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Art. VI.—*The Sand Ridges, Rock Floors, and other Associated Features at Goongarrie in Sub-arid Western Australia; and their Relation to the Growth of Lake Goongarrie, a "Dry" Lake or Playa.*

By J. T. JUTSON

(Geological Survey of Western Australia).

(With 3 full page illustrations).

[Read June 13th, 1918].[1]

Introduction.

Goongarrie is a small mining township fifty-five miles north of Kalgoorlie, on the railway from Kalgoorlie to Leonora. Its height above sea-level is 1277 ft., and it is situated on the Great Plaeau of Western Australia, where the climate is sub-arid and the rainfall slightly under ten inches per annum. The conditions therefore are not such as obtain under "normal" erosion; and as the topography appears to be unique and indicates to some extent the respective rôles of wind and water erosion in sub-arid Western Australia, this paper is submitted.

Summary.

The southern portion of Lake Goongarrie, a "dry" lake or playa, is described. It possesses dissected "high" lands, "low-lands," piedmont plains (some of which are truncated by low cliffs), rock cliffs, rock floors and small shallow rock basins on or towards its western side, with sands and silts on the eastern. In addition, there are small "islands" and "peninsulas," which are chiefly sand ridges, towards the western side. Between the sand ridges, which run approximately east and west, are narrow arms of the lake, which are rock-floored in their western portions, and tend to be silt-covered in their eastern portions.

Water action has cut the valleys in the hard rock of the "high" lands; it is mainly responsible for the "lowlands" by the cutting back (westward) of softer rocks; and also for the piedmont plains at the foot of the steep cliffs. The action of the rain has been

1 By permission of the Acting Government Geologist of Western Australia.

largely or mainly responsible for the slow gravitative drift of detritus over the lowlands.

Portions of the lowlands have been changed by erosion into the rock- and silt-floored channel-like arms of the lake; and between the arms sand ridges have been built up. Detritus, due mainly to rain action and forming the continuation of the surface of the lowlands, underlies the sand ridges, but it has been entirely stripped off, and the bed-rock has been denuded, in the arms. The floors of such arms are not therefore merely "resurrected" surfaces; and they have probably been cut during the formation of the sand ridges.

The rock floors of the lake, its arms, the rock basins, the rock cliffs, and the low cliffs of the truncated piedmont plains are believed to be dominantly due to wind action.

The lake and probably the whole adjacent topographic system are regarded as migrating westwards, and the relations of the component parts of the system to one another are unique and without a known parallel elsewhere.

General Description of the District.

