EARTH SCIENCE JOURNAL, VOL. 1, No. 2, 1967

AEOLIAN ACTIVITY IN A UREWERA CATCHMENT

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Abstract

Analyses of sedimentary deposits on the Otapora flat and adjacent flood plain areas of Whakatane River demonstrate that aeolian activity is important even in a humid (BB'r) forested catchment. The importance of relief and wind conditions are shown. A tentative assessment of potential feral pest damage and increased sheetwash from a forested Urewera catchment is advanced.

INTRODUCTION

At first glance it would appear unusual, at least anomalous, and perhaps even unrealistic to discuss aeolian activity within the Urewera country in the Bay of Plenty region. Much of the area is forested, rainfall ranges from 175 cm to over 250 cm annually and it is relatively evenly distributed (de Lisle and Kerr, 1963). Garnier (1950) has classified the area as 'wet' for all seasons of the year. However, aeolian activity is not confined to dry areas as it has been recorded from an even wetter area, the Haast River (H. S. Gibbs, N.Z. Soil Bureau pers. comm.). Furthermore, the Bay of Plenty region is one of the least windy — in terms of strong winds — of any region in New Zealand.

The Bay of Plenty region, of which the Urewera country forms an important part, is a series of mountains, plateaux and basins (Nat. Res. Survey, 1962). Despite the considerable variety present there are clear cut boundaries which reflect the geological history and striking contrasts in parent material. Faulting, folding, warping, marine incursions and eustatic change have all been present: over the last 9,000 years there have been some 26 different eruptions in 18 major stages from the Taupo volcanic centre (Healy, Vucetich and Pullar, 1964) and a much more recent one from Tarawera in 1886. In addition, geodynamic processes of alluvial deposition, changing river channels, movement of coastal sands, estuarine fluctuations, lagoon infilling and aeolian activity are currently at work within this region.

Parent materials include old indurated sedimentaries, a wide range of volcanics (particularly ignimbrite sheets and pumice and ash showers) and recent sedimentaries — sands, peats and alluvium forming low gradient alluvial plains.

In the east 900-1,500 m high folded and deeply faulted block mountains of Urewera greywacke (banded argillites and alternating siltstones and sandstones) rise abruptly above plains, lower hills of Tertiary materials, and volcanic plateaux. Within the region mountains or uplands in the south and to the west result in the area being open only to the north where lowlands predominate along the coast.

The major rivers of the Bay of Plenty region are north-draining and are all strongly oriented to structural fault lines. Thus the Rangitaiki River flows along the Waiohau fault traversing the Galatea, Waiohau, Te Mahoe, and Whakatane basins. Within the greywacke uplands the Whakatane River follows the Whakatane fault, the Waimana River the Waimana fault, the Waiotahi River the Waikaremoana fault, the Waioeka River follows partly along faults and, in the west, the Tarawera River is closely associated with the western margin of the Whakatane graben — a great structural downfaulted area extending from Taupo through the active andesitic volcanic cone of White Island to the Kermadec Islands.

METHODS

The Whakatane River flood plain which varies between one and three miles wide in its lower reaches becomes confined, four miles south of Ruatoki, to a narrow faulted gorge between steeply sloping, flanking bush-covered, greywacke mountains of the Urewera National Park. Within this gorge small flood plains forming low terraces above the present river bed level were inspected at intervals throughout a distance of approximately six miles during May and June 1966. The statigraphy of the flood plain deposits were observed, and measurements taken of profiles. Measurements were recorded from a series of pegs of wind removal and deposition of fine river alluvial silt and of deposition by saltation of medium and coarse sands on the flood plain surfaces and on accessible dry areas of the river bed. The influence of relief, wind conditions, vegetation cover, ground moisture and presence of 1964 flood debris were noted. Comparisons were made with vertical aerial photographs taken nearly twenty years earlier of vegetation cover on the Tapuiwahine, Otapora, and Rangatipihi and other flats flanking the Whakatane River within the survey area.

RESULTS

Examination of profiles of the flood plain low terraces showed no evidence of airfall ash deposits (e.g. Kaharoa Ash) to act as a marker layer for possible dating of age of Otapora and other flats (Fig. 1).

The presence of fibrous root webs (probably of *Mariscus ustulatus)* within some profiles suggests considerable recency of layers above such zones.

