

## **AGGREGATES PAVE THE WAY TO VICTORY: WORK OF ROYAL ENGINEERS GEOLOGISTS AND QUARRYING COMPANIES DURING WORLD WAR II, ESPECIALLY FOR THE LIBERATION OF NORMANDY**

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### **ABSTRACT**

The Allied liberation of Normandy that began on D-Day, 6 June 1944, and the consequent North-West Europe Campaign that culminated in Victory in Europe on 8 May 1945, provide a classic case history of the military use of geologists and of quarrying for aggregates by British armed forces. Using geology, Major (later Lieutenant-Colonel) W.B.R. King helped guide the choice of Calvados rather than the Cherbourg Peninsula as an invasion area and Captain (later Major) F.W. Shotton helped plan the invasion routes across particular beach areas. Both compiled prospect maps to guide siting of numerous temporary airfields and boreholes to extract potable groundwater. Before and after the invasion, Shotton also intermittently advised Lieutenant-Colonel A.R.O. Williams: a former mining engineer with geological training who had served with distinction on Gibraltar, who was appointed in 1944 to found and command the Quarry Group Royal Engineers. The Group comprised five of the eight Royal Engineers Quarrying Companies formed during the war (numbers 125, 853, 855, 856, and 858), which had served variously in the UK, Faroe Islands, Gibraltar and Algeria/Tunisia before Normandy. (The other three of the eight, numbers 851, 854, and 857, after Scotland and North Africa, were serving at that time in the Mediterranean region, in the continuing Italian Campaign.) The Group began with a total key strength of about 900 all ranks, initially recruited mostly from the UK quarrying industry. It provided the aggregate required by 21st Army Group for road construction and repair, and hard standings for airfields and munitions/stores depots. As the Allies advanced, quarries worked by the Group in France were replaced by quarries in Belgium and finally Germany. In total, over 40 sites were operated during the 11-month campaign, to supply over 1.5 million tons of stone, rising to some 50 sites and 2 million tons by September 1945, when the Group was disbanded. Its achievements made a significant contribution to Allied victory, and influenced preparation of an authoritative Royal Engineers postwar textbook.

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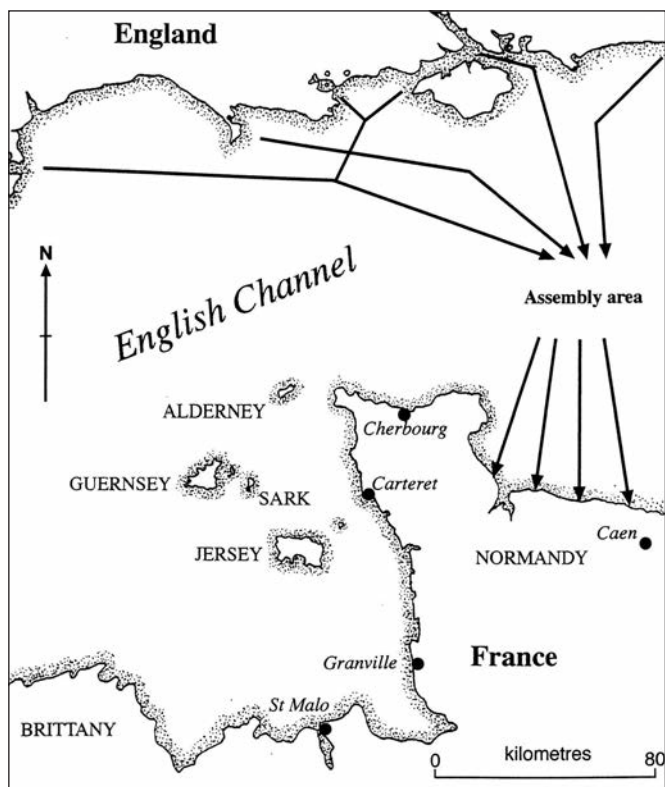
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### **INTRODUCTION**

6 June 1944, D-Day for Allied forces landing in Normandy, marked the greatest amphibious invasion in history. Nearly 7,000 ships and landing craft sailed from ports in southern England, assembled off the French coast (Figure 1), and then landed five divisions: the spearhead of the Allied Expeditionary Force. In total, over 75,000 British and Canadian and about 57,000 United States troops were landed by sea or air on that day, at a cost of about 4,300 Anglo-Canadian and 6,000 American casualties. By the end of June, the five divisions had been reinforced to form the British 2nd Army and the US 1st Army, together comprising 21st Army Group and in total over 850,000 troops. It is a story of heroism that has been told in many books and films, and is commemorated by extensive displays in an impressive D-Day Museum in Portsmouth, one of the major UK ports involved. But even the Museum makes no direct mention of how geologists and members of the UK extractive industry contributed to Allied victory in the

Battle of Normandy, and subsequent phases of the North-West Europe Campaign that culminated in Victory in Europe on 8 May 1945.

That is the story told here, combining a summary of earlier publications to provide context with new data from unpublished records. It begins with an account of geological work and of foundation of the Quarry Group Royal Engineers (RE) in preparation for D-Day; tells then of the foundation of eight Quarrying Companies RE earlier in the war and the operational service that preceded five Companies being combined to form the Group; and concludes with an outline of the Group's work successively in France, Belgium and Germany. For brevity in citation, except where otherwise indicated in the text, details of military history are derived from Dear & Foot (1995) and further references therein; of the Quarry Group RE from Williams (1950) and a more extensive unpublished history preserved at the National



**Figure 1.** Map illustrating major Allied invasion routes from England to Normandy, 6 June 1944: much simplified. From Rose et al. (2002), courtesy of Springer Verlag.

Archives, Kew (as file reference WO 205/1190); of individual Quarrying Companies RE from file MT 39/492 at the National Archives, plus 40 other files (within WO 166, 169, 170, 171, 175 and 176) each containing up to a dozen monthly War Diaries for these units, prepared initially as ‘secret’ documents but now declassified; and of the military promotion dates of particular officers from contemporary editions of the *Army List*, also accessed at the National Archives. Imperial rather than SI units are used, for consistency with the historical sources.

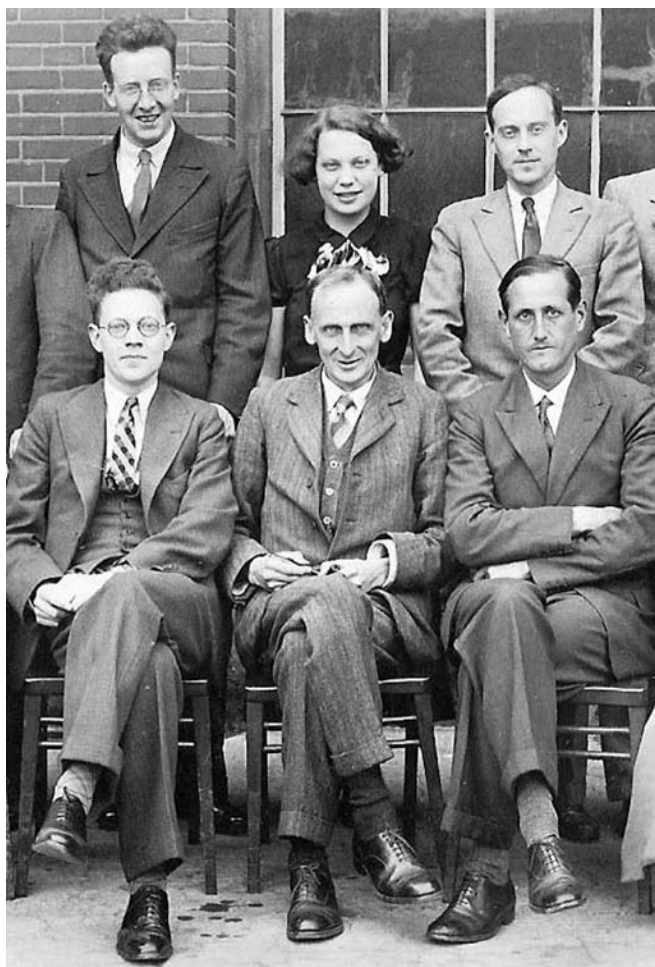
### GEOLOGISTS IN OPERATIONAL PLANNING AND PREPARATION

It was a geologist, Major W.B.R. King of the Royal Engineers, from 1931 until the outbreak of war in September 1939 Professor of Geology at University College in the University of London, who was influential in routing the invasion not through the port of Cherbourg and the Cotentin Peninsula extending from it to the south but across the beaches of Calvados to the east of the Peninsula (Figure 1).

‘Bill’ King (Figure 2) had served as the first of three geologists appointed to the British Expeditionary Force on the Western Front, in Belgium and northern France, during World War I (Rose & Rosenbaum, 1993a: Rose, 2004, 2009). He served from June 1915 until the end of the war, effectively as a hydrogeologist to guide the work of Well Boring Sections of the Royal Engineers drilling wells for potable water, before returning briefly to an appointment with the Geological Survey of England and Wales, and then teaching at the University of Cambridge until his appointment as a professor in London in 1931.

