Further Precambrian (Ediacaran) fossil discoveries in Charnwood Forest, Leicestershire

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Abstract: In addition to the two new fossil locations previously described within Charnwood Forest, multiple new fossil planes, including new locations, have been discovered over the last year. Multiple disc-form fossils abound in these localities. Probable new species are described, albeit largely as single specimens. One of the newly discovered localities offers the highest concentration of fossil forms to be found within Charnwood Forest to date.

Within the last two and a half years, some of the classic Charnwood sites for Precambrian fossil forms have been systematically reappraised and similar localities have been assessed for new exposures. As a result, 24 new fossil-bearing bedding planes have been discovered within Charnwood Forest; some occur within already-known fossiliferous sites, but many are from locations where no fossils had previously been described.

The outcrops of Precambrian rocks in rural Leicestershire represent the core of the Charnwood Anticline, in which strata of the Blackbrook Group are succeeded by the Maplewell Group (Moseley & Ford, 1985). The Blackbrook Group includes the rocks of the Ives Head Formation, which is famed for a bedding plane containing the oldest known Precambrian macrofossils in Britain. The forms *Ivesheadia lobata*, *Shepshedia palmata* and *Blackbrookia oaksi* were described in the 1990s (Boynton and Ford, 1995) and their status as definite species has been hotly debated since. The theory that they are taphomorphic in origin (*i.e.*, decaying biota preserved as indistinct forms, commonly in death assemblages) has gained some followers (Liu *et al.*, 2010). Within the Maplewell Group, older beds of the Beacon Hill Formation have yielded sparse, simple fossil discs and microbial matting within Bradgate Park. The Beacon Hill beds are succeeded by the Sliding Stone Slump Breccia (SSSB), representing a series of submarine slumps and general disturbance of the sediments, and is further succeeded by strata of the Bradgate Formation. It is within the Bradgate Formation, particularly close to its interface with the SSSB, that the majority of Charnwood fossils are found, including the iconic *Charnia masoni* (Ford, 1958).

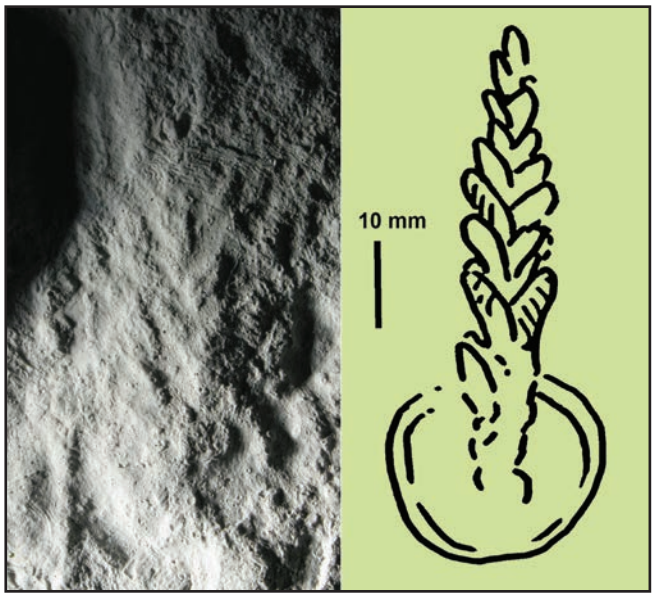

Figure 1. *Cast of* Charnia masoni, *with some second-order branching visible in parts.*

One possible reason why the Maplewell Group seems to contain the most fossils in the Charnwood Forest is that it represents a period of intense volcanic activity. The fossil-bearing beds are volcaniclastic in origin, being fine layers of ashy material spewed from nearby volcanoes in Precambrian times (Carney, 2010). The ash, upon landing on the adjacent sea surfaces, precipitated out as multitudes of fine layers, each just millimetres thick. These engulfed delicate, soft bodied, benthic creatures, entombing and preserving them.

The fossils are often termed as biota, in that their status as plants or animals is unknown. Since many of the fossils are found in strata exhibiting no ripple marks, deposition in water deeper than about 50 m depth is generally suggested (Carney, 2010), but other than this there is no indication of the water depth. If little light would have reached potential photosynthetic plants, it is likely that the delicate forms are animalian, some being akin to extant, deep-water, soft corals, as seen in dark, benthic zones of today's oceans.

