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Potassium-Argon Ages on the Newer Volcanics of Victoria

By Aziz-ur-Rahman* and Ian McDougall*

Abstract: Fourteen samples of lavas from ten scattered localities in the Newer Volcanics of Victoria give K-Ar ages that range from 1·6 to 4·2 m.y. These results confirm that the volcanism occurred during the Pliocene and Quaternary. In conjunction with palaeomagnetic data previously obtained the results emphasize that the geomagnetic time scale is quite well defined for the last 4 m.y.

A basalt from near Bacchus Marsh has a measured age of 4·03 m.y. This age is of particular significance because Fenner has shown that substantial movement has occurred on the nearby Rowsley Fault subsequent to the eruption of the basalt which has been dated.

Lavas in the ancestral Barwon and Moorabool River valleys of the Geelong area are about 2·1 m.y. old; as these basalts have been warped the latest tectonic activity in the region must be younger than very Late Pliocene.

The vertebrate *Glaucodon ballaratensis* described from the Smeaton area is probably younger than the age of 2·1 m.y. obtained on a basalt thought to underlie the sediments in which the fossil was found.

Volcanic rocks of the Grant Volcano, south of Portland, are at least 2·76 m.y. old (Late Pliocene). Previously these rocks were regarded as Lower Pleistocene.

INTRODUCTION

The Newer Volcanics of Victoria crop out over an area of about 25,000 km^2, mainly to the west of Melbourne (Fig. 1). The lavas, which range from a few metres to 150 m in thickness, were erupted from numerous vents, and are mainly olivine basalts (Edwards 1938). The Newer Volcanics are entirely subaerial and overlie marine sediments ranging up to Late Pliocene in age. Geomorphological and radiocarbon dating evidence indicates that eruptions continued into Recent times (Gill 1964). Previous K-Ar dating of the Newer Volcanics shows that volcanism commenced at least 4·5 m.y. ago in the Pliocene (McDougall *et al.* 1966).

In this paper we present 14 new K-Ar ages on samples from the Newer Volcanics; these provide further confirmation that the eruptions occurred in the Pliocene and Quaternary. Data on basalts from the Geelong and Portland areas contribute to knowledge on the geological history of these regions. The age data together with palaeomagnetic measurements on the same rocks are of some importance in relation to the geomagnetic polarity time scale.

PALAEOMAGNETIC INVESTIGATIONS

Following on the earlier studies of Irving and Green (1957) and Green and Irving (1958), Aziz-ur-Rahman (1971) carried out more detailed palaeomagnetic work on samples of the Newer Volcanics directed primarily toward palaeosecular variation. At least three oriented samples were collected from each site. Alternating field demagnetization was used to remove secondary components of magnetization from each sample. The mean direction of magnetization obtained from all samples closely approximates that of the present rotation axis of the earth. Of the 8 sites from which samples were dated in this study, 4 sites showed normal polarity and 4 showed reversed polarity.

K-Ar DATING

The samples used in the present study were selected from those collected for the investigation reported in Aziz-ur-Rahman (1971). In addition several samples from earlier collections were used. The specimens chosen were from sites not previously dated by McDougall, Allsopp and Chamalaun (1966); the selection was made after