He was called up from the Army Officers Emergency Reserve on 13 September 1939, ten days after the start of World War II, and sent again to France with the new British Expeditionary Force: the same man, to essentially the same place, to do the same sort of job as in World War I. But on 10 May 1940 the German Army attacked westwards, the Force was defeated, and some three weeks later largely evacuated from Dunkirk. Bill King too was evacuated, but not before he had earned a Military Cross for his courage in convoying ammunition: his geological expertise was redundant in retreat. Back in England, King was sent to Northern Command for a year, but then appointed Staff Officer (SO) (Geology) at General Headquarters Home Forces: the Forces which were to develop into 21st Army Group.

In 1943 the Allies began planning in earnest for a return to France. Once Normandy rather than the Straits of Dover had been selected as a potential invasion route, the Cotentin Peninsula was the area initially chosen. Capture of Cherbourg, it was argued, would provide a suitably major port through which men and supplies could be routed once the beach-head was established. However, to establish that beach-head, air superiority over the battlefield was essential. The distance from



**Figure 2.** Part of a photograph showing W.B.R. King (Professor of Geology at University College London, visiting examiner), seated front right, and F.W. Sbotton (Lecturer in Geology), standing rear left, with members of the Lapworth Club at the University of Birmingham, 1934. From Ludford (2009), courtesy of Dr. Albert Ludford and the Geological Society of London.



England was such that aircraft based in England could only spend a short time in theatre before returning for refueling. As SO (Geology), Bill King was therefore tasked with selecting sites for a dozen temporary airfields to be rapidly constructed in the beach-head area. These would sustain the fighter cover necessary to protect Allied ships and troops from *Luftwaffe* attack, and the rocket-firing ‘Typhoons’ that would harry German tanks and vehicles when mounting the predictable counter-attack.

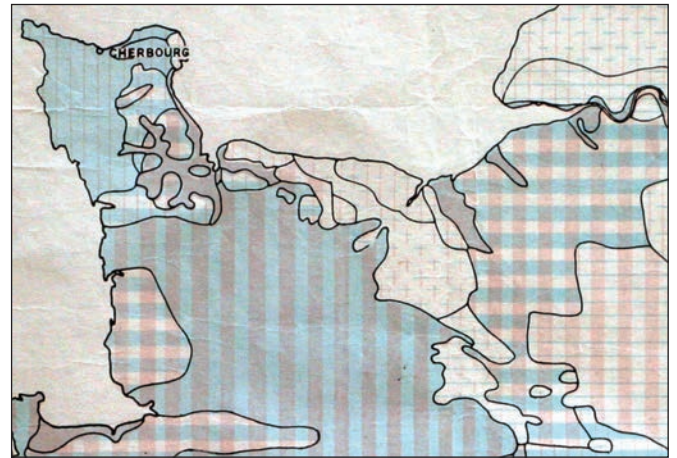
King realized that the bedrock of the Cotentin Peninsula formed part of the Armorican Massif: a region of strong crystalline basement, largely granites, schists and highly indurated medium to coarse-grained sandstones (‘quartzites’), of Precambrian to Palaeozoic age (Figure 3). In spite of its general flatness and low altitude (<100 m), the surface undulates as a consequence of stream erosion (the main rivers in deep valleys) and differential weathering (resistant strata forming distinct ridges), and supports a cover of woodland and ‘*bocage*’: small fields separated by hedges and ditches. Terrain more suitable for the rapid construction of airfields lay to the east, in the Calvados region of Normandy. There Mesozoic rocks forming the western margin of the Paris Basin dipped very gently eastwards. Near-horizontal Mid-Jurassic limestones, broadly similar to parts of the Inferior and Great Oolite successions long quarried in the Cotswold Hills and Oxfordshire in England, formed a plateau between the towns of Bayeux and Caen. Capped with a thin (<5 m, most commonly 2.5 m) cover of Quaternary loess, this was a well-drained region, of large fields, generally well-suited to the rapid construction of temporary airfields (Rose & Pareyn, 1995, 1998, 2003; Rose, 2008).

King combined geological and topographical data in mid-1943 to generate a map (Figures 4 and 5) of North-

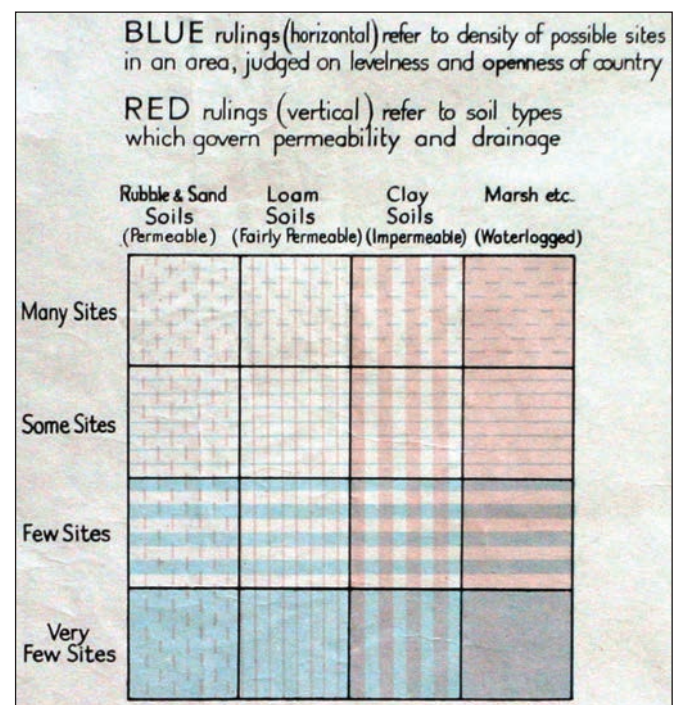


**Figure 3.** Part (showing Normandy) of the NW sheet of the 1:1 million geological map of France published by the War Office in 1943 (as GSGS 4452: reprinted from the Carte géologique de France, 3rd edition, of 1933). Bedrock of the Cherbourg (Cotentin) Peninsula forms part of the Armorican Massif, whose components are predominantly very old (Precambrian in age: coloured pink; or early Palaeozoic: dark olive green) and very strong (granites: coloured red), with a complex pattern of outcrop. In contrast, bedrock from the Calvados (Bayeux-Caen) region eastwards is much younger and weaker; largely Mid-Jurassic limestones (blue) to Cretaceous chalks (green) which dip gently eastwards as part of the western margin of the Paris Basin. Only the thickest deposits of more recent (Quaternary) age can be shown on a map of this scale, notably those (coloured pale buff) flooring the major river valleys.

West Europe, including Normandy, which classified ground according to its relative suitability for rapid airfield construction. It was this map supported by his advice that helped determine the choice of invasion area.



**Figure 4.** Part of a map of northern France prepared by W.B.R. King in mid 1943 showing ground classified according to its suitability for the rapid construction of temporary airfields. For key, see Figure 5. From Rose et al. (2006), courtesy of the Lapworth Museum of Geology, University of Birmingham, and the British Cartographic Society.



**Figure 5.** Key to map illustrated as Figure 4. From Rose et al. (2006), courtesy of the Lapworth Museum of Geology, University of Birmingham, and the British Cartographic Society.

Once that choice had been made, King was involved in the initial stages of a wide range of geotechnical tasks to help prepare for the invasion (Table 2 in Rose, 2008), notably generation in September 1943 of the first maps in a series of groundwater prospect maps at the scale of 1:50,000 for much of the French coast between Cherbourg east to Calais (Robins et al., 2007; Rose et al., 2010). However, in October 1943 he was promoted to the rank of lieutenant-colonel but released from the army



