THE DURAND MINE

AND

FIRST WORLD WAR TUNNEL SYSTEM IN THE GRANGE AREA

OF

THE CANADIAN MEMORIAL PARK, VIMY

REPORT BY

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REPORT ON THE DURAND MINE AT VIMY

SUMMARY

1. From the date that the French 10th Army gained a lodgement on the Vimy Ridge in September 1915, until its' capture by the Canadian Corps of British 1st Army in April 1917, the combatants engaged in extensive underground mine warfare. Many miles of fighting tunnels, defensive laterals and support subways were driven within the Ridge. At least 250 mine and camouflet charges were exploded along its' 5 mile length.

2. In preparation for the Canadian assault of 9 April 1917 fourteen mines were prepared. In the event only five were employed, two being used prior to the attack. How many of the remaining nine were subsequently neutralized or removed is unknown, nor is it known whether other "sitting" charges may have been left in the Ridge.

3. In 1985 one such mine was found in a chamber 170 ft (52m) North East of the present guides office and at a depth of 65 ft (20m). Investigation in June and August of 1988 revealed that the original charge would have been about 5000 to 6,000 lbs (2,250 to 2,700 kgs) of ammonal packed into between 200 and 250 rubberised bags. The indications are that the detonators and primers are still in place.

4. Subsequent chemical analysis showed that water action has leached out the ammonium nitrate content of the original ammonal, about two thirds of the original volume. The compound remaining consists of 6 parts alluminium, 5 parts TNT and 1 part charcoal. It was established by testing that even when wet this can be detonated. Taking a "worst case scenario", detonation of the residual 2,000 (or so) lbs (900 kgs) of explosive could break surface, do some structural damage to the site guide house and harm parts of the preserved GRANGE subway. It would also release toxic gasses into the complex of tunnels with which the mine gallery is connected.

5. Access to the mine chamber is by descent of an incline from the water point chamber of the GRANGE subway, and thence through several galleries which include ascent of an eroded stairway (see diagram 2). The total distance is about 450 ft (150 m) and takes about 20 minutes with due precautions. Whilst the approaches are reasonably sound and permit easy movement there is one point where roof slabbing is occurring. The actual mine gallery involves crawling and is in a dangerous state; rock falls are likely to attend any careless movement. Two such occurred in the course of investigation. There is also a risk of toxic gasses, notably carbon monoxide, depending on atmospheric conditions. The narrow mine gallery is without any ventilation and nitrous fumes or carbon dioxide could also accumulate.

6. The possibility of inadvertent detonation of the mine charge cannot be discounted, perhaps as a result of a lightning strike on the surface as occurred with an abandoned mine under the Messines Ridge in 1957. However the chances of such an event are judged extremely remote. Keeping the matter in perspective regard must be given to the probability that there are also other mines remaining in the Ridge and the certainty that a large quantity of unexploded munitions remain within the topsoil.

7. In considering the options particular considerations are:-

a. The difficulty of access and perilous state of the mine gallery.

b. The gas hazards.

c. A risk that if the detonators are partially corroded then movement could set them off resulting in explosion of the primers and even the main charge.

8. a. Withdrawal of the charge is not impracticable, the safest and possibly cheapest option being to sink a shaft the 65 ft (20 m) to one side of the mine gallery. The report recommends however that the charge be left undisturbed, the gallery blocked (to deny any future access) and the area immediately above the charge fenced off. As an additional precaution the GRANGE subway should be closed during thunderstorms.

b. If it is considered essential to dispose of the charge then an alternative recommendation is to blow it with a heavy 200 lb (90 kg) initiating charge. This course of action would require acceptance of the "worst case" possibility of some damage to the guide house and its' services, and possibly to parts of the GRANGE subway. There would be a subsequent need to monitor carbon monoxide levels in the subway for up to one year.

9. Of the other eight mines not used, two were positioned in the GRANGE area. One of them was situated under the DUFFIELD craters, about 250ft (75m) south of the DURAND mine and similar in characteristics. It has been established with reasonable confidence that this was cleared. The other was a large offensive mine of 20,000lbs (9050kgs) located immediately south of the BROADMARSH crater -almost under the road junction at that location. It is not known whether this was left in situ. Access to the approach tunnel is probably attainable with modest resources. Subject to the condition of the tunnel an inspection should be made to determine whether the charge is present and primed, and whether it presents a significant risk to the general public. Research to identify the sites of the other six unused mines in the area may also be merited.

10. Given that even well cleared Great War Battlefield sites present some slight hazard through buried munitions and charges, it is suggested that prominently displayed liability disclaimers may be considered prudent in todays legal climate.

11. It is stressed that even though based on extensive research and much expert advice, the information in the report involves some informed deductions and may be subject to revision as further facts become available. The opinions and recommendations are those of the author and should be subjected to independent assessment before being accepted.

Rapport sur la mine DURAND à VIMY.

Résumé.

1.A partir du moment où la 10° Armée française prit pied sur la crête de VIMY en septembre 1915,jusqu'à sa capture en avril 1817 par le corps canadien appartenant à la 1° Armée britannique,les combattants menèrent une guerre de mines considérable.De nombreux kilomètres de tunnels et galeries furent creusés sous la crête et au moins 250 mines et camouflets ont explosés sous ses 8 km de longueur.

2.En vue de l'assaut canadien du 9 avril 1917,14 mines furent préparées.Seules 5 furent mises en oeuvre,2 ayant été utilisées avant l'attaque.On ne sait pas combien des 9 mines restantes ont été neutralisées ou enlevées,pas plus qu'on ne sait si d'autres charges préparées ont été laissées sur place,sur la crête.

3.En 1985,une de ces mines a été retrouvée dans une chambre située à 52 m au nord est de la maison du guide actuelle,à une profondeur de 20 m.Des investigations en juin et aout 88 révélèrent que la charge d'origine devait être de l'ordre de 2 250 à 2 700 kg d'ammonal emballés dans 200 à 300 sacs caoutchoutés.Des indices montrent que les détonateurs et charges d'amorçage sont encore en place.

4.Des analyses chimiques ultérieures ont montré que l'action de l'eau avait lessivé et emporté le nitrate d'ammonium de l'explosif d'origine,soit 2/3 du volume initial.Le reliquat représente 6 parts d'aluminium,5 parts de TNT et 1 de charbon de bois.Des tests ont prouvé que ce mélange,même mouillé,pouvait exploser.Dans le cas le plus

défavorable,l'explosion des 900 kg résiduels pourrait crever la surface du sol,causer des dégâts à la maison du guide et endommager certaines parties du souterrain GRANGE.Elle provoquerait également l'émanation de gaz toxiques dans le réseau de tunnels avec lesquels la galerie de mine est reliée.

5.L'accès à la chambre de mine se fait par un plan incliné à partir de la chambre du point d'eau située dans la souterrain de GRANGE,et de là,à travers plusieurs galeries avec notamment une montée dégradée.La longueur totale est de l'ordre de 150 m,et en faisant attention,il faut environ 20 mn pour la parcourir.Alors que les abords sont relativement sains et permettent de se mouvoir aisément,il existe un endroit où le plafond est en train de s'effriter.La galerie de mine réelle nécessite que l'on marche à quatre pattes et présente un danger.Si l'on ne fait pas attention en se déplaçant,des chutes de pierres risquent de se produire.Ceci s'est produit 2 fois pendant la reconnaissance.Il existe également un risque de présence de gaz toxiques,notamment d'oxyde de carbone selon les conditions atmosphériques.L'étroite galerie de mine n'a aucune ventilation et des vapeurs nitreuses ou de gaz carbonique pourraient s'accumuler.

6.On ne peut exclure une explosion par inadvertance de la mine,provoquée probablement par la foudre tombant sur le sol,comme cela a été le cas en 1957,avec une mine abandonnée à la crète de MESSINES. Toutefois la probabilité que ceci se renouvelle est très faible.Gardant ceci en mémoire,on doit tenir compte de l'existence probable d'autres mines dans la crête et être certain qu'il reste une grande quantité de munitions non explosées dans la couche de surface.

7.En examinant les options,une attention particulière doit être por-

tée sur:

a.l'accès difficile et l'état dangereux de la galerie de mine.

b.les risques de gaz.

c.le rique que,si les détonateurs sont partiellement corrodés,tout mouvement peut les déclencher,faisant exploser les charges d'amorçage,voire la charge principale.

8.L'enlèvement de la charge est possible et la solution la plus sûre et probablement la moins chère serait de creuser un puits de 20 m à coté de la galerie de mine.Toutefois le rapport recommande que l'on ne touche pas à la charge et que la galerie soit fermée pour empêcher tout accès ultérieur et que la partie immédiatement au dessus de la charge soit entourée d'une barrière.Une précaution supplémentaire consisterait à fermer le souterrain GRANGE pendant les orages.

b.S'il est essentiel de faire disparaitre la charge,une autre solution consisterait à la faire exploser avec une charge lourde de 90 kg.Cette solution nécessite l'acceptation du cas le plus défavorable,avec quelques déteriorations de la maison du guide et du souterrain GRANGE.Par la suite,il serait nécessaire de surveiller le niveau d'oxyde de carbone dans la souterrain pendant un an.

9.Des huit autres mines restantes,deux ont été localisées dans la zone GRANGE.L'une d'entre elle était située sous les entonnoirs DUFFIELD,à 75 m environ au sud de la mine DURAND dont elle a les mêmes caractéristiques.Il a été établi avec quasi-certitude qu'elle a été éliminée. L'autre était une mine offensive importante de 9 050 kgs,située juste au sud de l'entonnoir de BROADMARSH,presque au dessous du croisement de routes.On ne sait pas si elle a été laissée sur place.De moyens modestes permettrait d'accéder au tunnel d'approche.Selon l'état du tunnel,on devrait faire une inspection pour déterminer si la charge est encore là

et amorcée,et si elle constitue un danger significatif pour le public. Des recherches mériteraient d'être faites dans cette zone afin de localiser les six autres mines.

10.Ceci étant,même les champs de bataille de la grande Guerre qui ont été parfaitement dépollués présentent encore des risques mineurs en raison de la présence de munitions et charges enterrées,et il est suggéré que,dans le climat juridique actuel,il serait prudent de bien faire savoir que toute responsabilité serait déniée en cas d'accident.

11.Il est souligné que même si elles sont fondées sur une recherche approfondie et sur des avis experts,les renseignements contenus dans le rapport entrainent quelques déductions logiques qui peuvent être révisées lorsque d'autres éléments seront disponibles.Les avis et recommandations sont ceux de l'auteur et devraient être soumis à un examen indépendant avant d'être acceptés.

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ONE - 172 TUNNELLING COMPANY MINING PLAN OF LA FOLIE SECTOR (Copied from original colour copy and annotated with subsequent information).

TWO - PLAN OF PRESENT GRANGE SITE AT 1:1000 SCALE AND ACCESSIBLE SECTION OF GRANGE SUBWAY AT 1:500 SCALE.

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BACKGROUND

1. Historical.

a. Following stabilization of the Western Front in 1914 the German lines were situated to the West of the Vimy Ridge. In a series of battles through 1915 the French 10th Army forced the Germans back onto Vimy Ridge but were unable to retain the heights. Intensive mining activity developed as both sides contested the ridge.

b. The British 3rd Army took over the area in April 1916, with responsibility subsequently transferred in August 1916 to the British 1st Army. Royal Engineer Tunnelling Companies progressively took over from their French mining colleagues and successfully countered a German mining offensive which peaked in July/August 1916. (1) and (2)*

c. In August 1916 tunnelling schemes were put in hand and mines placed for a proposed Autumn offensive which was then cancelled. (1)* Thereafter until late Feb 1917 both sides confined themselves to defensive operations underground, allowing the British Miners to concentrate on construction of previously planned infantry subways and dugouts. The German Pioneers were partly redeployed to construction of the Hindenburg line.

d. To support the Vimy/Arras operations planned for April 1917 further mining schemes were started in January, incorporating those of the Autumn 1916. This provoked another spate of underground warfare as the Germans tried to counter the threat. (1) and (2)

e. On 9 April 1917 the Canadian Corps assualted the Ridge and secured it in three days. The Germans withdrew 5 miles (8 kms) east into the Douai Plain. The Tunnelling Companies were immediately redeployed to other tasks apart from some small parties required to inspect and clear the German mining system. (2)and (3)

f. It seems likely that some of the subways continued in use until the Allied advance in September 1918. There is an unsubstantiated reference to the LICHFIELD Subway being linked to the German VOLKER subway providing a covered route through the Ridge. (4) No information has been found on the work of salvage teams although these may be assumed to have scoured the subways but probably not the fighting tunnels.

*NOTE - Cross references to bibliography, see Annex A.

g. In the early 1920s the French nation presented 250 acres of the Ridge in perpetuity to the people of Canada. This was developed into a memorial park dominated by the twin pylons of the Canadian memorial. Most of the subways and dugouts were scavenged for timber before being blocked off by the civil authorities. However a Captain Simpson of the Royal Canadian Engineers arranged for the conservation of the front line section of the GRANGE Subway, which was incorporated in the Memorial Park and opened to the public in 1926. (5)

h. The surviving part of the GRANGE Subway was briefly occupied by British troops in 1940 and is known to have been visited by German Pioneers. (6) It then appears to have been left derelict until 1945. Subsequently it was renovated and reinforced several times and is presently the subject of an RE project for further conservation work. It enables access to most of the former La Folie Sector mining system. Recent investigation indicates that apart from the tunnels closest to the GRANGE Subway, the mining system has lain undisturbed for many years, in places possibly since 1917. (Enclosure One shows the complete British mining system for the Sector, and some of the German tunnels. Diagram 1 shows the complex in the vicinity of the GRANGE subway).

2. Mines and Mine Explosions.

a. It is not known how many mines and camouflet charges (see definitions) were blown during the two years that the Ridge was contested. Approximately 60 such explosions were recorded in the La Folie Sector. (7) Averaging this across the whole Ridge would suggest about 250 charges were exploded ranging from 500 lbs (225 kgs) to 30,000 lbs (13,500 kgs), with the majority in the range of 2,500 lbs (1,100 kgs) to 6,000 lbs (2,700 kgs). Since "sitting" charges were frequently prepared to cover contingencies it is reasonable to suppose that a substantial number may have been placed but not used.

b. In preparation for the attack of 9 April 1917 The Canadian Corps Scheme of Operations (8) indicates preparation of 11 mines to destroy enemy positions, 6 mines for fougasse effect (see definitions) and 9 bored mines to blow ditches for protected approaches across no mans land. In the event few mines were employed. So far as can be established the final position was:

SEE TABULATION OVERLEAF

	Mines (including fougasse)	Bored Mines
Abandoned with no charges laid.	3	1
Blown before 9 Apr 1917 for defensive purposes.	2	-
Blown in support of the attack.	3	2
Laid but for tactical reasons not used.	8	-
Unknown (no information found).	1	6
TOTAL	17	9

c. Of the 8 or 9 mines not used three are known to have been prepared in the vicinity of the GRANGE Craters as follows:

(1) BROADMARSH Offensive Mine. Depth 50 ft (15 m). Charge 20,000 lbs (9050 kgs).