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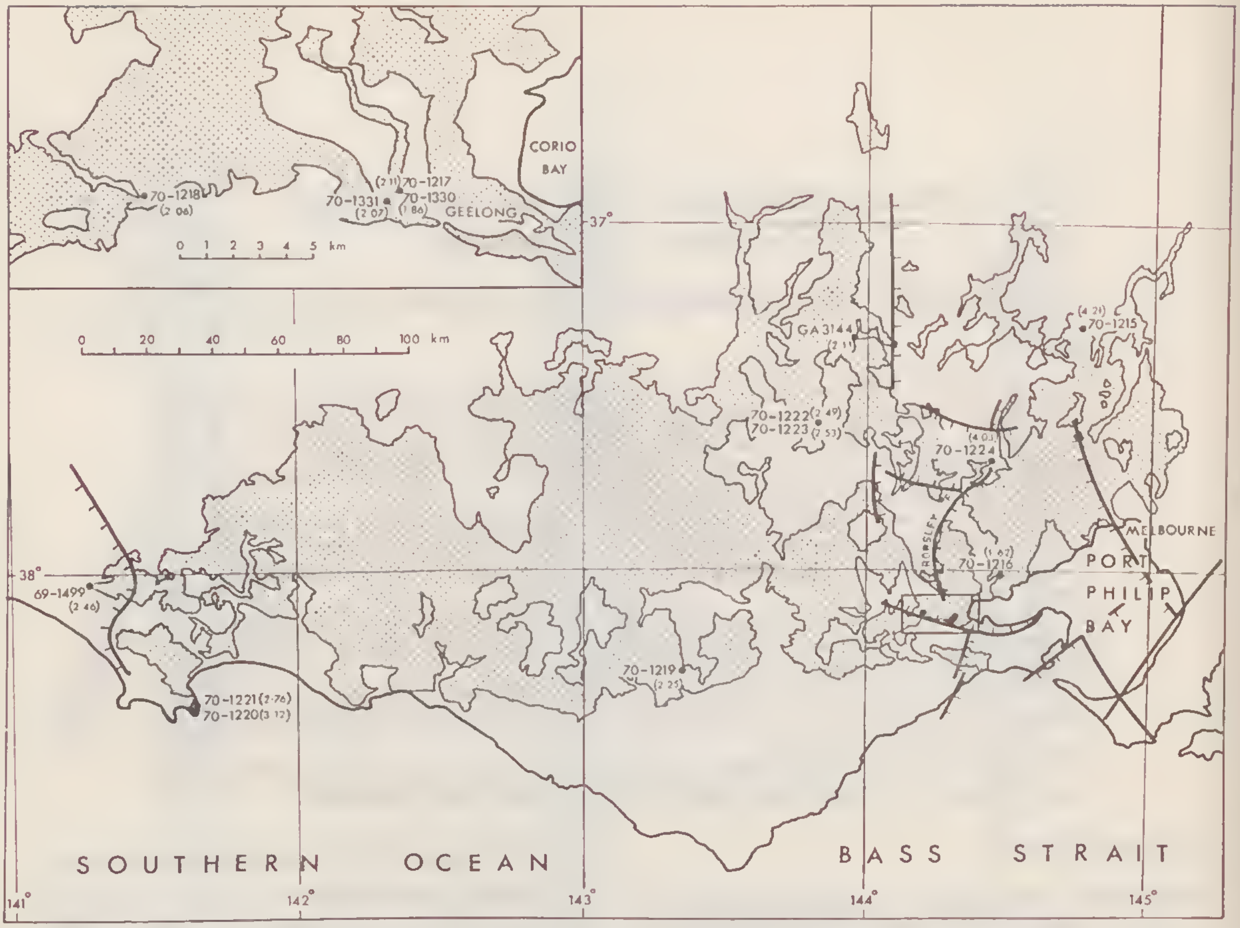

FIG. 1—Map of Victoria showing the distribution of Newer Volcanics and the localities of the samples used in this study. Figures within brackets indicate the calculated age in million years.

examination of numerous thin sections. Only those samples were used that showed little or no alteration to minimize the possibility of loss of radiogenic argon after crystallization. However some of the samples contained glass or fine grained or imperfectly crystallized intersertal material which may be prone to argon leakage. As a check on such behaviour in some cases two or more different samples from the same locality were measured. A brief petrographic description together with detailed locality information is given in the appendix.

Techniques of measurement used in this study were given previously (McDougall 1966); argon was determined by isotope dilution and potassium by flame photometry. The weight of sample for individual argon extractions ranged from 12 to 30 g. The constants used in the calculation of ages are: $\lambda_e = 0{\cdot}585 \times 10^{-10}$ yr^{-1}, $\lambda_\beta = 4{\cdot}72 \times 10^{-10}$ yr^{-1} and $K^{40} = 1{\cdot}19 \times 10^{-2}$ atom per cent. Results are listed in Table 1; errors quoted are one standard deviation based upon the internal precision of the measurements in each determination (McDougall *et al.* 1969). The magnetic polarity of each lava sampled is also given in Table 1 from Aziz-ur-Rahman (1971).

