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SANDS FROM THE SQUEAKY BEACH AREA, WILSONS PROMONTORY, VICTORIA, AUSTRALIA

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Abstract

The textural and constituent composition of eight sand samples from Squeaky Beach and adjacent beaches on Wilsons Promontory, and one sample from the Squeaky Beach foredune are described. The Squeaky Beach sands are composed almost entirely of quartz grains which are very uniform in size (of medium sand size), are mostly subrounded to rounded, and have a fairly high degree of sphericity. Sand samples from Picnic and Norman Bay beaches contain nearly 40 per cent of organogenic carbonate. They are not as well sorted as the Squeaky Beach sands, the grains have a lower degree of roundness, and their maximum size-grade is fine sand.

The squeaking sound emitted by the dry sand of Squeaky Beach when walked on results probably from shearing of successive layers of the regularly packed grains. The eroding Squeaky Beach foredune appears to be the immediate source of much of the sand of the adjoining beach. The primary source of the sand minerals is almost certainly the Wilsons Promontory Granite. The relatively high content of organogenic carbonate in the Picnic and Norman Bay sands has probably come mainly from the disintegration of local aeolianite.

The marked suitability of the Squeaky Beach sand for the preservation of flowers and foliage is apparently related to its composition of very uniform rounded quartz grains. They permit even contact between sand and plant plus adequate aeration for drying.

Introduction

Squeaky Beach is part of the shore of Leonard Bay (Fig. 1) and is so called because the dry sand squeaks when walked on. The sand belongs to the interesting type known as singing sands. However, it was not because of the sound phenomenon that the writer's attention was drawn to the Squeaky Beach sand; it followed an enquiry from our Senior Preparator as to why this sand was more suitable than most for the preservation of flowers and foliage. The drying of flowers and foliage in sand is a very old method of preservation, and it can give very good results.

In June 1970 mid-tide sand samples were collected from the middle and extreme S. and N. ends of Squeaky Beach, while low-tide, high-tide and backshore samples were taken from midway along the beach; also a sample from the crest of the foredune towards the N. end. As the Squeaky Beach sands are different from those of adjacent beaches, mid-tide samples were collected also from about midway along the beaches at Picnic Bay and Norman Bay. Figure 1 shows the sample localities and details are given in the Appendix. Samples of approximately 400 g were obtained by pushing down a thin metal cylinder to a depth of 8 cm, removing the sand around the outside of the cylinder, and sliding a thin board underneath.

No comprehensive account of the sands of the Squeaky Beach region has previously been presented, but some earlier work has been conducted. Parsons (1966) stated that the Squeaky Beach sand 'is almost pure silica ($CaCO_3 = 0{\cdot}1 - 0{\cdot}6$ per cent)', but the sand on the adjacent Norman Bay beach is quite calcareous. He noted that the sand composing the foredune flanking Norman Bay beach has a relatively high content of calcareous (shell) material, and that high waves were eroding it. Work on the geomorphology of Wilsons Promontory has recently been carried out by Tuddenham, who (pers. comm.) considers that the sand of Squeaky Beach is derived mainly by marine erosion of the adjacent foredune. Two English research workers on singing sands, Thomas and Jones (1964)