The fossils are very delicate forms, and they are preserved in negative epirelief, typically with about 2-3 mm of amplitude. They cast little shadow, and generally require oblique lighting, typically at dusk or dawn, to allow the morphology to become apparent.

Altar Stones locality

The Altar Stones, near Markfield, represent a completely new fossil locality (Bowers, 2013). The initial discoveries involved three discal forms, including one with a sinuous attached stem and mop-headed frond. Further exploration over an area of 0.85 square metres has revealed an additional 19 discoid forms, four of which have multiple concentric rings (diameters 10–60 mm). Additional fossil forms discovered include: a) an ivesheadiomorph (52x40mm), b) a *Hiemalora* aff. *stellaris* (Hofmann *et al.*, 2008) specimen with a raised disc diameter of 15mm, and multiple, linear, anchoring features with lengths exceeding 100mm, and c) a small *Charnia masoni* form (Fig. 1) with co-attached discoid holdfast (disc diameter 20 mm, frond length 60 mm).

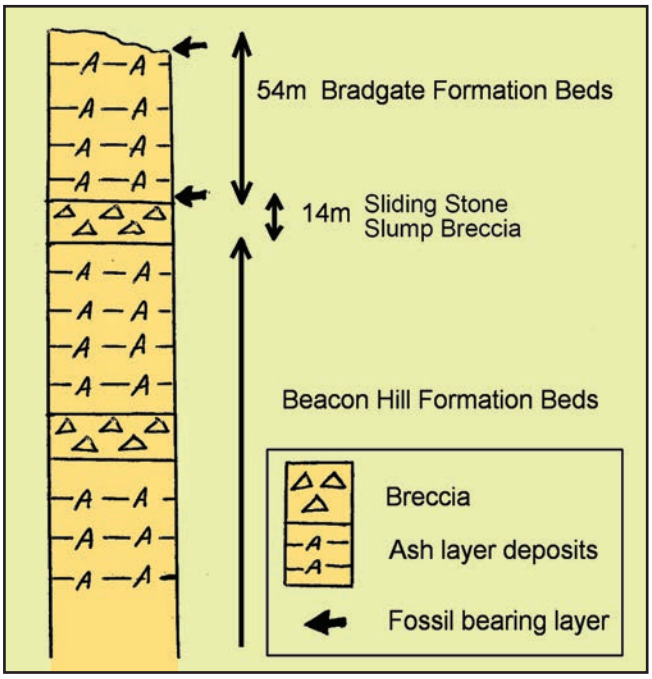

***Figure 2**. Stratigraphy of the Altar Stones locality.*

A further fossil bedding plane has been discovered, in Bradgate Formation strata estimated to be 54 metres higher in the stratigraphic succession than the beds originally recorded (Fig. 2). This bedding plane has sparse disc fossils (20–40mm diameter) and an area interpreted as indicating microbial growth. The latter consists of multiple sinuous bands, indicating microbial growth structures within a benthic biofilm. Microbial matting structures have also been found in the Blackbrook Group (Ives Head Formation). They are also reported from the Maplewell Group (Beacon Hill Formation of Bradgate Park) (Carney *et al*., 2000).

New western locality near Markfield

A large fossil bedding plane has been discovered within the western limb of the Charnwood Anticline, and is currently undergoing investigations into species number, diversity and distribution. It is 15.6 metres long with an average width of 2.5 metres, dipping at 41°. It lies within the Bradgate Formation, immediately above the SSSB. Lichen cover restricts study to only about 65% of the fossiliferous bedding plane, but 265 discs have been recorded to date, and the total number of discs present is likely to exceed 400. In terms of fossil concentration, this represents one of the richest fossil occurrences to have been discovered in Charnwood Forest to date.

Discs vary from oval to perfectly round forms, with diameters of 5–90 mm. Many discs have concentric rings, commonly four or seven in number. Additional frondose forms are present, but rare. Two small frondose forms, without attached discal holdfasts, are 17 mm in length. A curious frondose form (Fig. 3), 65 mm long, consists of four parallel structures, sinuously curved in the shape of a question mark, with an attached holdfast 23 mm in diameter. It resembles no previously discovered taxa and is probably a new species. A smaller and less distinct, yet similar. form has been discovered nearby. A small Charniomorph fossil, 34 mm long and with attached holdfast, is present, and several linear structures appear to be fragmented rachis forms or stipes, the fronds and discs being curiously absent.

