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Spits and Tombolos in the Southwest Archipelago of Finland

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ABSTRACT

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Approximately one-third of the 73,000 islands in coastal Finland comprise the southwest archipelago. This region of recent marine sedimentation and late-Pleistocene glacial deposition is superimposed upon a southwesterly-sloping, dissected Precambrian peneplain surface of the Fennoscandian Shield that is undergoing postglacial rebound of 4-5 mm/yr. Most of the islands are rocky; beaches are found mainly on those islands mantled by glaciofluvial deposits in the form of eskers or from end moraines. Coastal processes have reworked the beach sediment into spits and tombolos in accordance with the predominant wave and fetch regimes. Sites where 9 spits and 10 tombolos were found in the study area are at islands in the Rymättylä and Parainen parishes and along the Salpausselkä III ridge.

KEY WORDS: *Archipelago, beach processes, coastal morphology, Finland, islands, postglacial rebound, spits, tombolos.*

INTRODUCTION

There are 73,000 islands‡ in coastal Finland; and of these, about one-third constitute the southwest archipelago (Figure 1). This is a 120-km-wide region with three distinct zones: outer bare, rocky islands; middle till-covered rocky islands; and inner islands and peninsulas of rock, with till, silt and clay deposits (GRANÖ and ROTO, 1986). Summit elevations decrease from 50-70 m at the inner zone to only a few meters in the outer zone.

Throughout the southwest archipelago shores there are only 3% sand and gravel beaches, 13.5% on the inner and middle archipelago shores (PYÖKÄRI, 1978), and only the very occasional spit or tombolo. Such coastal features, formed by wave-transported sediment, are only found at islands mantled by glacial till or outwash deposits. Reworking of the sand and gravel within these deposits, by normal coastal processes, results in spits and tombolos adjusted to the predominant wave regime. The interplay between the bedrock geology, postglacial rebound, and glacial and coastal processes has produced these features, and these relationships are discussed here, in an effort to further clarify the geomorphology of this portion of Finland.

The bedrock geology of the southwest archipelago consists of fractured and faulted Precambrian granites and schists of the Fennoscandian Shield that comprise the peneplained surface which slopes gently southwest (ALESTALO, 1985; GRANÖ and ROTO, 1986). Superimposed on these features are the deposits of drift transported to the region by the continental ice sheet during the late Pleistocene Epoch, and a thin veneer of marine sediments. Most notable are the ground moraine and ridges (eskers, drumlins and end moraines). The material comprising these landforms was deposited beneath and in front of the ice sheet in a subaqueous environment (ERONEN, 1983). The eskers and end moraines have had a distinct effect upon the coastal morphology of the islands. In a sense, these linear features form a grid of outwash sand and gravel where they cross the otherwise rocky islands of the archipelago.

Some aspects of the emergent eskers in southern Finland have been reported upon by GRANÖ, (1958, 1977, 1981) and by GRANÖ and SCHWARTZ (1987). These glaciofluvial depos-

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‡ Defined as being 500 m^2 or larger.

