Brightling Mine

British Gypsum

Introduction

Extraction at the Brightling Mine has been in continuous operation since 1963 but origins of the industry are much older and provide an early example of the application of scientific knowledge to the exploration for minerals. In the C19th a deep borehole was constructed on land to the southwest of the village of Mountfield in 1876. It was drilled following agreement by a group of geologists, at the Brighton meeting of the British Association for the Advancement of Science to investigate the strata beneath the oldest exposed rocks in southeast England. The discovery of 4 seams of gypsum in the Upper Jurassic Purbeck Limestone Formation led to the establishment of the Sub Wealden Gypsum Company Limited which is now part of British Gypsum owned by the French multinational Saint-Gobain SA.

The manufacture of plasterboard in East Sussex remains an important industry providing essential products for the internal lining and finishing of most of domestic and commercial buildings in the south and southeast of England. The majority of raw materials for plasterboard are now largely obtained from desulphurisation of coal fired power station flue gases, but gypsum mined at Brightling is still used to augment supplies and used as an additive in the manufacture of Portland Cement.

Noel Worley 2010

Gypsum and its Properties

Gypsum is the most common of the sulphate minerals, and occurs in three varieties known as satin spar, alabaster, and selenite, the latter is a colourless and transparent variety. Upon heating, up to about 65°C gypsum dehydrates to form a $CaSO_4.0.5\ H_2O$ phase called *bassanite* known more commonly in the industry as '*hemihydrate*'. Further heating dehydrates the sulphate completely, giving a polymorph of anhydrite ($CaSO_4$), g-$CaSO_4$, at about 95°C - soluble anhydrite. This latter process was used at Mountfield to produce anhydrous plaster marketed locally as *Sirapite*. This type of plaster when set has the advantage of producing a much harder finish surface than other types because of the smaller volume of water needed for mixing.

Gypsum, along with anhydrite, is a constituent of evaporites which are sediments formed by precipitation of minerals through evaporation of either marine or terrestrial waters. Gypsum may also be formed by contact between sulphuric acid and calcium bearing rocks (limestones). Sulphuric acid may be derived from weathered or oxidised sulphide deposits, or from sulphurous emissions of volcanic origin.

Gypsum can also be produced as a by-product of a number of chemical processes including the production of phosphate based fertilisers, titanium dioxide and desulphurisation of flue gases. The latter process is responsible for the production of large quantities in Britain, Europe and North America.

The characteristic to surrender water molecules at low temperature arises because of attachment by weak hydrogen bonds to sulphate / calcium sheets in the molecular structure that produces hemihydrate plasters. The hemihydrate is highly soluble in water and therefore after wetting will firstly dissolve and 'set' becoming solid as new gypsum crystals start to develop. The new crystals will adhere to most surfaces because they typically nucleate and re-form in needle shapes and the sharp ends readily mesh together to form a strong material or mechanically bond with other materials. The latter properties form the basis of the manufacture of plasterboard, building plasters and building adhesives that consume most of the gypsum produced.

A further important feature of gypsum is its fire retardation properties, therefore gypsum products are used for this purpose in buildings and are recognised by fire and insurance authorities throughout the world.

Gypsum is non-toxic to humans and can be helpful to animal and plant life. In fact, it is beneficial to man and his environment when used:

- As a soil additive to improve the workability and water penetration of soils. Sometimes called 'land plaster' it is particularly effective with crops which require substantial amounts of sulphur.
- To overcome the corrosive effect of alkalinity by the addition of sulphates to the soil.
- To settle dirt and clay particles in turbid water, particular ponds, without injury to aquatic life.
- For surgical and orthopaedic casts, as plaster of Paris.
- To neutralise salt after sea flooding and enable grass to grow more easily along roadways.

Gypsum (calcium sulphate) is recognised as acceptable for human consumption:

- As a nutrient and/or dietary supplement as a source of calcium.
- As a conditioning agent for water used in the brewing of beer and as an agent to control the tartness and clarity of wine.
- As an ingredient in canned vegetables such as potatoes, carrots and peppers to neutralise natural acids, and as an optional ingredient in flour, white bread, ice cream, blue cheese and other foods.
- As a certified additive for drugs and cosmetics.

High strength gypsum plasters and ground gypsum are used in many other professions and industries such as ceramics, dentistry, surgery, coal-mining, sculpture, metal and other foundries, automotive, aircraft and agriculture. It is also used as an additive by cement manufacturers in the production of cement.