RESULTS

The ages measured on the 14 samples from 10 widely scattered localities (Fig. 1) range from 4·2 to 1·6 m.y. This spread of ages falls completely within the age range of 4·5 to 0·57 m.y. previously reported by McDougall, Allsopp and Chamalaun (1966) for lavas from 12 different localities throughout the Newer Volcanic province. Thus the new results strengthen the view that eruption of the Newer Volcanics occurred mainly in the Pliocene and Quaternary, as the Pliocene-Miocene boundary is thought to have an age of about 5·5 m.y. (Berggren 1969) and the

TABLE 1

Potassium-Argon Ages on Lavas of the Newer Volcanics of Victoria

Sample number	Field number	Polarity	Potassium %		Rad. Ar^{40} $\times 10^{-5}$ cc NTP/g	$\frac{\text{Rad. } Ar^{40} \times 100}{\text{Total } Ar^{40}}$ (%)	Calculated age (m.y.) ± S.D.		Locality
70-1216	AV54	R	0.972 0.979	0.974	0.632	21.4	1.62 ± 0.03		20 km S-W of Werribee
70-1217	AV60	R	0.926 0.931	0.923	0.781	58.2	2.11 ± 0.02	2.01 ± 0.13 (70-1217, 70-1330, 70-1331)	Geelong Quarries Ltd., Fyansford, Geelong
70-1330	UV47	R	0.925 0.926	0.926	0.688	31.2	1.86 ± 0.02		Mobile quarry, Fyansford, Geelong
70-1331	UV50	R	0.906 0.915	0.911	0.753	35.0	2.07 ± 0.02		Fyansford quarry, Fyansford, Geelong
70-1218	AV71	R	1.025 1.016	1.021	0.823 0.856	49.6 55.9	2.02 ± 0.02 2.10 ± 0.02	2.06 ± 0.05	Pollocksford, 10 km west of Geelong
70-1219	AV77	R	1.076 1.077	1.077	0.967	58.6	2.25 ± 0.03		Armytage quarry, Armytage
70-1222	AV101	N	1.038 1.033	1.036	1.029	51.4	2.49 ± 0.03	2.51 ±0.03 (70-1222, 70-1223)	Council quarry, Alfredton, Ballarat
70-1223	AV105	N	1.076 1.069	1.073	1.084	59.1	2.53 ± 0.03		
69-1499	WU11	-	1.288 1.311	1.300	1.270	31.9	2.46 ± 0.03		11 km south of Dartmoor, about 1 km east of Glenelg River
70-1220	AV87	N	0.793 0.805	0.799	0.997	17.0	3.12 ± 0.04		Portland Harbour Trust Quarries, south of Portland
70-1221	AV89	N	0.974 0.971	0.973	1.071	33.6	2.76 ± 0.03		" " " " "
70-1224	AV112	N	1.915 1.918	1.917	3.087	75.9	4.03 ± 0.04		1 km S-W of Bacchus Marsh
70-1215	AV45	N	3.029 3.046	3.038	5.107	78.6	4.21 ± 0.05		Melbourne Hill Quarry, near Lancefield
GA-3144	-	-	1.971 1.971	1.971	1.662	51.7	2.11 ± 0.03		West Berry Consols Mine, about 2 km west of Smeaton

Pliocene-Pleistocene boundary an age of about 1·7 to 1·8 m.y., accepting the base of the Italian Calabrian Stage as the most reasonable definition for the base of the Pleistocene (Berggren *et al.* 1967, Phillips *et al.* 1968, McDougall and Stipp 1968).

