The explosion crater at Fauld

While in no way a natural feature, the huge crater above the Fauld gypsum mine, 8 km northwest of Burton upon Trent, is one of the more bizarre components of the East Midlands landscape. It originated in one of the world's largest explosions of wartime munitions, which were being stored in the old mine. The site has changed little since then, and still warrants a visit; there is nothing else like it in Britain.

Gypsum, alabaster and anhydrite

The Tutbury gypsum is the lower of the two major gypsum horizons within the Mercia Mudstone that have been exploited in the Trent Valley region. It lies about 35 m below the Newark gypsum, and 75 m below the Rhaetic Blue Anchor Formation, the marker horizon by which the two gypsums are always traced within the monotonous sequence of red mudstones. Both beds consist of anhydrite ($CaSO_4$, anhydrous calcium sulphate) at depth.

The original gypsum ($Ca_2SO_4.2H_2O$) was deposited by incomplete evaporation of shallow saline waters in bays temporarily cut off from the sea along the desert shorelines of Triassic Britain. Conversion of the gypsum to anhydrite occurs when the increased pressures and temperatures of burial cause dehydration during the lithification process, generally at depths of around 400 m. Re-conversion, from anhydrite back to gypsum, requires only the addition of water within the deep weathering process, and generally starts when denudation lowers the surface to within about 100 m of the mineral. Both these depth figures vary with local conditions of geothermal gradient, groundwater availability and geochemistry, and it is considered that alabaster, instead of normal gypsum, was produced by rapid, cold hydration at shallow depths in a periglacial environment (Mossop and Shearman, 1973).

Today the anhydrite survives at depth, but the outcrop along the southern slope of the Dove valley, west of Tutbury (Fig. 1), is of gypsum. This forms a variable and discontinuous bed of mineral lenses that reach up to 6 m thick. Though much of the gypsum is soft, featureless and almost chalky in structure, some of it is of the stronger, crystalline, translucent variety known as alabaster (Firman, 1984). This is highly valued as an attractive and easily carved ornamental stone. The Fauld material can provide very large blocks and is notably pure and clean, with less of the red streaking that

