OTHER VOLCANIC ROCK OCCURRENCES

4.0 Introduction

Small areas of Late Triassic volcanic rocks occur throughout Ipswich Basin, but because of either restricted outcrop area, limited exposure, and/or thickness/extent of the unit, insufficient data exist to justify detailed study of individual areas. The geology of these areas is given in this chapter. Included in these isolated volcanics rocks are those in and around Ipswich, on Moreton and Stradbroke Islands, and in drill holes.

4.1 Ipswich Area

The greatest diversity of volcanic rocks cropping out on the surface of the Ipswich Basin occurs in the Ipswich area (Fig 4.1). At the base are the basaltic andesites and andesites of the Weir Basalt and Sugars Basalt, which together with those of Moreton Island, constitute the only outcrops of mafic rocks. The Weir Basalt and Sugars Basalt are overlain by felsic pyroclastic rocks of rhyo-dacitic (Hector Tuff), and rhyolitic (Mount Crosby Formation tuff and Brisbane Tuff) composition.

4.1.1 Geological Background

In the Ipswich area, the Ipswich Coal Measures are subdivided into the Kholo Subgroup and Brassall Subgroup (Fig. 1.5) (Cranfield *et al.*, 1989). The coarse grained scree deposits, fanglomerates, and fluviatile sedimentary rocks of the Kholo Subgroup's Blackwall Breccia, Mount Crosby Formation, Colleges Conglomerate, and Cribb Conglomerate contrast with the quiescent fluviatile-lacustrine activity (during which coal measures accumulated) of the Brassall Subgroup which followed. All significant volcanism occurred in the Kholo Subgroup.

The basal formations of the Kholo subgroup comprise the laterally equivalent scree deposits of the Blackwall Breccia and the sub-aerial basaltic-andesite Sugars Basalt and Weir Basalt. Overlying these basal deposits is the Mount Crosby Formation, a dominantly conglomeratic unit, which contains two thin tuff horizons. In turn,

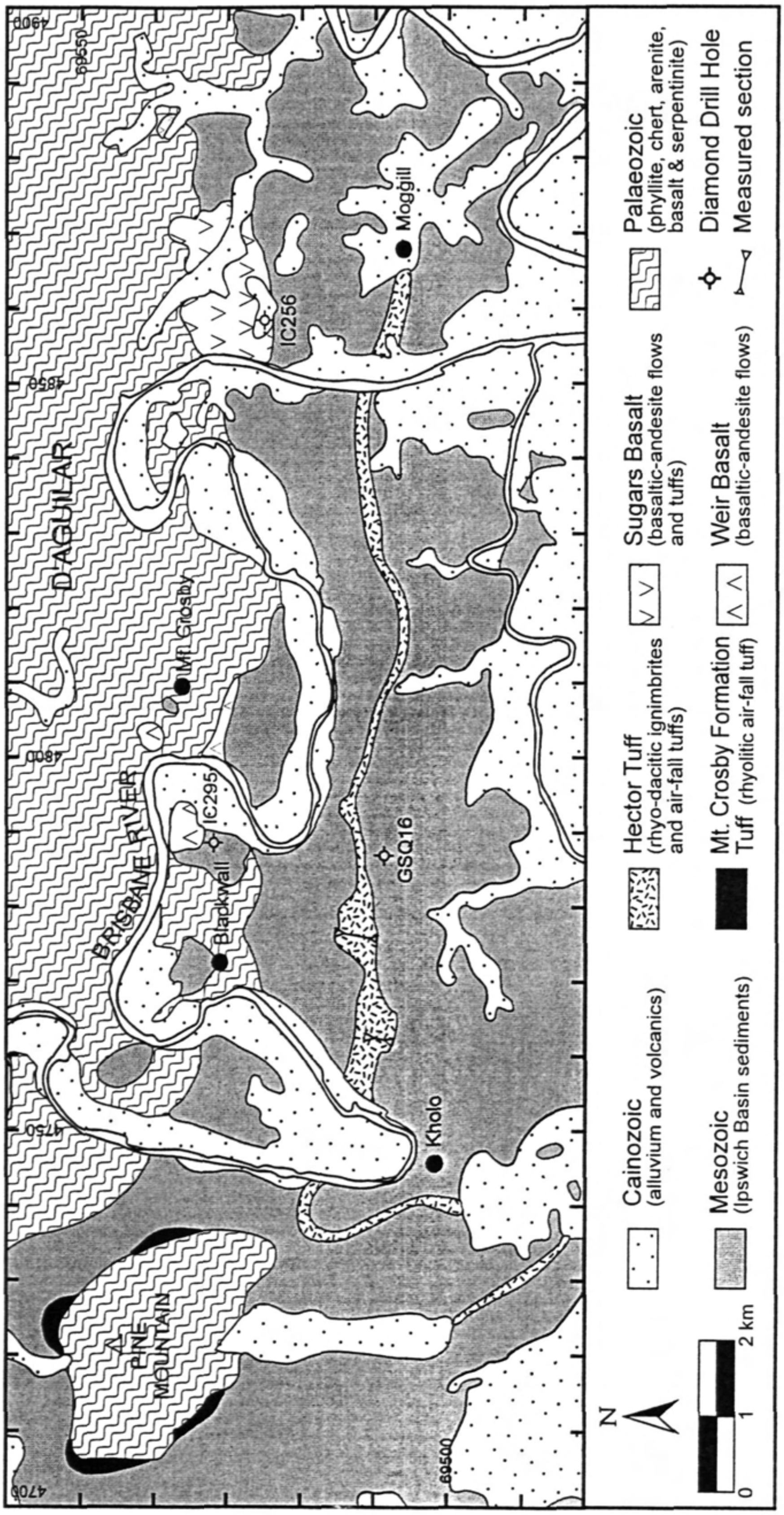

Figure 4.1 Geological map of the area north of the city of Ipswich, based on Ipswich 1:100,000 sheet map (Cranfield *et al.*, 1989). For location, see figure 1.1. The adjacent measured sections at Francis road and to the east are located on the single line northeast of Kholo.

overlying the Mount Crosby Formation, are the conglomerates and sandstones of the Colleges Conglomerate (Cranfield *et al.*, 1989). The Hector Tuff, which followed the Colleges conglomerate, contains ignimbrites and air-fall tuffs, together with fluviatile and lacustrine sedimentary rocks. The final formation of the Kholo Subgroup is the fluviatile Cribb Conglomerate (Cranfield *et al.*, 1989).

4.1.2 Mafic Rocks of the Ipswich Area

The Sugars Basalt crops out in the Moggill area and the Weir Basalt in the Mount Crosby areas (Fig. 4.1). Both are of basaltic-andesite composition, and are probably lateral equivalents. Geochemically, the basalts of both units are similar, except the Weir Basalt has labradorite, while the Sugars Basalt has bytownite (Appendix D), and some subtle variations detailed in chapter 5. The units were originally differentiated by Allen (1959), who suggested that the two units were probably laterally equivalent. Houston (1965), from unspecified palaeomagnetic evidence, reported that the Weir Basalt was approximately 10,000 years older than the Sugars Basalt, though the resolution of this 10,000 years difference between flows in the Late Triassic is questionable. Webb and McNaughton (1978) using the K-Ar whole-rock method, determined the age of the Sugars Basalt as 229 and 232 Ma, which corresponds to the Carnian stage.

4.1.2.1 Weir Basalt

According to Cranfield *et al.* (1989), the Weir Basalt has a maximum thickness of 30 m in DDH NS 295 (Houston, 1965) (Fig. 4.3) and 11 m at its type section, and is defined as an altered porphyritic basalt. It overlies members of the Blackwall Breccia, and is in turn overlain by the Mount Crosby Formation. The Weir Basalt is exposed over an area of only 0.25 km^2 (Cranfield *et al.,* 1989), and comprises multiple lava flows, including amygdaloidal and non-amygdaloidal, porphyritic and aphyric basaltic-andesites. Within the Geological Survey of Queensland drill hole NS 295 (Fig. 4.3), four separate lava flows were identified.

4.1.2.2 Sugars Basalt

The maximum recorded thickness of the Sugars Basalt is 105 m in DDH NS 256 (Houston, 1965) (Fig. 4.2), and has a thickness of approximately 37 m at its type section in the abandoned Hawksbury/Sugars Quarry (Cranfield *et al.*, 1989). The formation is defined by Cranfield *et al.* (1989) as an amygdaloidal basalt. At the type section of the Sugars Basalt, at least seven separate lava flows, and an air-fall tuff occur. In the quarry, stratigraphic relationships between individual flows are obscured by the irregular shape of the flows. The maximum thickness of an individual flow in the quarry is 10 m, but most flows are much thinner. The flows in the quarry include non-porphyritic and porphyritic, and amygdaloidal types.

Cooling columns that are restricted to individual flows indicate that the thermal history of individual flows is unique, and that time gaps separated individual flows, although given the comparatively small thickness of the flows, these breaks in activity may not have been more than a few years.

The air-fall tuff in the Sugars Basalt is light green-grey, contains abundant feldspar and pyroxene phenocrysts, and is mineralogically similar to the basaltic-andesite lava flows with which it is interbedded. A tuffaceous horizon (102-115 m, Fig. 4.2) in DDH NS 256, which intercepted 105 m of the Sugars Basalt, can be correlated with the tuffaceous bed in the type section, based on lithological and stratigraphic similarities between the two tuffs. Up to 9 additional lava flows occur above the lava flow that overlies the tuff in the type section. To total depth, this indicates a total 17 lava flows and an air-fall tuff constituting the Sugars Basalt. Unfortunately NS 256 did not penetrate basement rocks, and therefore the total number of lava flows occurring could not be determined.

4.1.2.3 Eruptive History

The Weir Basalt is considered a lateral equivalent to the Sugars Basalt because of broad chemical similarities and the common stratigraphic position of the two formations in the Ipswich Basin. Four flows with total thickness 30 m constitute the Weir Basalt and it is therefore likely that the Sugars Basalt, which has a total thickness of about 105 m in NS 256 and 37 m at the exposed type section, when combined contain about 125 m, at least seventeen separate flows, indicating it was closer to the vent, was

