SEDIMENTARY AND FAUNAL FACIES ASSOCIATED WITH THE DRAINING OF CROPSTON RESERVOIR

by

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Summary

Cropston Reservoir was emptied in 1965 for the first time in 95 years of use. This event produced a dramatic change in a formerly stable environment. The slow uniform deposition of sediment from suspension was replaced by a completely new pattern of erosion, sedimentation and dessication: the molluscan fauna of the reservoir was exterminated. The character and distribution of sedimentary facies and faunal assemblages are described and analysed in terms of their likely preservation in the geological record.

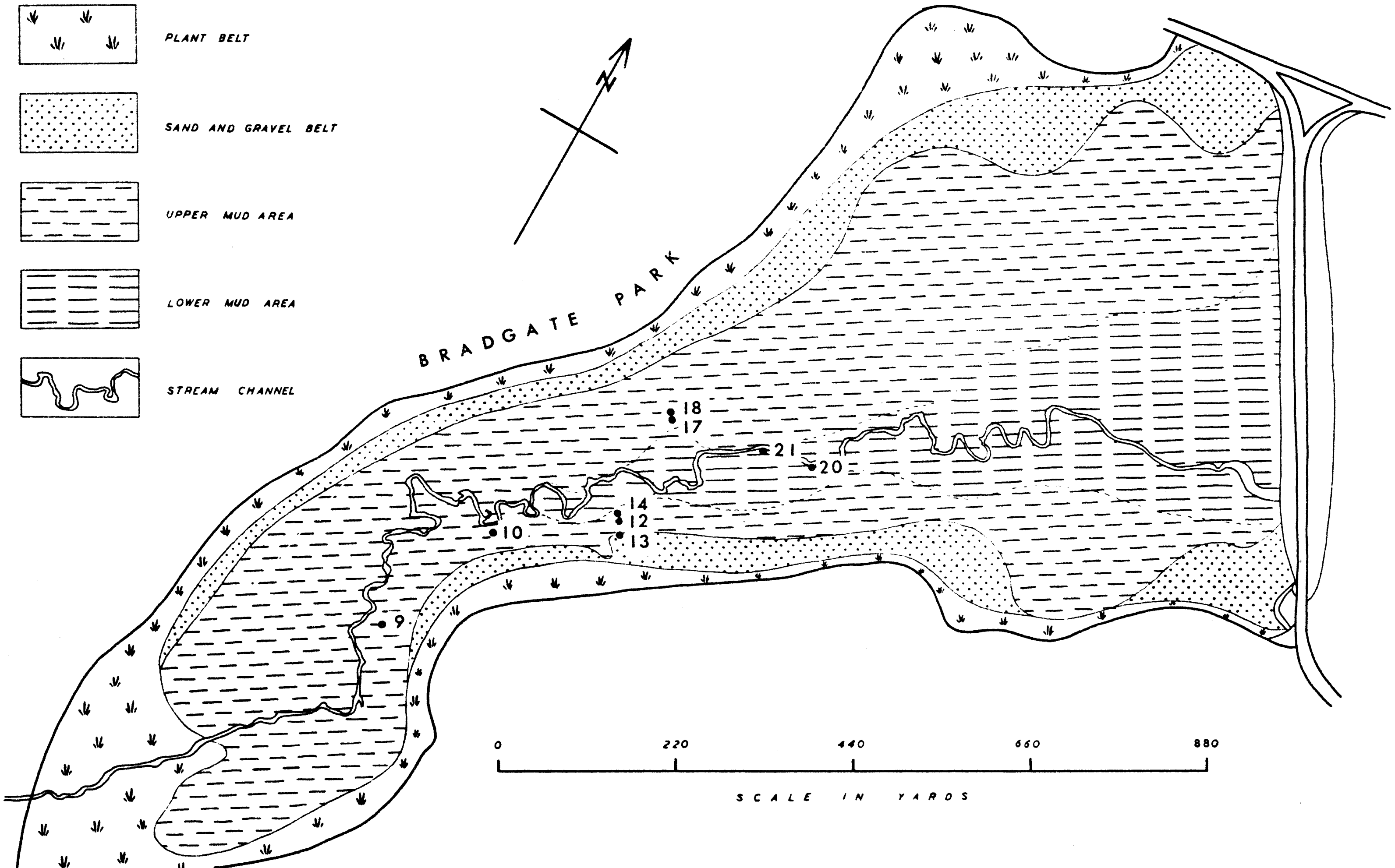
Introduction

The present is the key to the past. This paper is concerned with an event which took place in 1965; the emptying of Cropston Reservoir. The geological effects of this event on sedimentary facies and faunal assemblages are described, in the firm belief that such observations are the basis for the uniformitarian interpretation of the geological record of the past.

