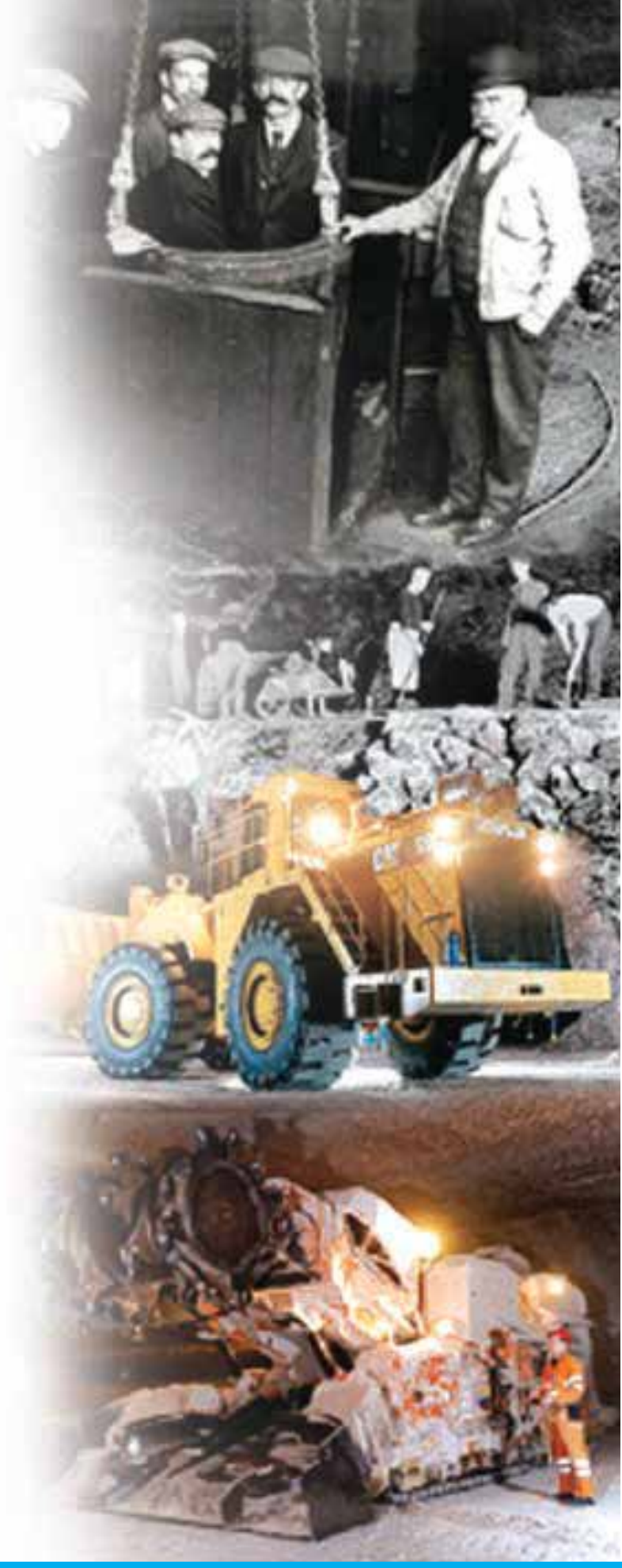
WINSFORD ROCK SALT MINE

ITS HISTORY, WORKINGS AND PRODUCTION.



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WINSFORD ROCK SALT MINE HISTORY

The beginning of the story.

Rock salt was first found in Northwich in 1670 but it wasn't until 1844, when prospectors were looking for coal with which to heat saltpans, that rock salt was discovered in Winsford.

During the 17th Century the two primary uses for rock salt were those of strengthening weak brine for white salt production and providing salt licks for cattle.

In the 1720s, the River Weaver which provided access to the River Mersey by Liverpool became a key route for salt transport, with the cattle licks being exported as far as Australia and New Zealand.