Many discal holdfasts seem to overlap, and some forms are found whereby a large, faint, discal holdfast has seemingly been overlain with numerous smaller disc forms (Fig. 4). It is possible that the scarcity of large frondose elements within the fossil distribution, the presence of juvenile frondose forms, the overlying disc structures, and the composition of the bedding plane (being somewhat rough and uneven) illustrate that this part of the Precambrian sea bed was influenced by periods of turbulence. The location of the fossil plane is close by presumed Precambrian volcanoes (Carney, 2000), suggesting that disturbances caused by volcanicity and submarine slope failure may have caused the frondose fossil parts to be swept away, leaving only the discal holdfasts. Re-colonisation of the sea floor was

***Figure 3**. Probable new species, with a wide, banded frond attached to a discoid holdfast.*

***Figure 4**. Group of discoid holdfast fossils, one of which shows concentric banding.*

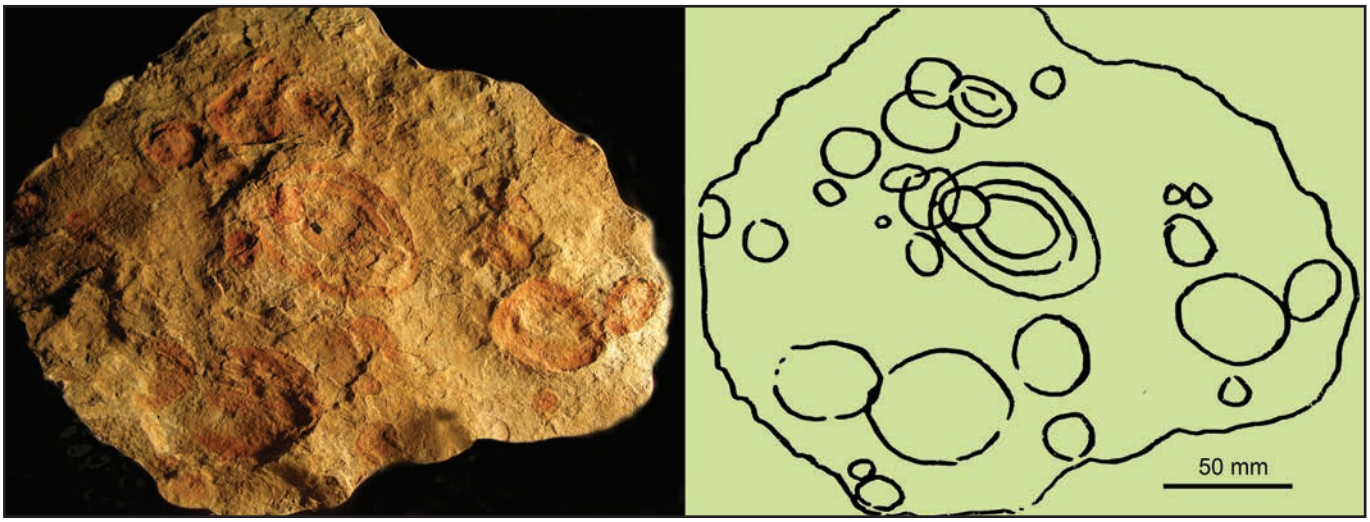

***Figure 5**. Cast of a small block of loose stone that contains 26 fossils of discoid holdfasts.*

in a continuous state of flux; small colonies tried to take hold, but again were quickly extinguished, as shown by the overlying discal holdfasts (Fig. 4). The new fossil plane illustrates a death assemblage of preserved fossil forms, in complete contrast to the vibrant life assemblage of the Memorial Crags, where large and juvenile fossil forms co-exist (Bowers, 2013). A cast of a small representative area of the fossil plane shows 26 discs, many of which overlap their neighbours, all within an area measuring only 200x250 mm (Fig. 5).

Bradgate Park

A previous study of the classic Memorial Crags fossil plane (Bowers, 2013) revealed the numerical extent of its fossils, and more than 250 fossil forms have now been catalogued. Two small fossil planes near to the classic Memorial Crags locality, and within the late SSSB beds, have revealed simple and double-ringed disc holdfast fossils.