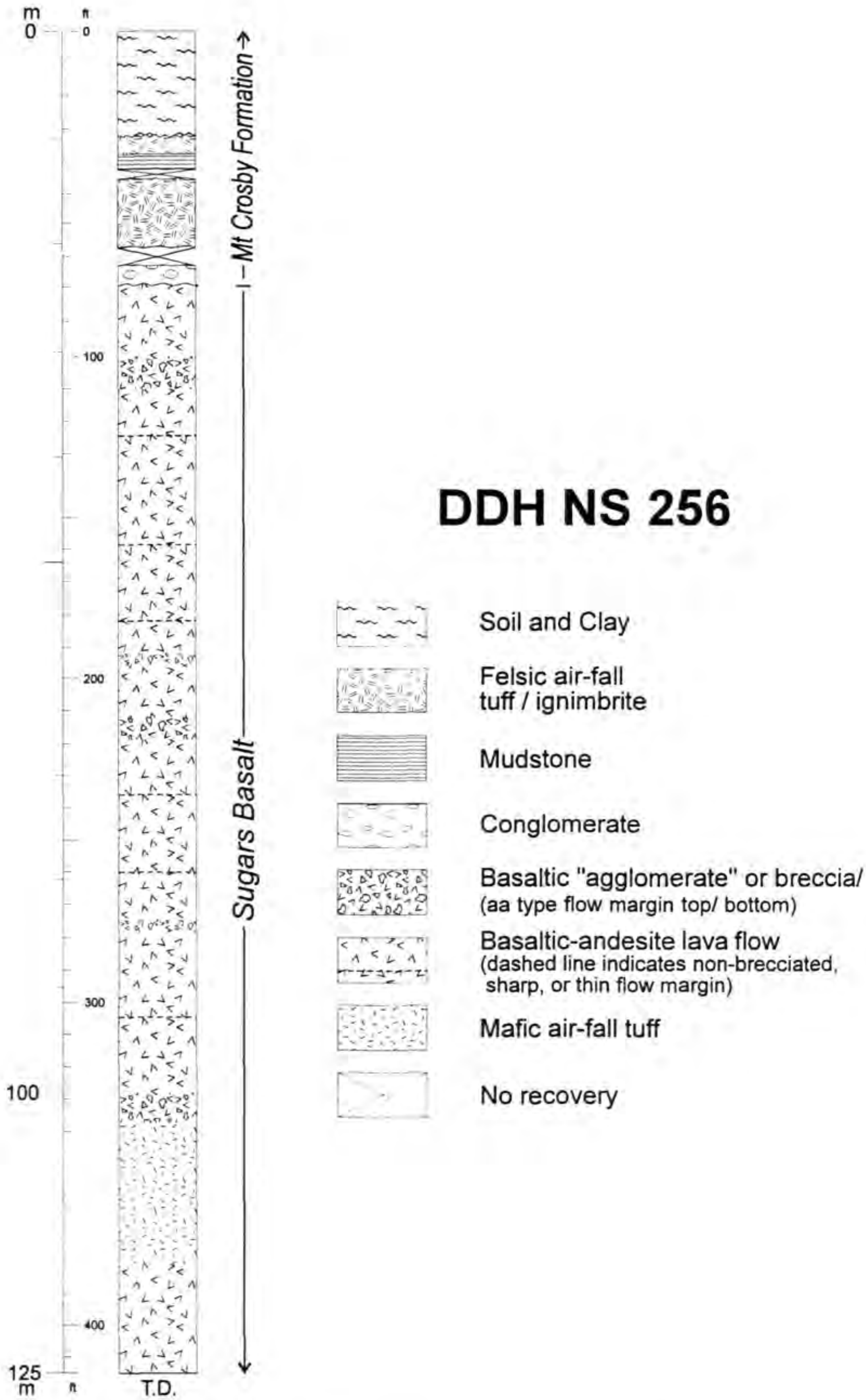

Figure 4.2 Drill log of GSQ NS 256, based on Houston (1965) and a re-examination of the core.

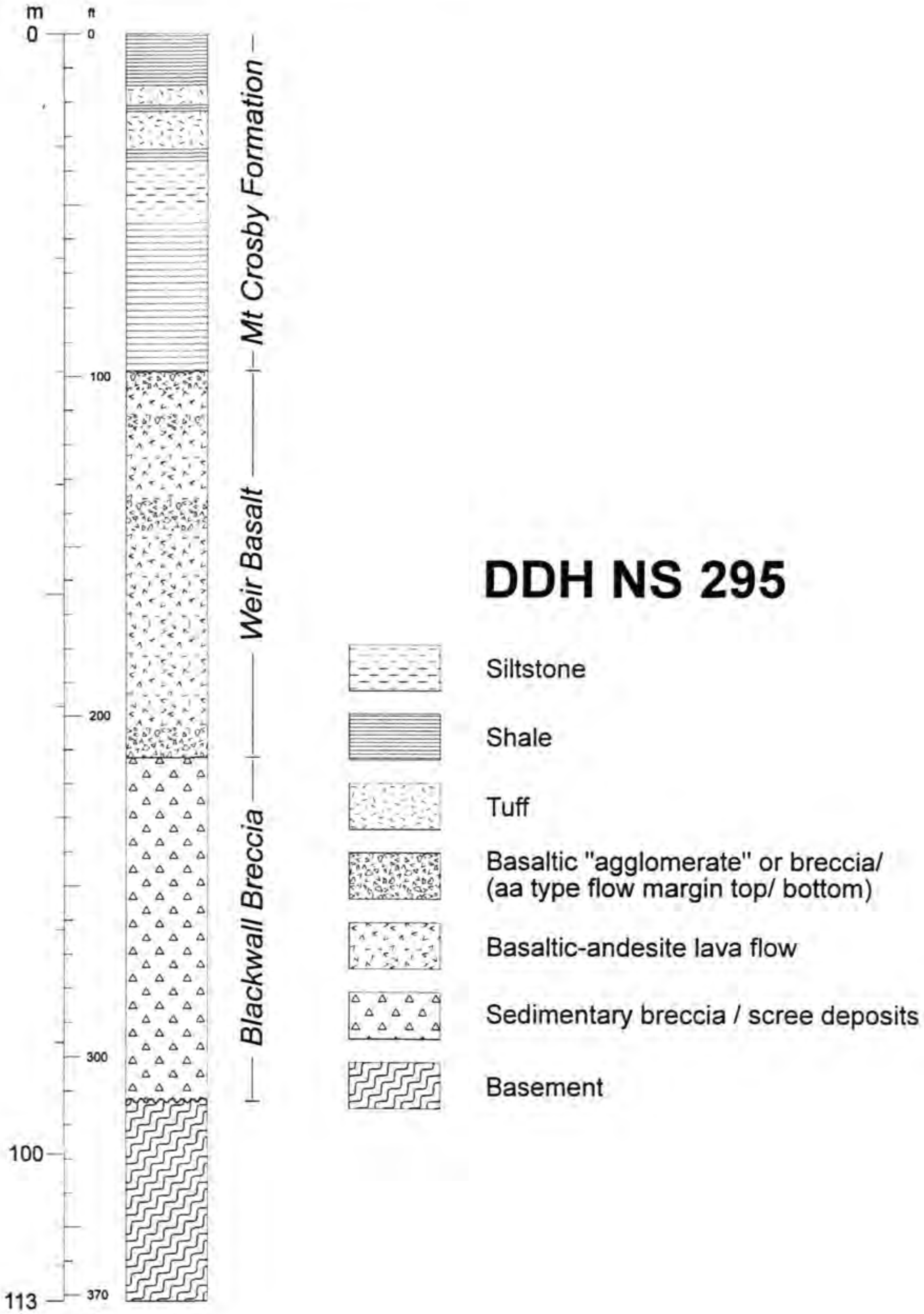

Figure 4.3 Drill log for GSQ NS 295 based on Houston (1965) and a re-examination of the core.

in an area exposed to more prolonged activity, or was ponded.

Houston (1965) described what she considered "*inter-pillow material*" (hyaloclastite?) (Plate 4.1) in two flows in NS 256, but suggested that it was impossible to prove that any pillows are present in drill core. No evidence exists to suggest conclusively if either of the formations were erupted entirely sub-aqueously or sub-aerially, but the scarcity of hyaloclastites between most flows, the lack of interbedded epiclastic sedimentary rocks, and short breaks between eruptions indicate dominantly sub-aerial emplacement.

Basaltic-andesite lavas do not commonly form extensive magmatic pyroclastic eruptions, the results of which would normally be a proximal spatter cone derived from fire-fountaining (Cas and Wright, 1987). The air-fall tuff represents more likely the product of a phreato-magmatic eruption. The extent over several square kilometres of this tuff precludes the possibility that the tuff was the result of a small secondary eruption caused by lava entering water, instead, it implies that lava was emplaced directly into, or though, ground or surface water. Considering the stratigraphic position of this tuff, together with the record of prior (dominantly sub-aerial) eruptions with no preserved tuffs, I suggest that a crater lake may have developed in the vent, and the air-fall tuff represents a vent clearing process prior to the emplacement of the final three lava flows. If the vents of the Sugars Basalt were not polygenetic, then it is equally possibly that a vent emerging through a body of water, such as a lake, formed the air-fall deposits. Or it is possible that the emergent lava came into contact with, or was erupted through, a substantial groundwater or geothermal aquifer, following a similar pattern to the 1886 eruption of Tarrawarra, New Zealand (one of the few documented plinian fall deposits associated with a basaltic centre), where a reservoir of geothermal water was thought to play an integral role in producing the plinian eruption and consequent air-fall deposits (Walker *et al.*, 1984).

4.1.3 Tuff in Mount Crosby Formation

The Mount Crosby Formation overlies the Blackwall Breccia and the Weir Basalt and the Sugars Basalt (Cranfield *et al.*, 1989). It consists of polymictic conglomerate with minor mudstone, arenite and lithic tuff. A Carnian age is indicated by microflora (Cranfield *et al.*, 1989).

Deeply weathered green tuff, altered to chlorite, and with a porphyritic texture, crops out east of Pine Mountain (Fig. 4.1). The two tuffs in the tuffaceous section of the Mount Crosby Formation are separated by a thin interbedded tuffaceous arenite and mudstone (Fig 4.4). The upper slightly coarser-grained tuff contains abundant dense lithic clasts composed exclusively of black chert (average size 3 mm). Small slightly flattened pumice clasts give it a foliated appearance (parallel to bedding) when weathered, suggesting that this upper unit could be an ignimbrite. The phenocrysts in both tuffs are of plagioclase feldspars, quartz, alkali-feldspars, and biotite altered to chlorite.

In DDH NS 295, two tuff beds in the Mount Crosby Formation Tuff (Fig. 4.3), the upper tuff 1.3 m thick, and the lower tuff 3.7 m thick, are separated by a 30 cm thick mudstone. The tuffs contain phenocrysts of quartz, alkali-feldspar, and plagioclase feldspar. The lower tuff contains altered glass shards, pumice clasts, and clay rich patches that pseudomorph pumice. The lower succession with a flow-like texture and parallel clasts may be an ignimbrite. The tuff is rhyo-dacitic in composition, similar to the Hector Tuff (see Chapter 5).

Houston (1965) noted two tuff horizons separated by a 1.5 m thick shale in the Mount Crosby Formation in DDH NS 256 (Fig. 4.2). The upper tuff, 1.4 m thick, was described by Houston (1965, p 5) as containing "*fine green blebs*", possibly pumice clasts altered to chlorite. The second tuff, 5.3 m thick, described as being "*argillically altered*", contains minor lithic fragments and quartz and feldspar phenocrysts. Almond (1982), reporting a tuff in the Mount Crosby Formation in DDH GSQ Ipswich 26 (Fig. 4.9), did not mention how many separate horizons of tuff were encountered. The 25 m thick tuffaceous horizon in NS 93 (Hawkins, 1956) (Fig. 4.10) has been reinterpreted as part of the Mount Crosby Formation because the characteristic lower ignimbrite and separating shale beds are apparent (see section 4.4.3).

Informally thought to be a lateral equivalent of the Brisbane Tuff, the two tuffs of the Mount Crosby Formation, both of which are probably ignimbritic in origin, cannot be conclusively correlated with the Brisbane Tuff. They are more dacitic than the Brisbane Tuff, and their dense lithic clasts are different from those of the Brisbane Tuff,

