

§ 2. The Fauna of Australia.

An authoritative article describing in some detail the principal features of the Fauna of Australia was given in Year Books No. 1 (see pp. 103 to 109) and No. 2 (see pp. 111 to 117), while a synoptical statement appeared in No. 3 (see pp. 73 to 76). Considerations of space, however, preclude the inclusion in this issue of more than a passing reference to the subject.

§ 3. The Flora of Australia.

In Year Books No. 1 (see pp. 109 to 114) and No. 2 (see pp. 117 to 122) a fairly complete though brief account was given of the Flora of Australia, and in Year Book No. 3 similar information in a greatly condensed form will be found on pp. 76 to 78. Space in this issue will not permit of more than a mere reference to preceding volumes.

A special article dealing with Australian fodder plants, contributed by J. H. Maiden, Esq., F.L.S., Government Botanist of New South Wales, and Director of the Botanic Gardens, Sydney, appeared in Official Year Book No. 6, pp. 1190-6. A special article on the grasses and saltbushes of Australia, contributed by E. Breakwell, B.A., B.Sc., Agrostologist at the Botanic Gardens, Sydney, appeared in Year Book No. 9, pp. 84-90. Year Book No. 10 contained two special articles; one dealing with Australian eucalyptus timbers, contributed by R. T. Baker, F.L.S., appeared on pp. 85 to 92, and one by H. G. Smith, F.C.S., dealing with the chemical products of Australian eucalypts, appeared on pp. 92-98.

§ 4. Seismology in Australia.

A brief statement regarding the position of seismology and seismological record in Australia appeared in Year Book No. 4, pp. 82 and 83.

§ 5. The Geology of Australia.

1. **General.**—Independent and authoritative sketches of the geology of each State were given in Year Books No. 1 (see pp. 73 to 103) and No. 2 (see pp. 78 to 111). Want of space has precluded the insertion of these sketches in the present issue of the Year Book, and it has not been considered possible to give anything like a sufficient account of the geology of Australia by presenting here a mere condensation of these sketches. Reference must, therefore, be made to either Year Book No. 1 or No. 2, *ut supra*.

2. **Geological Map of Australia.**—The map shewing the geographical distribution of the more important geological systems and formations, which appeared on page 51 of Year Book No. 12 and in preceding issues, has been discontinued pending the preparation of a new map embodying later information.

3. **The Plains and Peneplains of Australia.**—A special article dealing with this subject appears on pp. 82-88 of Year Book No. 12.

4. **The Building Stones of Australia.**—Independent and authoritative descriptions of the building stones of each State (with the exception of Queensland) will be found in Official Year Book No. 9, pp. 446-466.

A special article dealing with "The Building Stones of Queensland" will be found on pp. 89-95 of Year Book No. 12.

5. **Past Glacial Action in Australia.**—A special article on this subject will be found in Year Book No. 13, pp. 1133 *et seq.*

§ 6. Evidences of Past Volcanic Action in Australia.*

(A) Australia.

1. **Introduction.**—It will help to make clear the nature of the evidence of past volcanic action in Australia if we consider briefly the conditions under which such activity is developed on the earth at the present time, and the nature of present-day volcanic products.

* Contributed by Ernest W. Skeats, D.Sc., A.R.C.S., F.G.S., Professor of Geology and Mineralogy, University of Melbourne.

The geographical distribution of active volcanoes at present lies mainly along two lines, the one passing through the West Indies and the Mediterranean, the other girdling the Pacific, passing well to the east of the present coast-line of Australia, and stretching from the Kurile and Japanese Islands, through Java, New Guinea, New Hebrides, and New Zealand to the Antarctic at Mount Erebus. These lines lie near or along the margins of continents and ocean basins, and are regions of present crustal instability along which the forces of folding or faulting, with accompanying earthquakes, from time to time are renewed. Other lines of weakness are submarine, and at intervals along such lines volcanic islands such as Samoa and Hawaii have been built up. These lines may be pictured as lines along which the earth's crust is weak and fissured and the vertical rock pressure less than in adjoining areas. Such conditions are favourable for the rise of molten rock to the surface, along fissures, from the highly heated depths of the crust, and its passage to the surface may be facilitated by lateral crustal pressure or warping of adjoining areas, and by the expansion of highly heated gases present in the molten magmas as the result of diminished pressure above the fracture zones.