The composition of the flood plain deposits varied widely, ranging, from large coarse waterworn greywacke gravels through smaller pebbles, pumice grits, coarse and fine sands, silts, loams and clays, but a general pattern was present (Fig. 1A). Evidence of sand deposits bedded by wind activity were obvious only in upper layers (Fig. 1B), suggesting several alternatives: (1) that such activity was restricted to recent deposits, (2) that such structures, if present earlier, were destroyed in later floods, or (3) that incorporation of such layers with silt and the growth of vegetation broke down such distinctive bedding.

Wind stripping of open surfaces devoid of a vegetation cover was very marked on days of strong winds estimated at above 8 metres per second (18 m.p.h.) velocity (Figs. 1 C, D). Because of the juxtaposition of mountains and highlands on all sides except the north of the Bay of Plenty region and the prevalence of westerly wind circulation with passage of fronts and highs, much of the wind becomes oriented as either northerly or southerly. This was observed to be particularly marked within the Whakatane and Waimana river gorges where the wind is funnelled along

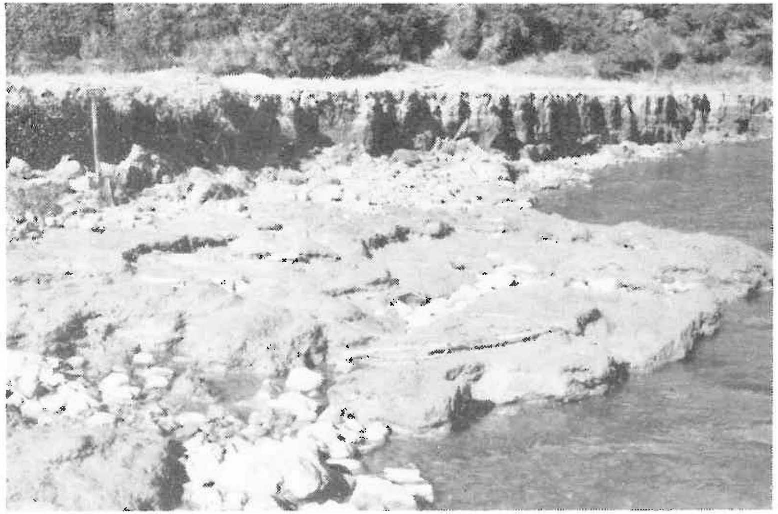

Fig. 1.A Whakatane River, Otapora flat and flanking steep bush-covered valley wall.

Fig. 1.B Up-valley and down-valley bedding in miniature barchans from wind saltation of sand particles overlying coarse gravels and silt of the 1964 flood.

Fig. 1.C Fine silt deposits stripped from dry river bed deposits and adjacent flats by down-valley winds. Note also the steep slopes and narrow valley that help funnel winds.

Fig. 1.D Long tongues of silt remain in the lee of obstacles 24 hours after the surrounding area had been stripped bare by wind. Wind winnowing of sands is also obvious.

the river valleys (Fig. 1C). Cold katabatic winds flowing from the uplands reach considerable velocities as they flow along the narrow valleys. Such conditions would be equally true of the Waiotahi and Waioeka rivers.

Removal of depths of from two to eight cm of fine silt were recorded in less than 24 hours from Tapuiwahine, Otapora and Rangatipihi flats (Figs. I C, D). At three sites more than nine cm of silt were removed during the sampling period. Although these values are given for a 24-hour period it is highly probable that such removal was restricted to approximately half this time as wind velocity dropped considerably after 9 p.m. on most evenings. Where shallow dry deposits of silt were present these were probably removed at the rate of between 1.5 to 2.5 cm per hour although it was not possible to check back at such short intervals. Stripping of fine silt was less from dry river bed deposits as nowhere was the depth recorded as great as on the low terraces of the partially vegetated flats.

Wind removal of fine dust was observed only during strong southerly winds as strong northerly winds did not occur during the period of field investigation. However, evidence that northerly winds of velocities strong enough to produce cross bedding of sands by saltation was present in many places (Fig. 1B). Such winds would also be able to remove silt if present. No evidence was found of cross-bedding of sands in any direction other than up-valley or down-valley. Because of local relief characteristics, notably the steep slopes and narrow width of the river valleys (Fig. 1C), winds transverse to the longitudinal axis of the valley would either be characterized by a high turbulent convective component and a relatively low laminar component in the wind flow or would be funnelled up-valley or down-valley.