(2) Two fougasse mines in the DUFFIELD/GRANGE Group of craters.

d. The mine charge that is the direct subject of this report is almost certainly one of the two fougasse mines referred to in 2c above. Located just south of DURAND Crater it will hereafter be termed the "DURAND mine". Its location is clearly defined and shown on the plan at Enclosure 2 with the probable location of the other fougasse mine, termed hereafter the "DUFFIELD mine". The BROADMARSH mine was situated just to the North of the junction of the D55 (Neuville St V-Givenchy Road) and the minor road to Vimy/Thelus. It is just off the top left hand corner of Enclosure Two. Approximate UTM grid ref is 836805.

3. Development of the DURAND Mine Gallery.

a. The first definitive archive reference to the DURAND mine gallery is in a mine explosion report dated 21 Jun 1916 by 172 Tunnelling Company RE when the gallery was badly shaken and partially filled in by a German camouflet. (9) A further mine explosion report of 3 July 1916 shows the tunnel (the left hand fork of P77N) completed as per current configuration (see Enclosure One). The depth below surface of the chamber is given as 65½ ft (20 m).

b. Details of the development of this part of the mining system are given in Annex C. P77N was started by 15/6 Companie de Genie of the 7th Regiment de Genie in early 1916 and further developed by 172 Tunnelling Company when they took over the underground workings of the La Folie Sector on 22 May 1916. (3) Initially entered by a shaft beneath the present location of the ladies toilets, it was later connected by a down stairway to the main North-South lateral J1 and thence to other inclines. In November 1916 the forward end of the GRANGE Subway, then under construction, was connected through incline P76K to the lateral, providing the present means of access to the DURAND mine.

c. Available records - (2), (3) and (9) - show intensive mine fighting in the DUFFIELD and GRANGE group during June, July and August of 1916. There is reference to suspected German galleries and mines to the North of the DURAND crater. It therefore seems probable that the DURAND mine was prepared during this period as a defensive "sitting mine", then incorporated into the cancelled offensive scheme for the Autumn of 1916, and subsequently the April 1917 plan.

d. Before firing a mine the gallery was invariably tamped (see definitions) but curiously this does not appear to have been done for the DURAND mine. It may be surmised that the gallery was kept open to allow use of the chamber as a listening post, and to permit maintenance of the firing circuits. It should be noted that the charge was certainly laid by the British, the normal French mining explosive being cheddite.

4. Discovery of the Mine Charge. In 1985 a Canadian Historian induced one of the GRANGE guides to give him access to the fighting tunnels and accompany him on an impromtu exploration. Lacking a plan of the workings they appear to have randomly investigated some of the tunnels leading off the laterel going to the North of the GRANGE Subway and thus entered the DURAND mine tunnel. On return to the surface they reported to the Superintendent of the Canadian Memorial Park (M. Pierret) that they had found at the head of the tunnel a cache of 150 to 200 sacks of a grey powder, presumed to be explosive. A copy of the original sketch plan is at diagram 2.

5. Subsequent Investigation.

a. On 11 February 1988 a French team of firemen, engineers and explosives disposal personnel entered the old fighting tunnels with the intention of investigating removal of the presumed explosives. However they concluded that there was a significant risk of encountering toxic gases and withdrew.

b. From an earlier visit I was aware of the gas hazards and in the process of arranging for specialist equipment and personnel to investigate this in the course of a planned reconnaissance for an engineering project to repair and renovate part of the GRANGE Subway. M. Pierret consequently raised the matter of the suspected explosives with me. I agreed to investigate and (unaware of the quantity involved) to remove the material if safe to do so. I was also able to establish from the description that the substance was probably ammonal, an ammonium nitrate and TNT based explosive.

c. In early June 1988, accompanied by a number of Royal Engineer specialists, I entered the tunnel described and found what was clearly part or all of a mine charge. We removed a small quantity for analysis and photographed the charge and tunnel approaches. With the aid of a Great War mining plan of the sector (see Enclosure One), dowsing techniques and surface survey we established the ground location of the charge as being about 170ft (52m) North East of the Guides Office (see Enclosure Two).

d. Subsequent analysis of the substance and research work is covered further on in the report. As this established that the charge was potentially capable of detonation I made a further visit in late August to identify more closely how much explosive was involved and to confirm that the detonators were still in place. I endeavoured to move sufficient bags to reach and withdraw the detonators, but it became apparent that I was

unlikely to accomplish this without disturbing them. No further action has been taken excepting barring the immediate surface area above to the public.

e. From subsequent archive research I was also able to narrow the options for the site of the DUFFIELD mine to two probable tunnels. In January 89 I investigated these and established with certainty that they are clear (see Annex G).

THE SITE

6. The Approaches and Location.

a. Access to the DURAND mine is described in Annex D, shown in diagram 1 and illustrated by the enclosed photographs. The following points are emphasised:

(1) Upon descent of the incline beyond the grill by the magazine (in P76K) it is important to test for toxic gases particularly carbon monoxide (CO).

(2) Although most of the North-South lateral system is in safe condition, slabbing (see definitions) is occuring at the North end of J1 and careless movement could result in a partial roof fall (see photo 2). One large slab fell during the June 1988 investigation.

(3) The ascent of the staircase into P77N (see photo 3) involves an upwards crawl at the top over loose rocks which may be displaced. The ascent should be made by only one person at a time.

(4) The state of the P77N gallery deteriorates progressively and extensive slabbing has occurred (see photo 4). At the junction of the left hand fork to the DURAND Mine a serious roof fall occurred following the first entry in June 1988 (see photo 5).

(5) The DURAND mine gallery is about 3½ ft (1.2 m) high and in places the rock is very fractured. The former timber supports are completely rotten (see photos 6 and 7). Great care is needed in moving along this passage to avoid initiating a roof fall. (One such occurred during my investigation in August 1988).

(6) The mine chamber appears to be in sound condition. However as there is no ventilation it is essential to test for toxic gases whilst in the chamber. Particular hazards are carbon monoxide, carbon dioxide, and nitrous fumes. (It should be noted that carbon monoxide and methane were encountered elsewhere in the underground system. The extent of contamination may vary with surface atmospheric pressure.)

b. The relative surface location of the mine is illustrated in photo 11. Broadly it is 170 ft (52 m) North East of the guides office and public toilets, as shown by Enclosure Two.

7. The Mine Chamber.

a. The mine chamber and contents are illustrated in the sketch plan at diagram 3 and photographs 8 and 9. Originally the ammonal bags would have

been stacked close to the roof but for reasons explained further on the stack has subsided to about half its original volume.

b. By moving some of the bags at one side of the mine chamber I was able to determine that the stack was from 6 to 8 bags deep. From this I calculated that between 200 to 250 bags are situated in the chamber, giving an original charge of 5,000 to 6,000 lbs (2,250 to 2,700 kgs) assuming a standard filling of 25lbs (11.5 kgs) of ammonal in each bag. This is what may be expected for a fougasse mine at a depth of 65 ft (20 m).

c. The bags were neatly stacked on a footer and header basis. It was clear that they had not been disturbed since emplacement.

d. The firing circuit wires and detonating cord led into the centre of the main stack. It is almost certain that the detonators and primers are still in place, but I was unable to reach them without taking an unacceptable risk.

e. It was apparent that the chamber floods from time to time. At one corner there was evidence of a soak away. Some slight roof collapse has occurred forming a small pile of rubble on top of the bags but there is no apparent risk of the detonators - which are well padded in the pile - being set off by further roof falls. There were no tree roots protruding into the chamber which is solid chalk without earth filled fractures.

THE EXPLOSIVES

8. Bags.

a. Most of the explosive was contained in strong rubberised sacks measured at 21 x 6 x 6 inches (53 x 15 x 15 cms), clamped at the neck with two bolted wooden battens. (A small amount was in rotted sandbags.) This conforms with common British practise at the time whereby ammonal was often decanted from bulky 50 lb (23 kg) storage tins into rubberised bags, normally containing 25 lbs (11.5 Kg) of explosives.

b. The rubberised bags are perished in parts, sufficient to let in water, but otherwise in quite good condition. An empty sample bag is held by M. Pierret. The size may be judged from photo 10.

c. A number of bags were opened by cutting with a knife. In all cases the contents were very wet, in some the compound was a liquid slurry. One half full sample bag weighed 22 lbs (10.1 kg) giving a content of 19.3 lbs (8.7 kgs). Water content was 20.3% giving a compound content of 15.4 lbs (7.0 kg). This is surprisingly high and suggests some bags were overfilled with 30 lbs (13.6 kg) of ammonal.

9. Analysis.

a. In June 1988 a sample from one bag was sent for analysis and testing to the Royal Armaments Research and Development Establishment (RARDE). Their report CRA 780 dated 1/7/88 is enclosed as Annex E.

b. RARDE advised that the constituents of the sample suggest that the original explosive was British service ammonal, but that the action of water over the years has leached out the main chemical (ammonium nitrate)

which is very hydroscopic (soluble in water). The comparative results were as follows:

Chemicals	Original Ammonal		
	% Content	Proportions (approx)	Compound analysed by RARDE
Ammonium Nitrate	65%	22 parts	Nil
Trotyl (TNT)	15%	5 parts	5 parts
Charcoal	3%	1 part	1 part
Aluminium	17%	6 parts	6 parts

These figures explain why the bags were only one third to a half full. Most or all of the ammonium nitrate has been dissolved depending on the condition of the bags.

10. Tests.

a. The Tests done by RARDE are also detailed in Annex E. These established that on initiation with a detonator:

(1) A wet sample gave minor deflagration (see definitions) with slight explosive effects.

(2) A dry sample resulted in detonation with medium explosive performance.

b. Neither wet nor dry samples would burn on ignition with a fuze. Separate tests have since shown that considerable heat is needed to ignite the compound which is 50% aluminium.

11. Conclusions from Analysis and Tests.

a. Theoretically ammonal will neither detonate nor burn when wet. By an ironic twist the leaching out of the ammonal nitrate has resulted in TNT based explosive compound which I am advised is similar to an American bomb filling explosive "tritonal".

b. The compound appears to be relatively inert, which means it cannot be initiated by shock or crushing, nor readily ignited by fire. However, the RARDE report shows that it may be initiated by a detonator even when wet, and would almost certainly be so if a primer or other explosives were present. However in its wet state the explosion is slow with a lifting effect and of limited power.

12. Detonators and Firing Circuits.

a. The detonators for the charge would almost certainly have been the electric No 13 (Mark 111) (Land), see Annex F. These would have been placed inside TNT or guncotton primers. 172 Tunnelling Company normally used guncotton. (6) Detonators and primers would probably have been sealed inside rubberised bags.

b. Without inspecting the detonators there is no way of establishing their state. They could still be in good condition, or they may have corroded and the fulminate of mercury filling dispersed. As the tube was made of tin the probability is that they are only partially corroded. This is the worst case because if through corrosion the bridge wire from the electric connections are loosened, then movement could result in scraping of the fulminate of mercury against the tube. This could be sufficient to set it off and cause an explosion.

c. Guncotton is a very resilient and moderately sensitive explosive. If a detonator were initiated it is probable that the guncotton primer would detonate setting off any other primers nearby. Even if this did not detonate the former ammonal compound it would have fatal consequences for anyone in the DURAND mine tunnel and probably bring down the roof.

13. Consequences of Detonating DURAND Mine.

a. A retired explosives expert, Mr Bryan Earl, kindly undertook a number of calculations regarding the possible effects of detonating the DURAND mine. (7) He took the worst possible case, which assumes that there is 2,500 lbs (1,130 kgs) of explosive in the chamber, and that it all detonates - in practical terms an unlikely event.

b. Mr Earl calculated that at a depth of 60 ft (18 m) a charge of 2,300 lbs (1,043 kgs) would break surface, possibly throwing some debris up to 250m. Even if the explosion did not break surface it would create a large underground cavity which could then collapse forming a crater.

c. Employing "The Morris formula" (see note below) the ground shake effect of a complete detonation of 2,500 lbs (1,130 kgs) of the explosive would be approximately as follows:

Location	Ground Movement		Possible Effect
	Inches	MM	
Guide House	0.059	1.5	Some structural damage. Possible breaking of water pipes and mains.
Entrance to GRANGE Subway	0.05	1.3	Displace weak supports. Falls of rock at weak points of roof.
Area of GRANGE Subway requiring repair work.	0.02	0.51	Some loose rock may be displaced. Suspect beams may be further weakened hastening possibility of failure.
Farmhouse to the west of GRANGE Subway CWGC Bldg	0.012	0.3	No structural damage but loose tiles or similar might be displaced.

(Note: The Morris formula is A = K/C - d where A = amplitude of ground movement in thousands of an inch, K = site factor assessed as 200 for chalk, C = charge weight in lbs and d = distance in ft).

d. If the tunnel was not tamped there would be severe air blast but this would probably be contained by the constriction at the top of the stairs into former gallery P77N. A large amount of toxic carbon monoxide and nitrous gases would be released. If the charge failed to break surface these would be contained below ground and necessitate monitoring of the pollution level in the GRANGE Subway for a long period, possibly a year or more. Even if the charge broke surface there would be a need to monitor gas levels for several months.

[NOTE: IT IS EMPHASISED THAT THE LIKELY EFFECTS WOULD PROBABLY BE MUCH LESS. HOWEVER EXPLOSIVE CAN BE UNPREDICTABLE AND FOR PLANNING PURPOSES THE "WORST CASE" HAS BEEN ASSUMED.]

14. Prospect of Detonation.

a. In 1957 an abandoned mine charge under the Messines Ridge exploded during a thunderstorm. (10) The reason is not known but there are three feasible explanations:

(1) Build up of static electricity in the ground prior to a lightning discharge which may have generated a high voltage current, or electromagnetic impulses in the firing circuit.

(2) A lightning strike on a tree could have resulted in a high voltage discharge along a tree root into the mine chamber, setting off a detonator or primer.

(3) Heavy concussion from a lightning strike which might have caused sympathetic detonation of a detonator or primer. This seems an unlikely cause.

b. There are major differences between the Messine mine and DURAND mine which need to be considered:

(1) A long delay between setting and use was anticipated with the Messines mines. Explosives and firing circuits were waterproofed with great care, being contained in rubber bags inside pitch sealed metal containers. In 1957 they may still have been in good condition.

(2) The ground at Messines is clay. Tree roots may have grown down into the chamber. There is no evidence of this in the chalk at Vimy.

(3) Chalk is a much better insulator than wet clay. The chances of static build up or lightning discharge through the 45 ft (13 m) of chalk between the Vimy topsoil and the DURAND mine seems improbable.

(4) The wiring of the circuit in the DURAND mine is completely corroded so electric charges could not be conveyed to the detonators, nor static or electromagnetic impulses built up in the wire. At Messines, 32 years ago, the wiring may still have been in fair order.

c. As stated in para 7c the detonators of the DURAND Mine are well padded within the bags of explosives. Minor falls from the roof of the chamber should not effect them, and a major collapse seems unlikely.

d. It appears that the chance of detonation through natural causes is extremely remote. The greatest risk of inadvertent detonation is through "human agencies" tampering with or disturbing the detonators.

