**Feature**

**Fortress Wytschaete: geological controls on the German frontline in Flanders, 1914–1917**

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The Battle of Messines (*Wytschaete Bogen*) of June 1917 is hailed as a triumph of military geology, with the simultaneous explosion of some 19 mines leading to the Allied destruction of the German frontline positions. This story is well known and rightly celebrated; but less well understood and often overshadowed by this success is the story of the effectiveness of the German fortress positions. These were constructed in late 1914 in order to maintain the strategic aim of holding the Allies in the west while pressing the Russians through a series of offensives in east. In this, they were highly effective, even in the face of continuous Allied bombardment This paper seeks to redress this unbalance in our understanding, drawing on archaeological evidence and archival resources to present a clearer picture of the nature of the German positions.

*All that had just been made could cave in and collapse within half an hour. In many positions the shell ploughed earth gave in so that entrenching baskets and fascines had to be worked in for stabilization. Sacks of sand were in short supply and those sacks filled with the blue Ypres clay were not allowed to be used on the parapets as not to alert the enemy of our mining activities. Even more difficult was the construction of concrete bunkers as the high water levels did not allow the construction of deep foundations. All trenches were furnished with wooden grids because of the groundwater.*

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In Flanders, the weight of the German military invasion that had commenced on 4 August 1914 was such that the French and British troops fell back to the line of the Marne, where, in September 1914, the Germans were held; counterattacks followed and out-flanking positional warfare developed as both sides attempted to trap their enemies, and to ‘turn their flanks’ in a series of battles that became known as the ‘Race to the Sea’. With the armies locked in a fierce struggle, the battles moved inexorably closer to the Belgian Coast, and by November 1914, both armies in the west had ground to a halt in parallel lines that stretched from the North Sea to the Swiss Frontier (Fig. 1).

At the ancient Belgian city of Ypres (Fig. 2), the Allies faced the German lines that swung around in a great arc *–* The Ypres Salient. The beleaguered city would be held by the Allies for the rest of the war; but it was the German stronghold constructed according to the principles of their military manual, *Stellungsbau* – the construction of field positions – that was to hold the Allies in place. And central to these positions was the ridge that stretched from the village of Wytschaete to that of Messines – *Wytschaete-Bogen*.

Yet, while most accounts concentrate on the Allied efforts to break through and capture the ridge, very little credit is given to the German defenders who constructed their lines with the greatest attention to detail – until now. It is fortunate that over the past ten years two major archaeological investigations, at Messines and last year, at Wytschaete – with the crowd-funded Dig Hill 80 excavation – has revealed the strength and tenacity of the German defence, and their skills employed in constructing a fortress that would endure.

***Kriegsgeologie:* ‘war geology’**

The idea of digging trenches in the Great War was sound, and it was not just to satisfy the soldiers’ desire to ‘go to ground’ under fire. Trenches would stop invading armies in their tracks, and create a barrier against further progress. Yet with all the advantages of digging trenches, all too often it was a matter of circumstance – rather than planning – that led to their construction. Early on, this was perhaps to be expected, as the British military manual on field defences noted: ‘No precise rules can be laid down as to the manner in which a defensive position is to be occupied or intrenched… The only reliable guides are a thorough knowledge of the effects of fire, and a practiced eye for ground’

Such ‘practiced eyes’ demanded experience, and in 1914 this experience had yet to be earned. A new term emerged, ‘the front’, which embodied the stalemate conditions of a new type of warfare, of mutual siege, where small matters of geography assumed great importance. Here the ‘practised eye for ground’ would attempt to pick out the most suitable conditions for the lines of trenches that snaked across Europe – and by 1918 the war of position assumed levels of great sophistication.

For the British Expeditionary Force, sandwiched between what remained of the Belgian armies (reinforced by the French) at the coast, and the French armies in Artois, Flanders would become the place of battle for another four years of a hard war. The First Battle of Ypres, in November–December 1914 was a component of the ‘Race to the Sea’, with British troops holding on grimly in the face of a determined German army. For their part, the German engineers were clear that they must consolidate their positions. Facing them, the British toiled in and around the clay plain of Ypres, while the Germans set about holding the high ground that faced the town on three sides, in what became known as the Ypres Salient (Fig. 3).

