NOTES ON THE PLEISTOCENE DEPOSITS AT LEMONTHYME CREEK IN THE FORTH VALLEY

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(With three text figures)

ABSTRACT

The Pleistocene deposits at Lemonthyme Creek in the Forth Valley are further described. The pollen content of the glaciolacustrine sediments, the petrography of the tillite, and the compaction and cementation of the tillite are discussed.

INTRODUCTION

The following information is the result of further examination of the Pleistocene deposits in the Lemonthyme Creek Area of the Forth Valley. The deposits were originally described by Paterson (1965), and the present article records the results of an examination of pollen grains from the glaciolacustrine sediments, a petrographic description of the tillite, and a study of the compaction and cementation of the tillite.

GLACIAL DRIFT SEQUENCE (S.J.P.)

The drift sequence (Figures 1 and 2) consists of a basal tillite[4], interbedded tillite, varves, mudstones and siltstones, gravelly to bouldery till, and carbonaceous clays, silts and sands. These are overlain by periglacial solifluction material. The sequence is thought (Paterson, 1965) to contain the deposits of two glacial stages. The tillite, varves, mudstones and siltstones are thought to be the deposits of the first glacial stage, and three tillite layers indicating glacial advances have been recognised together with two varve-mudstone-siltstone layers indicating glacial retreats. The second glacial stage is thought to have commenced with the glacial advance that deposited the blanket of gravelly to bouldery till. It appears that this advance blocked the lower Lemonthyme Valley and created the lake in which the clays, silts and sands were deposited. The final filling of this channel was completed by periglacial solifluction. The probability of two glacial stages is inferred from the marked lithification of the tillite as compared with the overlying till.

POLLEN CONTENT OF THE CARBONACEOUS CLAYS, SILTS AND SANDS (S.L.D.)

Core from Drill Hole 5825 has been examined to ascertain the pollen content. Pollen grains in all the samples are sparse and poorly preserved, and a brief examination of all the samples suggests that there is little difference between them as far as pollen is concerned. The most abundant pollen is that of *Nothofagus*, which is represented by a number of types, including members of the *brassi* group (which no longer occur in Australia). There is also quite a variety of coniferous pollen grains, including *Microcachryidites antarcticus* Cookson and *Dacrydium mawsonii* (Cookson) Cookson, which are morphologically similar to the pollen of extant Tasmanian conifers. Other pollen grains occur only in small numbers; they apparently represent only a few different species, but this conclusion may be influenced by the paucity of pollen in the samples. Fern spores are present in all samples and, although the numbers are small, quite a wide variety of different types were found.

A rough count of 100 pollen grains from the top and bottom samples (76′ and 147′) confirmed the general opinion outlined above. Of the pollen grains whose structure could be made out, the sample at 76′ contained 65% *Nothofagus*, 26% conifers, 3% of proteaceous types and 6% of other kinds of pollen. The sample from 147′ contained 71% *Nothofagus*, 22% conifers, 3% proteaceous types and 4% of other kinds of pollen. Myrtaceous pollen was observed in the top sample (76′), pollen of Casuarinaceae at 92′ and 111′ and pollen of Ericales at 147′, but in each case only one or two pollen grains were found, so that these differences between levels cannot be regarded as significant. It is possible that the species of the more abundant pollen types and the spores may vary at different levels, but it was not possible to investigate this matter.

Many of the pollen grains could be either Tertiary or Quaternary age, and even a detailed examination of the material might fail to establish the status of some of these. Many of the *Nothofagus* pollen grains are considered to be Tertiary species. A random count of 50 *Nothofagus* pollen grains from the sample at 76′ was made, and this shows that at least half of the *Nothofagus* pollen could not belong to either of the extant Tasmanian species of the genus, and that at least four species are represented in the deposit. These include species of the *brassi* group, which is now confined to New Guinea and New Caledonia. This apparently means either that the pollen is derived, and that Tertiary material has been incorporated in these Pleistocene deposits, or that more than two species of *Nothofagus* (including members of the *brassi* group) existed in Tasmania during the Pleistocene period. Unfortunately, the nature of the material is such that it is impossible to decide between these alternatives. The pollen is poorly preserved, and thus it is possible that all or most of it is derived. There are no obvious differences between the

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(4) Tillite—used in the rock sense as a consolidated and indurated till, but without the age connotation applied by Penck that the rock formed during glacial epochs anterior to the Pleistocene (Rice, 1955).