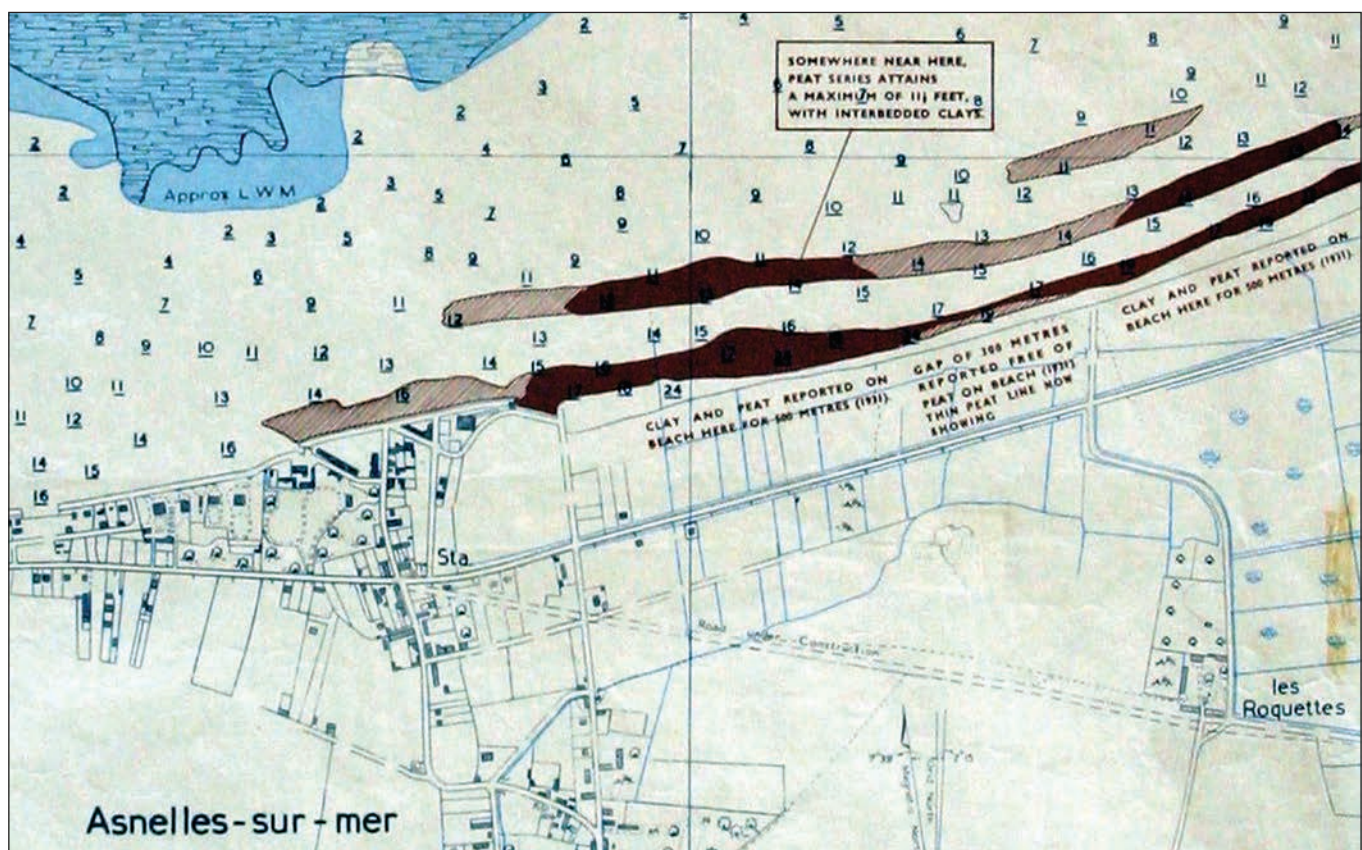
to take up appointment as Woodwardian Professor of Geology in the University of Cambridge. He was succeeded as SO (Geology) at HQ 21st Army Group by a protégé, Captain F.W. Shotton, also then of the Royal Engineers.

'Fred' Shotton (Figure 2) had been taught by King whilst an undergraduate at Cambridge. After graduation, he had lectured on geology at the University of Birmingham before appointment to the staff at Cambridge, but volunteered for the Army Officers Emergency Reserve on King's recommendation as war loomed (Rose & Rosenbaum, 1993b; Rose & Clatworthy, 2008). Called up eventually in 1940, he had served in the UK as King's assistant before service from May 1941 as the military geologist within General Headquarters Middle East Command, based in Egypt, at Cairo (Rose, 2012). The Allies were victorious in North Africa in May 1943; another geologist, Captain J.V. Stephens, was sent there from the UK in June to participate in the subsequent Sicilian and Italian Campaigns (Rose & Clatworthy, 2007); and the now veteran Shotton returned to England in September.

It was Shotton who was to gain distinction by extending the series of groundwater prospect maps (at scales of both 1:50,000 and 1:250,000) initiated by his mentor Bill King (Robins *et al.*, 2007; Rose *et al.*, 2010); apply his geological expertise to a wide range of other tasks as planning for D-Day advanced (Rose *et al.*, 2006; Rose & Clatworthy, 2008); and serve in the theatre of

operations as SO (Geology) at HQ 21st Army Group until Victory in Europe was assured. He prepared many specialist geotechnical maps to guide military operations, presenting geological data in a way that their relevance to the task in hand could easily be appreciated by non-geologist staff officers. One example of such maps is the series of 1:5,000 maps of the invasion beaches, which predicted the occurrence of clay and peat in places beneath contemporary beach sands (Figure 6): potential natural obstacles to vehicle mobility across particular beach areas, determined from geological maps and literature, aerial photographs and beach observation, and covert auguring by commandos swimming ashore at night. Other examples might be chosen from the variety of soils maps and airfield construction potential maps, generally at scales of 1:250,000, 1:50,000 or 1:25,000 (Rose *et al.*, 2006), that guided rapid construction of British temporary airfields in Normandy and beyond, facilitating the air superiority later widely credited as a major factor in the achievement of Allied victory. In Normandy alone, 23 British airfields were constructed or repaired within the first three months after D-Day (Rose & Pareyn, 1995, 1998, 2003), and 125 in North-West Europe as a whole during the 11-month campaign.

Shotton's service as a geologist was evidently much appreciated by the military: he was promoted to the rank of 'temporary' major in January 1944, and in 1945 awarded an M.B.E.



**Figure 6.** Part of Sheet 74 Asnelles-sur-Mer of France 1:5000 series, 1st edition January 1944, with overprint in brown dated 23 March 1944 showing interpretation of beach conditions: peat and clay (solid dark brown); problematical occurrences of peat and clay (lined paler brown); and areas of thin sand cover, likely to have yielding patches (palest brown). Distance west-east across this figure is 2 km. See Rose *et al.* (2006) and Rose & Clatworthy (2008) for further description. Reproduced courtesy of the Lapworth Museum of Geology, University of Birmingham.

## **BILL WILLIAMS, COMMANDING OFFICER OF THE QUARRY GROUP ROYAL ENGINEERS**

Publications already cited provide detailed accounts of war work by Bill King and Fred Shotton, so this need not be described further here. Rather, it is timely to draw attention to the wartime achievements of another distinguished but lesser known military 'geologist': Arthur Robert Owen Williams (Figure 7).



**Figure 7.** A.R.O. Williams at Chatham in January 1940; part of a group photograph of members of the newly-formed 170 Tunnelling Company Royal Engineers. From Wilson (1992), courtesy of the Institute of Materials, Minerals and Mining, London.

Bill Williams was born about 1905, educated in England at Malvern, and from 1922 to 1926 studied at the Royal School of Mines (RSM: now part of the Imperial College of Science, Technology and Medicine, London) (Anon., 1989). Subsequent issues of the Register of the Associates and Old Students of the Royal School of Mines indicate that he graduated as an Associate (A.R.S.M.) in Metallurgy rather than Geology, but the Prospectus of the Royal School of Mines published in the Imperial College Calendar for the session 1922-23 shows that geology was a component of the A.R.S.M. Metallurgy curriculum. Indeed, geology at this time included 'crystallography, mineralogy, petrology, dynamical geology, tectonic geology, stratigraphical geology, physiographic geology, palaeontological geology, and (optionally) determinative mineralogy' and so was a significant feature of the course (C. Harpham, pers. comm. 2010).

According to the Register, on graduation Williams made his career in the metal mining industry. He was employed briefly in 1926 by Riley, Harbord & Law, before appointment as a 'learner' (and later promotion to chief sampler and shift boss) with Consolidated Gold Fields at Robinson Deep in South Africa. From 1930 to 1937 he worked sampling, surveying and mining at the Kanshansi Mine in what was then Northern Rhodesia (now Zambia), returning to England as Assistant to the Chief Engineer at the London Office of Consolidated Gold Fields. In 1938 he was seconded to Gold Fields American Development Company Limited, and took up residence in Toronto. However, when war broke out in September 1939, he returned as quickly as possible to the UK, to volunteer for active service.