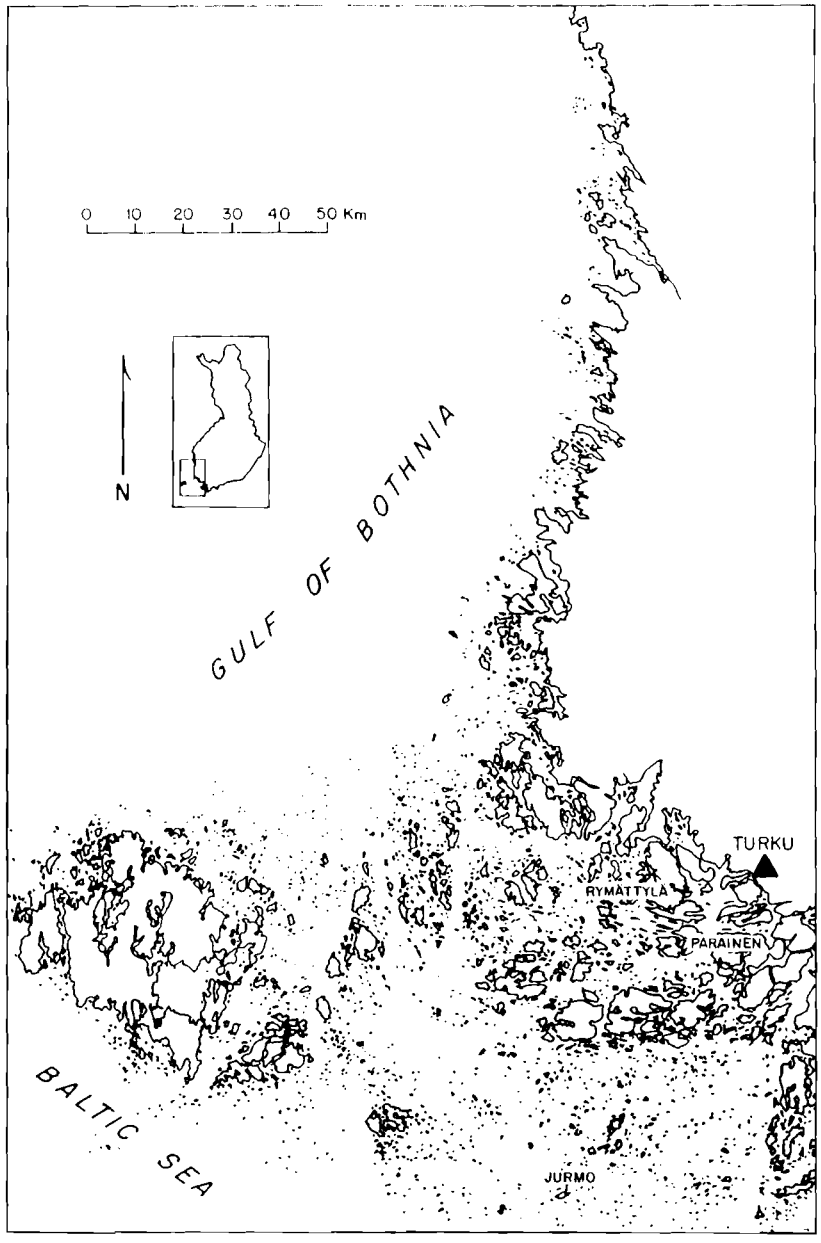

Figure 1. Location map for the southwest archipelago of Finland.

its are aligned in a general northwest-southeast orientation in the archipelago region, behind (landward of) and perpendicular to the northeast-southwest end moraines. Within the study area, remnants of eskers are found today upon islands in the Rymättylä and Parainen parishes (Figures 1 and 2).

The end moraines in the outer island zone consist of three ice-marginal ridges (Figure 2), composed of till and outwash deposits, known as

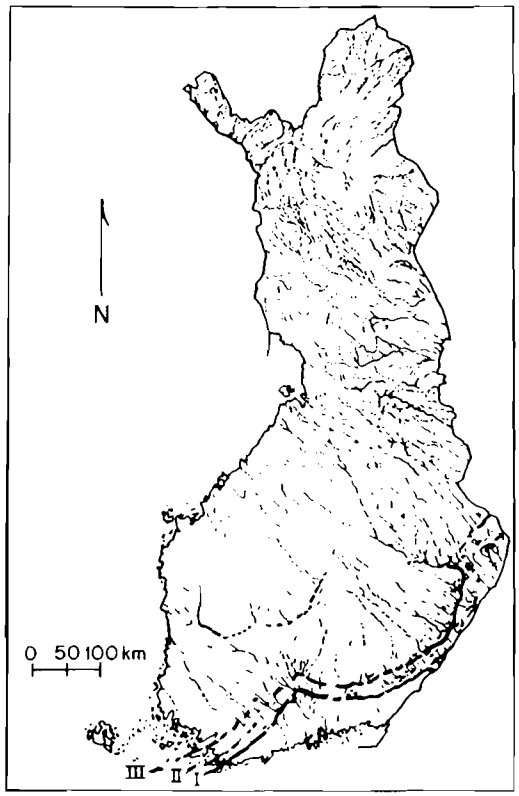

Figure 2. Glaciofluvial and till deposits in Finland. Eskers are oriented in a radial northwest-southeast pattern, and ice-marginal ridges (Salpausselkä I, II and III) in an arcuate northeast-southwest pattern.