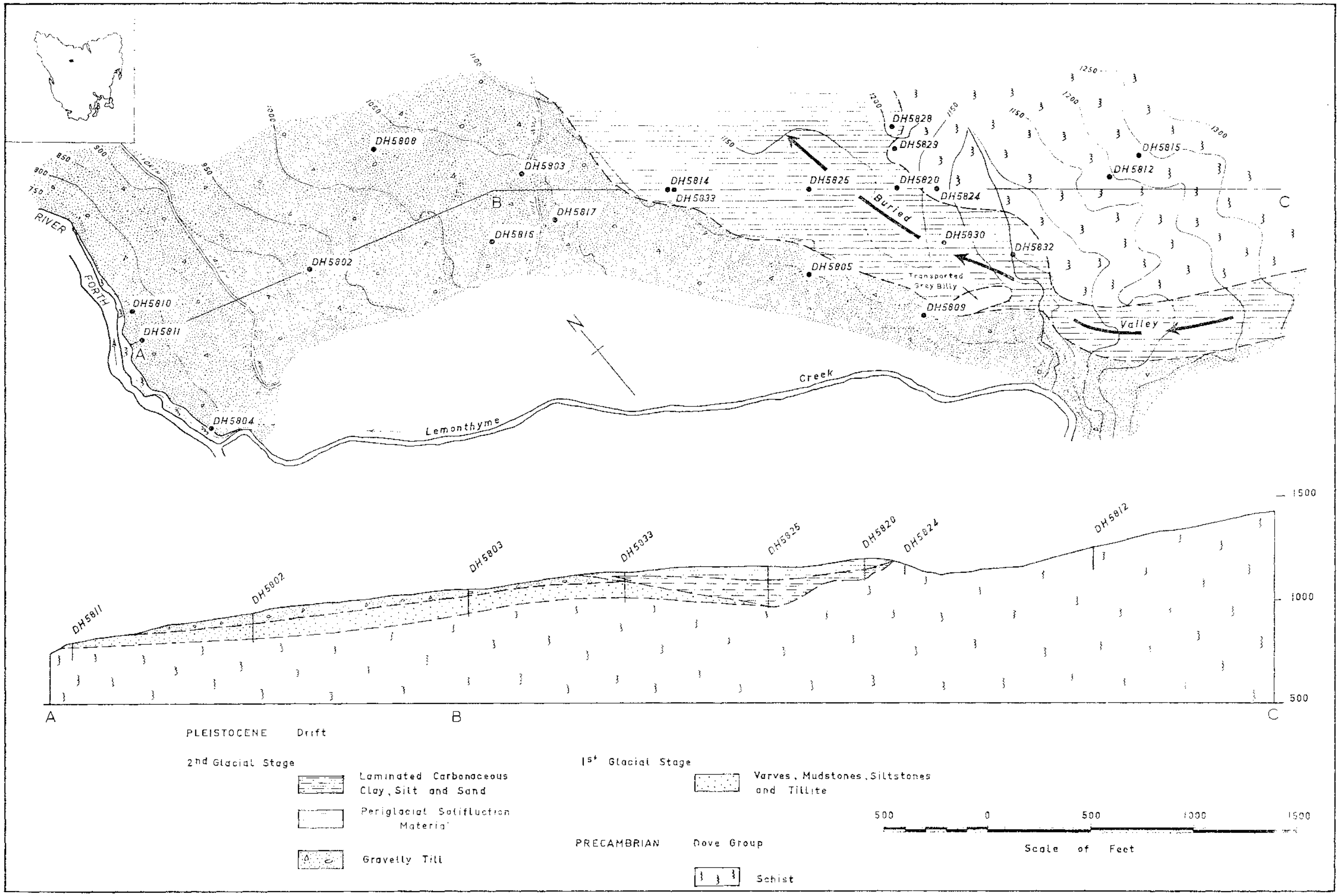

FIG. 1.—Pleistocene deposits in the Lemonthyme Creek Area of the Forth Valley.