Cropston Reservoir (SK 5410 and 5411), supplying water to the City of Leicester, is situated alongside Bradgate Park, at the southeastern edge of Charnwood Forest. It was opened in 1870 and remained in continuous use until it was emptied for alterations in the spring of 1965. During this period a varied molluscan fauna became established; the shores and parts of the floor of the reservoir were colonised by plants; and a uniform deposit of unstratified black mud accumulated on the bottom. While the reservoir was empty, the opportunity was taken to measure the volume of the accumulated sediment (Cummins and Potter, 1967), and at the same time observations were made on the sedimentary phenomena associated with the draining of the reservoir, and collections were made of the fauna.

Sedimentary facies

The sedimentary phenomena associated with the draining of the reservoir can be considered in relation to five different environments in the reservoir; the shore line plant belt, the near shore sand and gravel belt, the upper mud area, the lower mud area, and the stream channel. The approximate distribution of these environments is shown in Text-figure 1. In the discussion of each of these, the following points are considered in turn:- (i) the conditions prevailing before the reservoir was drained; (ii) the immediate effects of the lowering of the water level; (iii) the effects of the prolonged exposure which followed; and



TEXT FIG. 1. CROPSTON RESERVOIR. SEDIMENTARY ENVIRONMENTS AND FAUNAL SAMPLING LOCALITIES

(iv) the nature of any permanent record of these events which might be preserved in the sediments if, after the reservoir was refilled, sedimentation continued as before (i.e. ignoring the cleaning and alterations which were carried out while the reservoir was empty).

The shore line plant belt consisted of an almost continuous bed of reeds growing near to the top water level. In places along the north-western shore, there were patches of Equisetum extending into the reservoir beyond the margin of the reed bed. Except at the southwestern end of the reservoir, near the point of entry of Bradgate Brook, there is no deposition of sediment along the shore line. The draining of the reservoir did not represent a catastrophic change in the shore line environment, which is subject to recession of water level every time there is a drought. The reeds continued to flourish during the period while the reservoir was empty, and there seems little likelihood of any permanent record of the events of 1965 being preserved in this environment.

The near shore sand and gravel belt is situated beyond the margin of shore line plant growth, all round the reservoir, except at the southwestern end. The sand and gravel is derived from the underlying boulder clay. Permanent deposition of mud had not taken place here for several reasons. Wave action during stormy weather, and exposure during periods of drought are two of the obvious factors determining the non-deposition of mud in the near shore environment. Distance from the source of sediment seems to be a significant factor too, as the width of the sand and gravel belt generally increases towards the northeastern part of the reservoir, away from the point of entry of Bradgate Brook. The general tendency for mud to accumulate in topographic lows at the expense of the adjacent higher areas (Cummins and Potter, 1967, p. 39) may also be important. The draining of the reservoir produced no immediate effects in this environment. The effects of prolonged exposure here, as in other parts of the reservoir, was an extensive colonisation by land plants; the common flowers and weeds of the countryside. These advanced from the shore line downwards in an ever thickening forest, while isolated plants colonised the more distant parts of the reservoir in increasing numbers. No permanent record of the draining of the reservoir will be preserved in this environment, as it is not an area of sediment accumulation. The plants which colonised the area will have died and decayed, leaving no trace of their former presence.

The greater part of the reservoir was floored by a variable thickness of black mud (Cummins and Potter, 1967, Text-fig. 1). For the purpose of the present discussion it is necessary to divide this mud floored area into two parts, an upper mud area extending down to a depth of about twenty feet below top water level, and a lower mud area occupying the deepest parts of the reservoir.

In the upper mud area large patches of the water moss Fontinalis were growing, particularly in the southwestern half of the reservoir: elsewhere the surface of the mud was bare. In this area, there were two immediate effects of the draining of the reservoir: the deposition of mud ceased, and the water moss died and was left drying on the surface of the mud. The prolonged exposure which followed resulted in the drying and shrinking of the mud, with the consequent development of mud cracks. The cracks were generally triangular in cross section, and a typical pattern of cracks was illustrated by Cummins and Potter (1967, Text-fig. 3). Where the mud was very thin, however, the cracks were more closely spaced and were either rectangular or trapezoidal in cross section, leaving small isolated polygons of hard dried mud resting on the substratum. The upper mud area was also colonised by plants, as described above.

