CHAPTER FIVE

ORIGIN AND EVOLUTION OF THE THIRLMERE LAKES BASIN

5.1 INTRODUCTION

In Chapter One of this thesis, it was mentioned that the bedrock valley in which Thirlmere Lakes lie appeared to be a relict stream course, in that its width and depth are related more to those of the Nepean and Bargo Rivers to the east than of nearby streams such as Cedar Creek and Couridjah Creek (Fig. 1.2).

Various lines of evidence, albeit inconclusive, will be given in this chapter to show that the valley may represent a former course of a river which formed part of the Nepean and/or Wollondilly River systems. This evidence has been gained from a perusal of the literature pertaining to the physiography of the Sydney region, as well as a study of aerial photographs covering the western part of this region, and quantitative comparisons of the various drainage patterns in the study area, in combination with interpretation of the valley fill sequence previously described. A discussion of the possible sequence of events in the evolution of the lakes to their present form is also included.

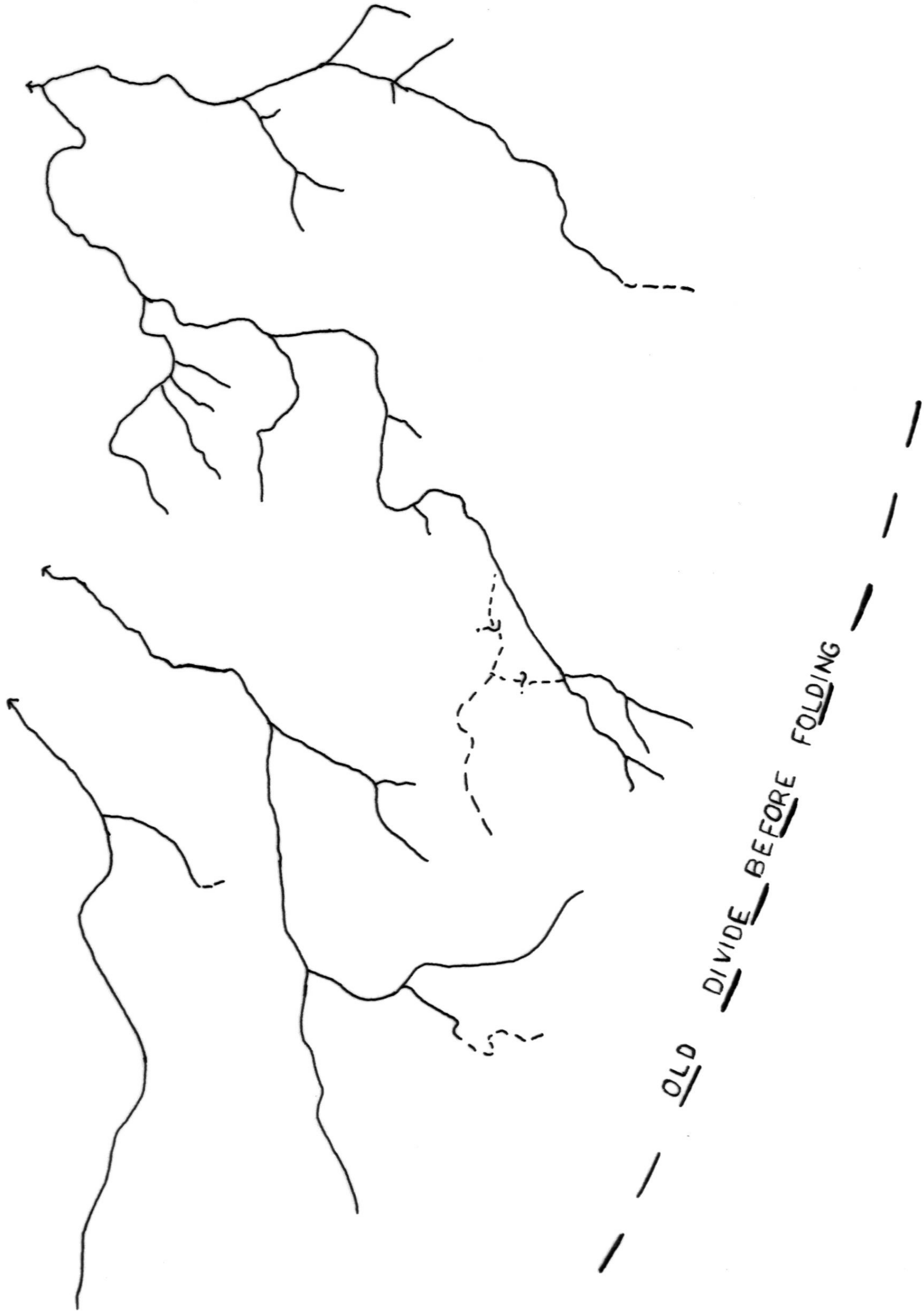
5.2 EVIDENCE OUTSIDE THE STUDY AREA

5.2.1 Previous Literature on the Physiography of the Sydney Region: While literature on the geology of the Sydney Basin is extensive (see, for example, Packham, 1969, and Mayne et. al., 1974, and bibliographies contained therein), very little work on the geomorphology of the area has been recently published. For information about the drainage systems and their origins, one needs to refer to the pioneering work published early this century by such people as Edgeworth David (1896; 1902), Griffith Taylor (1911; 1923; 1958), Andrews (1903;, 1905; 1910), Woolnough (1906, with T. G. Taylor), and Craft (1928a; 1928b; 1931a to d; 1932; 1933). While the geomorpholgical concepts outlined in this work may be somewhat outdated, the keen observation and recording of these workers allows one to collect information regarding the form of the various rivers in the area and interpret this in the light of modern geomorphological theory.

