Geo-Marine Letters (1989) 9:109–118

Geo-Marine Letters
© 1989 Springer-Verlag New York Inc.

The Geological Significance of Kelp-Rafted Rock along the West Coast of South Africa

M. W. Woodborne[1], J. Rogers,[2] and N. Jarman[3]

[1]Geological Survey of South Africa, Marine Geoscience Unit, University of Cape Town, Rondebosch, 7700, South Africa, [2]Marine Geoscience Unit, University of Cape Town, Rondebosch, 7700, South Africa, and [3]Sea Fisheries Research Institute, Seaweed Research Unit, University of Cape Town, Rondebosch, 7700, South Africa

Abstract

Angular to well-rounded pebbles and cobbles have been observed along the southwest coast of South Africa, attached to holdfasts of three species of kelp: *Ecklonia maxima*, *Laminaria pallida*, and *Laminaria schinzii*. A kelp-rafted clast has been dredged from the outer shelf and other clasts have been observed *in situ* in up to 5 m of water near Cape Town. The clasts have been found on both rocky and sandy shores as well as in a large backshore lagoon on the exposed Atlantic coast of the Cape Peninsula. Isolated clasts in a mid-Holocene lagoon were probably rafted ashore during winter storms in the mid-Holocene.

Introduction

Algal transport, in particular kelp-rafting, is one of the mechanisms suggested to explain the sporadic occurrence of cobbles and boulders in finer-grained marine sediments. This process has been reported particularly from the northeastern seaboard of the Pacific Ocean (Emery 1960, 1963, Emery and Tschudy 1941, Menard 1953, Shumway 1953).

Emery and Tschudy (1941) pointed out that it is very difficult to identify kelp-rafted material in marine sediments as the kelp is readily decomposed. Thus it is only through the examination of rocks recovered with algal matter still attached to them from beaches or from deep-sea dredges, that a better understanding of this transport mechanism can be reached.

Although algal rafting is to be expected off the many coasts (Fig. 1), there are few published reports on the topic from outside North America (e.g. Dunn 1911, Kudrass 1974). In the case of South Africa, data on the widespread kelp beds themselves have only recently become available as a result of an intensive kelp research program conducted by the University of Cape Town and the Sea Fisheries Research Institute (Field and others 1980).

The purpose of this article is to report specifically on instances where kelp-rafting has been observed along and off the South African coast and to comment on its local geological significance.

Previous Work

Dunn (1911) published illustrations of kelp-rafted cobbles from sandy beaches in Australia and New Zealand. Subsequent studies report kelp-rafted cobbles both on the beaches and on the deep ocean floor off the coast of California (Emery 1960, 1963, Emery and Tschudy 1941, Shumway 1953), on sandy beaches at Cape Cod in Massachusetts (Ben-Avraham 1971), and in deep-ocean sediments from the Gulf of Alaska (Menard 1953). An experimental study in the western Baltic Sea of nearshore transportation of pebbles with attached algae is reported by Kudrass (1974).

More recently, Huggett and Kidd (1983/84) were able to present a list of criteria for the identification of kelp-rafted material, based on a study of exotic materials recovered from the northeast Atlantic Ocean. According to their work, kelp-rafted clasts can be distinguished from ice-rafted clasts as they have no striations or facets, are often comprised of soft lithologies