After a return to the earlier conditions of sedimentation, following the refilling of the reservoir, a permanent record of the draining of the reservoir should be preserved in the sedimentary sequence. A bedding plane parting should be present in the otherwise unstratified mud, and splitting would be greatly facilitated by the presence of plant remains at this level, both the indigenous water moss and the exotic land plants which colonised the area while it was exposed. The mud cracks might also be preserved, though they would not be as easy to detect at a mud-mud interface as at the more usual sand over mud occurrence. In the areas of very thin mud, one might expect a basal mud polygon breccia.

The lower mud area is distinguished from the upper by the presence of sediment deposited during the draining of the reservoir. This extra sediment differs from the earlier sediment of the area in having thin laminae of silt interbedded with the mud. These silt layers are most abundant near the stream channel, and show linear markings indicating transport by bottom currents. Layers consisting almost entirely of deciduous tree leaves were also found. These sediments, deposited during the draining of the reservoir, were generally about an inch thick, and thicker near the stream channel. The source of this extra sediment is probably to be found in the rapid erosion of the stream, through the accumulated sediment on the floor of the reservoir and into its old channel. The volume of the sediment involved is of the right order. The prolonged exposure, which followed the draining of the reservoir, resulted, as in the upper mud area, in the drying and cracking of the mud. The main mud cracks cut through the full thickness of sediment, but subsidiary cracks also developed, which were restricted to the upper, laminated sediment. This laminated sediment also tended to split along the lamination, with the upper layers curling up at the edges and parting from the underlying sediment.

As in the upper mud area, a permanent record of the emptying of the reservoir should be preserved in the sedimentary record. A bed of laminated sediment should be present in the otherwise unstratified muds, this bed being the lateral equivalent of a fossiliferous bedding plane in the upper mud area. The mud cracks will be easily detected by their passage through the laminated bed. The bedding plane separating the laminated sediment from the overlying muds will be characterised by the presence of plant remains.

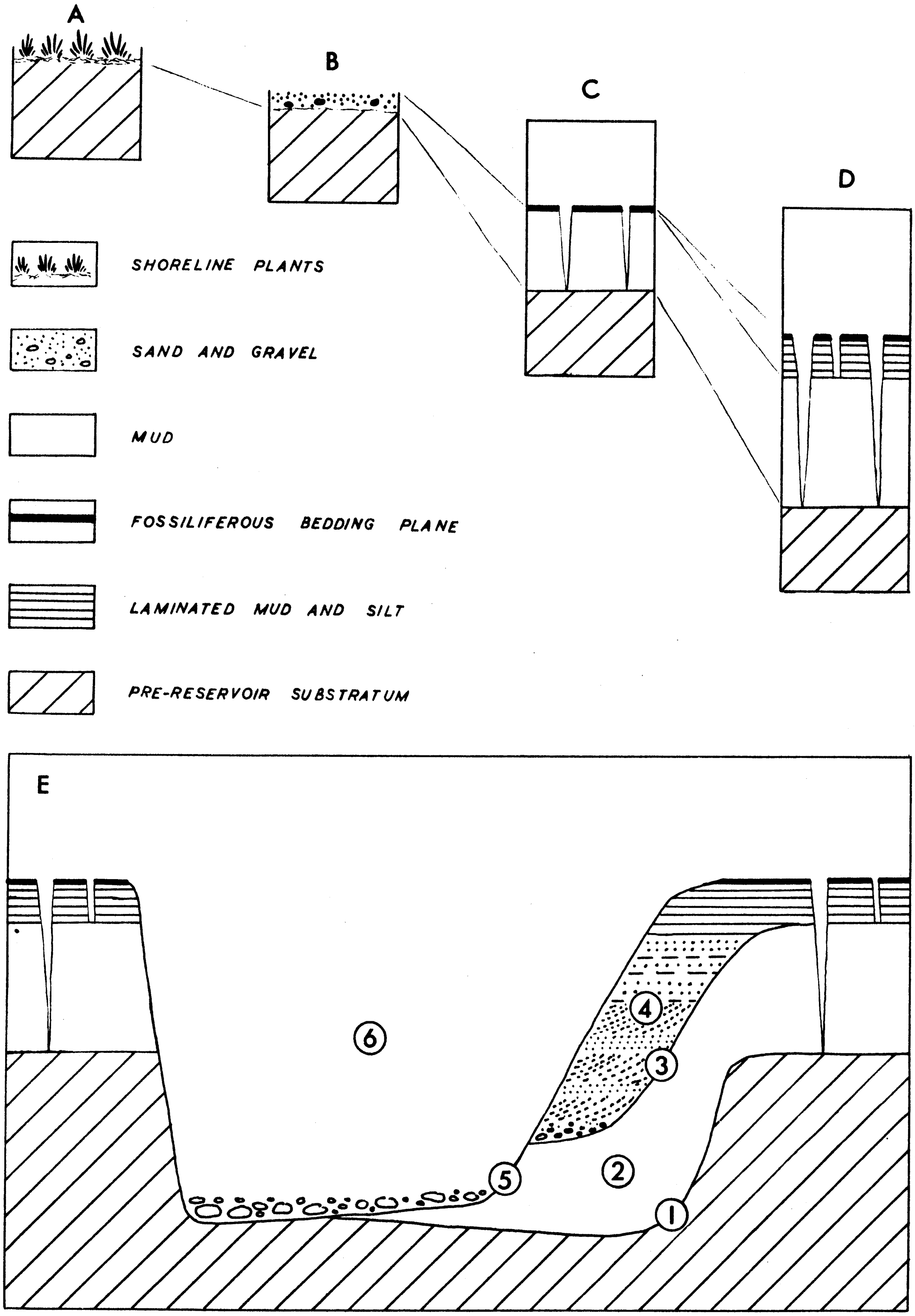
The stream channel is not a normal environment of the floor of the reservoir. During the period from 1870 to 1965, the old channel of Bradgate Brook became filled with reservoir mud in the manner already described for field boundary ditches (Cummins and Potter, 1967, p. 39). The immediate effect of the draining of the reservoir was the re-establishment of a stream channel. As the water receded, the stream began to cut down rapidly through the reservoir muds and, once a channel was formed, it was widened by lateral erosion, partly through the soft mud and partly into earlier alluvial deposits and boulder clay. The vast amounts of fine sediment thus released, were carried in suspension into the receding waters of the reservoir and deposited in the lower mud area, as described above. The coarser sediment was transported by the stream as bed load.