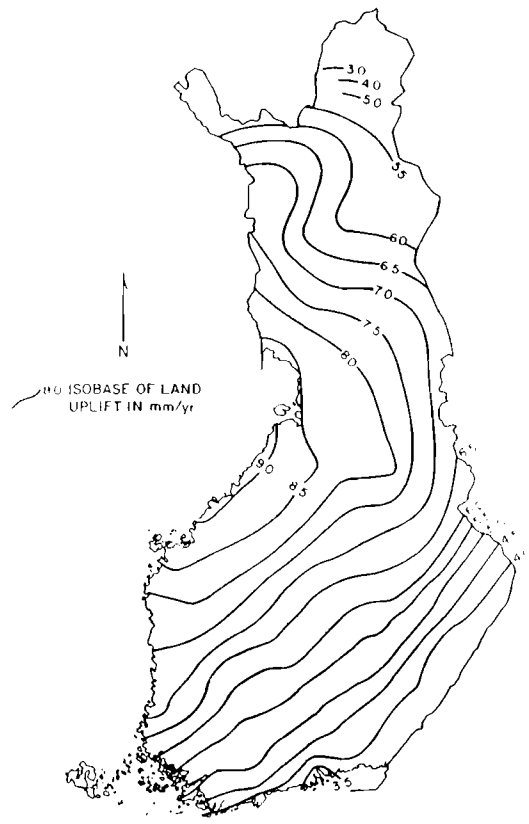

Figure 3. Absolute uplift rates in Finland, based upon recent relevelling data (after SUUTARINEN, 1983).

Salpausselkä I, II, and III (AARTOLAHTI, 1972). The Salpausselkä III, landward of I and II, is the only one whose highest points rise above the sea today as islands in this region and, as such, extends northeastward from the island of Jurmo to Sandön and Sandskär near the mainland somewhat south of Parainen Parish (Figures 1 and 2).

Following wastage of the continental ice sheet, this entire complex of bedrock, peneplain surface, glacial drift, and marine sediment, has been undergoing uplift; more rapid at first, but still considerable, by world-wide standards. The dome-like nature and different absolute uplift rates are shown in Figure 3. Compensation for a eustatic rise on the order of 1 mm/yr must be made, to arrive at a relative sea level change (ERONEN, 1983; KAKKURI, 1987; MÄLKKI, 1987). The result of this considerable postglacial rebound of the southwesterly-sloping bedrock surface is that the innermost islands of the three aforementioned zones have been uplifted highest and exposed the longest, thus developing a soil profile and subsequent vegetation; whereas the outer zone islands are hardly exposed above the limits of breaking waves and are essentially bare rock. However, where sufficient quantities of sand and gravel exist, that is to say, where an island was overlain by a portion of an esker, end moraine, or outwash, spits and tombolos have developed under the influence of wave action, and with continuing uplift.

Winds in the southwest archipelago region are mainly from the southwest, with wind from the other compass directions moderately balanced (Figure 4). Predominant waves, for the most part, correspond to this pattern as well; with the exception of those sites where a limited

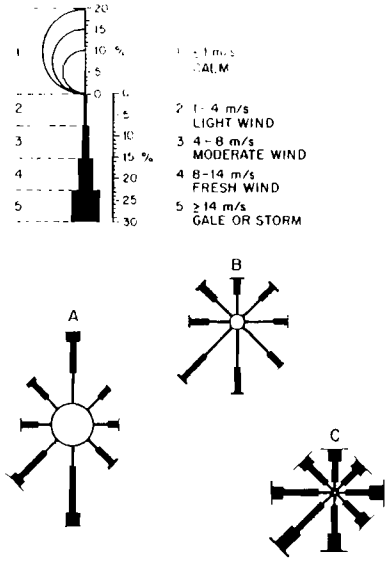

Figure 4. Wind roses for the southwest archipelago region, 1961-80; (A) Southwesterly region, (B) Turku region, (C) Southeasterly region (after HEINO and HELLSTEN, 1983).

southwest fetch causes wind and waves from another direction to take precedence. Thus, most of the spits found in the study area have developed in a northeasterly direction. Only a few were formed under the influence of any but southwesterly waves. On the other hand, the matter of tombolo development between islands is more complicated (FARQUHAR, 1972). The manner of tombolo development is fairly obvious where a cuspate spit has grown in the wave shadow of a small island, with converging shore-drift along the shore of the larger island, until the cuspate shape connects the two and a tombolo is formed. Here the dominant fetch is beyond the smaller island, or two fetches towards the wave shadow zone are balanced from opposite directions along the shore of the larger island. It is more difficult to tell, from surface geomorphology alone, how two larger islands became linked by wave processes. A spit could grow from one to the other under one dominant wave regime, or shore-drift could enter the space between the islands from a combination of waves and fetches.