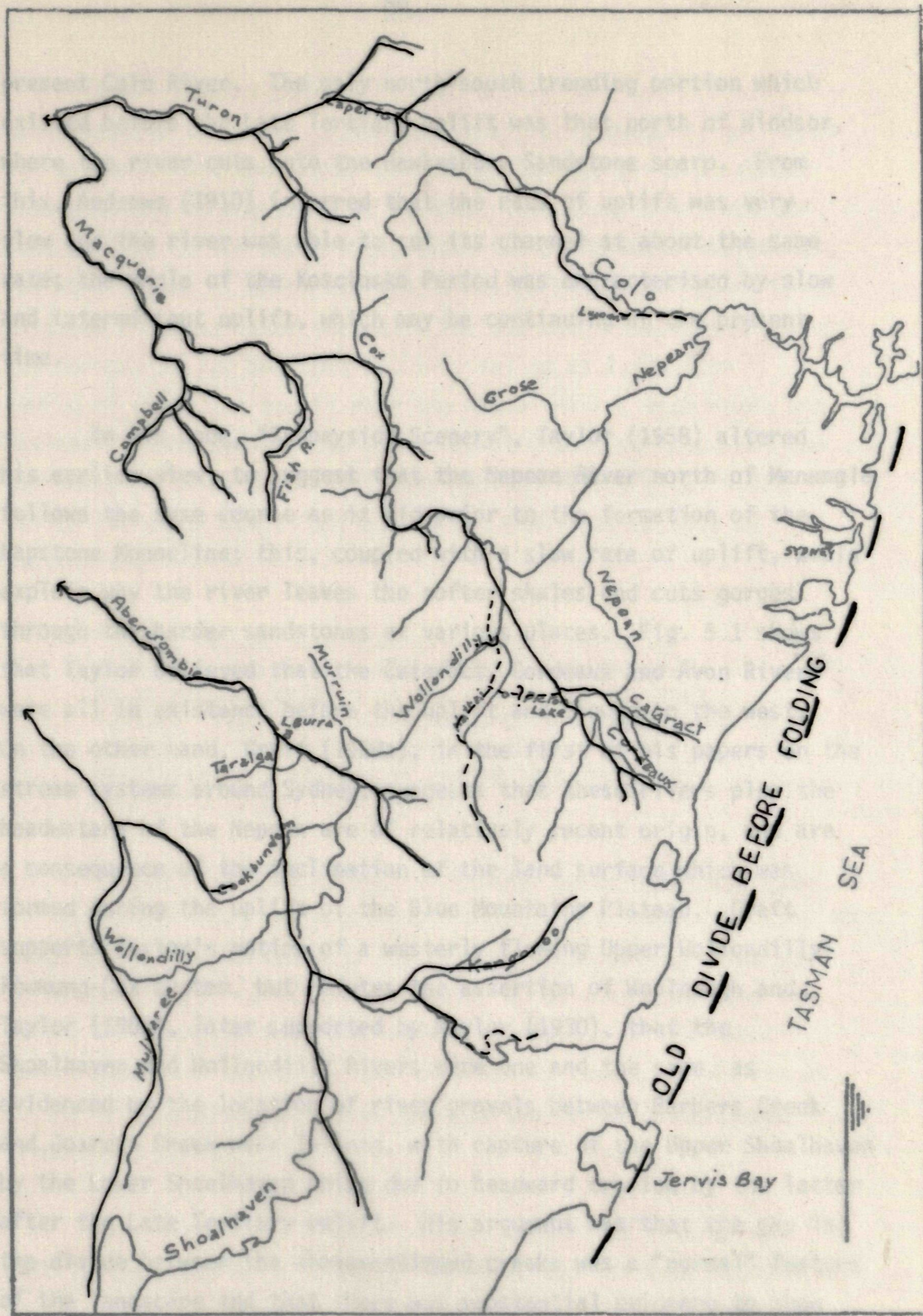
Many of the early workers chose to describe anomalous features of the landscape, such as, for example, the sharp bends in the Shoalhaven and Hawkesbury Rivers, the meridional nature of the dominant drainage direction, and the presence of swamps, lakes and gravel beds in curious places. It is therefore not surprising that early reference is made to Thirlmere Lakes (under their former name of Picton Lakes) by Griffith Taylor (1911, 1923, 1958), by Frank Craft (1928) and by the authoris of the 1932 A.N.Z.A.A.S. Congress Handbook.

In his earlier publication, Taylor locates Thirlmere Lakes immediately to the west of the monoclinal fold running north-south through Kurrajong and Glenbrook; he implies, by his association of the origin of the lakes with that of Mountain Lagoon, that the faulting which was associated with this monoclinal folding (see Section 2.1.1 above) truncated and dammed a former drainage line, giving rise to the lakes. However, he makes no mention of former direction of flow, but from his maps of postulated Late Tertiary conditions, reproduced in Fig. 5.1, the nominated direction of flow was to the west. He believed that the Main Divide was once farther to the east than the present coastline and that rivers such as the Shoalhaven, Cataract, Capertee, Goulburn and Hunter all flowed to the west. He referred to the Wollondilly and Nepean Rivers as subsequent, whereby the gradual uplift of the Main Divide during the Kosciusko Period (see Section 2.1.2 above) diverted the westerly flowing drainage along lateral (i.e. north-south) lines. This view was supported, or pre-empted, in part by Andrews (1903; 1905) who believed that the peneplain formed during Miocene times sloped gently from west to east and that the former course of the Hawkesbury was generally east-west along the line of the

Fig. 5.1 : T. G. TAYLOR'S POSTULATED TERTIARY DRAINAGE PATTERNS FOR EASTERN N.S.W.

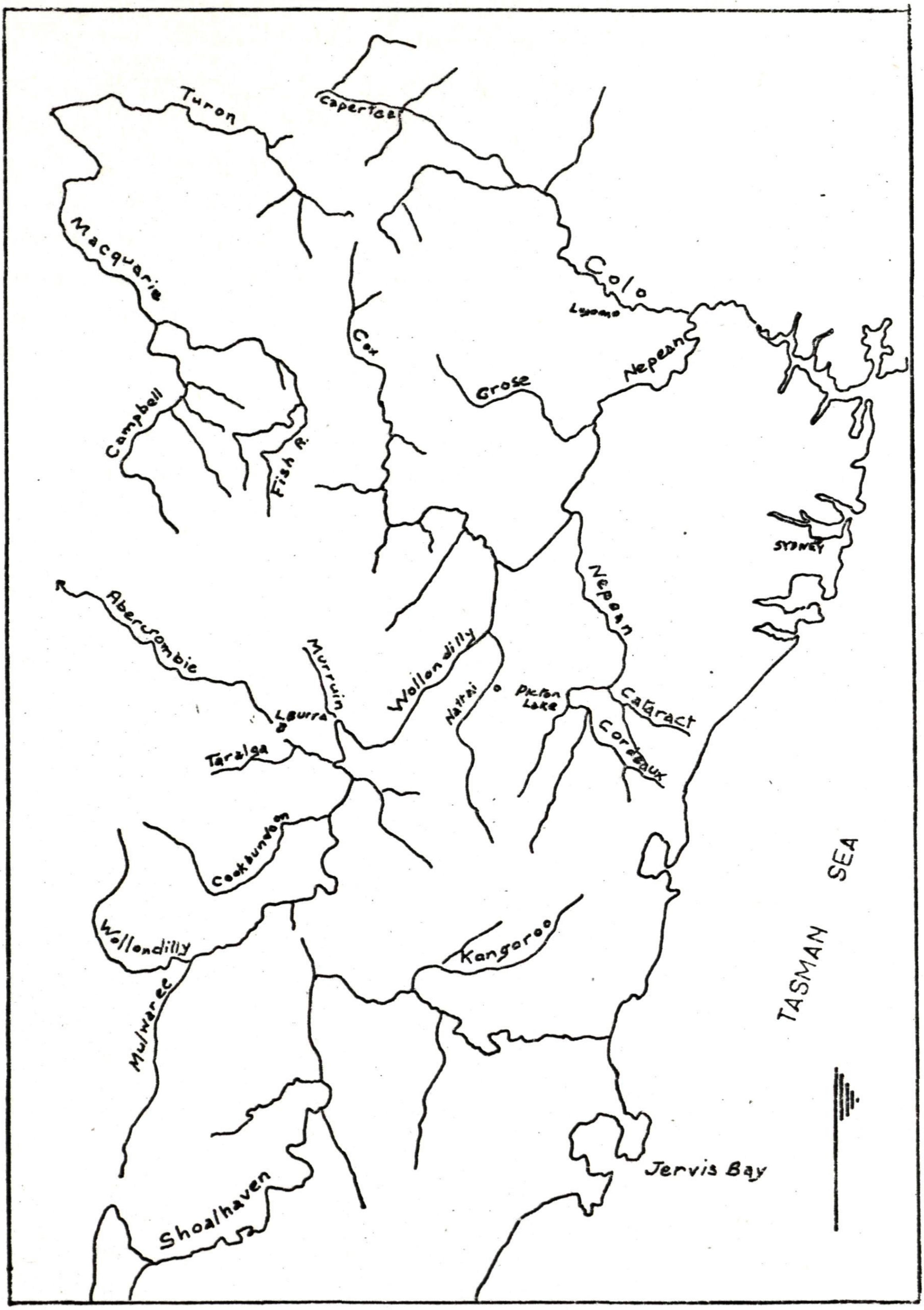


a-postulated Late Tertiary river systems



a-postulated Late Tertiary river systems

b-present river systems



b-present river systems

present Colo River. The only north-south trending portion which existed before the Late Tertiary uplift was that north of Windsor, where the river cuts into the Hawkesbury Sandstone scarp. From this, Andrews (1910) inferred that the rate of uplift was very slow and the river was able to cut its channel at about the same rate; the whole of the Kosciusko Period was characterised by slow and intermittent uplift, which may be continuing at the present time.