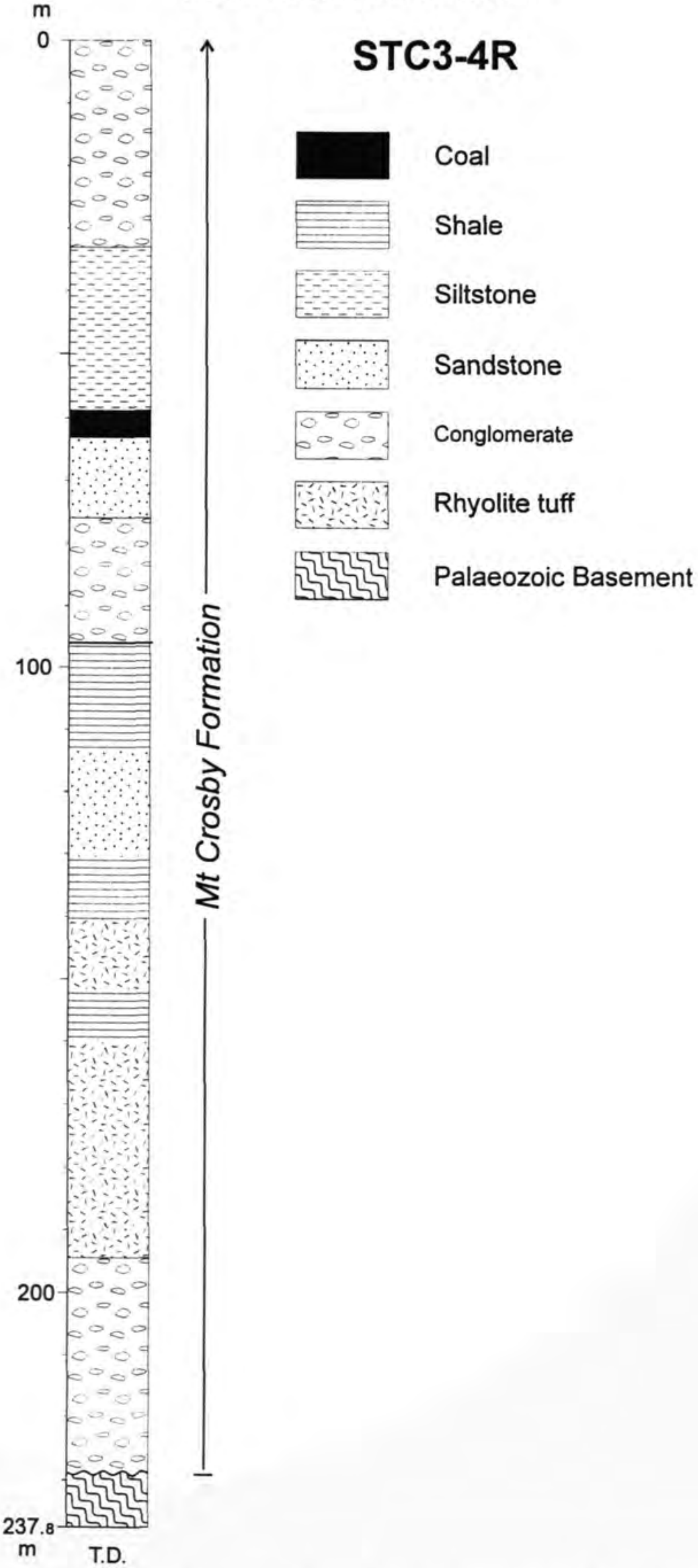

Figure 4.4 Drill log of STC 3-4R, through the Mount Crosby Formation near Pine Mountain (after Cranfield *et al.*, 1976).

being smaller in volume and exclusively black chert, whereas the Brisbane Tuff contains phyllite as well as chert. Additionally, the Brisbane Tuff shows evidence of a greater degree of crystal enrichment than the Mount Crosby Formation. The different chemistry of the unit is enough to suggest it was formed by a different eruption from the Brisbane Tuff.

4.1.4 Hector Tuff

The rhyo-dacitic Hector Tuff comprises air-fall tuff, ignimbrite, mudstone, arenite, and minor conglomerate, shale, and coal (Fig. 4.5), conformably overlies the Colleges Conglomerate, and is conformably overlain by the Cribb Conglomerate. Cranfield *et al.* (1989) indicate a Carnian age by microflora. The formation extends throughout the Ipswich area (Fig. 4.1) but good outcrops occur only near the type section where the unit is 22 m thick (Cranfield *et al.*, 1976; Cranfield *et al.*, 1989). The maximum thickness of 87 m is in DDH NS 93 (Houston, 1965; Hawkins, 1956). The unit thins eastwards, accompanied by a reduction in the amount of primary pyroclastic rocks, and the easternmost occurrences lack primary volcanic rocks. A 42 m section of the Hector Tuff in GSQ Ipswich 26 was recorded by Almond (1982)(Fig. 4.9).

4.1.4.1 Volcanic Facies

Outcrops of much of the formation is arenite or mudstone that are reworked tuff. Primary volcanic rocks include thin ignimbrite flows, air-fall tuff, and accretionary lapilli tuff.

The ignimbrites are normally grey-green, most are unwelded, but some have welded texture. Clast types are difficult to determine because of the advanced weathering, but small pumice clasts (up to 3 cm) and rare chert clasts were identified at some localities. The thickest individual ignimbrite is less than 5 m thick. In GSQ Ipswich 26, Almond (1982) reported an 11 m thick succession of tuff at the base of the unit. She described an undoubted ignimbritic texture (Plate 4.2) thus (p. 520): "*...some chlorite and lenses of cryptocrystalline silica are present. Some of the lenses may represent fiamme structures as they are flattened parallel to bedding.*"

Air-fall tuffs, when the volumes of re-worked tuff preserved in the form of

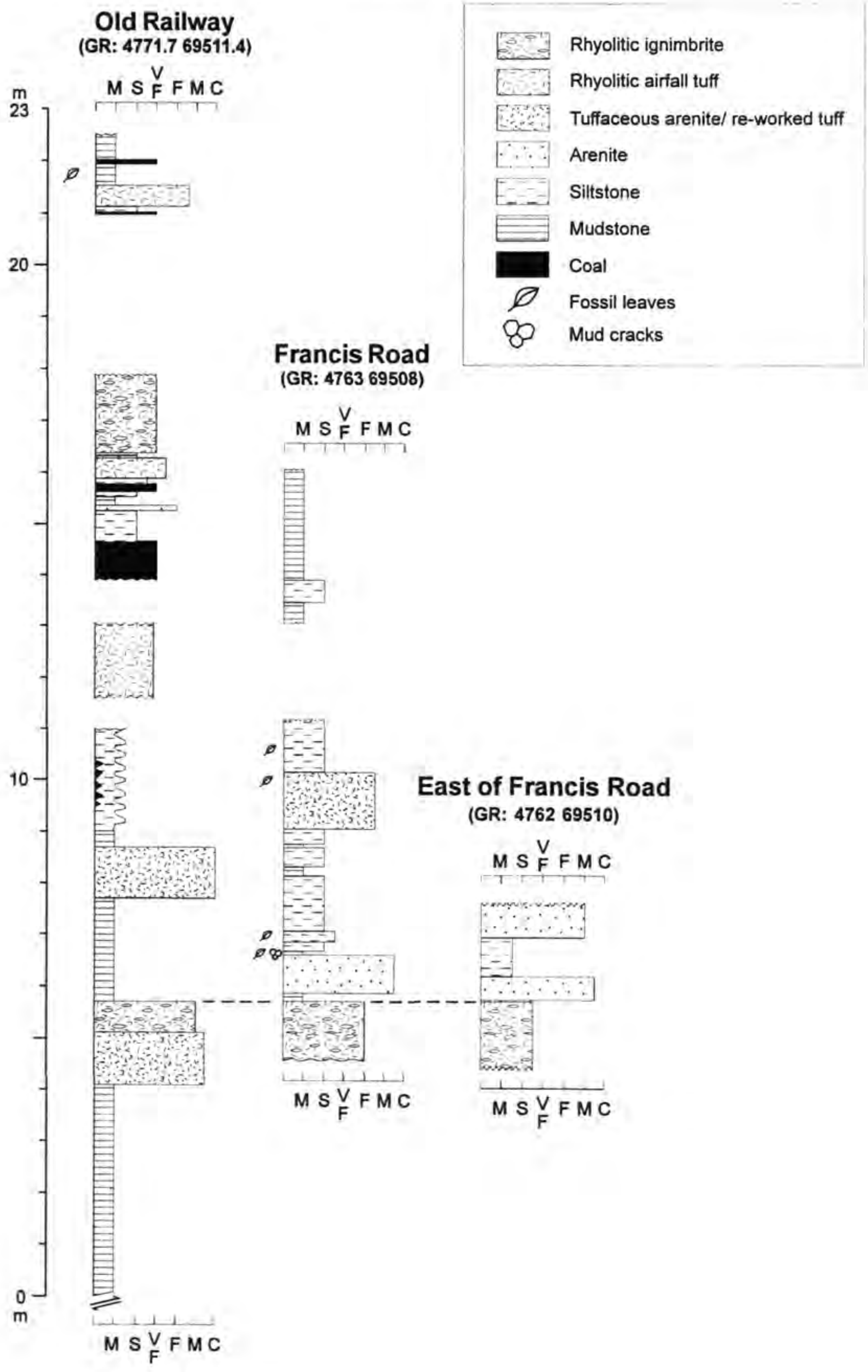

Figure 4.5 Measured sections of the Hector Tuff from near the type section, location shown on Figure 4.1. The lower ignimbrite has been used to establish correlation.

tuffaceous arenites are included, are volumetrically the most abundant volcanic rock, although the primary air-fall tuffs themselves are not as abundant as the ignimbrites. The air-fall tuffs are green, fine grained, and only rarely porphyritic. Primary tuff is no thicker than 1.5 m, and re-worked tuffs (in the form of tuffaceous arenite) accumulated up to 5 m.

A 10 cm thick accretionary lapilli tuff containing lapilli of approximately 0.5cm diameter is interbedded with carbonaceous shales of the Hector Tuff (GR: 4794.5E, 69513.8N). The tuff is porphyritic, and contains phenocrysts of feldspar and biotite. The overlying carbonaceous shales contain *Dicroidium* leaves, which indicate Triassic. Accretionary lapilli tuff, 5 cm thick, is also found in GSQ Ipswich 26.

4.1.4.2 Environments of Deposition and Eruptive History

The Hector Tuff was deposited in environments ranging from lacustrine to fluviatile, and the preservation of the pyroclastic material is related to their deposition environment, with the greatest accumulations of pyroclastic rocks occurring in the lacustrine dominated environments in the west. The easternmost outcrops of the Hector Tuff were deposited in a fluviatile system, typified by coarser volcanic detritus and occasional conglomerate, and lacking carbonaceous material and mudstone of the western occurrences.

In the west, thick coal, carbonaceous shale, mudstone, siltstone, and fine-grained sandstones in the type area indicate a lacustrine environment. Of the measured sections near the type area (Fig. 4.5), the Old Railway section is dominated by carbonaceous mudstone, while the Francis Road section is dominated by siltstone and fine sandstone, lacking carbonaceous horizons. The Francis Road section was probably located on the margin of a lake delta, possibly in crevasse splays, with mud-cracks indicating occasional sub-aerial exposure. Almond (1982) noted that the sandstone in GSQ Ipswich 26 has small-scale cross bedding, and grades into sandy siltstone, also possibly indicating crevasse-splay deposits.

4.2 Volcanics on Moreton Island

4.2.1 Geological background

As show on figure 2.1 rock exposures at the northeaster tip of Moreton and North Stradbroke Islands are interpreted (Whiteaker and Green, 1980) as Ipswich Basin volcanic and sedimentary rocks overlain by Clarence-Moreton Basin sedimentary rocks.

The volcanic rocks comprise rhyolitic lavas in the northernmost outcrops and sub-aqueously emplaced mafic lavas on the easternmost outcrops (Fig. 4.6). The mafic lava flows underlie sedimentary rocks of the Ipswich Basin, probably disconformably (the contact is not exposed). The contact between the mafic and rhyolitic lava flows is likewise not exposed, but the rhyolite probably succeeds the mafic lavas because the rhyolite occupies the higher parts of the island, is not as pervasively altered as the andesites, and is overlain by the Jurassic Woogaroo Sub-group (Fig. 4.7). Considering the general stratigraphy of the Ipswich Basin (particularly the Ipswich area), where mafic flows precede felsic activity, I infer that the rhyolite is younger than the mafic flows.

At least two tuffaceous arenites, probably representing re-worked tuffs, were found in the Ipswich Basin sedimentary rocks overlying the mafic lava flows. The tuffaceous beds could be related to the air-fall tuffs of the Ipswich Basin, such as the Hector Tuff, Mount Crosby Formation tuff, Brisbane Tuff, or an as-yet undifferentiated tuff; or they may have been derived from the rhyolitic lava flows outcropping 1 km to the north, either as eroded material, or weathered and decomposed local air-falls associated with these flows. Similar tuffaceous rocks were recorded by Crook and Hoyling (1968) in the epiclastic section of the Ipswich Basin in APS Matjara 1 drillhole to the southeast (Section 4.4.4).