Williams was speedily appointed to a Regular Army Emergency Commission, as a second lieutenant in the Royal Engineers with effect from 14 November 1939. He was assigned to 170 Tunnelling Company Royal Engineers (Wilson, 1992). This was the first of the Tunnelling Companies RE formed during World War I but disbanded at its end to be re-formed, at the School of Military Engineering, Chatham, in late 1939. In early 1940 Williams went with 170 (and 172 Tunnelling Company raised soon afterwards) to excavate underground facilities for the British Expeditionary Force in France, but was soon ordered back to England to found and command 180 Tunnelling Company. He was thus in the UK and spared participation in the disastrous Battle of France and retreat to Dunkirk in May/June 1940. Promoted to the rank of captain and then major in 1940, he led 180 Tunnelling Company to Gibraltar in October. There it participated in an extensive military tunnelling programme through the Jurassic limestone and dolomite bedrock (Wilson, 1945; Rosenbaum & Rose, 1991; Rose, 2001). On 15 August 1942 Williams was promoted, to the ranks of 'substantive' major and 'temporary' lieutenant-colonel, and given overall command of tunnelling operations on Gibraltar, as Commanding Royal Engineer (C.R.E.) of 3rd Tunnelling Group. His earlier work on Gibraltar had also been rewarded with an M.B.E. He seemingly left Gibraltar in late 1943 or early 1944, for by March 1944 he was serving in the UK as C.R.E. of 9th Line of Communications (L. of C.) Troops Engineers, based at Doncaster. On 15 March he attended a meeting at HQ Northern Command in York where he learnt that he was to be assigned, with 9 L. of C. Troops Engineers, to the Works Directorate of 21st Army Group, then preparing for the Allied liberation of France. Five Quarrying Companies Royal Engineers, the only such units to be assigned to 21st Army Group, were to be placed under his command: numbers 125, 853, 855, 856, and 858. These would form the Quarry Group Royal Engineers, and as they did so, he would relinquish command responsibility for other RE units within 9 L. of C.

## **FOUNDATION OF QUARRYING COMPANIES ROYAL ENGINEERS**

Like Tunnelling Companies, Quarrying Companies had first been formed within the Royal Engineers during World War I, for service with the British Expeditionary Force on the Western Front, in Belgium and northern France. Like them, they were disbanded following the end of hostilities, but re-formed during World War II, to



serve again in France, with the new British Expeditionary Force (BEF).

Documents now preserved in the National Archives, at Kew, in file MT 39/492, reveal that formation of a Quarrying Company RE was proposed in June 1939, as war seemed likely. This was still in the planning stage for men and equipment when the BEF asked in October that its formation be stopped. The French had refused to allocate the BEF a quarry on the grounds that they themselves could meet all BEF requirements for aggregate.

However, as the BEF was reinforced to about 400,000 men, and plans were formulated to enlarge it further, by a second army, the situation changed. On 16 March 1940 the possibility of raising Quarrying Companies amongst other specialist Royal Engineers companies was raised. Plans then developed rapidly through April, and on 6 May a meeting was convened in London by the War Office to consider formation of eleven Quarrying Companies RE. Chaired by a Royal Engineers colonel, this was attended by representatives of the War Office, Ministry of Transport, Institute of Quarrying, British Granite and Whinstone Federation, British Slag Macadam Federation, and British Limestone (Roadstone) Federation.

Letters and messages sent after the conference generated an instant and impressive response from the UK extractive industry. On 7 May came the news that H.K. Symington had offered to recruit a Quarrying Company at once in south-east Scotland. On 8 May, J.E. Weatherill, Manager of the Skipton Rock Co. Ltd., offered

to raise a Company of 120 men under his management for service overseas. Indeed, by 8 May there were firm offers to raise Companies not only in Airdrie, Scotland, and Skipton, in the West Riding of Yorkshire, England, but also in North Wales (Bangor) and Mid Wales (Festiniog). By 25 May it seemed probable that complete Companies could be raised in seven, probably eight, UK districts. By 12 June five of these Companies were in process of formation, and efforts were in hand to recruit men and potential officers.

But by then the BEF had been evacuated, and the surrender of France to the Germans (on 22 June) was imminent. Quarrying Companies were no longer needed for service in France. On 20 June it was announced from the War Office that their formation would be curtailed, except for Companies that had progressed too far to be stopped without considerable disappointment and possible hardship. Thus of the eleven Companies envisaged in May, only four were formed in 1940, in July (Table 1).

The Battle of France had been lost, and there was no immediate military need for aggregate. But the aerial Battle of Britain that summer and then ‘the Blitz’ (the intensive bombing by the *Luftwaffe* of British cities from August 1940 to mid-May 1941) brought an urgent large-scale need for new military capabilities: dealing with unexploded ordnance. Accordingly, after basic training in military and appropriate skills, the four Quarrying Companies were employed from October in ‘bomb disposal’ roles. 125 was based at Chelmsford in Essex, 851 at Blackheath and the south-east of London, 853 in

Company	Foundation date	Place of origin	Officer Commanding
123	<i>not formed</i>	<i>Airdrie, Scotland</i>	<i>H. K. Symington</i>
125	1 Jul 1940	Skipton, Yorkshire	J. E. Weatherill
851	31 Jul 1940	North Scotland	R. D. Forrester
852	<i>not formed</i>	<i>Lanark, Scotland</i>	
853	17 Jul 1940	Cornwall, England	J. Setchell
854	24 Jul 1940	Central Wales	T. W. Owen
855	22 Apr 1941	from 681 General Construction Company RE	H. W. Morton
856	June 1941	[Barton Stacey, Hampshire]	
857	2 Oct 1942	from 851 at Garelochhead	P. G. J. Gray
858	23 Mar 1943	[Street, Somerset]	W. H. R. Evans

Note: 856 and 858 were founded at specific training camps, but personnel were drawn largely from existing Royal Engineers units rather than directly from the civilian extractive industry in particular geographic areas

**Table 1.** Foundation of Quarrying Companies Royal Engineers 1939-1945.

south-west England, and 854 in south London and Surrey. By January 1941, 853 had cleared some 500 bombs within the counties of Devon, Cornwall, Somerset, Dorset, Wiltshire and Gloucestershire, but mostly in or near the port of Bristol; 854 had dealt with 161 bombs of all sizes, including a landmine weighing two tons, plus innumerable anti-aircraft shells and flares; and 125 and 854 had been similarly busy. Quarrymen, it seems, coped well with handling explosives.

## **MILITARY QUARRYING IN THE EARLY YEARS OF THE WAR**

In January 1941, the four Companies were restructured and re-rolled. Each was now reduced in size to normally comprise three officers and about 170 other ranks, and from August their commanding officers were all reduced from the rank of 'acting' major to that of 'acting' captain, appropriate to the smaller unit size. (Establishments changed during the war: a change notified about January 1944 increased the number of officers to four, and restored the senior officer's rank to that of major.) Officers and men with particular bomb disposal expertise formed the nucleus of other companies, and the Quarrying Companies were designated at last for more suitable employment.

125 was sent north to Halifax in Yorkshire, for training and mobilization for imminent service overseas in a tropical climate. But that assignment was successively delayed, and in October, finally cancelled. With training complete in May but no prospect of the expected movement orders, Major Weatherill (as he then was), its Officer Commanding, gained approval to base the Company at Skipton, to work quarries at Skipton and Southowram. Weekly output averaged about 1,200 tons of aggregate (totaling over 55,000 tons by 31 December), bought by the War Office from Weatherill's former employer, the Skipton Rock Co., for two shillings and six pence per ton. The men were thus usefully employed, and having been recruited mostly from the Leeds, Bradford and Skipton district, content to be based in their home area whilst waiting expectantly for their promised tropical posting.

The other three Companies were assigned roles in the UK, to support the enhancement of ports and airfields critical to British success in the maritime Battle of the Atlantic then in progress. 851 and 854 were sent to Scotland, to quarry aggregate mostly used to build jetties and roads for new ports, such as the military port at Garelochhead with access to the Clyde estuary. By 31 July, 854 had delivered 41,000 tons, and was working a double shift: from 06.15 to 14.15, and 14.15 to 22.15, per working day. Output achieved 16,427 tons in September, but slowed to 4,475 in December as winter and construction projects diverted energies. Both 851 and 854 were to continue this work in Scotland for a full two years, until January 1943. They were joined there from May to December 1941 by 855 Quarrying Company, deployed north soon after its formation (in April 1941) in southern England. Their work was eventually taken over by 857 (also on formation) from October 1942 to July 1943, succeeded in turn by 125 and 856 from autumn 1943 until their deployment to Normandy in summer 1944. Five of the eventual eight Companies to be raised

served therefore at some time in Scotland, an indication of the importance of this work to the war effort.

853 was also assigned to support construction of shore facilities and airfields for the Battle of the Atlantic, but in Northern Ireland, from January 1941 to May 1942. Londonderry became a major port for convoy protection vessels. Royal Air Force Coastal Command squadrons on similar duties flew initially from four airfields and a flying boat base, but 15 new airfields were soon constructed, and the province also later acted as a bridgehead for American troops and aircraft being sent to Europe. Significant aggregate production began in April 1941 at Briar's Quarry, Carrowdore, in County Down, and Morrow's Quarry, White Mountain, in County Antrim. By 20 May 1942 the Company was to produce over 136,239 tons of stone, primarily from these two sources, before its return to England.