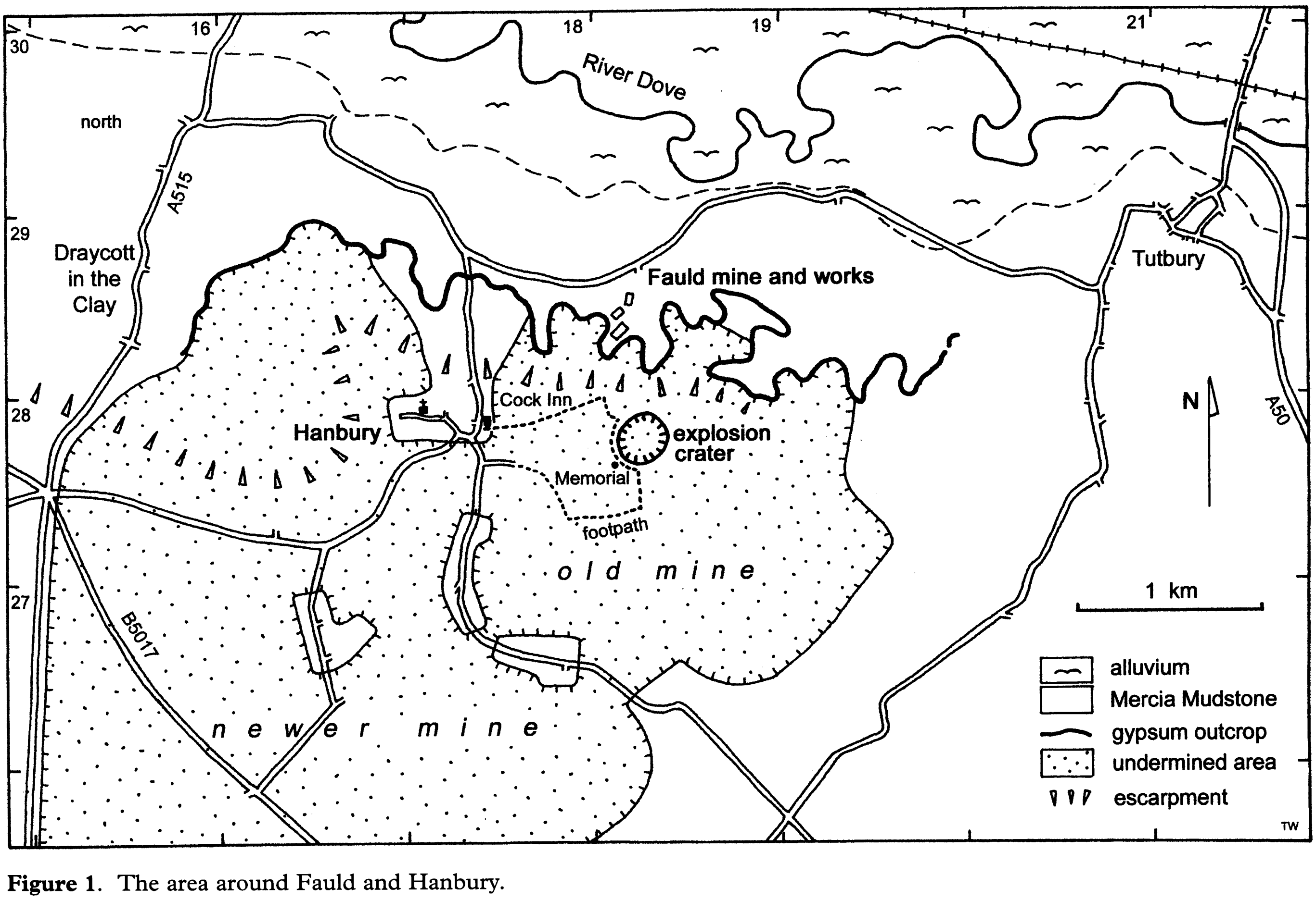

Figure 1. The area around Fauld and Hanbury.