In those cases where more than one sample was dated from an individual lava flow the agreement between the ages ranges from excellent (70-1222 and 70-1223, Ballarat) to quite marked disagreement, with differences well outside experimental error. In the Geelong area at Fyansford three samples were dated from a single flow in the Moorabool Valley and the measured ages found were 1·86 m.y. (70-1330), 2·07 m.y. (70-1217) and 2·11 m.y. (70-1331). The specimens from this lava contain about 20 per cent of glass charged with microlites and the results suggest that significant loss of radiogenic argon may have occurred at least from sample 70-1330. The two concordant ages at about 2·1 m.y. may record the time of eruption of the lava but nevertheless this should be regarded as a minimum age. Similarly the two samples from the Portland area differ considerably in their measured ages. The potassium contents of the two samples are considerably different from one another so that it is likely that the specimens were collected from two distinct flows or intrusions that may be of different age. Although the samples are virtually holocrystalline they both show incipient alteration and minor development of mineraloids in voids; thus the ages must be regarded as minima. The remaining samples dated contain small but variable amounts of poorly crystallized intersertal feldspathic material or glass and show ubiquitous partial iddingsitization of olivine; the ages determined probably are a good approximation to the time of crystallization of the lavas.

GEOMAGNETIC POLARITY TIME SCALE

The polarity time scale for the last 4 m.y. of geological time is now well documented (McDougall and Chamalaun 1966; Cox, Doell and Dalrymple 1968; Cox 1969; Grommé and Hay 1971). The new results from Victoria are plotted against the presently accepted configuration of the time scale in Fig. 2 together with previous data on the Newer Volcanics.

The results from the 8 new sites (4 normal, 4 reversed) all are consistent with the time scale. Four of the dated sites fall within the lower part of the Matuyama Reversed Epoch and show reversed polarity; hence none of the samples falls within the normal polarity events of short duration that are recognized in this epoch. Two of

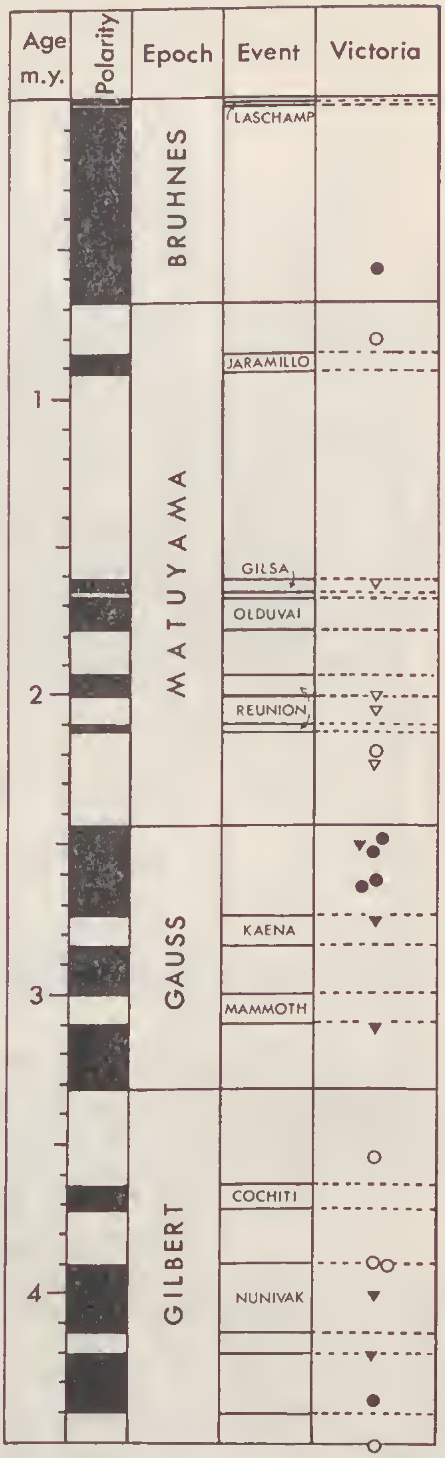

FIG. 2—Diagram showing the magnetic polarity and the age for the Newer Volcanics of Victoria. The polarity time-scale is based on Cox (1969) and is modified for Olduvai and Réunion events according to Grommé and Hay (1971). Circular symbols represent the data from McDougall, Allsop and Chamalaun (1966), while the triangles are based on the present study. Filled symbol normal polarity, open symbol reversed polarity.

the lavas with normal polarity belong to the Gauss Normal Epoch and the remaining two fall within two of the normal events in the Gilbert Reversed Epoch. The consistency of these data serves to emphasize that the geomagnetie polarity time scale for the last 4 m.y. is now quite well defined.