Among present-day types of volcanic activity are the wide lava floods poured out from fissures, as in the volcanic regions of Iceland and the centralized vents or volcanoes generally localized at intervals along fracture lines. Such a volcano commonly consists of a conical hill with a central crater and a vent or plug communicating with the interior. The crater may become enlarged by violent explosions or subsequent collapse, and may be broken across or breached by lava flows pouring over a low lip of the crater. Cones may consist entirely of lava, of scoria, of tuff, or of ash, or these may alternate and form a composite cone.

When the activity is effusive, lavas are poured out; when explosive, fragmental materials, such as scoria or tuff, accumulate round the vent. Dykes of volcanic rock frequently radiate from the necks of the volcanoes, and if these reach the surface may form parasitic cones. Volcanoes active on land may have their lavas and ashes interbedded with deposits of land or lake origin, while in submarine eruptions the products become intercalated between marine sediments, and may ultimately rise above the surface to form volcanic islands, so numerous in the Pacific Ocean.

The chemical composition of lavas may be highly siliceous, forming so-called acid lavas, such as rhyolite and obsidian; intermediate in character, giving rise to such rocks as trachytes and andesites; or basic, that is, with low silica percentage and rich in lime, magnesia and iron, in which case basalts and allied rocks are formed. Grouped in another way certain lavas may be described as calcic, in which lime and magnesia are present in greater quantities than potash and soda. Of this group, andesites and basalts are examples. Another group constitutes the alkalic rocks—rich in soda or potash—to which rhyolites, trachytes, and phonolites belong. A third group is recognised—the so-called spilite series—consisting of basic lavas, rich in albite feldspar, usually submarine in origin, and associated with cherts.

Calcic and alkalic lavas, such as basalts and rhyolites or phonolites, may be poured out successively from the same or adjoining vents, indicating that some process of separation or differentiation has gone on in the reservoir of magma beneath the surface. While this is so, these three groups—the calcic, alkalic, and spilitic—are often associated with more or less distinct types of earth movement or earth structure, the calcic group with regions undergoing subsidence by folding or warping, though also associated with plateau movements, the alkalic closely associated with plateau movements of elevation or depression and often near fault lines, while the spilite or albite rich basic series appears to be formed normally as submarine flows at some distance from a shore line and at moderate depth.

Examples illustrating all the above phases, physical and chemical, of volcanic action are to be found among rocks of various geological ages in Australia, and we may now proceed to review in a summarized way the distribution of volcanic rocks in Australia, both geographically and geologically. It will be understood that our knowledge of the geology of the more remote parts of the continent is vague and uncertain, and that in the older rocks of the geological record it is sometimes difficult or impossible to recognise the existence of volcanic products on account of the great chemical and structural changes which they have undergone. Commencing with the oldest rocks, and working up the geological column, it will be convenient to record the principal volcanic rocks in each State and in Papua in turn.

2. Pre-Cambrian Volcanic Rocks.—(i) *Western Australia.* In the Pilbara gold-field, the Warrawoona beds consist of basic lavas and sills, in places altered to greenstone schists. At Kalgoorlie ancient sediments rest on a group of basic rocks forming the Boulder auriferous belt. Quartz dolerite is the most important rock. The igneous series is probably mainly intrusive. In the Norseman field, in the southern part of the State, bedded amygdaloidal lavas are associated with the pre-Cambrian sediments. On the South Coast, from west to east of Mount Barren, occur sills of amphibolized quartz-dolerite.

In the Kimberley division occurs the Nullagine series which, while apparently younger than the Warrawoona series, may be pre-Cambrian, and appears to be not younger than older Palæozoic. Associated with the sediments of this series submarine basalts, dolerites, amygdaloidal andesites and submarine ashes occur in great profusion on the Leopold Plateau.

In the Murchison gold-field, tuffs occur at Meekatharra and in the Yalgoo field at Mount Singleton. In the West Pilbara field, augite-andesites and quartz-felsites or rhyolites occur near the base of the series.