In his book, "Sydneyside Scenery", Taylor (1958) altered his earlier view, to suggest that the Nepean River north of Menangle follows the same course as it did prior to the formation of the Lapstone Monocline; this, coupled with a slow rate of uplift, would explain why the river leaves the softer shales and cuts gorges through the harder sandstones at various places. Fig. 5.1 shows that Taylor believed that the Cataract, Cordeaux and Avon Rivers were all in existence before the uplift and flowed to the west. On the other hand, Craft (1928a), in the first of his papers on the stream systems around Sydney, suggests that these rivers plus the headwaters of the Nepean are of relatively recent origin, and are a consequence of the inclination of the land surface which was formed during the uplift of the Blue Mountains Plateau. Craft supports Taylor's notion of a westerly flowing Upper Wollondilly-Kowmung-Cox system, but refutes the assertion of Woolnough and Taylor (1906), later supported by Naylor (1930), that the Shoalhaven and Wollondilly Rivers were one and the same, as evidenced by the location of river gravels between Barbers Creek and Joarmin Creek near Tallong, with capture of the Upper Shoalhaven by the Lower Shoalhaven being due to headward erosion by the latter after the Late Tertiary uplift. His argument was that the gap in the divide between the abovementioned creeks was a "normal" feature of the landscape and that there was substantial evidence to show that the local drainage had existed for a very long time and was currently being rejuvenated.

Craft (1928a) noted that the railway line near Picton Lakes was 150 ft (50 m) higher than the line through Bargo, which was evidence that the monocline through Kurrajong and Glenbrook also extended to the south of Picton. This older fold face had been altered to the north by at least two differential movements, the most recent of which was the formation of the Kurrajong Fault. Evidence of these later movements include the formation of a rock-cut terrace in the Wollondilly River valley at 1,400 feet (466.6 m) above sea level, near the Nattai River, into which the Wollondilly has cut a gorge up to 700 ft (233.3 m) deep, and the terracing of silty deposits in Burragorang Valley (i.e. valley-in-valley features; Craft, 1928b). Craft concludes (p.648) by stating that

> "... it may be laid down as a fairly definite rule that the steam systems arranged materially as at present existed at the end of the Tertiary Period. Since then, continuous uplift has allowed streams to become entrenched in their old courses, and subsequent changes of course have been the exception rather than the rule ..."

5.2.2 <u>Disrupted Drainage Patterns Between Kurrajong and Picton</u>: Aerial photographs have enabled pin-pointing of topographic features which may relate directly to the folding and faulting along the "Lapstone Block". Discussion with Dr. J. G. Jones has lead the writer to recognise that the surface expression of the "block" varies along its length (which has probably lead to confusion as to its true nature) but can be generalised to the three forms illustrated in Fig. 5.2.

The first (Fig. 5.2a) where the monoclinal fold on the east is subtended by a fault to the west, has its type expression in the region of Mountain Lagoon[1] (Fig. 5.3a). It is thought that a formerly easterly flowing creek was dammed by the movement which created the Kurrajong Fault; its former valley to the Colo River to the east is now occupied by Taylors Creek which is

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[1] N.S.W. Dept. Lands 1290 St Albans; Run 55; Nov. 1964; 5054 5055

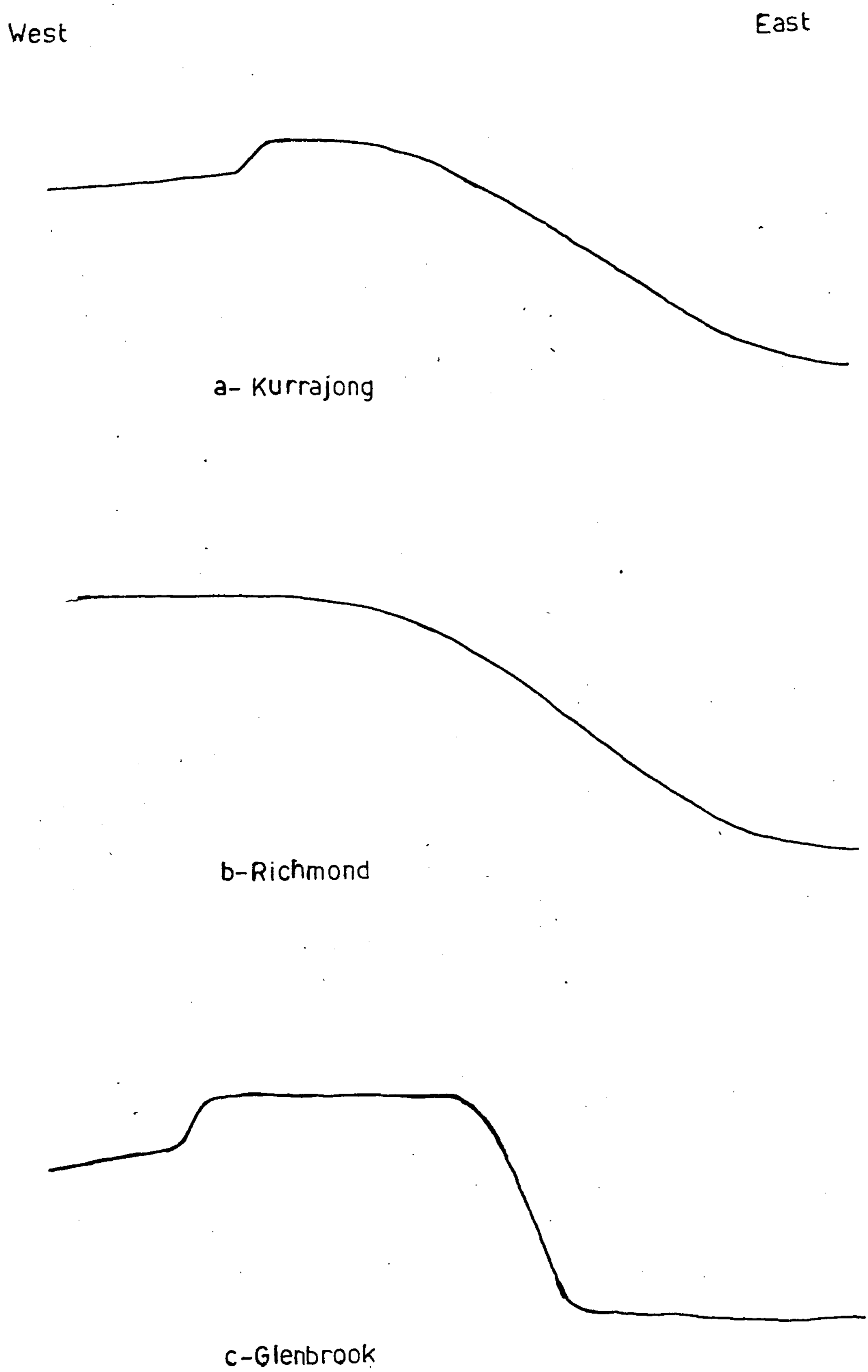

Fig. 5.2 : VARYING SURFACE EXPRESSION OF LAPSTONE "BLOCK" AT REPRESENTATIVE LOCATIONS (not to scale)