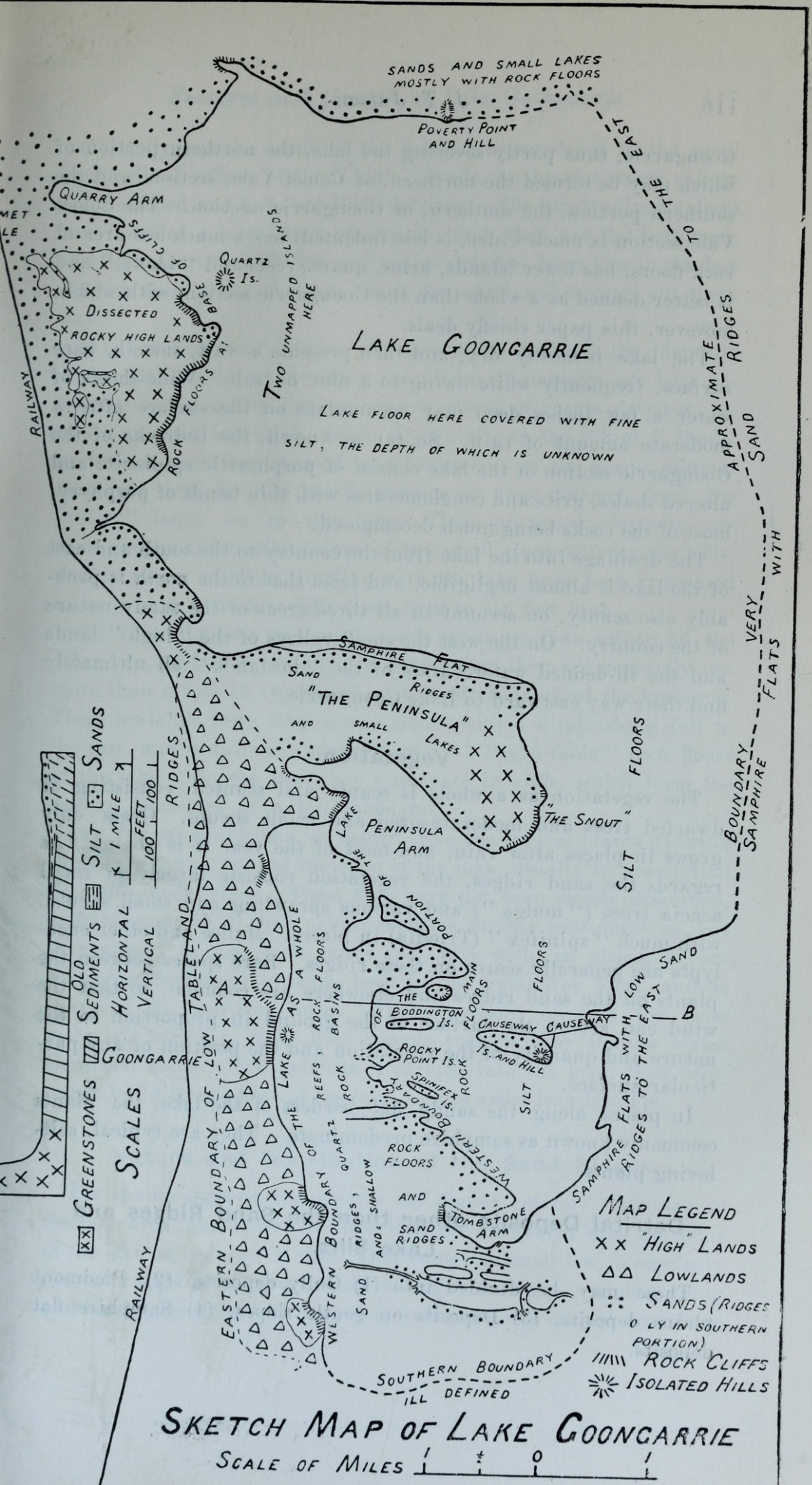
The main physical features are:—

(1) Three small belts of "high" lands consisting of hard resistant "greenstones," dissected by small early mature valleys, with a maximum depth of about 100 feet.

(2) The "lowlands," which consist chiefly of decomposed basic schists and form rather extensive areas (as compared with the "high" lands) of flat or gently sloping surface. They form with the "high" lands a north-north-west trending belt of country.

(3) The "dry" lake, or playa, known as Lake Goongarrie, which lies to the east of (and about 100 feet below) the township, and also to the east of the "high" lands and "lowlands," and of the mining township of Comet Vale, eight miles to the north. This playa is about eleven miles long in a north-south direction, with a greatest width from east to west of about six miles. It has rock cliffs and rock floors on the western and sands on the eastern side,[1] and, in addition, possesses (especially in the south-western portion) nunerous islands, sand ridges, arms and quartz reefs and "blows." A long "peninsula" projects eastward between Comet Vale and

[1] The greater portion of the eastern side of the lake has not been traversed by the writer, but from the parts actually examined and from distant views, it is practically certain that the whole side has practically similar characters, that is, low sandy shores free from rock cliffs and rock floors.



SKETCH MAP OF LAKE GOONGARRIE

SCALE OF MILES 1 ½ 0 1

Goongarrie, thus partly severing the lake, the northern portion of which may be termed the northern, or Comet Vale, section, and the southern portion, the southern, or Goongarrie, section. The Comet Vale section is much wider, is less indented, has a much less area of rock floors, has fewer islands, arms, quartz reefs and "blows," and is better defined as a whole than the Goongarrie section, with which, however, this paper chiefly deals.

The lake is mostly dry, and then presents a vast, smooth, bare surface, frequently white owing to a film of salt. Wide sheets of water a few inches deep may accumulate on the surface after a moderate amount of rain. So far as known, the bedrocks of the Goongarrie section of the lake consist of porphyritic epidiorite and altered shales, grits and conglomerates with thin bands of porphyry, most of the rocks being much decomposed.

The drainage into the lake from the country to the south and east of the lake is almost negligible, and from that to the north is probably also scanty, on account in all three areas of the sandy nature of the country. On the west the small valleys of the "high" lands and the ill-defined watercourses of the "lowlands" all ultimately find their way eastward to Lake Goongarrie.

Vegetation.

The vegetation as a whole is scanty and stunted, consisting of dwarfed trees and moderate-sized and small shrubs. Grass only grows in places after rain, and most of the year it is absent. As regards the sand ridges, the vegetation consists largely of small acacia trees ("mulga") and various sprawling and small shrubs, with much "spinifex" (Triodia) in places. Mallee and other eucalypts are generally scarce on these ridges. Bare spaces between the plants on the sand ridges and elsewhere are common, so that the wind can act on the surface of the ground in proportion to the nature and quantity of the vegetation and the position of any particular surface.

In places along the sandy flat borders of the lake, the plants commonly known as samphire predominate. They are typical, salt-loving plants.

Detrital Deposits other than the Sand Ridges and Lake Silts.

These may be divided into (1) Gully deposits, (2) Piedmont plains deposits, (3) Deposits on gentle slopes, (4) Samphire flat deposits.