No Ipswich Basin sedimentary rocks were observed overlying the rhyolitic lavas - instead Early Jurassic quartz arenites directly overlie (at point B on Fig. 4.7) the rhyolites with an erosive contact between the formations. The Ipswich Coal Measures near the Cape Moreton Light-house also underlie the Jurassic sedimentary rocks, with a low- angular unconformity, implying that they occupy a stratigraphic horizon similar to that of the rhyolitic lavas. It is thought that the rhyolitic lava flows to the north formed a topographic high. The Ipswich Coal Measures, which contain some detrital material from the rhyolites, were then deposited around the rhyolites. Both the rhyolites and Ipswich Basin sedimentary rocks were then eroded before the Jurassic Clarence-

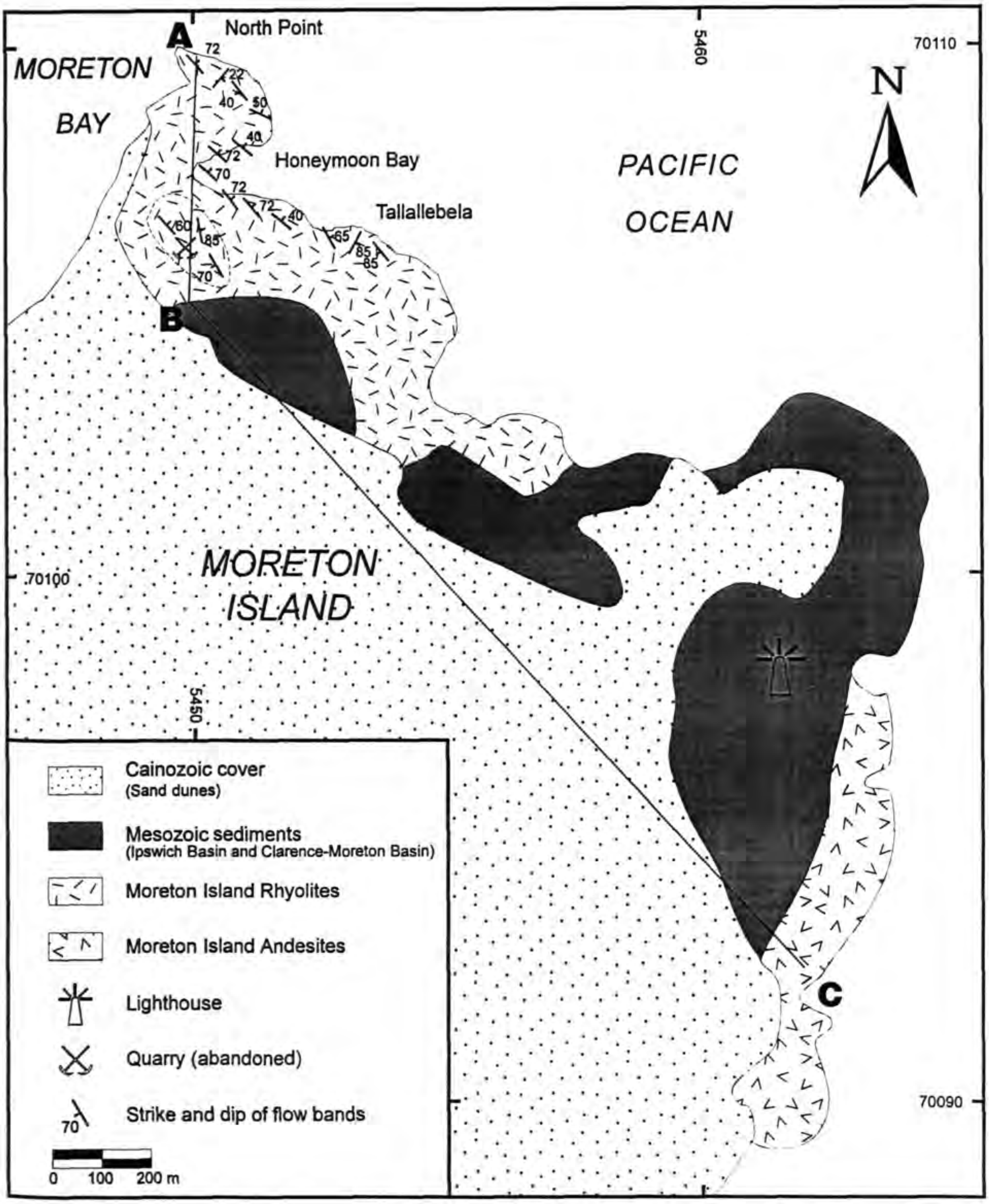

Figure 4.6 Detailed geology of the northeastern tip of Moreton Island. (For location, see figure 1.1)

Moreton sedimentary rocks were deposited on top of them (Fig. 4.7).

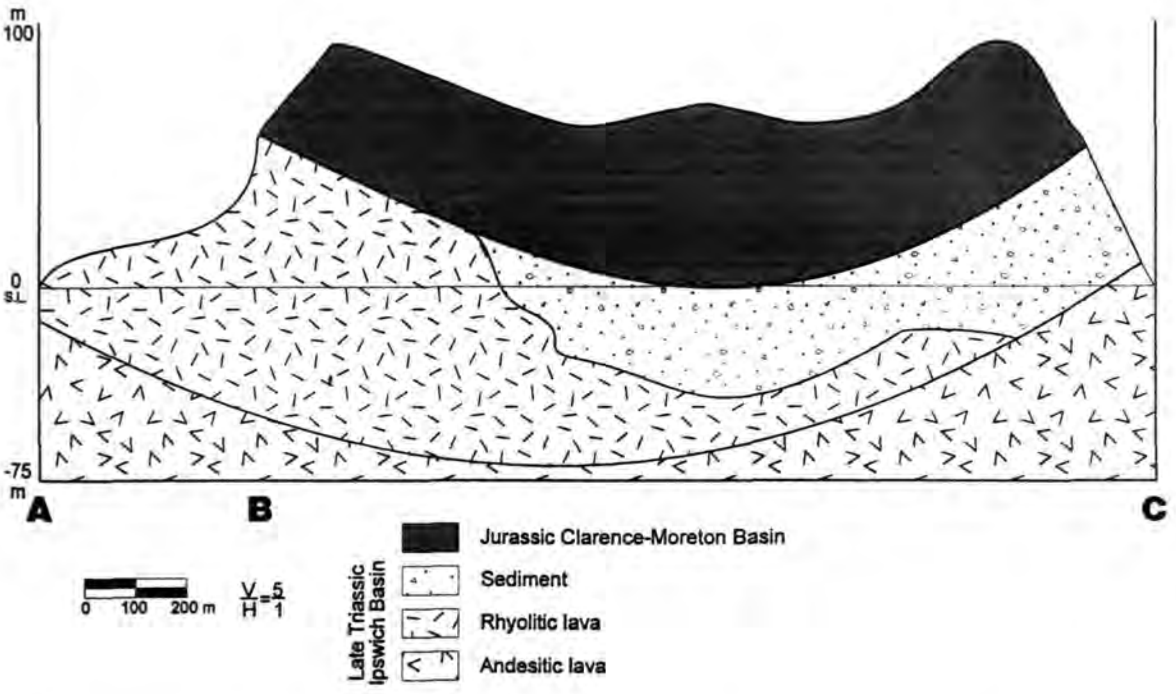

Figure 4.7 Diagrammatic cross-section through Moreton Island illustrating stratigraphic relationships. Cainozoic sand deposits are not shown. The "Mesozoic Sediments" of Figure 4.6 have been split between the Ipswich Basin and the Clarence-Moreton Basin.

4.2.2 Mafic Rocks

The mafic rocks are confined to a small, almost inaccessible area at the base of the cliffs below the Cape Moreton Light-house (Fig. 4.6). They are altered green andesitic lava flows, volcaniclastic arenites with an iron stained matrix, and possible air-fall tuffs. The lava flows are quench fractured, with hyaloclastic textures and ferruginous and carbonate infillings of cracks at their margins, suggesting sub-aqueous emplacement. The flows are non-vesicular and rarely porphyritic. The interbedded volcaniclastic arenites and possible air-fall tuffs may have been derived from secondary pyroclastic eruptions accompanying the entry of the lava flows into water.

4.2.3 Rhyolites

Rhyolitic lava flows that lie below the Jurassic sandstones of the Clarence-Moreton basin on the northeastern tip of Moreton Island (Fig. 4.6) probably overlie the mafic lava flows and precede the deposition of the Ipswich Basin sedimentary rocks. The rhyolites are probably the same age as other rhyolitic lavas of the Ipswich Basin, on Stradbroke Island and in the Chillingham Volcanics.

4.2.3.1 Facies

The most common facies preserved in the rhyolite lavas is flow-banded lava. The flow bands are exclusively in the mm domain size, are commonly highly contorted, and steeply dipping (Plate 4.3). Spherulites are restricted to the sub-mm scale, except in a narrow zone near North Point and as clasts in a breccia at Honeymoon Bay, where they are up to 5 cm. The spherulites in the breccia at Honeymoon Bay occur intermingled with flow banded rhyolite clasts, and it was not possible to determine if they formed *in situ* or were transported.

Rhyolitic autobreccias are rare but near the interpreted margin of a dome at Honeymoon Bay a breccia overlies and truncates older rhyolitic lavas (Plate 4.4). Some breccia bodies are planar, are parallel to bedding, suggesting they formed as the flow base. The breccias are supported by a matrix of medium- to coarse-grained material altered beyond recognition, possibly originally glassy (Plate 4.5). The breccia blocks have subtle flow banding, and each block shows a different flow banding orientation, suggesting they had been transported and rotated. Additionally this suggests that the blocks may have devitrified prior to both brecciation and emplacement. The breccias probably represent a crumble breccia facies of the flow front, as opposed to an autobreccia generated from internal shear stresses in the lava flow, and are similar to that the crumble breccias described by Bonnichsen and Kauffman (1987) for Miocene lavas in Idaho.

4.2.3.2 Structures

Flow banding in the rhyolitic lavas has a comparatively constant northwesterly strike and an average dip of 70° to the northeast. In Honeymoon Bay, at the contact between two lavas, the older dome maintains the steep foliation, whereas the overlying lava has irregular flow-banding. The steep flow banding in the older lava indicates a likely lava dome (as opposed to a lava flow), and the northwesterly strike probably reflects the original geometry of the feeder conduit of the dome.

4.2.3.3 Interpreted Mode of Emplacement

At least two generations of lava emplacement occurred on Moreton Island. The first, lava dome, phase, responsible for most of the rhyolitic lavas on the island, is characterised by steeply dipping flow bands, few spherulitic patches, and little autobreccia. The younger lava, whose mode of emplacement could not be determined due to limited exposure, contains more varied textures, including spherulitic patches and autobreccias. A significant time break between the emplacement of the lava dome and the second lava is indicated by the truncation of steeply inclined flow-banded rhyolitic lava by crumble breccias of the younger lava (Plate 4.4) at Honeymoon Bay. The break between flows was long enough to allow for the devitrification of the lava of the first dome, and erosion to expose the flow banded centre of the dome.

4.3 Rhyolite on Stradbroke Island

4.3.1 Geological background

Stradbroke Island, like Moreton Island, is an island of Cainozoic sand built up behind a barrier of Late Triassic undifferentiated rhyolitic lavas that form the northeastern corner of the island (Fig. 4.8).

4.3.2 Rhyolite

The rhyolitic lavas which crop out on Stradbroke Island are typically flow banded on a mm to cm scale, and contain abundant quartz and feldspar phenocrysts. Many of the quartz phenocrysts appear to be broken, and the flow banding flows around the broken phenocrysts, not through them, suggesting that the crystals had formed and broken prior to the last episode of flow movement, and almost certainly prior to effusion. The rocks resemble the ignimbrites in the Brisbane Tuff, except they lack clasts or xenoliths of basement and do not contain so many feldspar phenocrysts.

Although the origin of the broken quartz crystals is difficult to explain, the most likely explanation is that they were broken by the internal movement of the lava flow. It is unlikely that the lavas represent a rheomorphic flow; the broken phenocrysts are a bi-product of explosive eruption, as the flow banding in the lavas lacks the near planar form expected for rheomorphic ignimbrites. Additionally the size and form of the flows are inconsistent with the large volumes possessed by modern rheomorphic ignimbrites.

