THE GEOLOGY OF THE M.1. MOTORWAY IN NORTH LEICESTERSHIRE AND SOUTH NOTTINGHAMSHIRE

by

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Summary

The construction of the M.1. Motorway has provided numerous temporary excavations in Permo-Triassic rocks in areas where the detailed stratigraphy was little known. The rocks of the Keuper Series were exposed south of the River Trent, from the Waterstones Formation at Kegworth to the overlap of the Charnian Rocks by high formations of the Keuper Marl, south of Shepshed. North of the River Trent, the passage of low formations of the Keuper Marl down through the Waterstones and Keuper Basement Beds to the Pebble Beds was displayed in an almost continuous section. After crossing Coal Measures the Motorway continued on Upper Permian Rocks, exposing a new facies of the Lower Magnesian Limestone near Strelley, and at Nuthall, an almost complete sequence of Permian rocks with their unconformity on Middle Coal Measures.

Introduction

During 1963, 1964 and the first half of 1965, the construction of the M.1. Motorway through North Leicestershire and South Nottinghamshire has provided a unique geological traverse of this area, in the form of the numerous cuttings and drainage trenches excavated during the early stages of road construction. These excavations are on a scale approached previously only when the railways were built in the late 19th and early 20th centuries. Work in the area began in 1961, when the major bridges for the Sandiacre - Stapleford By-Pass were constructed; this excludes the bridge over the motorway at the three-level interchange at Sandiacre, begun in 1963.

The geology of the area through which this section of the motorway passes was described by Fox-Strangways (1900 and 1905) and by Gibson et al. (1913). Detailed accounts on the geology of the ancient rocks of Charnwood Forest have been published by Watts (1947); a paper by Bosworth (n. d.) describes in detail the Keuper Marl / Pre-Cambrian unconformity. Adjacent areas to the Motorway have been described by Taylor (1964, 1965), and mention was made of the geology of the M. 1. route in a general article on the motorway by Osborne (1960).

This article records the details noted from regular visits to the sections of the M. 1., from the northernmost Pre-Cambrian exposure, close to the Charnwood Granite Company quarries (SK 491173), to the junction of the M. 1. with the A. 610 trunk road at Nuthall (SK 516445), a distance of 19 miles. The road crosses the River Trent at Sawley (SK 466309) and the River Erewash at Stanton Gate (SK 382484). The details of the route are illustrated in Text-fig. 1.

The East Midlands Geological Society visited the excavations on June 6th, 1965; this article includes, substantially, the record of that meeting, but additional exposures are mentioned which were either available before that date or which were cut after it.

Rocks encountered during the excavations included glacial boulder clays and gravels, recent river gravels and alluvium, Triassic and Upper Permian Rocks, Lower and Middle Coal Measures, and the Pre-Cambrian Rocks of Charnwood Forest. Only superficial comment is here made on the Pre-Cambrian Rocks, as a more detailed study of them is in progress at Leicester University. The Coal Measures were largely excavated prior to motorway construction by opencast coal mining; little undisturbed ground remains, but one or two exposures of interest were uncovered and are described. The greater part of the article is concerned with the Permo-Triassic exposures.