(ii) *Northern Territory.* In the Woggaman province submarine lavas are recorded, but, with this exception, the references are all to highly metamorphosed rocks which on indefinite evidence are referred to as altered tuffs. These are recorded from such localities as the Katherine River above the telegraph station, Arnhem Land, Marranboy tin-field, Yenberrie wolfram-field, Pine Creek, Mount Diamond, Brilliant, Woolngie, the Woggaman province, and the Tanami district.

3. Cambrian Volcanic Rocks.—(i) *New South Wales.* The uralitic dolerite (amphibolite) dykes of Broken Hill may be of Cambrian age.

(ii) *Victoria.* In several localities in western, central, and eastern Victoria, notably at Mount Stavely near Geelong, Heathcote, Mount William near Lancefield, Mount Major near Dookie, the Howqua River, and Waratah Bay, a big series of ancient basic lavas, agglomerates, and tuffs, with interbedded cherts and associated shales in places, underlie conformably the Lower Ordovician sediments, and appear to be exposed along axial lines trending roughly north and south. At the Dolodrook River, near Mount Wellington, basic submarine tuffs are interbedded with Upper Cambrian fossiliferous limestones, and constitute the Heathcotian series. The cherts and shales contain Upper Cambrian marine fossils. The volcanic rocks constitute submarine flows and ashes, and some of them are rich in primary or secondary albite, and therefore belong to the spilite series of rocks.

(iii) *South Australia.* Uralitic dolerite dykes at Blinman and Mount Remarkable are possibly of Cambrian age.

(iv) *Tasmania.* In the Dundas district, the central and western part of the Zeehan field, the Leven Gorge, Gunn's Plains, the North West Coast in Barkworth's Bay west of Goat Island, a mixed series of sediments and volcanic rocks occurs. They extend on an axial line parallel to the West Coast from Bass Strait to Birch's Inlet, in Macquarie Harbour. They are probably of Upper Cambrian age, and resemble the Heathcotian series of Victoria. They include slates, porphyroids (crushed quartz and felspar porphyries), breccias and submarine tuffs, and vesicular lavas resembling the spilite or amygdaloidal diabase of German authors.

(v) *Northern Territory.* In the Edith River district and other areas southward from it are extensive developments of basalt, dacite, volcanic agglomerates with boulders up to 4 feet in diameter, and tuffs several hundreds of feet in thickness. At Maude Creek, amygdaloidal basalt occurs. South of Rendezvous Hill, near Roper Bar, sandstones of apparently Cambrian age overlie natrolite basalts. South of Red Lily a similar basalt is interbedded with quartzites, but may be an intrusive sill. From Hodgson Downs to McArthur River basalt covers a great area of timberland country. On Nutwood Downs station, 5 miles from Tamumburini, acid tuffs are interbedded with the quartzite series. In the Pine Creek district, near Blackfellows Creek, and Swamp Billabong on Daly-Road, dolerites are apparently interbedded in the Lower Cambrian series, and similar rocks occur in the Victoria River and Willaroo districts.

4. Ordovician.—(i) *New South Wales.* In the Orange-Cadia district andesitic lavas and tuffs are associated with Ordovician sediments, while andesites also occur in the Forbes-Parkes district. There is also a great development of contemporaneous basic tuffs in the Upper Ordovician rocks of the Lyndhurst gold-field.

(ii) *Victoria*. At Mount Easton, near Wood's Point, loose-textured nodular beds, with included lapilli of andesite, appear to be submarine tuffs and are interbedded with Upper Ordovician sediments.

(iii) *Western Australia*. In the Townsend Range, in latitude 26° S., close to the South Australian border, and near the base of the series, are vesicular basalts and dolerite lavas apparently interbedded with sediments, and presumably of submarine origin. They may be of Ordovician age.

5. *Silurian*.—(i) *New South Wales*. At the Jenolan Caves, rhyolites, some of which are intrusive, and tuffs are interstratified with Silurian sediments. In the Orange, Yass, the Federal Territory of Canberra, and Cobar districts, rhyolites, some of which also are intrusive, and tuffs occur. In the Forbes-Parkes district andesitic lavas and tuffs are associated with Silurian sediments.

(ii) *Victoria*. In the Thomson River district, near Walhalla, in an Upper Silurian limestone, flakes of biotite and chlorite, and bands of tuffaceous fragments suggest some submarine volcanic activity, but the fragments may be of detrital origin.