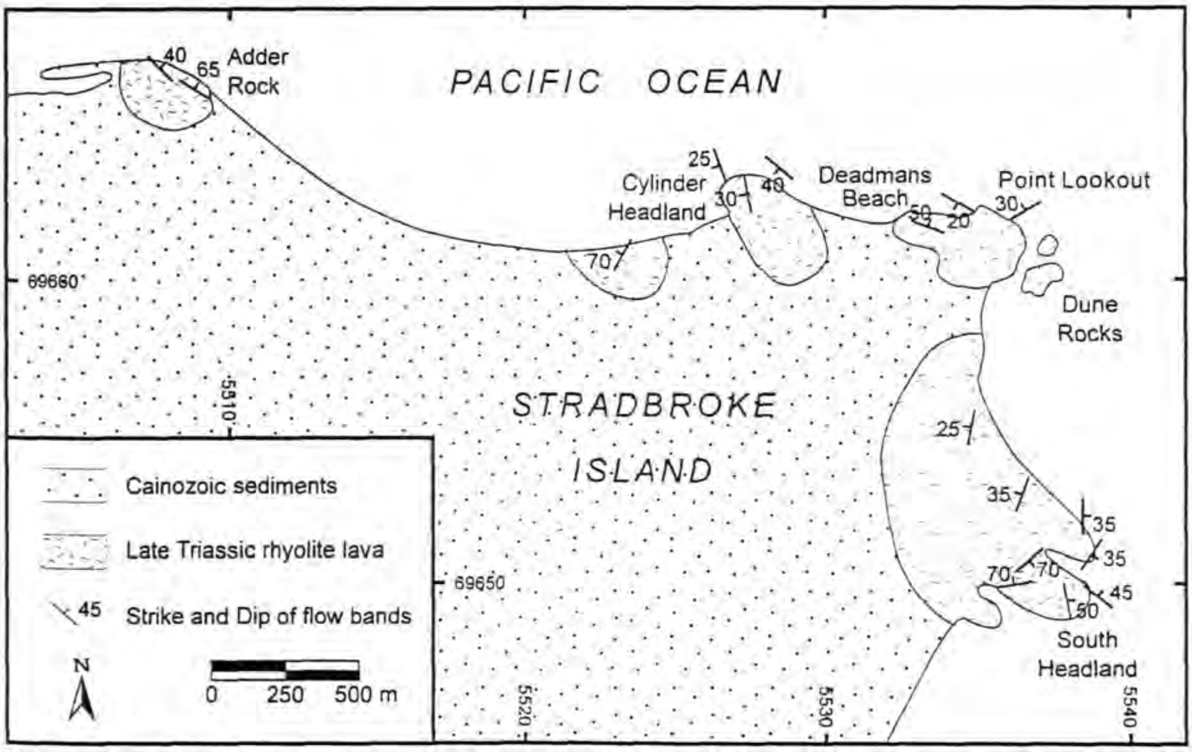

Figure 4.8 Detailed geology of the northeastern tip of North Stradbroke Island. (For location, see figure 1.1)

In the Adder Rock area, rocks contain large (0.5-10 cm) gas vuggs infilled with comb quartz, or less commonly with magnetite/hematite (Plate 4.6). The magnetite/hematite infillings are typically more complete than those of the quartz infillings (Plate 4.6). Half of these vuggs show some flattening/ compression/ attenuation. The possible compaction mechanisms include: the movement in the flow during vugg formation; preferential growth of the vugg within certain (near-horizontal) flow bands; or lateral aggregation of neighbouring spherical vuggs.

4.3.2.1 Ignimbrite-like Facies

Most of the lavas on Stradbroke Island are rhyolitic lavas and autobreccias. Some rocks at Point Lookout (Fig. 4.8), occurring in isolated small zones, have an ignimbrite-like texture, but the absence of recognisable fiamme or pyroclastic flow structures probably precludes their being truly ignimbritic.

The ignimbrite-like lavas contain clasts of rhyolite, and are overlain by quartz-rich porphyritic flow-banded rhyolitic lavas identical to those exposed elsewhere on the island. The rhyolite in these clasts is altered, dark grey, non-porphyritic, contains mm scale flow banding, and (unlike its host) has few quartz phenocrysts. The clasts are broadly spaced, typically less than 5 cm in length, and show slight rounding of the edges. The breccia is dissimilar to regular flow-dynamic- induced autobreccias, or crumble breccias. In places, the matrix has subtle flow banding, which indicates that it was, in part, liquid during emplacement. The weathered nature of the outcrop makes it impossible to determine if the flow banded matrix was truly flow banded or just a flow banded clast with poorly defined margins. Additionally, it was not possible to determine if the subtle flow banding of the matrix was the same as that which overprinted the clasts.

While the ignimbrite-like rocks could represent a fine-grained crumble breccia of the over-running flow, the unique characteristics of the rhyolitic fragments which make up the facies (non-porphyritic as opposed to quartz phenocryst rich porphyritic) probably indicate that they were not derived from the overlying lavas as a direct parent. The rhyolitic breccia could be either a pre-effusive pyroclastic vent-clearing eruption which sampled older, unexposed rhyolites; or perhaps a zone of lenticular auto-breccia in the lava flow. It is unlikely to be a true pyroclastic deposit at the base of the lava, because the matrix of the breccia is indistinguishable from the overlying and underlying layers, and the texture of the rock matrix is more like a lava flow. The form of the lenticular zones suggests an origin from the internal flow dynamics of the lava. Dadd (1992) documented structures in the Ngongotaha lava dome in New Zealand which bear a striking resemblance to the rocks on Stradbroke Island. The rhyolitic breccias at Ngongotaha were formed from either the drawing out and eventual dismemberment of plastic glassy layers with a low shear stress as the shear stress in the surrounding lavas increased (Dadd suggests that differential changes in hydration can promote changes of rheology and cause premature devitrification to form a heterogeneous body which responds differently to shear stress) or the breccias formed *in situ* through selective devitrification, or both.

Of the options, a modified version of the first may have formed the Stradbroke Island ignimbrite-like lavas. The lenticular breccias Dadd (1992) describes at Ngongotaha are texturally similar to the host lava, and have similar phenocryst assemblages. The "clasts" in the rocks at Stradbroke Island are essentially non-porphyritic, whereas those of their host are porphyritic. The phenocrysts in the host also had developed prior to the cessation of flow of the lava, so that they had formed before the breccia developed. Therefore, on Stradbroke Island, it is unlikely that the breccia clasts were *simple* differentiates of the host rock. The fact that these clasts do have a different (macro) phenocryst assemblage provides a suitable mechanism for establishing the differential stress regimes between the host rock, and the (eventual) clast rock, namely that the rocks were of slightly different composition. This in turn may have affected other factors such as plasticity or differential devitrification. Unlike Dadd's (1992) model, which involves differential hydration and/or devitrification ultimately modifying the plasticity of an originally homogenous host, the host at Stradbroke Island was possibly heterogeneous from the start. The source of the different magma remains uncertain. Three possibilities explain the different composition:

1) The clasts formed by crystal segregation, and possibly represent a form of gravity- or shear-generated cumulate residual;
2) The magma was originally heterogeneous; or
3) A still plastic non-porphyritic lava from an older flow was incorporated as xenoliths in the lavas at vent.

In light of the usual homogeneity of lavas and the complexities of generating crystal segregation on such a small scale, the latter explanation seems most likely.

4.3.2.2 Structure

The lavas between Point Lookout and Cylinder Headland dip westward at 30°, have little or no flow folding and uniform structure, suggesting they are possibly part of a flow lobe. Lavas include spherulitic (Plate 4.8) and flow banded (Plate 4.7). In the Adder Rock area (Fig. 4.8), steep (70-80°) north-easterly dipping flow banding shallows into flow banding with more moderate dips (40°) over 300 m. The rocks in the Adder Rock region have a surprising conformity in strike, and have few flow folds.

South of Dune Rocks, and extending through to South Headland, the lavas show more evidence of flow folding (Plate 4.7), and have steep dips, consistent with the structure of a lava dome. The north-north-easterly trending axial traces of folds corresponds with the overall structural of the flow banding.

4.3.2.3 Interpreted Mode of Emplacement

Three periods of distinct effusive history may be represented on Stradbroke Island. The earliest phase may have been a non-porphyritic flow-banded rhyolite, preserved as clasts in other ignimbrite-like lavas. If the clasts in the *ignimbrite-like* lava flows were formed by processes within their host flow, as opposed to an older clast incorporated in the flow, then the earliest phase of effusive activity is that of the porphyritic lavas.

At least three generations of porphyritic lavas were then emplaced from domes near Adder Rock and South Headland, and possibly other sites not presently recognisable. Age relationships between the two domes could not be determined as no cross-cutting relationships were observed. The South Headland dome contains two emplacement events. The lava flows between Cylinder Headland and Deadmans Beach are probably earlier and emanated from the South Headland dome, as their flow banding follows a similar strike to the South Headland dome, which is markedly dissimilar from Adder Rock. At Point Lookout these flows are overlain by other lava flows which can be directly traced back to the South Headland dome. The younger flows can be differentiated from the older by their distinctive chaotic flow banding (Plate 4.7) and zones of autobreccia.

4.4 Possible Stratigraphic equivalents in Drill Holes

4.4.1 QAO "The Overflow" No.1

QAO "The Overflow" No.1, drilled by the Queensland American Oil Company as a petroleum exploration well south of Brisbane in 1960 (Siller, 1963; Houston, 1967a), intersected 424 m of undifferentiated volcanic rocks at its base. The succession comprised lava flows of olivine basalt, trachyte, and andesite (Houston, 1967a) at the same stratigraphic position as the mafic rocks in the Ipswich area and GSQ Ipswich 26. Houston (1967a) reported six analyses from the drill hole (Appendix C), but without trace element data, correlation with the other units is not possible. All analyses have high volatile components, indicating extensive alteration, which prevents geochemical correlation as they show neither a collective consistency, nor any direct systematic chemical similarities with other volcanic rocks of the Ipswich Basin. The mafic samples, however, show a similar trend to other mafic rocks of the Ipswich basin, being slightly alkaline, and anomalously enriched in TiO_2.

4.4.2 GSQ Ipswich 26

GSQ Ipswich 26 was drilled southeast of Ipswich in order to sample Clarence-Moreton and Ipswich Basin rocks. Material intercepted from 919.9 m to 1238.8 m (Almond, 1982) consisted of volcanic rocks and volcano-clastic sedimentary rocks with no known surface equivalents. Almond (1982) differentiated this volcanic sequence into seven units designated A through G (Fig. 4.9). Air-fall tuffs equivalent to the Hector Tuff and Mount Crosby Formation tuff were also identified by Almond (1982).

4.4.2.1 Subunits A, B, C and D

No material from Subunits A, B, C or D was preserved by the GSQ, therefore Almond's (1982) description is the only source. Subunit A consists of volcaniclastic sediment ranging in grain size from pebble conglomerates through to siltstones. The only primary volcanic rock is a thin tuff at the top. The composition of this upper tuff was not reported; however, Almond (1982) considered that volcanic detritus was basic to intermediate in composition. Subunit B consists of 28 m of altered olivine basalt.