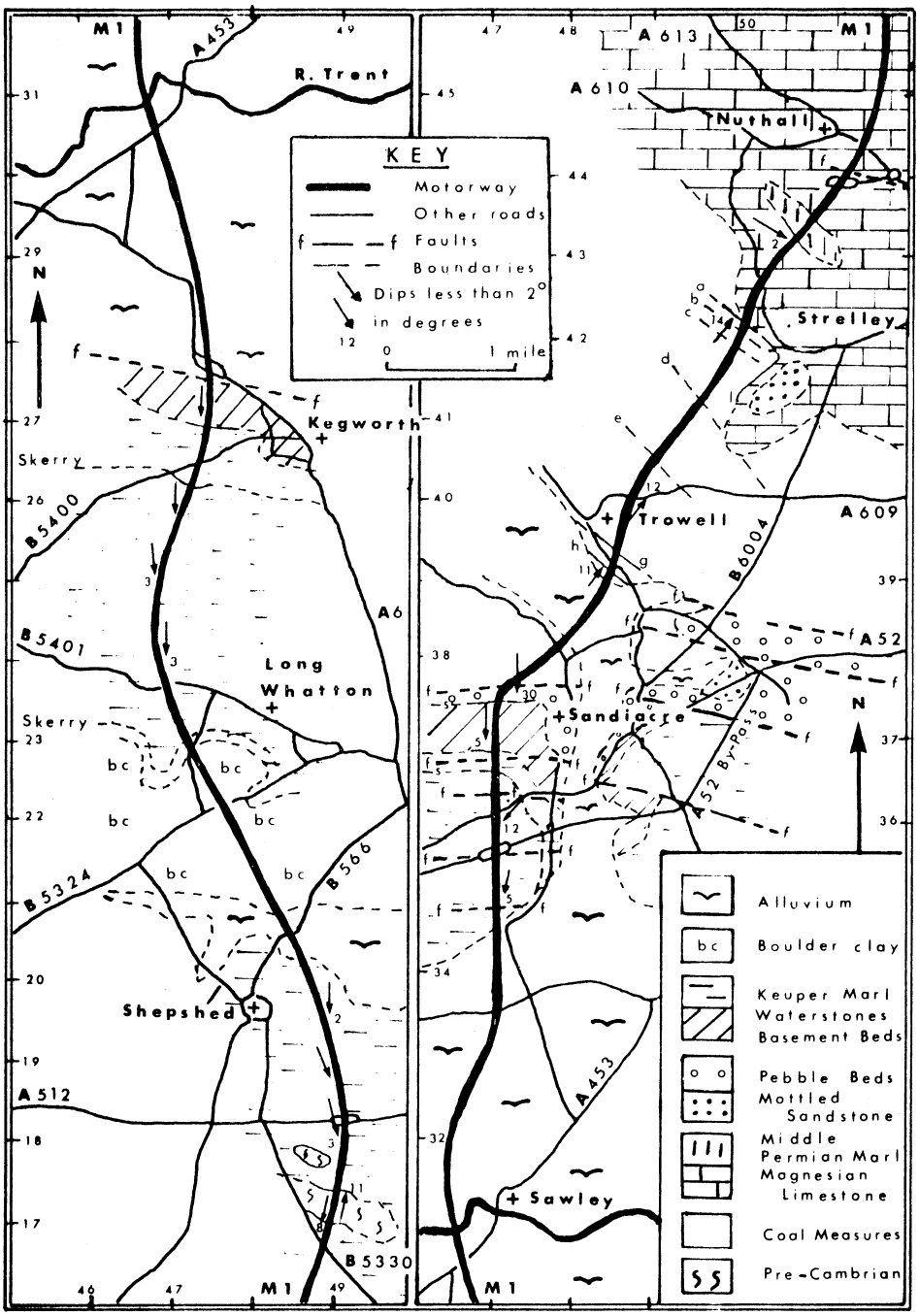
Detailed geology of the Motorway

The Motorway south of the River Trent

Of the three main cuttings in Charnwood Forest, the one just south of the junction of the motorway with the A. 512 (SK 491173) was chosen as the starting point for the examination of the Triassic deposits, which extend continuously northwards to the River Trent. The Pre-Cambrian rocks were seen to be mainly syenites, similar to those of the adjacent Charnwood Granite Company quarries (SK 487180); in addition there were altered bedded deposits (hornfels) showing a steep northerly dip and the contact of the hornfels with the syenite. Overlying these rocks are basal Triassic deposits exposed on both the north and south sides of the cutting and showing breccias in contact with the upper surface of the Pre-Cambrian rocks. As is usual with the Triassic breccias of this area, its fragments were largely composed of local rocks, in this case of syenite and hornfels derived from the adjacent rock outcrops, the remains of local scree deposits. Here indeed, the classic unconformity of the Charnwood Forest region, described so meticulously by Bosworth(n. d.), was well displayed in a new excavation. The footings for the bridges over the B. 5330 (SK 489166) and under the A. 512 (SK 491183) were dug mainly in red and green fine - grained siltstones and mudstones, and failed to reach the Pre-Cambrian rocks. Nothing was found which would indicate the horizon of the Keuper Marl which overlapped onto the older rocks at these localities.