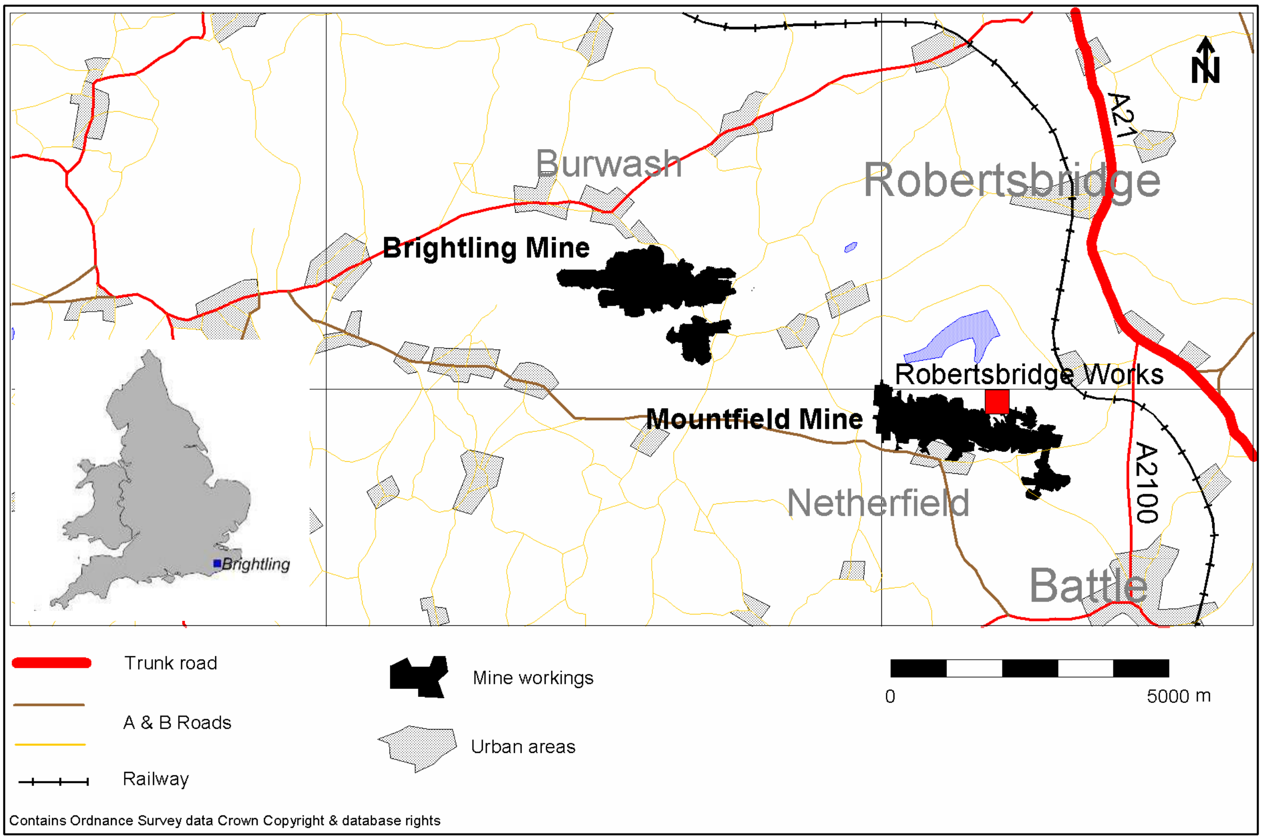

Fig 1. Map showing the location of gypsum mining operations in East Sussex

History of Gypsum Extraction in East Sussex

Mining at Mountfield

Gypsum mining in Sussex can be traced back to a meeting of the British Association for the Advancement of Science, held at Brighton in 1872. The geologists at this assembly resolved to sink a borehole, as deep as could be made, through the oldest rocks, the Purbeck Beds exposed at the surface at Limekiln Wood near Mountfield (fig 1). A subscription was raised and it is likely that the project attracted commercial as well as scientific interest and support as there was a possibility that the coal seams might also be discovered.

Fig 2. Mountfield Mine and plaster works in the late 19th century. The Woodland Shaft some 45m deep was used to raise gypsum to the surface.

The borehole constructed by the Diamond Rock Boring Company at Counsellors Wood eventually reached a depth of 1,905ft when the drilling rods broke and the project was stopped. No coal was found! The investment of £6,000 (c£500,000 today) was not devoid of commercial interest, however, since several thick seams of gypsum had been found at depths between 130 and 160ft.

The Sub-Wealden Gypsum Co. Ltd was formed on 10th May 1876 and mining commenced by sinking a shaft about 60yds from the borehole (fig 1). Progress was difficult and slow on account of the isolated location, until a railway link had been constructed to the main London to Hastings line at a point south of Robertsbridge. This business was led by William Joel Kemp a local chemist.

An early description of the operations in 1881 refers to beds of gypsum from 6-7ft high (no. 1 seam), into which headings of a similar width were driven by drilling and blasting. These were all connected by a network of underground rails to carry the gypsum to the shaft bottom, where it was hoisted to the surface by a steam winding engine. During the 1880s, the mine was a small but significant contributor to the total U.K. production, raising about 8,000 tons per annum with a value (at the mine) of about £9,000.