An additional fossil bedding plane lies, 4–5 metres stratigraphically below that at Memorial Crags (Bowers, 2013). It occurs in fine-grained strata of the SSSB, where two large disc holdfasts and a *Charniodiscus* frond (Ford, 1958) were discovered. Subsequently this bedding plane has been found to hold a further 11 discal holdfasts (diameters 20–160 mm), together with a small frondose form 35 mm long.

A further small exposure of a bedding plane within the SSSB has been discovered near to the War Memorial, with a single, double-ringed disc holdfast present. Dale Spinney, a walled, wooded area within the park, has also been found to contain multiple small, faint, discal fossils, within beds of the Bradgate Formation.

Another fossil plane (an area 3 m long by 2.5 m high) lies about 25 m below the War Memorial bedding plane, within the Beacon Hill Formation. It contains numerous simple discs, two large bosses (presumed large holdfasts) and a *Charnia masoni* form that is 132 mm long with an associated holdfast 22 mm in diameter (Fig. 6). The fossil plane is weathered, requiring very oblique, dawn lighting to allow the fossil forms to stand out well, as their negative epirelief is only 2 mm.

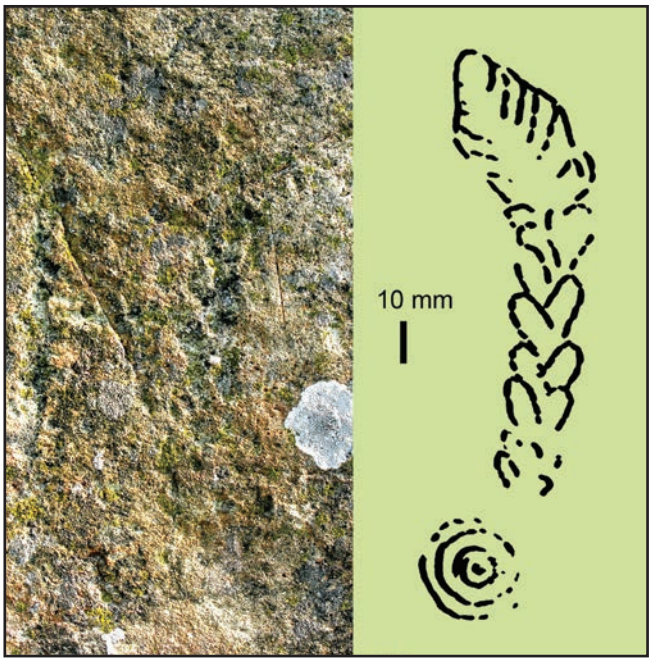

***Figure 6**.* Charnia masoni *fossil in low epirelief, from the Beacon Hill Formation in Bradgaete Park.*

Warren Hill Woods locality

North of Bradgate Park, the Warren Hill woods mainly contain outcrops of the Beacon Hill Formation of the Maplewell Group. At the eastern end, the SSSB and Bradgate Formation strata are exposed, and this interface has a fossiliferous bedding plane, exposed over an area only 2 m long by 0.75 m wide. It resembles the classic Memorial Crags bedding plane in appearance, and occurs at precisely the same stratigraphical level. The bedding plane contains 17 discal holdfast impressions and a unique concertinaed form, which is probably a new species unlike any other known taxa. This consists of a small discal holdfast, 13 mm in diameter, with an attached lanceolate frond that is very long (estimated at 273 mm) relative to its width. The specimen is contorted, and could be interpreted as a living form that has collapsed and concertinaed upon itself (Fig. 7).

***Figure 7**. A species that is probably new, with a frond that has crumpled onto itself, above its attachment to a discal holdfast.*

The Outwoods locality

The previously recognised fossil locality (Boynton, 1978) has been re-evaluated to reveal 65 fossil forms. In addition, five new fossiliferous bedding planes have been discovered in The Outwoods. Among the newly discovered forms are possible worm traces, identified as sinuous wavy markings upon the bedding plane and extending for distances of up to 150 mm. Numerous discal fossils have also been found, including a small specimen 30x26 mm (Fig. 8), with a short co-attached stem and feathery frond, akin to a juvenile *Primocandelabrum* species (Hofmann *et al.*, 2008).