(1) Gully deposits consist of the detritus accumulated in the small longitudinal valleys of the "high" lands, as the transverse valleys are V-shaped and have but little detritus. The longitudinal valleys have reached a later stage of erosion, and they are flat-bottomed, although narrow, with fine and coarse detritus from two to six feet deep on their floors, through which the occasional streams cut their way.

(2) The piedmont plains deposits really include the deposits under (3), but for convenience the piedmont deposits are here restricted to the gently sloping narrow plains of coarse detritus, up to six or eight feet thick, which lie opposite to the "high" lands, and which have been formed by a coalescence of the coarse alluvial fans laid down by the small streams as they debouch from the "high" lands on to the lake. These piedmont deposits are traversed by the continuations of the small streams from the hills, and in places at their junction with the lake have been truncated so as to now form low cliffs from four to six feet high.

(3) These deposits are much more extensive than either of the other two, and they consist of a veneer (for they are generally not more than a foot or two thick) on the soft bedrock of the lowlands. These lowlands form long gentle slopes with a diminishing fall to the east, and usually merging into the "billiard-table" rock floors of the lake. On the west they terminate in cliffs, which form the eastern boundary of a low tableland.

(4) The samphire flats, so named from the typical plants growing there, are found around the edge of the lake, usually in association with the sand ridges. These flats have not been closely examined, and the question of their origin requires further consideration, but they appear to consist of sands and clays with, in places, a considerable amount of gypsum, both in the crystalline form, and as "kopi," the powdery form. Where gypsum cements the loose materials together, these flats become traversed by shallow water channels, along which detritus is carried into the lake, thus helping to build up the floor of the lake, and to assist its migration.

Nature and Distribution of the Sand Ridges

The sand ridges at Goongarrie are almost entirely restricted to the lake area, and those now described are associated with the arms of the lake on its western side. They comprise small low, irregularly shaped ridges from about three to eight feet high, which, going eastward, pass gradually into long and regularly shaped ones from