A ‘salient’ is a bulge in the front line, usually jutting forward into enemy held territory. Such bulges are dangerous as, over extended, they are easier to attack and observe. The Ypres Salient was particularly dangerous, formed in the early days of the German drive towards the coast. As one post-war commentator noted: ‘The Germans had driven in wedges towards Ypres until our lines had fallen back closer to the city, and the ground was a bastion thrust out dangerously in a wide arc, like an English bow full-drawn, and encompassed by the enemy whose skill and strength had seized the high ground everywhere’.

Following the low rising hills to the east of the town, the Salient defined an arc of trenches with a long axis running approximately north–south, facing east–west. Running around the hills, the German line, and British line following it, passed southwards over its saddle back, and down to the damp valley of the Lys and on to Armentières. ‘Understanding the ground’ was an important task in the development of this underground war, and a sophisticated science of ground engineering was deployed in its development.

Just prior to the war, in 1913, military fortification engineer Hauptmann Walter Kranz (Fig. 4), coined the phrase *Militärgeologie* – later, with the outbreak of world conflict, it became simply *Kriegsgeologie.* Yet Kranz’ original idea – that geology would have a large role to play in warfare, and particularly in the type of fortress or static warfare that would be enacted just a year later – was taken seriously only when war broke out in Europe.

It was natural that Kranz’s approach should take root, however. After all, geology dealt with the nature of the land surface over which men, animals and machines travelled; it gave answers to the kind of obstacles that they may face; it controlled the way in which fortifications were built, above and below ground, and it provided answers for resourcing armies – particularly in the supply of water. A wartime lecture – *Kriegs-Geologie* (1915) – by W. Salomon of Heidelberg University, explained: *‘*Geology is practical and necessary: to prove the stability of parapets and trenches and the stability of dug-outs; to identify the speed of digging excavations; to identify water supplies; to assist in rain water and waste water removal; to supply building materials; and to identify mineral raw materials’.

Though Walter Kranz had first advised that a geological service for the Imperial German Army be established in 1912, it took the outbreak of war for this to be considered in detail. As late as April 1914 the Inspector General of the Imperial German Engineer Corps wrote to the Prussian minister of war that: ‘The Inspector General sees no need for the establishment of military geologist positions. In the field, events proceed so rapidly that even in trench warfare the employment of a geologist is out of the question…’

Just a year later, the geological support provided to the German Army after its slow start grew to be impressively organised, and was embodied directly into the army structure by 1916. Then, each of the twenty-eight field survey companies contained geological sections (*Geologen Stellen*), and requests for geological assistance would be made directly to them. There would be some ~250 geologists employed in the German army by the end of the war (and a further 60 with the Austro-Hungarian army). Though the actual number of geologists in German service during the Great War grew to be relatively large, their impact was reduced, and many served in lowly positions; they were expected simply to advise, but not supervise. But at least they were actively engaged on the ground.

And then there was military mining. Such activity involves the excavation of tunnels, galleries and dug-outs – in fact in any subsurface excavation that can aid the army, whether in an offensive or defensive sense. The use of military mines is centuries-old. Arguably the greatest success for military miners and their geological advisors was to come in June 1917, when the Messines–Wytschaete Ridge was captured by the British in what could arguably be considered one of the most effective and successful battles of the war. Not surprisingly, a deep understanding of geology had played a major role in prosecuting the coordinated mine offensive that launched the first attacks. Writing in 1935, Walter Kranz, the man who had done so much to precipitate geologists into their future role as military scientists, commented ruefully on what might have been: ‘If German geologists with military training had, immediately after the beginning of mining operations, at the latest in 1915, made a thorough survey of the whole Wytschaete salient, and if our miners from the beginning would have checked their advice tactically and technically, and if found correct would have followed this with all available means, the British would never have been so successful with their Wytschaete explosions…’.

***Ton und Sand*: clay plain and sand ridges**

From Ypres southwards, Flanders comprises an extensive plain: its flatness relieved only by a series of low hills no greater than 50 metres high that partially embrace the city of Ypres.