In May 1942, 125 was at last sent overseas, together with 856, which had been raised in 1941 (Table 1) and employed quarrying in southern England (at Salisbury in Cretaceous Chalk, Bournemouth in Cenozoic sands and/or Quaternary gravels, and Woodstock, Oxfordshire, in Mid-Jurassic limestones). Both went not to a tropical climate but to the Faroe Islands, a constituent country of the Kingdom of Denmark half way between Scotland and Iceland. The Islands were occupied by British troops on 12 April 1940, following the invasion of Denmark by German forces, in order to strengthen British control in the North Atlantic whilst the Battle of the Atlantic was in progress. Between 1942 and 1943 Royal Engineers built the only airport on the islands, and the two Quarrying Companies were deployed to aid this and associated construction work. War Diaries show that from early June, up to seven quarries in total were in operation, providing aggregate for a Flying Boat Base, sea wall, airfield runway, petrol dump, camp area, and construction works at the bay head, working parts of the 3,000-m-thick sequence of Cenozoic lavas and pyroclastic rocks (Noe-Nygaard, 1962) which form the islands' bedrock. On 31 July 1943, as work came to an end, the final total output for the two companies over little more than 14 months was recorded as 897,766 tons.

In July 1942, 855 also went overseas. After quarrying in Scotland, it had joined 125 quarrying at Skipton in Yorkshire in January 1942, but in July it was shipped to Gibraltar. This 6-km<sup>2</sup> peninsula, jutting south from Spain at the western entrance to the Mediterranean Sea, is dominated by its famous 'Rock': a sharply-ridged crest of steeply-dipping Early Jurassic limestone and dolomite with peaks over 400 m high (Rose, 2001). Ceded to Britain by the Treaty of Utrecht in 1713, Gibraltar had been developed as a fortified naval base, one of the key harbours from which the Royal Navy sought to dominate the maritime world. Prior to the start of the war its airfield, on the narrow isthmus to the north of the Rock, had been small and insignificant. However, Gibraltar was important as a staging post between the UK, Malta, and Egypt, and later as a base first for the Allied (largely American) invasion of North-West Africa, and then of southern France. This required that the airfield be extended to cope with more and larger aircraft. For extension, land had to be reclaimed from the sea, by means of large quantities of 'fill'. A start was made in 1941, using spoil from tunnel excavation. In February

1942 an Excavator Company, a unique unit in the Royal Engineers, was formed on Gibraltar, comprising a headquarters, two motor transport sections and a quarrying section. Its main strength (five officers and over 200 other ranks) came from Royal Engineers, drivers, and pioneers shipped from the UK, but additionally one officer and 25 other ranks from the Royal Canadian Engineers provided a Diamond Drill Section to aid blasting. The Company worked an old quarry on the north-east side of the Rock, and developed a new quarry in its North Face, adjacent to the airfield. Both were in massive slopes of weakly-cemented Quaternary scree breccia. 855 Quarrying Company joined this work in June, and from September also provided working parties to assist 807 Road Construction Company RE, newly-arrived to take part in airfield construction. By July 1943 the full planned extension was complete, and  $1.15 \times 10^6$  m<sup>3</sup> of fill had been placed in position: one of the great British military construction achievements of the war. From August, Royal Engineers units involved in airfield construction were therefore progressively dispersed to other duties.

## **MILITARY QUARRYING IN THE MEDITERRANEAN REGION**

855 moved from Gibraltar to quarry briefly in North Africa, returning to the UK from the port of Algiers in January 1944.

851 and 854 had arrived in Algeria much earlier, departing from Scotland in January 1943, to be followed by 857, also from Scotland, in July. Initially this was to support Allied forces engaged in the North African Campaign, which had begun with largely American landings in French Morocco and Algeria (soon reinforced in the east near Algiers by the British 1st Army) in November 1942, and culminated in capitulation of German-Italian forces in Tunisia in May 1943. Thereafter the Companies assisted development of the infrastructure necessary to support troops occupying and confining prisoners of war in the eastern region, and those staging to campaigns in Sicily (from July) and mainland Italy (from September). 851 was to work a series of quarries in the northern part of Algeria, with seven in operation in the region of the port of Bone as its work drew to a close in January 1944. 854 was similarly busy, in Algeria and finally Tunisia, reporting in May 1943 that although all demands for stone were being met, the unit had not enough men to work all the quarries then in operation. Men of 857 arrived in Algiers on 28 July, but their quarrying plant only on 18 August. The unit was involved with quarrying and road construction near the port of Bizerte in Tunisia by October, moving back to Algiers in December to take over two quarries from 855 as this unit prepared to return to the UK. But primarily, or so it seems from its War Diaries, this unit was in waiting for movement across the Mediterranean, to Italy.

Apart from 855, which moved back to the UK in January 1944, all Quarrying Companies in North Africa moved to Italy: 854 via Taranto in December 1943 to Avelino for most of the year, and northwards to Perugia in November; 857 mostly via Naples in March 1944 to support the British 8th Army; and 851 also via Naples in March. These Companies changed HQ locations and the

quarries worked to keep pace with Allied troops as they fought their way northwards, all being still in operation when the war in Europe ended on 8 May 1945. Thereafter, 854 remained in Italy until disbanded on 5 December. 857 moved on into Austria in July, operating there until disbanded on 31 January 1946. 851 remained in Italy, and was still in operation at the close of 1945, when its War Diaries come to an end. All three of these Companies therefore spent their entire time in military quarrying in only three areas: Scotland, North Africa, and Italy (briefly for 857 also adjacent Austria), and thus mostly overseas.

## **PREPARATION FOR ACTION IN NORMANDY**

Early in 1944, two Quarrying Companies had long been working in England, 853 since return from Northern Ireland in May 1942, 858 since its formation, in March 1943.

853 had been based at the Drill Hall, Woodstock, Oxfordshire, since June 1942, working Mid-Jurassic limestone in the Gibraltar (Bletchington) and Kirtlington quarries nearby to provide crushed stone for the massive Central Ordnance Depot then under construction at Bicester, a few miles to the east. Quarrying continued until August, when the Company moved to an RE Training Camp, for intensive training until early September. In early October it moved again, to a camp at Otterburn, near Newcastle-on-Tyne, and there spent 2.5 days per week on general military and engineering training, the rest of working time quarrying stone, primarily for the construction of gun spurs and ammunition dumps. Military training culminated in a 6-week period away in February/March, followed by more quarrying in late March through most of April. Thereafter the Company was in transit camps at Selkirk, Scotland, and Tonbridge, Kent, before embarking for Normandy on 17 June.

858 had begun forming on 23 March 1943 in Somerset, where it received basic military and engineering training, and technical training at Underwood Quarries, near Wells. On 30 July it moved to the Drill Hall, Woodstock, initially to take over from 853 whilst 853 went to its training camp but to share quarrying duties thereafter. Work began on Gibraltar Quarry the next day, to maintain output of stone for the Central Ordnance Depot: 9,447 cubic yards in August, 9,851 in September, 8,543 in October, 5,366 in November (a decrease caused by diversion of energy to military training), and 6,737 in December. 858 continued quarrying at similar monthly rates, punctuated with two weeks of military training in March/April, until handing over the Woodstock accommodation and Gibraltar Quarry to 855 Quarrying Company on 10 May, and moving first to Ravenfield Camp, near Rotherham, Yorkshire, before staging southwards and finally embarking for Normandy on 24 June.

856 had been based at Shandon, near Garelochhead, in Scotland, quarrying for two military ports, since returning to the UK from the Faroe Islands in September 1943. By 16 May 1944 it too had completed a move to Ravenfield Camp for military training, before staging south in June, and finally embarking for Normandy on 10 July.

