Blea Tarn, Langdale

[NY 293 044]

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Introduction

This small, shallow, upland lake in Cumbria (Figure 6.12) is situated at an altitude of 190 m and is surrounded by rocky, mountainous Borrowdale Volcanic terrain, reaching up to 470 m (Figure 6.13). It lies in a through valley that hangs above Little Langdale, into which it drains. The basin was eroded by ice moving from Great Langdale to the north via a col at 220 m, and the tarn is not dammed by a moraine as the drainage overflows a bedrock ridge west of Tarnclose Crag. The shore of the tarn consists mainly of glacial drift and solifluction deposits covered by a thin peat. The site is important because lake cores have revealed detailed palaeoenvironmental reconstructions of Late-glacial and Holocene vegetational changes in the Lake District, including the Elm Decline (Pennington, 1970, 1973, 1975a, c). Data on changes in environmental geochemistry over these periods also are available (Pennington and Lishman, 1971) and the diatom stratigraphy has been described by Haworth (1969).

Description

Long Late-glacial cores, including interstadial deposits, were analysed in detail for pollen, diatoms and geochemistry. The Late-glacial pollen and environmental geochemistry diagrams are illustrated in ^{14}C 6.14 and 6.15, and a summary of the diatom record for the Late-glacial and Flandrian (Haworth, 1969) is shown in (Figure 6.16). Percentage and absolute pollen diagrams were prepared from replicate cores and the diatoms were analysed from a parallel core. A summary of the stratigraphy and pollen zonation for the Late-glacial period is given in (Figure 6.17) and the Flandrian pollen diagram is given in (Figure 6.18).

Interpretation

The results from the detailed core analyses show that there was no Loch Lomond ice in this upland basin (Walker, 1966a). The glacial drift ridges from around the tarn therefore must date from the closing stages of the Devensian deglaciation. Varved clay above a sandy silt indicate annual couplets of sedimentation into a lake fed by glacial meltwater sources. The long Late-glacial profile is important because it provides a record of the Windermere Interstadial in the uplands that can be compared with the lowland Lake District sites of Blelham Bog and Low Wray Bay, Windermere. A detailed comparison of the pollen assemblage zones is given in Pennington (1977).

Late glacial

At Blea Tarn the pollen assemblage dominated by *Salix herbacea* has been interpreted as a flora of snow-bed tolerant communities by comparison with Norwegian mountain lakes (Pennington, 1973). It has been linked to the lowermost organic layer at Blelham Bog and both indicate warmer conditions than during the same interval in Holland and Scandinavia. This zone persisted until the opening of the woodland biozone, with juniper. There is evidence of a climatic recession that followed the first juniper phase, with a return to a more chianophilous vegetation with *Betula nana* and *Lycopodium selago,* but no evidence in the stratigraphy for any renewed frost-disturbance of the soils. It suggested to Pennington (1970) that it was quite possible in the oceanic conditions of western Britain that temperatures may not have fallen very low during this period but that snowfall may have increased in the mountains, with an adverse effect on the flowering of juniper. The expansion of tree birches was delayed compared with the lowland Lake District sites and the maximum annual deposition of *Betula* pollen coincides with the beginning of minerogenic sedimentation indicative of late-interstadial soil erosion (Pennington, 1973). This shows that soil erosion began at this altitude before the end of the Windermere Interstadial. This is supported by evidence from Coleoptera in the Windermere sediments for falling temperatures before the end of this interstadial. The pollen diagrams from all the higher altitude sites, such as Blea Tarn, Devoke Water and Bummoor Tarn, show lower percentages of total *Betula* pollen than in the lowlands, with for example 20–30% of the total pollen of land plants contributed by *Betula* at these sites and 40% in Low Wray Bay, Windermere and 60% at Blelham Bog (Pennington, 1970). During the Younger Dryas the sediment accumulation rates and pollen influx rates are high and this is taken to corre spond to secondary deposition from reworked slope deposits as periglacial processes operated in the catchment.

The diatom history indicates more stable conditions than in lowland lakes, but a number of nutrient-demanding species were found only in Late-glacial and early post-glacial deposits, whereas in the lowest Late-glacial layers, species that live near glaciers were found. The inception of organic matter deposition in the earliest Flandrian was accompanied by an abrupt expansion in the diatom flora, which was dominated by planktonic species. This has been interpreted as indicative of a rapid increase in temperature at the time. Several alkaliphilous taxa, including *Asterionella formosa, Gyrosigma acuminatum* and *Navicula dicephala,* were present throughout the Boreal period, although the pH was probably more or less neutral. These species underwent decline or disappeared about the Boreal–Atlantic transition, when *Achnanthes minutissima* and *Synedra nana* came to dominance. At this time, *Pinnularia* species appeared, and the frequency of *Eunotia* species rose, the overall assemblage being more tolerant of acid conditions. It has been suggested that the gradual disappearance of some taxa may have been caused by the inwash of organic material that had been building up constantly in the lake catchment, rather than a sudden climatic change. The Atlantic period shows minor shifts in the flora so that basiphiles disappeared. An increase in epiphytic species probably reflected the onset of *Sphagnum* bog formation adjacent to the lake. Sub-Atlantic acidification as a result of forest removal and soil erosion, as at Devoke Water, has not been detected at Blea Tarn, nor has the recent eutrophication shown by Pennington (1943) from Windermere and in Esthwaite Water by Round (1961).