The distinguishing factors in identifying a connecting feature as a tombolo is that there be a sandy substrate and, possibly, one or more beach ridges situated longitudinally along the length of the connection. Not all hollows between islands can be called tombolos. Where extensive marshes exist, and the substrate is only a thick soil, then it is apparent that a former lagoon has been infilled by sedimentation or uplifted, or both. However, where the ground between two islands is covered with large boulders, the linkage can be ascribed to exposure of ground moraine covering the region between two topographic highs.

FIELD OBSERVATIONS

Rymättylä Parish (Figure 5)

There are three pairs of tombolo-linked islands in Rymättylä Parish, each due to the presence of an esker in this region.

At Kruununmaa, a tombolo 20 m in width and 50 m in length connects the island with that of Kotokari. There is a sandy substrate under a very think soil covering, and a small marsh on both sides of the tombolo. The fetch to the north and south is limited, but both appear to have been influential in the development of this feature.

The fetches at the tombolo connecting Vähä-Kuusinen with Iso-Kuusinen are also limited, but oriented particularly well for the predominantly southwest waves. The tombolo is built of sand and gravel and measures 100 m in length and 60 m in width. What appears, on maps, to be another tombolo on the southwest side of Iso-Kuusinen is a marsh indicative of uplift of the shallow lagoonal area there. The offshore island is bare rock and provides no source of sediment.

The gravelly tombolo between Vähä-Tyyrholma and Iso-Tyyrholma (Figures 5 and 6) is 40 m wide and 80 m long. Here, though the only fetches are to the northwest and southeast, the greater open distances compensate for the orientation differing from that of the other two pairs of islands.

Parainen Parish (Figure 7)

Esker deposits, along a north-south line, are much more extensive in Parainen Parish than in Rymättylä Parish. Spits and tombolos are quite well developed on several of the islands (NIITTYMÄKI, 1979).

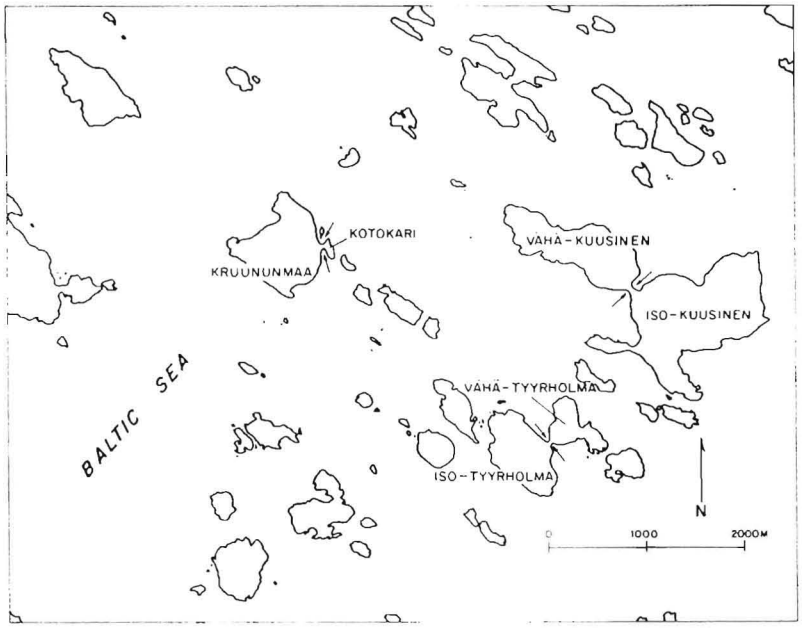

Figure 5. Tombolo locations among the islands in the Rymättylä Parish. Paired arrows indicate tombolos.

Figure 6. The gravelly tombolo between Vähä-Tyyrholma and Iso-Tyyrholma (Photo: M. L. Schwartz).