6. *Devonian*.—(i) *New South Wales*. (a) *Lower Devonian*. In the south-east of the State, at Taemas, 5,000 feet of acid lavas and tuffs occur, while the overlying Lower Devonian marine limestones are more or less tuffaceous throughout. At Tamworth, spilite lavas and interbedded tuffs occur.

(b) *Upper Devonian*. In the Yalwal district, and also near Eden, rhyolites and basalt flows are prominent.

(ii) *Victoria*. (a) *Lower Devonian*. In north-east and east Victoria the Snowy River porphyries consist of a volcanic series stretching from the Murray River southwards to Nowa Nowa, and from Cobberas, on the west, through the Mitta Mitta district to Corryong, in the north-east of the State. They consist of lavas and ashes from volcanic foci developed along meridional fractures close to a sinking shore line, and include porphyroids, trachytic-andesites, quartz-porphyrates, quartz-ceratophyres, and stratified ash beds. They pass upwards near Buchan into andesitic lavas and dykes or, in other places, into calcareous tuffs, which merge upwards into mid-Devonian marine limestones. The rocks of Noyang, in Dargo, may be of the same age, and include alkali rocks allied to quartz-ceratophyre. Rocks allied to the dacites, containing quartz and garnet, occur in the King Valley, and from Mount Timbertop and the Howqua River, towards Buller Creek, underlie Lower Carboniferous sediments, and may be of Lower Devonian age.

The main dacite series of central Victoria appears to have been the product of subaerial Lower Devonian volcanoes, and forms thick masses, in places 2,000 to 3,000 feet in thickness, of biotite or hypersthene dacites. Near Lilydale, toscanites form the base of the series. The Dandenong Ranges, Healesville to Warburton Ranges, the Marysville district, Mount Macedon, and the northern part of the Strathbogie Ranges are largely composed of lavas, with occasional tuffs of this rock series.

(b) *Upper Devonian or Lower Carboniferous*. The Upper Palaeozoic sediments stretching from Ben Cruachan past Mount Wellington to the Snowy Bluff and northwards to the Howqua district, in Victoria, contain intercalated volcanic rocks. The rocks are mainly rhyolites and rhyolite tuffs. At Mount Wellington the lava is 2,000 feet in thickness. Thin lava flows of amygdaloidal basalt occur at Mount Wellington, and at the Snowy Bluff eight thin flows occur separated by beds of sandstone and shale.

In western Victoria, quartz porphyries, possibly intrusive, may be correlated with the Upper Palaeozoic acid volcanic rocks of eastern Victoria. They occur between Hamilton and Cavendish, and near the latter place appear to underlie the Grampian sandstones. In the latter rock in places there occur dykes, sills, and possibly lavas of an acid character. The intrusive members may be as young as Upper Carboniferous.

7. *Carboniferous Volcanic Rocks*.—(i) *New South Wales*. Lower carboniferous volcanic rocks occur in the Barraba-Tamworth district, as andesitic tuff in the mudstones of the Burindi series, and as lavas and tuffs of rhyolite trachyte and andesite in the overlying Rocky River series. Further south, in the Hilldale-Dungog area, tuffs are interstratified with mudstones in the Burindi series. At Currabubula, 130 miles N.N.W. of Newcastle, fine-grained acid tuffs occur at the top of the Burindi series. During this volcanic period small flows of basalt and local eruptions of soda rhyolite occurred, while pyroxene andesite was intruded into the Burindi series. The recently described

Kuttung series of Middle and Upper carboniferous age, especially at Paterson, Clarence town, Seaham, and Eelah, includes large areas of soda rhyolites, toscanites, dacites, hornblende andesites, hornblende mica andesites, pyroxene andesites, and pitchstones. Near Pokolbin, potash rhyolites, soda rhyolites, trachytes, albite trachytes, and andesites occur. In northern New England, in the Drake gold-field near Bolivia and Tenterfield, rhyolites and tuffs are represented. Near the top of the Kuttung series, come important volcanic rocks with extensive outpourings of basalt, tuffs, and agglomerate, succeeded by sills and dykes of normal, albite, and teschenitic dolerites, hornblende and pyroxene andesites, and, lastly, by trachytoid quartz ceratophyres.