North of the A. 512, the red and green siltstones were exposed in shallow excavations, with dips of two or three degrees to the south-south-east. After crossing a small steep valley east of Shepshed, finer grained rocks, dark red and green mudstones with thin skerry beds (grey-green dolomitic siltstones), were exposed at the summit of the next ridge (SK 488198).

A major lithological change occurred to the north of the B. 588, where the motorway passes through Piper and Oakley Woods (SK 480215), cutting deeply into boulder clays. The realignment



Text-Fig. 1. The Geology of the M.1. Motorway in North Leicestershire and South Nottinghamshire.

a = Top Hard Coal; b = Dunsil Coal; c = 1st Waterloo Coal; d = Clay Cross Marine Band; e = Deep Hard Coal; g g = Black Shale Coal; h = Ashgate and Mickley Coals; s = Skerry in Keuper Marl.

of B. 5324 and local access roads provided extensive excavations in this material, to a depth of 20 feet. The boulder clay contained numerous erratics, including chalk and flint; Gryphaea sp., belemnites, brachiopods and oolitic limestones (Jurassic); blocks of Triassic marls and skerries; Coal Measures sandstones and coal; dolomitised limestones, cherts and cherty limestones with corals from the Carboniferous Limestone. All these fragments were embedded in a fine grained blue clay which weathers brown. Records of chalky boulder clay are not very common west of the River Soar; similar deposits are known well to the north at Risley (Swinnerton 1948, p. 77) and to the south at Coton Park and Cole Orton (Fox-Strangways 1900, p. 39, and 1905, p. 39). The deposit excavated on the motorway thus increases the known distribution of chalky boulder clay; the chalky material must be derived from the east. The inclusion of Carboniferous fragments therefore illustrates the complex nature of the deposit, for this material seems to have come from the north. There was no obvious division between clay containing only Mesozoic fragments from that containing essentially Carboniferous fragments.

The Keuper Marls return again north of the B. 5324, at the bridge taking the motorway under the unclassified road to Long Whatton (SK. 473228). The top of the cutting here is in sandy drift deposits, with numerous pebbles. Near the bottom of the cutting a thick series of skerry beds were uncovered, individual layers attaining thicknesses of 12 inches. These skerries are grey-green siltstones and sandstones often containing dolomite, gypsum and calcite. The thicker beds were very porous and contained voids in the rock up to $\frac{1}{4}$ inch diameter. Other beds contained gypsum nodules of about the same size; presumably leaching has removed the gypsum in some cases to create these voids. The skerries outcrop in the road leading to Long Whatton and have been seen in drainage trenches for new housing estates to the south of the village (SK. 477236); the skerries can therefore be grouped as the Long Whatton Skerry. In its general lithology this compares closely with the Cotgrave Skerry described by Elliott (1961, p. 220). Older beds, mainly red marls with thin green beds and dolomitic seams, outcrop to the next bridge (over the B. 5401).

To the north only shallow cuttings in red marls occurred until the larger excavation between Highfield and Mole Hill Farms was reached (SK. 472259). In this cutting another series of skerry beds were exposed. This is a thicker sequence than at Long Whatton and again many of the sandstones were porous. No gypsum nodules were located in this locality, but there were examples of salt pseudomorphs and ripple marks. The skerries outcrop to the south of Kegworth and can be referred to as the Kegworth Skerry. In a general way the lithology of the skerry is similar to the Plains Skerry described by Elliott (1961, p. 218) but not all the structures normally associated with the Plains Skerry in the Nottingham area were found on the motorway site.

Lower beds in the sequence were examined in the motorway cutting northwards to the B. 5400. At the bridge, (SK. 474265) the appearance of laminated siltstones and mudstones suggest the lowest beds of the Keuper Marl and north of the bridge the junction of the Keuper Marl with the underlying Waterstones is crossed. The top beds of the Waterstones are red shales and micaceous siltstones, and thin sandstones. The lower, thicker sandstones which are typical of the group were presumably not reached by the excavations in this cutting.

