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Potassium-Argon Ages from the Quaternary Succession in the Warrnambool-Port Fairy Area, Victoria, Australia

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Abstract: The Yangery Basalt of the Warrnambool area has an age of 1·95 m.y. and is therefore Late Pliocene. The Woodbine Basalt exposed on the coast between Port Fairy and Cape Reamur is 0·30 m.y. old. This provides an age for a low stand of the sea, as the subaerially erupted Woodbine Basalt fills a valley cut to a depth of at least 30 m below present sea level.

INTRODUCTION

In the Warrnambool-Port Fairy area of the southwest coast of Victoria, detailed geological studies by Gill (1943, 1947, 1967) reveal a remarkable record of Quaternary events related to the changing sea levels associated with the glaciations of this period. The stratigraphic record includes eruption of basalts of the Newer Volcanic Series and deposition of marine and aeolian sediments. In this article we report K-Ar ages on these basalts, providing important data on the timing of the events in the region.

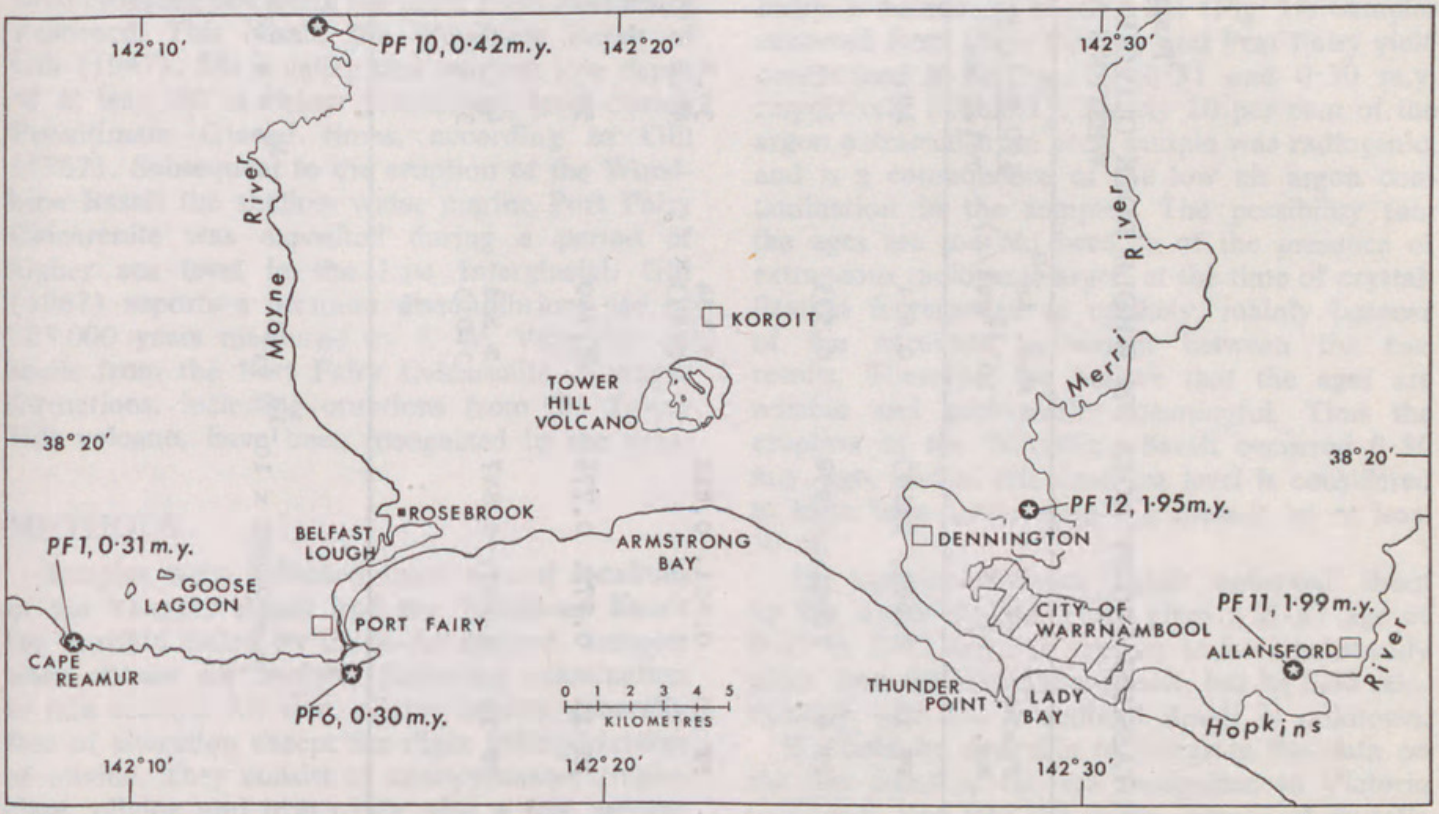

Fig. 1—Outline map of the Warrnambool-Port Fairy area showing the location of the samples dated.

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TABLE 1
POTASSIUM-ARGON AGES ON WHOLE ROCK OLIVINE BASALTS FROM PORT FAIRY-WARRNAMBOOL AREA, WESTERN VICTORIA

Lab. No.	Field No.	K wt. %	Rad. Ar^{40} (10^{-12} mol/g)	100 Rad. Ar^{40} / Total Ar^{40}	Calculated age (m.y.) ± 2 s.d.	Locality	
72-307	PF 1	1.099, 1.103	0.611	19.0	0.312 ± 0.005	Cape Reamur Warrnambool 1:100,000 WC 998501	Woodbine Basalt
72-312	PF 6	1.001, 0.998	0.535	19.4	0.301 ± 0.008	Sewer outfall, Port Fairy Warrnambool 1:100,000 XC 085492	
72-316	PF 10	0.811, 0.811	0.584 0.633	30.8 40.8	0.404 ± 0.017 0.438 ± 0.007	19 km N of Port Fairy Warrnambool 1:100,000 XC 015696	
72-317	PF 11	0.773, 0.776	2.740	59.9	1.99 ± 0.05	8 km E of Warrnambool Panmure 1:63,360 497659	