8. *Permo-Carboniferous Volcanic Rocks.*—(i) *New South Wales.* In the Lower Marine series in the Maitland district, extensive flows of natrolite basalt occur, while in the Drake gold-field in northern New England, andesitic lavas and tuffs are represented, which have been referred to this period.

At the close of the Upper Marine series, at Illawarra on the South coast, submarine lavas and tuffs 1,000 feet thick, and ranging from basic to intermediate in composition, are represented. They include alkali rocks such as orthoclase-basalts (latites), and continue on a reduced scale to the period of the Upper Coal Measures. During this latter period small basaltic flows were poured out in the coal measure swamps. At Murrurundi, on the north-west margin of the coal basin, basalts were poured out to a thickness of several hundred feet. At Newcastle, the Nobbys chert near the top of the Permo-Carboniferous series consists of silicified rhyolite tuff.

(ii) *Queensland.* In the Bowen River district the lower series includes basalts and melaphyres exposed over wide areas. In the Mackay district coarse volcanic agglomerates, basalt, dolerites, and felspar porphyry are represented.

In the Upper Bowen series, in the type area, plains of basalt and porphyry occur. In the Mackenzie River and at Bowen, basalts and copper-bearing tuffs are interbedded in the Upper Marine sediments, while andesites, possibly of this age, occur on the Dawson River, and at Mount Morgan. At Gympie, amygdaloidal basalts, andesites, and volcanic ash are interbedded with sediments. Eight miles from Warwick, on the Darling Downs, is an extensive development of rhyolites, which may be of Upper Carboniferous age or may belong to the Lower Marine series of Permo-Carboniferous age. The latter sediments in this district are largely tuffaceous.

(iii) *Northern Territory.* In the Pine Creek, Victoria River, and Tanami districts, basalts and other volcanic rocks of doubtful age are, by some observers, referred to this period.

9. *Triassic Volcanic Rocks.*—(i) *New South Wales.* The Narrabeen series, of Lower Triassic age, consists partly of shales composed of redistributed tuffaceous material.

(ii) *Queensland.* At the base of the Ipswich sedimentary series, at and near Brisbane, occurs a coarse rhyolite tuff of Triassic age.

10. *Jurassic Volcanic Rocks.*—(i) *Victoria.* The extensive lacustrine sandstones and mudstones developed in western Victoria, the Otway Ranges, near Geelong, and in South Gippsland are composed largely of plagioclase, chlorite, and quartz, and may represent tuffaceous or redistributed tuffaceous material.

(ii) *Tasmania.* Probably at the close of the Jurassic, or during the Cretaceous period, gigantic intrusions, chiefly sills up to 500 feet thick of diabase, occurred in Tasmania, forming the precipitous tiers of that island. They are probably associated with plateau movements of subsidence and faulting.

11. *Kainozoic Volcanic Rocks.*—(i) *New South Wales.* The Kainozoic volcanic rocks of this State, as in Queensland and Victoria, have a threefold development. The oldest consist of an Older Basalt series consisting of cappings on the residuals of an old peneplain, as on the Blue Mountains tableland and the Bald Hills near Bathurst, and they also form deep leads near Kiandra. The middle series consists mainly of alkali rocks, and occurs principally in groups of extinct cones of limited area. The Canoblas mountains, near Orange, the Warrumbungle mountains, near Coonabarabran, and the Nandewar mountains, near Narrabri, are the best known. The sequence at Canoblas, which is generally similar to the other areas, consists from below upwards of comendites and quartz trachytes, alkaline phonolitic trachytes, and andesites.

In the Mittagong-Bowral district occur residual volcanic plugs of alkaline syenite allied to bostonite. The Gib Rock and Mount Jellero consist of similar conical masses of alkaline trachytes. Alkaline trachytes occur also near Dubbo and various places in the Northern Rivers district. In the Kiama district sills of nepheline syenite and tinguaite occur, and monchiquite dykes, which may be post-Tertiary in age.