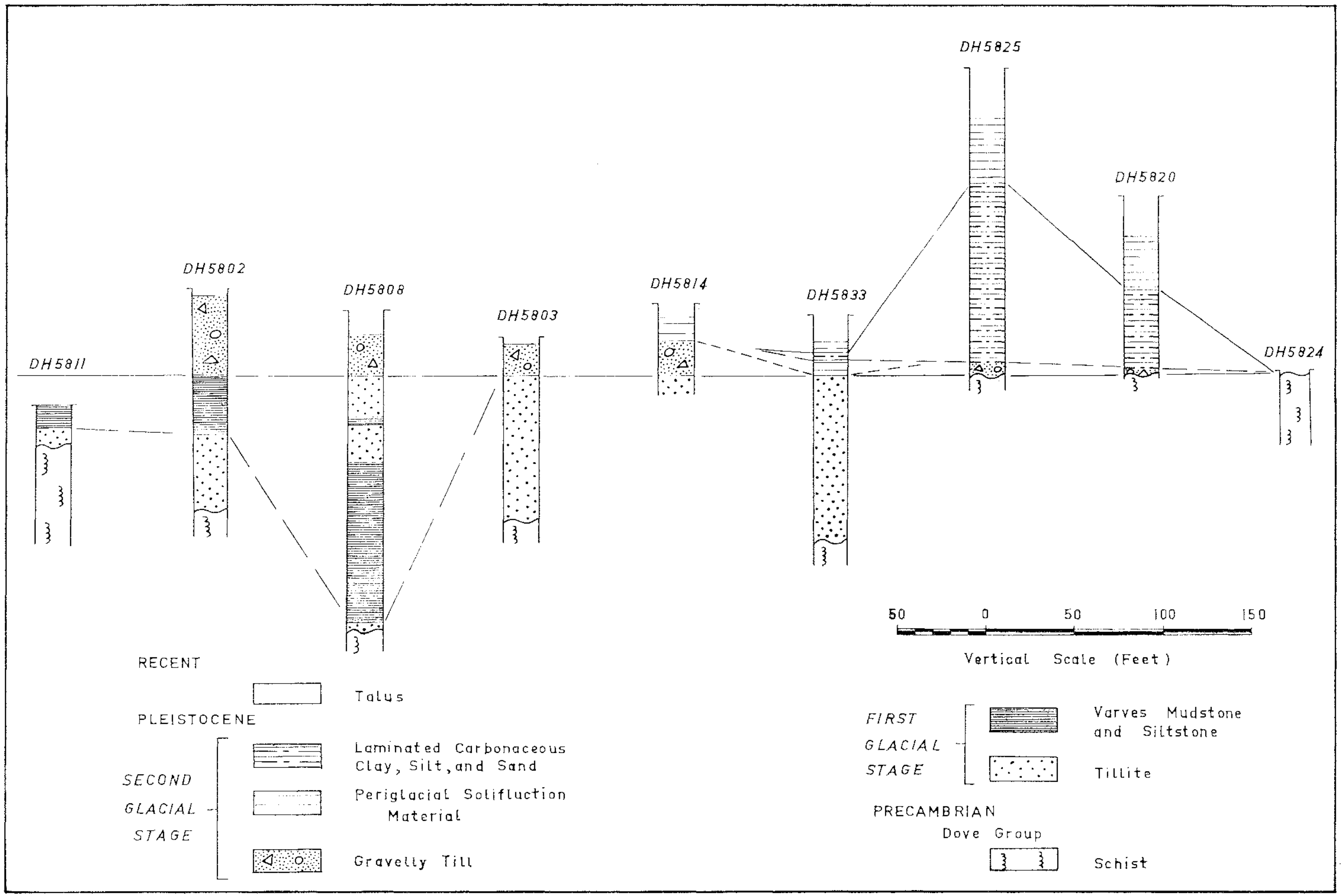

FIG. 2.—Stratigraphic Cross-section—Lemonthyme Creek Area.