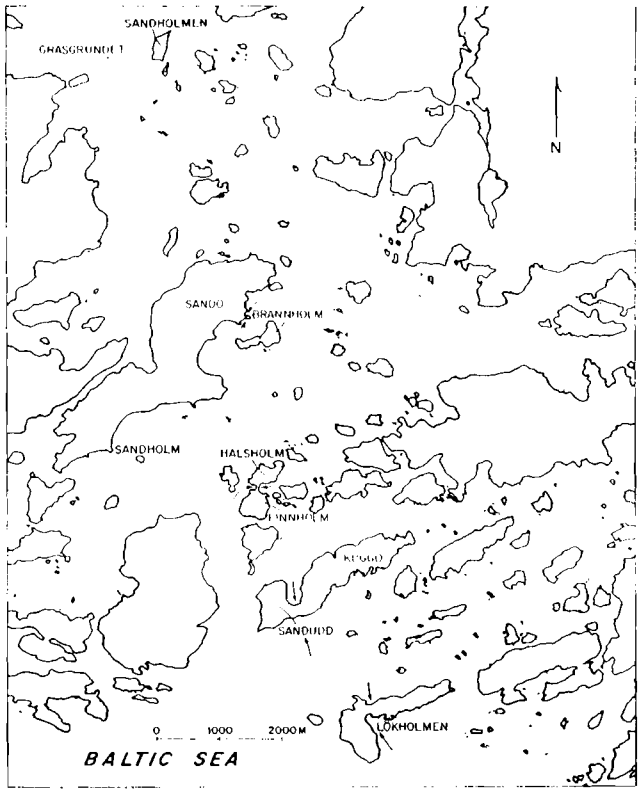

Figure 7. Tombolo and spit locations among the islands in the Parainen Parish. Paired arrows indicate tombolos.

Starting at the south, there is a broad (200 m) tombolo connecting the two parts of Lökholmen. This tombolo has well-developed, sandy and parallel beach ridges extending along its 140 m length. As with the Tyyrholma islands, the open fetches are predominantly to the northwest and southeast.

The tombolo linking Sandudd with Kuggö is 150 m wide, 100 m long, and has several prominent beach ridges along its length, perpendicular to the north and south fetch exposures. A small excavation pit on Kuggö contained stratified layers of sand and pebbles, and sand underlay the soil in the swales between the beach ridges.

The tombolo between Finnholm and Halsholm is not shown on bathymetric charts of 1968 and 1972, thus it may be the youngest geomorphic feature reported here. Approximately 30 m wide and 100 m long, the feature has one longitudinal beach ridge and some thin soil covering a sandy base. As can be seen in Figure 7 there is limited fetch in all directions.

The tiny island of Sandholm has a small spit, about 15 m in length, oriented to the north; away from the southwesterly fetch. The coarse sand of the spit grades to pebbles and cobbles at the island source.

With Brännholm blocking waves from any direction but the northeast and the southwest, a cuspate spit has grown into a tombolo linking Sandö with a small rock outcrop. The tombolo is composed of sand, and is 20 m wide and 80 m long. The low area between the two parts of Brännholm is covered with ground moraine boulders; and, therefore, cannot be considered a tombolo.

Gräsgrundet and Sandholmen both have sizeable spits, 80 m and 150 m, respectively, developed to the northeast. At both sites there is a

clear diminution of sediment size from gravel on the islands to sand in the middle and distal end of the spits.

Salpausselkä III (Figure 8)

The Salpausselkä III till and outwash deposits occur on a string of islands from Jurmo on the southwest (VARJO, 1960) to Sandön and Sandskär on the northeast (FOGELBERG, 1964; EDELMAN, 1968).

Though Jurmo has a number of spit-like projections at each end of the island, these prove to be, on close inspection, linear exposures of cobbles and boulders from the glacial end moraine ridges, now reworked by wave action. In other words, they are in *situ* deposits, and are not built of shore-drifted sediment. There is, however, one tombolo in the southwest area, where cobbles form a feature 20 m wide and 80 m long (Figure 9). Blocked completely on the south and southwest by a large cobble-boulder ridge, this tombolo has formed in the wave shadow of a small offshore rocky island; where there was influence of the only large fetch possible, from the north.

To the northeast of Jurmo sand and gravel spits have developed in a northeasterly direction from the islands of Sanden (100 m length) and Sandören (60 m length). In this very exposed region the southwest fetch and wave regime dominate.

At the island of Husskär, a 20-m-wide tombolo connects with a small rocky knob 45 m to the northeast. Due to the small size of the island and its elliptical shape, it is probable that southwesterly waves refract around both sides of Husskär to transport sand and gravel for the growth of the tombolo.