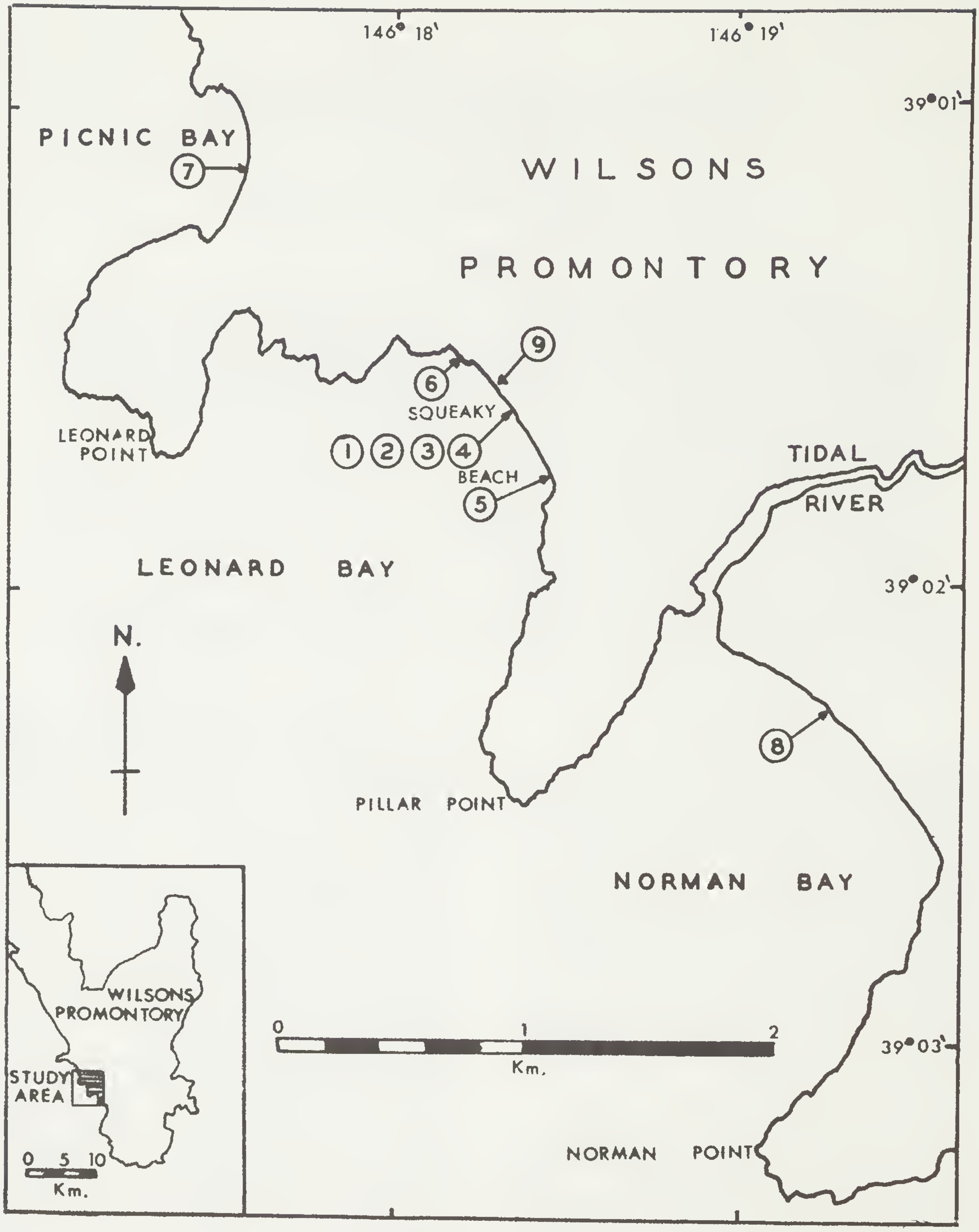

Fig. 1—Location of sample stations.

studied a number of Australian samples including one from Squeaky Beach, and found that, like the others, it has a high degree of uniformity of grain size.

Geomorphology, Geology and Environment

On the W. coast of Wilsons Promontory bays with sandy beaches alternate with cliffs. In length the beaches (Fig. 1) are approximately: Picnic Bay 594 m, Squeaky Beach 686 m, and Norman Bay 1,200 m.

The maximum width of sand on Squeaky Beach was 68 m, being widest near the ends where the angle of slope was small. The shore gradient was slightly steeper in the middle where the shore measured 39 m. Backshore width was generally small. Similar conditions were encountered on the Picnic Bay and Norman Bay beaches.

The bays are exposed to W. winds. Wind data from the Wilsons Promontory Lighthouse indicate that the monthly prevailing wind direcrection is W. for all months except July (NW), August (NW. and W.), and December (W. and NE.). As the bays have protruding headlands with deep water immediately offshore, it is probable that the sand moves to and fro within each bay, with little longshore drift. Coastline features show the results of the Flandrian Transgression. The cliffs plunge into the sea, and there are no shore platforms. Evidently the rock is too resistant for platforms to have developed within the relatively short period since submergence.