The thickest units in GSQ Ipswich 26 are felsic lavas and tuffs, and occur in several horizons, separated by some of the mafic units. The lowest preserved felsic unit is Almond's (1982) subunit C, 20 m of conglomerate, sandstone, and a 9 m thick *"lithic*

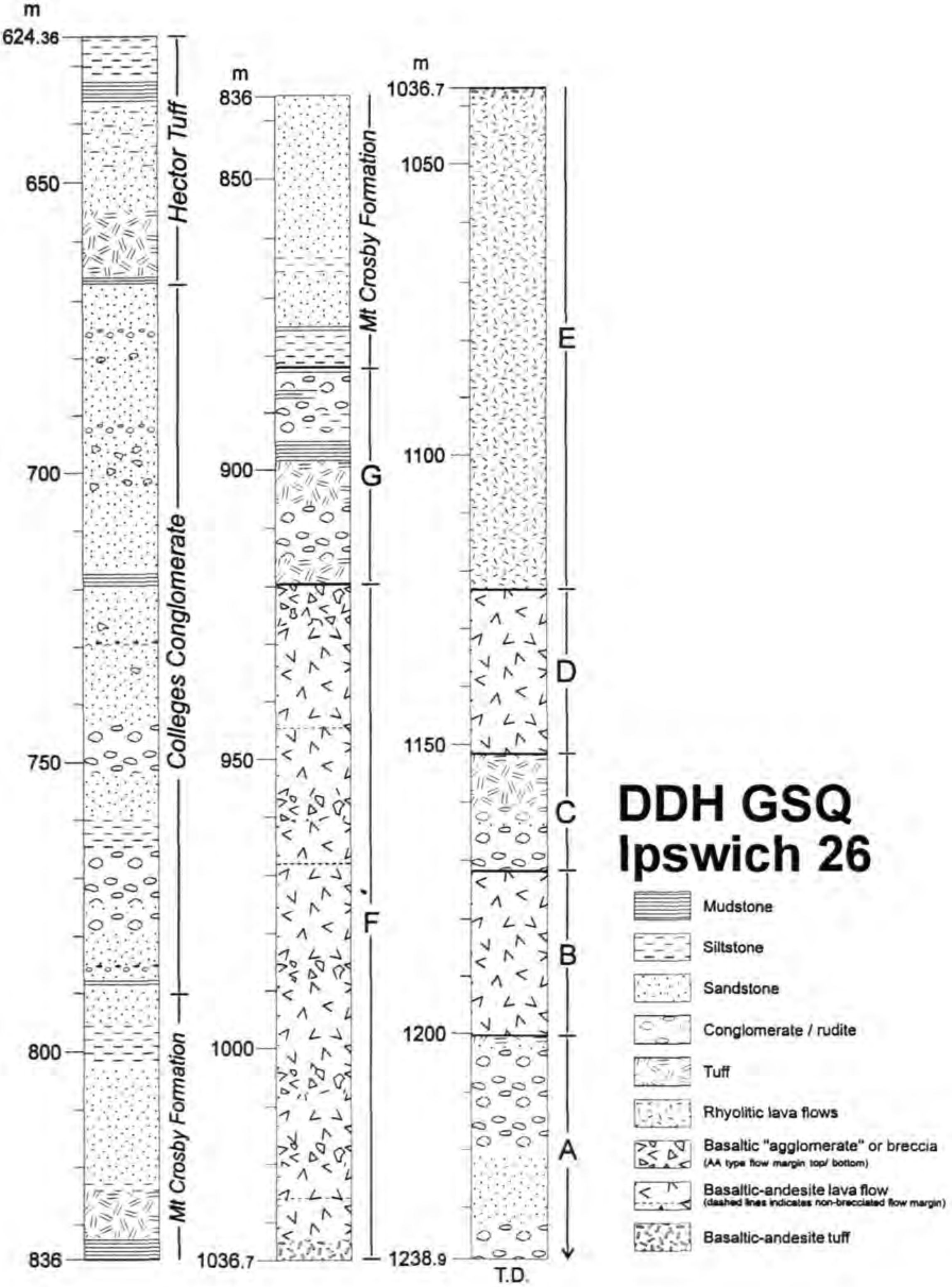

Figure 4.9 Drill log of GSQ Ipswich 26 based on Almond (1982) and reinterpretation of drill core.

crystal tuff", whose description matches that of an ignimbrite. Almond (1982) describes clasts of both sandstone and silicic plutonic rocks in the base of this ignimbrite. Subunit D, which overlies a 20 m thick interval of rhyolitic tuffs, is reportedly an altered (chloritic) basalt.

4.4.2.2 Subunit E

Almond (1982) described subunit E as consisting 86 m of rhyolitic lavas and breccias. Although he implied multiple flows, this whole succession is probably a single flow with internal breaks generated from internal shear stress in the lava. Geochemical analysis of samples from the least altered portion of this interval (Plate 4.9) (collected near the centre of the flow) have shown that this flow is of rhyolitic composition, but dissimilar to the other felsic rocks of the Ipswich Basin in having a more "arc like" chemistry (see chapter 5). Much of the lava flow is highly altered. The top 25 m of the unit shows signs of extensive haematitic alteration, and carbonate veins are common throughout the flow.

The base of the flow is highly brecciated, although domains of non-brecciated material also occur. While most of these breccias are probably intra-flow flow breccias generated by the internal dynamics of the flow, the mode of brecciation of the base of the flow is uncertain. It is possible that the base may in part be a crumble breccia, however, some of the core examined has shown that parts of this breccias possess a near jig-saw like fit, implying possible quench fracturing by water or some form of post-emplacement brecciation.

4.4.2.3 Subunit F

The 117 m of subunit F was identified by Almond (1982) as ten andesitic flows (Fig. 4.9). Geochemical analysis of several flows in this interval shows them to be trachy-basalts to trachy-andesites. The degree of alteration is varied, although not as pervasive or extreme as in the underlying felsic subunit, indicating that the alteration of the underlying felsic subunit was probably penecontemporaneous with its emplacement.

Most, if not all, of subunit F is believed to have been sub-aerially erupted and exposed long enough to allow erosion of the flow tops. Both pyroclastic and effusive members exist in the sequence. A thin dacitic ignimbrite and an air-fall tuff make up the identified pyroclastic members, both of which were emplaced by a sub-aerial eruption. Several erosive contacts and weathered margins between different beds indicate sub-aerial exposure (Plate 4.10). Many flows possess little or no brecciation at their tops, although zones of vesiculation commonly mark the tops of flows in this interval. It is likely that any brecciated tops were eroded, or the lava was sufficiently plastic not to generate a breccia carapace. The nature of the erosive contacts in this succession, together with the preservation of possible weathered margins, indicates that significant time gaps separate some of the flows, and that the flows were probably (at least in part) sub-aerially emplaced.

4.4.2.4 Subunit G

Subunit G is composed of 37 m of polymictic rudite, with clasts including felsic and mafic volcanic rocks, re-worked epiclastic rocks, and metamorphic rocks from the Palaeozoic basement. Almond (1982) observed that the lower part is mainly conglomerate, while the top is mainly breccia. Both clast and matrix supported rudites occur, although the latter is more common. In addition to the rudites there are several siltstone and mudstone layers. These siltstones and mudstones are similar to the martix of the matrix supported rudites. Almond (1982) suggested that the siltstones and mudstones are tuffaceous in origin, and that green-brown tuffs also occur interbedded towards the top of the succession, though my observations suggest this succession has been re-worked. Almond (1982) furthermore suggested that the breccias are "mud flow" deposits emplaced in the final phase of volcanism.

4.4.2.5 Interpreted Origin and Significance

The material in GSQ Ipswich 26 represents a significant accumulation of volcanic rocks from several different episodes of volcanism, some of which are not recognised elsewhere in the Ipswich Basin. Based on the predominance of re-worked volcaniclastic material in subunit A, Almond (1982) suggested that it is likely that the volcanic pile extends below subunit A. A BMR seismic transect through the Ipswich and Esk Basins (O'Brien *et al.*, 1991) lends credence to this view, indicating a thick sequence of rocks at the base of the Ipswich Basin near the South Moreton Anticline, which are thought to be early rift sedimentary and volcanic rocks of the basin. Whether all of the material interpreted from the seismic section to occur at the base of the basin is of Late Triassic age, or for that matter associated with the Ipswich Basin, remains un-resolved.

Almond (1982) suggested that subunit E was comparable with portions of the Chillingham Volcanics. Chemically, however, these rocks are sufficiently dissimilar to the Chillingham Volcanics to question this correlation, as discussed in Chapter 5. Furthermore, the chemistry of these rocks is suggestive of a greater arc influence (lower TiO_2 etc.), and less crustal contamination than the Chillingham Volcanics. While both subunit E and the Chillingham Volcanics are similar in that they are both contain rhyolitic lavas, it is unreasonable to assert a correlation based on this evidence alone, especially considering that the relative stratigraphic position of subunit E is apparently somewhat older than the Chillingham Volcanics. This is especially so if Almond's (1982) correlation of subunit F with the Sugars Basalt is accepted, as by inference, the Chillingham Volcanics are probably stratigraphic equivalents of the Brisbane Tuff which stratigraphically overlies the Sugars Basalt.

The rocks of subunit E are significantly more altered than the rocks of subunit F and indicate a break between them. Subunit E may have been emplaced into water, while subunit F was entirely sub-aerially emplaced. All of this confirms a significant time break, during which the nature of volcanism and environment of deposition changed.

Almond's (1982) comparison of subunit F to the Sugars and Weir Basalt does earn some credence. Chemically subunit F is similar to the surface occurrences of mafic rocks (in particular to the Weir Basalt). Differences, however, remain:

1) Subunit F has a broader compositional range (from basalt through almost to dacite) than either the Sugars Basalt or the Weir Basalt.
2) Subunit F is more extensively altered than either the Weir Basalt or the Sugars Basalt. Typically subunit F rocks are quartz normative, and have normative corundum levels of at least 6%, whereas many samples of the Weir and Sugars Basalts are neither quartz normative nor as corundum normative as subunit F.

From a physical volcanology perspective, the history of subunit F is broadly similar to both the Sugars and Weir Basalts. All were sub-aerially erupted, are of approximately the same thickness, and with a similar number of flows. Additionally, the mafic volcanic rocks of the Ipswich area are interbedded with a minor volume of pyroclastic rocks as is the mafic succession of GSQ Ipswich 26. Texturally, the air-fall tuff in subunit F is dissimilar to the air-fall tuff in the Sugars Basalt, which has limited stratigraphic extent. No ignimbrite facies are known in the Weir Basalt or the Sugars Basalt. Therefore correlation using the pyroclastic facies as marker horizons cannot be justified.

Subunit F and the Weir and Sugars Basalts occupy a similar stratigraphic horizon. In DDH NS 295 (Fig. 4.3) (Houston, 1965) in the Mount Crosby area, 20 km to the north, the mafic volcanic rocks of the Weir Basalt are underlain by the breccias and clastic sedimentary rocks of the Blackwall Breccia (Fig. 4.3). In GSQ Ipswich 26, the mafic rocks of subunit F underlie the breccias of subunit G; however, Houston (1965, p. 4) noted that the clast content of the Blackwall Breccia in DDH NS 295 was bi-modal, with some clasts of Palaeozoic basement, and others "*predominantly of fragments of basic volcanics similar to the Weir Basalt and quite unlike the known basic volcanics from the Nearnleigh-Fernvale "Group"* ". Outcrops of the Blackwall Breccia near the Mount Crosby Weir also contain clasts of presumably Triassic mafic volcanic rocks. The relationship of the breccia with the outcropping basalt is unclear, though the breccia is thought to underlie at least part of the Weir Basalt.

Subunit G resembles several deposits near the base of the Ipswich Basin, such as the breccia at the base of the Brisbane Tuff (Chapter 2) and also in the lowest recognised unit in the Ipswich Group (and subsequently Ipswich Basin), the Blackwall Breccia. Almond (1982) regarded subunit G as a possible equivalent of the Blackwall Breccia, but noted differences, such as the association of interbedded sedimentary rocks with the subunit G, the greater angularity of clasts in the Blackwall Breccia, and the dominantly volcanic composition of the clasts of subunit G. These differences, however, can be attributed to proximal/distal effects. Most of the Blackwall Breccia, as with breccias at the base of the Brisbane Tuff, were deposited sub-aerially as screes. Therefore, in origin, subunit G does not differ markedly from either the Blackwall breccia, or the breccias at the base of the Brisbane Tuff, and a loose correlation between subunit G and other breccias of the Ipswich Basin is likely, this material probably reflecting the first response to uplift of the flanks of the Ipswich Basin.