The gravel moved slowly along the stream bed and seldom reached the retreating edge of the reservoir. In places where the stream never completely exposed its old bed, a spread of such gravel was preserved overlying earlier reservoir mud.

The sand fraction was carried rapidly along, and only came to rest when the velocity of the stream was checked on entering the reservoir. Such deposits of sand were generally only temporary, and were removed by further stream erosion as the level of the water in the reservoir continued to fall. But in some places sand beds were preserved in one or other bank of the stream. The most usual sediment in this situation was well sorted fine sand, frequently cross-bedded, with the cross-laminae dipping down stream. These sand deposits, generally less than a foot thick, rest on an eroded surface of black mud and are overlain by a few inches of laminated sediment of the type found in the lower mud area. In places, where thicker deposits were preserved, they may be pebbly at the base, and there may be interbedded mud layers.

A permanent record of the events of 1965 will be preserved in the stream channel environment. A full record typical of this environment (Text-fig. 2.) might be summarised as follows:- (1) the old channel of Bradgate Brook (pre-1870); (2) reservoir muds deposited in old channel (1870 to 1965); (3) erosion surface due to stream erosion during period of lowered water level (spring 1965); (4) sands and gravels (spring 1965); (5) stream channel cut through sands, gravels and earlier reservoir muds (summer 1965); (6) reservoir muds deposited in 1965 channel and on 1965 sands and gravels (post-1965).

The sedimentary facies related to the draining of the reservoir, which will separate the reservoir muds of the future from the underlying muds of the past, are summarised below and illustrated diagrammatically in Text-figure 2.



Text-figure 2 Geological records of the draining of Cropston Reservoir. A - Shoreline plant belt: B - Near shore sand and gravel belt: C - Upper mud area: D - Lower mud area: E - Stream channel; (1) Old channel (pre-1870), (2) Reservoir mud (1870-1965), (3) Channel erosion surface (spring 1965), (4) Sands and gravels (spring 1965), (5) Stream channel (summer 1965), (6) Reservoir mud of the future.

(i) Shore line plant belt:- No record.

(ii) Near shore sand and gravel belt:- No record.

(iii) Upper mud area:- Fossiliferous bedding plane; abundant plant remains; possible preservation of mud cracks.

(iv) Lower mud area:- Bed of laminated muds and silts; some layers rich in deciduous tree leaves; mud cracks; fossiliferous bedding plane with plant remains at top.

(v) Stream channel:- Beds of sand and gravel; erosional contacts; laminated sediment as in lower mud area may be present at top of sand beds.