In the Sydney-Blue Mountains area occur dykes radiating from east of Botany Bay. They include basalt, monchiquite, nephelinite, and basanite, and are probably of Middle to Upper Kainozoic age. Essexite or analcite-dolerite forms a sill (?) at Prospect, near Parramatta. Many volcanic necks occur in this region, some filled wholly or partly with basalt, while others are only explosive steam vents filled wholly or partly with non-igneous breccia from the wall rock. Occurrences at Hornsby and the Basin in the Nepean River are of this character. A volcanic neck at Dundas, near Parramatta, consists of basalt, agglomerate, and xenoliths of basic and ultrabasic plutonic rocks.

Tinguaite occurs at Kosciusko, Berrigan, and Mount Stormy. Leucite-basalts are found at Cudgellico, Byrock, El Capitan, and Harden, and nepheline-basalt at Capertee and Mount Royal.

The Newer Basalt series, the plateau-basalts, occur as extensive sheets resting on the younger tableland or peneplain. Their greatest development is in New England, where they cover some hundreds of square miles near Inverell, Glen Innes, Armidale, Walcha, and other localities. On the central tableland they are met with in the Orange, Blayney, and Oberon districts, and on the southern tableland between Cooma and Bombala. They appear to have developed mainly from fissure eruptions, as no cones are found, and tuffs are rare.

(ii) *Victoria.* The threefold development of Kainozoic volcanic rocks is more clearly shewn than in any State except, perhaps, Queensland, and the association in some localities with marine or lacustrine sediments enables their relative age to be approximately determined. The lowest series consists of the Older Basalts. They are developed in and around Melbourne at Royal Park, Essendon, Broadmeadows, and Keilor, where they underlie Lower Kainozoic marine sediments. They are represented also near Geelong, at French Island, and Phillip Island. At Cape Schanck, a bore penetrated them for over 800 feet, while at Flinders another bore passed through over 1,200 feet of older basalt. They are widespread in South-east Gippsland, as at Buln Buln, Leongatha, Neerim, Mirboo, etc., while in North Gippsland they cap the plateau sometimes at elevations of over 5,000 feet, as at Mount Feathertop and Dargo High Plains.

The Middle Kainozoic series consists of alkali rocks. In the Western district of Victoria anorthoclase aegirine trachytes occur at Carapook, Coleraine, Mount Koroit, Koolomert, and the "Giant Rock" at Watong Vale. Near Casterton two small lava flows of phonolite occur. In central Victoria, at Mount Macedon, the sequence from below upwards appears to be lavas of anorthoclase aegirine trachyte, volcanic plugs or mamelons of solvabergite forming the Camel's Hump, the Hanging Rock, and Brock's Monument, anorthoclase basalt lavas and flows of macedonite and woodendite, followed by olivine bearing trachytes and limburgite. Near Macalister's Rock, north of Mount Macedon, a tuff contains well-developed but minute nepheline crystals. Nepheline basalts also occur near Greendale. Volcanic hills of trachyte and trachy-phonolite, such as Blue Mountain, occur between Blackwood and Daylesford. The monchiquite dykes of Bendigo and Castlemaine, and similar dykes near Daylesford and Melbourne, may be genetically related to the alkali rocks. In north-eastern Victoria eight volcanic plugs or dykes of tinguaite and phonolite occur in the highlands south of Harrietville, while a nepheline phonolite volcano forms Gallows Hill near Tolmie, about 14 miles north-east of Mansfield. At Frenchman's Hill, just north of Omeo, a volcanic hill, with central core of solvabergite, has on its flanks lavas of anorthoclase trachyte and a more or less radial system of dykes, including pegmatites, quartz veins, bostonites, diabase, trachyte, and seven or eight dykes of nepheline phonolite. In Benambra, at Mount Leinster, a volcanic hill consists of solvabergite, anorthoclase trachyte, and dyke rocks allied to variolite.