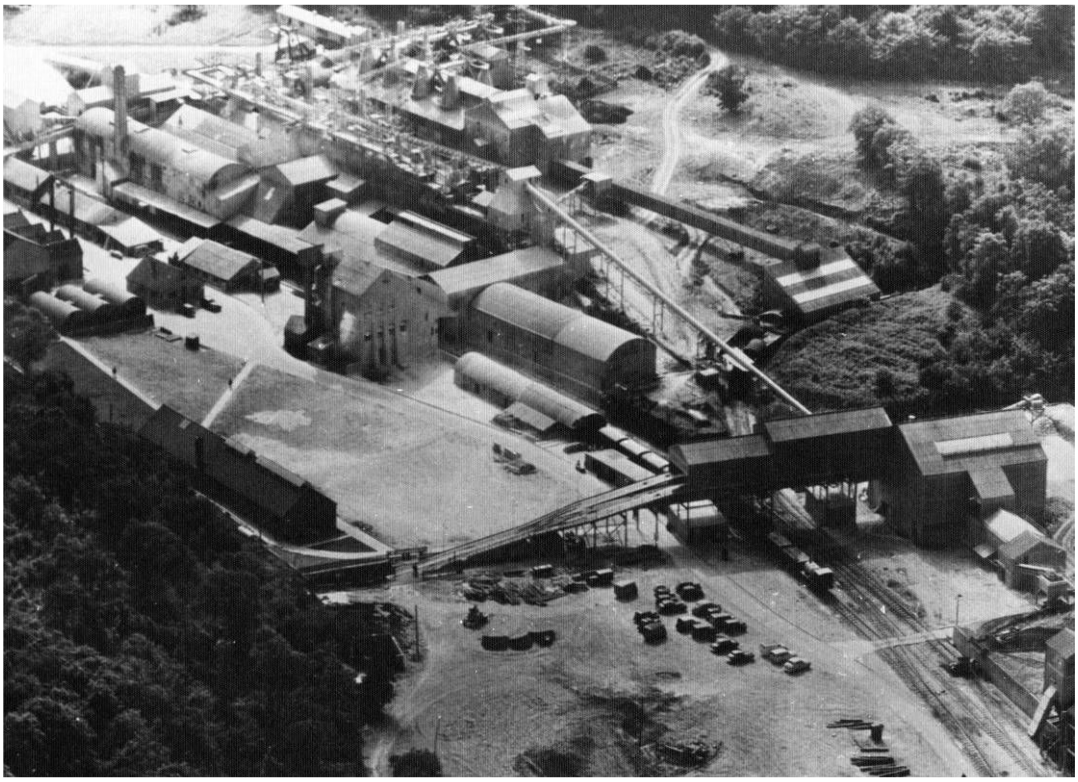

Fig 3. Mountfield Mine in the 1950's. The new drift with endless rope haulage system is seen in the foreground; behind is the plaster factory with *Sirapite* kilns in centre background. Note the overhead gantry system for charging the kilns and extensive rail sidings – nearly all finished goods were exported by rail.

During the 1890's, the gypsum mine's workforce gradually rose from 15 to 27 men underground and from 22 to 60 on the surface and the business amalgamated in 1903 with the Kingston Gypsum Company of Nottingham to form the Gypsum Mines Limited. The new company operated from two sites, Mountfield and Kingston serving markets in the midlands and south of England. Both manufactured plaster marketed under the name *Sirapite*, an anagram derived from 'Paris' the latter being the widely used colloquial name for gypsum plaster.

During the post WW1 building boom the mine expanded to meet increased factory output that had grown comprising 26 kilns. Mine output was augmented by the development of the no. 4 seam and the business acquired by British Plaster Board Limited (BPB) in 1936. It was about this time that the mining method changed to regular room and pillar working.

The demand for construction materials After WW2 led to large injection of capital investment in the mine. This involved the construction of a new inclined drift equipped with endless rope haulage and new surface processing plant that was replaced by a conveyor system in the late 1960's (fig 3) when the mine became fully mechanised.

Further pressure on reserves was partly alleviated by the installation of a heavy media separation plant that permitted anhydrite contaminated gypsum to be worked. This plant continued to operate until the early 1990's when Mountfield Mine also closed because of the virtual exhaustion of its reserves.

In its latter years the Portland Sandstone was also mined where it had been exposed by working the no. 4 seam. This enterprise developed in response to the shortage of aggregate in the area and the material was used to produce road base as well as coated material. A small coating plant was erected at Mountfield in the 1960's and finally closed in 2007.

Fig 4. A modern view of the Robertsbridge Plasterboard Works in the valley of the River Line.. The overland conveyor from Brightling Mine can be seen top right that feeds into the circular shaped covered homogenising stockpile building. The site of the old Mountfield Works and mine is present in the background.

Brightling Mine

Brightling Mine was opened in 1963 in order to develop gypsum resources in the no. 1 seam in the Brightling inlier as the Mountfield mine reserves became progressively depleted (fig 7). The mine was developed by constructing twin 1 in 6 drifts in a westerly direction from a topographically low point near the Dudwell valley to intersect both the no. 1 and no. 4 seams.