The opening of the mine.

Winsford Rock Salt Mine (or Meadow Bank Mine as it was originally known) officially opened in 1844 with the sinking of 1 and 2 Shaft. The 4ft_ shafts were lined with timber and puddle clay. Buckets were used to lower men and materials and for elevating the excavated rock.

1 and 2 Shaft were originally sunk to 65m (210ft) and then subsequently sunk to the current depth of 150m (500ft), which allows for better quality salt to be mined.

Early mining methods.

During the 19th Century mining production methods were basic but effective: between 1844 and 1892, one million tonnes of rock salt were mined at Winsford.

Black power explosives, hand picks and shovels were used to excavate the rock, which was then transported in wooden barrels. Up until the introduction of electricity to the Mine during the 1930s, tallow candles were stuck to the rock and used to light the working face. Bundles of unused candles can still be found in the old cavity of the Mine to this day!

The room and pillar method of mining, which involves leaving pillars of rock salt behind to support the roof, was adopted from the start at Winsford and, during the 19th Century, the extraction rate was high at 90% (compared to current day extraction rates of between 68% and 75%) The 'rooms' that were left behind after mining had an average roof height of 8 metres and a width of 20 metres – whilst this made for a relatively safe and easy working environment compared to coal mines, it wasn't without its dangers as candles and gun powder do not mix!

The demise of the rock salt trade.

During the late 19th century the salt industry descended into chaos due to over-capacity. In 1888, Salt Union, which consisted of 66 salt operators from the area, was formed in an attempt to bring order to the market.

However, with salt also being supplied from the Northwich Mines, the market remained over-supplied. Despite having mined out some one million tonnes of rock salt, the Winsford Mine was shut down in 1892.

In 1928 the last mine in Northwich flooded, resulting in the re-opening of the Winsford Mine. The Mine re-opened with technology on its side and to a new era and rapid expansion of the mine began in the 1950's due to the use of rock salt to de-ice the country's expanding road network system. It has since grown steadily and, today, the Mine at Winsford now stretches 5km east to west and 3 km north to south.

Further information on how the Mine advanced in technology to its current day practices using the Continuous Mining Machine, can be found in the Production Methods section of this document.

GEOLOGY

Early formation of rock salt.

Salt at Winsford was formed some 220 million years ago during the Triassic geological period. At this time the United Kingdom was still attached to Europe, and central England consisted of a series of inland seas that were regularly replenished by the surrounding seas. The combination of the inland seas and the desert environment led to slow evaporation over many millions of years, resulting in the formation of the salt beds which lie under Cheshire and the surrounding areas. During this process, substantial quantities of sand blew in from eastern deserts, helping to create the pink tinge by which Winsford rock salt is recognisable today.

Although the original salt bed is now fragmented, it can be traced from its starting position in Carrick Fergus, Northern Ireland, from where it dips below the Irish Sea before reappearing around central England to then dip under the North Sea. The final part of the salt bed lies across Europe and, in fact, Scandinavia is the only European country without its own natural salt supply.

Winsford's rock formation.

The final rock formation at Winsford has four distinct rock salt seams or 'halite' as it is known (halite is taken from the Greek word 'hals', meaning salt). Each rock salt seam averages 25 metres (80ft) in thickness.

The remaining strata consist of rock salt with Keuper Marl bands and Keuper Marl (see diagram). The youngest of the Triassic rocks in the series, Keuper Marl is usually amber or brown in colour, although on occasions it can be blue or green. Due to many of the influencing geological aspects, the colour of Winsford's salt varies greatly – it can range from clear to pink through to dark brown, although a mixture of dark brown and pink is most commonly found.

Whilst Marl is impervious over time water has penetrated the exposed salt beds, dissolving the salt and creating a' wet rock head' above the Mine. This resulted in wild brine springs presenting themselves on the surface, and it is this brine source that was used for white salt production during the 19th and early 20th Century. The overuse of wild brine springs led to subsidence in many of the local areas over the years, with the result that wild brine pumping is now prohibited and has been replaced with a controlled method of brine removal using boreholes known as 'solution mining'.