15. Other Mines And Munitions.

a. General. The DURAND Mine needs to be considered in the context of the explosives and munitions that remain under the surface of all Great War Battlefields. At a conservative estimate there must be several hundred thousand unexploded shells and mortar bombs contained within the topsoil of the Vimy Ridge. There may well be a number of British, French and German mine and camouflet charges in tunnels that were blown in before they were used, and others that may just have been left. If especial concern is to be attached to the DURAND Mine then it would be consistent to extend this concern elsewhere.

b. The BROADMARSH and DUFFIELD Mines.

(1) Of the eight or nine other charges not used on 9 April 1917, the BROADMARSH and DUFFIELD mines are situated within the public area of the Memorial Park. (My research has not extended to determining whether any of the others are beneath public areas). The largest was the BROADMARSH Mine at 20,000 lbs (9,050 kgs) situated almost under the road junction North East of the GRANGE area. The DUFFIELD mine was probably similar to the DURAND mine.

(2) On 14 Jan 89 I examined the two most likely sites for the DUFFIELD mine (see Annex G). The indications are that it had been placed in the right fork of gallery J2 but was subsequently cleared.

(3) Whether the BROADMARSH mine remains in place is not known. Access to the approach tunnel P77D is blocked at its junction with P78G (see Enclosure One) and near one of the two original entrances. Examination of the blockage suggests that it might be cleared without much difficulty provided the roof immediately above the blockage is supported. Optionally access might be obtained by sinking a shaft from the surface of about 15 ft (5m) depth just forward of the blockage. Either course of action would require only modest resources. Whether the state of the tunnel permits subsequent investigation can only be determined after entry. It is known that about 50 ft (15m) length, after the first bend, was damaged in 1917 by a German camouflet and subsequently recovered. With rotting of supports this section may be dangerous but otherwise it is likely that the tunnel will be sound.

(4) If it can be safely achieved inspection of the BROADMARSH mine chamber would be prudent.

c. Other Mines. I expect to be able to determine the original positions of most of the other unused mines, grid references being available in reference (8). If any of these are found to be situated under public

areas, and if it cannot be established that they were cleared, consideration should be given to the possibility of gaining access and inspecting the sites.

POSSIBLE COURSES OF ACTION

16. Options. The potential options available concerning the DURAND mine are considered below with the main advantages and disadvantages. In summary they are to:

a. Remove the charge.

b. Chemical decomposition.

c. Burn charge.

d. Withdraw detonators and leave charge.

e. Detonate charge.

f. Leave in situ.

17. Removal of Charge.

a. Advantages. Eliminates any potential hazard to the site or general public.

b. Disadvantages.

(1) Approaches. Access to the mine tunnel are convoluted and involve passing along tunnel J1 which is slabbing. For any major activity it would be essential to support J1 and open up the top of the stair case. The mine tunnel itself is in a dangerous state. Extensive work would be needed to support it. This would be a lengthy and expensive operation. Alternatives would be to drop shafts either beside the guides office into tunnel P77N, thereby shortening approaches, or even the 65 ft (20 m) directly to the mine chamber.

(2) For any extensive work in the mine gallery and chamber pumped air ventilation would be required.

(3) During removal of the bags there remains a considerable risk from disturbing the detonators. As already stated an explosion, even of the detonators and primers alone, would kill any persons within the confined space.

c. Conclusion. To approach and remove the charge along the existing tunnels would be a major operation and dangerous. The safest procedure would be to drop a working shaft beside the mine chamber. This would resolve ventilation problems, and allow easy access with specialised equipment to neutralize detonators or for remote working. It would however be a big operation and still present hazards.

18. Chemical Decomposition of Charge.

a. Advantages. Complete neutralization.

b. Disadvantages.

(1) Access and approaches present similar problems to removal (para 17).

(2) Using a chemical to destroy fulminate of mercury from the detonators may not work if the detonators have not corroded, and it may destabilise the TNT. The converse applies to neutralizing the TNT with Chemical. (7)

(3) Conclusion. An expensive and uncertain option.

19. Burn Charge. Not worth further consideration. Ventilation would have to be installed. Even if wet compound would burn considerable heat would have to be generated. This would set off the detonators and primers and probably result in an explosion.

20. Withdraw Detonators.

a. Advantage. Complete neutralization of charge.

b. Disadvantage. As already stated there is considerable risk in attempting to reach and withdraw the detonators.

c. Conclusion. A possible option, risky for persons attempting the task.

21. Detonate Charge.

a. Advantage. Eliminates the problem. Effectively another form of removal.

b. Disadvantages.

(1) In setting firing circuit there is some risk from state of approach tunnels but with care this need not be great.

(2) IF the whole charge detonated there could be some damage to the guides office and parts of the GRANGE Subway (see para 13).

(3) Carbon monoxide and nitrous gases may be introduced to the tunnel system and thence to the GRANGE Subway. This hazard could be minimised, and public safety assured by regular monitoring.

c. Conclusion.

(1) Damage assessment (para 13) is on a worst case basis. It is probable that effects would actually be small. However even the "worst case" damage would probably be considerably cheaper to remedy than the costs of removing the charge.

(2) This is a practical proposition if potential damage is acceptable. Mr Early (7) recommends a heavy initiator of about 200 lbs (90 kgs) of explosive. This could be relatively easily placed. Tamping the charge would involve several man days work and could be supplemented by reactive explosive tamping. Gas problems would be minimised by effective tamping.

22. Leave Charge Undisturbed.

a. Advantages. Simplest and cheapest option with no need to put any persons at risk through working on the charge.

b. Disavantage.

(1) Does not change basic situation. There remains the remote possibility of natural circumstances causing an explosion.

(2) Possibility of subsequent interference with charge - but this could be eliminated by blocking access.

c. Conclusion. This is my favoured option but it depends on acceptance of the very small chance of an accidental detonation. It accepts the reality that other charged mines probably exist under many battlefield areas and that the topsoil contains enormous quantities of unexploded munitions. There is a risk of accidents at all Great War battlefield areas.

RECOMMENDATIONS

23. Recommended Action.

a. Providing certain precautionary measures are taken (see para 24) it is my opinion that the risk to the public of leaving the charge undisturbed, and in place, is so remote as to be within the acceptable parameters of the day to day hazards of life. In the context of a Memorial Park, situated on Great War battlefield, it should be well within the safety expectations of those who choose to visit.

b. My recommended alternative would be to neutralise or eliminate the charge by blowing it (para 21). However removal should not be precluded. The work entailed and risks involved are for the relevant disposal experts to assess.

24. Recommended Precautions. If the charge is left undisturbed and in place I recommend the following precautionary action:

a. To block off tunnel P77N by placing a barrier of sandbags containing a cement mix either in the P77N tunnel or at the head of the staircase from J1 into the tunnel. Within a short period the action of normal water seepage will set the bags into a concrete barrier.

b. To fence off the area immediately above the charge to a radius of about 60 ft (25 m) from centre and put up public exclusion notices.

c. To deny access to the GRANGE Subway during thunderstorms and to evacuate the tunnel should a thunderstorm occur whilst guided tours are in the tunnel. (This should in any event be a routine precaution in view of the amount of metalwork in the tunnel and the tendency for lightning to strike cave and tunnel entrances).

d. To place at prominent points throughout the park suitable liability disclaimers advising the public that they visit at their own risk.

25. Further Investigations.

a. It is suggested that if practicable, access be gained to the BROADMARSH mine tunnel, a check be made on whether the charge is still in place, and if so the potential hazard assessed. I am willing to do this if the resources and time can be made available.

b. It may be possible to establish from the available records the sites of some or all of the other five mines not fired on 9 April 1917. If any of these are situated under areas open to the public consideration should be given to their investigation.

DISCLAIMER

26. Disclaimer. The statements, opinions and conclusions of this report are based on such facts as I have been able to obtain through research into archive and other materiel, expert opinion and estimates or assessments based on personal observations and the available evidence. They nevertheless constitute a personal view and may be open to correction if other factors become known. The conclusions are my own and should be subjected to independent examination before being accepted as a basis of action.

G P G ROBINSON
Lieutenant Colonel
Royal Engineers
HQ Royal School of Military
Engineering
Chatham

CPT13B-A/A5

ANNEXES

A. BIBLIOGRAPHY AND REFERENCES.

B. DEFINITIONS.

C. DEVELOPMENT OF THE MINING SYSTEM IN THE GRANGE AREA AND BACKGROUND TO THE DURAND AND DUFFIELD MINES.

D. ACCESS TO DURAND MINE.

E. RARDE REPORT CRA 780 DATED 1/7/88.

F. DETONATOR ELECTRIC No 13 (MK 111) (L).

G THE DUFFIELD MINE.

H. ACKNOWLEDGEMENTS.

DIAGRAMS

1. MINING COMPLEX IN THE VICINITY OF THE GRANGE SUBWAY.

2. ORIGINAL SKETCH BY ROCH DE BELLE FEUILLE SHOWING ACCESS TO DURAND MINE CHAMBER.

3. SKETCH OF MINE CHAMBER AND CONTENTS.

4. THE SUBWAYS AND APPROXIMATE POSITIONS OF MINES LAID

PHOTOGRAPHS

ENCLOSURES

ONE - 172 TUNNELLING COMPANY MINING PLAN OF LA FOLIE SECTOR (Copied from original colour copy and annotated with subsequent information).

TWO - PLAN OF PRESENT GRANGE SITE AT 1:1000 SCALE AND ACCESSIBLE SECTION OF GRANGE SUBWAY AT 1:500 SCALE.

ANNEX A TO
RE ADP 10/84
DATED 31 JAN 89

BIBLIOGRAPHY AND REFERENCES

(1) Report dated 30 July 1917 by the Inspector of Mines (GHQ) on work done by the Tunnelling Companies in support of the operations of 9 April 1917 (PRO reference WO 158/138).

(2) First Army Mining Summaries (PRO reference WO 158/198).

(3) 172 Tunnelling Company War Diary (PRO reference WO 94/244).

(4) VIMY! by Herbert Fairle Wood.

(5) THE VIMY MEMORIAL. Souvenir booklet produced by the Directorate of Public Affairs & Veterans Affairs, Canada, 1984.

(6) Papers of and correspondence with Herr Olaf Grieben, formerly adjutant to the Commander of Mining Troops on the Vimy front in 1916 and 1917.

(7) Mining Plan La Folie Sector scale 1 inch to 120 ft. PRO reference 153/913 document 29 (see also Enclosure One).

(8) Canadian Corps Scheme of Operations for Assault on Vimy Ridge dated 19 March 1917 (PRO reference 158/424).

(9) Third Army Mine Explosion Reports April 1916 to August 1916 (RE Library reference 940.3.623.25).

(10) Letter dated 23 July 1988 to Lt Col Robinson from Mr Bryan Earl M.Sc, ACSM, MIMM, C.Eng.

(11) YPRES. THEN AND NOW by Mr John Giles.

(12) WORK OF THE RE IN THE EUROPEAN WAR 1914-19 MILITARY MINING - Published by Secretary of the RE Institution 1922 (RE Library).

(13) MILITARY ENGINEERING (Vol IV) DEMOLITIONS AND MINING 1923 (RE Library).

(14) TUNNELLERS by Captain W Grant Grieve and Bernard Newman published about 1934 (available from RE Library).

(15) WAR UNDERGROUND by Alexander Barrie, first published 1962 (RE Library 940.412.42).

(16) THE WORK OF THE MINER ON THE WESTERN FRONT 1915-18 by H Standish Ball 1919 (Proceedings of the Institute of Mining and Metallurgy - available in RE Library).

(17) FLANDERS AND FRANCE REVISITED by Captain B D Plummer MC in Bulletin No 5 of Tunnellers' Old Comrades Association 1929.

(18) ARRAS, LENS - DOUAI AND THE BATTLES OF ARTOIS - Illustrated Michelin Guide approx 1925 (RE Library, 40.3(084) 11C).

(19) Diary of Major R Stokes RE, assistant Controller of Mines GHQ (PRO reference WO 158/137).

NB: Copies of all the PRO documents referenced above are available in the RE Library.

13B-A6

ANNEX B TO
RE ADP 10/84
DATED 31 JAN 89

DEFINITIONS

CAMOUFLET	A mine charge designed so that it will not break the surface. Normally employed to destroy or disrupt enemy workings. A crater may be formed because of collapse of the consequent chamber formed by the explosion.
COMMON MINE	A mine charge designed to break surface with a crater width approximately twice the depth of the mine.
DEFLAGATORY EXPLOSION	A "slow burning" explosion with strong lifting effect but limited explosive power.
FOUGASSE MINE	A mine charge situated and designed to bury enemy positions rather than to blow them up.
GALLERY	A section of a tunnel, strictly a specific part of a system of tunnels but often used to describe a simple system.
INCLINE	A sloping or stepped tunnel as distinct to a vertical shaft.
LATERAL	Tunnels running parallel with the front line, and usually just ahead of it; generally at a deep level. Intended to connect together workings, facilitate natural ventilation, provide secure start points and access for saps and act as an underground defense line.
SAP	A trench or tunnel driven towards the enemy. Also used to describe trenches or tunnels to dead end (no through) positions.
TAMPED (TAMPING)	Back filling of explosive charges to contain and maximise the explosion. For mine charges this was usually done by blocks of sandbags interspersed with air gaps. Typical tamping for a 6,000 lbs (2,700 kg) mine would be 15 ft (4.5 m) solid + 5 ft (1.8 m) air space + 10 ft (3.1 m) solid + 5 ft (1.8 m) air space + 10 ft (3.1 m) solid. It will be appreciated that tamping was a major task.
SLABBING	The process of rock breaking away along lines of weakness or fissures/cracks. Where the width of a tunnel exceeds the span of natural weakness in the rock, or where the rock has been cracked by explosions or other means, then slabs may fall unless support is provided.

ANNEX C TO
RE ADP 10/84
DATED 31 JAN 89

DEVELOPMENT OF THE MINING SYSTEM IN THE GRANGE AREA AND BACKGROUND TO THE DURAND AND DUFFIELD MINES

References:

A. Third Army Mine Explosion Reports (Bibliography (9)).
B. 172 Tunnelling Company Plan of La Folie Sector (Enclosure 1).
C. 172 Tunnelling Company War Diary.
D. First Army Weekly Mining Summaries.
E. Diary of Major R Stokes RE, Assistant Contoller of Mines GHQ.

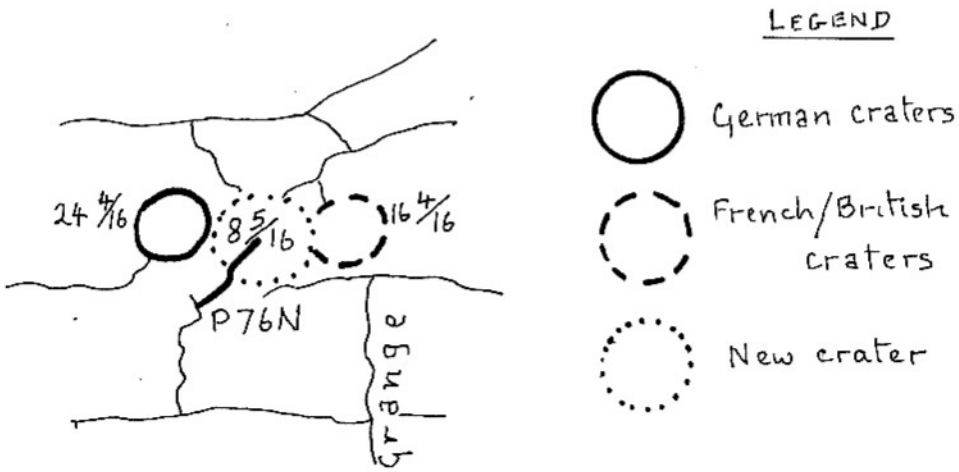
1. Situation on 4 May 1916.

a. For some months preceding handover to 172 Tunnelling Company RE on 22 May 1916, the underground defence of the La Folie Sector was the responsibility of 15/6 Companie of 7th Regiment du Genie, loaned from the 10th French Army.