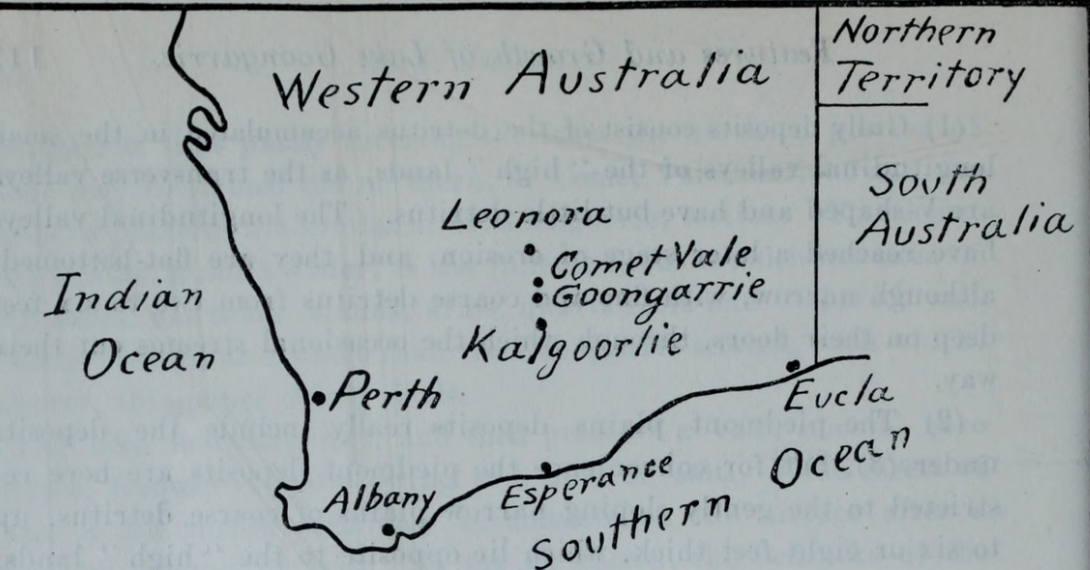


Fig. 1

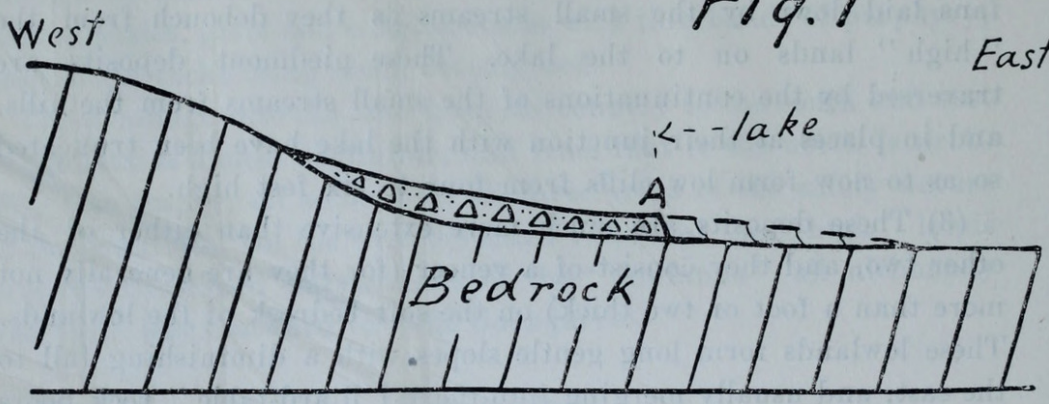
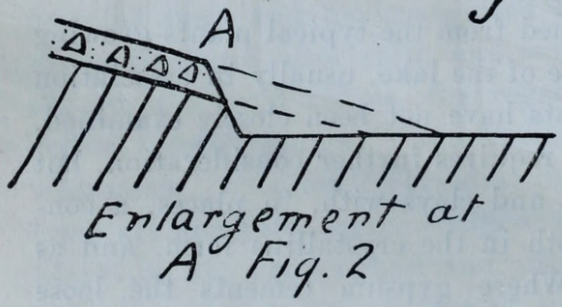


Fig. 2



Enlargement at A Fig. 2

Piedmont plain now ending in a low cliff.

Present surface

Former surface

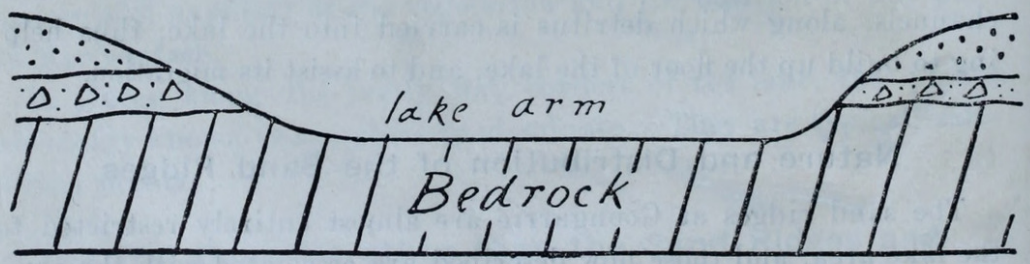


Fig. 3

"Wash"

Blown sand.

about eight to thirty feet high, and, going westward, pass into mere embryonic ridges and thence into the surface deposits of the "lowlands." The regular ridges trend approximately east and west; are all fairly parallel to one another; have in some instances fairly steep sides, which may indicate scouring[1]; and form peninsulas and islands as well as bounding some almost closed arms of the lake.

The ridge sands consist of small and well rounded grains, chiefly of quartz and subordinately of ironstone. Gypsum occurs in and on the margin of the lake, but gypsum dunes have not been noticed, although they may possibly have been overlooked.[2]

The vegetation already described holds the sands to some extent, but the ridges can hardly be regarded as fixed.

The blown sands mostly do not rest directly on the bedrock, but overlie a detrital deposit from one to three feet or more thick, which consists of a mixture of fine clayey material, fine and coarse sand, and much detrital angular vein quartz, the fragments of which are usually under one inch in size. This deposit, which lies on the bedrock, is evidently due to water action and gravitional drift, and is no doubt the counterpart, and probably a continuation of, the third class of detrital deposits (other than sand ridges and lake silts) described above.

Rock floors, which in places are covered with white quartz detritus from adjacent reefs, or with a veneer of silt, bound the irregular ridges, and also at their western ends, the regular ones; but towards their eastern ends such regular ridges may be abutted upon by the lake silts, as well as by rock floors.

The Rock Cliffs, Rock Floors, and Rock Basins of the Lake.

The "lake" or "lake area," as here used, includes the lake as a whole; that is, the area where water may rest on bare floors (either of rock or of silt), although the surface may be broken by islands. The "main portion of the lake" is that part of the surface which is almost free from obstructions, and on which after heavy rain a practically continuous sheet of water might lie. Its outline is easily followed.

(1) *Rock Cliffs.*—The higher rock cliffs, composed of greenstones, occur along the eastern borders of the "high" lands, that is, the

1 See Cornish, V. "On the Formation of Sand Dunes," Geog. Journ., ix. (1897), p. 288.
2 "Kopi" (powdered gypsum) occurs, but not as definite ridges.

western border of the lake, and there reach a height of about 100 feet.

The lower ones, composed of the altered sediments and porphyries, occur mostly along the western margin of the main portion of the lake. Both groups are receding westward.

(2) *Rock Floors.*—The rock floors may be divided into three groups, namely—(a) those of the main portion of the lake, (b) those of the arms of the lake between the regular sand ridges, and (c) those associated with the quartz reefs. The rock basins are separately described.