The Upper Kainozoic to recent volcanic rocks in Victoria form very extensive plains, stretching from Mount Gambier in South Australia, through the Western district of Victoria to Melbourne, and in several places, as in the Loddon Valley, fill old valleys and run for long distances north of the present Main Divide. They cover over 6,000 square miles of surface, and are diversified by hundreds of small volcanic cones or puy's in various stages of preservation or dissection, and probably the most recently active cone was the

compound one of Tower Hill, west of Warrnambool. Tuffs from Tower Hill overlies dunelimestones containing still existing species of shells. Other well-preserved cones are Mount Noorat and Mount Franklin. Mount Bullenmerri, near Camperdown, consists of a caldera with crater enlarged probably by explosion, and now forming a lake. Breached cones occur as at Mount Leura, near Camperdown, and Mount Buninyong, near Ballarat. Broad depressions of the surface of the lava plains have formed extensive but shallow lakes, such as Lakes Colac and Colongulac. In places, the present streams have trenched deep and sometimes wide valleys through the lava plains. The Newer Basalt flows in and near Melbourne, as, for instance, at Clifton Hill, Burnley, and Footscray, have been extensively quarried for road metal and building stone. The rocks are mainly olivine basalts, but analcite has been recorded from a coarse olivine-augite dolerite or essexite occurring as boulders in the tuffs at the base of the volcanic series at Lake Bullenmerri. The eruptions probably proceeded mainly from fissures now concealed beneath the lava flows and connected with plateau movements of elevation and subsidence and faulting, which affected Victoria at intervals from Post-Pliocene to recent times. In some places the sequence is first tuffs, then lava flows, while the later volcanic cones consist mainly of scoria and tuffs. Well-preserved volcanic bombs are found on the flanks of many of the cones. Many of the tuffs are well bedded, and excellent sections are seen at places such as Tower Hill, Lake Bullenmerri, and Lake Burrumbeet. The flooding of such a large area of Victoria with basalt obliterated the old streams, and the sealing up of these old river valleys formed the deep leads which contained rich deposits of gold-bearing sands and gravels, as at Ballarat, Ararat, and the Loddon Valley.

(iii) *Queensland.* Volcanic rocks of three series and of different age are represented. The oldest consist of extensive basalt flows and basaltic tuffs and agglomerates in south-east Queensland between Ipswich and the New South Wales border, and were probably the products of fissure eruptions. Basalts of this series are widespread on the Darling Downs, as at Warwick and Toowoomba. The thickness of this series is usually less than 100 feet, but at Mount Lindsay it is over 1,500 feet. The middle member of the volcanic series consists of alkali rocks largely rhyolite and trachyte tuffs and agglomerates, rhyolite and pitchstone dykes, and extensive lavas of rhyolite and trachyte. Rhyolites especially occur in the southern part of south-east Queensland near the MacPherson Range, and trachytes in the south-west of the area along the line of the main range. Probably of the same age as this middle series are the volcanic plugs, flows, and associated tuffs of the Glasshouse Mountains, the Esk, the Yandina district, Mount Flinders, and Fassifern, Cainbale Creek, and Woodhill areas, in which, while andesites and dacites occur, as in the Glasshouse Mountains and the Esk district respectively, the main development consists of alkali rocks, such as trachytes, soda trachytes, and soda rhyolites. To this period may also be referred the volcanic rocks of Spring-sure, in Central Queensland, which also have a threefold development, an older basalt series of agglomerates and lavas, followed by an alkali series of noseau trachytes or trachy-phonolites, in which precious opal has been found, and succeeded in turn by a newer series of basalts. Somewhat similar alkali rocks occur at Mount Lareombe, south of Rockhampton and in the hills near Yeppoon, to the north-east of Rockhampton.

Possibly the leucite basalts of the Normanby Reefs, in the Cooktown district in North Queensland, may belong to the middle alkali series of other areas in the State.

The upper series of Kainozoic volcanic rocks in Queensland consists of basalts and andesites in successive and numerous flows in the south-east part of the State. At the Lamington plateau, the maximum development of 2,000 feet of basalt occurs, Agglomerates and tuffs are not found in the southern part of south-east Queensland, but occur on the main range and at Toowoomba. Basaltic rocks of uncertain age, possibly Upper Kainozoic, occur in various localities, such as the Anakie, Clermont, and Herberton districts.

(iv) *South Australia.* Small basaltic vents or puy's of Upper Kainozoic to recent age occur in the south-east part of the State from Mount Schank, the best-preserved cone, to Mount Graham, a distance of 35 miles. Mount Gambier is the largest cone, and consists of ash, scoria, and lapilli. Small flows of basalt have issued from lateral fissures near the base of the cones. The crater is Brown's Lake; other lakes, such as Blue Lake and Leg of Mutton Lake, are not craters, but due to subsidence. On Kangaroo Island, lava possibly of somewhat greater age filled up a valley from Kingscote to Rettie's Bluff, 5 miles west of Kingscote.