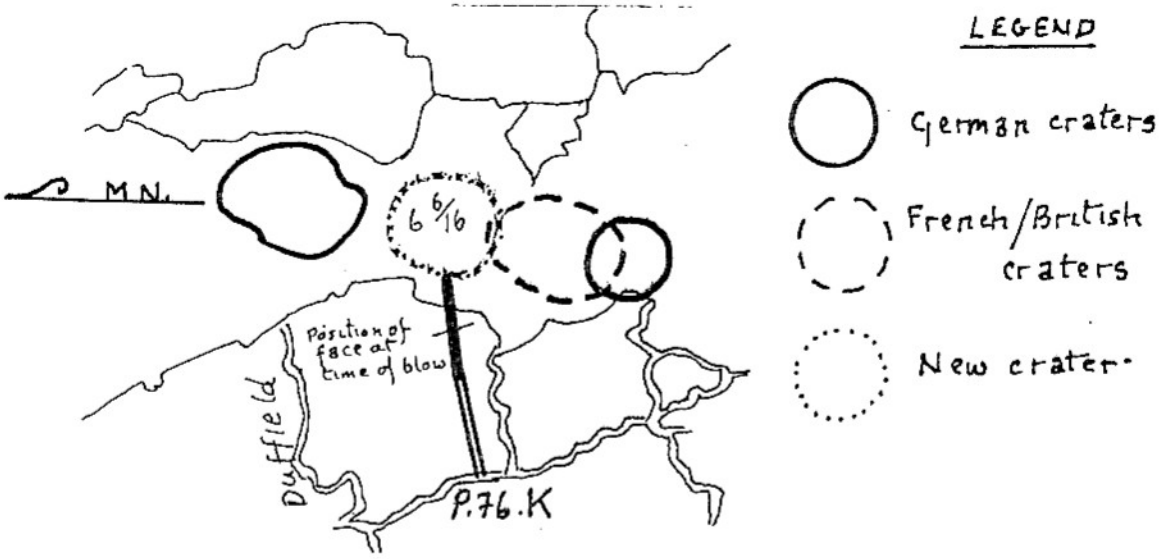
b. A report (Reference A) of a German blow against gallery P750 on 5 May 1916 is accompanied by the map at Appendix 1. This is the first identified record of the mining situation in what was to subsequently become the DURAND/DUFFIELD/GRANGE area. The German crater dated 24.4.16 has been established as being the original GRANGE crater. A short French gallery P76N is shown immediately to its' South. It is probable that other tunnels were in work to the immediate North.

2. Mines on 8 May and 6 June 1916 Extending GRANGE Craters.

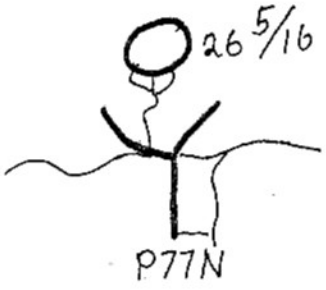
a. On 8.5.16 a mine of 4,000 kgs (8,800 lbs) of cheddite was blown from P76N. This created a crater with high lips linking the GRANGE Crater with the French crater of 16.4.16 as illustrated below. It is reported that it destroyed two German trenches and that the British Infantry occupied the near lips of all three craters.



b. On 6.6.16 the Germans attempted to destroy the P76K gallery with a mine laid under the GRANGE crater as illustrated below. It did no damage.



3. Initial Development of P77N (DURAND Mine Tunnel). A very brief report in Reference A states that on 25.5.16 the Germans exploded a small mine just North of the 'P76' crater (probably GRANGE Crater) but that it did no damage to P77N. A small and rough diagram (see below) reveals that the P77N galleries, now containing the DURAND Mine, had been well developed by 15/6 Coy before handover to 172 Tunnelling Coy RE.



4. Combined Mining and Infantry Attack on Duffield Trench and P77N on 21.6.16. On 21.6.16 the DURAND mine gallery was badly shaken by an enemy mine. The subsequent report by Major Syme, OC of 172 Coy makes interesting reading:

To Controller of Mines, Third Army

In confirmation of my telegram No S.110 dated 21-6-16, the enemy exploded a mine at 9.40 pm last night at a point in front of DUFFIELD Communication Trench. No damage was done to our observation line, but a crater of apparently about 100 ft diameter with high lips was formed, joining on to the one blown by them on 26-5-16.

Immediately following the explosion three parties of German bombers attempted to raid our trenches in neighbourhood of P77N and P77H mines.

They were driven back and the near lip of the new crater held and consolidated.

The mine was sprung during "Stand to" and no men were underground.

P77N was damaged by the blow, but no gas could be detected. The left gallery is badly shaken and partially filled in, but is still open to the face and should be clear in 24 hours. The right gallery is nearly filled in, with loose chalk, but appears open to the last bend. It should now be possible to re-open and continue there to protect the near lip of the new crater.

21-6-16

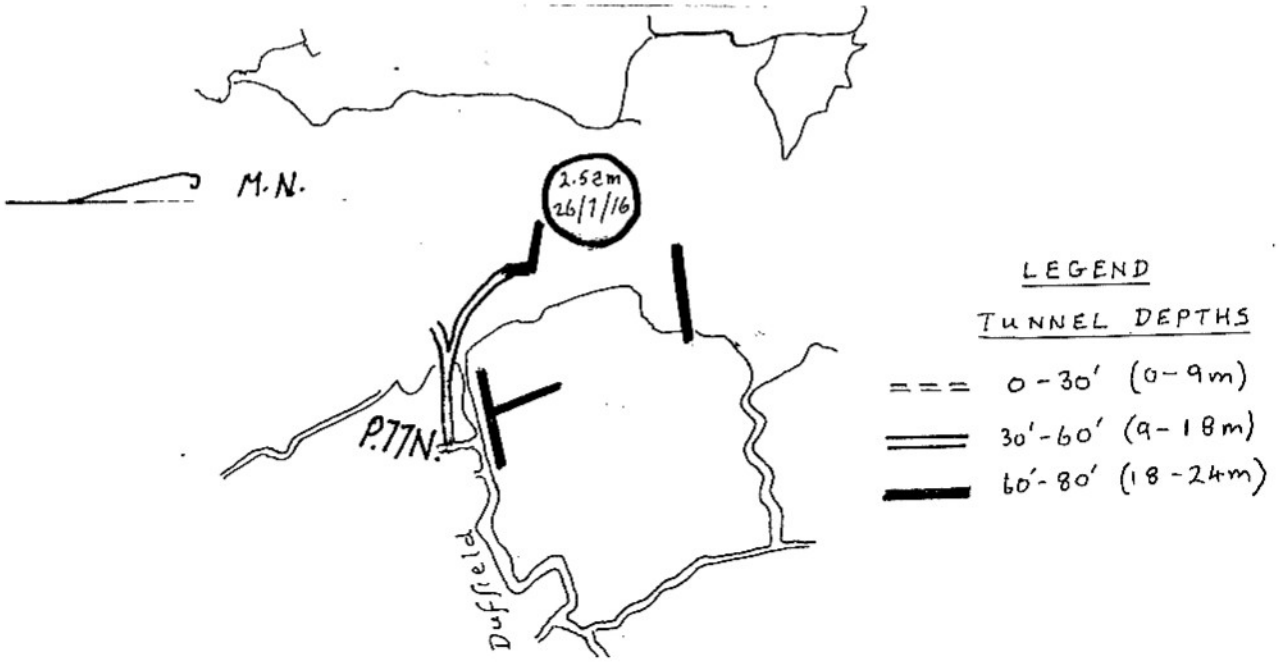
G A Syme
Major
OC 172 Coy Royal Engineers

5. Situation on 3 July 1916. Between 28 June and 1 July 1916 there were a series of actions involving galleries of P750. Suspecting a mine attack the British fired a series of borehole charges to force the Germans to show their hand. The Germans finally responded with a camouflet on 1 July 1916. The map accompanying the subsequent report, copy at Appendix 2, shows the mining situation in this area as at 3 July 1916. Note that the DURAND mine gallery, the left hand fork of P77N, has been fully developed to its' present length and configuration.

6. Mining Attack Against P77N on 26 Jul 1916.

a. On 26 July 1916 the Germans attacked the right hand gallery of P77N. This destroyed 50 ft (15 m) of the gallery and partially filled another 30 ft (10 m), but it was reported that it could easily be recovered. A small crater about 75 ft (22 m) was formed in the GRANGE crater. There were no casualties apart from a canary overcome by gas.

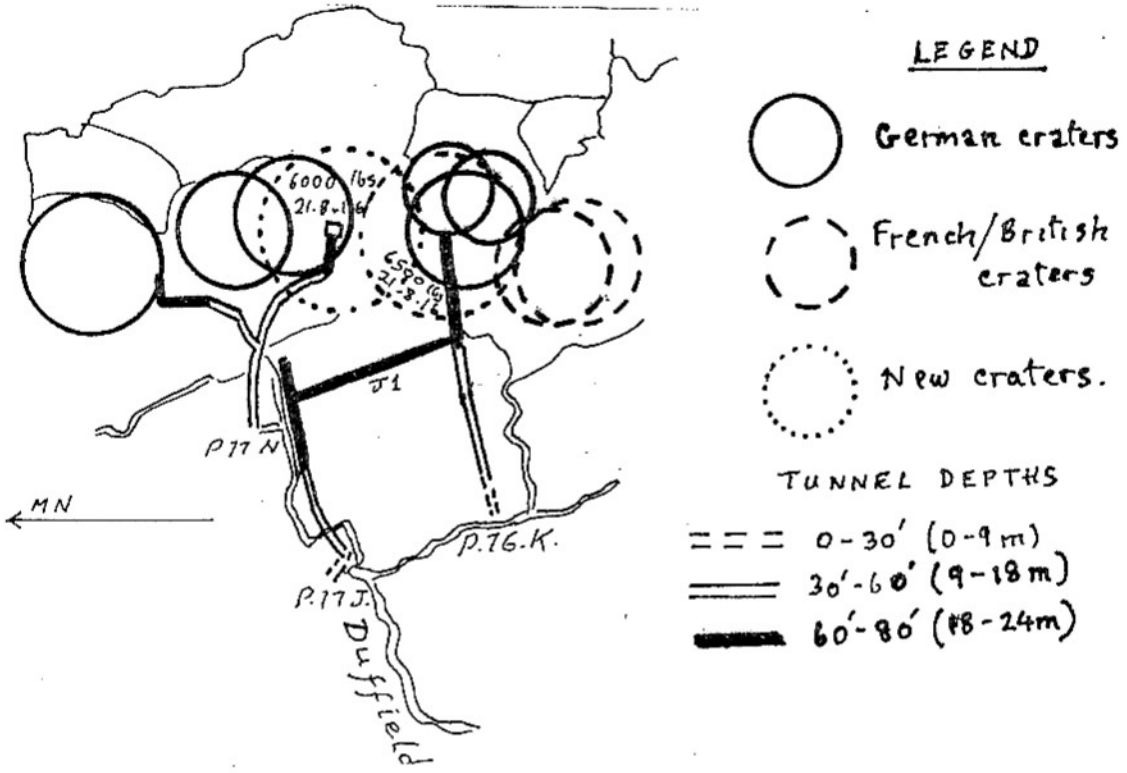
b. The diagram accompanying the 172 Coy report shows that work has started on the P77J incline and the J1 lateral.



7. British Mining Attacks in DUFFIELD/GRANGE Group in late August.

a. On 16 August 1916, 172 Coy blew a 2,500 lbs (1,130 Kgs) ammonal charge from the left hand gallery of P750 (depth 46 ft/ 14 m) against a German gallery believed to be only 6 ft (2 m) away. The nearside lip of the exisiting crater was raised and occupied by the British Infantry.

b. On 21 August 1916 two mines of 6,000 lbs (1,830 kgs) and 6,500 lbs (1,980 kgs) were blown from the ends of the P77N right hand gallery and P76K respectively. A copy of the report diagram is shown below. Note that the P77J incline has been linked by the J1 lateral with P76K.

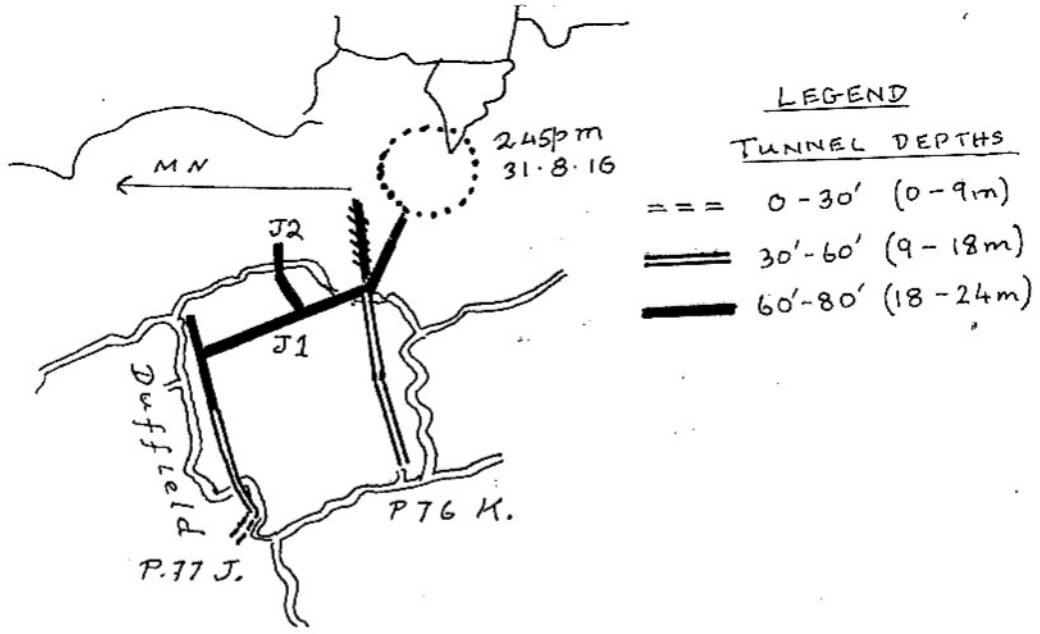


c. Reference A contains full details of the P76K mine. An extract is attached for interest as Appendix 3.