The mine is situated in the High Weald Area of Outstanding Natural Beauty that is characterised by series of deep heavily wooded valleys. The mine was carefully sited to cause minimum visual impact and is completely concealed within the landscape. Planning conditions prohibit the export of any materials by road from the site because the local highways were designed mainly

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for agricultural use. An aerial ropeway was therefore constructed to link the mine to the factory at Mountfield a distance of some 3.5 miles. The route has been sensitively chosen so that the structure would be seldom seen by taking advantage of the woodland and valleys. Parts of the ropeway were hidden in tunnels. The ropeway was replaced by a curved conveyor which is one of the longest single conveyors in the UK installed in 1986 (fig 5).

The direction of mine advance continued in a westerly direction along the axis of the anticline for a distance of over 3 kms to a maximum depth of working is some 300m. The increasing distance from the mine entrances resulted in the construction of two large diameter ventilation shafts in 1979.

The relatively high carbon content of some of the shale associated with the gypsum beds is responsible for the presence of small amounts of methane gas. The mine acquired flame safety lamp status on account of a small gas ignition that occurred in the late 1960's.

The pattern of extraction comprises a series of north and south advancing production panels using square set duplex room and pillar methods working the no. 1 and no. 4 seams (fig 6). At Brightling the rooms are generally extracted at 14m centres with 6.5m rooms and 8 m pillars being left. In the deeper parts where the burden is greater extraction rates are reduced. and extraction ratio is varied from 70% to 68%. The pillars are adequate to secure the roof without the need for artificial support systems.

The mine is structured around a production face typically 15 to 20 headings wide. The production equipment consists of two electro-hydraulic drill rigs, which drill blast holes to advance the mine headings. Once the headings have been blasted, it is made safe by scaling any loose rock from the mine roof and sides. The rock is excavated by a Load Haul Dump machine and transported to the crusher. Once the material has been crushed it is transported to the surface on conveyor system with a series of crushers on route to further reduce the size of the mine rock. After the mine heading has been emptied of rock the whole process is repeated. Ancillary work is undertaken by a small team of men whose task is to ensure that the mine infrastructure is maintained close to the production face to ensure the mining cycle is efficient.

The organisation of the working week is based on a consecutive shift operation generally starting Monday morning and finishing on Friday. The pattern of shift working is determined by demand for the product and the past mine output has approached 1 M tonnes pa however output has fallen to some 150,000 tonnes pa. All output is currently obtained from the no. 4 seam (fig 10) and no working is taking place in the no. 1 seam and supplies rock, consisting of a blend of anhydrite, and gypsum to the cement manufacturing industry as well as small quantities to the factory located some 5 miles to the southeast.

Fig 5. The Brightling Mine to Robertsbridge overland curved conveyor installed in 1986.