In contrast, the strong southerly down-valley winds capable of aeolian removal of dust have a very strong laminar component and little vertical or convective movement. This is to be expected due to the increased velocities achieved through funnelling effects.

Although removal of large quantities of fine silt was observed this was concentrated chiefly in a sharp defined belt of wind from ground level to about 10 metres high. Wind carried dust higher during stronger squalls but never to very high levels. A similar pattern was observed in February 1967 following flooding caused during the passage of Cyclone Dinah (Mr C. Pain, pers, comm.).

Wherever flood debris such as logs, branches or dead matter vegetation was present transverse to the longitudinal axis of the river valley and thus athwart the wind, long tongues of silt remained protected from wind removal in the lee of such obstructions (Figs. 1 C, D).

Similarly, in hollows where ground water was present resulting in the silt remaining moist the wind did not remove the silt. In some cases also where a thin crust had developed due to pooling of water the surface resistance was sufficient to preserve the silt layer until undercut from the edges.

Cross bedding created by saltation of sand particles by strong winds following removal of silt were recorded in many localities. These miniature barchans although on a micro scale and rarely over five inches high were confined to materials deposited during the 1964 flood and to localities where grass, sedges or other vegetation was absent (Fig. 1B).

Subsequent deposition of the wind-carried dust would be localized close to the levee banks or margins of low river terraces when the valleys widened into broader flood plains and when wind velocities would tend to decrease due to the lessened funnelling effects of relief. The distribution of Opouriao silt loams in narrow belts very close to natural levees would appear to be derived basically from water deposited silt following flooding and overflowing and also from aeolian removal from flood plains and subsequent deposition later further along the stream. It is suggested that this latter source may have become more prominent in recent decades (McKelvey, 1965). Pullar (1965) records substantial deposition possibly at a greater rate in the post Tarawera period than prior to this from profiles mapped in parts of the Rangitaiki Plain.

Although the bulk of the Whakatane River catchment is forested great increases in numbers of feral pests, especially deer and opossums since their liberation in the early decades of this century have considerably reduced the protection properties of the forest. The cumulative effects of these animals in destroying or modifying the major functional components of the forest, namely forest canopy, shrub species and forest floor have reduced the forest's capacity for precipitation absorption, for water regulation, and for soil stabilization.

Red deer particularly have been widespread throughout the Urewera forests. Severe depletion of shrub species and opening and drying of the forest floor by deer result in considerable impairment of the protection efficiency of such forests. The marked preference by red deer for warm slopes of gully-heads frequently results in marked depletion of the shrub canopy and opening and drying of the forest floor and compaction of the soil. Regeneration of forest species is limited by browsing and such opening of the forest creates conditions favourable for opossum establishment. Thus the forest canopy is also opened by opossums. The cumulative effect of this combination results in greatly reduced precipitation interception, removal of the pumice veneer and loose thin skeletal soils by sheetwash and slipping, and greatly increased and more rapid surface runoff. Studies have shown that soil compaction by animals greatly reduces soil pore space thereby reducing soil water infiltration capacity, thus increasing surface runoff, and subsequently erosion (Campbell, 1945-46; Nordbye and Campbell, 1951; Walker, 1959; Glass and Drost, 1962). Furthermore effects of deer are most marked at highest altitudes where floristic composition of forests is poorest but where precipitation is greatest.

Inspection of photographs of the survey area taken less than 20 years ago showed productive farmlands fenced and grassed on the Tapuiwahine flat and good pasture on the Otapora flat, despite a large flood in 1944. In the 1964 flood these areas were devastated by flood waters, scoured in places by the Whakatane river overflowing and deeply covered in boulders, sand and silt in places burying fences. Steep fans and cones of large coarse material debouched from the many small tributary streams on to these two flats.