DATA FROM THE GEELONG AND BACCHUS MARSH AREAS

Geelong lies near the southern margin of outcrop of the Newer Volcanics and in a region where the pre-basaltic geology is well known (Singleton 1941; Coulson 1938; Bowler 1961, 1963; Spencer-Jones 1967). The basement consists of Palaeozoic and Mesozoic rocks upon which a thickness of up to 100 m of mainly marine sediments was deposited from the Late Oligocene into the Late Cenozoic. The youngest pre-basaltic sediments are the Moorabool Viaduct Sands of Bowler (1963); this formation contains marine faunas of supposed Kalimnan and Werrikooian ages (Singleton 1941). However T. A. Darragh (pers. comm.) has re-examined the molluscan fauna from this formation in the Moorabool River area and regards the age as Cheltenhamian (Upper Miocene). As shown by Coulson (1938) and Bowler (1961) the area became emergent and a drainage system developed into which basalts of the Newer Volcanics flowed and spread out over the surrounding plains. Rivers were displaced laterally and proceeded to re-excavate valleys which themselves were subsequently filled by more basalt; since that time the drainage has again re-established itself by lateral migration.

An excellent example of lava that partly fills a younger valley is the basalt that occupies the ancestral Moorabool River Valley between Viaduct and Fyansford (Bowler 1961); the flow is up to 50 m thick. This lava has been extensively quarried and three samples were collected from such quarries near Fyansford (70-1217; 70-1330; 70-1331). As previously discussed two of the samples give concordant ages of 2·07 and 2·11 m.y. whereas the third sample gave a somewhat younger age of 1·86 m.y., presumably because of loss of argon. The best estimate of age of eruption is therefore given as 2·09 m.y. This age is Late Pliocene as the Pliocene-Pleistocene boundary has an age of about 1·7 to 1·8 m.y. as discussed above.

Another basalt was dated from Pollocksford, about 10 km west of Geelong adjacent to the Barwon River. Bowler (1961) showed that the basalts here are filling the ancestral Barwon River which joins the Moorabool River just south of Fyansford. The measured age of 2·06 m.y. for the Pollacksford basalt is indistinguishable from that on the basalt in the Moorabool River Valley; petrographically the samples from both areas show marked similarities as all are characterized by abundant glass with microlites. The measured ages, petrography, and geomorphology are mutually consistent and strongly suggest that these young valley filling lavas were erupted at the same time, possibly even from the same source. Coulson (1938) and Bowler (1961) clearly demonstrated that after eruption of these young basalts warping and faulting took place locally with displacements of up to 70 m. The faulting therefore occurred in the latest Pliocene or in Pleistocene times. Fenner (1918) and Bowler (1966) showed that the faulting in the Geelong area forms part of a much more extensive system of faults which have controlled the development of a large depression partly occupied by Port Phillip Bay.

The western boundary of the Port Phillip Sunkland is marked by the Rowsley Fault which was described in detail by Fenner (1918). This major fault (Fig. 1) has an approximately northerly strike and extends from near Geelong to north of Bacchus Marsh over a distance of more than 50 km. Fenner (1918) estimated that the average throw on the Rowsley Fault is about 250 m west side up. He showed that much of this movement occurred subsequent to the eruption of the Newer Volcanics of the Bacchus Marsh area. Thus the age of 4·03 m.y. on sample 71-1224 from a lava close to Bacchus Marsh on the downthrown side of the fault gives an older limit to the age of the Rowsley Fault, which therefore must be Pliocene or younger. The age results from the Geelong and Bacchus Marsh basalts provide strong evidence that there has been significant movement on the faults bounding the Port Phillip Sunkland in Late Pliocene or younger times as previously suggested by many workers.

DATA FROM THE PORTLAND AREA

The geology of the Portland area was described in considerable detail by Boutakoff (1963) who emphasized its importance particularly in relation to the Pleistocene Period and fluctuations in sea level in response to glaciation.