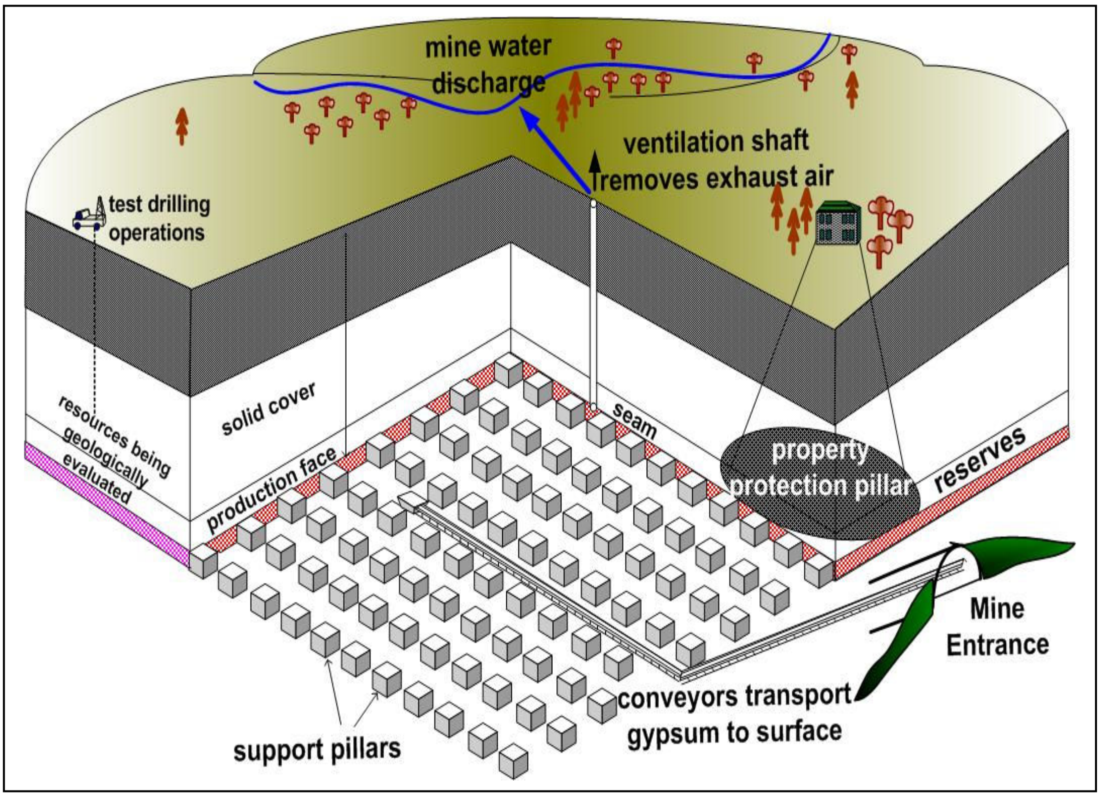


Fig 6. Cartoon illustrating the arrangements of a typical room and pillar mine

Geology

Stratigraphy

The evaporite resources, gypsum and anhydrite, in East Sussex all occur within the Upper Jurassic Lulworth Formation (140 Ma BP) of the Purbeck Limestone Beds that rest conformably upon Portlandian age calcareous sandstone (fig 8). The Purbeck Limestones are about 20m thick outcrop in a series of faulted inliers the two largest of which occur at Brightling and Mountfield located to the northwest of Battle (fig 7). The evaporites are not exposed anywhere at the surface on account of their solubility in groundwater.

Deposition took place during late Jurassic times in the northern part of a shallow sedimentary basin known as the Wealden Basin that covered most of the southeast of England. The London Brabant massif formed the northern margins of the basin and erosion of this land mass provided a source of clastic sediments particularly for the Portland Sandstone that comprises a well sorted calcareous cemented sand with an ammonite / bivalve (oysters) fauna deposited in a shallow warm open sea.