Fauna

The main object of research in the reservoir was the determination of the volume of the accumulated sediment. After a brief examination of the whole area, work was concentrated on the collection of data for the isopach map (Cummins and Potter, 1967, Text-fig. 1) from which the sediment volume was obtained. During the rapid initial examination of the area, a number of shells was collected, particularly the larger species. A thorough faunal sampling programme was hopefully envisaged, but, by the time sufficient data on sediment thickness had been collected, this was no longer possible. The plant colonisation of large areas of the reservoir had proceeded to such an extent as to leave very little of the floor exposed. The faunal sampling of the different environments was therefore somewhat uneven.

Quantitative sampling was carried out at seven localities, ranging between ten and twenty feet below top water level. The method of sampling employed at these localities was as follows:- one or more square yard sample areas were laid out on the ground with string and nails, and every shell in each sample area was collected. These localities, which are shown on the map (Text-fig. 1) are as follows:- 9 (2 samples), 10 (2 samples) and 14 (1 sample), are in the upper mud area, and are situated on flattish ground within the old flood plain of Bradgate Brook: 12 (2 samples), 17 (3 samples) and 18 (1 sample), also within the upper mud area, are situated on sloping ground above a distinct break in the slope, which marks the edge of the old flood plain: 13 (1 sample) is at the lower margin of the near shore sand and gravel belt. At localities 12, 13, 17 and 18, it was clear that the shells, together with caddis fly larva cases, plant fragments, and other debris, had been subject to redistribution by wave and current action as the water level was falling. At localities 9, 10 and 14, there was no evidence of such disturbance.

The shallower parts of the reservoir were not sampled systematically, because of the dense cover of vegetation which developed there during the summer. The lower mud area was not sampled in the manner described above, because the shells were distributed so sparsely that the chance of finding even a single shell in a randomly placed square yard sample area would have been slight. The stream channel sands were sampled at two localities, 20 and 21 (Text-fig. 1). At these localities the shells were hand picked from the sand in the field. No special sampling techniques were employed to enable quantitative comparisons to be made between localities.

A list of the molluscs found in the reservoir is given in Table 1. In addition to the listed molluscs, two marine shells were found, Littorina littoralis (Linné) and Ostrea edulis Linné. The source of these strays must be human, and they belong with the various human artefacts also found in the reservoir, such as bottles and other pieces of picnic equipment. Other faunal remains include fish scales and bones, bird bones, and crayfish (Astacus fluviatilis). Fish remains were not common, because the fish living in the reservoir were netted and taken elsewhere before the reservoir was emptied.

TABLE 1

Molluscan fauna of Cropston Reservoir, listed in the order used in the census (Ellis, 1951). Abundance of species in each environment indicated as follows:- C - very common, often over 50% of sample; c - common, present in most samples, often over 10% of sample; p - present, but always less than 10% of sample; K - very common (*Anodonta cygnea*), but population density of large bivalves, in terms of numbers per unit area, much lower than for smaller species; k - easily found without searching in areas not sampled. The faunal list for the lower mud area is certainly incomplete, owing to lack of collecting.

	Near shore	Upper mud	Lower mud	Stream channel
GASTROPODA				
Valvata piscinalis (Müller)	C	C	p	c
Potamopyrgus jenkinsi (Smith)	p	p		c
Lymnaea palustris (Müller)	p			
L. stagnalis (Linné)	k			p
L. auricularia (Linné)	k		p	p
L. peregra (Müller)	k	p		c
Planorbarius corneus (Linné)			p	
Planorbis carinatus Müller				p
P. vortex (Linné)		C		
P. leucostoma Millet		p		p
P. albus Müller	p	c	p	p
P. crista (Linné)	p	c		
Ancylus fluviatilis Müller				c
BIVALVIA				
Anodonta cygnea (Linné)		K	K	p
Sphaerium corneum (Linné)			k	p
Pisidium amnicum (Müller)				p
P. casertanum (Poli)				p
P. subtruncatum Malm				p
P. henslowanum (Sheppard)		p		p

EXPLANATION OF PLATE 19

Fig. 1 *Valvata piscinalis* (Müller). (4.7 mm.)

Fig. 2 *Potamopyrgus jenkinsi* (Smith). (4.7 mm.)

Fig. 3 *Planorbis vortex* (Linné). (7.7 mm.)

Fig. 5 *P. albus* Müller. (4.9 mm.)

Fig. 4 *Ancylus fluviatilis* Müller. (4.9 mm.)

Fig. 7 *Sphaerium corneum* (Linné). (7.1 mm.)