(a) The rock floors of the main portion of the lake occupy a considerable area of its western part, being traceable for a mile from west to east along a line just north of the Boddington Island. They are either almost wholly devoid of any detritus or possess a mere film, or a thickness of two or three inches of fine silt. In places they are slightly furrowed along the strike of the rocks, but this does not destroy the "billiard table" character of the floors.[1]

The actual plane of the surface may be slightly inclined or undulating, but precise levelling is needed to determine the directions of slope. So horizontal, however, are some of the rock surfaces that when rain falls (unless it be long continued) it simply rests on such surfaces without flow. This feature was observed by the writer in a part of the lake outside its main portion.

(b) The east-west trending arms of the lake associated with the regular sand ridges are rock-floored wholly or partly (except that a veneer of quartz debris from quartz reefs may lie upon them in places). Towards the eastern ends of the arms the rock floors are not always visible, as they may be buried under fine silt, which is believed to be nowhere in the arms more than a foot thick. The arms at their western ends in some instances break up into smaller irregular arms, which in places pass gradually into the "lowlands" previously referred to.

(c) The rock floors associated with the quartz reefs occur in the western portion of the lake, and mostly beyond the western boundary of the main portion of the lake. Although they may be regarded as portions of the lake, they yet form a number of more or less independent areas, owing to the occurrence of numerous and prominent quartz reefs which are from two to twenty feet high. These reefs, under exposure to the atmosphere, break up fairly rapidly, and consequently have a mass of debris around them which tends to cover

1 See Jutson, J. T., *Geog. Journ.*, December, 1917.

and protect the underlying rocks from erosion. Consequently, such rocks rise as hillocks with a central quartz reef. The uneven ground facilitates slight corrosion by water, and, in the lowest portions, deposition of fine silt a few inches thick. Where debris from different reefs meets, "stone fields," and to a less extent, "pavements," of white quartz result.

(3) *Rock Basins.*—True rock basins, by which are meant hollows with "live" rock surrounding them, are believed by the writer to occur in the lake floor, west of the main portion of the lake. The rocks are either decomposed porphyritic epidiorite or decomposed upturned sediments. These basins occur where the quartz reefs just referred to are so numerous. The basins are usually roughly circular or elliptical in shape; range in their longer diameters from 20 or 30 yards to 12 chains or more; and are so shallow (not being more than a few inches below the rock rim) that it is difficult by the eye alone to determine the difference of level.

The basins are occupied by fine aqueous silts a few inches thick; and after rain, water remains in the hollows and has no outlet, except where, as in some localities, an outlet appears to have been cut by water from an originally closed basin; and so one basin may connect with another by a shallow water channel.

The Silt Floors of the Lake.

Where the lake surface is not rock-floored, it is covered by a detrital deposit consisting usually of fine silt, composed chiefly of mud and subordinately of very fine sand. Taking the lake as a whole, by far the greater area is covered by silt, but to what depth is not known. This silt is usually of a dark red colour, owing to the contained oxide of iron, although the actual floor of the lake becomes white owing to the formation of a film of salt. No fossils have been found in the silts. The latter are, however, impregnated with common salt; and gypsum is abundant in the form of crystals from a quarter of an inch to four or five inches in length. The silts below the surface are practically always moist. Their thickness over most of the lake is not known, but towards the southern end bores showed that from where the rock floor ended at the western end of the Causeway Island to the eastern shore at the end of the Causeway, a distance of about a mile, the rock bottom sloped gradually to the east, until it was apparently about twelve feet below the lake surface at the eastern shore. Further information is desirable as to other portions of the lake, the portion tested by the bores being narrow compared with areas in the lake farther north.

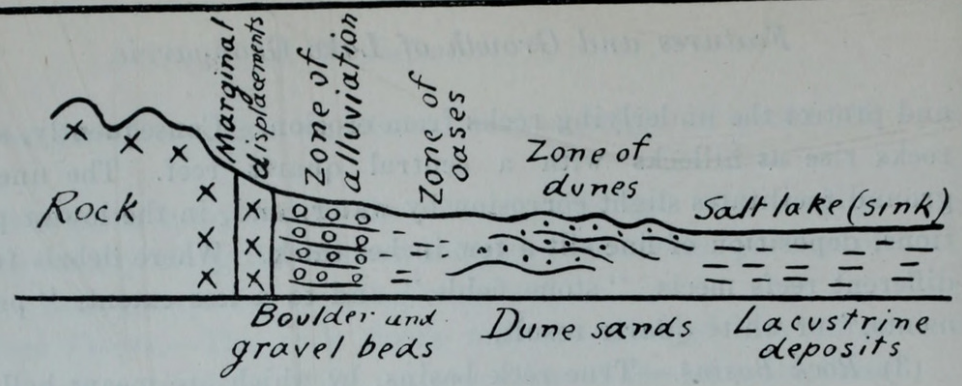


Fig. 4 (After Hobbs)