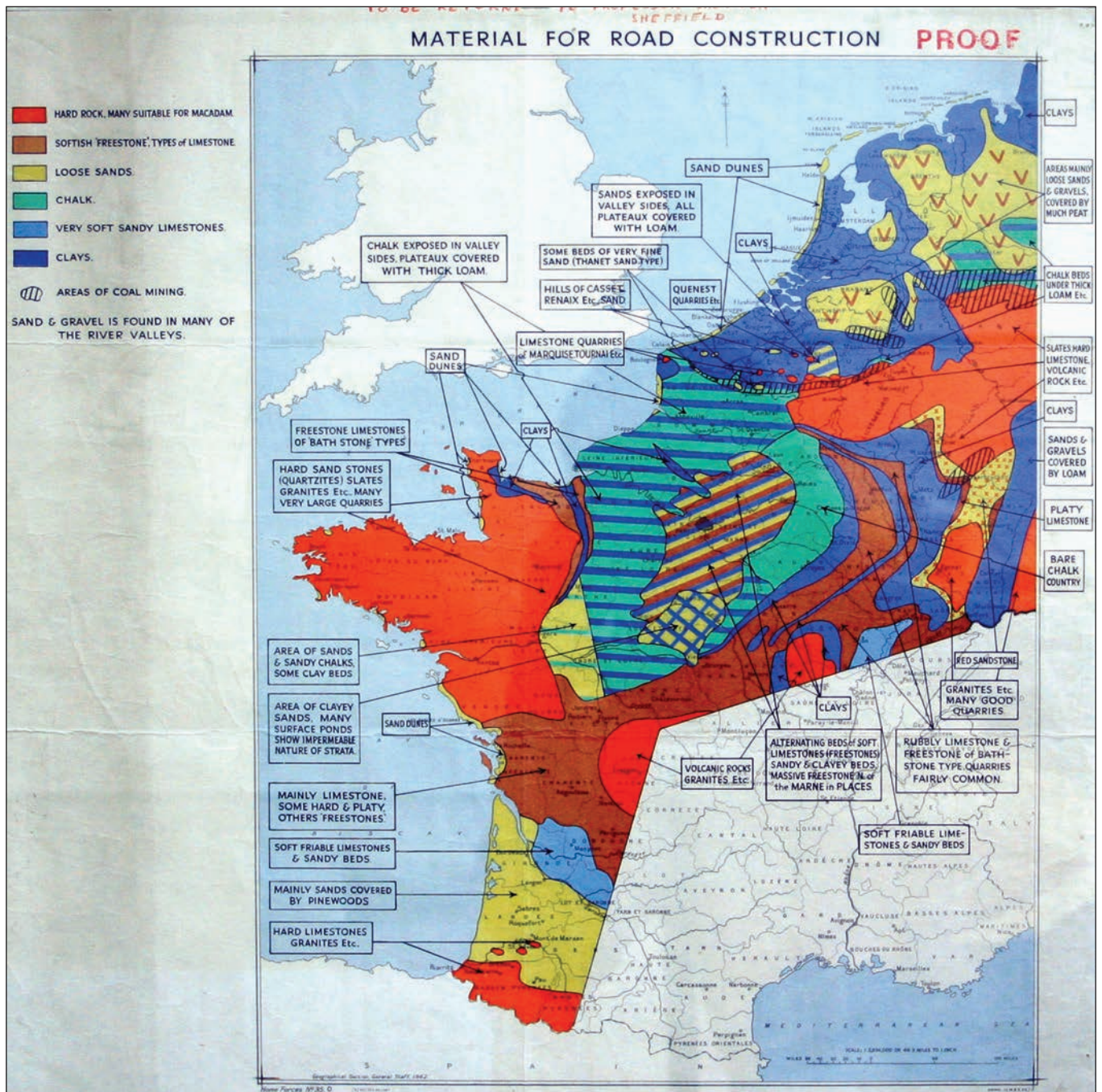


125 was also quarrying for military ports in Scotland, based at Garelochhead, until it too moved to Ravenfield Camp, arriving on 1 June. Despite a warning order on 29 June to prepare to move at 48 hours notice, it did not move south until mid July, and finally embarked for Normandy on 4 August.

855 had arrived back in England from Algeria on 4 January 1944. Thereafter it was based in training camps until taking over the Gibraltar Quarry from 858 on 10 May. However, barely a month later, on 15 June it moved to Ravenfield Camp, beginning its subsequent move south on 22 July, and embarking for Normandy on 31 July.

All five of these Companies had thus by this time gained long experience in their specialist military role,

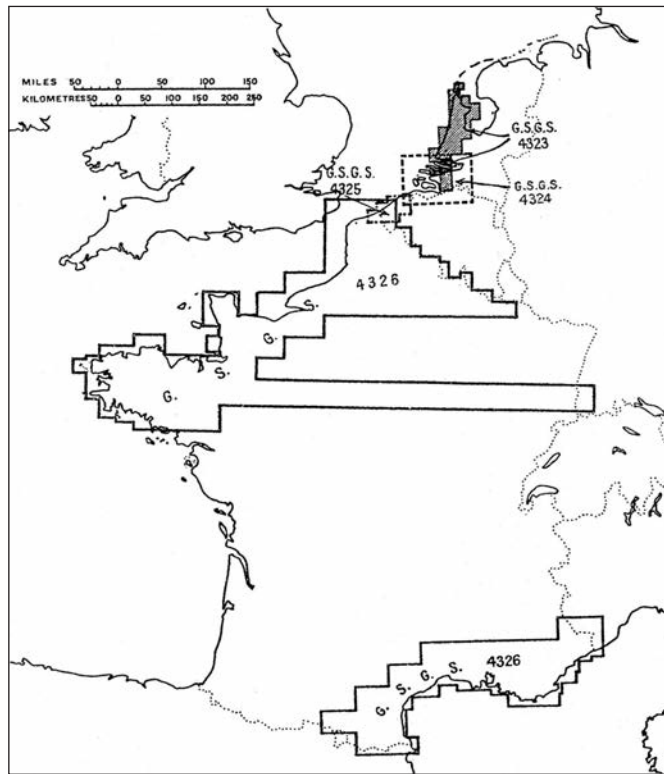
and had benefited from periods of additional military training in the six months prior to embarkation. 853, scheduled to be the first Quarrying Company in action, was temporarily put under direct command of the British 2nd Army shortly after the Quarry Group 'formation' conference on 15 March and did not rejoin the Group as such until the arrival of Bill Williams as C.R.E. in Normandy in early July. The other four Companies were routed through Ravensfield Camp, where their preparatory equipment and training was directed by Williams himself. As part of his own preparation, he was issued with a set of Technical Intelligence Service Local Resources map sheets, which later proved to be rather inaccurate with regard to quarry intelligence (although such intelligence had been gathered since at least mid-1943: e.g. Figure 8). He was, however, put in touch with



**Figure 8.** Material for road construction: western and northern France, Belgium and Holland. Proof copy of map originally at scale of 1:2,934,000 (46.3 miles to 1 inch) prepared for British Army printing in May 1943. From Rose et al. (2006), courtesy of the Lapworth Museum of Geology and the British Cartographic Society.



Fred Shotton as SO (Geology) at HQ 21st Army Group, from whom he received a set of French geological maps at scale of 1:80,000 reprinted by the Geographical Section General Staff (Figure 9), together with what he later acknowledged was much useful information regarding rock types in the beach-head area. Indeed, after Victory he concluded 'Field reconnaissance yielded much useful information of a detailed nature but for an overall picture geological maps proved invaluable' (Williams, 1950, p. 223).



**Figure 9.** Index to medium scale geological maps of France, Belgium and the Netherlands reprinted by December 1943 by the Geographical Section General Staff of the British Army. Coverage available in 1944 comprised 30 sheets of GSGS 4323 (The Netherlands) at 1:50,000, four sheets of GSGS 4324 (The Netherlands) at 1:200,000, 12 sheets of GSGS 4325 (Belgium) at 1:40,000, and at least 113 sheets of GSGS 4326 (France) at 1:80,000. Small-scale maps were reprinted for France (GSGS 4452, 1:1 million) and Germany (GSGS 4505, 1:2 million). From Anon. (1943).

### THE QUARRY GROUP IN NORMANDY

The Quarry Group in Normandy comprised a headquarters plus five Quarrying Companies: 853 whose components arrived at Courseulles (slightly east of Ver-sur-Mer, Figure 10) between 18 and 22 June; 856 which arrived a few miles to the west at Le Hamel (due north of Asnelles, Figure 6) between 29 and 30 June; 858, 855 and 125 which all arrived via the Mulberry Harbour even further west, at Arromanches (Figure 10) on 29 July, 31 July and 6-7 August respectively. The leading elements were thus in theatre 12 days after D-Day, 6 June, during the 'build up' rather than 'assault' phase, and the final three Companies only after the 'breakout' from the beach-head had begun, on 25 July. Each Company comprised 4 officers and 173 other ranks (52 quarrymen, 50 drivers, and sundry tradesmen), to be supplemented

in theatre by about 100 unskilled men (from the Pioneer Corps, prisoners of war, or local civilians). Essential equipment comprised a range of excavators, a dozer, compressors, rock drills and drill steels, crushing and grinding units, and vehicles. In total the Group thus had an established initial strength of just over 900 troops of all ranks. All arrived safely, except for part of 858, which lost three men killed and five injured when the ship carrying its heavy equipment was torpedoed en route. The ship was beached in England to prevent it sinking, and it was to be many weeks before the men of 858 were to be re-united with their own heavy equipment.

Stone was required for road widening and repair, and for construction of new roads (such as that to bypass the town of Bayeux, Figure 10). On D-Day, over 8,000 vehicles landed in Normandy, and by 50 days later there were over 150,000 in an area little more than 20 miles broad and 10 miles deep (32 by 16 km), generating intensive road use. The weight of some of the vehicles and the passage of those equipped with caterpillar tracks proved destructive to road surfaces in a region that had previously experienced only relatively light traffic, and road maintenance (as expected) became a serious problem. Moreover, much of the land within the developing beach-head area was put to military use, not only for airfields but also for field hospitals, stores depots, vehicle and gun parks, most of which required hard standings and so added to the military demand for aggregates. The focus of the Quarry Group's activities lay within the British sector of operations, initially to support the British 2nd Army and subsequently 21st Army Group as a whole as, from late July, it developed into an Anglo-Canadian force (British 2nd plus Canadian 1st Armies, the US 1st Army being joined by the US 3rd Army thereafter to found the adjacent 12th Army Group), but there was close British/American cooperation as appropriate.