The effect of Winsford's geology on its mining operations.

The beds of salt worked at Winsford are relatively flat (see diagram). There are two economically workable beds of salt known locally as Zone 'B' and Zone'F'. These beds lie between 130 and 220 metres below the surface. As discussed earlier the bed is, on average, 25 metres thick but the purest salt is located in the lower part of the bed.

To access the working areas in the Mine it is necessary to navigate through 'folds' in the rock. A 'fold' is the result of ground pressure forcing the rock to bend up or down and, if there is enough pressure, the plastic properties of rock salt and the denser surrounding rocks can force the fold to the surface where it manifests itself as a salt dome. Examples of this can be found in South America and the North Sea. Whilst there was insufficient pressure for a salt dome to form in the Cheshire salt beds, at Winsford we do have a series of monoclinal folds running in the east to west direction.

The Mine is also dictated by another geological feature - 'faults'. Faults are again caused by pressure but, unlike folds, the pressure build-up becomes too great and causes the bed to break away. During this period the bed may rise or fall as a result of the break away. At Winsford the Mine is bounded by two major downthrow faults on the east and west. These are known to be 'competent', which means that the break in the rock has not created a pathway for water or posed any other threats to the Mine's stability. However, despite our favourable geology, we do not mine beyond the fault lines.

Due to the folds and fault lines present at Winsford, careful exploration for future workings must be taken. Rotary-drilled boreholes from the surface are made every 500 metres or more frequently if a fold is detected. Horizontal and vertical boreholes are also taken at intervals from the faceline in order to confirm the location of the working horizon within the bed, and these investigations are supported through the use of seismic surveys.

SHAFTS

How the Mine workings are accessed.

The Mine at Winsford has always been serviced by vertical shafts. As discussed in the history section the original shafts, 1 and 2, were installed in 1844 and continued to elevate the bulk of production, despite the sinking of 3 Shaft in 1941. Amazingly, 1 & 2 Shaft remained in use for nearly 130 years before being sealed and grouted in the 1970s.
The original shafts were ultimately replaced by 3, 4 & 5 Shaft.

No 3 Shaft – personnel access.

No 3 Shaft, as with all the subsequent shafts, is circular in cross-section. The shaft was originally brick-lined but was later reinforced with a concrete lining. The diameter is 3.05 m (10ft) and the depth, including the sump, is 163m (550 ft) although the decking level is around 150 m (500 ft).

No 3 Shaft is currently used for personnel access but the original lift has been upgraded. The original comprised two double-deck cages operating in balance running on steel rail guides and driven by a single-drum, manually controlled winding engine. The lift was replaced in the 1970s by a fixed self-service lift, similar to a car park lift. It is unusual to find a fixed lift cage in a mine but the stability of the rock salt at Winsford affords us this luxury.

The lift takes approximately one minute to descend.

No 4 Shaft – ventilation and material access.

No 4 Shaft, installed in 1963, is the downcast shaft situated one mile away from 3 Shaft. The shaft is significantly larger, measuring 4.88m (16ft) in diameter, and has a concrete lining. The total depth of the shaft is 189m with the decking level situated at 183m. The lift consists of a cargo compartment (lower), measuring 7 metres in height, 2.4 metres in width and 4 metres in depth, with a personnel carrier (upper). The lift takes approximately five minutes to descend.

No 4 shaft serves as the principal service shaft, by means of which the majority of underground equipment and materials are brought into the Mine. All major mechanical items for use underground are dismantled into suitably sized component sub-assemblies at the surface and placed into the cargo compartment via transit capsules, forklift trucks or hoisting

Once the equipment arrives at the base of 4 Shaft it is transported to the underground workshops for assembly.
Due to the process required to bring machinery into the Mine, the majority of machines never leave it.