Wilsons Promontory is composed of ?Devonian granite (Reed 1959), with some Quaternary deposits. It is a coarse-grained porphyritic type containing feldspar crystals up to 10 cm long and 5 cm wide. Quartz, orthoclase, subordinate plagioclase, and biotite are the main minerals; black tourmaline is a widely distributed accessory mineral. Aeolianite of Pleistocene age is found along the coast at Darby River to the N., at Oberon Bay to the S., and a small outcrop overlies granite near the mouth of Tidal River (Parsons 1966).

Laboratory Procedure

Each sand sample was dried and reduced in bulk with a Jones splitter to about 75 g. Soluble marine salts and plant matter were removed by decantation, and after drying the sample was sieved using Wentworth intervals. A cumulative frequency curve and a histogram were constructed for each sample; the median diameter and Trask's sorting coefficient were determined. Size fractions were examined under a binocular microscope. To determine the weight percentage of acid-soluble material, another split of about 75 g was made from each sample. Following washing, this was treated with dilute 1 : 2 hydrochloric acid and the acid-soluble matter was removed.

Heavy minerals were separated from the ·06 - ·25 mm size-grades of each sample using bromoform, and the weight percentage of heavy minerals (index number) for this size range was determined. The heavy mineral fractions of mid-tide samples 2 and 7, and of dune sample 9, were examined in detail. An Alnico hand magnet was used to detect the presence of magnetite; its relative abundance was estimated and the grains returned to the heavy mineral fraction prior to mounting in Canada balsam for examination under the microscope. Heavy mineral species were identified under the petrological microscope and their relative proportions were determined by counting random fields of grains in each microscope slide. Percentages were determined to the closest integer; less than 0·5 per cent was recorded as a trace.

Textural Composition of the Sands

Results of the mechanical analysis of the sands are presented in Table 1 and Fig. 2.

Median Grain Size: Median grain size of the beach sands ranges from 0·34 mm to 0·14 mm. The samples from Squeaky Beach vary little in their median grain size, and the three mid-tide samples have almost identical medians. Median grain size decreases slightly from low-tide through mid-tide level to high-tide mark in the row of samples taken midway along Squeaky Beach. The median grain size of the beach sand from Picnic Bay and Norman Bay is significantly lower than that from Squeaky Beach. Since wave energies and current velocities in the different bays vary little, a

Table 1 STATISTICAL CONSTANTS OF WILSONS PROMONTORY SANDS

Sample No.	Md (mm)	Q3 (mm)	Q1 (mm)	So	Acid-soluble per cent
1	0.34	0.41	0.28	1.21	0.7
2	0.32	0.37	0.27	1.17	0.4
3	0.29	0.34	0.25	1.17	0.6
4	0.33	0.40	0.28	1.19	0.5
5	0.30	0.34	0.26	1.14	0.4
6	0.31	0.37	0.25	1.22	1.0
7	0.20	0.29	0.16	1.35	37.6
8	0.14	0.18	0.11	1.28	39.0
9	0.26	0.35	0.20	1.25	0.7

Key: Md = Median, Q3, Q1 = Quartiles, So = Sorting coefficient

difference in source is suggested to account for the smaller medians. The Squeaky Beach dune sand has a median diameter lower than any of the adjacent beach sands, but the difference is not great.

Considering the proximity of granite cliffs, medians of the beach sands are all surprisingly small. The small median diameters of the Squeaky Beach samples suggest that most of the mineral grains had a relatively long detrital history. In fact, it seems probable that most of the terrigenous matter in the sands of the study area was liberated from the granite many thousands of years ago; with changes in sea level, it may have passed through the surf zone a number of times. Most of the marine skeletal material (common in the Picnic Bay and Norman Bay beach sands) probably has been through more than one cycle of erosion, and was incorporated in dunes during the Pleistocene. The similarity in median diameter of the Norman Bay and Picnic Bay sands suggests similar source materials and similar conditions of deposition.

Sorting: Trask's (1932) coefficient of sorting (So) of the samples are listed in Table 1. Sorting values range from 1·35 to 1·14; they are all well sorted. The beach samples from Squeaky Beach have sorting coefficients between 1·14 and 1·22, and have a higher degree of sorting than those from Picnic and Norman Bay beaches. The Squeaky Beach sample with the highest sorting is from the S. end and that with the lowest degree from the N. end; the difference presumably results from a variation in water turbulence related to coastline configuration. Samples in the row taken midway along Squeaky Beach have sorting coefficients that are identical or almost so. The Squeaky Beach dune sand has a coefficient of sorting greater than any of the shore samples from that Beach, but the difference is not large.