Further north the motorway is built on the embankment which will take it across the Trent flood-plain, which commences at the Lockington interchange junction (SK. 475276). Shallow boreholes indicate that the greater part of the flood-plain overlies Keuper Marl, which means that a fault north of Kegworth re-introduces this series of beds. Nothing is known of the horizons of the Keuper Marl which are present, as the bore-hole programme was concerned mainly with determining the depth of the gravel deposits. It is known, however, that Keuper Marl with the Tutbury Gypsum outcrops at Radcliffe-upon-Soar, to the east of the motorway, and also at Chellaston to the west, so that the Keuper Marl here (immediately north of the Kegworth fault) and mid-way between the localities may also be at about the same stratigraphical level.

Beyond the Kegworth fault are the lowest horizons of the Keuper Marl and to the south again the sequence of Keuper Marls is ascended up to the skerry at Long Whatton. From there to the Hathern - Shepshed road, the horizons overlain by the boulder clay can only be surmised; presumable younger horizons. No records of the Tutbury Gypsum are known from this area or from the area south of the Hathern - Shepshed road, but the Keuper Marl here may well be of this age.

The motorway north of the River Trent

The motorway crosses the River Trent in a broad curve at Sawley, the first cutting being excavated at Wilsthorpe Lodge (SK. 471351). The Keuper Marls were exposed in the cliff below the Lodge and consisted mainly of red siltstones and mudstones with occasional laminated beds. A feature of this section was the faulting which affected the rocks. In the 100 yards long cutting there were four small faults, but without the assistance of marker beds it is difficult to estimate their throws. The marl dips at 3 or 4 degrees to the south, so that older beds are encountered to the north. At the A. 52 By-Pass bridge (SK. 471356), the mudstones were affected by small scale puckering, minor folding and further dislocations. Continuing northwards, the dip of the beds increases to a maximum just south of the old A. 52 bridge (SK. 472361). The amount of dip here was 12 degrees to the south-west.

The structure described indicates movements in beds which are famous for their low dips and absence of faulting. Unfortunately the absence of marker horizons makes it difficult to estimate the combined effect of the structures. The absence of skerry beds in this section suggests that the overall effect is to cause repetition of the sequence.

The first series of skerry beds occurs at road level, at the base of the cutting just north of the bridge carrying the old A. 52. The rise of these beds to the top of the cutting is accelerated by a number of small faults. Having attained the ground surface level, the skerries form the surface to a small east - west valley, utilised by the Stanton road (SK. 472369). The only sedimentary structures found in these beds were miniature ripple marks. Minor faulting occurred throughout this section and as the next beds seen north of the Stanton road are close to the Waterstones, it is possible that a small fault, downthrown to the south by about 20 feet occurs to the south side of the valley.

Below the skerry beds, large nodules of hard marl contained veins of fibrous gypsum. This was the only occurrence of gypsum of this type in the motorway section.

Mention can now be made of the stratigraphical position of the Keuper Marl north of the River Trent. The lowest beds are at the Stanton road bridge and the youngest at Wilsthorpe Lodge, with a series of skerry beds dividing the sequence into two parts. This skerry outcrops to the west of the Erewash valley, where it created water problems during the construction of the A. 52 By-Pass road. The skerry would seem to have a similar stratigraphical position to that exposed in the Chilwell Brickworks (Taylor, 1964 p. 26) and to that exposed to the south of Kegworth, although the marls below the Sandiacre Skerry may be a little thinner.

The abutments for the Stanton road bridge were excavated in laminated marls and siltstones. At road level the siltstones are micaceous and a little to the north there appear the first yellow, fine grained micaceous sandstones. This is the Keuper Marl/Waterstones junction. The main mass of Waterstones, about 35 feet thick, appear as the road begins to turn to the east and were well exposed in the cutting, eventually reaching the ground surface level on the west side of the motorway overlooking the Golf Course (SK. 478382). Diligent search failed to locate fossils but some of the thicker beds contained well-formed calcite and gypsum crystals in small voids within the sandstone. No conglomerate occurs at the base of the Waterstones.