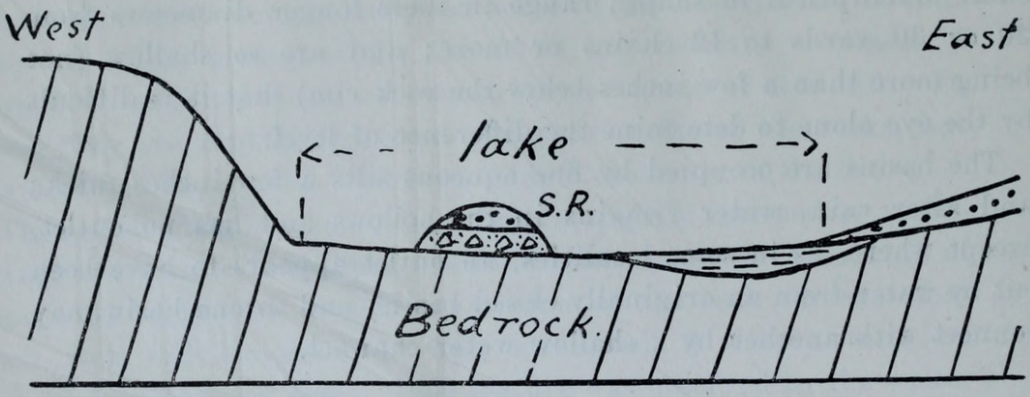


Fig. 5

S.R. Sand dune overlying "wash"

Lake silts

Sands of the eastern shore

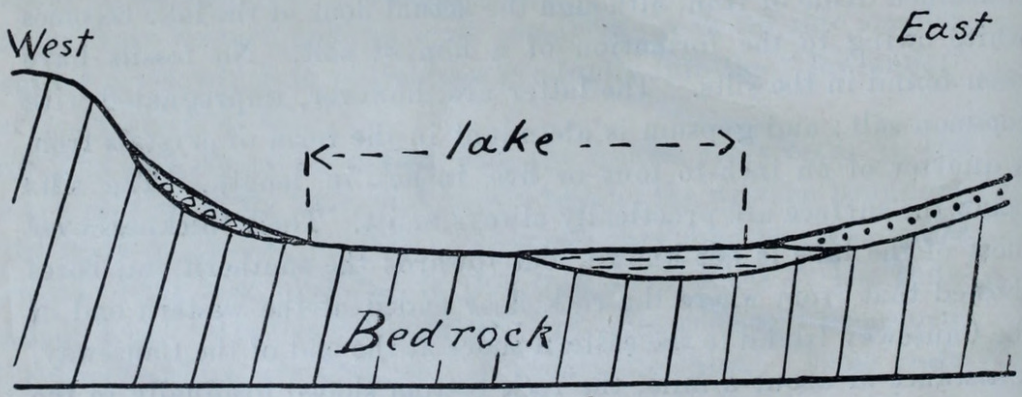


Fig. 6

Detritus on lowlands

Lake silts

Sands

Unique Characteristics of West Australian Playa Country as compared with other Areas.

So far as the writer's reading and observations extend, the features described above are quite unique, and nothing really similar has been found in any other part of the world. Elsewhere the general sequence from the high land to the playa surface across the various belts, is, according to Hobbs,[1] (1) the high land, (2) the zone of the dwindling river with its sloping bench of coarse rubble and gravel, (3) the belt of sand dunes which are often separated by narrow flat-bottomed basins carrying detritus, and (4) the central sink, which contains the true lacustrine deposits of clay and separated salts. There is no mention of bedrock floors here. Detrital deposits occur continuously from the foot of the high lands to the central sink.

At Goongarrie, proceeding from the high lands eastwards in a line just north of the Boddington Island across to the fine silts of the playa on its eastern side, the high lands of hard rocks terminate by fairly steep slopes or cliffs; thence follows a narrow piedmont plain made up of coarse detritus, brought down by the transitory streams, and having a gentle eastward fall; but such plain, instead of gradually sloping into flatter country, with a change to finer detritus, either ends abruptly in a low cliff (about four to six feet high) with a rock floor at its foot, or merges gradually into a rock floor. The piedmont plain is thus in the former case truncated. The rock floor extends eastwards for about one and three-quarter miles, broken only by quartz reefs and their detritus, by sand ridges, and by films of fine detritus in the rock basins or on the rock floors between the sand ridges. Farther east the fine silts cover the rock floor of the lake. In other places there is no piedmont plain, the high steep cliff being abutted by the rock floor. In others again the gently sloping "lowlands" take the place of the "high" lands. The sudden cessation of detritus and the occurrence of the bare rock floors are most striking, the rock floors possessing the appearance of having been recently swept by a gigantic broom.