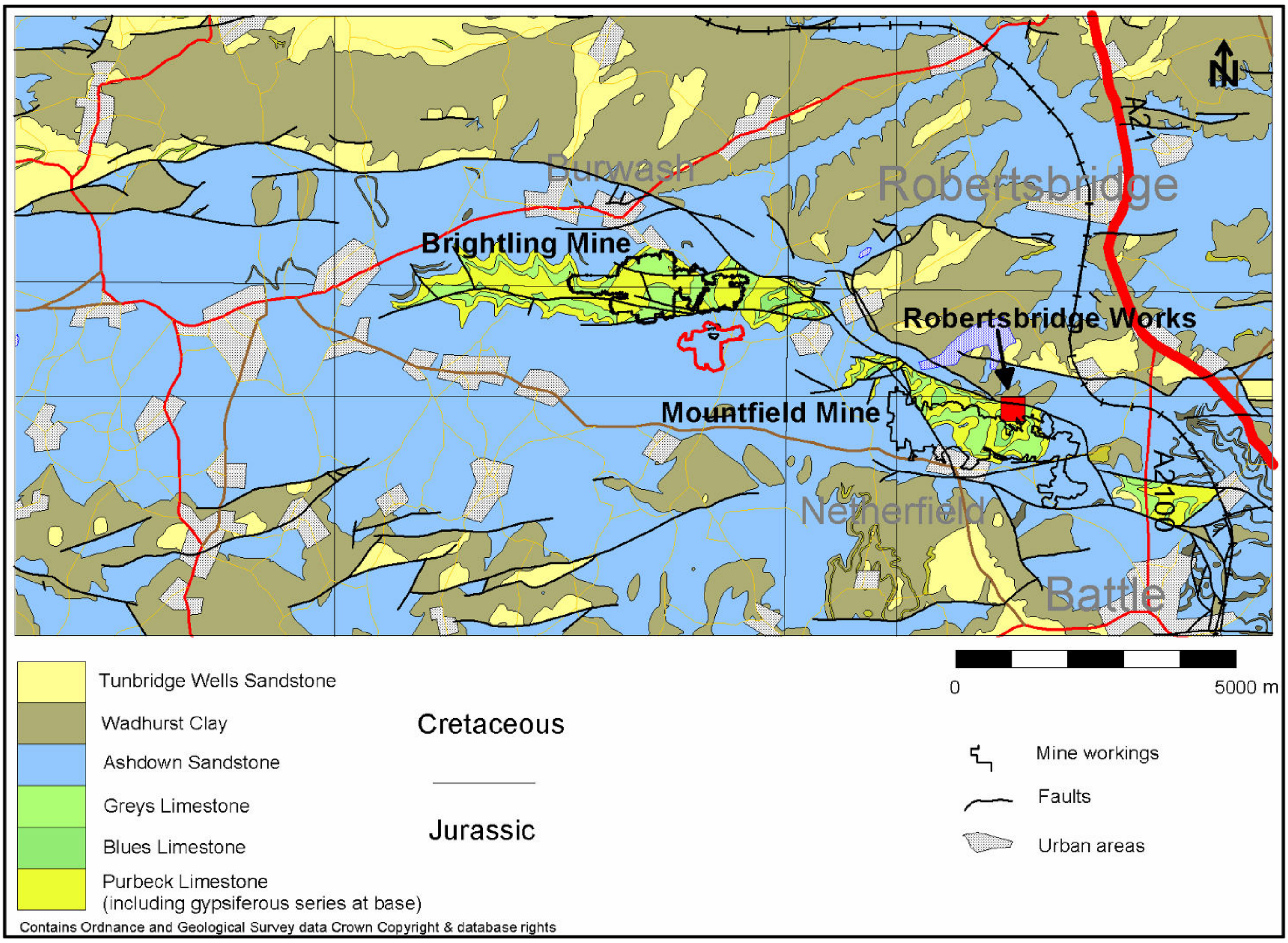


Fig 7 Geological Map of the Brightling Mountfield inliers

The marine conditions of the Portlandian gave way to more marginal shallow environments in Purbeck times where deposition was dominated by evaporites, carbonates and mudstones in the inter-tidal zone on a shelf margin slope. Calcareous mudstones / stomatolite cycles alternate with thicker beds of nodular sulphate evaporites that are interpreted as subaerial *sabkhas* that were deposited during periods of low humidity and hyper-salinity produced by evaporation of sea water.

The latter part of the Purbeck is characterised by a thinly bedded sequence of limestones and shales that represent varying water salinity and depositional depths. These include brackist water limestone crowded with gastropods, tidal flat deposits with algal stromatolites, palaeosols, ironstone beds and lignite.

Where sufficient thickness of sulphate has accumulated each is therefore accorded the status of 'seams'; the oldest being referred to a number 4 seam and so on. The no. 4 seam is thickest and is generally extracted at working heights of about >3 m. The no. 1 seam is thinner being typically worked at 2.5m but has been more extensively worked because of its higher gypsum content (fig 8)