The lowest beds of the Waterstones overlies a thick (3 feet) bed of coarse yellow friable

sandstone. Lower beds consist of thin dark red marls and similar sandstones alternating for about 15 feet. These appear to be the local representatives of the Keuper Basement Beds. The road now trends to the north-east and the lowest Triassic beds seen on its line are the Pebble Beds, which can be seen exposed at The Cloud (SK. 477377) on the east side of the motorway. The first layer of large pebbles was taken to be the junction of the Keuper Basement Beds with the Pebble Beds. The Pebble Beds at The Cloud have abnormally high dips, 35 degrees to the south; only the upper beds are exposed, forming a cliff-like feature overlooking the Erewash Golf Course and the Erewash Valley. The dip of the beds and a feature indicate the location of a large east-west fault which separates the Pebble Beds from Upper Carboniferous strata, to the north. The fault was not exposed by the road works, as an embankment commences at about the point where the fault would have been expected.

The motorway now turns towards Stanton Gate (SK. 480381) and the River Erewash. An old quarry, situated on the Erewash Golf Course (SK. 472378), probably marks the outcrop of the Crawshaw Sandstone and bore-holes have located the principal marker horizons of the Lower Coal Measures in the Golf Course area, including the Alton Marine Band and the Kilburn Coal.

The motorway north of the River Erewash

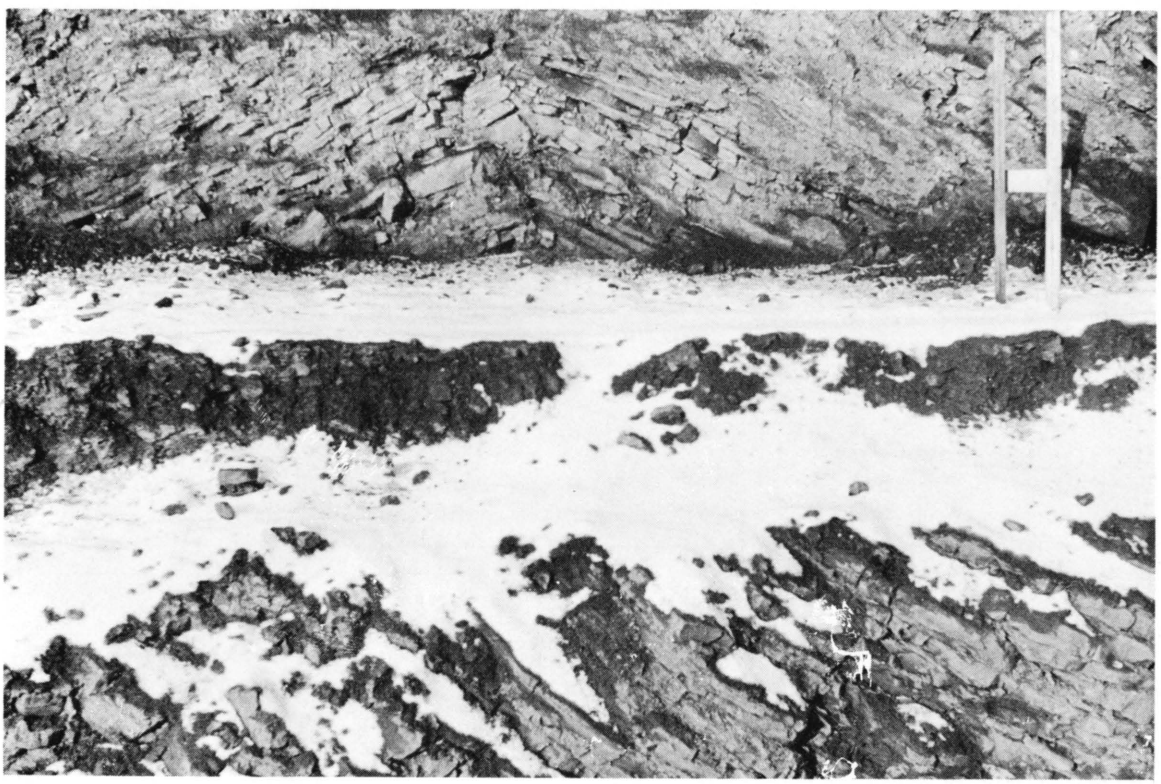
The River Erewash flood plain is much less extensive than that of the River Trent. Even so, it obscures outcrops for almost a mile. The next series of cuttings are at Trowell (SK. 487393) where the motorway has been driven below the B. 6003 and the adjoining railway line. The cutting exposed two thick coal seams, separated by only 10 feet of mudstones. Both these coals were of good quality; they were encountered along the length of the motorway as far north as the road bridge. Above the coals were a thick series of mudstones which graded up into sandstones. These rocks form the feature to the east of the motorway, overlooking the Erewash Valley. The excavations under the road show that a small fault occurs downthrowing to the north, and a third thick coal outcrops just beyond the railway bridge. This coal, about 5 feet 6 inches, is of very poor quality and is almost certainly the Black Shale Coal. The other coals are lower in the sequence and will probably be the Ashgate Coal with the Mickley Coal below.