Geochemical analyses on the first core were correlated by pollen stratigraphy with the core on which absolute pollen analysis was conducted (Pennington, 1973) and the two data sets were compared using principal components analysis, to illustrate the usefulness of this method in zoning hitherto unfamiliar profiles (Pennington and Sackin, 1975). A significant feature of the Blea Tarn absolute pollen diagram is that the concentration of pollen is high in the minerogenic deposits of the *Artemisia* pollen zone (post-interstadial) in the period of the Loch Lomond Advance. Severe periglacial soil disturbance is indicated by this. Using the curves for carbon and sodium (Figure 6.15) as indicating, respectively, the accumulation of soil humus and the relative erosion rate of mineral soils (Mackereth, 1966), the later part of zone I and the whole of zone II are seen as periods of soil stability; during which a continuous vegetation cover became established. The onset of renewed instability of soils, which reached its maximum development in the Younger Dryas, can be seen to coincide in the later part of the Windermere Interstadial with vegetation changes. A fall in the iron and manganese curves is interpreted as showing the presence of humic acids and reducing conditions in the soils, leading to podsolization and the spread of *Empetrum* heaths during the transition from the Windermere Interstadial to the Younger Dryas cold period. At the transition between these periods at Blea Tarn there is an interesting silty mud deposit that has about 50 narrow laminations, which are not graded varves but could represent a series of solifluction silts formed in a period of severe winters (Pennington, 1970). The pollen in this laminated deposit indicates a vegetation of *Empetrum* heath locally, with *Betula* pollen either from distant transport or as a secondary component in the soliflucted soils.

Manley (1962) had suggested that between 50 and 100 years of cold summers and heavy winter snowfall could have been sufficient to reestablish glaciers in the Lake District high corries during the Younger Dryas and suggested that persistent flooding, associated with the disturbed chilly climate, prevailed. However, the chemical analyses from Blea Tarn show that the input of material into the tarn soon included mineral material so high in calcium and sodium that it must be regarded as unweathered drift from soil layers deeper than those that had been leached during the Windermere Interstadial. This is evidence that there was more severe periglacial erosion in this basin than had occurred since the Devensian glacial.

Contrasts in sediment composition between, on the one hand, the clays and silts below the interstadial deposits and, on the other hand, the post-interstadial minerogenic sediments, can be interpreted as indicative of a different origin. The high iron content and bright haematite colour of the lowest pre-interstadial sediments are consistent with a drift source from the highly haematized rocks of part of Great Langdale, which was pushed over the col at 220 m in early stages of deglaciation, when ice was still thick in Great Langdale. As this ice shrank below the level of the col, the composition of sediment deposited in Blea Tarn changed to that of the local rocks, which have less iron. The low drift ridges probably represent the final deposition from the Great Langdale ice lobe.

Holocene

The post-glacial sediments of this small basin accumulated relatively rapidly in early Flandrian times and this site is a useful location for critical ^{14}C dating of the changes in forest composition as the tree genera reached this site in their early Flandrian migration, and for a comparison with the more lowland valleys. The Boreal hazel maximum is lower than in the valley lakes, for example; furthermore, elm, which appears at the zone V–VI boundary, expands faster and further here than in the lower valleys. This suggested to Pennington (1964) that soils on the Borrowdale Volcanic rocks had a higher base-status in the early Flandrian than now. Late in subzone VI a pine maximum occurs at Blea Tarn, accompanied by small peaks of heather and *Sphagnum* and it has been suggested that this represents a local succession of well-drained marginal areas during the phase of lowered water levels late in subzone VI. Nevertheless, the presence of *Sphagnum* is surprising in this dry period. The expansion of alder at the VI–VIIa boundary is sudden and coincides with a stratigraphical change and it has been regarded as the tree of basin swamps up to high altitudes. On dry ground the forest consisted of oak, elm and birch.