The lower degree of sorting of the Picnic Bay and Norman Bay beach sands, when compared with those of Leonard Bay, is noteworthy, particularly in view of the smaller median diameters of the former sands. This relationship between sorting coefficient and median diameter is the opposite to that found by Beasley (1969) in a study of some Port Phillip Bay beach sands, where a decrease in the degree of sorting generally corresponds with an increase in median grain size. At Wilsons Promontory the relationship is apparently controlled mainly by source, since wave energies and current velocity conditions are similar.

Although the Squeaky Beach sands are very well sorted, beach sands on other parts of the Victorian coastline have an even higher degree of sorting (Beasley 1969).

Histograms: Fig. 2 shows that all of the sand samples are unimodal. A conspicuous maximum size-grade occurs in the medium sand grade of the samples from Squeaky Beach, and fine proximate admixture exceeds coarse proximate admixture in each of them. The conspicuous maximum towering above the neighbouring grades, and the small spread of these samples, indicates a high degree of sorting. The sample from the foredune flanking Squeaky Beach also has its maximum in the

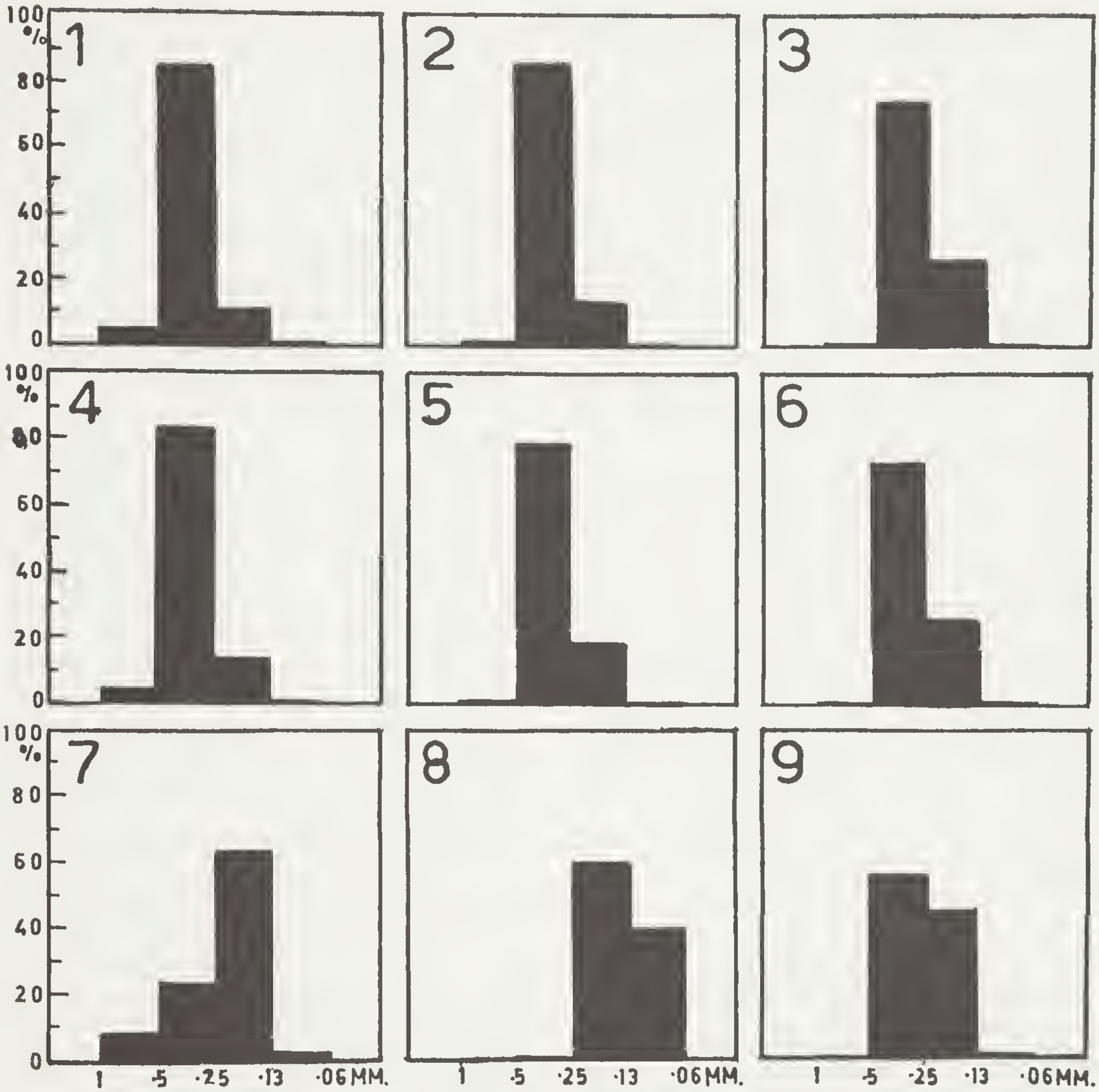

Fig. 2—Size-analyses of sands.

medium sand grade, with fine proximate the dominant admixture. In the dune sand, however, the maximum size-grade is not so conspicuous, and the amount of fine proximate admixture is greater than in the beach sands.

Unlike the Squeaky Beach sands, the samples from Picnic Bay and Norman Bay beaches have their maximum in the fine sand grade. The histograms reveal that these sands are finer in grain size than those of Squeaky Beach. Coarse proximate admixture exceeds fine proximate admixture in the Picnic Bay sample, but the fine proximate admixture is greater than the coarse admixture in the Norman Bay beach sand. In these two samples, the maximum size-grade is not so conspicuous as it is in the samples from Squeaky Beach, and the histograms also reveal a wider spread of size-grades; this indicates a lower degree of sorting. The shape of the histogram indicates that the beach sand from Picnic Bay has the lowest degree of sorting of the samples examined.

Constituent Composition of the Sands