No 5 Shaft – rock salt elevation.

No 5 Shaft, the last shaft to be installed, was completed in 1973. It is positioned approximately 100m north of No 3 Shaft. The shaft dimensions are similar to 4 Shaft - 4.88m (16ft) in diameter with a concrete lining and an overall depth of 164.5 m. 5 Shaft's primary function is the elevation of the finished rock salt.

No 5 Shaft consists of a winding engine and two cage over skip combination units suspended on ropes, which operate in balance. The skip loading station is located 155m below the surface, with the skip portions being of the bottom-dump type and each having a capacity of 9 tonnes. The rock winding process is completely automatic, although it can be manually controlled when necessary for maintenance, personnel riding or shaft inspections.

VENTILATION

How the Mine is ventilated.

In every underground Mine fresh air must be introduced to dilute and flush out fumes generated by diesel vehicles and shotfiring. This is particularly important at Winsford, as the Mine uses the largest wheeled loading shovel underground in the United Kingdom, which runs on diesel.

Ventilation requirements can vary due to the rate of rock salt production and diesel vehicle movement, but there are always minimum requirements needed for general day-to-day operations.

No 4 Shaft serves as the main downcast shaft. Here the two fans are located at the shaft bottom underground and these operate in parallel. The larger fan is fitted with a baffle-type silencer to reduce the noise level in the shaft bottom area.

On average, the fans deliver between them 135 cubic metres of fresh air per second.

Maintaining a constant temperature of 14ºC.

Air drawn into the Mine is initially circulated through specially constructed air conditioning tunnels, known as the de-watering tunnels. This enables any excess moisture contained within the air to condense in a controlled manner, thus minimising its effect on the Mine. The rock temperature stabilises the Mine air temperature to a constant 14ºC. Once the air has left the de-watering tunnels it is directed to the faceline, from where it begins a nine-hour journey around the perimeters of the Mine workings.

Due to the vast expanse of void space at Winsford (23 million cubic metres) the airflow needs to be channelled. This is achieved through the combined use of auxiliary and booster fans positioned around the Mine; heavy duty PVC and Hessian brattices hung between pillars and automatic roller shutter doors.

Overall, the salt beds at Winsford provide a very safe natural environment and we do not have to contend with methane and gas issues which can occur in collieries or other mines. However we still monitor constantly and frequently take air samples to comply with statutory requirements.

STRUCTURE

How the Mine is supported.

Since the Winsford Mine opened in 1844, extraction of the salt has been via a square-patterned room and pillar method of mining. The pillars of rock salt left behind support the roof structure, whilst the connected rooms of void space provide tunnels for access – on the last count these were in excess of 137 miles.

The 19th and early 20th century workings comprised one large cavity (known as old cavity), based around 1 & 2 Shaft, which is still stable and fully accessible today.

Determination of pillar sizes.

During the 1950s the decision was taken to regulate the size and location of the pillars and our current extraction rate is between 68% and 75%, although this is dependent on several factors, mainly those concerning the depth of the salt bed and surface geography.

A considerable amount of work has been carried out since 1958 by staff of the Mining Department at Newcastle University, with investigations undertaken into the rock mechanics for designing the Mine workings. In particular, instruments were developed to measure rock creep and strata deformation in strategic places in the Mine. Although Winsford has a long history of stability, it is the nature of rock salt to creep (move) over time and this must be constantly monitored.

Over a long period of time the results from these investigations and other measurements have provided a bank of knowledge when deciding on the size of pillars in new mining zones and, ultimately, the long-term stability of Winsford. Today, a typical void space left behind after extraction is 20m wide x 8m high, with 20m_ pillars being left to support the over-burden. The system at Winsford does not have to use roof bolting, metal mesh or pillar supports.