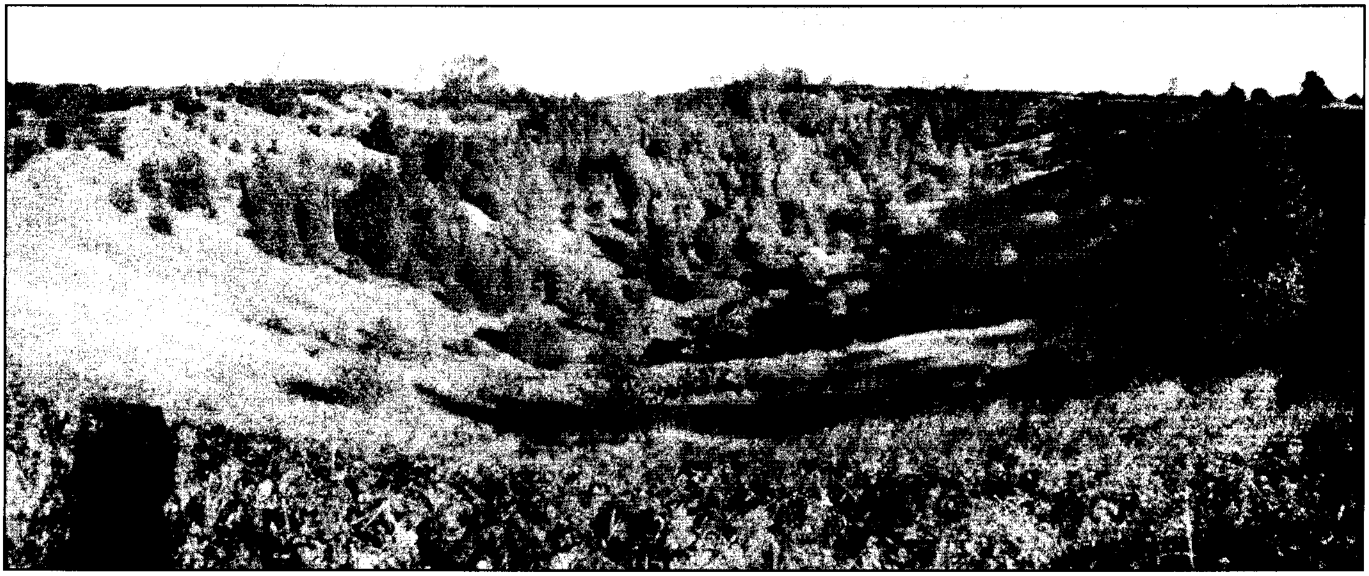

Figure 2. The explosion crater seen from its southern rim.

characterises the locally well-known alabaster from Chellaston. At Fauld, the best alabaster was found in lenses 5-12 m across, randomly distributed within the chalky gypsum.

The gypsum dips very gently to the south, and passes under the rise of a very gentle escarpment, so that its mudstone cover is up to 90 m thick a few kilometres south of the outcrop. The hills also have a thin veneer of glacial till. As the cover increases, the gypsum progressively gives way to its ancestral anhydrite. There is no clear demarcation, but an intermediate zone has a remnant core of anhydrite with gypsum at both base and top in contact with the mudstone. Joint lines also have vertical sheets of gypsum through the anhydrite, and neatly demonstrate the gradual conversion where water can reach the mineral.

Mines and mining

Alabaster was used as long ago as 1080 to build the archway over the western door of Tutbury church. The early sources were small open quarries and short drift mines along the outcrop between Tutbury and Draycott-in-the-Clay, but these are no longer recognisable. The contorted outcrop of the gypsum (Fig. 1) winds round the old quarries, with the modern and disused mine entrances at their southern ends. Further east and west the mineral bed is too thin for economic working. As time went by the mines had to extend further into the hill, and were amalgamated into fewer, larger operations. The Fauld mine dates from before 1800, when it was one of three almost horizontal drift mines into the hillside at the back of the old quarries.

All the mines are pillar-and-stall operations, whereby about 25% of the mineral was left in place to support the roof and ground above. The early workings were all for ornamental stone, and have no regular pattern, as the galleries (or stalls) followed the best quality of alabaster. The miners used blasting to excavate their headings, until they found a lens of good alabaster. Then all blasting stopped, and the stone was cut out by hand (Trafford Wynne, 1907). The roof was undercut as a "topping" slice a metre high was dug out of the poor quality upper stone. Working in this, the miners advanced until they were about 1.5 m in from the face, and then dug a gutter down to the base of the bed. They also dug out side slots. Normally the bed was about 2 m thick, and would be split free at the floor and mid-height, by hammering steel feathers and wedges into horizontal auger-drilled holes. Blocks 1 m thick, 1.5 m wide and up to 6 m long were thereby extracted intact, and hand-sawn to size, or to cut out poor stone, before being carted to daylight.

Plaster was produced by roasting gypsum and inferior alabaster, and its production overtook that of alabaster before 1900. The mines all became one and were modernised by British Gypsum, as they were extended to the southwest in a regular square grid of excavated stalls each 6 m wide between square pillars 6 m across. Production was gypsum for a plaster factory at the mine entrance, together with increasing amounts of anhydrite, which is used in cement. Small amounts of alabaster were extracted almost on demand from remaining ground in the old mine, until resources were exhausted in the early 1990s. One of the larger blocks produced in the later years was carved into a bath as a wedding present for Princess Margaret in 1960.

Today, Fauld is Britain's leading source of anhydrite, and produces no gypsum at all. The workings extend more than 6 km to the south (well off the map in figure 1), in a belt 2-4 km wide. At depths of 60-90 m the mineral is pure anhydrite. The depth also aids mine stability, as the totally unweathered roof mudstone is a strong material. Only at shallow depths, in workings many years ago, were problems occasionally encountered - with natural dissolution cavities in the gypsum and softening of roof mudstone at <15 m below rockhead. A few sinkholes developed in fields near Hanbury where weathered mudstone was met in the mine roof beneath a previously unknown gravel-filled buried valley. Except for these, subsidence has not been a big problem at Fauld. As an extra precaution, pillars of in situ gypsum have been left under Hanbury village and beneath some clusters of houses just to the south (Fig. 1). The Cock Inn at Hanbury was underpinned in 1981, but the soft weathered mudstone had probably caused as much movement as had any mining.