The constituent composition refers to the acid-soluble (mainly organogenic carbonate) content and the content of terrigenous, mineral matter in the sands. Rock fragments were not present in any of the samples.

Acid-soluble Content: Weight percentage of acid-soluble material in each sample is listed in Table 1, and ranges from 0·4 to 39·0 per cent. That of the Squeaky Beach samples is very small, varying from 0·4 to only 1 per cent. In the row of four samples taken midway along Squeaky Beach, that with most soluble material (0·7 per cent) is the low-tide one. The mid-tide samples from the S. end and midway along the beach have the same soluble content, but the sand from the N. end contains more. This higher content may be due to difference in water turbulence. The sample from the foredune flanking Squeaky Beach contains only 0·7 per cent. Both the Picnic Bay and Norman Bay beach sands have acid-soluble material approaching 40 per cent, which is considerably higher than that of the other samples.

Microscopic examination indicates that organogenic carbonate makes up almost all of the acid-soluble content. All size-fractions of the Picnic Bay and Norman Bay beach sands contain marine skeletal material, and it is abundant in most fractions. Shell material was observed in most of the size-fractions of the Squeaky Beach sands, usually being more common in the very fine fraction than in the others.

Mineral Content: The mineral content of the sands consists mainly of quartz, almost all of which is the transparent to translucent variety of granitic origin, but small amounts of opaque reef quartz occur. Feldspar grains are very rare in the Squeaky Beach sands, but more common in the Picnic and Norman Bay beach sands. Biotite occurs in small amounts in all samples, and is also more common in the Picnic and Norman Bay samples. Tourmaline is a conspicuous minor constituent; its abundance in the heavy fractions is indicated below.

Most quartz grains in the Squeaky Beach samples are colourless, but a few are yellowish and brownish from a thin coating of limonite. The grains in these samples are mostly rounded to subrounded, adopting Powers' (1953) roundness scale, but in the finer fractions they are commonly subangular with some angular. The degree of roundness of the grains is greater than that of the Picnic and Norman Bay sands. Many quartz grains in the Squeaky Beach samples have a high polish.