Two basaltic samples were dated in the present study from the Portland Harbour Trust Quarry on the east side of Cape Sir William Grant, 6·5 km south of Portland. Our specimens were obtained from what Boutakoff (1963) describes as a plug complex that occupies a volcanie centre between the two volcanic subsidence calderas which are postulated to underlie Nelson and Grant Bays. Boutakoff (1963) included the basaltic rocks of Cape Sir William Grant in his Second Phase of

Volcanism which he assigned (p. 31) to the Lower Pleistocene for reasons outlined in the following. Just to the north of Portland Boutakoff (1963) mapped Second Phase basalts overlying the Werrikoo and Maretimo Members of the Whalers Bluff Formation. To the west of Portland in the Dartmoor area the Crawford Member of the Whalers Bluff Formation crops out in what is regarded as a geometrically equivalent position to the basalts overlying the Werrikoo Member at Portland. The Crawford Member contains *Pecten* (*Notovola*) *meridionalis* which is thought to be indicative of cool waters; Boutakoff (1963) therefore used this as a marker for the beginnings of the Pleistocene, following Singleton (1941). Thus the age of the basalts of the Portland area are of some importance in relation to the Pleistocene as presently recognized in Victoria. Unfortunately no age data are available on basalts directly overlying the Werrikoo Member at Portland but as these basalts are thought by Boutakoff (1963) to be time equivalents with those of Cape Sir William Grant results on the latter are also of significance.

The two basaltic rocks from Cape Sir William Grant give measured ages of 3·12 m.y. (70-1220) and 2·76 m.y. (70-1221), establishing that the volcanism occurred at least 2·76 m.y. ago. This age is regarded as Late Pliocene on the basis that the Pleistocene began about 1·7 to 1·8 m.y. ago as previously mentioned. How can the Pliocene age suggested from the dating of these basalts be reconciled with the lower Pleistocene age favoured by Boutakoff (1963)? One alternative is that the basalts in the Grant and Nelson volcanoes are older than those overlying the Werrikoo Member at Portland. Another alternative is that the basalts of both areas are of the same age, as Boutakoff (1963) suggests, in which case the disagreement on their age may well be related to definition of the Pleistocene. It is implicit in Boutakoff's writings that the beginning of the Pleistocene coincides with the first marked climatic cooling in the Late Cenozoic. The difficulties of using the criterion of cooling to establish the beginning of the Pleistocene were emphasized by McDougall and Stipp (1968). There is now strong evidence that cooling and glaciation occurred well back into the Late Cenozoic (Stipp *et al.* 1967, Curry 1966, McDougall and Wensink 1966, Armstrong *et al.* 1968) and Denton and Armstrong (1969) showed that some glacial deposits in Alaska are more than 10 m.y. old. Consequently, as previously mentioned, many workers have preferred to return to a stratigraphic definition for the beginning of the Pleistocene. The most commonly accepted definition takes the base of the Calabrian Stage in Italy as the base of the Pleistocene, the age of which is about 1·7 to 1·8 m.y. Therefore it is possible that the climatic cooling indicated by the fossils contained within the Crawford Member of the Whalers Bluff Formation relate to a time earlier than the beginning of the Pleistocene if the stratigraphic definition for the base of this Period is accepted.

The basaltic rocks of the Grant and Nelson Volcanoes to the south of Portland have developed on them an extensive erosion surface at 27 to 30 m above present sea level according to Boutakoff (1963). Boutakoff argues that this erosion surface is the result of marine planation at a time when sea level was considerably higher than at present, as he found no evidence for tectonic uplift. Boutakoff (1963) suggests that the planation occurred during the Mindel/Riss interglacial which is thought to have been about 150,000 years ago (Shotton 1967). Our K-Ar results on the Grant basalts show that the erosion surface developed subsequent to 2·76 m.y. ago; therefore it is quite possible that the development of the surface occurred considerably earlier than the Mindel/Riss interglacial. Unconformably overlying the erosion surface are the thick calcareous aeolianites of the Bridgewater Formation; this formation may likewise be much older than previously thought, and may span a much greater time than previously suggested.

