CH ₄ (%)	CO (%)	O ₂ (%)	Flow rate (l/hr)	Atmospheric Pressure (mB)	Boreholes Flooded
12/07/2023	1.5	22.9	0	7.7	11.8	1006 (falling)	No
18/07/2023	1.9	29.9	0	0.0	0.0	1015 (falling)	No
27/07/2023	4.1	37.6	0	0.0	0.1	999 (falling)	No
08/08/2023	2.5	35.4	0	0.0	1.3	1011 (rising)	No
15/08/2023	2.1	29.1	0	3.1	0.0	1011 (rising)	No
15/09/2023	5.7	35.7	0	0.0	0.0	1011 (rising)	No

* With the exception of oxygen which is recorded as minimum

Table 2: Methane concentrations

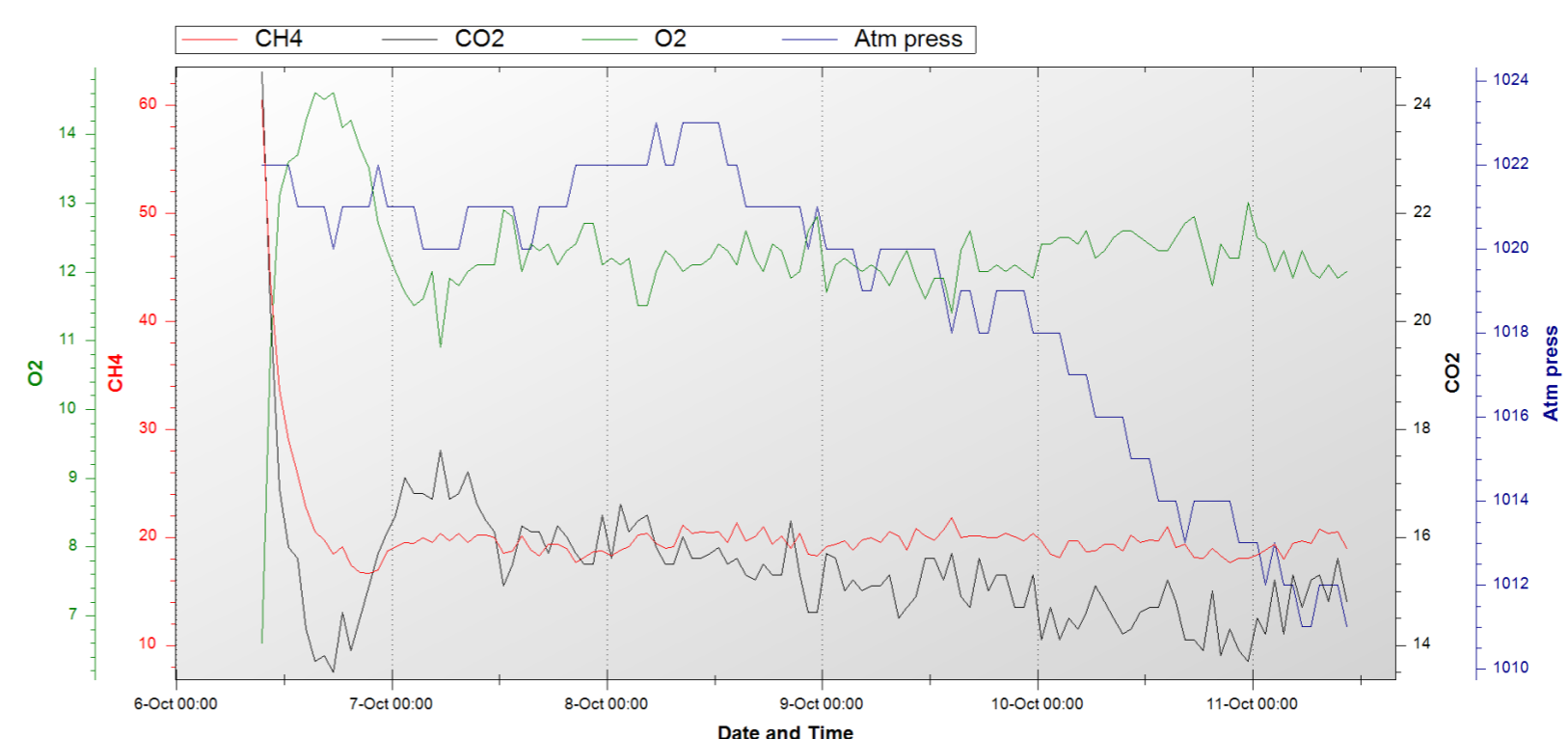
Monitoring Visit Date	Maximum Recorded Methane Concentration					
	WS201 (%)	WS202 (%)	WS203 (%)	WS204 (%)	WS205 (%)	WS206 (%)
12/07/2023	3.5	0.0	1.3	22.9	0.2	2.2
18/07/2023	4.4	0.0	0.0	22.6	0.0	29.9
27/07/2023	6.3	9.2	2.3	28.8	2.3	37.6
08/08/2023	4.8	1.7	0.8	16.6	0.0	35.4
15/08/2023	1.5	1.3	0.0	29.1	0.3	20.6
15/09/2023	7.3	8.5	2.4	32.1	0.6	35.7

Continuous gas monitoring

Continuous gas monitoring was installed using the landowners' additional boreholes. See right, results of gas monitoring from one of the additional boreholes. Continuous gas monitoring did not record flow, and spot readings were taken.

Continuous gas monitoring recorded methane concentrations of up to 60% before decreasing to a consistent reading of between 20 and 25%. Carbon dioxide concentrations spiked at around 24% before dropping to between 14 and 18% for the remainder of the monitoring. While these were the worst concentrations recorded on-site, the other four boreholes recorded elevated levels of both methane and carbon dioxide consistently.

On two occasions, flow was recorded at low and falling atmospheric pressure, which revealed that both methane and carbon dioxide levels were also decreasing.



*Graph representing continuous gas monitoring in one borehole

Conclusion and recommendations

It is considered likely that the gas levels recorded were generated from the breakdown of organic material entrained within the imported inert material and voids created through insufficient compaction during deposition.

In order to surrender the permit to the Environment Agency, the landowners were required to prove methane levels were decreasing in low and falling atmospheric conditions and with no flow across a minimum of two visits.

To enable efficient development of the site, it was recommended that at least six months of continuous gas monitoring (inclusive of flow) be undertaken to capture the worst case scenario and to inform gas protection measures or further monitoring or assessment. This would be supplemented with further intrusive investigation to delineate the extent of existing soft zones or voids and to enable testing of imported material for organic content.

The story isn't finished: more intrusive works and chemical testing are being undertaken with the results to be confirmed.