The mid-Flandrian sediments contain a very precise pollen-stratigraphical record of the Elm Decline, for which entirely consistent ^{14}C dates were obtained (Pennington, 1970, 1975c). Elm pollen reached 20% of the total tree pollen in subzone Vila and the decline at the end of this zone is seen as a sudden drop to between 2 and 4% whereas in the large lowland lakes the percentage before the decline is smaller and the decline not so sudden. Vegetation changes associated with the Elm Decline, as reconstructed from percentage and absolute pollen analyses, have been integrated with the record of soil changes contained in sediment geochemistry, to reconstruct the palaeoenvironment of the Langdale valleys at the time of the activity of the Neolithic axe-factories on the north-eastern crags of Great Langdale (Pennington, 1973, 1975c). A consistent picture emerged of temporary forest clearance in the woods around Blea Tarn, but permanent destruction of forest that contained more pine and birch at higher altitudes on the ridges and plateaux. A detailed pollen analysis of the appropriate levels at Blea Tarn is shown in (Figure 6.19). In Episode 1, the fall in elm pollen, attributed to the collection of leafy branches for fodder, is dated at 5300 years BP to 5200 years BP, and Episode 2, involving sufficient expansion of grasses and *Plantago lanceolata* to indicate forest clearance, covers the period from about 5000 years BP to a little before 4000 years BP with its peak of intensity at about 4500 years BE Evens *et al.* (1962) suggested *c.* 4500 years BP to 4000 years BP as the probable dates of the main export phase of the axe factories.

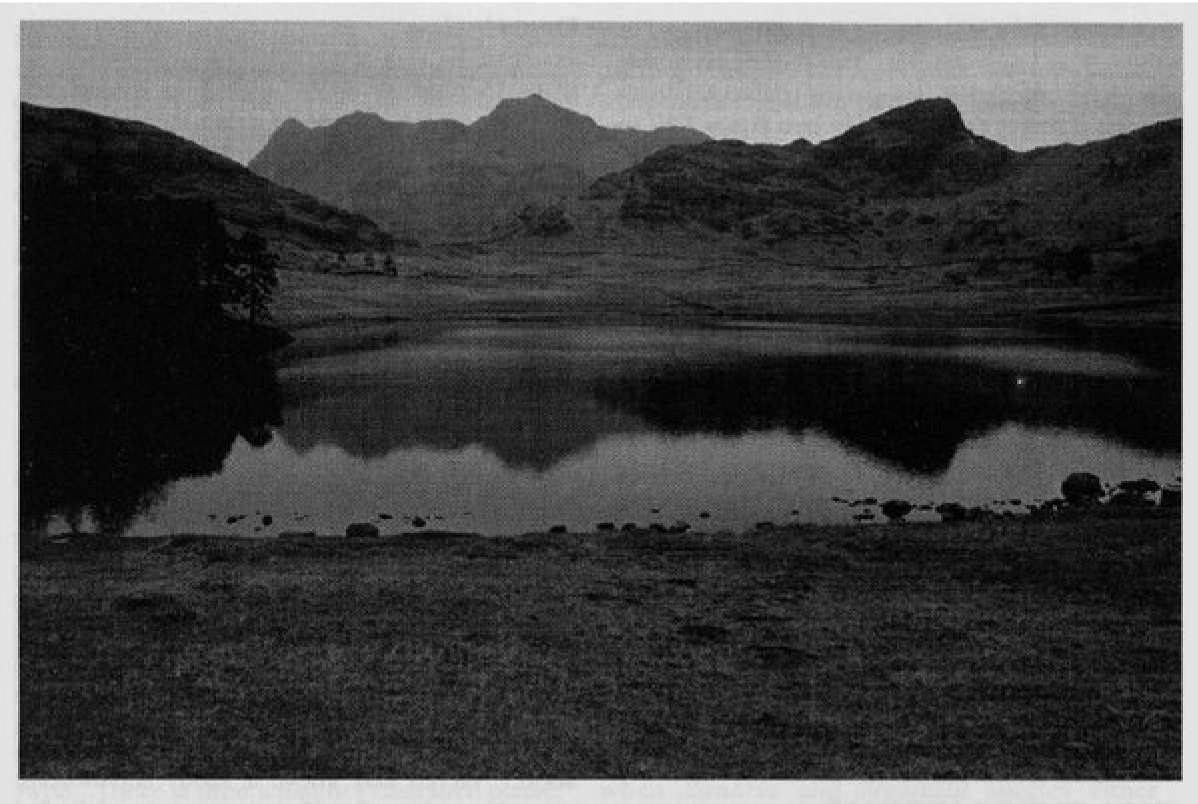
On the evidence of the pollen diagram, human activity in the Langdale area was maintaining clearings in the forest from *c.* 5000 years BP until some centuries after 4500 years BE Stratigraphical evidence indicates that increased soil erosion, consistent with the effects of forest clearance, accompanied the beginning of Episode 2 (Pennington, 1970). The percentages of grass and herb pollen are higher at Langdale Combe and Angle Tarn (Walker, 1965), suggesting a less dense forest, but the results in general are consistent with those from Blea Tarn. In what appears to be the later stages of the Neolithic period, at the three sites at the head of Great Langdale above about 400 m, a great and permanent expansion of grass and sedge pollen, accompanied by plants such as *Plantago lanceolata* and *Rumex acetosella,* and by *Calluna,* indicates the main deforestation horizon. After this, grassland and communities dominated by heather must have exceeded forest at this altitude. Walker (1965) found wood charcoal in the muds at Langdale Combe at this horizon, and at Angle Tarn this horizon coincides with a change to a more acid type of inwashed humus. The charcoal evidence suggests that here the forest above 400 m was cleared by deliberate burning. This seems to have accelerated soil changes resulting from leaching at this altitude, and permanently altered the environment from forest to open moorland. Ash pollen appears shortly after the Elm Decline and forms a continuous curve from this period upwards, but in the large lakes it is rare. Probably the decline of the elm opened up an opportunity for ash to enter the upland woods.