**Figure 10.** Map showing positions of main roads, railways and British military quarries in Normandy during 1944. After Rose & Pareyn (1995), courtesy of Blackwell Publications.



Initially, production was started in existing (but partly disused) quarries at Creully, Esquay, Douvres, Reviere, Carpiquet, Blay, and Tilly-sur-Seulles (Figure 10 and Table 2). Later, a new quarry was opened at Ver-sur-Mer. Apart from two quarries near Esquay, in Quaternary sands or gravels, all these quarries were within Jurassic limestones. They produced a rock that was weak and generally unsuitable for road repair, but within the restrictions imposed by the frontline and British/American sector boundary, there were no alternatives. At Creully (Figure 11) and comparable sites (Figure 12) the rock quarried was a Mid-Jurassic shallow-

water limestone with well-developed cross bedding, worked previously for building or rough walling stone and somewhat similar to the Mid-Jurassic limestones worked in England at the Gibraltar and Kirlington quarries. These strata dipped gently to the north-east, exposing Early Jurassic strata further inland, toward the south-west margin of the Jurassic outcrop. Quarries in these Liassic limestones were developed at Blay, Les Ormes, and Tilly-sur-Seulles, working well-cemented limestone beds 0.10-0.35 m thick alternating with thinner marls, the limestones having previously been worked to burn for lime production.

Location	Company RE	Total tons	Rock type
Creully	853	122,739	Mid-Jurassic limestone
Reviere	856/858	44,653	Mid-Jurassic limestone
Douvres	856/858	29,907	Mid-Jurassic limestone
Esquay-sur-Seulles	853/125	31,194	Quaternary sand
Esquay: La France	125/856	25,792	Quaternary sand
Ver-sur-Mer	856/858	5,778	Mid-Jurassic limestone
Mouen	853/856	85,714	Cambrian quartzite
Carpiquet	856/125	107,203	Mid-Jurassic limestone
Blay	855	43,982	Liassic limestone
Tilly-sur-Seulles	125	11,196	Liassic limestone
Perrières	856	70,197	Ordovician quartzite
Les Ormes	855	1,323	Liassic limestone
Etavaux	125/858	65,724	Silurian (?) quartzite
Cocherel	858	5,189	Quaternary alluvial gravel
Fontaine	858	5,270	Cenozoic clay-with-flints
Maltot	856	7,703	Silurian (?) quartzite
St. Martin-des-Besaces	855	5,809	Ordovician quartzite
Le Pont Roc	125	780	Mid-Jurassic limestone
	TOTAL	670,153	

Note: Output shown here and in Tables 3 and 4 is for stone delivered rather than stone produced; some stone was produced but stockpiled rather than delivered, and in Belgium significant quantities were delivered initially from captured stock

**Table 2.** Stone delivered by Quarrying Companies RE in France 1944.



**Figure 11.** Creully, the most prolific of the 'soft rock' quarries operated by the Quarry Group RE in Normandy: photographed in 2001, showing face some 4 m high cut through Mid-Jurassic cross-bedded bioclastic limestones. From Rose & Pareyn (2003), courtesy of the Geologists' Association.



**Figure 12.** Royal Engineers at work in a limestone quarry in Normandy during 1944. Photo courtesy of the Royal Engineers Museum and Library, Chatham.



Good roadstone became available only with the capture of Mouen (Figure 13), SW of Caen, toward the end of July. This provided access to strong, steeply-dipping Cambrian quartzites flanking a NW-SE prolongation of the Precambrian Armorican basement.

Bill Williams was diligent in visiting sites during operation, and in reconnaissance for new sites, sometimes accompanied by Fred Shotton to provide geological guidance. Weak rock quarries were set aside as those yielding stronger rocks became accessible with the progress of battle. Creully, Douvres, Reviere, Ver-sur-Mer, Blay, and Tilly, were successively abandoned, and the quartzite or well-cemented Palaeozoic sandstone quarries at Perrières, Etavaux, Maltot and St. Martin-des-Besaces brought to production. Choice of these particular quarries from the many that became potentially available with the expansion of the beach-head was dictated primarily by considerations of proximity to areas most needing stone and the rapidity with which production could be started. The Perrières quarry was deemed the best, with good road and rail access. Production began at the end of August and continued until the end of the war in May 1945, supplying British and American forces with over 70,000 tons of stone, nearly all crushed, from this one source. However, as the Allied armies advanced, so French quarries were replaced as sources of aggregate by quarries in Belgium and finally Germany. East of Caen, bedrock in France is principally of Cretaceous sediments (Figure 3), mostly chalks, capped in places with a

significant thickness of clay-with-flints and with some thick deposits of Quaternary gravel in the major (Seine and Eure) river valleys but otherwise with no potential sources of good aggregate other than the urban areas reduced to rubble by aerial or artillery bombardment. The Marquise group of eleven quarries near Boulogne worked an inlier of older, stronger rocks, but although these were important to British troops in World War I, they were quickly bypassed in World War II.

### **THE QUARRY GROUP IN BELGIUM AND GERMANY**

The Normandy phase of quarrying came to an end on 15 September. Allied troops had broken out of the extended beach-head area and advanced some 400 miles eastwards between 25 July and 7 September, across northern France to liberate Belgium. They consolidated their position in the Low Countries during the winter months, and between 16 September and 30 November the Quarry Group extended its activities to Belgium, at the same time maintaining some production in the Caen-Bayeux-Falaise region (Figure 10) to meet demands for aggregate in the Rear Maintenance Area of 21st Army Group. By early November, 125 was quarrying at Etavaux; 853 at Mouen; 855 at Blay, St. Martin and La France; 856 at Perrières, Carpiquet and Maltot; and 858 (east of Figure 10) at Fontaine, Cocherel and Rouen (in urban rubble). In mid November, part of 855 was sent to Ostend in Belgium, to crush Carboniferous limestone (found in a large dump near the docks) for tarmac



**Figure 13.** Mouen, the most prolific of the 'hard rock' quarries operated by the Quarry Group RE in Normandy: photographed in 2001, showing steeply-dipping Palaeozoic quartzites; excavator indicates scale. From Rose & Pareyn (2003), courtesy of the Geologists' Association.

manufacture, and elements of the Quarry Group progressively took over responsibility for organizing the supply of all stone and tarmac from Belgian sources. The huge stocks of crushed rock found in Belgium, as well as the need to form other Royal Engineer units within the manpower ceiling imposed on 21st Army Group, led to the disbandment of 858 in December 1944. The last Quarrying Company RE to be formed, it was deemed appropriate that it be the first to be disbanded – despite protests from the Quarry Group against any diminution of its overall manpower.

From 1 December 1944 to 16 April 1945, the Quarry Group concentrated activities in Belgium, where it controlled the supply of stone to two armies (1st Canadian and 2nd British) and their Line of Communications. Most came from quarries in porphyry (Table 3) near Brussels, principally at Lessines north-west of the city (the quarries at Unies, Nouvelles, Cosyns, Vandevelde, Mouplon, Sarts, Notte, and Cardon controlled by a selling organization in Brussels, plus Willocq, Denure and Le Porphyre), at Bierghes, and at

Quenast (the Quenast and Brabant quarries) to the south of the city, quarries mostly of impressive size (Figure 14). Quarries at Dongelberg to the east, and Opprebais, were operated from February onwards, to meet local demands and relieve the rail lift position at Lessines, which was always difficult, but their output was small in comparison. Initially stone was distributed from stock, but demand required that quarrying be implemented, and civilian labour involved. By 1 April 1945, 125 was controlling stone production and/or issues at Lessines, Bierghes, Quenast, Soignies and Antwerp; 853 quarrying at Cosyns; 855 (from its headquarters in Valkenswaard) controlling activities such as stone crushing or tarmac production at Nijmegen, Weerpelt, Schaft, Hamont, Weert, Waterscheide and Ben-Ahin; and 856 quarrying at Dongelberg and Opprebais (whilst still with one platoon operating at Perrières). Moreover, 4854 Flight Royal Air Force was also brought under command by this time, quarrying at Dongelberg and crushing dumped material at Le But.