(v) *Western Australia.* In the Kimberley district, basic lavas and ashes occur in the valleys of the Ord and the Bow rivers. On the Belen River, a dome or puy of basalt formed one of the foci from which lavas issued. In the southern part of the State, basalt flows occur near Bunbury, and other flows are located to the south, as at the Blackwood River and at Black Point on the South Coast, near Silver Mount. These may be of Middle or Upper Kainozoic age, and may belong to the same periods as those of South Australia and Victoria.

(vi) *Tasmania.* Basalt flows in many parts of the island overlie fluvial and lacustrine deposits, and form deep leads. In the north-east, basalt flows occur near Branhholme and Derby. In the north-west of the island, a basalt sheet caps the coastal plateau, as at Wynyard and Burnie. The above may belong to the Older Kainozoic series. In many other districts Kainozoic basalts occur, but it is difficult to place them stratigraphically. To such belong the basalts of Sheffield, Conara, Barham Plains, and Bothwell. The extensive basalt sheets probably developed from fissure eruptions. Numerous alkali volcanic rocks in Tasmania may belong to the middle part of the Kainozoic period, as is the case in many areas on the mainland. Alkali basalts or trachy-dolerites with analcite and nepheline occur at Table Cape and the Nut at Circular Head. Small volcanic cones cut through the diabase at Shannon Tier, and consist of melilite nepheline basalt, and a similar rock occurs as a lava flow at Sandy Bay, near Hobart. The alkali rocks of Port Cygnet, Woodbridge, and Kettering cut the diabase, and are probably of Mid-Kainozoic age. They include tinguaites and solvabergite porphyries, and appear to consist of minor intrusions.

(B) Papua.

1. *Upper Kainozoic to recent Volcanic Rocks.* The volcanic rocks are known to comprise hornblende andesites and basalts. In the island of Misima (St. Aigan) are thin flows of trachyte. The Papuan lavas appear to belong to two volcanic zones in which the Aird Hills, a series of small volcanic cones about 200 miles north-west from Port Moresby, belong to the southern zone, and the other zone is parallel and adjacent to the northern coast of British Papua. The great extinct crater, Dayman, 9,500 feet high, belongs to this latter belt, as does Mount Victory, 6,000 feet high. The latter cone is interesting, as it is, so far as is known, the only active lava-producing cone in the Commonwealth, while the small island of Dobu (Goulvain) in the D'Entrecasteaux group is a volcanic cone from which steam is emitted.

(C) Summary.

The foregoing remarks bring to a close a rapid survey of past volcanic action in Australia. It has been noted that few of the geological periods in the history of the development of Australia have been entirely free from some kind of volcanic activity. Specially prominent periods of volcanic energy were the Cambrian in the Northern Territory and Victoria, and the Upper Palæozoic, including the Upper Silurian, Devonian, and Carboniferous periods in eastern Australia, especially in New South Wales and Victoria. The Mesozoic was mainly a period of repose in Australia, but at its close the big sills of diabase invaded Tasmania. From the lower Kainozoic to the present day, eastern Australia, including Queensland, New South Wales, Victoria, Tasmania and part of South Australia, has been at intervals the scene of immense volcanic activity. In Victoria and South Australia, the latest eruptions not only flooded wide areas with basaltic lavas, but in the later stages of explosive activity formed many hundreds of small and frequently well-preserved scoria and tuff cones or puyes. Since then volcanic activity has become, for the time being, extinct on the mainland of the continent, and has shifted eastwards beyond the present continental borders, and now manifests itself at intervals along a line passing through Papua, the New Hebrides, and New Zealand.

NOTE.—Materials for this article have been taken from the publications of the Federal and State Geological Surveys, the Royal Societies of the various States, the Linnean Society of New South Wales, the Australasian Association for the Advancement of Science, the Federal and State handbooks for the British Association meeting in Australia in 1914, the Mining Handbook of West Australia, 1919, and from unpublished communications from Professor H. C. Richards of the University of Queensland, Mr. W. R. Browne of the University of Sydney, Dr. W. G. Woolnough, and the writer.