At the northeasterly end of the island chain being reported upon here, Sandön and Sandskär again exhibit spit growth to the northeast due to the waves from the southwest. The Sandskär spit is only 25 m in length, but the largest spit and most beautiful beaches in the study area occur on Sandön. At Sandön the sand and gravel spit is 200 m long, and continues awash as a shoal for some distance beyond that (Figure

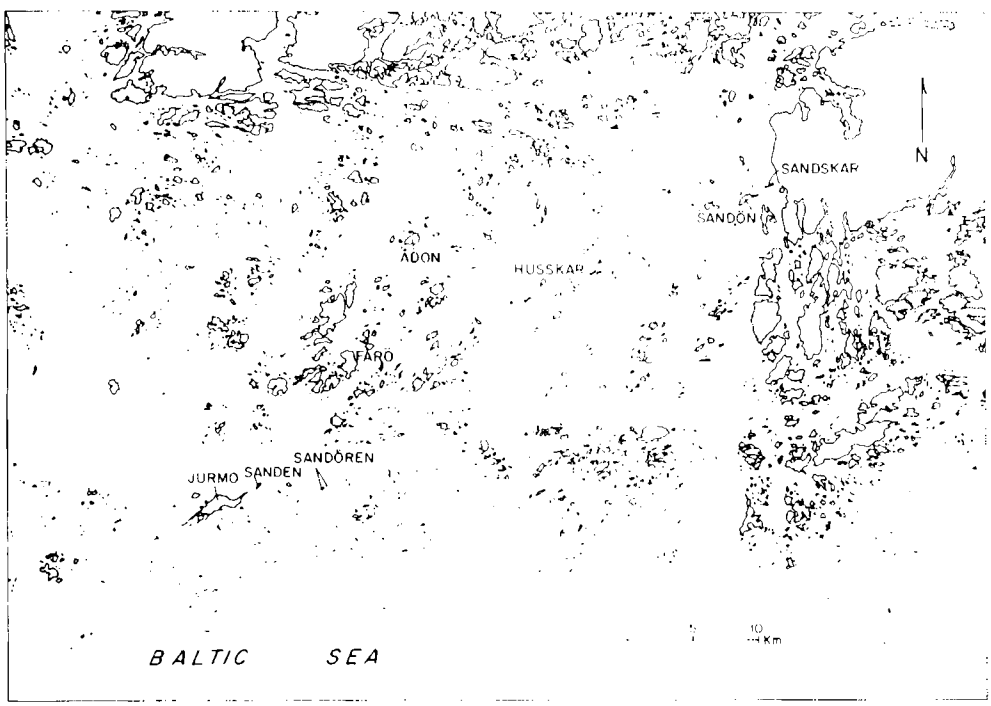

Figure 8. Salpausselkä III end moraine deposit locations in the southwest archipelago. The islands named in this figure indicate the general orientation of Salpausselkä III in the region.

Figure 9. Cobble tombolo connecting a small rocky island (left-background) to the larger island (foreground) of Jurmo (Photo: M. L. Schwartz).

Figure 10. The 200 m-long spit at the northeastern end of sandön (Photo: M. L. Schwartz).

10). On the northwestern side of Sandön, in the lee of the wind and waves, two small cuspate spits are developing towards each other from the larger island and a small island next to it. These spits almost bridge the strait which is only about 40 m wide between the islands.

Fårö and Ådön (Figure 8)

There are two other islands in this part of the southwest archipelago, possibly within the limits of the Salpausselkä III deposits, that show features of diagnostic value. The northeast cor-

ner of Farö has developed into a large gravelly cuspate spit, projecting some 110 m at the center. And, finally, at the island of Adön there is a small sandy cuspate spit projecting toward an island on the northwest, and a short sandy tombolo that connects a rock outcrop on the northeast. Outwash deposits on both islands are being transported by the predominant wave regime to build spits and tombolos in the same fashion as at all the other sites reported here.

SUMMARY

The many thousands of rocky islands (500 m^2 or larger) constituting the southwest archipelago of Finland are the topographic highs of a southwesterly sloping peneplain cut into Precambrian granites and schists of the Fennoscandian Shield. This surface, mantled by Pleistocene glacial deposits and marine sediment, is rebounding at a rapid rate that brings bedrock and sedimentary deposits into higher subaerial relief. Most islands of the outer archipelago are rocky and have no beaches at all. There are many small (5-30 m) till-generated sandy pocket-beaches in the inner and middle archipelago (PYÖKÄRI, 1978, 1979). However, where glaciofluvial deposits in the form of eskers or from end moraines were superimposed on an island, beaches, spits and tombolos are now formed. In the study area, eskers are found on islands in the Rymättylä and Parainen parish regions, and end moraine outwash occurs on the islands in line with the Salpausselkä III ridge. The spits and tombolos, developed from these glaciofluvial deposits, are locally oriented in accordance with the predominant wave and fetch directions. This report then, advances knowledge of the interaction between bedrock geology, glacial deposition, and coastal processes in the southwest archipelago.

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