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1 Hobbs, W. H. "Earth Features and their Meaning," New York, 1912, pp. 216-217, and fig. 231.

Various Possibilities considered as to the Origin of certain of the described Features.[1]

The following remarks are offered with regard to the origin of the rock cliffs and the various rock floors described above.

(1) Fluviatile action seems to be incapable of producing these features. The normal results are as stated by Hobbs, but here the results are abnormal. In the longitudinal valleys of the high lands where the rain becomes far more concentrated and, consequently, has much stronger erosive power than have the waters on the lake (despite the presence of some vegetation in the valleys, and its absence on the lake), there are normal fluviatile deposits (coarse detritus and small flood plains a few feet thick). Hence, as this concentrated water cannot remove the detritus and produce rock floors in the valleys, it seems impossible to account for the rock floors of the lake by the action of diffused terrestial waters, the function of which on flat areas is, so far as known, to deposit detritus rather than to remove it.[2]

(2) Marine action could produce steep rock cliffs, but billiard-table floors are hardly to be expected in rocks of the character described; nor can marine action be considered as having produced the valley-like arms of the lake. Moreover, there is no evidence that the sea extended in recent geological times as far inland as the area described. No marine fossils have been found, and there is no occurrence of normal water-worn pebbles, such as would be expected if the cliffs were attacked by the sea.

(3) The erosive activity of former deep, permanent lakes might produce cliffs, but rock benches and true gravels would be expected, and these do not occur.

(4) The wind remains to be considered. It is accepted by the writer as the dominant agent of erosion. Its main activity is deflation, as the actual breaking or wearing down of the rocks is due to ordinary atmospheric weathering, the beating action of rain, insolation, "exsudation," and wind corrosion, but details cannot be given here. In the removal of the detritus from the foot of the cliffs, the lapping of the temporary lake waters no doubt in places assists.

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1 It is not proposed to deal with the origin of the lake as a whole. The "dry" lakes occupy drainage lines of the country, and therefore must be considered at least partly of fluviatile origin For the various theories of the origin of these lakes see the writings of H. P. Woodward, A Montgomery, C. G. Gibson, J. W. Gregory, and the present writer.

2 There are some ill-defined, very shallow water channels across portions of the lake floor west of the main portion of the lake, but they would not have sufficient fall or scour to keep the floors free from detritus.

Reasons for Acceptance of the Wind Theory.

(1) The elimination of other possible agents as shown above.

(2) The occurrence of rock cliffs and rock floors on the western side, and their absence on the eastern side of Lake Goongarrie and of numerous other "dry" lakes; the impossibility of explaining these features by the fluviatile, marine, or deep permanent lake theories; and the fact that such lakes appear to be migrating westward.

(3) The ignoring in the marine and deep permanent lake theories of the present erosinal processes.

(4) The passage of the piedmont plains into lower-lying bedrock floors, and the truncation in places of such piedmont plains into low cliffs.

(5) The occurrence of rock basins. Solutions appears to be the only alternative to wind erosion for these basins, and it does not seem to apply.

(6) The relations of the sand ridges, of the arms, and of the lowlands to one another.

Origin of the Rock Basins.

As true rock basins seem to exist, they can only have been produced either (a) by the wind in its deflative capacity acting on the products of unequal weathering or in its corrosive and deflative capacities, or by a combination of all three methods, or (b) by solution. There are no grounds for believing that solution is acting differentially, so that the wind in one of the three modes suggested is apparently responsible. The shallowness of the basins and their partial filling by fine aqueous silts (which are apparently due to rain), are in accord with the generalization enunciated by Passarge[1] and adopted by Davis,[2] as to the influence of rain in preventing the formation of deep wind hollows.

The Relations between the Sand Ridges, Lake Arms and "Lowlands."

The low cliffs forming the western boundary of the lowlands are furrowed and cut back by rain, and from their base ill-defined stream courses, a few feet wide and a foot or two deep, extend eastward down the gentle slopes which are covered by a layer, prob-

1 Zeit. der Deut. geol. Gesell., 56 Band, iv., Heft, 1904, p. 208.
2 Geographical Essays, p. 307.

ably not more than 18 in. thick as a rule, of fine and coarse detritus.

The occasional streams that traverse the lowlands become diffused and rapidy die out; they have not carried down the whole of the detritus. Probably most of such detritus has been transported by the slow drifting action of rain acting on the fine material, and by the slow gravitational drift of the coarser material.