72-318	PF 12	0.845, 0.847	2.861 3.015	41.3 34.1	1.90 ± 0.06 2.00 ± 0.05	2 km N of Warrnambool Warrnambool 1:100,000 XC 291543	Yangery Basalt

$\lambda_e = 0.585 \times 10^{-10}\ yr^{-1}$ $\lambda_\beta = 4.72 \times 10^{-10}\ yr^{-1}$ $K^{40}/K = 1.19 \times 10^{-2}$ atom %

GEOLOGY

Underlying the whole area is the horizontal marine Port Campbell Limestone of Miocene age. To the north of Warrnambool, Gill (1967) has mapped the Yangery Basalt, which overlies the Port Campbell Limestone with erosional unconformity. The Yangery Basalt is considered to be Late Pliocene to Pleistocene on the basis of stratigraphic and geomorphological arguments. In an embayment in the old coastline formed by the basalts between Warrnambool and Port Fairy, Gill (1967) recognized and mapped a sequence of marine sands and aeolianites (Fig. 1). Because of the lack of evidence of tectonic movements, the interpretation of the history of the region is based upon the assumption that the major advances and retreats of the sea as recorded in the stratigraphy are glacio-eustatic in origin. The area concerned overlies a stable structural platform, the Warrnambool High of Wopfner and Douglas (1971).

The Warrnambool Aeolianite and associated formations are lithified dune limestones, stratigraphically younger than the Yangery Basalt. These formations are considered to be older than the subaerially erupted basalt of youthful appearance cropping out along the coast from Port Fairy westward. This basalt, the Woodbine Basalt of Gill (1967), fills a valley that was cut to a depth of at least 30 m below present sea level during Penultimate Glacial times, according to Gill (1967). Subsequent to the eruption of the Woodbine Basalt the shallow water marine Port Fairy Calcarenite was deposited during a period of higher sea level in the Last Interglacial. Gill (1967) reports a uranium disequilibrium age of 125,000 years measured by J. W. Valentine on shells from the Port Fairy Calcarenite. Younger formations, including eruptions from the Tower Hill volcano, have been recognized in the area.