For the period after 4000 years BP the course of sediment accumulation in this basin is problematical. From the first cores analysed it was postulated that prehistoric deforestation must have come late to this catchment because tree pollen predominated in the sediments to within *c.* 10 cm of the mud surface (Pennington, 1964; Pennington and Lishman, 1971). It then became apparent that the ^{14}C age of immediately subsurface sediments in some cores was nearly 4000 ^{14}C years BP and in short (1 m) cores from several positions, dating by ^{137}Cs and ^{210}Pb failed to show the consistent pattern usual in Cumbrian lakes (Pennington, 1981). These anomalous near-surface sediments contained almost entirely tree pollen, which agreed with the supposition that their age could be up to 4000 ^{14}C years BP and therefore that younger sediments were missing. It therefore is necessary to modify the view that this catchment remained forested longer than other Lake District upland catchments. The preferred hypothesis is that either continuous deposition of sediment must have ceased because of natural causes, such as increased wetness of climate since *c.* 4000 years BP or that during the 19th century the landscaping works associated with the establishment of conifer and rhododendron woods included gross disturbance of the tarn upper sediments. Hence the tarn does not offer a stratigraphically reliable record of sediment accumulation after 4000 years BP and its present mud–water interface is not natural.

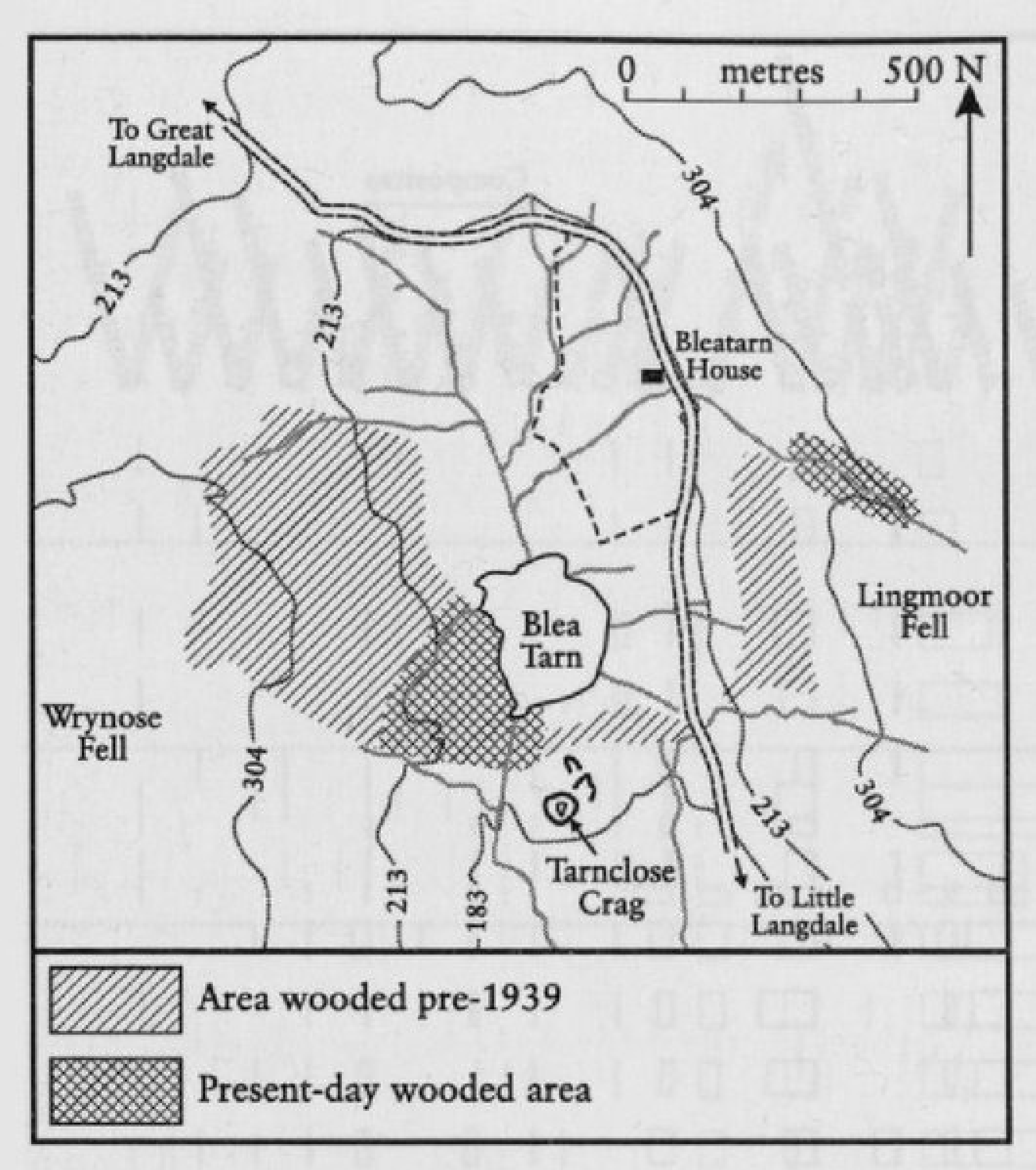
Conclusions

Blea Tarn is an important Quaternary site in the Lake District in that it shows the Late-glacial environmental changes already described at Blelham and Low Wray Bay, Windermere at a higher, upland location and it facilitates valuable comparisons between them. It thus shows comparable changes and vegetation differentiation with altitude. The site has again shown the value of absolute pollen diagrams in establishing a pollen zonation scheme when percentage pollen analysis had failed to do so. In the early Flandrian the rate of sedimentation was sufficiently rapid to allow the accumulation of a thick organic deposit, which has enabled important radiocarbon dating of changes in forest composition to be made. The pollen record picks out the Elm Decline, which has been dated accurately, and the vegetation changes associated with the period of activity associated with the nearby Neolithic stone-axe factories in Langdale have been documented.