The motorway now climbs to ground surface level and crosses over the A. 609 (SK. 489400). In the road cutting of the A. 609 are outcrops of the next important sandstone horizon, the Tupton Rock. The coals associated with this sandstone are below road level. The motorway now enters extensive open-cast coal sites, with much of the ground, forming the route of the motorway, 'backfilled' after the coal has been removed. The Clay Cross Marine Band was seen at the south-east end of Shortwood (SK. 495410; Motorway Services site) (personal communication from Mr. J.A. Smart of the Geological Survey) and the Catstone Hill opencast sites have excavated the Ell Coals, Waterloo Coals, Dunsil Coal and the Top Hard Coals (an ascending sequence).

Throughout this much excavated ground only small isolated areas of rock remain 'in situ' One of these was protected by a bridle path (SK. 453423) near Strelley and when the motorway went through this area, the Top Hard Coal was exposed for a distance of about 75 yards, dipping at 10 degrees to the north east. It was about 5 feet thick, with an excellent seat earth below. At a later stage in excavation, two lower coal seams were uncovered just to the north of the bridle path, the original opencast site having removed only the Top Hard Coal. These two lower seams, 3 feet 6 inches and 2 feet 9 inches respectively, would probably be the Dunsil Coal and the 1st or Upper Waterloo Coal: they are good bituminous coals. The excavation of these two seams and the 'backfilling' of the site took place so quickly that detailed measurements could not be made by the author.

The Permian Unconformity

Because of previous opencast activity and the rising base of the road over 'backfilled'



A small symmetrical fold in Lower Magnesian Limestone at the eastern end of the subway under the A.610 roundabout, eastern end of the Nuthall By-pass. (March 1965)

ground, the exact position of the Permian unconformity along the motorway could not be located accurately. Only the beds above the base of the Lower Magnesian Limestone were seen. These consisted mainly of thin, red dolomitic siltstones and sandstones; the dolomite occurs in the rock, as shown in thin sections, as a cement and as individual crystals but the bulk of the rock is of silica. Thin seams of dolomite, with large crystals, were readily distinguished by the buff colour of the rock.

The base of the Permian rocks was exposed in the adjoining Catstone Hill opencast site and has been described by Taylor (1965, p. 185). Further excavation in this area have revealed the very thin (one foot) development of Middle Permian Marl at the top of the Lower Magnesian Limestone, which at Catstone Hill is a sandy dolomite with numerous seams of breccia. Also close to the motorway is the old Strelley quarry (SK. 456423) which is composed of beds of sandy dolomite and occasional seams of breccia. The sequence here (and at Catstone Hill) is only 10 to 15 feet thick. It was therefore rather surprising to find on the motorway site the very hard dolomitic sandstones, which thickened gradually to the north making a third facies variation within a relatively short area.