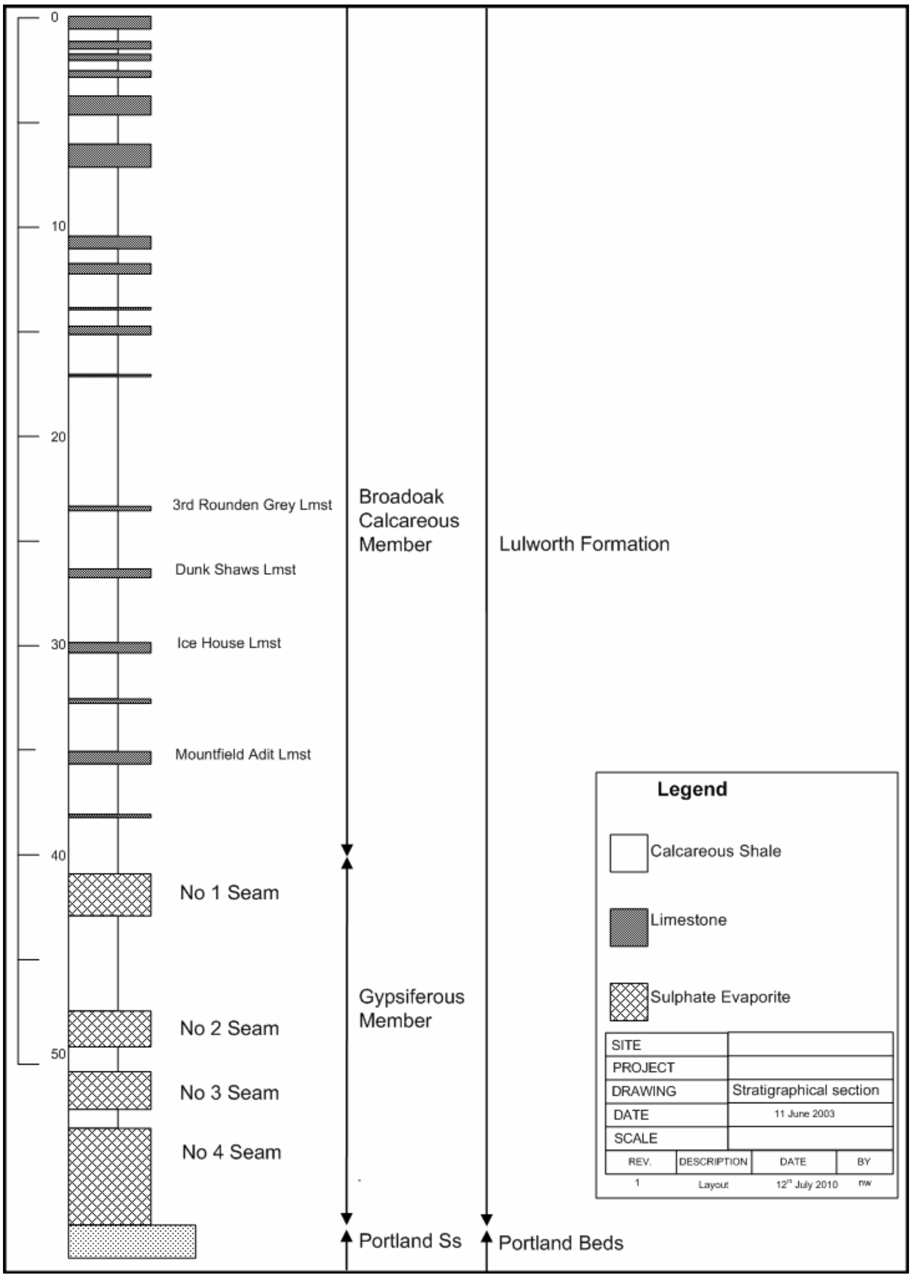


Fig 8. Lithostratigraphy of the Brightling Mountfield inliers

Structure

It was generally believed that the Purbeck inliers represent the eroded core of the Wealden Anticlinorium which implies that the geological structure is dominated by east-west, Alpine trending folds. The evidence from several hundred boreholes drilled in the evaluation of the gypsum resources suggests otherwise, and the most important structures comprise a series of tensional east -southeast trending normal faults mainly with southward throws. These may be sometimes in the region of 100 m. It is believed that these structures reflect deeper seated features in an underlying Palaeozoic basement and which were probably also responsible for exerting control over sedimentation. Smaller north to northwest-trending fault cut the fault blocks which are gently folded into periclinal structures, which small throws seldom more than 10m.

The geological structure is responsible for bringing the sulphate deposits to their current elevated position. Figures 7 and 9 illustrate the relationship between the elevated fault-blocks containing the best gypsum resources and mine workings

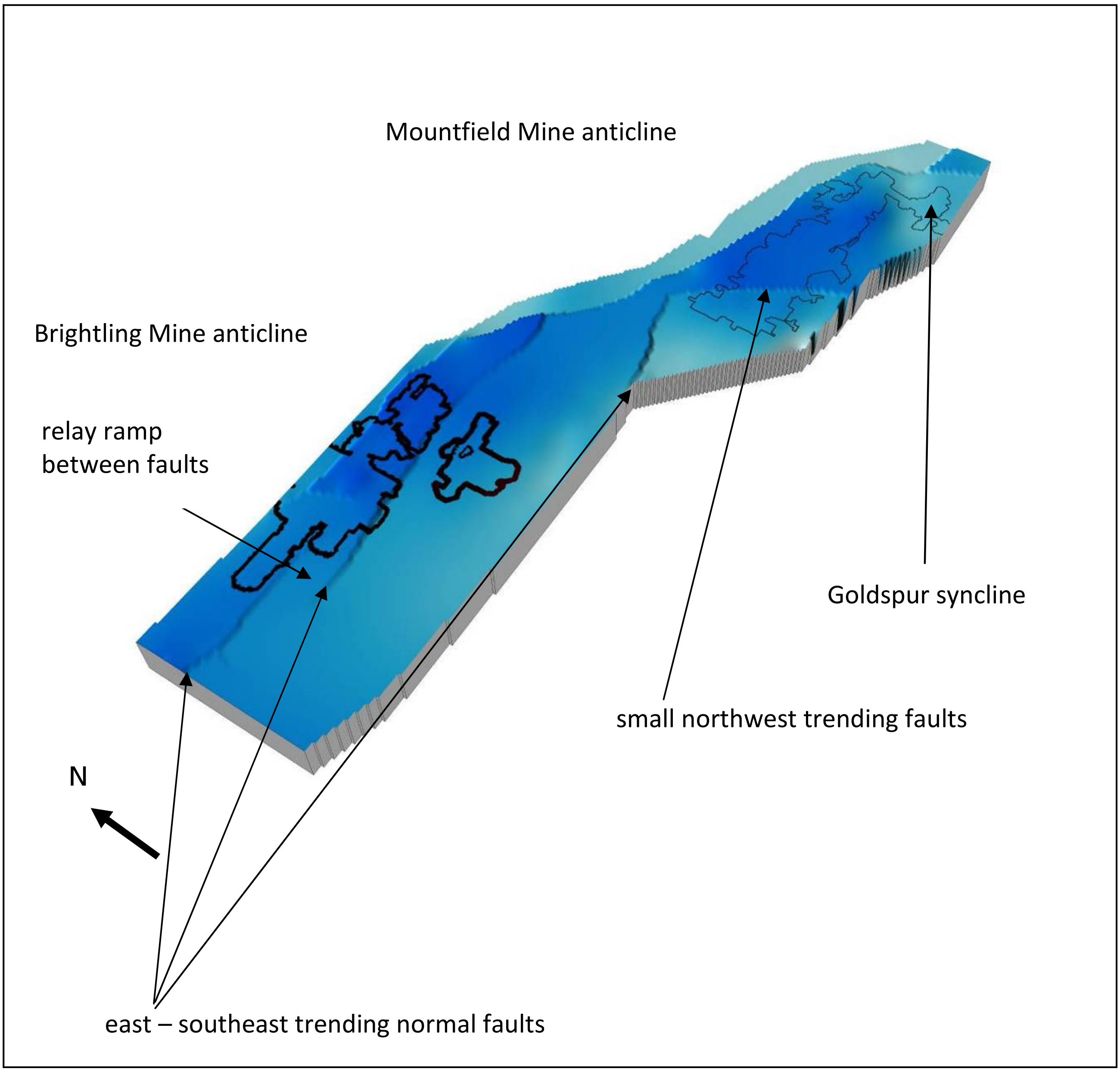
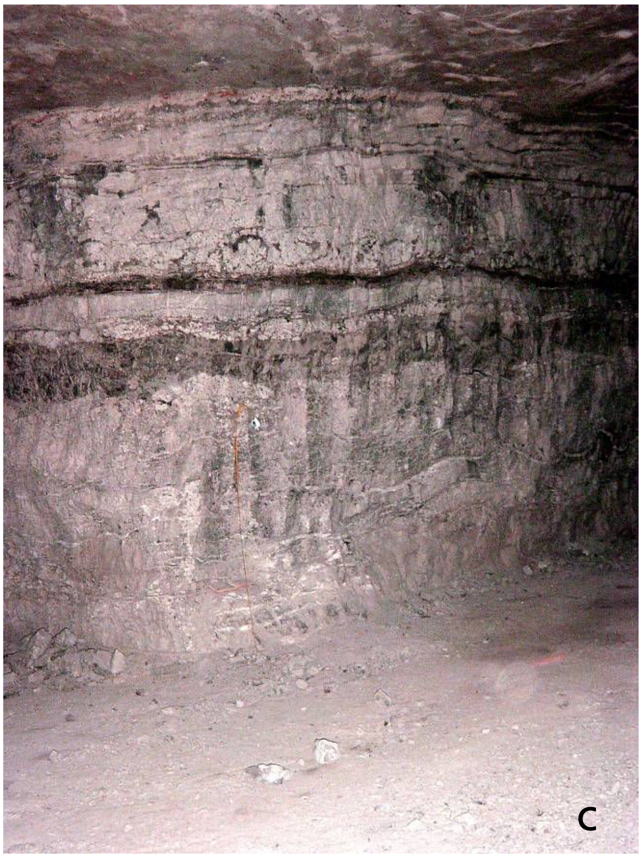