8. German Mining Attack on 31 August 1916 - Against P76K.

a. On 31.8.16 a heavy camouflet was fired by the Germans against a new right hand fork of P76K, as illustrated in the diagram below. This did comparatively little damage but resulted in the death by gassing of 136485 Sapper Follows E and admission to hospital of 112678 Sapper Adams C.

(diagram overleaf)



b. It should be noted that a gallery (J2) has been extended from the J1 lateral towards the enemy.

9. J2 Mine on 21 September 1916. On 21.9.16 a powerful mine of 10,000 lbs (3,050 kgs) of ammonal was fired against an enemy tunnel from the end of the J2 gallery referred to above. The 172 Coy war diary states:

"Crater formed between GRANGE and DUFFIELD with high lips on our side over looking German trenches and protecting our trenches from observation. Two enemy observation posts destroyed and cries heard."

10. October and November 1916.

a. By Oct 1916 the North-South Lateral had been completed throughout the La Folie Sector. In the GRANGE/DUFFIELD area the extensive cratering, fragmentation of the chalk and toxic gases from explosions would have made tunnelling difficult and dangerous. The Germans became relatively inactive (remaining so until March 1917) and the focus of the mine fighting shifted to the area of the TIDSA crater. 172 Company was able to concentrate its' efforts on the construction of dugouts and, from November 1916 the previously conceived construction of the GRANGE, GOODMAN and LICHFIELD subway complexes. On 26 Oct 172 Company was transferred from 17 Corps to the Canadian Corps when the latter took over the Vimy area.

b. P76K was further extended. A dugout now titled "The Magazine" was constructed (8.10.16). This was probably to support the mining activity and may have been an equipment or explosives store, a central listening post or a proto (rescue) station. At the same time the tunnel and chamber for a water point was extended North of the incline. This was completed on 22 November 1916 and appears to constitute the first work on what became the GRANGE subway.

c. More curiously a right hand fork to P76K (K2 on Reference B) was completed and chambered on 14 October 1916. This runs close and parallel to the lower level gallery K1 which had been completed on 6 September 1916. The reason for this apparently redundant gallery is not known but it must have been driven for some purpose. A mining plan in the RE Museum shows K1

as abandoned but as there is no record of its' destruction by enemy activity it may have been closed off for other reasons. One intriguing possibility is that it was driven too deep through the water table and flooded. This could explain why K2 is at a higher level and may account for the legend of an underground lake at the bottom of the P76K incline! Another factor is two shot holes in the roof of the former entrance to K1 suggesting that a charge had been prepared for blocking the gallery. Given the close proximity of a German tunnel (see Reference B) there may have been fears of an enemy break in, though there is no record of such an event. This may account for the other aspect of the legend that British and German troops drew water from opposite sides of the "underground lake".

d. In November the former J2 gallery was revived and driven under the South side of GRANGE Crater. This was chambered on 8 November 1916 suggesting an intention to place a mine or camouflet. Likewise P77J had been extended along gallery C1 and a chamber constructed under the North edge of GRANGE crater on 11 October 1916. This group of chambers in C1, J2 and K2 suggest an intention to place a series of mines. The missing "DUFFIELD" mine is likely to have been in one of these, most likely J2 or K2.

11. December 1916 to March 1917. Construction of GRANGE Subway.

a. In the four months of December 1916 to March 1917, most of the 172 Company effort was directed to construction of the GRANGE, GOODMAN/PYLONES and LICHFIELD subways, various dugout complexes and special positions for support weapons. Progress on the GRANGE subway is reasonably evident from the dates shown on Reference B. Much information has become available but is not directly relevant to this report.

b. Points on the GRANGE subway that may be worth noting are:

(1) The passage currently designated "Black Watch Tunnel" was intended principally to serve a Wombat drilling chamber situated near the North West lip of DURAND crater. The plan was to blow a deep ditch across no mans land to the immediate North of DURAND crater. In the event the nine German mines blown on 23 March 1917 creating LONGFELLOW crater wrecked the Wombat chamber and the project was abandoned.

(2) The chamber at the bottom of the main GRANGE entrance (on the left of the descent) was a telephone dugout. It was completed about 15 March 1917.

(3) The four Y saps either side of the GRANGE subway near the main defence line entrance were trench mortar positions built from below and broken out for the attack.

(4) In addition to the existing Command complex there is another large dugout complex, now blocked to access, off the GIVENCHY ROAD "tributary" of the GRANGE subway. Was this perhaps a forward HQ for 3rd Canadian Division?

12. Final Connections to DURAND Mine and Circumstances Preceding the Attack of 9 April 1917.

a. The only major works in the fighting tunnels after December 1916 were construction of the staircase connecting P77N to P77J completed on 27 January 1917. A new shaft also appears to have been sunk to P77N on 3 January 1917 - was the earlier shaft destroyed by shellfire? With this work the system assumed the configuration that may be seen today as shown in Diagram 2 and Enclosure 1.

b. References C and D remark on German tunnelling activity in the DURAND area during February and March 1917. The DURAND mine may have been left untamped to allow maintenance of a listening post at the end of this left fork off P77N.

c. (1) The big German blow of nine mines on 23 March 1917 which resulted in LONGFELLOW crater may have been aimed at creating an obstacle to an infantry assault between BROADMARSH and DURAND craters but if so why not wait and blow as the infantry crossed? An alternative is that it was targetted against suspected British mines in the area. In the event it damaged only the GRANGE wombat chamber. BROADMARSH, DURAND and DUFFIELD mines were unaffected.

(2) Because of the obstruction caused by the LONGFELLOW craters the Commander of the 3rd Canadian Division decided that his infantry would be impeded if more craters were created on the DURAND front and he cancelled the blows intended to support his attack. Whether he was right to do so is a matter for debate.

d. In the lead up to the attack 172 Company were employed on a wide range of tasks as listed in Appendix G to the Canadian Corps scheme of operations. These were as diverse as drilling pipe mines, constructing dugouts, extending an old French mine gallery into LICHFIELD Crater for laying signal lines, tunnelling special weapon positions and continued enhancement of the subways. In this period PYLONES and GOODMAN subways were joined to make GOODMAN much the longest at 5649 ft (1722 m).

e. Immediately before the Canadian attack all of the 172 Company miners, excepting a few listening posts, were withdrawn from the fighting tunnels for maintenance of subway entrances and other suport tasks such as breaking out the special weapon positions from below and entrances into no-mans land. During the attack three parties of those in the GRANGE area were employed blowing access routes through the lips of the LONGFELLOW craters, and mining sections accompanied the attacking infantry to inspect German dugouts and subways, clear booby traps and clear and survey German tunnels. Immediately thereafter the whole Company was put to road construction in the battle area excepting those clearing the German mine system and lifting booby traps. Whether the men of 172 Company ever entered their La Folie Sector tunnels again is not known, nor why at least one easily accessible mine charge was left in place. The tunnels remain largely intact in their original form, a hidden monument to the 21 officers and men of 172 Tunnelling Company Royal Engineers who were killed in the course of mining operations on the VIMY Ridge.

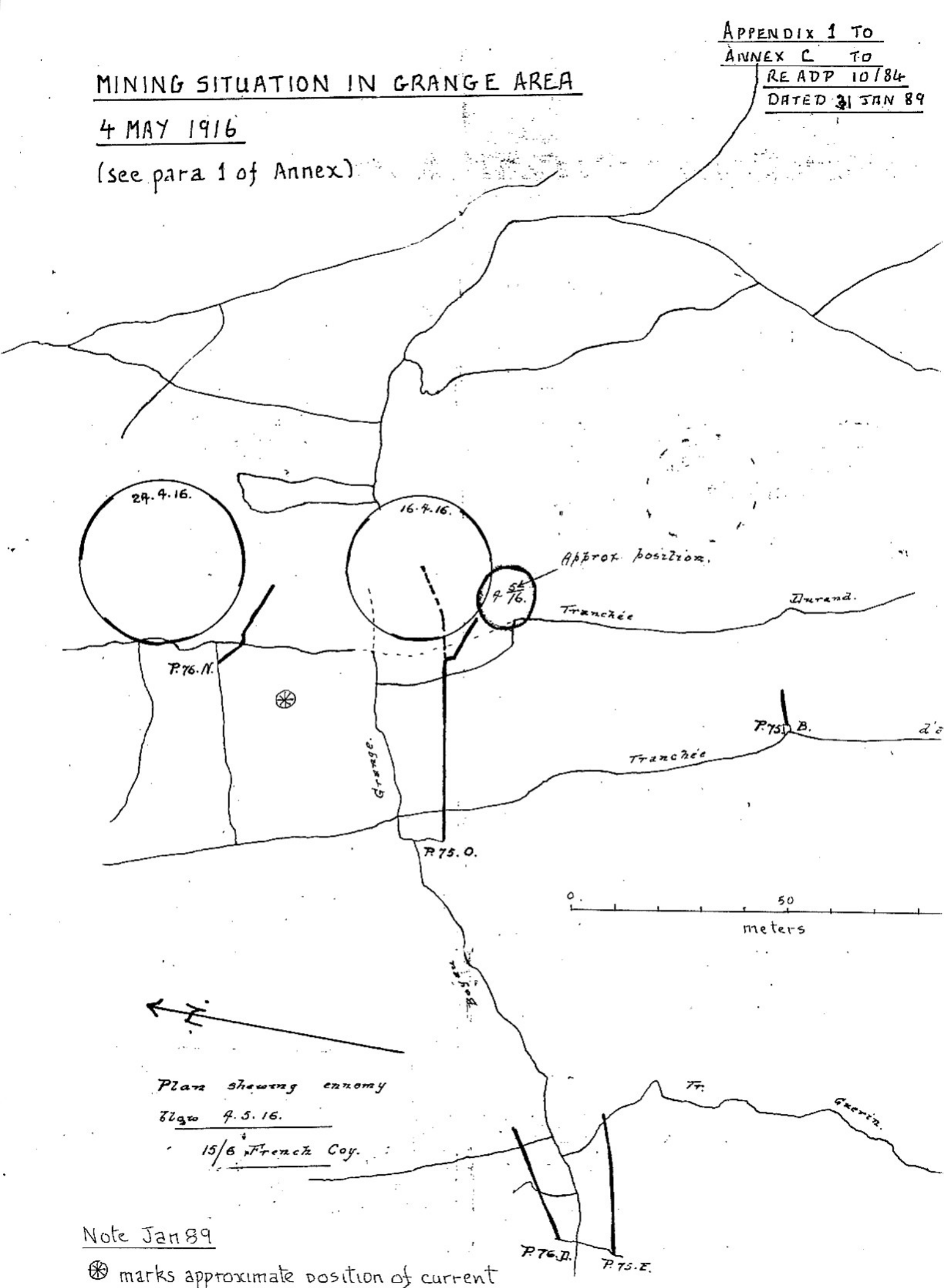
13B-A8/10

APPENDIX 1 TO
ANNEX C TO
RE ADP 10/84
DATED 31 JAN 89

MINING SITUATION IN GRANGE AREA

4 MAY 1916

(see para 1 of Annex)



Plan shewing enemy
Wks 4.5.16.
15/6 French Coy.

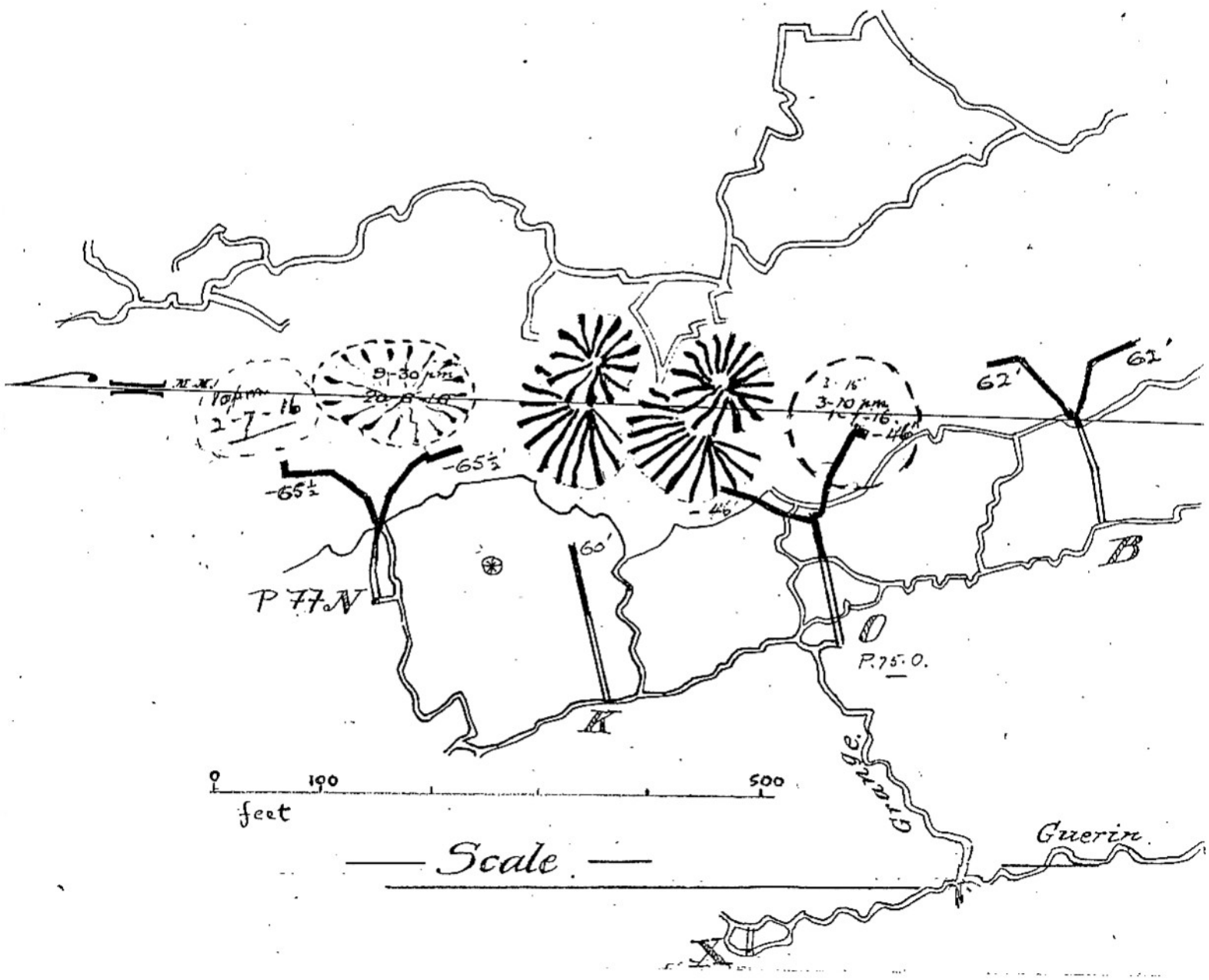
Note Jan 89

⊛ marks approximate position of current entrance to GRANGE subway

APPENDIX 2 TO
ANNEX C TO
RE ADP 10/84
DATED 31 JAN 89

MINING SITUATION 3 JULY 1916
DURAND - DUFFIELD - GRANGE AREA

172 Coy: RE —



Notes Jan 89

Entrance to K is present site of cherry tree.

Entrance to P77 N is where guides office is currently located.