Besides the new bedding planes, two small fossils have been found in loose blocks within the Outwoods. Both show *Cyclomedusa* aff. *davidii* forms, one with a concentric discoid form 13x11 mm (Fig. 9), similar to the Ford/King specimen at the University of Leicester's Geology Department (#LEIUG 96879).

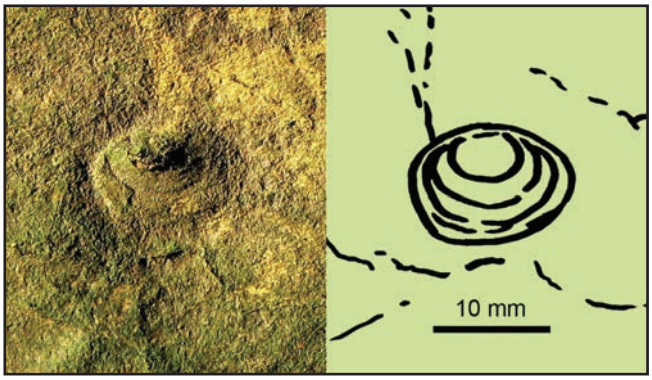

***Figure 9**. A small specimen of* Cyclomedusa davidi *found in a loose block in The Outwoods.*

Beacon Hill locality

Whereas the Beacon Hill beds have yielded small numbers of faint discs within Bradgate Park, historically the Beacon Hill locality itself has been found to be almost barren of fossils, with just a few discs known upon a fossil plane within the parkland (Helen Boynton, pers. comm.). Eight fossiliferous bedding planes have now been discovered within the Beacon Hill locality. Upon each are one or two scattered, simple, disc forms, each 8–150 mm in diameter (Fig. 10).