As the detritus slowly travels down the slopes of the lowlands, much of the fine material is removed by wind and rain, and hence loose sands begin to accumulate, and are built by the wind into miniature ridges. Consequently, the bed-rock becomes exposed and surface drainage becomes more concentrated. Thus there is a distinct change from the detritus-covered slope, with practically no distinct water channels to the miniature sand ridges and rock-floored channels between. The miniature ridges grow into regular sand ridges, and the small channels grow into the largely rock-floored arms of the lake. In the area of the miniature ridges, and of the irregular sand ridges, water, once it is concentrated in definite channels owing to wind action, must remove some materials; but water action must almost fail in the more eastward areas, where the regular sand ridges occur, the rock-floored channels become pronounced arms, and the surface becomes lower; although portion of the quartz detritus that rests on the floors of the arms is probably carried there by rushes of water.

It therefore seems to the writer that the wind is mainly responsible for the arms as well as for the sand ridges, inasmuch as the wind apparently blows the detritus from the arm areas on to the parallel sand ridges, and in doing so, exposes the bed rocks, which in turn must be corraded to some extent by the blown sand as well as further disintegrated by ordinary weathering, the products of such weathering being carried away by the wind.

It might be argued that the longitudinal sand ridges are merely the remains of a one-extensive continuous sand-covered area, which has been eroded either by wind or water so as to form the lake arms. The sand of the ridges can, however, in any case, be explained only as wind-borne, and on the "lowlands" there are few sand ridges, such ridges being, in the area referred to, almost always associated with rock floors, so that the above supposition would not apparently hold good.

The dominant winds appear to be westerly. The sand ridges and lake arms are therefore approximately parallel to such direction and the ridges are longitudinal ones, with bare troughs

between. Cornish[1] regards longitudinal ridges as due to strong winds, and Free[2] also points out that they seem to occur where the supply of sand is small, relative to the strength of the wind. In the bare open lake arms the wind blows with great force, the difference of strength of the wind in the arms and on the sand ridges (which bear "mulga" vegetation) being very marked. As already shown, the blown sand of the ridges rests on detritus due to water action and gravitational drift, and this deposit, which is evidently identical with and a continuation of that of the "lowlands," in turn rests on the bedrock; hence the material has been available to assist in the formation of the sand ridges, and its removal from its original position has helped to form the rock-floored arms.

These rock floors, in almost every instance, rise as they approach the sand ridges; it is therefore reasonable to conclude that the rock floors of the arms are not merely "resurrected" areas, but that they have suffered erosion during the formation of the sand ridges. It might be objected that the sand ridges may have been in existence before the arms were formed, and that the two features are not necessarily connected, but in view of their constant association and of the transition from the lowlands to the sand ridges and arms, this objection has little or no validity.

In narrow arms the rock floor in cross section is distinctly, although but slightly, concave, and in the lowest portions a few inches of fine silt may occur. This silt has no doubt been laid down under quiet water. No flow of water was observed in any channel after moderately heavy rain, but after long continued rain a distinct flow would probably take place. The unfurrowed rock surface, and the very gentle slope to the east, together with the association of sand ridges and lake arms, however, forbid any serious erosion by water. It may be noted in this connection that as the channels or arms widen, the concave character of the arms in cross section usually becomes less and less until there is a level floor with gently rising edges at the sand ridges.

The rock-floored arms pass eastward into the rock floor of the main lake[3]; and at the eastern extremity of some of the sand ridges, as well as at the western end of some of the arms, low rock cliffs occur which are in process of reduction to a rock floor, the latter growing westward by such means. An example of this is shown at the eastern end of Rocky Point Island.

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1 Op. cit., pp. 292-293.

2 U.S. Dept. of Agriculture. Bureau of Soils. Bulletin No. 68 (1911), p. 65. See also Blake, Q.J.G.S., vol. 53 (1897), p. 229.

3 Some arms towards their eastern ends have floors of fine silt.

Where the "high" lands abut directly on to the lake, the sand ridges and arms may be unconnected with the "lowlands."

Westward Migration of the Whole Topographic System.

It would appear, therefore, that the "lowlands" originally extended farther east, but by the processes above described, strips have been removed to at least partly form the sand ridges, and, by such removal, the arms of the lake have been formed and the bedrock planed down. The process is still apparently going on, the arms, and probably the sand ridges, extending westward, while bedrock at the eastern ends of the sand ridges is being planed to a level rock floor. The "lowlands" are being removed at their eastern side but the western side is extending westward by the wearing away of the low tableland and connecting cliffs. The heads of the drainage lines are cutting back westward, and such lines are being obliterated in their lower portions by the westward advance of the lake rock floors. As the latter grow westward the silt will tend to spread over them, hence the silt floors are probably extending westward, and they, in turn at their eastern margin, appear to be encroached upon by the sands.

Thus there seems to be a westward migration of practically the whole system, rock cliffs, rock floors, the lake itself (including the eastern and western shores), the lake arms, the sand ridges, the "lowlands," and the silt floors. If this conclusion be correct, it shows how portions of the country are being laterally planed away at a comparatively high level, and as wind is regarded as the governing factor, it also shows what an important part it is playing in the shaping of the land surface.