⊛ marks approximate position of current entrance to GRANGE subway.

APPENDIX 3 TO
ANNEX C TO
RE ADP 10/84
DATED 31 JAN 89

Army Form W3376

MINE EXPLOSION REPORT (BRITISH)

Third ARMY XVII CORPS 60th DIVISION
172 TUNNELLING COMPANY RE SECTOR P
DATE: 21.8.16 TIME: 7.30 pm

Location and depth of Charge	Face of P76K. Depth 76 ft.
Nature of Ground	Chalk broken by previous blows
Details of Charge:	6,000 lbs. Ammonal in rubber bags. Primer - 2 electric detonators in guncotton primer surrounded by commercial caps.
Tamping:	15' solid + 5' air space + 10' solid + 5' air space + 10' solid
Reasons and Authority for Mine	Proximity of enemy gallery. Authority C of M
Effects of Explosion:	
Dimensions of Crater	Impossible to ascertain.
Underground Effects	70-75 ft of gallery destroyed, lateral between J & K shaken but not seriously damaged.
Estimated HRR	75 feet.
Surface effects	Crater formed one bombing post filled in. German lip possibly slightly heightened.
Gas Conditions	Our galleries free from gas.
If against enemy gallery, estimated distance:	18 ft
Infantry action regarding Crater:	Lip re-occupied as before blow. New galleries being started from lateral to project lip.
General Remarks:	Exact surface effects difficult to say owing to the blow taking place in the middle of the old craters. A lot of earth was thrown on to the enemy's side, which has probably filled in his bombing post, though it has also given him some high OPs.

(Sketch attached). Date: 23.8.16 Signed: G A Syme Major RE

13B-A11

ANNEX D TO
RE ADP 10/84
DATED 31 JAN 89

APPROACHES TO DURAND MINE

See Diagram 1, Enclosure One and Photographs.

1. Entrance to the mining system is gained through a locked grill door on the left beyond the water point in GRANGE subway and immediately past the "magazine". The passage containing the drill door is the former P76K gallery.

2. Beyond the grill door concrete steps descend about 12 m distance to a platform. On the right further concrete steps go down into the deep lateral connecting with the tunnels to the South. Ahead the P76K incline continues downwards reducing in height for a part of the way to about 1.2 m. 20 m from the platform and just past a crumbling gallery to the right there is a junction with the J1 lateral going North. Further progress in P76K is denied by the complete blockage of the incline. At this point tests should be made for toxic gas, particularly CO.

3. The J1 lateral is entered up a very short stepped incline. The gallery, which is at a depth of about 18 m (60 ft) below the surface, is square cut, approximately 1.8 m high and 1 m wide (see photo 2). Timber supports had originally been set into the side of the tunnel but have disappeared completely, probably salvaged. The necessity for supports becomes apparent just past the junction with a gallery to the right (J2). Over a length of about 15 m serious roof slabbing is occurring as evidenced by rock and rubble on the floor. Care is needed in traversing this point. Accidentally striking the roof with a helmet could dislodge large slabs of chalk.

4. The J1 lateral is 50 m long and level. At the end if forms a junction with the former P77J gallery. To the right this leads into a fragile tunnel amongst chalk fragmented by mine explosions. To the left it slopes upwards, gently at first, leading to a blocked off entrance that connected with DUFFIELD trench. The incline contains the remains of wooden trolley rails.

5. A few meters up-slope from the J1 lateral a much worn stairway ascends to the right (see photo 3). Ascent without aids is simple, although if the chalk were wet it could be slippery. About 5 m up the stairs the tunnel is partially choked with rubble and a belly crawl is necessary. There is a risk to persons at the bottom from displaced rocks.

6. The crawl leads into the former P77N gallery close to the base of a former shaft (on the left) which is now completely choked with clay and rubble, presumably tipped in for the purpose of blocking it. This shaft is probably directly below the ladies toilets in the guide house. Fortunately there is no evidence that they leak! Depth below surface at this point is about 8 m (25 ft).

7. To the right a square cut gallery about 1.5 m high and 1 m wide leads downwards. The floor is littered with wire and other junk, and with completely rotted timber supports. Initially the tunnel is sound but slabbing is occurring (see photo 4). 20 m along at the junction with the DURAND mine tunnel to the

left, there have been heavy falls of rock, one of which occurred after our first entry to the tunnel in Jun 88 (see photo 5). Ahead the gallery gets even more fragile as it enters the fractured chalk under the mine craters. The route to the mine charge is along the tunnel to the left.

8. The DURAND mine gallery is approximately 40 m in length and goes through several bends. It varies in both height and configuration, in places being no more than 1 m high and 0.8 m wide. It is in a very fragile state and as we discovered slight carelessness can cause a rockfall. Photos 6 and 7 show parts of the tunnel. It is emphasised that great care is needed in traversing this tunnel. There should be a 5 m gap between persons moving in the tunnel so only one will be caught by a rockfall.

9. The mine chamber, 20 m (65 ft) below surface, is shown in photos 8 and 9 and described in the body of the report. Surprisingly the rock at this point is in good condition as evidenced by the absence of former timber supports.

10. There is no ventilation in the P77N galleries. Attention should be given to the possibility of toxic gases which because of the clay and metal in the incline, and explosives in the chamber, could include hydrogen sulphide and nitrous gases. Carbon monoxide remains a constant hazard.

11. The total distance from the grill at the GRANGE subway to the mine charge is only 150 m (450 ft). It takes about 20 minutes for three persons to travel the distance taking reasonable care.

ANNEX E TO
RE ADP 10/84
DTD 31 JAN 89

RARDE - CHEMICAL ANALYSIS REPORT

DATE: 1/7/88
ORIGINATOR/BRANCH: Major A S Hogben EODTIC
DATE SAMPLE REC'D: 17/6/88
SUBJECT: Mine Charge Vimy Ridge

EC3 FILE REF: CRA 780
ORIGINATORS REF: TIC 7
LAB SAMPLE NO: 405
SAMPLE DISPOSAL DATE: Retained
LAB METHOD REF: -

SAMPLE DESCRIPTION

Plastics screw capped container sealed with tape, label and contents as follows :-
Label - Sample of explosive from mine charge at Vimy Ridge from Lt Col CPC Robinson RF ADP Br HQ RSME xt 2214.
Contents - Damp looking crumbling dark greenish grey mass containing metallic particles.

RESULTS OF ANALYSIS

A. CHEMICAL ANALYSIS

1. Spot tests indicated the presence of aluminium and TNT and the absence of ammonium and nitrate.
2. Thin layer chromatography and Infrared analysis confirmed the presence of TNT.
3. Duplicate 1gr samples were dried and successively quantitatively extracted with toluene, water and dilute hydrochloric acid to remove TNT, water soluble materials and aluminium. The residual charcoal material appeared to be wood charcoal. The extraction results are were follows :-

WET SAMPLE

% Volatile Matter	32.6	- Water
% Toluene Soluble	26.0	- TNT
% Water Soluble	1.2	- Water Solubles in Charcoal
% Acid Soluble	34.9	- Aluminium
% Residue	5.3	- Charcoal

DRY SAMPLE

% TNT	38.5
% Aluminium	51.7
% Charcoal	7.9
% Water Solubles	1.9

B. PHYSICAL TESTS

1. Cartridge Case Test

An indication of the explosive performance of a material is assessed by initiating a 2gr charge with a No.6 aluminium detonator in a 0.303" cartridge case. The weight of the base and the deformatiom of the cartridge case is a a guide to the explosive performance. This test was carried out on both the wet and dry samples with the following results :-

WET SAMPLE - Minor deflagration, slight explosive performance
DRY SAMPLE - Detonation, medium explosive performance.

2. Bickford Fuze Test

This test is to assess the ease of igniton of an explosive material under light confinement. A length of Bickford Fuze has a surface contact with 3gr of the explosive in a test tube. The ease and type of ignition is recorded. The wet and dry samples were subjected to this test. The limited sample only permitted one experiment, the results were as follows :-

Wet and dry samples failed to ignite.

CONCLUSION

A. Chemical Analysis

No reference to a TNT/Aluminium/Carbon explosive could be found in our limited reference library but a 80/20 TNT/Aluminium explosive was manufactured in the early 1900's.

No ammonium nitrate was found in the sample submitted making the identification of the sample more difficult. Assuming that the orig inal sample did contain ammonium nitrate and the sample is an Ammonal explosive, comparisions can be made. Comparing the ratio of charcoal to aluminium to TNT in this sample with the same ratio in known Ammonals, the sample can be identified as British Service Demolition Ammonal (BSD Ammonal).

	DRY SAMPLE		BSD Ammonal	
	%	Ratio	%	Ratio
TNT	38.5	4.9	15.0	5.0
Aluminium	51.7	6.5	18.0	6.0
Charcoal	7.9	1.0	3.0	1.0
Ammonium Nitrate	-	-	64.0	-

B. Physical Tests

A single negative result in the Bickford Fuze test does not eliminate the possibility that a second sample could ignite.

The wet material has slight explosive properties. The dried material detonated. Since one small wet charge shows explosive performance the worst possible case must be the criteria applied in deciding which action to take. The worst case would be a bag of pristine explosive wired up to a faulty detonator. It must be stressed that no amount of unsuccessful firings of the material would prove the wet material inert having obtained one positive result.

C. Reference B Paragraph 7

A. Detonator - No advise can be given on the state of the detonators but if the mercury fulminate has been exposed to the elements of the soil and the soil is alkaline, there is every possibilty that the fulminate has decomposed.

B. TNT Primers - The TNT in the sample does not appeared to have degraded. It must be assumed that this is also the case for TNT primers under the same conditions.

C. Charge Weight - We have no records showing the charge weight of the bags.

D. M. Keeble.

(Mrs D M Keeble)
CRA Section
EC3 Division
RARDE
FORT HALSTEAD

Copies to: Originator
File

ANNEX F To
RE ADP 10/84
Dated 31 Jan 89

THE DETONATOR, ELECTRIC, No. 13, MARK III (LAND).

EXTRACT FROM THE TREATISE OF AMMUNITION 1915

ELECTRIC DETONATORS.

Bridges and firing currents.—There are three kinds of bridges used in detonators and fuzes, known as Naval, Field and Siege, and Submarine, the bridge for all N.S. fuzes, &c., being made of platinum and silver, which is very fuzible, and consequently fuzed with certainty when fired. For land and submarine services an alloy of platinum with iridium is employed. The latter metal increases the resistance and thus allows the bridge to be made rather thicker and stronger.

Details of the various bridges are given in Table 40.

Firing currents.—Detonators with Naval bridges should fire without appreciable delay with a current of 1 ampère, but should not fire when a current of ·32 ampère is applied for 4 seconds; those with L.S. bridges with a current of ·8 ampère, but should not fire with a current of ·32 ampère for 4 seconds; while the S.M. detonators are tested, all for over-sensitiveness with a current of ·8 ampère, which must not fire the detonator within 4 seconds, and 2 per cent. are tested for under-sensitiveness with a current of 1 ampère which must fire the detonator within 4 seconds.

The current for firing these detonators and fuzes is derived from a battery of voltaic cells, or the Exploder, Dynamo, Electric Quantity.

Detonator, Electric, No. 13, *Mark III* (*Land Service*).

(*Plate CII.*)

The Detonator, Electric, No. 13, *Mark III* | *L* | consists of the following parts:—

Head, 2 insulated wire terminals, 2 copper pole pieces, iridio-platinum wire bridge, brass socket, tin tube and charge.

The head is of ebonite with a hemispherical top; two holes are bored through it lengthwise for the reception of the wires and pole pieces. The conducting wires are composed of 3 strands of tinned copper; they are covered with pure indiarubber, and then with an outer cover of vulcanized indiarubber. To the ends of the wires, which fit into the head of the detonator, are soldered two short tinned copper poles, which are flattened to prevent them turning round after they are fixed and so breaking the bridge.

The pole pieces are dipped into hot guttapercha cement, and forced into the holes prepared for them in the head; they project ·1 inch and are ·25 inch apart at the ends, and are connected by a bridge of iridio-platinum wire soldered with pure tin. The bridge is surrounded by a tuft of guncotton yarn.

The conducting wires are brought together above the head and frapped with waxed thread; the ends are bared and are of unequal length to minimise the risk of a short circuit when connected up.

Attached to the lower part of the head is a flanged brass socket; this supports a tin tube. The tube and lower part of the socket are filled with a charge of about 43 grains of fulminate of mercury, which surrounds the bridge and the ends of the pole pieces. The bottom of the tube is closed by shellac putty.

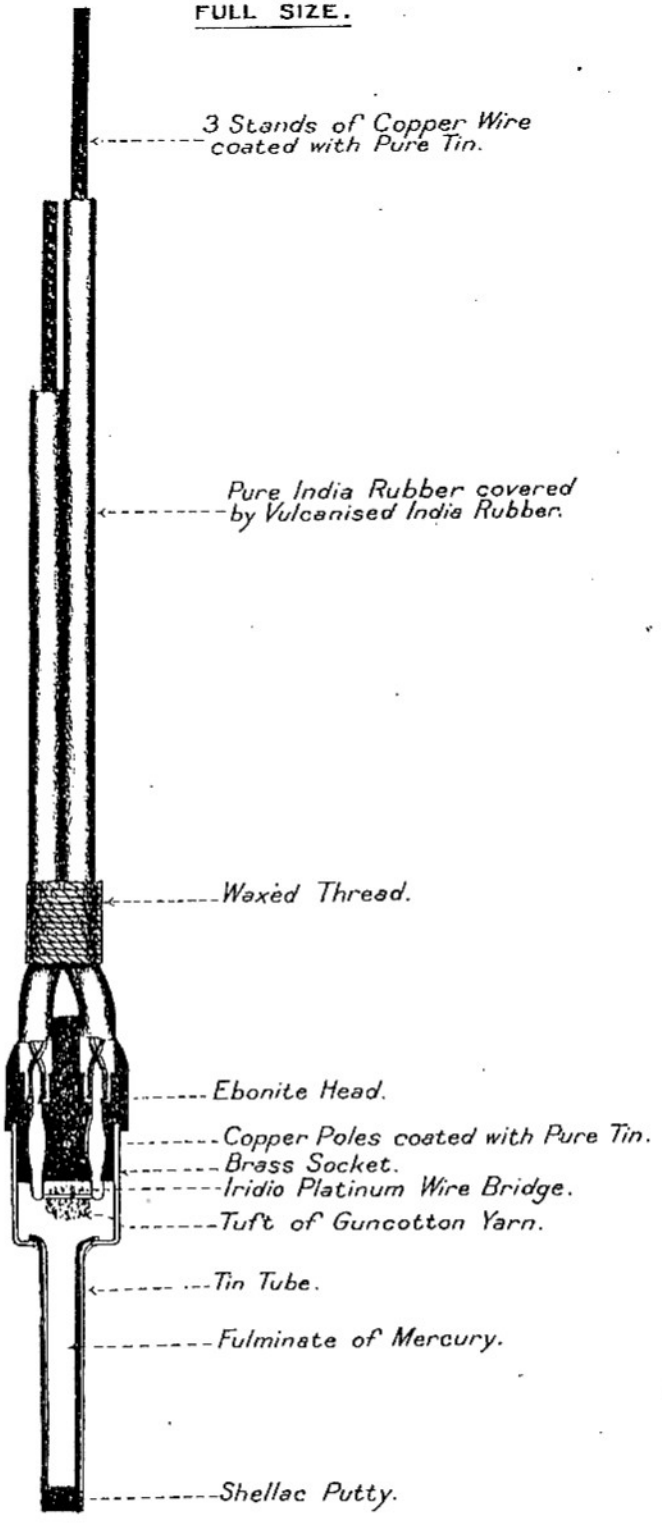
Colour.—The head and socket are painted white and the tube red.