PRODUCTION METHODS – DRILLING AND BLASTING

For nearly 70 years the mining method for winning rock salt at Winsford was through the use of drilling and blasting techniques with the aid of machinery. Although technology in the 1930s wasn't as sophisticated as it is today, the fundamental technique didn't vary, although over the years bespoke machinery was developed for Winsford.

The production sequence was essentially a five-stage process - undercutting, drilling, blasting, loading out and scaling.

To see Drilling and Blasting in operation please refer back to the home page of the website and select 'video clips'.

Undercutting.

Before undercutting began, the surveyors would mark out the face with spray paint, to ensure that operations were carried out at the correct mining horizon. This was done at the start of each morning as there could be up to seven faces to be worked on.

The undercutter was then brought in. This looked and cut like a giant chainsaw, but used tungsten cutting picks instead of blades. Its purpose was to create a 4.6m deep slot for blast relief and, throughout the majority of the Mine workings; this 'stepped' effect can be seen.

Drilling.

Once the floor had been undercut, a drill was used to create a 'drag cut' pattern of holes in the face. This means that the first half of the face was drilled horizontally and the latter holes angled towards the floor. The 'drag' was created by the final holes almost meeting with the undercut floor, which would drag the salt out when the shot was fired.

Although many different types of drills were used over the years at Winsford, the last drill was a computer controlled hydraulic drilling jumbo, powered by electricity but driven using a diesel engine.

The jumbo had two drilling arms that measured the size of the face from the surveyor's centre line and then transferred this information to the on-board computer, which stored the drill patterns. The drilling arms began to operate independently and would drill approximately 70 holes. The rig had an air flushing facility to enable the salt cuttings to be removed from the drilled holes in preparation for charging with explosives.

Blasting.

Using a platform, the shotfirers charged the holes with explosives and electronic detonators then initiated the blast. The bottom row of holes would be the first part of the sequence to be detonated; this was to ensure there was sufficient clearance at the face for the remaining rock to fall as a pile, and not to project outward of the tunnel.

A typical blast would yield 1,250 tonnes of salt. It was customary for blasting to take place at the end of the shift around 3pm, following which it was the duty of the shotfirers to check that the surrounding area was safe and stable for loading out to take place.

Loading out.

Once the area had been cleared by the shotfirers it was safe to enter and remove the rock salt for processing. This was carried out by varying sizes of wheeled loading shovels machines, which loaded from the front using large buckets. Today, Winsford has the largest wheeled loading shovel in any underground mine in the United Kingdom – the Komatsu WA800 which has the capacity to carry 18 tonnes of rock salt in its bucket. *(Continued on next page...)*

PRODUCTION METHODS – DRILLING AND BLASTING

Loading out (Continued).

Up until 1978 the wheeled loading shovel machines loaded the broken rock salt into Foden dump trucks, which hauled it to the crushing plant. From 1978 this was superseded by the feeder-breaker system, which enabled the rock salt to be put directly onto conveyor belts that led to the plant. This significantly reduced diesel fumes within the Mine and speeded up the production process.

Scaling.

Scaling of the blasted areas was required to remove any loose rock and to make the area safe. In the earlier days teams of hand scalers standing on a platform carried out this process. Later, the introduction of mechanical scalers quickened the process up and created a safer roof, as the picks on the rotating barrel scraped the whole roof and not just the loose rock. As mentioned earlier, scaling does not need to be followed by roof bolting at Winsford because of the competent beam of salt left in the Mine roof.

The crushing and screening process has not changed over the years. Please refer to the end of the next section, 'Production – Machine Mining' to complete the production cycle.

MACHINE MINING PRODUCTION

The Continuous Mining Machine.

In January 2002 Salt Union Ltd purchased a Continuous Mining Machine (JCM) to replace the traditional method of salt extraction via drilling and blasting. This was to be the most significant change to production methods ever seen at Winsford Rock Salt Mine.

Many mining machines were considered during the selection process, which eventually lead to the purchase of a JOY 12HM36, with 'JOY' being the name of the manufacturer.