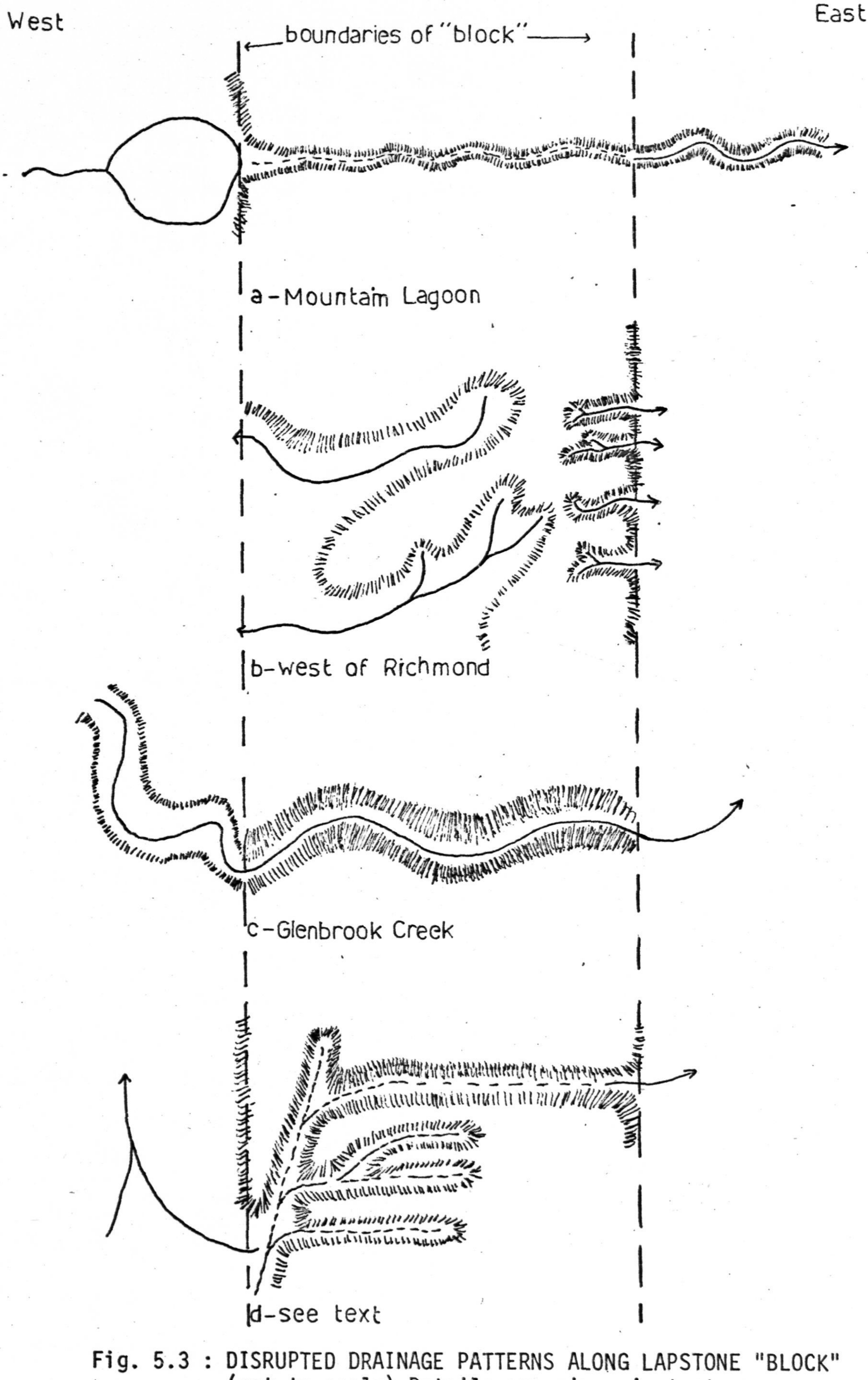

Fig. 5.3 : DISRUPTED DRAINAGE PATTERNS ALONG LAPSTONE "BLOCK" (not to scale) Details are given in text.

rapidly cutting back through the uplifted "block" (Taylor, 1958). Further south at Kurrajong, aerial photographs[1] show how streams on either side of the "block" are eroding back and may eventually remove all traces of the "block".

The second type (Fig. 5.2b) illustrates the classical form of a monoclinal fold and to which the name of Lapstone Monocline was originally given. To the west of Richmond[2], upland stream valleys are alluviated and flat-bottomed, while creeks cutting into the eastern face of the fold are elongated, narrow and branchless (Fig. 5.3b).

The third type (Fig. 5.2c) is clearly illustrated at Glenbrook[3], where Glenbrook Creek has incised a precipitous gorge through the sandstone to debouche on the eastern side into the Nepean River. Here, uplift and downcutting have kept pace with each other (Fig. 5.3c).

Elsewhere[4], reversal of drainage has occurred, whereby formerly westerly flowing creeks now drain to the east; portions of their former valleys can be traced back to where they now lie high and dry on top of the uplifted "block", and easterly flowing, precipitous creeks are rapidly cutting back. This situation is illustrated in Fig. 5.3d.

Thus, it can be seen that tectonic movement in the Sydney region has substantially affected the form of the drainage system, by allowing rejuvenation, by drainage reversal, and by

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1 N.S.W. Dept. Lands 1464 Penrith; Run 1W; Aug. 1966; 5008, 5009
2 N.S.W. Dept. Lands 1460 Penrith; Run 6W; June, 1966; 5054, 5055
3 N.S.W. Dept. Lands 1622 Penrith; Run 1L; June 1969; 5012, 5013
4 N.S.W. Dept. Lands 1460 Penrith; Run 2W; July, 1966; 5147, 5148

damming up of former drainage lines. The possibility that the Thirlmere Lakes valley represents part of the course of a former major river similarly affected is a very real one, especially when viewed in the light of Taylor's hypotheses about the former courses of rivers such as the Cataract and Cordeaux (Fig. 5.1). The effect of the uplift of the "Lapstone Block" on the Thirlmere Lakes valley may have been as illustrated in Fig. 5.4, but this needs to be discussed in the light of evidence of the origin and evolution of the valley which can be gained from the study area itself.