The highest rocks exposed on this section of the motorway occurred in the cutting north of the bridle path bridge (SK. 435427). The top of the dolomitic sandstones is overlain by about 10 feet (to the top of the cutting) of dark red and green marls. Thin seams of coarse crystalline dolomite and thin dolomitic siltstones occur irregularly.

The road now begins a gradual descent to the A. 610 at Nuthall; the next series of excavations were noted at the interchange island and along the eastern section of the Nuthall By-Pass, at present the link road between the A. 610 and the motorway.

The eastern section of the Nuthall By-Pass

The excavations along the Nuthall By-Pass exposed a nearly complete Permian sequence typical of the area. It compares very closely with the Kimberley sequence (Gibson et al., 1913; Taylor, 1965, pp. 183-4). Rocks exposed were:

Lower Magnesian Limestone		15 feet
Dolomitic Siltstones		15 feet
Basal Breccia	up to	2 feet

- unconformity -

Middle Coal Measures

The breccia was exposed at the eastern end of the dual carriage way, as it approaches the A. 610 junction (SK. 520439). It is lithologically identical to that seen at Kimberley. Eastwards, the easterly dip and minor faulting takes the breccia underneath the A. 610 roundabout. Westwards there is a larger fault, the Cinderhill Fault, downthrown to the west, which brings the Lower Magnesian Limestone down to the floor of the cutting again. In the vicinity of this fault, particularly on the south side of the cutting, excellent exposures of the Permian/Middle Coal Measures unconformity were seen; the coloured Coal Measures mudstones and siltstones were exposed for a maximum depth of 15 feet.

Above the breccia, the well-bedded grey dolomitic siltstones contain abundant mica and plant remains. Presumably the grey colour will eventually change to buff tones by oxidation of the iron oxides, as at Kimberley.

The top of the sequence is made up of the Lower Magnesian Limestone, a coarse - medium grained dolomite, typical of much of the area of Southern Nottinghamshire, e.g. at Bulwell and Linby.

Because of the faulting and local variations of dip, this rock occurs at the A. 610 traffic island and along the whole length of the cutting west of the large fault, to the interchange junction where it was examined in the footings for the bridges. In this area the dolomite contains more quartz than further east.

A final point of interest concerns the Lower Magnesian Limestone at the A. 610 island. The rocks are involved in a number of small but intense folds with wavelengths of only about 25 yards, dips in the limbs of the folds being over 30 degrees (Plate 14).

It would appear, then, that the Lower Magnesian Limestone and Dolomitic Siltstones of the Kimberley - Nuthall area change southwards into the dolomitic sandstones exposed in the Strelley section of the motorway.

Conclusions

The excavations along this nineteen mile stretch of the M. 1. motorway illustrate the geology of the area in much the same way as a geological section illustrates the geology of a map. On this occasion the excavations have added considerable detail to the outline geological maps which existed previously.

The absence of Keuper Marls, with commercial quantities of gypsum, west of the Soar Valley suggests that the overlap of the Trias deposits on the Pre-Cambrian rocks of Charnwood Forest occurs at stratigraphical level just below the Tutbury Gypsum, although only further investigation can confirm this, since the beds may occur beneath the chalky boulder clay deposit or below the weathered marl zone south of the Shepshed - Hathern road.

North of the River Trent, additional details have been made available on the stratigraphy and structure of the Keuper Marl. The Keuper Basement Beds are now known as far west as Sandiacre, differing from those of the Nottingham area mainly in the thicker and coarser friable sandstone beds.

In the area underlain by Coal Measures, opencast excavation and prospecting has been mainly responsible for the detailed knowledge now available for this area, but the discovery of three coal seams at Trowell can be attributed to motorway construction.

At Strelley, the motorway exposed yet another facies of the Lower Magnesian Limestone and confirms the wide lateral extent of the Middle Permian Marls.

Finally at Nuthall, excavations provided briefly, a sequence of Permian strata comparable to that at Kimberley but complicated by the presence of faults and minor folds both of which are associated with the Cinderhill Fault, a structure affecting the underlying Coal Measures to a much greater extent.

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