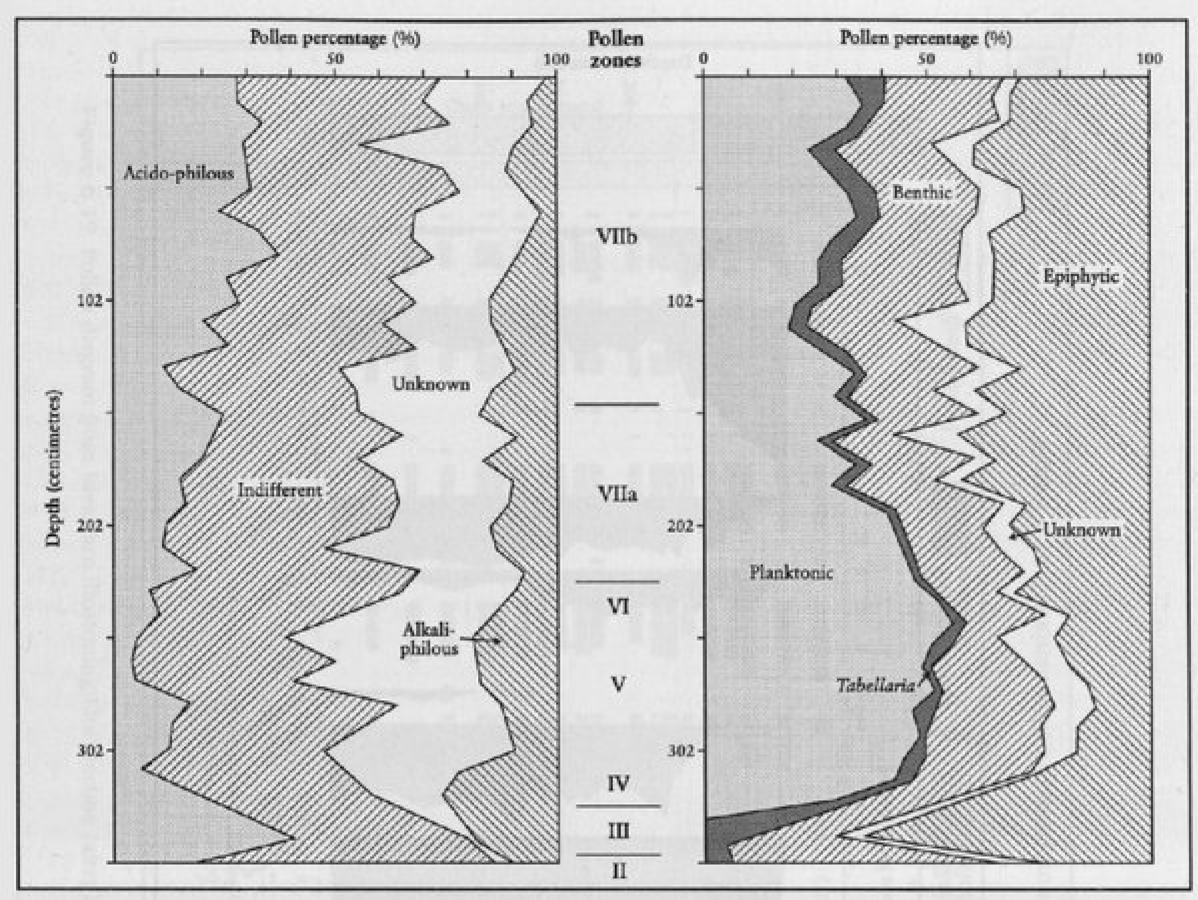
References



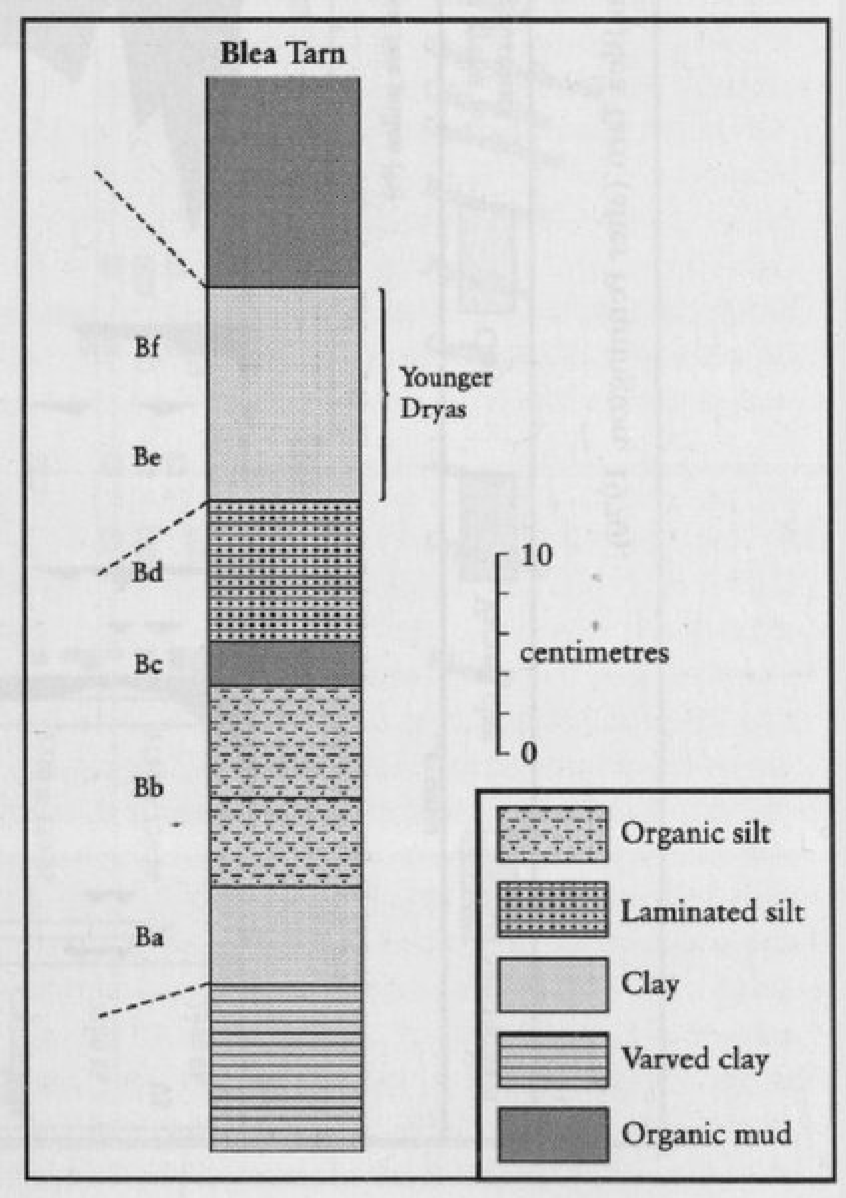
(Figure 6.12) Blea Tarn looking towards Langdale Pikes. (Photo: D. Huddart.)