preservation of the relevant *Nothofagus* pollen and the rest of the pollen in the sample, and thus it is unlikely that only this *Nothofagus* pollen is of derived origin. Some slight evidence against a derived origin for the bulk of the pollen is found in the fact that the pollen, although not abundant, is present in workable quantities, and that the same pollen flora appears to be represented through about 70′ of the deposit.

STRATIGRAPHIC POSITION OF THE CARBONACEOUS CLAYS, SILTS AND SANDS (S.J.P.)

In view of the uncertainty expressed above about the origin of some species of *Nothofagus* pollen grains, the following note is included to clarify the stratigraphic position of the sediments.

The sediments were deposited in a buried valley (Figure 1), a former channel of Lemonthyme Creek, which has been defined by drilling and seismic survey. Drill Hole 5833 on the western edge of the channel revealed the stratigraphic relationship, and indicated that the laminated carbonaceous clays, silts and sands overlie tillite. A maximum thickness of 110′ of these sediments were found in Drill Hole 5825, and the sediments have a dip of 3° and are overlain by 65′ of solifluction material. The presence of boulders, cobbles and pebbles of Jurassic dolerite and Tertiary basalt in the tillite clearly indicated that it is a Pleistocene tillite and that the sediments are thus part of the Pleistocene sequence. Before Drill Hole 5833 was drilled Spry (in Paterson, 1965) had concluded that the sediments in the buried valley were Pleistocene glaciolacustrine in origin from a petrographic study.

PETROGRAPHY OF SOME TILLITE SPECIMENS (G.A.J.)

The rock consists of angular to sub-rounded fragments ranging in size from 90 x 45 mm. to 2 x 1 mm. and a dark greenish brown matrix. Under the microscope the larger fragments are seen to consist of basalts, greywackes, siltstones, quartzites and quartz schists (the majority of the drill cores indicate a predominance of dolerite boulders, cobbles and pebbles (Paterson, 1965)). Basalt fragments predominate and they range from hypohaline types to completely holocrystalline types, though hypocrystalline are the most common. Larger fragments of basalt contain olivine, but in smaller fragments olivine is pseudomorphed by a brownish green material with a lamellar structure resembling iddingsite, though in places some of this material appears isotropic. Interstitial glass in the hypocrystalline rocks is partly or wholly altered to a similar material and this appears to have a very low birefringence. Apart from this alteration the rocks are absolutely fresh. A number of different grain-sizes and textures may be recognized among the basalt fragments some types being tachylytes with feldspar microlites, others fine granular basalts and others again medium to coarse grained ophitic rocks which might be called dolerites. All these rocks appear to be alkali basalts of Tertiary age and no Jurassic tholeiitic dolerites have been positively identified.

Tiny chips of the same rocks and minute fragments of quartz and pyroxene with or without cementing material form a kind of mortar between the larger fragments. These range in size from about 0.2 mm. to less than 0.001 mm.

One slide Drill Hole 5808-27′ shows definite cementing material binding the smaller chips of the mortar and forming a film around larger fragments. This cementing material closely resembles the brownish-green material found as an alteration product of glass and of olivine in the basalt fragments. It has a lamellar structure with tiny fibres arranged at right angles to the edge of the rock fragment (figure 3). It is possible that some of this material is a clay mineral of the montmorillonite group, possibly nontronite, though these minerals, like so-called iddingsite, have a medium birefringence, whereas much of the dark green material in these rocks appears to be nearly isotropic. It is possible that the cementing material is a mixture of clay minerals of the kaolinite and montmorillonite groups or even a chlorite, and the matter can probably be decided only by X-ray. It is of interest to note that in some rocks the alteration product of olivine, formerly identified as iddingsite, has in some cases proved to be an admixture of montmorillonite and iron oxides. In places a carbonate mineral also acts as a cement (Figure 3).