The explosion

In 1937 part of the old alabaster mine workings was taken over by the RAF for use as a munitions store. Up to 40,000 tonnes of bombs and explosives were stored there, all well away from the contemporary mine roadways.

On the morning of 27 November 1944, an armourer found a damaged exploder on a 450 kg bomb that was within a pile of similar bombs. It appears that he tried to remove the exploder, but used the wrong equipment (Major, 1999). At about 11am, it exploded, setting off its bomb, then the whole pile of bombs, then about 3500 tonnes of high explosive bombs stored in the immediate area of the mine.

The explosion was the world's largest accidental blast (though fortunately without the enormous death toll of the munitions ship explosion in Halifax, Canada, in 1917). It was seen or felt 60 km away, was heard in London, and was recorded on seismographs all across Europe. Well over a million tonnes of rock and soil were blasted into the sky, leaving a crater 250 m across. The bomb store in the mine had been about 35 m below the surface, and the blast hole would have reached somewhat deeper before the sides slumped in, but claims that the crater was 75 m or even 120 m deep appear to be exaggerated.

Upper Castle Hayes Farm was directly above the explosion; it completely disappeared, along with the six people in it at the time. Flying rocks damaged the church, the hall, the inn and many houses in Hanbury village. Some rock debris landed 10 km away. The dam of a small reservoir just north of the crater failed; a flood wave mixed with 50,000 tonnes of blast debris destroyed the plaster factory at the working mine entrance, killing 33 workers within. In total, 80 people died in the explosion and its aftermath.

Rocks and mud were strewn across the countryside, and the clean-up was a massive task. The Cock Inn and the Hanbury village hall were rebuilt. One section of the mine no longer existed, and adjacent areas had partially collapsed. It took a year of delicate work to remove the thousands of tonnes of ordnance that were reachable, but it is estimated that 3000 tonnes of unexploded bombs remain within the collapsed mine.

The crater today

A circular footpath has been created to make the crater rim very accessible (Fig. 1) - though wellington boots are advised for visits in the winter and wetter months. Cars may be parked at the Cock Inn, in Hanbury, where the path starts beside a notice board. It heads east across open fields and beside woodland, and then loops round the southeast rim of the crater (which centres on NGR SK183278). Large *Keep Out* signs may be appropriate in view of the unexploded bombs that must lie within. The crater is still just over 250 m across, and is about 30 m deep (Fig. 2). Its floor is a chaos of broken ground, partly obscured by trees that are now mature; blocks of white gypsum 3 m across are visible from the rim. Rotational landslides in the mudstone have modified the original blast-excavated profile, so that the slopes are now gentle and covered with plants and shrubs; they appear to have reached stability. The overall profile resembles that of old meteorite impact craters or some volcanic craters, and its sharp rim distinguishes it from typical collapse dolines in limestone.

Standing beside the rim path, a memorial to those who died in the explosion was donated in 1990 by the munitions depot at Novara in Italy, that is a sister to the RAF depots at Stafford and Fauld. It is a very fine block of white biotite granite, probably from a quarry in Sardinia.

The return path loops southward back to Hanbury, passing a small concrete blockhouse over an air-shaft into the mine. Any fields that have been recently ploughed reveal numerous small blocks of white gypsum, all of which is blast debris that originated over 30 m below ground. Even larger gypsum blocks lie beside the path, left where the farmer has cleared them from his rock-strewn fields.

Perhaps these blocks give a greater feel for the scale of the explosion, because the big hole itself is almost beyond comprehension in terms of a single blast. Even though it is man-made, the Fauld crater is now a permanent feature of our landscape.

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