The plain itself is mostly made up of clays that were once called the ‘Ypres Clay’, a material that would become both a blessing and a curse to the soldiers and engineers who worked with it, and in it, during the course of the war. In Flanders, the striking colour of freshly cut clay was a major issue, particularly those engaged in deep mining. With the blue colour visible from the air, it would surely give away the fact that tunnels and mines were in the process of being dug, and even when put into sandbags to reinforce parapets. Fortunately, this startling colour did not last as its minerals very quickly change in the presence of air, soon becoming a brownish colour – surely a metaphor for the whole Ypres Salient

The Ypres Clay acted as a barrier for downwards movement of water, leading to a tendency for it to pool. It is not surprising that the soils that lie on top of the clay are very likely to be water-logged. Consequently, drainage from the flat and fertile fields of Flanders is slow, and to describe the soils during wet periods as ‘heavy going’ is more than an understatement. Mud become the norm; in military parlance, it became ‘bottomless’.

Friedrich ‘Fritz’ von Lossberg, mastermind of the German defence-in-depth strategy described its nature: The ground in Flanders consists of a very soft and fertile layer of humus [the soil] with a thickness of 1–3 metres. Under this layer of earth there is an impenetrable layer of clay about 1 metre thick. If this is perforated by artillery fire the groundwater oozes upwards into the shell craters and fills them to the brim…After showers of rain, which in Flanders are a common occurrence, the humus layer is turned into a swamp-like pulp which gives an advantage to the defender.’

Rising slowly up from the clay plain is a low range of hills that gained such gigantic importance in the war, and which curve to the east of the city of Ypres, creating a ‘bastion’ on the otherwise featureless plain. Occupied by the Germans from 1914, the ridges became a thorn in the side of the British. Every movement and suspicious activity was logged – and shelled if necessary. With the Germans on the ridge tops, the British struggled under four years of direct observation by the Zeiss field-glasses of their opponents. As General Ludendorff commented ‘The high ground between Ypres and the Roulers–Menin line…affords a extensive view in both directions. These heights were also exceptionally important for us, as they afforded us ground observation posts and a certain amount of cover from hostile view.’

This put severe strain on the Allied troops who toiled in the Ypres Salient, as one commentator noted ‘Because the enemy could see every move on our part in the Salient all movements had to be carried out in the dark, and ammunition, rations, and building materials were carted up by night as far as the road went and then laboriously man-handled into the actual position. The work was bad enough in the summer, but when the whole of the ground was one sodden quagmire of trodden and re-trodden slimy mud, the task was appalling.’

These ridges are composed of what geologists called the ‘Paniselian’, mixed layers of sand, clay and silt. With sand layers closest to the very top, the rain that falls on Flanders soaks away into the land until it meets the clay, and then sits there. This means that some layers are perpetually water-rich, such as the geological level the British called the ‘Kemmel Sands’ – a particularly wet layer sandwiched between clay (Fig. 5). These sands caused many problems for the German defenders.

Oberstleutnant Otto Füsslein, *Kommandeur des Mineure*, 4th German Army, was well aware of the difficulties: ‘Do you know the terrain of Flanders? The trench lines weaved their way over long and gently rolling ridges, through shallow depressions and across wide expanses of almost flat countryside. In the rich alluvial and sedimentary deposits forming the upper strata of earth and clay, water collected in the trenches, especially in the winter, and even more so in the mine galleries, initially only one or two metres below the surface and later four metres deep, progressively transforming them into quagmires.’

***Stellungsbau*: constructing the trench fortress**

Perched on the Messines–Wytschaete ridge, the German positions dominated the Allied lines. The defenders of these positions had no squeamishness about maintaining a strong line while the German strategy was focussed eastwards, in an attempt to defeat the Russians.

It was to the field manual *Stellungsbau* that the German engineers turned for guidance on constructing their positions (Fig. 6): ‘Field positions when constructed afford considerable advantages to the defence. The important points to be borne in mind by the *defence* in a *war of positions* are: 1, Economy for forces; 2, Diminution of losses and increase of enemy losses; 3, Utilization of ground so that conditions favourable for combat are obtained, while they are made unfavourable to the enemy.’