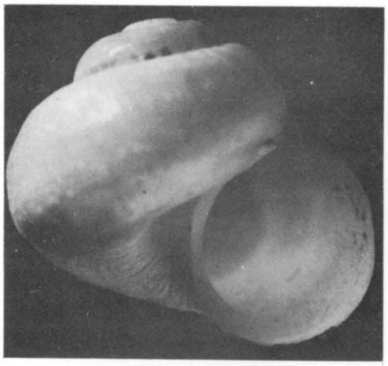
Fig. 6 *Pisidium henslowanum* (Sheppard). (3.8 mm.)

Fig. 8 *Anodonta cygnea* (Linné). (136.2 mm.)

All quoted measurements are of the maximum dimensions in each of the views given. The figured specimens have been deposited in the Department of Geology, University of Nottingham.

Figures of *Lymnaea palustris*, *L. peregra*, *Planorbis leucostoma* and *P. crista* are given in Rundle & Taylor, 1967, *Mercian Geologist*, vol. 2, no. 3, pls. 11 & 12.

Plate 19.



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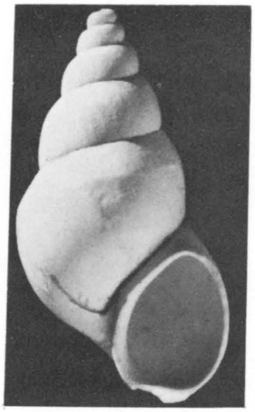

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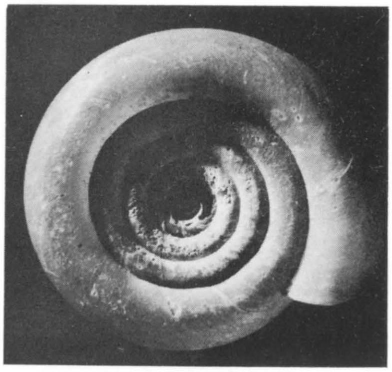

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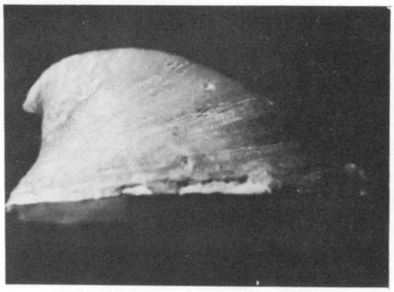

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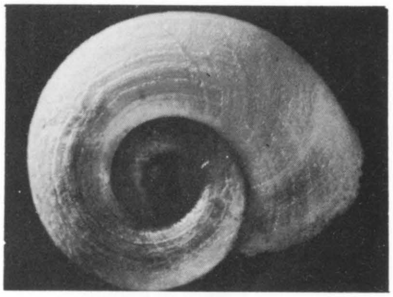

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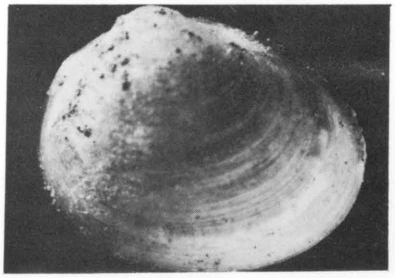

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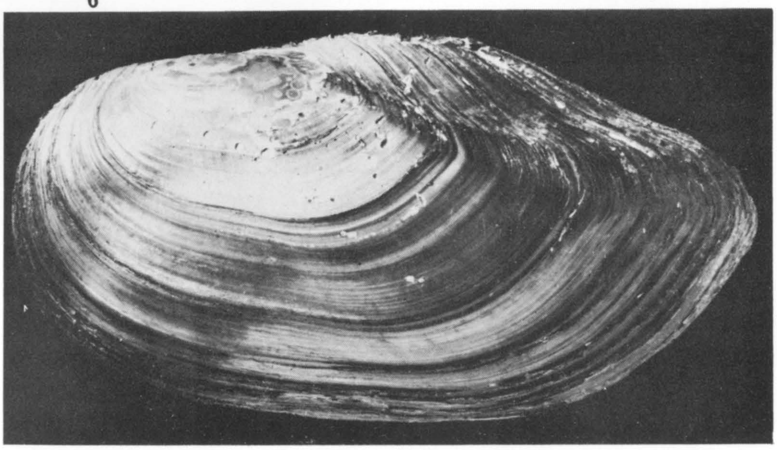

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The fauna of the reservoir will now be considered in relation to the environments (Text-fig. 1) described earlier in the paper, with the exception of the shore line plant belt, from which no material was collected.