5.3 EVIDENCE FROM WITHIN THE STUDY AREA

5.3.1 Comparison of Local Drainage Patterns: An attempt has been made to establish a relative chronology for the drainage in the area covered by Fig. 1.2 by comparing widths and depths of some representative reaches of streams. The data given in Table 5.1 show that while the sinuosity of the bedrock valley along Blue Gum Creek compares with that of the Bargo River (Fig. 1.2), the valley

TABLE 5.1 : BEDROCK VALLEY MORPHOMETRY

Location	Width (m)	Depth (m)	Sinuosity
Thirlmere Lakes	571	>100	2.33
Bargo River	206	116	1.20
Blue Gum Creek	300*	1108*	1.19
Little River	-	-	1.18
Cedar Creek	100	50	1.75
Stream in Ashfield Shale	-	-	1.25

* at Little River junction

width in the vicinity of Thirlmere Lakes is much greater than that of the Bargo River at a corresponding depth. Bearing in mind that only the minimum depth to bedrock beneath Thirlmere Lakes is known,

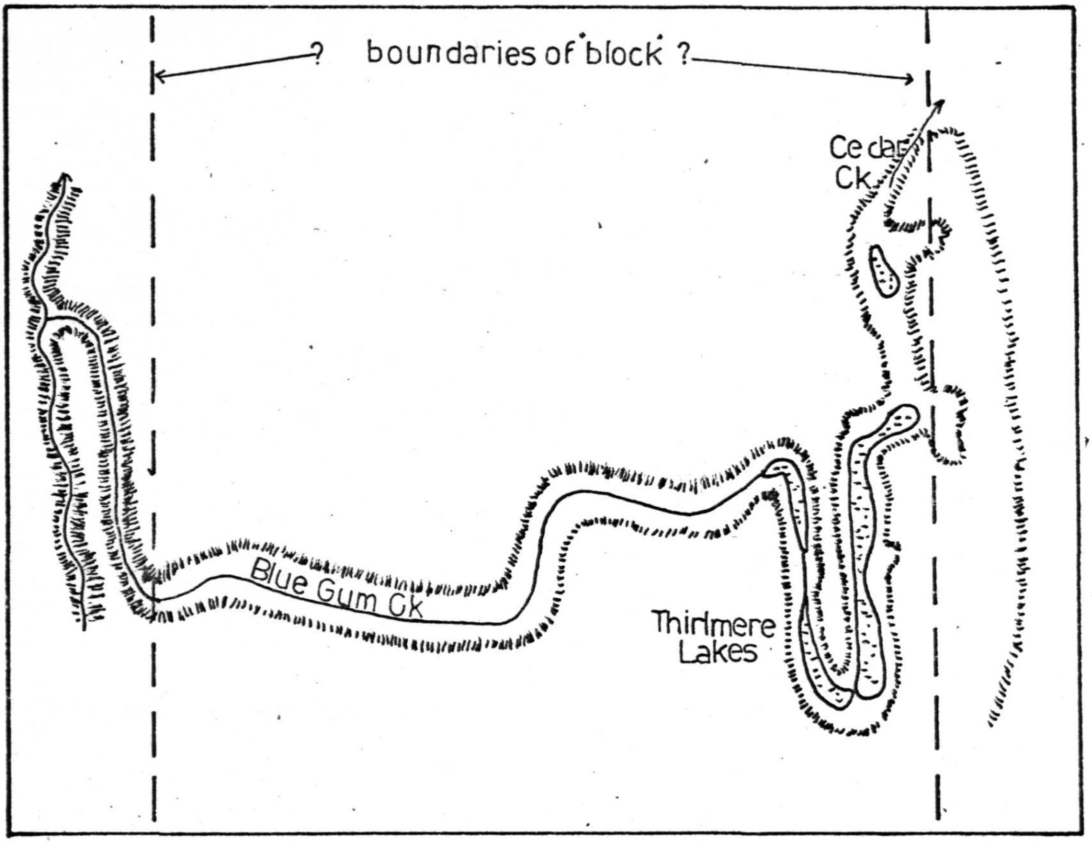

Fig. 5.4 : POSSIBLE EFFECT OF LAPSTONE "BLOCK" UPLIFT ON THIRLMERE LAKES (not to scale)

it would appear that wearing back of the bedrock valley sides has proceeded at a much faster rate or for a much longer period in the Thirlmere Lakes valley than in the Bargo River. Although the discharge of the "Thirlmere River" is unknown, the former can be discarded on the grounds that the physical environment of the two areas (particularly in terms of rock type) is essentially the same. While the Bargo River is downcutting vertically through the bedrock, the "Thirlmere River", in the period before aggradation ensued, may have been eroding laterally, thereby aiding the widening of the valley. Lateral erosion may have been assisted by the presence of a weaker shaleband. As the true outline of the bedrock valley beneath Thirlmere Lakes is largely unknown at this stage, one can merely postulate that the Thirlmere Lakes valley is wider than the Bargo River valley because back-wearing and/or downcutting has proceeded for a much longer time in the former area.

By comparison, the sandstone valley in which Cedar Creek flows is much narrower and shallower than either of the above-mentioned valleys and is therefore considered to be of more recent origin. The fact that its drainage network extends beyond the line dividing easterly from westerly-flowing drainage in the area (Fig. 5.5) suggests that headward retreat is occurring more rapidly in Cedar Creek than in, say, Couridjah Creek which is a tributary of Blue Gum Creek.

In calculating the sinuosities of the various rivers, it was found that the ratio of stream length to down-valley length varied considerably along any one stream; thus the giant meander bend of the Thirlmere Lakes valley need not necessarily indicate the great size of the river which cut it.

5.3.2 <u>Former Direction of Flow</u>: Aerial photographs and field reconnaissance show that the flat valley bottom extends downstream along Blue Gum Creek at least to the point where the 800 ft (266.6 m) contour is crossed. Valley cross-sections drawn from topographic maps (Fig. 5.6; locations on Fig. 1.2) show that the valley sides become more precipitous as the valley becomes deeper, but that the