BALLARAT AREA

About 25 km north of Ballarat in the vicinity of Smeaton a sample of basalt from the West Berry Consols Mine No. 1 Bore was dated and gave an age of 2·11 m.y., Late Pliocene. About 4·2 km north of this locality a fossil marsupial *Glaucodon ballaratensis* was described by Stirton (1957) from sediments that Gill (1957) regards as younger than the basalts of this area. Thus it seems likely that *Glaucodon* is latest Pliocene or younger in age. In sediments preserved under the basalts of the Smeaton area crocodilian remains have been found (Gill 1961, Gill, pers. comm.), which therefore must be Late Pliocene or older.

About 4 km west of Ballarat at Alfredton two samples probably from the same basalt flow give ages agreeing well at 2·49 and 2·53 m.y. These results together with the Smeaton age suggest that many of the basalts in the Ballarat area are Late Pliocene in age.

SUMMARY AND CONCLUSIONS

Potassium-argon dating on lavas of the Newer Volcanics of Victoria from ten additional localities confirms that the volcanism occurred mainly during the Pliocene and Quaternary. The ages and palaeomagnetic polarity data are all consistent with the geomagnetic polarity time scale as presently known.

The ages on basaltic rocks from the Geelong, Bacchus Marsh, Portland and Ballarat areas are of particular significance. The youngest lavas in the Geelong area partly fill ancestral valleys of the Barwon and Moorabool Rivers and have an age of about 2·1 m.y. These lavas show some evidence of warping. The 4·03 m.y. age on the basalt from Bacchus Marsh together with the detailed work of Fenner (1918) indicates that considerable movement on the important Rowsley Fault has occurred subsequent to the Middle Pliocene. The age results from Geelong and Bacchus Marsh confirm that tectonic movements, with which the formation of the Port Phillip Sunkland was associated continued into the Late Pliocene or possibly into the Pleistocene.

The age of basaltic rocks of the Portland area is important in relation to the recognition of what rocks in Victoria may belong to the Pleistocene Period. The basaltic rocks comprising Grant Volcano to the south of Portland were erupted at least 2·76 m.y. ago. Accepting that the base of the Calabrian Stage in Italy is presently the best available definition for the beginning of the Pleistocene (with an age of about 1·7 to 1·8 m.y.), then the Grant Volcano rocks are at least as old as Late Pliocene. Boutakoff (1963) regarded these volcanics as of the same age as the basalts overlying the Werrikoo Member of the Whalers Bluff Formation at Portland. If the correlation is correct then the Werrikoo Member is also Pliocene, and the climatic cooling indicated by fossils in the overlying Crawford Member of the Whalers Bluff Formation further to the west may also be of Pliocene age, rather than Pleistocene. It is clearly of considerable importance that further isotopic dating be carried out in the Portland region in order to assist in defining the Pleistocene Period in Victoria and in the elucidation of climatic variations in the Late Cenozoic.

The vertebrate *Glaucodon ballaratensis* appears to be younger than the 2·1 m.y. age found on a basalt from near Smeaton and is therefore Late Pliocene or younger in age.

ACKNOWLEDGMENTS

We thank Mr. E. D. Gill for providing the sample from Smeaton and for allowing us to include the result in this paper. Mr. P. Wellman kindly gave permission for us to use data on sample 69-1499. For advice on the geology of the Geelong area we thank Dr. J. M. Bowler and Mr T. A. Darragh. We are grateful to Dr. O. P. Singleton for many valuable comments on the manuscript. Technical assistance in the K-Ar dating was provided by Z. Roksandic and Mrs. R. Maier.

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Appendix

SAMPLE LOCATION AND PETROGRAPHIC DESCRIPTION

69–1499 About 11 km S. of Dartmoor between Glenelg River and road S. from Dartmoor through Drik Drik. Nelson 1:63,360 map, 38°01·7′S., 141°16·7′E. Olivine basalt. Phenocrysts of olivine with marginal alteration to iddingsite occur in fresh basaltic groundmass which contains about 5% of poorly crystallized, intersertal, sometimes turbid feldspathic material. Collected by P. Wellman.