All stages of cementation may be studied in these rocks and there appears to be no relation between this and depth of burial.

Drill Holes 5808-56′ and 5814-50′ show only a trace of cementation, though interstitial glass in basalt fragments are almost completely altered. In both these rocks cohesion rather than cementation appears to be holding the fragments together. Both slides were difficult to grind and tended to break up.

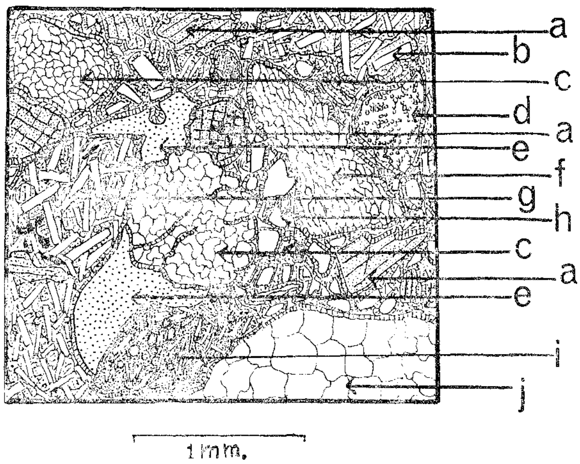

FIG. 3.—Tillite thin section—Drill Hole 5808-27′

The clay film enveloping fragments has been exaggerated in width to show the fibrous structure.

a = pyroxene fragment
b = ophitic dolerite
c = quartzite
d = fine intergranular basalt
e = carbonate
f = quartz schist
g = coarse intergranular basalt
h = quartz chip surrounded by clay mineral
i = hypohaline basalt

Drill Hole 5803-88′ shows glass altering to a brown-green clay mineral and a little carbonate material and only incipient cementation.

Drill Hole 5817-20′ contains fragments of basalt showing complete alteration of glass, a film of brown-green clay around basalt fragments and cementation of smaller fragments in the immediate vicinity of basalt fragments, whereas no binding material or clay film was detected in the immediate vicinity of or around fragments of sedimentary or metamorphic rocks.

Cementation, therefore, appears to be very patchy. It begins with alteration within the basalt fragments, forms a film about them and about small quartz fragments close to them and finally migrates to and envelops the sedimentary and quartzose fragments elsewhere.

CEMENTATION AND COMPACTION (S.J.P.)

Most of the tillite core is well consolidated. and tests have revealed compressive strengths of up to 2568 lbs./sq. in. and tensile strengths averaging 353 lbs./sq. in. This indicates that in compressive strength the tillite corresponds to a weak sandstone, but its tensile strength is better than that found in most sandstones (Krynine and Judd, 1957).

Dr. J. C. van Moort of the Department of Geology, University of Tasmania has briefly studied the degree of cementation and compaction of the tillite by comparing samples of tillite with samples of till from Rowallan and Parangana Damsites and from Lemonthyme Creek. He found that the mineralogical composition of the fraction below 64 microns to be similar in each case. The phyllosilicates detected were illite, montmorillonite and chlorite. Microscopically no special cement was detected. He also studied the water content of the fraction below 64 microns. The results are given in Table I.

TABLE I.

Water Content

	H_2O-%	H_2O+%
Rowallan Till	0.3	13.5
Parangana Till	2.5	9.5
Lemonthyme Till	5.0	13.0
Lemonthyme Tillite (Drill Hole 5833 Depth 85′)	2.7	4.0

The low value of H_2O- for the Rowallan till is considered to merely indicate that the sample was well air dried before heating. The low value for H_2O+ for the tillite, however, is considered to be significant and to indicate that the tillite is much more dehydrated and compacted than the other specimens.

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