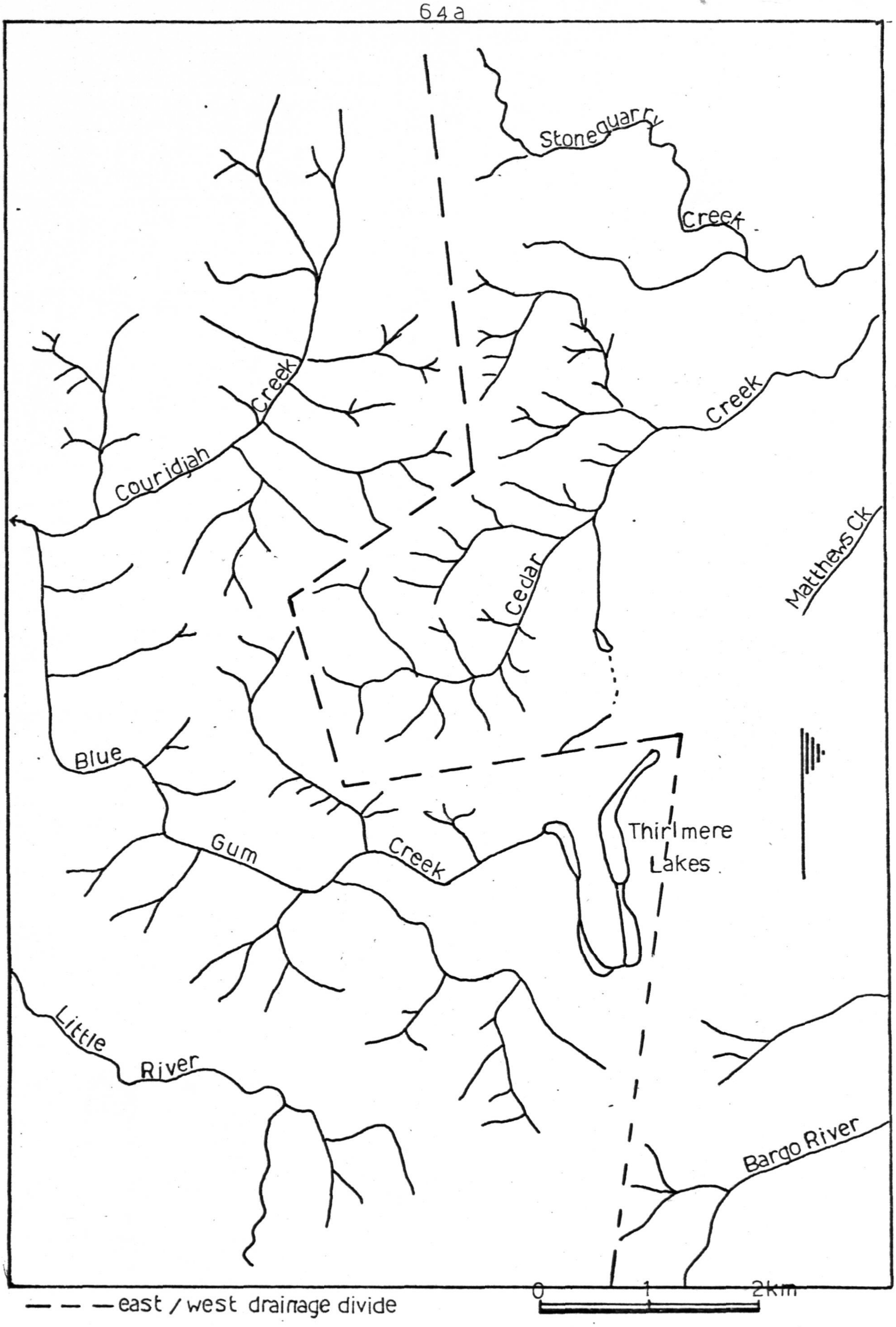

Fig. 5.5 : PRESENT DRAINAGE PATTERNS AROUND THIRLMERE LAKES, SHOWING BOUNDARY BETWEEN EASTERLY AND WESTERLY FLOWING STREAMS

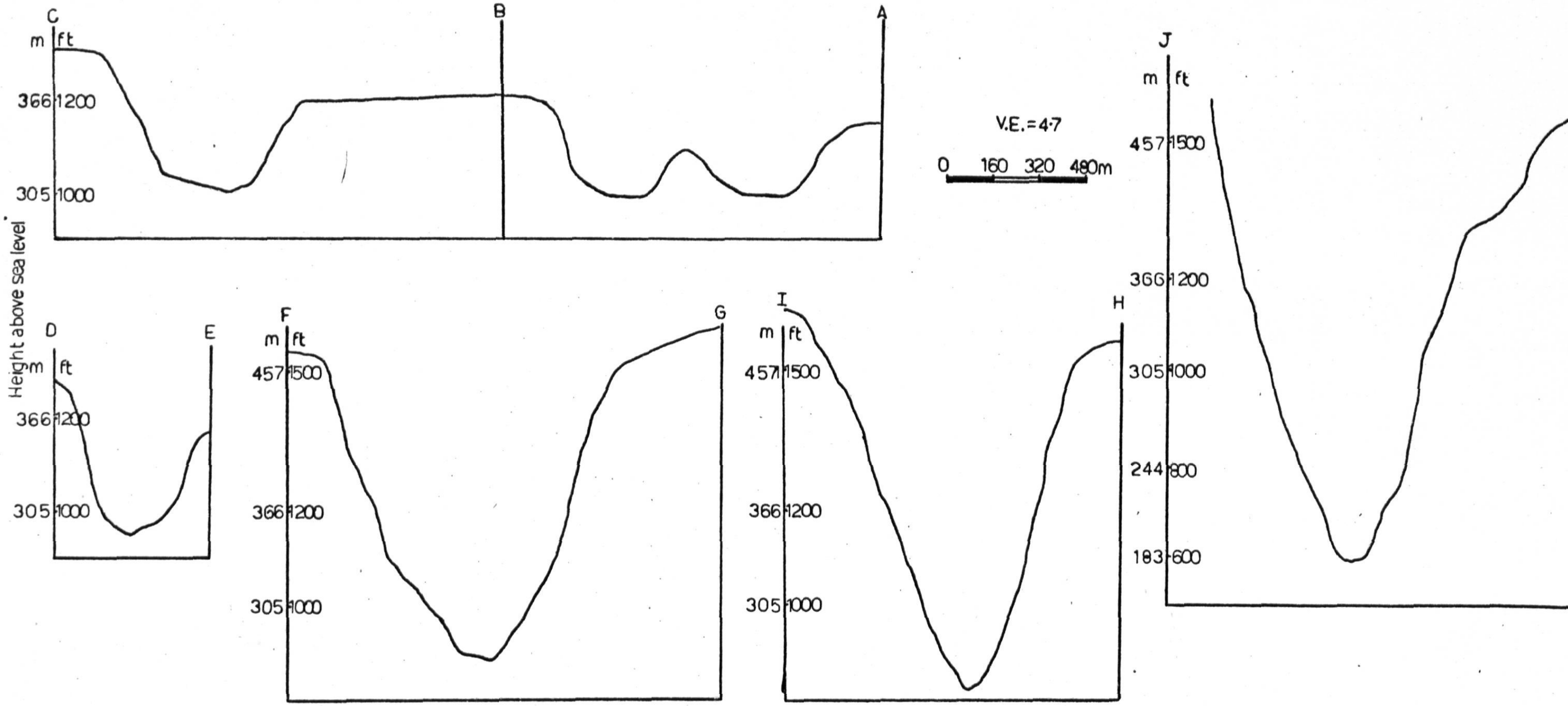

Fig. 5.6 : BLUE GUM CREEK VALLEY CROSS-PROFILES. The valley bottom becomes more v-shaped towards the west. Locations of profiles are shown on Figs. 1.2 and 5.7

actual width of the valley, at both the 1,200 ft (400 m) and 1,500 ft (500 m) contour lines, becomes greater as the junction with Little River is approached.

To the north of the lakes, the narrowest point occurs between Dry Lake and Cedar Creek. Bedrock outcrops in the headwaters of this creek, at about the 1,000 ft (333.3 m) contour level, while in Blue Gum Creek it is not encountered in the bed of the creek before the 800 ft (266.6 m) contour level is reached. Therefore, given that the bedrock beneath the lakes is at depths of greater than 50 to 60 metres i.e. 820 - 850 ft (273 to 283 metres) above sea level, then the bedrock valley bottom appears to decrease in elevation towards the west. Coupled with the increase in valley width in this direction, this points to a westerly flow direction for the stream which cut the bedrock valley.