Fig 9. Three-dimensional surface drawn on the base of the no. 4 seam.



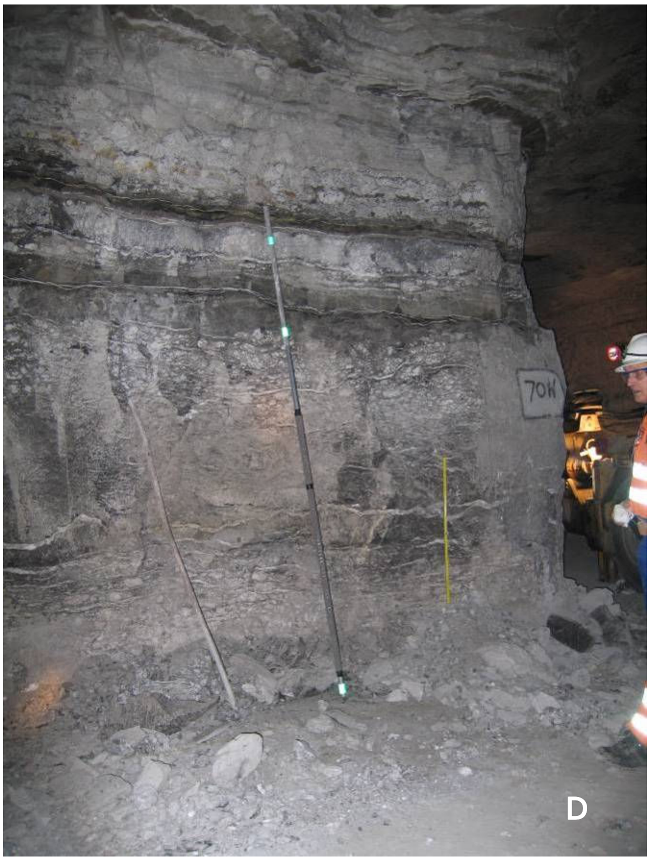


Fig 10 No. 4 Seam Brightling Mine.

A: Nodular anhydrite with gypsum prophyroblasts.

B: Algal stromatolites in dolomitic limestone

C & D: Typical seam section in current production area extraction in nos. 4 and 3 seams. The basal section is gypsum.