The facies relationships between both the breccia and mafic volcanic rocks in GSQ Ipswich 26 and elsewhere in the Ipswich Basin indicate that subunits G and F might be considered stratigraphically equivalent to each other, and equivalent to the Blackwall Breccia, Sugars Basalt, and Weir Basalt. Furthermore these units should best be treated as sub-facies of a single stratigraphic entity.

Alternatively, mafic volcanism in the Ipswich Basin commenced at an earlier stage in the region near GSQ Ipswich 26, as represented by subunit F. Material from this phase of volcanic activity was eroded, producing the breccias of subunit G and the Blackwall Breccia, possibly following a tectonic disturbance which uplifted the region. Against this idea is the proximal nature of the Blackwall Breccia. The site of volcanism may have then migrated north to the Mount Crosby area, where the Weir Basalt and Sugars Basalt were emplaced on top of the breccias. It is probably simpler to assume that mafic volcanic activity was occurring over a broad area for a sustained period of time, and that the breccias were derived from penecontemporaneous volcano-tectonic induced uplift of landforms.

4.4.3 NS 93

Houston (1965) and Hawkins (1956) described 275 m of undifferentiated volcanic rocks at the base of GSQ DDH NS 93 at Cooneana Estate south of Ipswich (Fig. 4.1). Unfortunately no core material has been retained by the Geological Survey of Queensland. Hawkins' description of the borehole was more concerned with the coal-bearing rocks, and about the volcanic rocks mentioned only tuffs and acid to intermediate lava flows. I have reconstructed the drill hole log (Fig. 4.10) from Hawkins (1956).

At a depth of 1,480 ft, a 36 m thick interval of interbedded tuff, shale, and conglomerate matches the Hector Tuff in stratigraphic position and lithology, and is underlain by 245 m of Kholo Sub-Group conglomerates.

Although unable to draw conclusions concerning the origin, nature, or

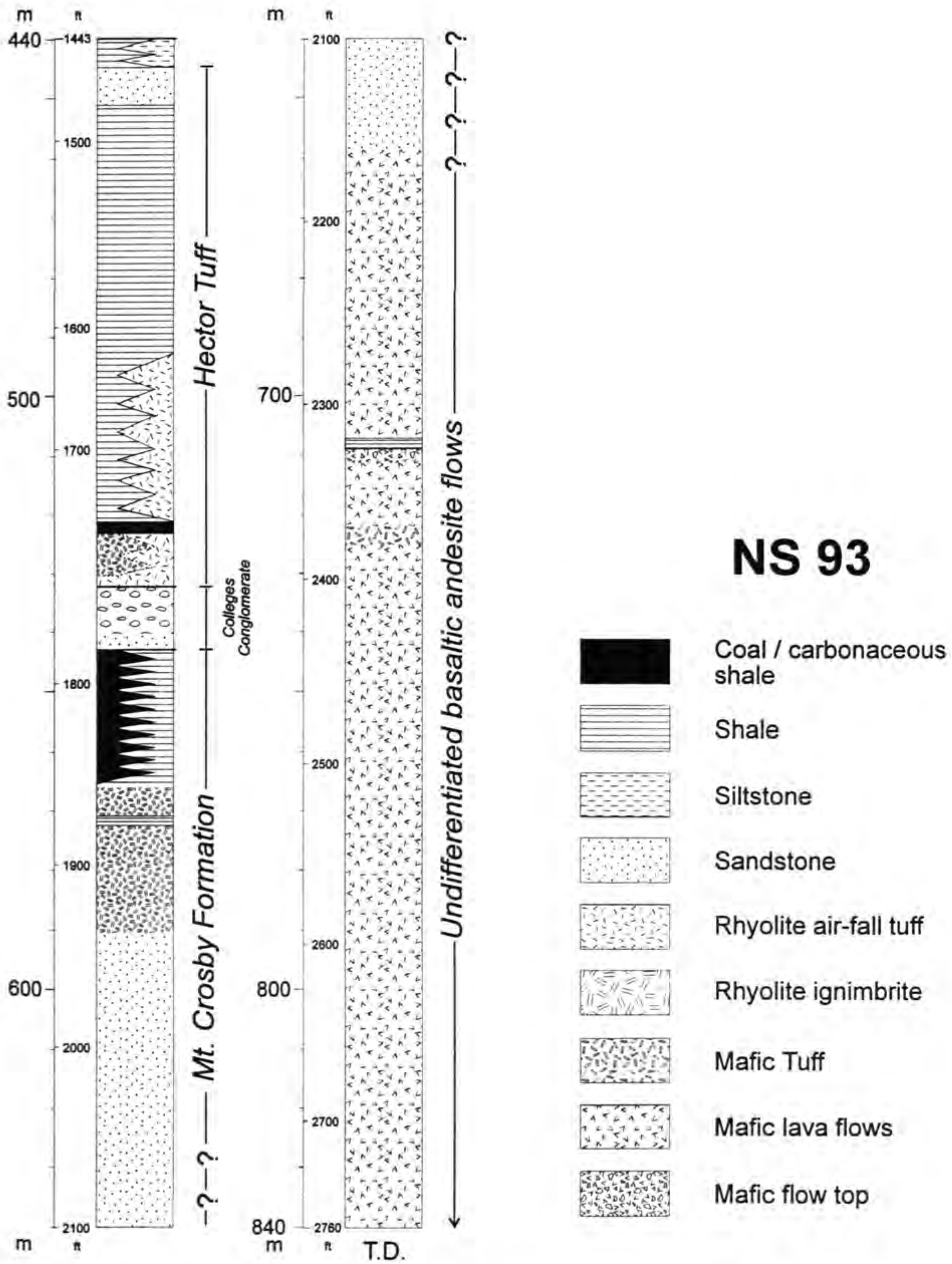

Figure 4.10 Drill log of GSQ NS 93 Cooneana Estate, based on reinterpretation of Houston (1965) and Hawkins (1956).

stratigraphic affinities of the rest of the rocks in the bore from Hawkins' (1956) descriptions, I suggest that part of the 25 m thick tuffaceous succession commencing at 1,859 ft (599 m) is probably an ignimbrite. The resistivity and self-potential curves and lithology indicate that a 1.8 m thick shale band separates two different tuffaceous horizons. Additionally, Hawkins' (1956, p. 218) description of the lowermost part of the tuffaceous section as "*The rock was comprised of light-grey sub-rounded rock fragments in a waxy greenish-grey matrix somewhat waxy in appearance. The matrix in particular, and the rock fragments to a lesser extent showed a type of plastic flowage effect as though all of the material had been in a mobile state at the time of deposition.*" matches that of an ignimbrite. Given the relative stratigraphic position of this ignimbrite, and two tuffaceous horizons, the lower of which is an ignimbrite, and that these horizons are separated by a shale band, this interval probably correlates with the tuff in the Mount Crosby Formation. The described lithologies of this tuffaceous section resemble those of the Mount Crosby Formation tuffs.

Hawkins described a second undifferentiated tuff only 1.5 m thick, commencing at 2,323 ft. This tuffaceous horizon, about 3 m above the first mentioned lava flows (which chemical analysis shows to be basaltic), is possibly related laterally to upward extensions of the basaltic activity beneath it. Additionally, this tuff is possibly correlative with the tuff at the top of the Sugars Basalt. Vesicular lava flows beneath this second tuffaceous horizon are at least 125 m thick, although the number of flows constituting this section was not reported.

Houston (1965) re-examined the volcanic rocks in this hole, and described them as including trachytic and basaltic lavas, together with tuffs and agglomerates. Re-appraising Houston's published chemical data (Appendix C), I regard the "trachyte" as related to the basaltic andesite, and the higher Na_2O probably caused by alteration. From petrological, chemical, and stratigraphic similarities, Houston considered that these rocks were equivalent to the Weir Basalt and Sugars Basalt, which crop out 12 km north of the drill hole.

4.4.4 APS Matjara 1

The APS Matjara 1 drill hole was sunk in the late 1960's east of Moreton Island to penetrate a prospective oil bearing anticline identified from seismic profiles. No oil was encountered, but 600 m of volcanic rock were, inferred to range in age from Middle to Late Triassic age. The dip in this interval was estimated at 48.5°, making the true thickness about 400 m. No usable material was retained by the GSQ. A stratigraphic log of the drill hole has been reconstructed from the company report of Crook & Hoyling (1968) (Fig. 4.11).

The lowest 139 m of the hole was described as being composed of volcanic breccia, and referred to as *subunit F*. From the descriptions of this breccia it was apparently basaltic. This was overlain by 44 m of mafic (probably andesitic) tuff, *subunit E*. *Subunit D* (169 m) is a rhyolitic lava flow, as is *subunit C* (91. 5 m). The separation of *subunit C* from *subunit D* seems to have been made on the basis of the presence of lithophysae in the lava, therefore both of these subunits can be considered the one lava flow. *Subunits B* and *A* are basaltic, the lower 105 m (*subunit B*) being lava flows, the upper 53 m (*subunit A*) appears in part to be that of a tuff or hyaloclastite. Crook and Hoyling (1968) believed that these last two subunits were correlatable with those at the headlands of Moreton Island, and that all subsequent material belonged to the Ipswich Coal Measures.

The Ipswich Coal Measures intersected in APS Matjara 1 contain two sets of pyroclastic rocks. An ignimbrite and an air-fall tuff are interbedded in the sedimentary rocks. The descriptions of this ignimbrite are too vague to allow for a correlation; however, three possibilities exist for correlatives:

1) the Brisbane Tuff;
2) one of the re-worked air-fall tuffs identified in the Triassic sandstones on Moreton Island (Section 4.2.1); or
3) a misidentification of one of the rhyolitic lava flows of Moreton Island.

The sequences described in APS Matjara 1 do not match the stratigraphy on nearby Moreton Island. On Moreton Island, the mafic rocks are interpreted as underling the rhyolitic lava flows. In APS Matjara 1, the only positively identified rhyolitic lava flows occur beneath the basalts, which were correlated with those on Moreton Island. The rhyolites in drill core may be related to an earlier phase of rhyolitic volcanism preceding the effusion of the mafic rocks. Most rhyolitic lava flows of the IpswichBasin