5.3.3 Evidence From Blue Gum Creek: The longitudinal profile of Blue Gum Creek, from the 1,000 ft (333.3 m) contour at the northern end of the lakes to its junction with Little River, is shown in Fig. 5.7. The gradient of the creek increases about half way along the length, at a point which corresponds to the change from a flat-bottomed to a v-shaped valley, and possibly indicates rejuvenation of the stream. Upstream from the knickpoint, the creek is actively cutting down through the valley fill deposits, which can be seen to consist of layers of cobbles, contributed by the tributary creeks, interbedded with finer sands and silts. At the point where the cobbles are first encountered, the creek descends a short (about 0.3 m high) "waterfall" it has created by cutting into a peat deposit. Whether this peat is of lacustrine or backswamp origin has yet to be established, but extrapolation of the base of the peat encountered in BH2 to the west (Fig. 5.7) places it at approximately the same elevation as the peat deposit exposed in the creek bed. Thus the possibility exists that the lakes extended at least as far as this i.e. twice their present length, at or shortly after the time of their formation. However, confirmation of this would require extensive drilling between

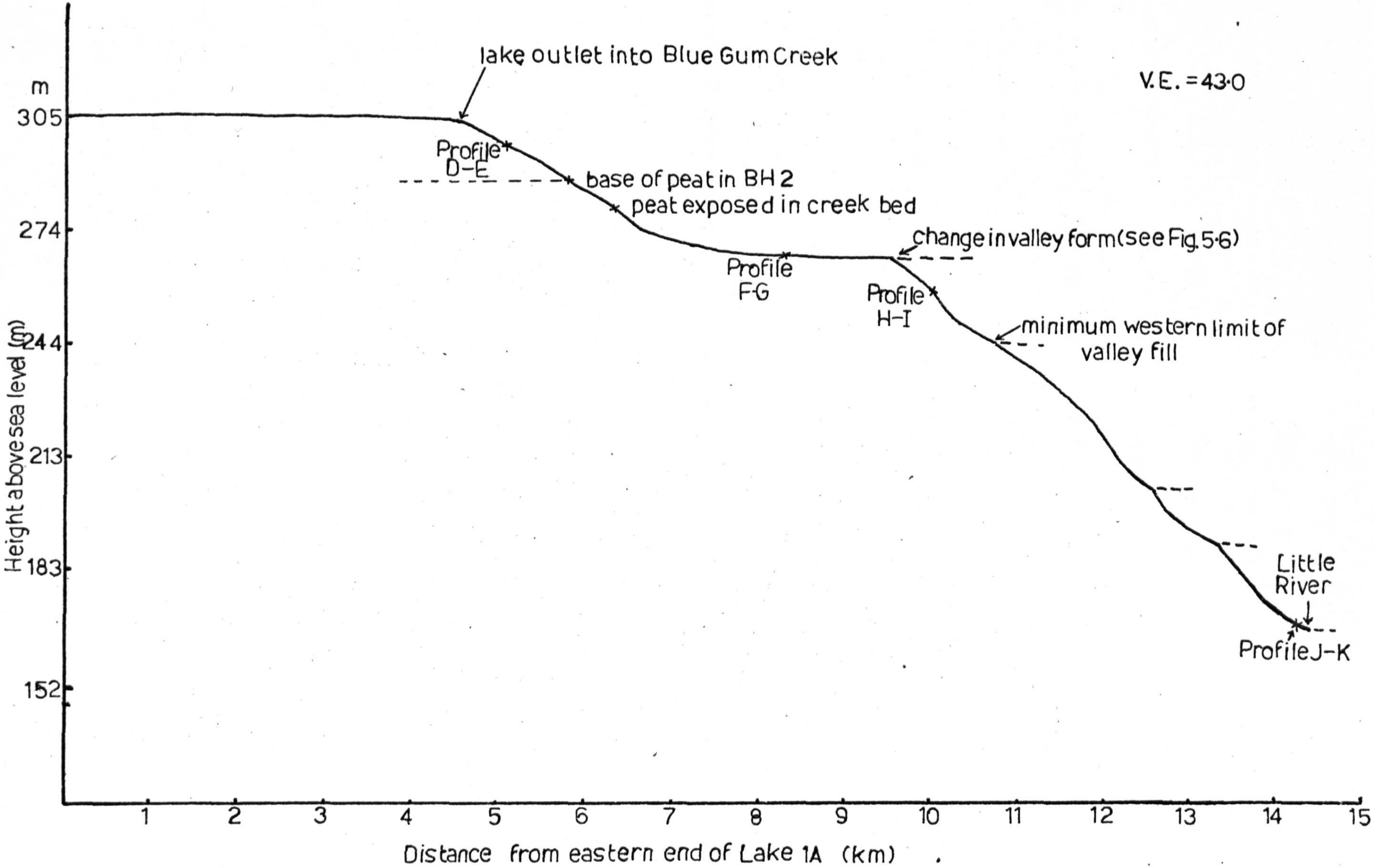

Fig. 5.7 : LONGITUDINAL PROFILE OF BLUE GUM CREEK. Note change in gradient at point where valley cross-profile becomes v-shaped.

the "waterfall" and the lakes.

Upstream from the "waterfall", the creek bed is colonised by sedges and paperbarks (Plates 5.1 and 5.2), which suggests that flow has been sluggish, if occurring at all, and the accumulation of peat could possibly proceed under these conditions. Thus, while the lakes in their present form may not have extended to the west, the area has at least been typified by swampy conditions; this situation will rapidly change, however, if the outlet from the lakes into Blue Gum Creek is maintained.

5.3.4 Synthesis: From the above discussion the following points can be made :

1. Bearing in mind the assumptions which have been made about the depth to bedrock and the form of the bedrock valley at Thirlmere Lakes, it appears that the valley may be of greater age than the surrounding drainage lines, such as the Nepean and Bargo Rivers to the east and Cedar Creek to the north.

2. With similar reservations, the decrease in the elevation of bedrock and the increase in the width of the bedrock valley to the west indicate that the direction of flow of the river which formed the valley was to the west.

3. The nature of the valley fill exposed along Blue Gum Creek suggests that at least swampy conditions have existed along this valley for the same distance again as the present length of the lakes, and that the draining of these swamps by Blue Gum Creek is a relatively recent phenomenon.

5.4 SEQUENCE OF EVENTS

At this stage, it will not be disputed that downcutting by a river assisted in the formation of the bedrock valley in which

Plate 5.1 : Blue Gum Creek, 100 Metres Downstream From Junction With Lake IV; View Downstream.
(Note paperbarks in channel)

Plate 5.2 : Blue Gum Creek, 1 KM Downstream From Junction with Lake IV; View Upstream.
(Note sedges and large paperbarks in channel)

Thirlmere Lakes now lie. Evidence given in Section 5.3.2 above suggests that this ancient river used to flow from east to west. The great depth of fill in the valley also suggests that river aggradation occurred, but at what stage in the sequence it ceased is unknown; evidence given in Section 4.3.4 above suggests that lacustrine conditions were in existence for the time represented by at least the top 20 metres of fill. There is no evidence to indicate the direction of flow of the aggrading river, so for the sake of simplicity it will also be presumed to be to the west. This is in accord with the hypothesis of Griffith Taylor (1911), whereby he suggested that the pre-uplift Tertiary drainage in the Sydney region was to the west, and the possibility exists that the Thirlmere Lakes valley represents the course of the ancient Cataract, Cordeaux or Nepean. It is also in accord with Craft's (1928b) statement that the drainage lines as we see them today are largely in the same position as they were before the Late Tertiary uplift, but that entrenchment of streams into their old courses has occurred; this effect may be seen in the activity of Blue Gum Creek today.