The near shore sand and gravel belt yielded specimens of Lymnaea stagnalis, L. auricularia, and L. peregra during early visits to the reservoir. Sampling at locality 13, where 37 gastropod shells were collected in a square yard, added Valvata piscinalis, Potamopyrgus jenkinsi, Lymnaea palustris, Planorbis crista, and P. albus. Among these V. piscinalis was completely dominant, forming seventy per cent of the sample.

The upper mud area was sampled at six localities. At five of these, the number of shells per square yard ranged from 12 to 55, with a mean value of 26. At the remaining locality (18), 91 shells had been concentrated by wave or current action into a small part of the square yard sample area. Ninety eight per cent of the 341 shells collected from this area belong to four species, Valvata piscinalis, Planorbis vortex, P. albus, and P. crista. The occurrence of two of these species, V. piscinalis and P. vortex, which together make up seventy five per cent of the total, seems to be related to water depth. V. piscinalis is the dominant species at shallow depths (less than ten feet below top water level), and P. vortex is dominant at greater depths (more than fifteen feet below top water level). This conclusion is based on the data from five localities on the southeastern side of the reservoir (Text-fig.): unfortunately the depth of the two localities on the northwestern side of the reservoir is not known with sufficient accuracy for inclusion in these plots. The fauna at locality 12 is close to that of the shallower locality 9. This could be due to wave or current action during the draining of the reservoir (see p.) rolling shells of Valvata piscinalis down from shallower depths. No significant trends were detected in the occurrence of Planorbis albus or P. crista. The shells of Anodonta cygnea were distributed all over the upper mud area. The population density of these large bivalves was considerably less than one per square yard.

In the lower mud area, the fauna was sparsely distributed. In this area the pre-emptying reservoir floor was buried beneath the sediment deposited during the draining of the reservoir. The few gastropod shells picked up in this area must be interpreted as members of a displaced fauna, brought in from their natural habitat by sedimentary processes. The only specimen collected of Planorbarius corneus came from this area, and was probably derived from the shore line plant belt at the top end of the reservoir. Anodonta cygnea was found all over the lower mud area, and must have lived there. Being a burrowing species, it would have worked its way up through the mud deposited during the draining of the reservoir and, when the water finally retreated, it died at or near the surface. Sphaerium corneum, a smaller burrowing bivalve, was also found in the lower mud area. The shells were in good condition, with the two valves together. Some were half buried in the mud in an "on edge" attitude, which may have been the position of life but is inconceivable as a position of deposition. It is concluded that Sphaerium corneum also lived in the lower mud area.

The crayfish (Astacus fluviatilis) an unexpected member of the reservoir fauna, was found in the lower mud area. This species is found living in Bradgate Brook, not far above the reservoir. The specimens found in the lower mud area were probably dislodged by strong current action, when the draining of the reservoir caused a sudden lowering of the local base level. They were carried into the receding waters of the reservoir and deposited, probably already dead, in a variety of attitudes.

The stream channel sands yielded a fauna of greater diversity than any other facies. The shells are abraded and broken, and were clearly transported and deposited with the sand as detrital grains. The fauna owes its diversity to the number of different environments from which it was derived. This fauna was sampled at two localities, and a total of 62½ shells was collected (a single valve of a bivalve counts as a half). The two most abundant species were Valvata piscinalis and Potamopyrgus jenkinsi, both easily transported forms. Planorbis vortex was not found, nor was P. crista. Planorbis carinatus, P. leucostoma

EXPLANATION OF PLATE 20

Fig. 1. Ventral view of crayfish (Astacus fluviatilis)(length 48.2 mm.). The attitude of the specimen indicates that it was already dead when deposited on the mud.

Fig. 2. Lateral view of crayfish (length 37.5 mm.). This specimen is lying on its left side with its right pincer raised, an attitude suggesting that it was deposited whilst still alive. This is the only specimen with any indication of being deposited alive.

Fig. 3. Lymnaea auricularia (Linné). The right-hand specimen is a typical adult shell (length 22.7 mm.) and the left-hand specimens, shown on the same scale, is an abnormally large (gerontic) shell (length 37.5 mm.). The gerontic shell has a prominent growth line corresponding to the normal limit of adult shell growth. This growth line, which clearly shows the characteristic inflected aperture of the adult, suggests that the shell represents an individual which had survived a mild winter as an adult and lived on for an additional year. This was the only gerontic specimens of this species found.

Fig. 4. Lymnaea stagnalis (Linné). Typical adult shell (length 37.6 mm.) on the left and a gerontic shell (length 49.9 mm.) on the right. The gerontic shell shows a prominent growth line on the reverse side to that shown, corresponding to the adult aperture. This was the only gerontic specimen of this species found.