Location	Company RE	Total tons	Rock type
Lessines (7 quarries)		577,928	Cenozoic quartz porphyry
Cosyns (military)		20,211	Cenozoic quartz porphyry
Bierghes		56,067	Cenozoic quartz porphyry
Quenast (2 quarries)		25,044	Cenozoic quartz porphyry
Willocq		10,723	Cenozoic quartz porphyry
Le Porphyre		13,390	Cenozoic quartz porphyry
Dendre		9,685	Cenozoic quartz porphyry
Soignies		27,698	Carboniferous limestone
'Asphalt block pavement'		49,751	Tarmac
S.A.C.U.P.		4,689	Tarmac
Dongelberg	856	15,354	Quartzite
Opprebais	856	11,870	Quartzite
Le But	125/853	3,392	Cenozoic quartz porphyry
	<b>TOTAL</b>	<b>825,802</b>	

Note: Since stone was mostly delivered from stock, this was achieved by deployment of small detachments of Quarry Company troops rather than by assignment of Companies for quarrying as such

**Table 3.** Stone delivered by Quarrying Companies RE in Belgium 1944/1945.





**Figure 14.** Quenast Quarry, Belgium (cf. Table 3), viewed to the south-east; photographed in March 2012 but showing infrastructure from old workings near the crest. © Emily Hunger.

From 17 April the Quarry Group began to move forward into Germany. Its HQ had prepared for the move prior to Allied crossing of the River Rhine in mid/late March by making a study of all available information regarding stone resources in northern Germany, by means of geological maps and publications and the help of the geologists then at HQ 21st Army Group (Majors F.W. Shotton and D.R.A. Ponsford: cf. Rose & Clatworthy, 2008). Its task on arrival was the organization of stone supplies from local sources, initially for the British 2nd Army and later for the whole of British forces east of the Rhine. By the time Victory in Europe was achieved, on 8 May, only three quarries were in operation (Table 4), in a line to the north of Osnabruck, but almost all of the Quarry Group had moved from Belgium to Germany before the end of May. It was to continue operations until the end of August, at times at a further 11 sites: quarries at Bentheim to the north-west and Bissendorf to the south of Osnabruck, and two at Steinbergen to the south-east towards Hanover, five in

basalt in the Hartz Mountains near Göttingen to the south of Hanover (Bramburg, Barterode, Guntersen, Dransfeld and Meensen), a ‘diabase’ quarry near Langelsheim north-east of this group, and a gravel washing plant at Rinteln near Steinbergen.

By then, three of the Quarrying Companies had been withdrawn to England with a view to service with South-East Asia Command (and so in Burma, Malaya or Sumatra). 856 embarked for the UK on 20 May, 125 entrained in Germany on 21 July, 855 on 25 July (although Victory over Japan on 15 August speedily removed the need for their further operational deployment). The Quarry Group briefly comprised a headquarters plus 853 Quarrying Company thereafter. Bill Williams was released from the Army on 23 August and succeeded as C.R.E. by Joseph Setchell, pre-war General Manager of the Old Delabole Slate Company, who had founded 853 and later taken command of 858. The Group ceased to be responsible for any stone

Location	Company RE	Total tons	Rock type
Piesberg	855	6,238	Carboniferous quartzite
Uffeln	125	0	Carboniferous quartzite
Engter	855	96	Jurassic limestone
	<b>TOTAL</b>	<b>6,334</b>	

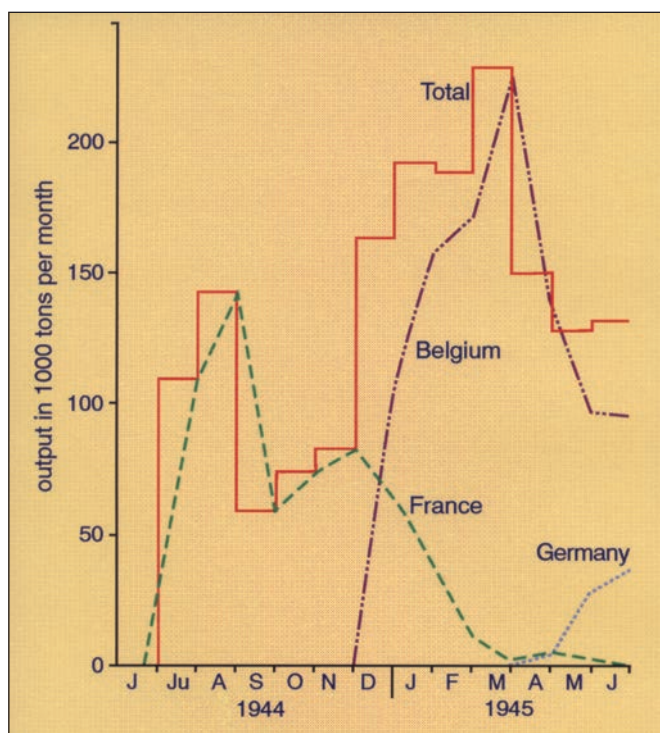
**Table 4.** Stone delivered by Quarrying Companies RE in Germany to 8 May 1945.

production outside Germany on 31 August, and was finally disbanded as such on 30 September. 853 remained in Germany to support the British Army of Occupation of the Rhine until adequate civilian support was in place. Then it too was disbanded, on 8 March 1946.

## CONCLUDING REMARKS

The Quarry Group worked or controlled some 40 quarries successively in France, Belgium and Germany (Figure 15) during the 11-month North-West Europe Campaign and delivered in total over 1.5 million tons of stone, sand and tarmac (Tables 2, 3 and 4). Work done in the four months following the end of hostilities brought the total of sites worked or controlled to about 50, and total deliveries to about 2 million tons, before the military requirement came to an end and the Group was disbanded. Although largely ignored by books on military history (e.g. Dear & Foot, 1995) and given scant mention even in the official *History of the Corps of Royal Engineers* (Pakenham-Walsh, 1958), the Group's output was of great importance to maintaining or developing the infrastructure of roads and airfields that contributed to the Allied Victory in Europe on 8 May 1945. Stone was also produced in North-West Europe by units of the Royal Air Force, specifically for airfield construction or repair. In other campaign areas, stone for British forces was provided by Quarrying Companies of the Indian Army (316 in Mesopotamia, 440, 441 and 442 in Burma) or by RE units that were not specialist Quarrying Companies. British military use of stone during World War II was thus substantial in its overall total and importance.

After the war, Bill King continued as Professor of Geology at Cambridge until his retirement in 1963, gaining many academic honours, including election as a



**Figure 15.** Monthly quantities of stone produced or distributed by the Quarry Group RE, between 23 June 1944 and 30 June 1945. After Rose & Pareyn (1995), courtesy of Blackwell Publications.

Fellow of the Royal Society and as President of the Geological Society of London (Rose, 2004). On release from the army, Fred Shotton took up appointment as Professor of Geology at the University of Sheffield in 1945, moving back to Birmingham as professor in 1949, and similarly gained academic honours that included election as a Fellow of the Royal Society and as President of the Geological Society of London (Rose & Clatworthy, 2008). Bill Williams, advanced from M.B.E. to O.B.E. for his wartime work with the Royal Engineers, returned to Consolidated Gold Fields as Resident Engineer in London and, during the next 20 years, became a director of many of the companies in the Group, including the parent company, from which he retired as Managing Director in 1970 (Anon., 1989). He was President of the Institution of Mining and Metallurgy 1961-1962, made a Fellow of Imperial College in 1969 (Catherine Harpham, pers. comm. 2010), and a Life Fellow of the South African Institute of Mining and Metallurgy in 1975 (Anon., 1989). The officers and men of the Quarrying Companies drawn from the UK extractive industry, so far as is known, largely returned to it.

A major legacy was that lessons learnt from the war were encapsulated within a Royal Engineers textbook published postwar to guide future generations. Its introduction notes (Anon., 1957, p. xiv):

'The quantity of stone required, in modern land warfare, for the construction, repair and maintenance of roads, airfields, and other engineering works, is likely to exceed that of any other item of engineer stores. Winning stone from the earth's surface and processing it to provide aggregate for constructional purposes are activities in which the military engineer is unlikely to gain much practical experience in peace-time. Furthermore, the civil engineer will find that under operational conditions, owing to the urgency of demands and probable limitations of equipment, the planning and development of Service quarries differ in many respects from commercial practice. This book has therefore been written to provide the information required for opening and operating Service quarries and gravel pits in war.'

'Geological considerations' merited a whole chapter in the book, prominently positioned as 'chapter 2', and contained the advice 'Sound geological knowledge is required for the selection and development of a quarry. Information and advice should be sought from the geologist at Army headquarters, as regards both the reconnaissance and the quarry plan' (Anon., 1957, p. 8). The model for this working relationship was seemingly that developed by Bill Williams of the Quarry Group and Fred Shotton as SO2 (Geology), and duly acknowledged by them both (Williams, 1950; Rose & Clatworthy, 2008, table 5). It was one of the reasons why Major-General Sir Drummond Inglis, the Chief Engineer of 21st Army Group, was to record after Allied victory that 'We had long appreciated the importance of geology in modern war' (Inglis, 1946, p. 177).

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