Damming of the ancient river to form the lakes may have occurred by either the outbuilding of alluvial fans, or by tectonic movement. However, it is unlikely for the two to have been mutually exclusive. The similarity between Thirlmere Lakes and other features in the Sydney region which have been affected by the uplift of the "Lapstone Block", as described in Section 5.2.2 above, is too great to be dismissed. The effect of the uplift on the valley as hypothesised in Fig. 5.4 may be close to the truth when one considers the great amount of fill in the valley, and that alluviation is one of the "symptoms" of tectonic disruption of drainage in the Sydney region. Another alluviated valley is found immediately to the north of Couridjah Creek, and may indicate the western edge of a possible uplifted "block", with the Thirlmere Lakes at the eastern edge. The occurrence of an earth tremor in this vicinity in 1973 (see Section 2.1.1 above) may also indicate the occurrence of modern tectonic movement here.

The tectonic movement postulated to be involved in the origin of the lakes may have been merely a tilting of the land-surface; the gradual rise in elevation from east to west (Fig. 1.2) would necessitate that the tilt was upwards to the west. However, if the ancient river flowed to the west, this type of movement would merely have resulted in incision rather than damming. If, however, the river had flowed to the east, a gradual tilting downwards in this direction (or upwards in the west) would have resulted in incision in the headwaters and aggradation downstream, with lake formation being due to the outgrowth of alluvial fans as base level rose. However, the evidence available points to a westerly-flowing river.

Thus, if we assume that the uplift of a "block" occurred, then did this trigger the alluviation of the whole valley or merely the formation of the lakes? The latter is more likely to be the case because, firstly, uplift usually results in incision rather than aggradation (*ceteris paribus*), and secondly, truncation of the headwaters of the ancient river must have occurred, albeit gradually, so that there may have been insufficient discharge for the transportation of sediment; headwater truncation would be more likely to result in cessation of flow. The cause of the change from incision to aggradation therefore remains a mystery.

In Section 5.3.4 and elsewhere, it was suggested that Thirlmere Lakes were formerly more extensive, at least to the west, than at present. Since that time, infilling via hillslope and alluvial fan accretion has occurred, and it is this fill which is being incised into by Blue Gum Creek at the present time. If this hypothesis is correct, then the lakes may have extended at least as far as the knickpoint in the longitudinal profile (Fig. 5.7), but any evidence for this would have been removed.

Thus, to summarise, the writer believes that the following sequence of events has occurred during the evolution of Thirlmere Lakes to their present form :

1. A westerly flowing stream incised a valley into Hawkesbury Sandstone; its headwaters may have been located in softer Wianamatta Shale to the east, but evidence of this is lacking;

2. For some unknown reason, aggradation ensued, and the valley was filled with fluviatile sediment to an elevation of less than or equal to 935 ft (311.6 m) above sea level in the immediate vicinity of the present lakes.

3. Tectonic uplift began, possibly along the postulated fault line shown in Fig. 2.3, cutting the ancient river off from its headwaters and resulting in ponding of the water on the surface of the uplifted area;

4. Infilling of this lake and/or swamp occurred via the outbuilding of alluvial fans (note that this was probably a contributing factor to the infilling of the valley while the river was aggrading, as depicted in Allen's (1965) model, shown in Fig. 4.3a above).

5. While infilling of the remaining lakes is proceeding at the present time, via both inorganic and organic sediment accumulation described in preceeding chapters, Blue Gum Creek is proceeding to erode the fill from the valley, and will probably eventually drain the present lakes.

While it is true that tectonic uplift may not have affected the area, and lake formation was merely due to the outbuilding of alluvial fans, this does not explain why there appears to be no trace of the headwaters of the ancient river. More importantly, it seems highly unlikely that the Late Tertiary tectonic movement which greatly affected drainage patterns elsewhere in the Sydney region (see Section 5.2 above) would not have influenced the formation of such an anomalous feature of the landscape as the Thirlmere Lakes. However, it must be emphasised that the sequence of events outlined above is merely a broad outline; the finer details have yet to be investigated.

Further research into the history of the Thirlmere Lakes area may take the following directions :

1. Extensive drilling and coring of the valley fill, and accurate mapping of the units encountered therein. These could be traced downstream along Blue Gum Creek and upstream to Cedar Creek.

2. Investigation of the peat exposed in Blue Gum Creek for evidence of a lacustrine depositional environment e.g. the presence/absence of sponge spicules and algal remains.

3. Investigation of other alluviated valleys in the area.

5.5 AGE

Only very broad indications of the absolute age of the various stages in the evolution of the valley and lakes can be given here.

The erosion of the bedrock to form the valley commenced some time after the end of the Triassic Period, but given that the sequence of events hypothesised above occurred, there is no way of knowing when downcutting ceased and aggradation commenced.

As stated in Section 2.1.2 above, it is generally believed that the tectonic movements which gave rise to the "Lapstone Block" occurred during the Late Tertiary Period and thus, in the above sequence of events, the buried peat which gave a radiocarbon age of greater than 40,000 years may date back to this time (i.e. at least 2 million years). However, it is also believed by some workers that uplift is continuing today, therefore lacustrine sedimentation in the valley could have commenced at any time between the initiation of the uplift and 40,000 B.P. Similarly, deposition within the present lakes could have commenced at any time.

CHAPTER SIX

CONCLUSIONS

In an environment as complex as that of Thirlmere Lakes, where we are dealing with geomorphic processes in three time periods (i.e. the present environment, the historical environment, and the geological environment), it is inevitable that many unanswered questions should be raised by a preliminary study such as the one reported in this thesis. Some of these questions could well be the starting points for further investigation in the area; for example :

1. What is the time span covered by the lacustrine sediments in the present lakes; is the clay beneath the organic sediment continuous right across the lakes?

2. What is the nature of the submerged bench revealed by the echosound traces? Is it a source of peat islands? Do the hypothesised changes in lake shape as a result of peat island formation&decay really occur?

3. Has bushfire always influenced sediment transport on the alluvial fans? Has the transportation medium of their sediments changed through time?

4. What is the nature of the sedimentary fill between -20 metres and bedrock? Can the sediments encountered above -20 metres be traced down valley, and what are the implications of the result of this investigation on the postulated evolution of the lakes basin? Can evidence of a possible extension of this valley be found outside the study area?

However, many of these questions are raised only with hindsight, and the following points may be made about the environment and evolution of Thirlmere Lakes :

1. The debris slopes and alluvial fans in the area are essentially the same in terms of depositional process and sediment cover; they differ only in plan form, and this is due to the greater net catchment area of the latter. It has been illustrated that desiccation of the landscape as a result of climatic change need not be invoked to explain the presence of alluvial fans in this environment.

2. That changes in water level in the lakes have occurred is evidenced in the sedimentary column, in vegetation zonation changes and in peat island formation; it yet remains to determine the magnitude and timing of these changes, but a study of submerged stumps showed that lake level has dropped in historical time by at least 4 metres. It appears that the outlet to Blue Gum Creek has only recently been obtained and the lake basin may have been closed for at least one hundred years.

3. The formation of floating peat islands has implications for lacustrine sedimentation in that, firstly, a regular increase in age with depth in the organic sediment may not occur, and, secondly, the classical regressive model of lacustrine "ageing" may be altered somewhat by this process, in that lakes may not be sites of continuous deposition; the formation of peat islands constitutes an erosional process, and is a mechanism whereby sediment within the lake is cycled.

4. The sedimentary fill in the valley is very deep, and while the relationship between lake formation and tectonic uplift in the Sydney area during Miocene times is merely hypothesised from little evidence, the valley fill is nonetheless very old. There is a strong possibility that the bedrock valley and much of the sediment in it

relates to the pre-uplift drainage pattern in the Sydney region.