Mark II was filled with 37 grains of fulminate of mercury; the wires were twisted above the head and were not frapped with thread.

Use.—For field and siege operations.

Packing.—25 in "Cylinder, No. 13 D, Mark I."

DETONATOR, ELECTRIC, Nº 13 (MARK III). (L).
§ 12547.
FULL SIZE.



3567. Malby & Sons, Lith.

Packing Electric Detonators.

All electric detonators are packed 25 in a tin cylinder around a rectifier. (*See* page 524.)

The latest cylinders have a central tube for the rectifier, so that it is easily got at without disturbing the detonators. These cylinders are closed by a tin band soldered on, and have their bodies and lids lined with sheet asbestos, which extends down the bodies as far as the tin diaphragm, which supports the detonators. The lining is to prevent heat from the soldering iron reaching the contents of the cylinder.

To obviate any risk from rough usage in transit, cotton wool is placed inside the cylinders, and each detonator fits into a separate hole in the tin diaphragm.

The cylinders are numbered to correspond with their contents.

ANNEX G TO
RE ADP 10/84
DATED 31 JAN 89

THE DUFFIELD MINE

Reference:

A. The Canadian Corps Scheme of Operations G.701 S.156/31/16 dated 19 Mar 1917 (Bibliography (8)).

1. The orders to 172 Tunnelling Company RE at Appendix "G" to Reference A state at para (2):-

> Two craters in the DUFFIELD GRANGE Group to affect German surface posts by fougasse effect. Map reference (A) S.22.c.2.3. (B) S.22.c.2½.1.

2. Examination of the map references shows that (A) was clearly the DURAND mine. The location of the enemy post referenced by (B) indicates that the DUFFIELD mine must have been situated at the head of either gallery J2 (right fork), or K1 or K2. J2 and K2 are open and accessible, K1 is blocked at the bottom of the P76K incline.

3. Gallery K1 presents an enigma. As stated in para 10c of Annex C it was completed and chambered at a depth of 70 ft (21m) on 6 Sep 1916, despite slight damage from a German camouflet on 31 Aug 16 (see Annex C para 8). Yet the parallel gallery K2 was constructed immediately afterwards and chambered at a depth of 50 ft (15m) on 14 Oct 1916. Miners had far too many tasks to be engaged in constructing redundant tunnels so why the duplication? Furthermore a 172 Company mining plan in the RE Museum shows gallery K1 as defunct.

4. a. The clear implication is that almost immediately following completion of K1 the gallery ceased to be usable. There are five evident options:-

> (1) The Germans blew a mine or camouflet shortly after 6 Sep 1916 and wrecked K1. However neither the 172 Company war diary, the 1st Army weekly mining summaries, nor the crater charts, indicate such an event. It can probably be discounted.
>
> (2) A mine charge was placed in K1, the gallery tamped and K2 constructed to defend the mine. This ponderous procedure would be contrary to normal practise and mining tactics. It is very unlikely.
>
> (3) K2 was driven below the water table, or below a water catchment point in the craters above, and consequently flooded. If flooding exceeded the capacity of the pumps the gallery would have been blocked.
>
> (4) The Germans broke into K1 and the tunnel was blocked off. (Note at Diagram 1 the close proximity of the enemy tunnels). The threat from enemy galleries would account for two bore holes in the roof of the former entrance at the bottom of the P76K incline. However such an incident should have reflected in the war diary or weekly summaries.
>
> (5) The British miners broke into a flooded section of German galleries and had to abandon K1. This is a feasible option.

b. Of the above the flooding hypotheses are much the most plausible. It would also account for the legend of the "underground lake" at the bottom of the P76K incline and it is possible that the gallery was used as a source of water. That K2 was constructed at a higher level lends credence to this supposition.

c. So far as the DUFFIELD mine is concerned the implication is that K1 can probably be eliminated as a possible site. An added factor is that K1 would have been too deep for effective fougasse effect.

5. On 15 Jan 89 I investigated galleries J2 (right fork) and K2 in company with Captain M Rosenbaum RE (a military geologist).

a. Gallery K2 was low, partially blocked and fragile in places; but we reached the chamber. It was empty and there was no evidence to suggest a mine charge had been set in it.

b. Gallery J2 was nearly 6 ft (1.8m) high and in reasonably good condition though with some roof slabbing. There was evidence of previous recessed timber supports which had subsequently been removed, probably as salvage. The end chamber was empty, but we found clay which may have been used as a packing materiel and the lid of a fuze tin. However of particular significance there were three partial blockages in the tunnel although no roof falls had occurred. These were situated approximately where tamping would be expected had a mine charge been placed.

c. We judged that a charge probably had been laid in J2, but that given the easy access, and the evidence of timber salvage, had been cleared subsequently.

6. In summary we concluded that:-

a. Gallery K1 probably flooded shortly after completion in Sep 1916 and would not have been used to site a mine.

b. The DUFFIELD mine was probably placed in gallery J2 but after 9 Apr 1916 it was removed in the course of salvage work.

c. Given that some uncertainty must remain regarding a mine sited in K1 the probability is that there are no charges still under the DUFFIELD craters.

CPT13B-E

ACKNOWLEDGEMENTS

Whilst help and advice has been received from many sources particular thanks is due to the following 'outside' individuals or organisations:

Mr Bryan Earl MSc, ACSM, MIMM, CEng for his expert advice on explosives and calculations on explosion effects.

The Explosive Ordnance Disposal Technical Information Centre, Royal Engineers for advice on explosive types and detonators and for arranging analysis.

Mrs D M Keeble, CRA Section of EC3 Division, RARDE, Fort Halstead for detailed analysis and testing of explosives.

Mr J Harding and Mr P Bevan of the Army Historical Section of Ministry of Defence London, for advice on archive sources and arranging loans of material from the Public Records Office.

Major (Retd) J T Hancock and staff of the RE Library.

Miss C M Reed (Curator) and Mr S Jones of the RE Museum.

The Kent Mine Rescue Organisation for extended loan of specialist equipment and advice on toxic mine gasses.

The following variously participated in the investigations into the deep mining system and the mine charges:

Major A A J McLean RE E & M Wing, 12 RSME - Jun 88.

Major I D Underwood RE 64 CRE, MWF RE - Jun 88

Major B S R Whitten RE (V) HQ RE, HQ NI and NI Dept of Agriculture Drainage Section - Jun 88

Captain M W Rosenbaum RE (V) CVHQ RE and Geology Dept, Imperial College - Jun 88 and Jan 89

SSgt B S Willis RE 14 Ind Topo Sqn RE - Jun 88 and Aug 88

Mr G Florence, Channeline Sewer Systems - Jun 88

Mr D Gillard Formerly Research Officer British Coal Board - Jun 88 and Jan 89

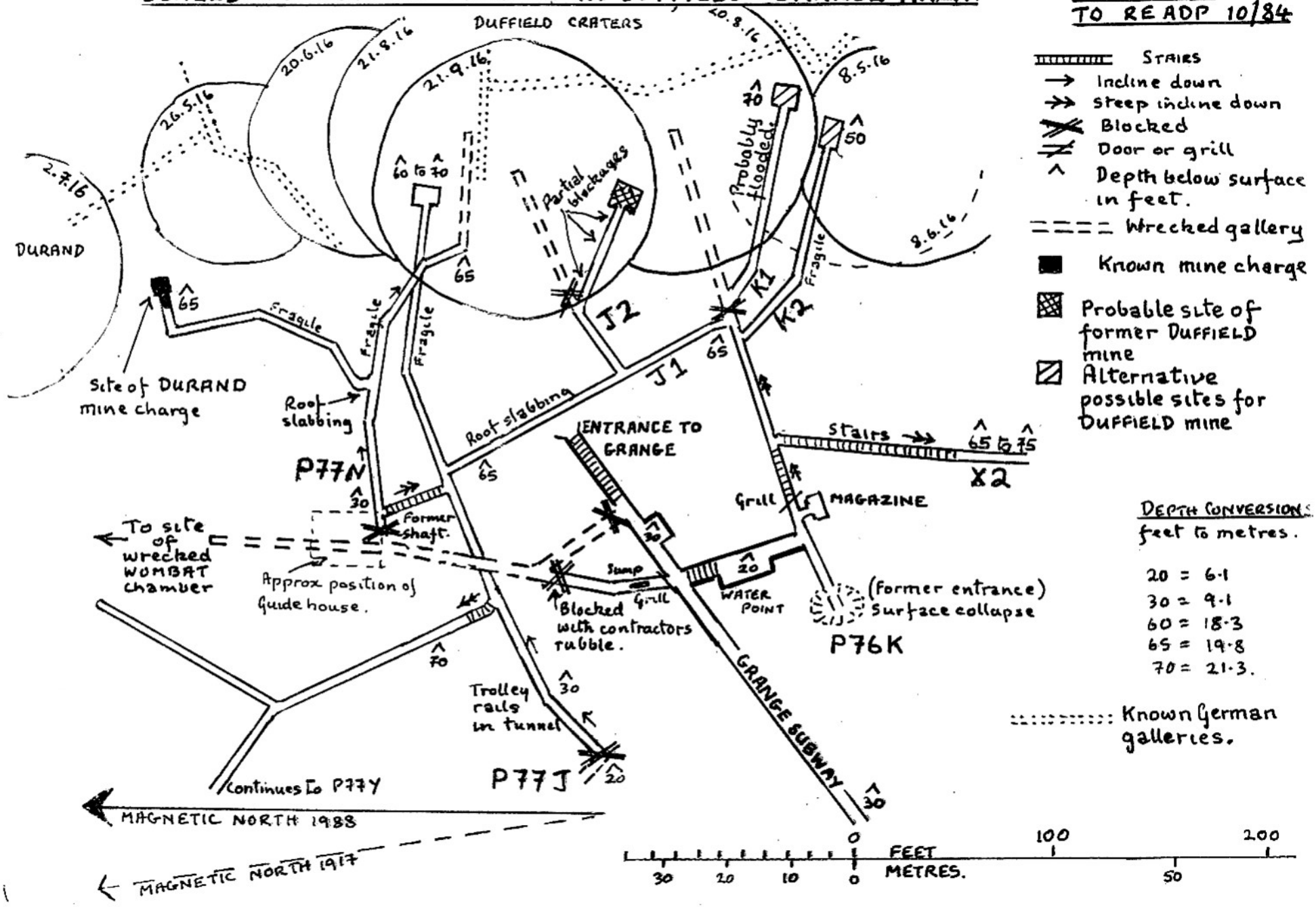
Cpl Young RE 14 Ind Topo Sqn RE - Aug 88

Major R I Braithwaite RE 24 Fd Sqn RE - Jan 89

The assistance given by, and patience of M. J F Pierret, Superintendent of the Canadian Memorial Park, Vimy, is especially acknowledged and appreciated.

SCALED DIAGRAM OF TUNNELS IN DUFFIELD - GRANGE AREA.

DIAGRAM 1
TO READP 10/84



Stairs
Incline down
Steep incline down
Blocked
Door or grill
^ Depth below surface in feet.
Wrecked gallery
Known mine charge
Probable site of former DUFFIELD mine
Alternative possible sites for DUFFIELD mine

DEPTH CONVERSIONS
feet to metres.

20 = 6·1
30 = 9·1
60 = 18·3
65 = 19·8
70 = 21·3.

Known German galleries.

DIAGRAM 2
TO RE ADP 10/84
DATED 31 JAN 89

DISCOVERY OF DURAND MINE
ORIGINAL SKETCH PLAN OF ROUTE

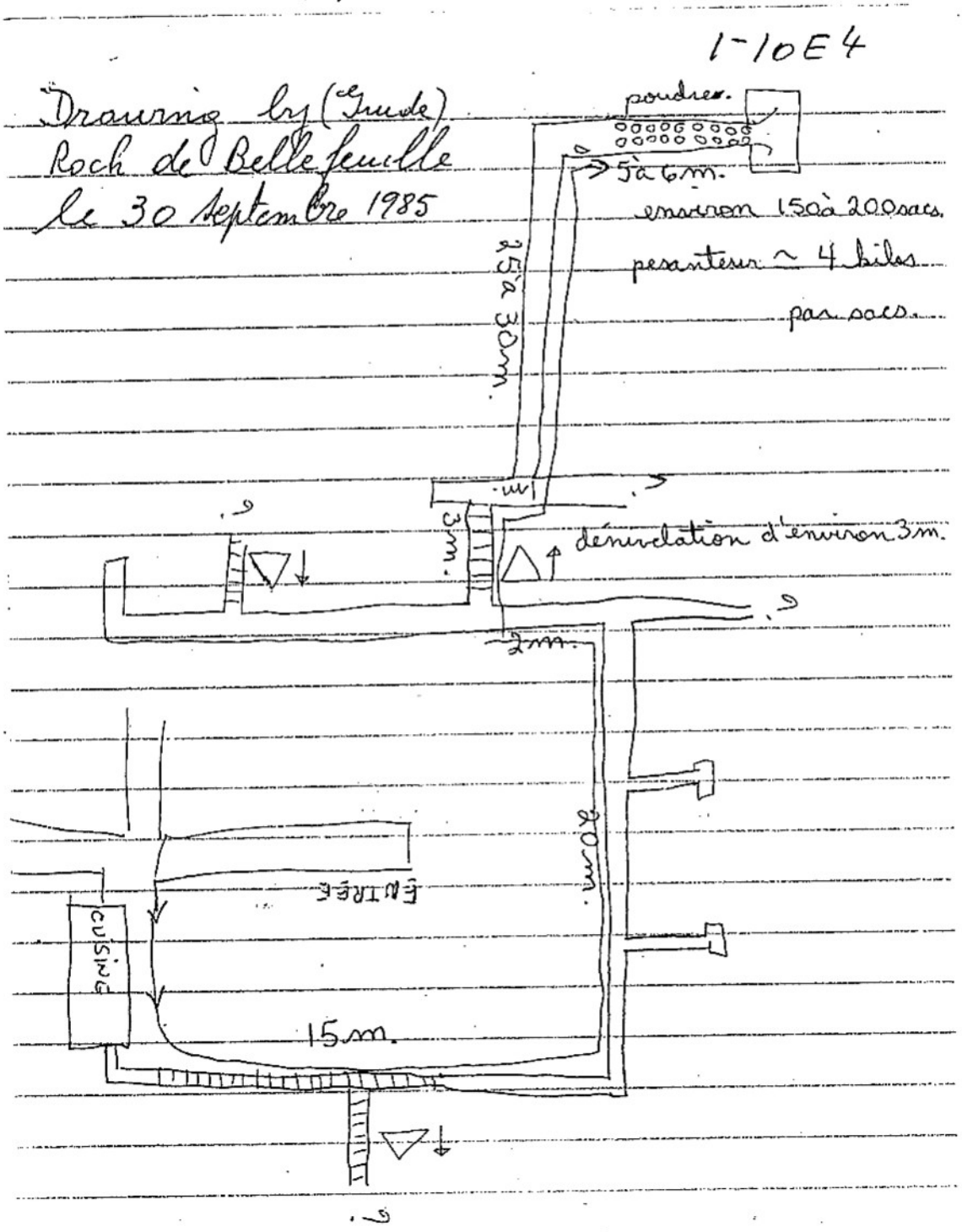
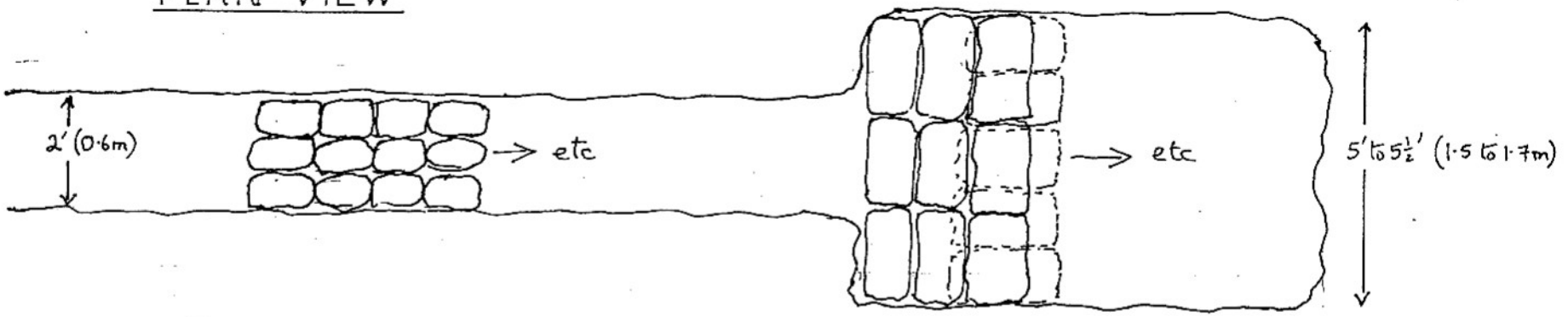