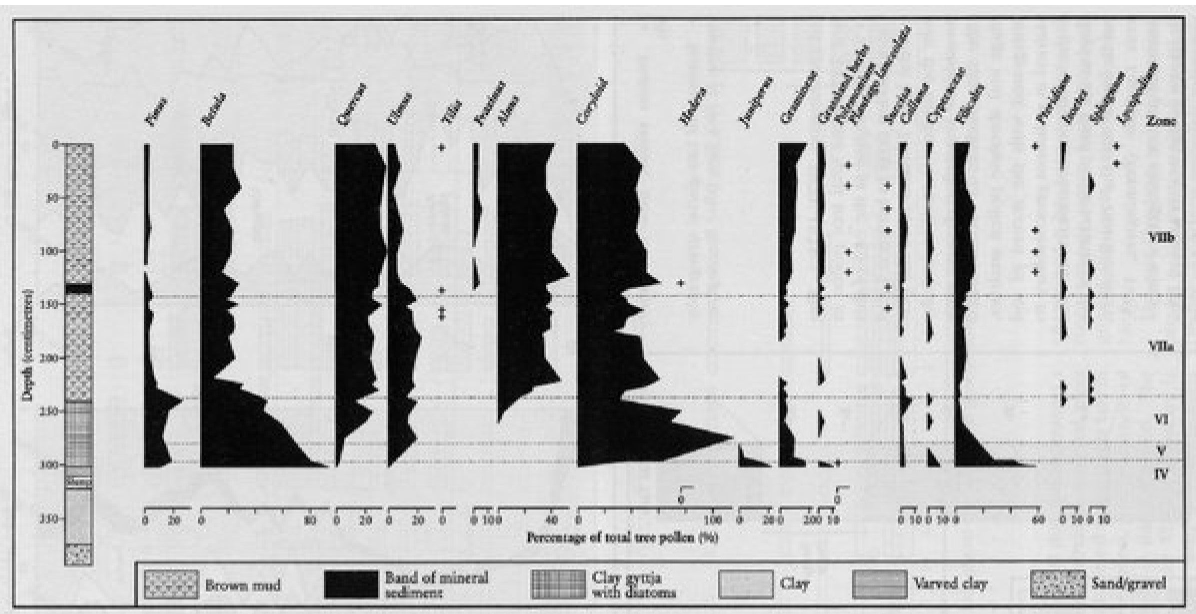
(Figure 6.13) Map of Blea Tarn and its drainage area.



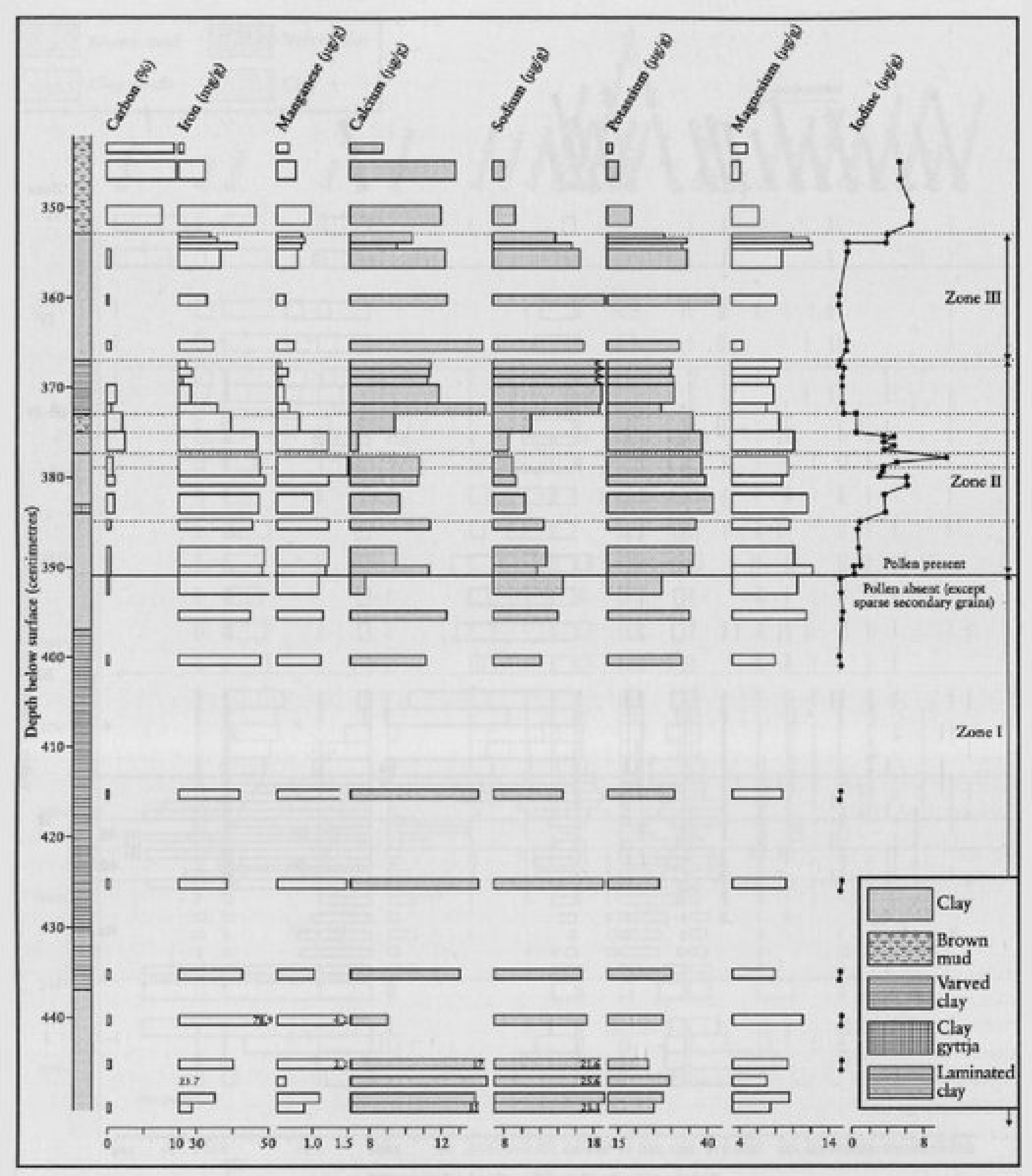
(Figure 6.16) Diatom record, Blea Tarn (after Haworth, 1969).