This last part that was perhaps the most significant, a commitment to ensuring the German trench lines were the strongest, as noted by the British General Staff in 1917: ‘Great use has been made by the Germans of natural strong points, such as villages, farms, and woods. In the villages, the borders and interior have been strongly organized, generally for all round defence, and a particularly desperate resistance has been offered in them.’

This was particularly the case at Wytschaete and Messines. When the men of *Das Infanterie-Regiment “Kaiser Wilhelm von Preußen” (2. Württemb.) Nr. 120* arrived in the sector they were impressed: ‘At first glance the men, who were not spoiled when it came to the quality of defensive works and dug-out construction, were quite pleased with what they found in it. The main combat line ran in a slight curve along the foot of a hilltop crowned with the ruins of Wytschaete and was in a relatively tidy condition…A number of well made communication trenches well furnished with direction and warning signs ran from the furthermost eastwards and up the slope, crossing through the forest of Wytschaete and the first and second reserve position before ending within the village on the hill. The village itself was quite shot up, although the layout of the streets was still discernible and numerous surviving cellars offered satisfying accommodation for troops ...’.

As had been suggested by Walter Kranz, drainage of field fortifications was a role for engineers and their geological advisors, and *Stellungsbau* noted sagely: ‘If the water level in the country is high, special measures to deal with it may be necessary’. Never a truer word was written about the clay soils of Flanders. In this respect, the German army became expert in the drainage of trenches as the war progressed. A British manual summarized German expertise in 1917: ‘Great attention is paid to drainage of trenches, as on the success or non-success of the measures taken may depend whether this position can or cannot be held in the wet season. It is laid down that the drainage must be done on a definite plan which must be carried out in good time. Drainage engineers and geologists are to be consulted, and use made of existing maps and plans. Wherever possible, the drainage water is to be led in the direction of the enemy, pipes being put through the parapet for this purpose.’

***Wytschaete Bogen*: the archaeology of a fortress**

German front-line trenches at Messines at the southern extremity of the Ypres Salient (south of St Eloi) were excavated in 2012–13 as part of a major replacement of water mains in the region. In 2018, a further opportunity was granted when a unique crowd-funded rescue excavation was carried out at *Hohe 80* (see [www.dighill80.com](http://www.dighill80.com)), at the heart of the German fortress of Wytschaete.

What the British called the Messines ridge – and the Germans *Wytschaete-Bogen* – is a spur of the main ridge system east of Ypres, and forms part of a wider plateau with Wytschaete to the northwest, and Messines to the south. As described above, this plateau had seen hard fighting in 1914, with the Germans wresting control of the high ground from the Allies. They had stabilized its position in early 1915, the Germans developing a dominant fortress that was at the heart of the Salient. It was composed of a frontline system of strongpoints that were designed to break up any attempt to take the ridge top by frontal assault, and with strongholds in the rear, built around the two villages that defined the ridge top. With the Germans occupying the high ground, with every spur and building built into the line as a fortress (as laid down in *Stellungsbau*). The British were forced to build trenches that were effectively 10 metres lower, facing the forward slopes of the ridge.

Capping the ridge top at Wytschaete are the driest sands, known to the British (not surprisingly) as the ‘Wytschaete Sands’ (Fig. 7). These bright yellow to ochre-coloured sands were encountered during the excavations at the hilltop of the village that gave the sands its name and must have been relatively easy to excavate, with exceptions (Fig. 8). At *Hohe 80* the German defenders had made use of the destroyed mill that in pre-war years had marked the hill-top, strengthening the cellars with concrete to protect them from the attentions of the Allied artillery intent on dislodging them (Fig. 9). Connected with these fortifications were trenches cut through the dry sands, interupted here and there with hard levels of pebbles that would have caused problems to men having to dig trench lines to their greatest depth (Fig. 10).

The soldiers of *IR120* described the conditions as they found them at Wytschaete: ‘All constructions and facilities necessary for a successful defence of the sector were available, yet nearly all of them lacked the sturdiness of construction, which was required to hold the sector in heavy and prolonged fighting without large losses of men and material.’