Plate 20.

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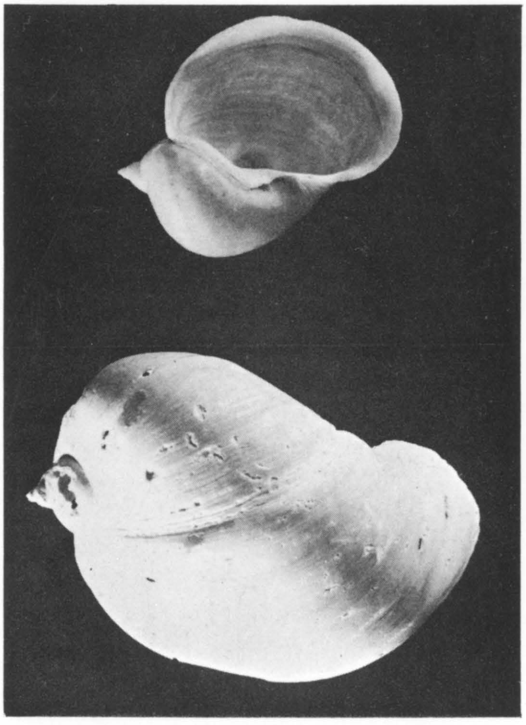

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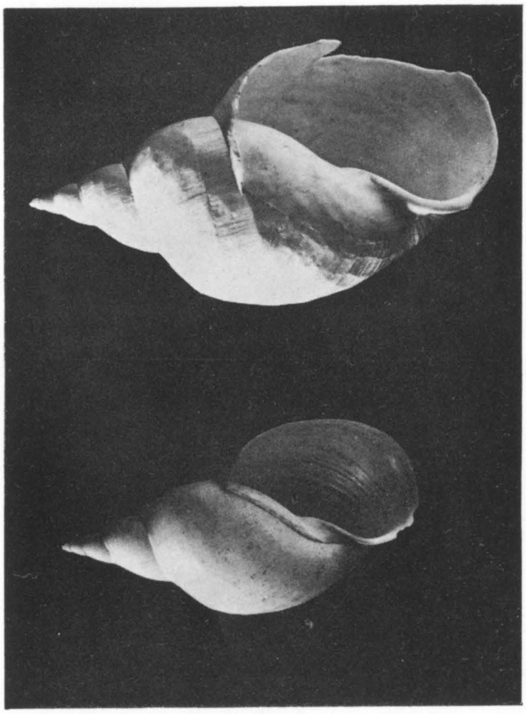

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and P. albus were present, but together made up less than ten per cent of the total. The scarcity of Planorbis shells in this facies may reasonably be attributed to their disc-like shape, which renders them unsuitable for transport in the bed load of the stream. Several species from the channel sands have not been found elsewhere in the reservoir, but have been collected in Bradgate Brook above the reservoir. These are Ancylus fluviatile, Pisidium amnicum, P. casertanum and P. subtruncatum. Potamopyrgus jenkinsi and Pisidium henslowanum have been found more abundantly in Bradgate Brook than in the reservoir. At least a quarter and possibly as much as half of the fauna of the channel sands is derived from Bradgate Brook: the rest comes from various environments within the reservoir.

The fauna of the reservoir is summarised below in relation to the sedimentary environments.

(i) Shore line plant belt:- No information.

(ii) Near shore sand and gravel belt:- Lymnaea stagnalis, L. auricularia and L. peregra prominent. Among the smaller species, Valvata piscinalis completely dominant.

(iii) Upper mud area:- Valvata piscinalis, Planorbis vortex, P. crista and P. albus. V. piscinalis dominant at depths less than about ten feet below top water level. P. vortex dominant at depths greater than about fifteen feet below top water level. Anodonta cygnea prominent.

(iv) Lower mud area:- Anodonta cygnea and Sphaerium corneum both lived in this deepest area of the reservoir, twenty to thirty feet below top water level. Displaced fauna of gastropods derived from other parts of reservoir sparsely distributed. A few specimens of crayfish, Astacus fluviatilis, derived from Bradgate Brook.

(v) Stream channel:- Varied molluscan fauna derived from different environments within the reservoir, and from Bradgate Brook outside the limits of the reservoir.

On the resumption of normal sedimentation, as described in the section on sedimentary facies (p.), a geological record of these faunas will be preserved in a fossiliferous bedding plane in the upper and lower mud areas, and in the stream channel sands. No fossils are likely to be preserved in the shore line plant belt or in the near shore sand and gravel belt, for reasons stated in the discussion of sedimentary facies.

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