This was followed by a second JCM in 2011 and a third JCM was added in 2014.

How the JCM works.

The JCM system is a single drumhead miner weighing in at 130 tonnes, with a total installed power of 1,005 Kilowatts (1,345 horsepower). The tungsten steel cutting picks fitted to its drum are short and sharp and these claw away the rock salt as the machine head moves up and down.

The rock that is cut by the JCM is loaded directly onto the Bridge Belt Conveyor. The Bridge Belt Conveyor acts as an 'arm' attached to the back of the machine, enabling the rock salt to travel directly out of the back of the JCM and onto the conveyor system, without the need for shuttle cars or loading shovels. It is fixed to the walking tail end, which allows it to move back and forth.

How the JCM advances deeper into the tunnel.

To enable the JCM to advance into the tunnel, an operator uses manual controls located on a platform at the back of the walking tail end. The base is lifted up on rails both sides and pushes forward on cylinders which enable it to 'walk'. Fixed conveyor structure is added in the gap created by the walking tail end.

Cutting Pattern.

To continue with the 'room and pillar' method of mining, a work pattern has been developed to minimise unnecessary set-up/movement of the JCM. The JCM's maximum cutting height is 4.6m (14ft) but at Winsford the average requirement for room height is 8 to 9 metres.

In order to achieve the correct roof height the JCM must cut the rock in two stages, the first of which involves removing the rock that is positioned in the upper 4.6 metres. The JCM cuts into the rock salt on a gradual gradient, creating a ramp that enables it to begin cutting the upper section. The machine then remains at this height until it has removed the entire tunnel (1km or 3/4 mile).

Pillars are created by cutting cross cuts at right angles to the main roadway. Due to the machine reach the pillar forming sequence only becomes complete once the cross cuts are joined up, following the removal of the parallel tunnel.

After the tunnel has been cut the JCM is driven out and the conveyor system dismantled. Stage two involves the removal of the lower section of rock and, to achieve this, the JCM and associated systems are set up again at the start of the tunnel. Cutting begins with the removal of the ramp followed by the rest of the tunnel.

To see the Continuous Mining Machine in operation please refer back to the home page of the website and select video clips.

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MACHINE MINING PRODUCTION

Crushing and Screening.

Once the rock salt has left the working face it is carried on the conveyor system to the underground crushing and screening plant. To avoid any waste metal entering the crushing plant, the rock salt is conveyed under metal detectors and magnets at three different points. A series of crushers and screens then reduce the size of the salt and separate it into 0-6mm and 0-10mm product.

The crushing plant and all the conveyors are automated and controlled from No 5 Shaft surface, where a controller monitors underground activity via television screens and passes any requests via radio.

Product Elevation.

The finished product leaves the crushing and screening plant via a conveyor leading to No 5 Shaft, from where it is elevated to the surface in 9-tonne bottom dump skips. Once the skip reaches No5 Shaft surface it discharges onto a conveyor which takes the salt to surface. En route, it is sprayed with a small dosage of a basic anti-caking agent, a treatment that enables rock salt to flow freely out of the gritter despite being stockpiled.

Surface despatch and stockpiling.

Surface stock levels are put in place ready for the start of the winter, enabling Compass Minerals to despatch product to customers with immediate effect during heavy winter demand. Additional salt is always readily available from both underground stocksand as a result of ongoing production. Compass Minerals business is wholly dependent on the severity of the winter and we must always be prepared to provide salt to our customers at a moment's notice!

The rock salt is despatched to customers within the UK mainly via 28-tonne tipper trucks, although a small percentage is also transported by rail. Due to surges in demand we operate a computer-based stock management system, into which customers input their usage and rock salt is sent out accordingly. The stock management system, combined with encouragement to restock during the summer months, ensures that Compass Minerals is always able to meet demand.

For further information about Compass Minerals business operations please refer to the main Compass Minerals site:
www.compassmineralsuk.com