Here, at the very top of the ridge, water was less of an issue – but as the lines sloped away towards the forest of Wytschaete and the British lines, the written advice of Walter Kranz was to be heeded, and the Germans made sure that their trenches were drained downslope to their enemies. This also affected the defenders, with a trench line close to the clay layers that needed special treatment. Here, the defenders deployed the bricks of the destroyed village to provide drier footing, and a central wooden drainage channel (Fig. 11).

Away from Hill 80, the rest of the ridge is composed of the various levels of the ‘Paniselian’, overlying, as always, the Ypres Clay. At Messines, the excavation site of 2012-13 uncovered that part of the German trench system that was located on the slopes of the Messines Ridge, just above the valley of the Douve. Here are found the water-logged Kemmel Sands, sandwiched between the clay-rich layers, and there were even wetter soils, typical of river valleys, that thicken to considerable depth in the valley of the Douve at the foot of the ridge (Fig. 5).

The trench system at Messines was constructed as a strongpoint in the German front line. In fact the excavations disturbed what was the German second line in the defensive system constructed here. By fate, the German lines here almost exactly follow the junction of the Kemmel Sands, between the 50 and 60 metre contours. While the centre of Messines sits on drier ground, the trenches constructed in front of the village sit squarely within the outcrop of the water-rich Kemmel Sands, and once again there was the threat of flooding from the ever-present impervious clay beneath (Fig. 12). Evidence of periodic flooding from the sands was provided by successive layers and levels of timber flooring and duckboarding – not unsurprising given the geological conditions here.

Also exposed in the archaeological investigations at Messines were narrow trenches that were boarded throughout, and that were revetted with a variety of means. This included the rescue of doors and other timbers from damaged and destroyed buildings in the village (Fig. 13). Timber used in trenches in this way was potentially dangerous – it could provide splinters that would add to the problems of men tightly packed in the line. Also, *in situ* brushwood hurdling that is commonly seen in German trenches. This type of revetment was the preferred means of protection – but was difficult to replace in the shell-blasted landscape of Flanders. *Stellungsbau* was clear on this point ‘The sides of trenches must not be revetted with any material that may make traffic in the trench impossible or even difficult after bombardment. Planks and timber should not be used if possible. Hurdles are not so objectionable. The best revetting material is sods or thin loose brushwood’ (Figs 6, 14).

The German trench system at Messines also included a concrete shelter with room for six or seven men (Fig. 15). While the concrete found in the drier conditions of the ridge top at *Hohe 80* was predominantly blockwork used to support and protect the ancient cellars of the mill buildings that once crowned the hill top, this was cast *in situ*. The cast concrete at Messines must have been a response to the damp conditions, as the soldiers struggled with the water-logging of the Kemmel Sands – water-rich *Schwimmsande –* beneath their feet.There was no hope of a mined dug-out here, and concrete was the solution. From its entrance was a carefully prepared rifle rack and a recess with hinged lid that contained German stick-grenades, found as they had been left by the last German occupants in June 1917.

At *Hohe 80*, the defenders had the chance to dig into the dry sands to construct a dugout as part of the complex of fortifications that that they had constructed – defended and re-inforced cellars, fire trenches and communication trenches all interlinked. Evidence of a shallow underground feature was found – though with no chance of a full excavation with time limitations. Even here, where the driest sands cap the ridge top, clay is not so far away – and as the slope falls away towards the German frontlines, so this material returns, and with it the flooding and need for drainage. Deep dugouts would have encounted difficulties.

Shallow mined tunnels were also uncovered in the excavations at Messines (Fig. 16). At a depth of just 2–3 metres, the protection given to them from howitzer shells was likely to have been limited headcover, though it appears that there is a rubble ‘burster course’ of building waste, suggesting that the tunnels were constructed as ‘cut-and cover’. Each tunnel has constructed using a ‘mining case’ timber revetment, supported by bridle joints and pegs. The tunnels have no inclined stairways to access them – just simple entrances from the trench line to the south of Messines. Most likely the purpose of these tunnels was for storage and concealment, rather than protection from artillery fire. Naturally, the tunnels sit between the 45 and 50 metre contours, in Paniselian sandy-clays that underly the difficult and water logged Kemmel Sands – a factor that suggests that, in winter at least, these tunnels had to be drained effectively, either by drains running downslope, or by pumping.