Evidence from profiles inspected along a six-mile strip of the Whakatane River suggested that surface runoff from the catchment could well be more rapid than formerly and that debris load, particularly fine silt from extensive accelerated sheetwash, may also be greater than formerly was the case. Aeolian activity, although probably always present to a small degree from the river bed following floods and on days when suitable wind conditions and soil dryness were present, may be currently more active especially in the sorting and bedding of medium and coarse sands from flood deposits on the low terraces above the present river bed. The presence in places of a fine silt layer of variable depth above definitely wind-sorted alternatively dipping beds of coarse sands themselves above coarse gravels deposited during the 1964 flood suggest that aeolian removal and deposition are at present actively occurring on the same site though at different times when conditions are suitable.

Evidence is present that since the 1964 flood the removal by wind of fine silt has been followed by sand sorting by winds from both up-valley, (northerly) and down-valley (southerly) winds. Subsequently aeolian deposition from a source either upstream or downstream has covered such beds with a fine silt layer again. In closely adjacent sites where vegetation has not been destroyed by flood deposits similar depths of materials (gravels, sands and silts) can be found but boundaries are indistinct. The sharp lithological boundaries associated with the different aeolian processes of deflation, saltation and deposition are absent.

The following description of a soil profile from the Otapora flat is representative of many similar ones associated with sites that have been relatively stable as low terraces, as far as can be judged, for a relatively long period of time.

Soil Profile	Otapora Flat, Whakatane River
Location:	N.Z.M.S.1 N.78 (436927)
Site:	River bank of river flood plain N.78 (43627)
Vegetation:	Sorrell, tall fescue and couch grass.
1	Up to 18 cm finely laminar silt and fine sandy silt; nearly horizontal bedding (aeolian); upper 5 cm dry, pale olive (5Y 6/3), below this moist, olive (5Y 5/3). Sharp lithological boundary.
2(a)	12 cm slightly dipping finely alternate saltation bedding, coarse sands (aeolian) over thin river alluvium sand and silt. Indistinct boundary merging with river gravels below.
2(b)	Variable thickness of river gravels; smooth rounded variable in size (6 mm to 4-8 cm greywacke gravels) with bands of small white water-deposited pumice. Distinct boundary. Horizons 1, 2(a) and 2 (b) all derived from 1964 flood aggradation.
3(a)	10 cm banding of coarse sands but pumice more obvious and often larger 3-9 mm (water deposited). Indistinct boundary.
3(b)	Merging of 3(a) into fine grey-brown sand ,10 YR 5/2). Sharp lithological boundary.
4	In places a yellow-brown (10 YR 5/2) sandy loam bed up to 28 cm deep is intermediate between 3 and 4(a).
4(a)	23 cm very dark grey-brown (10 YR 3/2) clay loam. Fibrous roots are present as a web. Granular crumb. In places intercalated with fine yellow-brown (10 YR 5/4) sand. Distinct boundary. This stratum and those above must all be relatively recent as indicated by the presence of the fibrous roots.
5	20 cm grey clay (10 YR 5/1) gleyed and mottled, compact massive, Sharp lithological boundary. (A fossil soil).
6	Sandy loam, light olive-brown (2.5 YR 5/3).
7	20 cm dark greyish-brown (2.5 YR 4/2) clay, sub-massive.
8	2.5-23 cm black and white coarse sand, variable thickness (2.5-5 cm to over 20 cm in places).
9	5-7.6 cm thin clay band. This compact soil overlying gravels was exposed as a 'pavement' where the upper horizons had been removed in the 1964 flood (Fig. 1A).
10	Coarse waterworn greywacke river gravels and boulders — widely assorted sizes.

CONCLUSION

Field evidence shows that aeolian processes can be active in parts of the Whakatane River valley. Although source areas of fine silt for removal by wind are restricted it is suggested that deterioration of the catchment qualities of the Urewera country by depredations by feral pests, especially red deer and opossums, have resulted in both increased and more rapid surface runoff of water as well as increased sheetwash. These result in increased flood hazard and destruction or despoilation by siltation of productive alluvial lowlands. The vast capital expenditure envisaged by the Bay of Plenty Catchment Commission to reduce flood damage on the lower reaches of the Whakatane River has recognized the problem of high catchment deterioration. If this is not halted source material for aeolian processes may become more widespread. Several writers have stressed the importance of maintaining forested water catchments in as near natural conditions as possible (Glesinger et al, 1962; Holloway, 1962). Browsing and trampling by introduced animals seriously impairs the water-regulation and flood-minimising effects of forested catchments.

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