In general, the rounder a quartz particle, the longer its abrasion history. Accordingly, the lower degree of roundness of the quartz grains in the Picnic and Norman Bay beach sands suggests a shorter detrital history than those from Squeaky Beach; many grains are subangular to angular, and some are very angular. This shorter history is supported by the greater abundance of feldspar and small "books" of biotite. It seems that some of the grains have been liberated fairly recently from the nearby granite.

Although not abundant, ironstained quartz grains occur more frequently in the Picnic and Norman Bay sands, and the ratio of ironstained to colourless grains is similar in the samples from these two beaches. The ironstained grains usually exhibit a higher degree of roundness than the colourless ones; they appear to have experienced a longer abrasion history.

The mineral content of the Squeaky Beach dune sand is similar to that of the adjacent beach sand. The appearance of the grains, including their degree of roundness, is also similar. Most quartz grains are colourless and many have a fairly high polish.

Heavy Fractions

The index numbers (weight percentages of heavy minerals) for the ·06 - ·25 grades range from 0·97 to 0·19, viz: sample 1, 0·19; sample 2, 0·21; sample 3, 0·33; sample 4, 0·48; sample 5, 0·30; sample 6, 0·28; sample 7, 0·23; sample 8, 0·28; sample 9, 0·97. The values for the mid-tide samples are similar. In the row of samples taken midway along Squeaky Beach the index number increases in value from low-tide through mid-tide and high-tide to a maximum near the foot of the foredune. The backshore zone is inundated by exceptionally high tides and by large waves during storms. Of the beach sand samples, the backshore one has the highest index number. However, the Squeaky Beach dune sand has an index number higher than any of the beach sands. The heavy minerals must have been transported by strong wind action from the beach.

The index numbers of the sands are low, all being below unity. Beach samples from near the Mt. Martha Granodiorite in Port Phillip Bay (Beasley 1969) have much higher index numbers. It seems that the source rocks of the Wilsons Promontory sand do not have a high heavy mineral content.

Magnetite was detected in the heavy fraction of each sample. Its abundance is about the same in each, and was estimated at 5 - 10 per cent.

The heavy mineral fraction of sample 2 (Squeaky Beach) is made up of the following constituents, listed as grain number percentages and, when less than 0·5 per cent, as a trace: apatite, trace; biotite, 1; black opaques, 32; brown opaques, 1; cassiterite, trace; garnet, 2; leucoxene, 3; monazite, trace, others, 1; topaz, trace; tourmaline, 55; zircon, 5. In the above list and those below, "others" refers to grains which could not be positively identified, usually because their weathered condition obscured diagnostic optical properties. Black opaque minerals are mainly magnetite and ilmenite, while brown opaque minerals comprise limonite and other ferruginous minerals. The heavy fraction of sample 9 (Squeaky Beach dune) contains the following percentages of minerals: apatite, trace; black opaques, 35; brown opaques, 1; garnet, 2; leucoxene, 4; others, 1; topaz, trace; tourmaline, 48; zircon, 8. Mineral percentages in the Picnic Bay (sample 7) heavy fraction are: anatase, trace; biotite, 4; black opaques, 41; brown opaques, 1; cassiterite, trace; garnet, 1; leucoxene, 9; monazite, trace; others, 1; rutile, trace; topaz, trace; tourmaline, 25; white mica, trace; zircon, 15.

A close similarity exists between the heavy mineral assemblage of the sand from Squeaky Beach and that from the adjacent dune. Similar species are represented, and the amounts of the various minerals are similar. The assemblages are predominantly of tourmaline and black opaque minerals, ilmenite being more abundant than magnetite. Next in order of abundance are zircon, leucoxene and garnet, but the combined amount of these minerals is less than 15 per cent in both assemblages. The great abundance of tourmaline (more than 47 per cent) is noteworthy. Biotite is not common in the Squeaky Beach assemblage and was not recognised in the dune heavy fraction; the flaky nature of the biotite particles could have retarded its transport by wind action from beach to dune.