METHODS

Samples were collected from several localities in the Yangery Basalt and the Woodbine Basalt for possible dating by the K-Ar method. Samples were chosen for analysis following examination in thin section. All were olivine basalts, generally free of alteration except for slight iddingsitization of olivine. They consist of clinopyroxene, plagioclase, olivine and iron oxide with a few percent of well crystallized feldspathic material. The absence of glass in the basalts and their unaltered character suggests that they are likely to have retained radiogenic argon quantitatively since eruption. Potassium was determined by flame photometry and argon by isotope dilution; details of techniques of measurement of the K-Ar ages were described previously (McDougall 1964, McDougall et al. 1969). Results are given in Table 1 which includes localities and grid references, and localities of the dated samples are plotted in Fig. 1.

RESULTS AND DISCUSSION

A sample from the Yangery Basalt just north of Warrnambool yields an age of 1·95 m.y., and a similar age of 1·99 m.y. was obtained on a basalt about 8 km east of Warrnambool. Clearly both samples belong to the same eruptive episode. Employing the stratigraphic definition that the Calabrian Formation of Italy is basal Pleistocene, the Pliocene-Pleistocene boundary has an age of about 1·8 m.y. (Berggren et al. 1967, Glass et al. 1967, McDougall & Stipp 1968, Hays & Berggren 1971). Thus the Yangery Basalt is Late Pliocene, and confirms that the stratigraphic sequence above this basalt formation in the Warrnambool-Port Fairy area is virtually wholly within the Quaternary.

The Woodbine Basalt flow is exposed continuously from Cape Reamur eastward to Port Fairy, a distance of about 8 km (Fig. 1). Samples collected from Cape Reamur and Port Fairy yield concordant K-Ar ages of 0·31 and 0·30 m.y. respectively (Table 1). Nearly 20 per cent of the argon extracted from each sample was radiogenic, and is a consequence of the low air argon contamination in the samples. The possibility that the ages are too old because of the presence of extraneous radiogenic argon at the time of crystallization is regarded as unlikely, mainly because of the excellent agreement between the two results. Therefore we believe that the ages are reliable and geologically meaningful. Thus the eruption of the Woodbine Basalt occurred 0·30 m.y. ago, and at this time sea level is considered to have been lower than the present by at least 30 m.

An unnamed olivine basalt collected about 19 km north of Port Fairy gives a K-Ar age of 0·42 ± 0·02 m.y.; it appears to be significantly older than the Woodbine Basalt, but its field relationship with the Woodbine Basalt is unknown.

It would be desirable to integrate the data on the low stand of the sea recognized in Victoria 0·30 m.y. ago into the world picture of eustatic changes in sea level and periods of glaciation. However, owing to the lack of reliable physical age data, there are considerable difficulties in doing this with any degree of confidence. Although progress has been made (Shotton 1967, Flint

1971), much additional stratigraphic and geochronologic information is required. Ultimately data from the deep-sea sedimentary cores may enable such world-wide correlations of glacio-eustatic sea level changes to be made, but even here there are wide differences in opinion on the age and number of cool periods recorded (e.g. Emiliani 1966, Hays et al. 1969, Hays & Berggren 1971). However, it is noteworthy that Hays et al. (1969), using data from the Caribbean and the Pacific, indicate a marked cooling at an estimated 300,000 years ago, corresponding to the fourth youngest cooling episode from the present-day. Our results perhaps are best regarded as providing key information that ultimately will enable such world-wide correlations to be made with confidence. They are a first step toward a physical time scale for changes in the sea level during the Quaternary of Australia for times beyond the limit of radiocarbon dating.

The basalts dated in this study provide additional evidence that the Newer Volcanics of Victoria were confined to the Pliocene and Quaternary (McDougall et al. 1966, Aziz-ur-Rahman 1972).

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