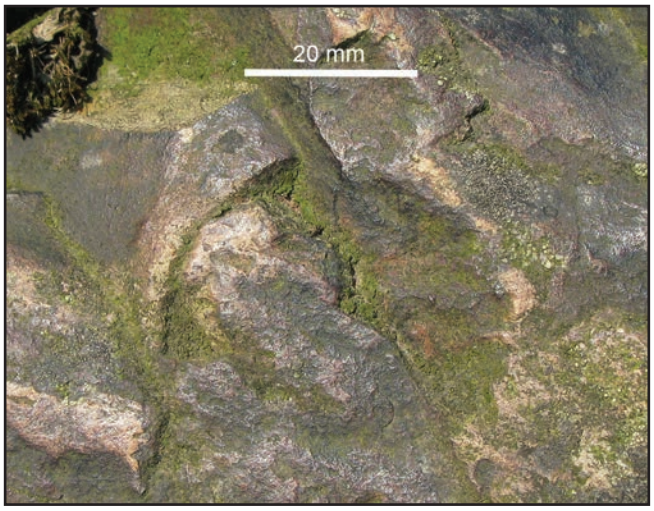

***Figure 10**. An ovoid disc holdfast fossil on a bedding plane within the Beacon Hill Formation.*

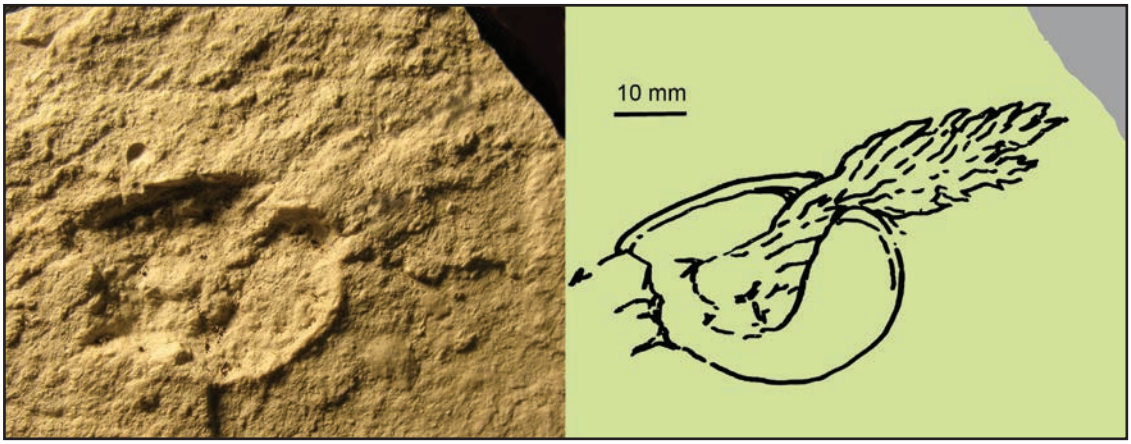

***Figure 8**. Discal holdfast, wide-based stem, attached to feathery frond, akin to the fossil genus* Primocandelabrum.

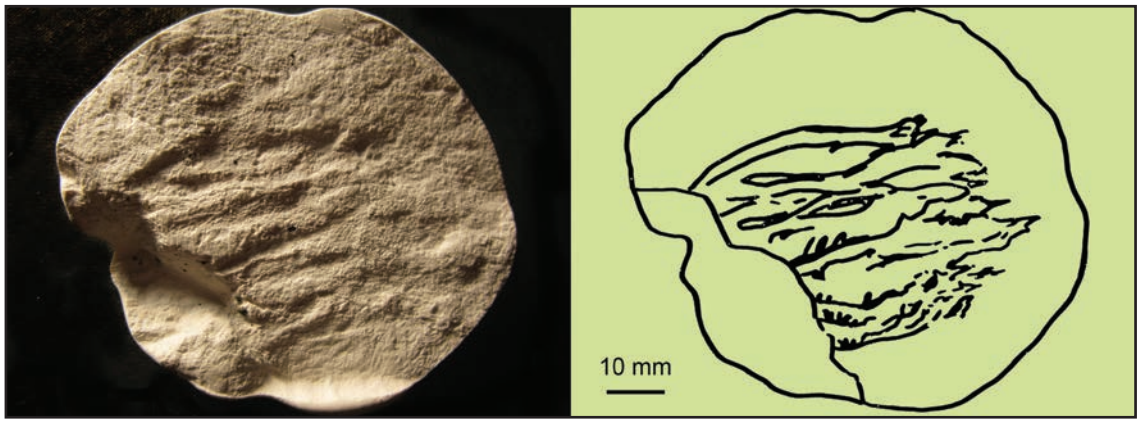

Figure 11. *Cast of an Ivesheadiomorph.*

Ives Head locality

Recent re-evaluation of the Ives Head Formation classic fossil bedding plane has revealed 49 fossil forms, exceeding the estimate of 12–15 fossil forms recorded previously (Boynton & Ford, 1995). One Ivesheadiomorph fossil, 45 mm long and 35 mm wide (Fig. 11) has been found on a bedding plane about 6 m below the recognised fossil plane. This makes it the oldest Precambrian macrofossil to have been found in Britain, and of a similar age to that of c.611 Ma, which is the best estimate for the main fossil plane (Noble *et al.*, in press).

The abundance of Ediacaran fossils

The newly discovered fossil forms raise many points of discussion. Firstly the occurrence of such delicate fossil forms was once thought to be rare, but the recent discoveries of many more fossil bedding planes refute this. Charnwood Forest was regarded as the location of the first unequivocal Precambrian fossil to be described, the iconic *Charnia masoni*. It was presumed that the Charnwood biota was relatively species-poor, and certainly poor in fossil numbers, compared to the other discoveries of Ediacaran (late Precambrian) fossil sites in Australia, Newfoundland, Russia and Namibia. However, discoveries of large fossil numbers at the quarry site of the *Charnia masoni* holotype (Wilby *et al.*, 2011), and now discoveries of many new fossil planes, and the new locations, challenge this concept. Intense Precambrian volcanic activity, across what is now southern Britain, combined with submarine debris flowage and volcanic ash fall-out, engulfed and entombed delicate, soft bodied creatures living in benthic environments. That the sediment has preserved the living forms is interesting enough, but that macroscopic life existed in such profusion is remarkable.

It is likely that many more new fossil sites will be discovered in Leicestershire in the near future. Any readers, who should happen to discover in Charnwood Forest anything they believe to be Precambrian fossils, are invited to contact the author to discuss their finds and arrange further investigations of the sites.

Acknowledgements

The author would like to thank Dr Helen Boynton for continued communication and discussion of ideas and theories about Precambrian fossil forms. Grateful thanks are also due to Andrew Johnson for working with the author in the field and for sharing the discovery of the Warren Hills Wood locality.

Location details for the new western locality, near Markfield, are intentionally not publicised, but are available to genuine researchers who contact the author.

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