**Geoarchaeological insights**

The Battle of Messines of June 1917 is hailed as a triumph of military engineering, with the simultaneous explosion of some 19 mines (though 24 were laid) and an effective barrage leading to the Allied destruction of the German frontline positions that encompassed the *Wytschaete-Bogen* fortress. This story is well known and rightly celebrated; but less well understood and often overshadowed by this success is the story of the effectiveness of the German ridge-top fortress positions. The two major archaeological investigations of 2012-13 and 2018 have revealed the complexity of this German fortress, composed of trench lines that contoured the ridge top and which had the two ridge-top villages and other features built into its frontline. It was this fortress that held the Allies at bay, from the capture of the ridge top in 1914, through to the loss of the fortress in the aftermath of the 1917 battle – only to be regained in spring 1918.

These archaeological opportunities have provided a unique insight into the complexities of the construction of a trench fortress, of the need for detailed understanding of *Kriegsgeologie*, of the vision of the engineer geologist Walter Kranz, and of the adherence to military guidance provided by an evolving guide, *Stellungsbau*, which was so successful at holding the Allies at bay for three long years.

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**Figure Captions**

**Fig. 1**. The Western Front in 1915, showing the main battlefield areas, and the main points of Allied offensives in 1915. The German lines, strongly held, were effective.

**Fig. 2**. The beleaguered city of Ypres, Flanders. The Medieval Cloth Hall under fire.

**Fig. 3**. Map of the Wytschaete Bogen/Ypres Salient , in June 1917. The German line followed the ridge top – formed by the Paniselian sands – for the majority of its length, providing views of the city of Ypres on the clay plain below. German engineers created strongpoints from destroyed villages and farms; both Wytschaete and Messines were made into ‘fortress villages’. The strongpoints were targeted by the British miners, and the Battle of Messines was won by co-ordinated mine explosions and artillery. The Germans were to recapture all they had lost in 1918(From Doyle, 1998).

**Fig. 4**. Walter Kranz, pictured in later life. Hauptmann Kranz was the ‘father’ of military geology (*militargeologie*) in 1913, which became *Kriegsgeologie* in wartime. The geological applications of geology were many and varied

**Fig. 5.** British Military ‘ground suitability map’ of Messines from 1917, showing the wet ‘Kemmel Sands’ (4). Red tones indicate drier conditions. The German trenches encountered during the Messines dig were very close to this water-logged layer.

**Fig. 6**. German trench construction, c. 1915.

**Fig. 7**. British Military ‘ground suitability map’ of Wytschaete from 1917, showing the capping of dry ‘Wytschaete Sands’ (Quaternary). Red tones indicate drier conditions.

**Fig. 8**. The ‘Wytschaete sands’ in situ, comprising relatively free-draining Quaternary iron sands and pebble horizons.

**Fig. 9**. Use of concrete at Wytschaete, showing reinforced mill cellars at the dry ridge top. The concrete blocks reinforcement is intended to withstand the Allied bombardment.

**Fig. 10**. Trench cut through the sands at Wytschaete. The dry conditions mean that preservation is poorer archaeologically.

**Fig. 11**. Use of brick floor to trenches at Wytschaete, enabling drainage. This trench line is closer to the clay layers that lie beneath the Wytschaete Sands, and as such, presented wetter conditions. Bricks salvaged from the ruined buildings of the village were used to floor the trench, with a central wooden drainage channel.

**Fig. 12**. Trench excavated at Messines, cut into the ‘Paniselian’ silts and sands, overlying damper conditions at floor level.

**Fig. 13**. Trench at Messines, cut into the ‘Paniselian’ silts and sands, the trench slopes revetted with reclaimed timber from destroyed houses.

**Fig. 14**. Messines: brushwood hurdles in position; note the flooded trench floor

**Fig. 15**. Messines: the use of concrete to combat the wet conditions encountered at the junction with the ‘Kemmel Sands’

**Fig. 16**. Shallow tunnel at Messines, excavated just above the level of the Kemmel Sands.