70–1215 Melbourne Hill, southern side of abandoned quarry. About 60 km N. of Melbourne, near Lancefield. Lancefield 1:63,360 map, 37°22·9′S., 144°34·6′E. Trachyandesite. Phenocrysts of patchy alkali feldspar set in feldspathic finely crystallized groundmass. Iron oxide is abundant together with minor iddingsitized olivine and fresh pyroxene.

70–1216 Abandoned quarry 20 km SW. of Werribee. Sample from SE. face of the quarry. Geelong 1:63,360 map, 38° 0·6′S., 144°28·3′E. Vesicular olivine basalt. Olivine phenocrysts with iddingsite rims set in basaltic holocrystalline, fresh groundmass.

70–1217 Geelong Quarries Ltd., Fyansford, Geelong. Sampled from upper terrace of quarry. Geelong 1:63,360 map, 38° 8·45′S., 144°18·55′E. Olivine basalt. Fresh olivine phenocrysts embedded in a medium grained groundmass of olivine, plagioclase, clinopyroxene with abundant (20%) intersertal opaque glass which contains numerous pyroxene microlites in sheaves. Locally some yellow mineraloid coating vesicles.

70–1218 Small abandoned quarry near Pollocksford about 10 km W. of Geelong. Sample from S. face of the quarry. Geelong 1:63,360 map, 38°8·5′S., 144°11·6′E. Olivine basalt. Petrographically very similar to 70-1217 but the intersertal glass with microlites is lighter coloured owing to crystallization of iron oxide as discrete grains.

70–1219 Armytage quarry, Armytage. S. face of the quarry. Colac 1:63,360 map, 38°16·6′S., 143°52·2′E. Olivine basalt. Olivine phenocrysts iddingsitized and set in well crystallized groundmass in which about 5% of poorly crystallized feldspathic material occurs intersertally.

70–1220 Portland Harbour Trust Quarry, on the E. side of Cape Sir William Grant, about 6·5 km S. of Portland. Sampled from S. wall of the quarry. Portland 1:63,360 map, 38°24·4′S., 141°37·7′E. Olivine basalt. Some chloritization of olivine phenocrysts and alteration of groundmass olivine. The rock is virtually holocrystalline in olivine, plagioclase, clinopyroxene and iron oxide but small amount of green mineraloid and slight chloritization along cracks in plagioclase.

70–1221 Location as for 70-1220, but from W. flanks of the quarry. Coarse doleritic basalt similar to 70-1220 and also showing some incipient alteration and some mineraloid.

70–1222 Council quarry, Alfredton, Ballarat.

70–1223 Sampled from W. face of the quarry. Ballarat 1:63,360 map, 37°33·6′S., 143°49·45′E. Olivine basalt. Iddingsitized olivine phenocrysts grading into the groundmass which is virtually holocrystalline and fresh. Minor calcite present.

70–1224 Abandoned quarry 1 km SW. of Bacchus Marsh on the southern side of Werribee River. Sampled from N. flank of the quarry. Ballan 1:63,360 map, 37°41·0′S., 144°25·5′E. Olivine basalt. Partly iddingsitized olivine phenocrysts grade into fine grained basaltic groundmass which although well crystallized contains abundant sheaves of pyroxene microlites.

70–1330 Mobile Quarry, Fyansford, Geelong. Same locality as 70-1217. Olivine basalt almost identical petrographically to 70-1217 and contains abundant dark glass with microlites.

70–1331 Fyansford Quarry, Fyansford, Geelong. Small abandoned quarry opposite Geelong Quarries Ltd. on S. side of the road. Olivine basalt. Similar to 70-1217 and 70-1330 but slightly coarser grained with a few per cent of green mineraloid and perhaps slightly less glass.

GA 3144 Basalt from depth of 16·8 m in West Berry Consols No. 1 Bore about 2·3 km W. of Smeaton, 25 km N. of Ballarat. Ballarat 1:250,000 map, approx. 37° 20·8′S., 143°54·4′E. Well crystallized rock with small phenocrysts of plagioclase and olivine set in a predominantly feldspathic groundmass together with olivine, iron oxide and clinopyroxene. Sample supplied by E. D. Gill.