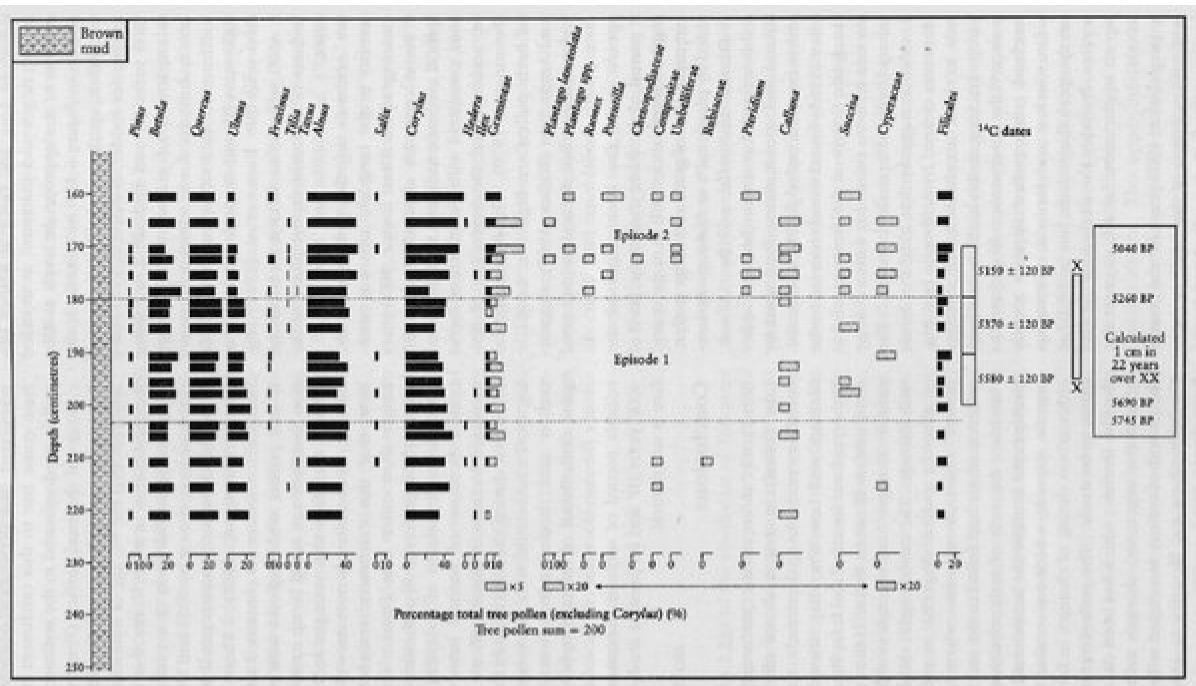
(Figure 6.17) Summary of Late-glacial stratigraphy and pollen zonation at Blea Tam (after Pennington, 1970).



(Figure 6.18) Flandrian pollen diagram from Blea Tarn (after Pennington, 1970).



(Figure 6.15) Late-glacial environmental geochemistry from Blea Tarn (after Pennington, 1970).



(Figure 6.19) Pollen diagram from Blea Tarn illustrating Elm Decline (after Pennington, 1970). X–X marks the positions of two ^{14}C date samples.