The heavy fraction of the Picnic Bay sample differs from the Squeaky Beach ones mainly in the percentages of the various mineral constituents. Black opaque minerals predominate, and tourmaline is next in order of abundance, followed by zircon, leucoxene and biotite. The tourmaline content is markedly lower than that of the Squeaky Beach assemblages, but the black opaques and tourmaline make up more than 65 per cent. Zircon, leucoxene and biotite contents are all higher than in the other samples. The Picnic Bay assemblage also differs by the presence of trace amounts of anatase, rutile and white mica; the white mica could be bleached biotite.

Heavy fractions of the samples consist predominantly of a granitic group of minerals, basaltic minerals such as augite and olivine being absent. The Wilsons Promontory Granite is naturally regarded as the primary source. Baker (1942) listed the heavy mineral assemblage in a representative sample of Wilsons Promontory Granite as: apatite (common), biotite (abundant), cassiterite (recorded in thin sections), chlorite (occasional), hematite (rare), magnetite (very rare), sulphides (very rare), tourmaline (recorded in thin sections), white mica (occasional), zircon (common).

The nature of the Picnic Bay heavy fraction suggests some difference in source from that of the Squeaky Beach assemblages. Some of the constituents may have come from aeolianite. However, the greater abundance of fresh biotite in the Picnic Bay assemblage, combined with the relatively slight abrasion of certain of the other mineral grains, suggests that at least some of the constituents were liberated recently from granitic rocks in the vicinity.

Sound Phenomenon

Squeaky Beach sand will emit a squeaking or singing sound when it is dry or nearly so. Such can be produced by walking on the sand, or striking it with the hand, foot or a stick.

When the sand is wet, it is silent. The sound phenomenon must be related to physical composition and textural characteristics. This sand is composed almost entirely of quartz grains, most of which are subrounded to rounded with a fairly high degree of sphericity. The degree of sorting is very high, more than 75 per cent of every sample falling into the medium sand size-grade. The sand is almost devoid of material less than 0·125 mm in diameter.

Conversely, the Norman Bay and Picnic Bay beach sands are silent. They contain a large percentage of shell material, and their degree of sorting is not as high. The sands contain an appreciable proportion of particles less than 0·125 mm in diameter. The roundness of the grains is also noticeably lower; many grains are angular.

The sound phenomenon is apparently connected with the nature of packing of the grains, which is controlled by size distribution and shape. Very fine particles have a clogging effect. Presumably, the pressure produced by walking on results in shearing, layers of the packed grains shifting over other grains. The character of the note is some function of friction.

Acknowledgement

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Explanation of Plate 7

Fig. 1.—Squeaky Beach from N. end with granite in foreground and background.

Fig. 2—Squeaky Beach with eroding foredune.

Fig. 3—Picnic Bay with wide, sandy beach.

Fig. 4—Looking S. along Picnic Bay beach, showing granite headland.

APPENDIX

Sample Stations

1. 358 m NW. from S. end of Squeaky Beach, low-tide.
2. 358 m NW. from S. end of Squeaky Beach, mid-tide.
3. 358 m NW. from S. end of Squeaky Beach, high-tide.
4. 358 m NW. from S. end of Squeaky Beach, backshore near foredune foot.
5. 23 m NW. from S. end of Squeaky Beach, mid-tide.
6. 23 m SE. from N. end of Squeaky Beach, mid-tide.
7. 311 m N. from S. end of Picnic Bay beach, mid-tide.
8. Midway along sandy beach fronting Norman Bay, mid-tide.
9. Crest of foredune towards N. end of Squeaky Beach.

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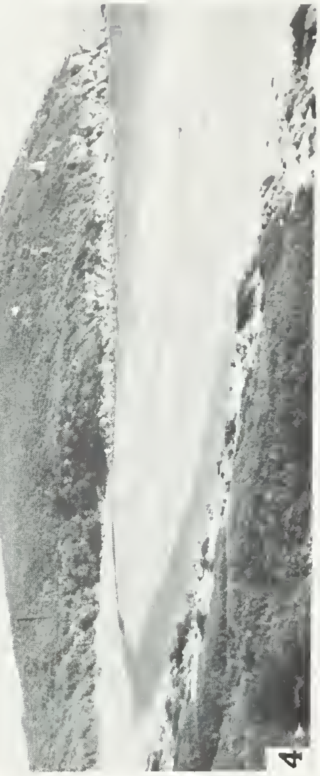

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