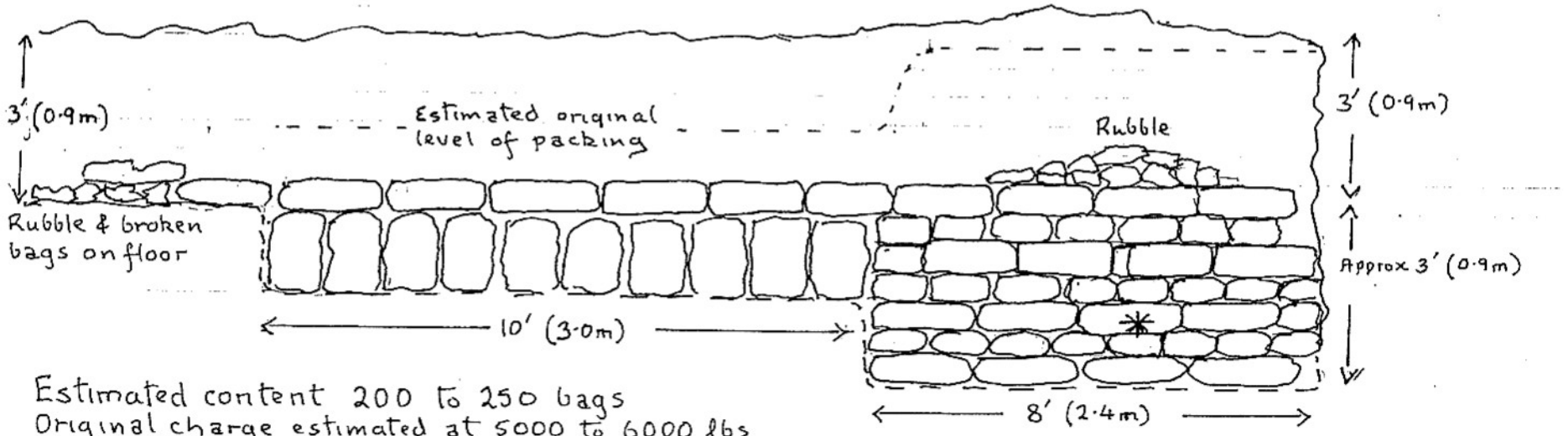
DIAGRAM 3 to
READP 10/84
dtd 31 Jan 89

SKETCH OF MINECHAMBER & CONTENTS.

PLAN VIEW



SIDE ELEVATION



Estimated content 200 to 250 bags
Original charge estimated at 5000 to 6000 lbs
(2250 to 2700 kg)

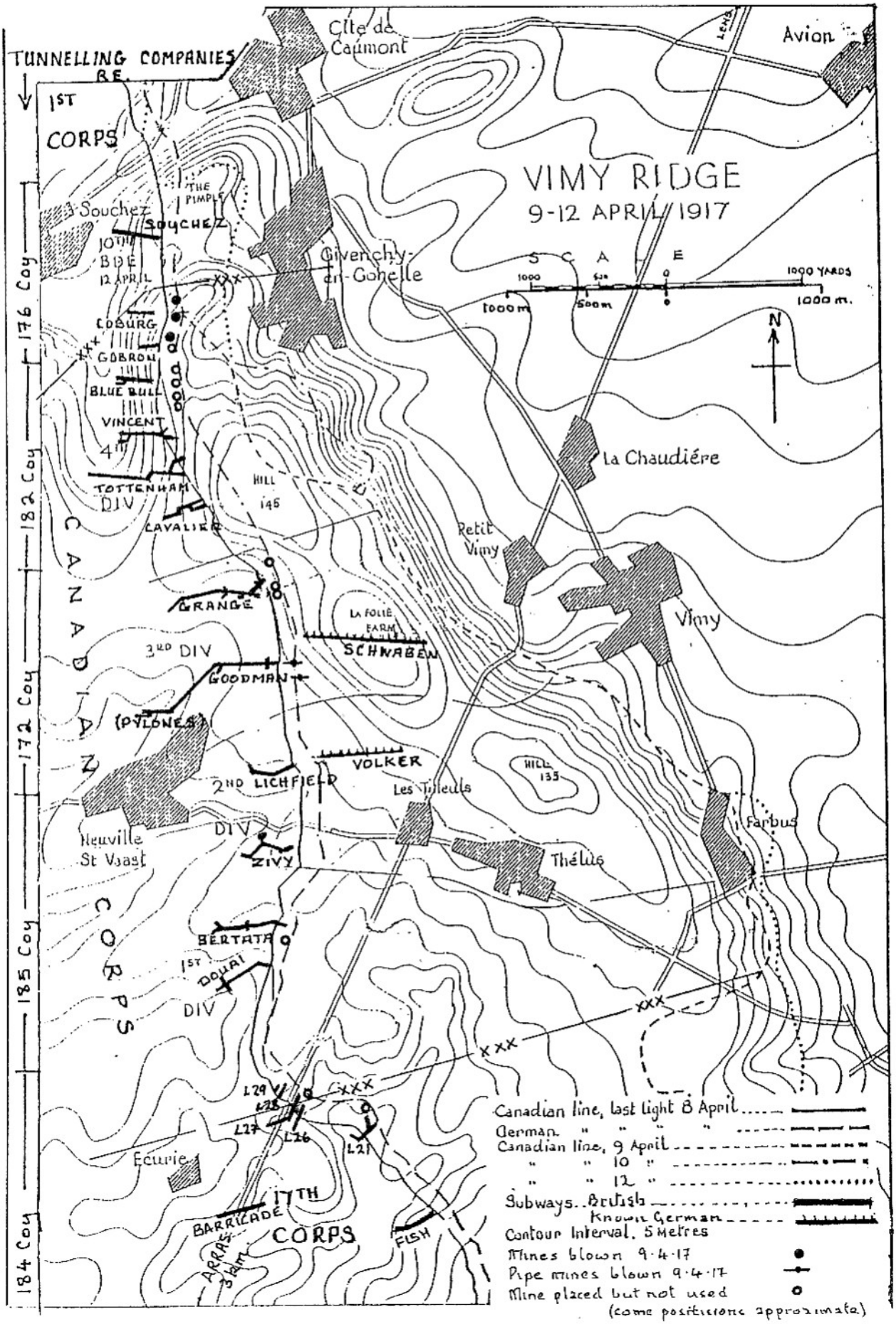
* Estimated position of detonators.

DIAGRAM 4 to
RE ADP 10/84
Dtd 31 Jan 89

VIMY RIDGE

THE SUBWAYS AND APPROXIMATE POSITIONS OF MINES LAID

Showing also dispositions of the Royal Engineer Tunnelling Companies.



PHOTOGRAPHS



PHOTO 1

General view in the main lateral G2 to the South of the GRANGE subway showing tunnel configuration, trolley rails, power cables and water hose. The figure is Maj Bob Braithwaite.



PHOTO 2

The J1 lateral between P.76.K & P.77.J showing the slabbing roof and consequent falls. Note recesses for original timber supports.



PHOTO 3

Stairway from P.77.J incline up to the p.77.N galleries. Total vertical ascent is about 30 ft (9 m).



PHOTO 4

The P.77.N gallery about 30 ft (9 m) beyond top of stairway.
Height about 4 ft (1.5m).
Note 'clean' slabbing and the former timber supports - now completely rotten.

PHOTO 5



Photo 5 above :-
View at 'Y' fork in P.77.N looking along the right hand gallery. The entrance to the DURAND mine gallery is at the left side of the photographer. The large pointed rock on the right fell in Jun 88 after the first entry into the mine gallery.

PHOTO 6

View along the gallery leading to the DURAND mine showing original timber supports and crumbling roof.
Height about 3½ ft (1.1m) as indicated by figure (Maj A Mclean).



PHOTO 7

Further view along the DURAND mine gallery. Note irregular shape, fractured chalk and slab about to fall from the roof. Height about 3½ ft (3.1m).



PHOTO 8 below :-
View from gallery into mine chamber.
See diagram 3 for illustration of the shape of the chamber.

PHOTO 8





PHOTO 9
View across ammonal bags into the mine chamber.
Note :-

Leads for firing circuit.

Stains on walls indicating former level of the bags.

Small quantity of roof debris within the chamber.

Tunnel and chamber in good condition and arched configuration providing support.



PHOTO 10

The ammonal bags (prior to disposing of the contents).

Scaling by Majors Underwood and Mclean!

PHOTO 11

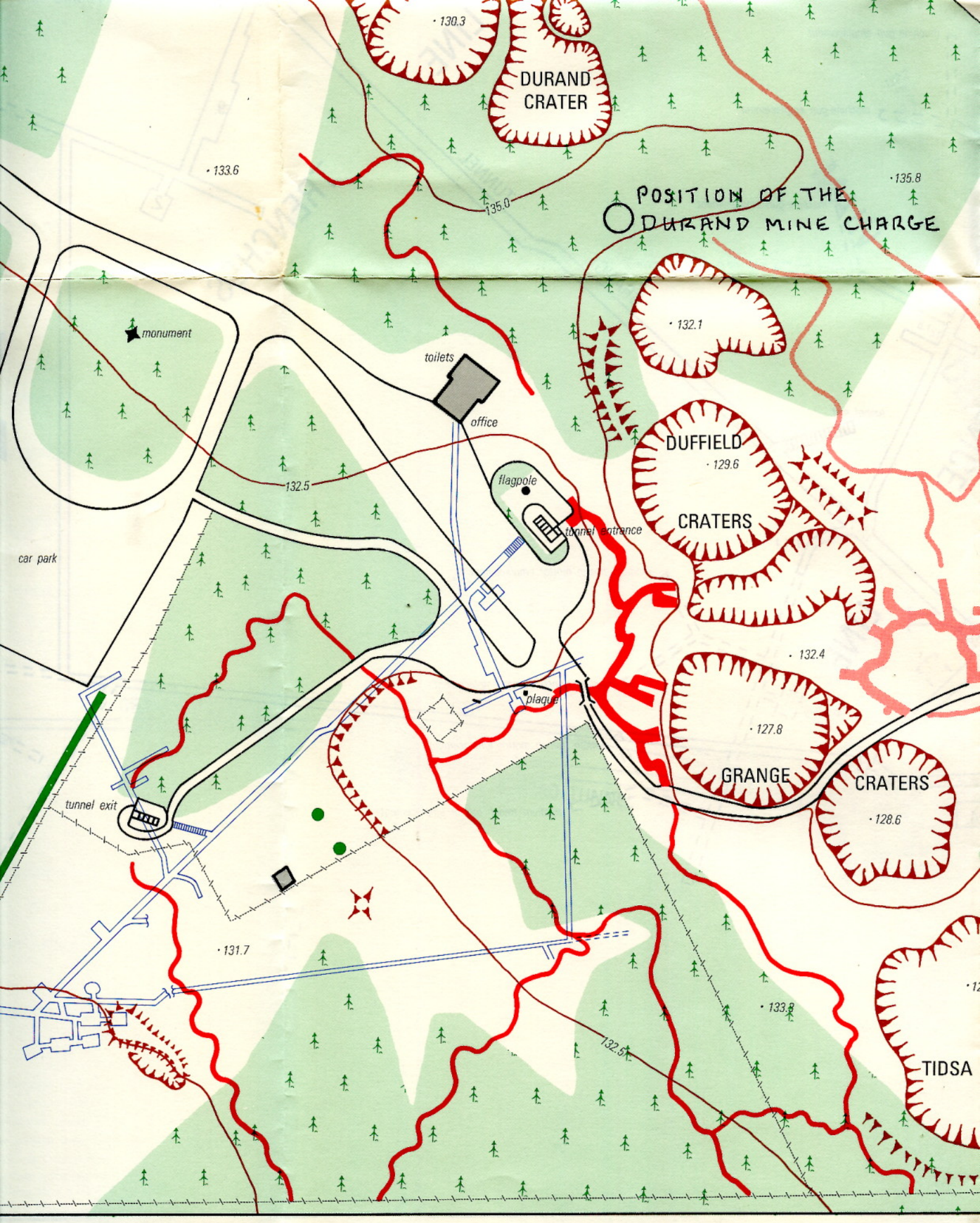


Photo 11 above :-
The area immediately above the DURAND mine looking approximately SW. The white mark in the foreground shell hole shows exact location. Roof of guides office visible at right centre.

PHOTO 12



The entrance to the fighting tunnels system from the GRANGE subway showing the grill door by the 'magazine'.
The P.76.K incline.


· 130.3
DURAND CRATER
· 133.6
· 135.8
POSITION OF THE DURAND MINE CHARGE
135.0
· 132.1
monument
toilets
office
DUFFIELD
· 129.6
CRATERS
flagpole
tunnel entrance
132.5
car park
· 132.4
plaque
· 127.8
GRANGE
CRATERS
· 128.6
tunnel exit
· 131.7
· 133.8
132.5
TIDSA