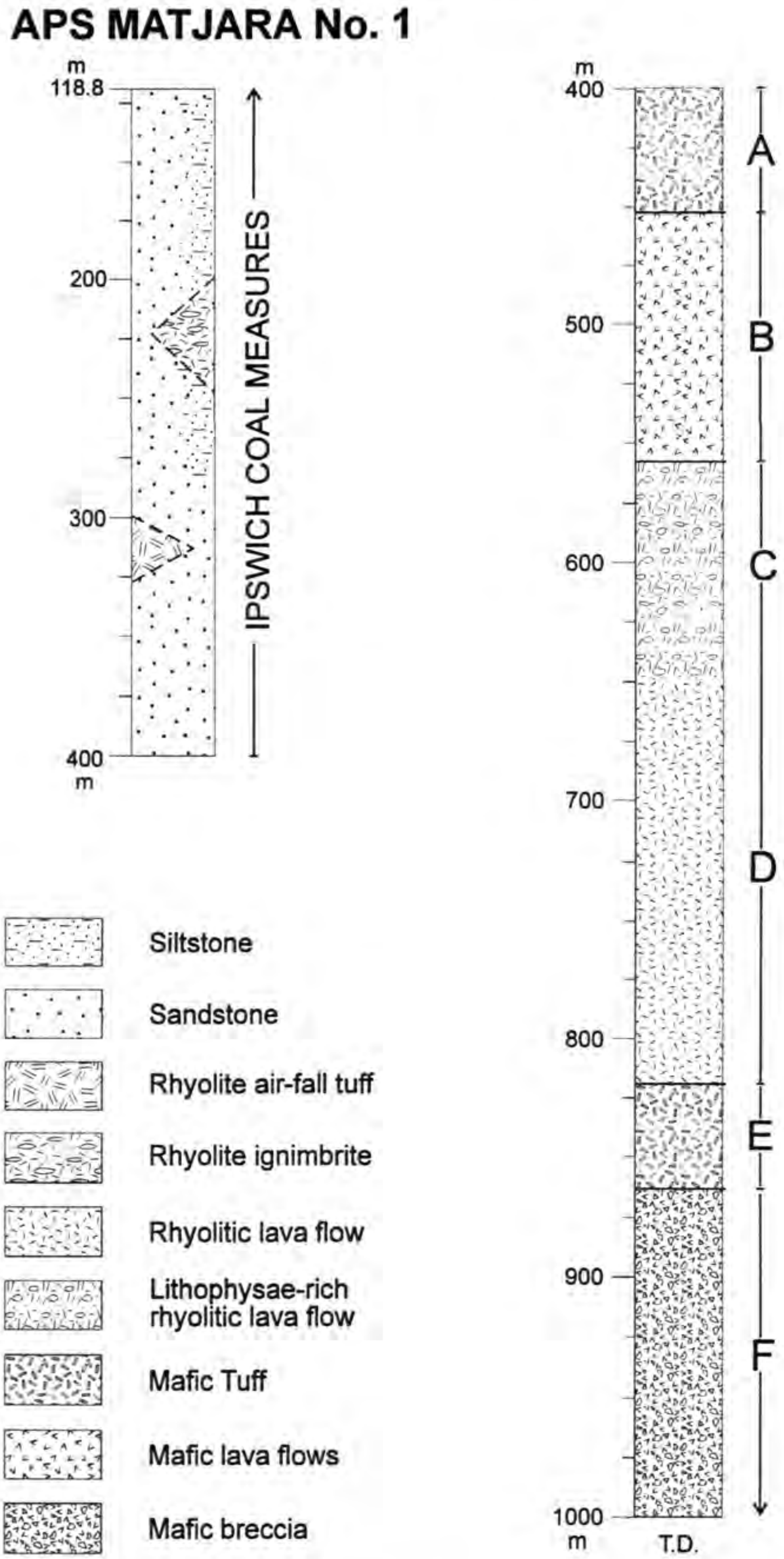

Figure 4.11 Drill log of APS Matjara No.1 (offshore southeast of Moreton Island), reinterpreted from Crook and Hoyling (1968).

post-date the major phase of mafic rock effusion, but in GSQ Ipswich 26, a significant accumulation of rhyolitic lavas is present, and suggests a previous episode of rhyolitic volcanism elsewhere in the Ipswich Basin. The weakness of this idea is in explaining the apparent absence of the Moreton Island rhyolite lava flows in APS Matjara 1.

4.4.5 Tamrookum Creek No. 1

Korsch *et al's* (1989) and O'Brien *et al's* (1991) "rift sequence" at the base of the Ipswich Basin in the area of the South Moreton Anticline was possibly intercepted in drill hole Tamrookum Creek 1. These rocks are described as consisting of "*felsic and basic lava flows and minor tuff*" (Korsch *et al.*, 1989, p 19). Detailed descriptions of these rocks do not exist in published records, and the material from the core was not available for inspection, therefore little can be inferred about these rocks. Korsch *et al.* (1989) and O'Brien *et al.* (1991) consider the "rift sequence" to be the same as the Chillingham Volcanics, which crop out 30-40 km to the east. The correlation with the Chillingham Volcanics is questionable because rhyolitic lavas (such as found in the Chillingham Volcanics) typically flow only a few kilometres away from the vent, far short of the 30-40 km to the South Moreton Anticline. Furthermore the material in Tamrookum Creek is apparently bi-modal, whereas the Chillingham Volcanics are purely silicic. I believe that a more appropriate correlation of Korsch *et al's.* (1989) and O'Brien *et al's.* (1991) bi-modal "rift sequence" and the Tamrookum Creek No. 1 rocks is with the older bi-modal suite in GSQ Ipswich 26, which is similarly confined to the vicinity of the South Moreton Anticline.

4.5 Volcanic Rocks at Mount Barney

Mount Barney is a Tertiary volcanic centre (Stephenson, 1956, 1959, 1960), which has upwarped Late Triassic strata during its emplacement. In his discussions of the regional geology Stephenson (1956, 1960) mentions basic and felsic "lava flows" which he considers to be Late Triassic, from plant fossils above and below the "lava flows".

The Triassic age is uncertain. Stephenson's (1956) account of the volcanic rocks amounts to a one page description of the petrography of three thin sections, with a brief introductory paragraph explaining their stratigraphic position between sedimentary rocks containing the Triassic *Dicroidium* flora, their thickness (50 to 300 ft), and their composition (intermediate to basic lavas and tuffs). No descriptions of field relationships are presented, nor are any maps indicating the distribution of the volcanic rocks or the locations of the thin sections quoted. Stephenson (1959) attributed the sedimentary rocks to the Latest Triassic-Jurassic Clarence-Moreton Basin, and interpreted rhyolitic to doleritic as sills of Tertiary age. Stephenson (1960) reverts to an interpretation of Triassic lava flows. Stephenson (1956, p 22) describes a 20 ft thick rhyolite flow in the Palaeozoic basement near Mount Barney as "*conformal with adjacent sediments ... a rude flow structure is developed with alignment of feldspars ... the upper contact is well exposed, is remarkably smooth and even, and the sediments above are bedded parallel*", and furthermore interprets a deep marine environment for the rocks. I interpret the rhyolite as a flow-banded sill because of its thickness, and contact relations. The deep marine environment is implausible for a rhyolitic lava flow. The interpretation of the sill in the Palaeozoic strata is extended to the Triassic strata.

4.6 Discussion and Conclusions

The Weir Basalt and Sugars Basalt are considered lateral equivalents because of broad chemical and mineralogical similarities and the common stratigraphic position of the two formations in the Ipswich Basin. Basaltic andesite lava flows and air-fall tuffs constitute the formations. The scarcity of hyaloclastites between most flows, the lack of interbedded epiclastic sedimentary rocks, and short breaks between eruptions indicate dominantly sub-aerial emplacement of the lavas. Houston (1965) and Hawkins (1956) described 275 m of undifferentiated volcanic rocks at the base of GSQ DDH NS 93 at Cooneana Estate south of Ipswich. This succession is comparable with the Weir Basalt and the Sugars Basalt.

Two thin ignimbrite bodies separated by a shale make up the rhyodacitic Mount Crosby Formation. Informally regarded as a lateral equivalent of the Brisbane Tuff, the two tuffs of the Mount Crosby Formation, cannot be conclusively correlated with the Brisbane Tuff. They are more dacitic than the Brisbane Tuff, and their dense lithic clasts are different from those of the Brisbane Tuff, suggesting different eruptions produced the two units.

The rhyo-dacitic Hector Tuff comprises air-fall tuff, ignimbrite, mudstone, arenite, and minor conglomerate, shale, and coal. The unit thins eastwards, accompanied by a reduction in the amount of primary pyroclastic rocks. The easternmost outcrops of the Hector Tuff were deposited into a fluviatile system, typified by coarser volcanic detritus and occasional conglomerate, and lacking carbonaceous material and mudstone of the lacustrine dominated western occurrences.

Sub-aqueous mafic lavas (probably of basaltic andesite composition) were the first volcanic rocks deposited on Moreton Island. At least two generations of rhyolitic lava dome emplacement occurred following the mafic lavas, and two tuffaceous arenites, probably representing re-worked tuffs, occur in the Ipswich Coal Measures on the island. The APS Matjara 1 drill hole, offshore from Moreton Island, penetrated 400 m of volcanic rocks including rhyolitic and mafic lavas. The mafic rocks are probably equivalent to those on Moreton Island. The rhyolites apparently underlie the mafic rocks, placing rhyolites in a horizon equivalent to subunit E of GSQ Ipswich 26.

At least three generations of porphyritic lavas were emplaced from at least two domes at Adder Rock and South Headland.

320 m of undifferentiated volcanic rocks were intercepted at the base of GSQ Ipswich 26. Subunit E of this sequence (rhyolitic lavas) has no direct correlatives in outcrop; however, the mafic rocks of subunit F and scree deposits of subunit G are similar to the Weir Basalt, the Sugars Basalt, and the Blackwall Breccia.

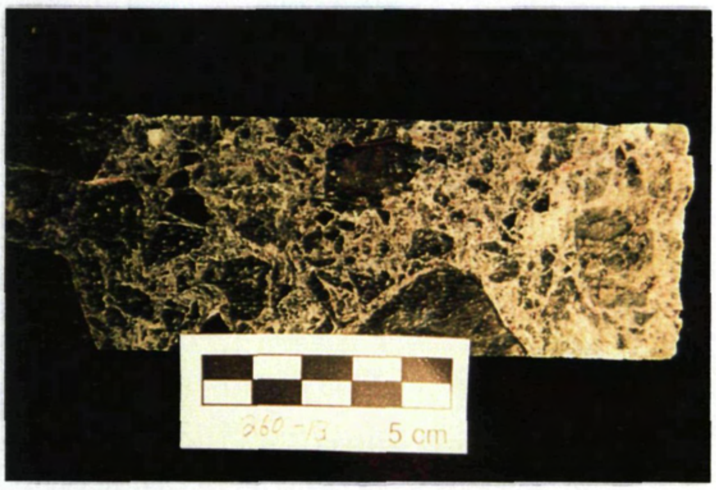

Plate 4.1 Hyaloclastite or Houston's (1965) "inter-pillow material" from NS 295. Although providing evidence of sub-aqueous emplacement for this flow, most lavas of the Sugars and Weir Basalt were emplaced sub-aerially.

Plate 4.2 An air-fall tuff (top) and ignimbrite (below) of the Hector Tuff in GSQ 26. Ghosts of pumice clasts are obvious in the ignimbrite.

Plate 4.3 Steeply inclined flow banding in rhyolitic lavas on Moreton Island. (GR:5450E, 70108N)

Plate 4.4 Steeply inclined flow banded lava on Moreton Island, truncated and overlain by a crumble breccia of an overlying flow. (GR:5450E, 70108N)

Plate 4.5 Close-up of a crumble breccia on Moreton Island. The different orientations of flow banding in the clasts indicate that the rocks had devitrified prior to brecciation.(GR:5450E, 70108N)

Plate 4.6 Vugg in a lava filled with haematite and comb quartz. Adder Rock, Stradbroke Island. Scale is in cm. (GR:5508.5E, 69666N)

Plate 4.7 Flow folds in lava, Stradbroke Island.(GR:5533E, 69662N)

Plate 4.8 Plan view of a rare spherulitic lava from Deadmans Beach, Stradbroke Island.(GR: 5534E, 69662N)

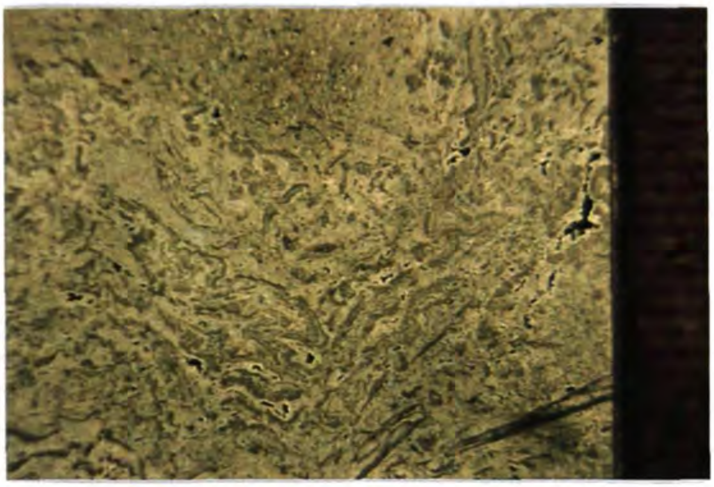

Plate 4.9 Close-up view of flow banded rhyolitic lava of subunit E, GSQ 26. Scale in mm.

Plate 4.10 Erosive contact between an amygdaloidal (below) and a coarser basaltic-andesite lava flow of subunit F, GSQ 26.