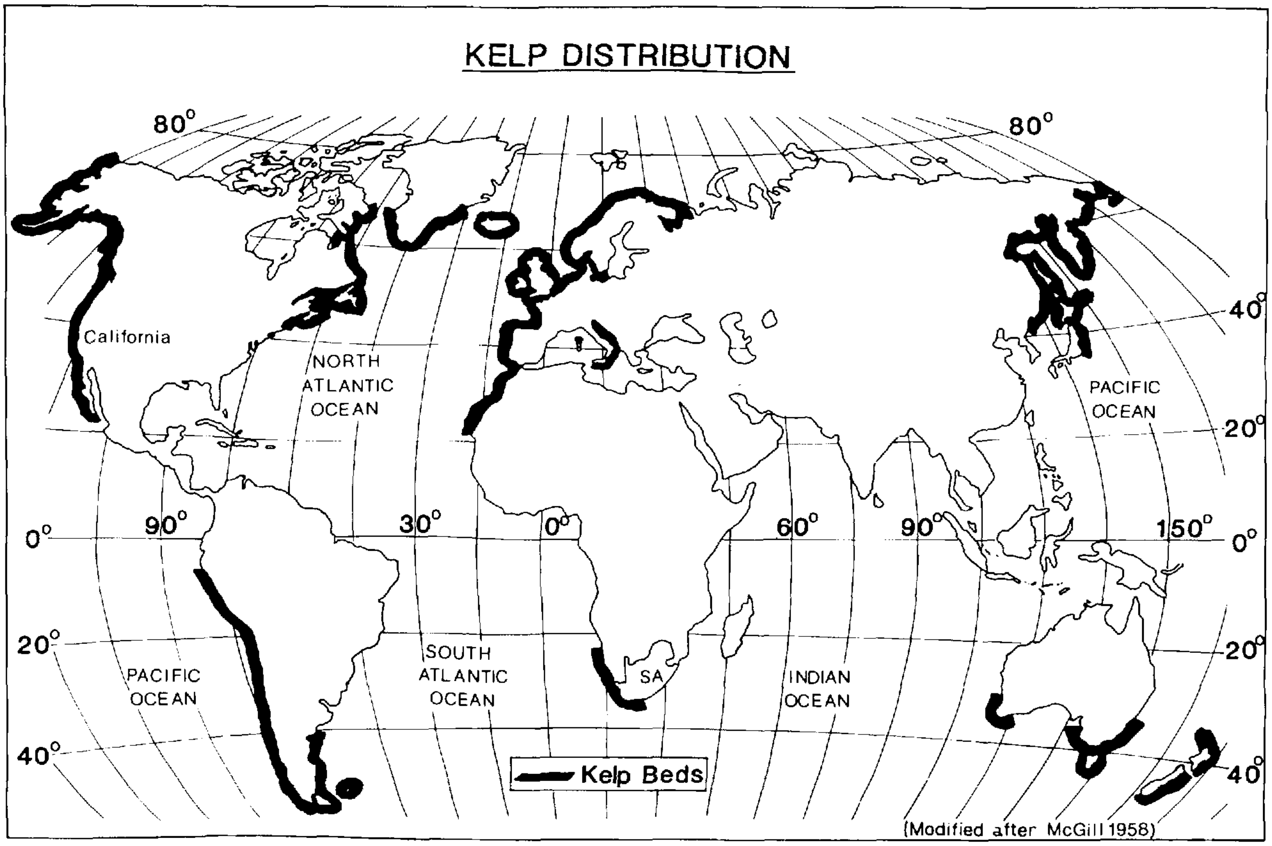

Figure 1. Worldwide distribution of kelp (Modified after McGill 1958).

that exhibit pholad borings and, more rarely, may still have traces of the kelp affixed to the clast.

Kelp-rafting off the South African coast is briefly dealt with by Stewart (1974) and Gentle (1987). Stewart (1974) discussed the occurrence of rounded cobbles of pre-Mesozoic rocks dredged from the outer continental shelf which is underlain by Cenozoic rocks. Gentle (1987) specifically described a dredge sample of rounded pebbles of Late Precambrian greywacke attached to decaying kelp in 350 m of water northwest of Cape Columbine (Fig. 2) where Neogene phosphorites form the local bedrock.

Distribution of Kelp

The term kelp is widely used in reference to the genera of larger brown algae or seaweeds (Emery 1963). Worldwide, the distribution of kelp (Fig. 1) is confined to cool waters of high latitudes or to areas of strong upwelling along the western coasts of continents in subtropical latitudes (Mann 1973, McGill 1958). Optimal conditions for kelp plants are determined by a number of environmental factors such as the quality and quantity of light, temperature, water turbidity, water turbulence, nutrient levels, and bottom topography (Bolton 1986, Emery and Tschudy 1941, Field and others 1980). These parameters determine the maximum depth at which kelp can grow. In general kelp occurs from the intertidal zone to a maximum depth of about 30 m (Emery and Tschudy 1941). The juvenile plants attach firmly to a stable substratum such as exposed bedrock, boulders, cobbles, abalone (*Haliotis midae*) shells, or even holdfasts and stipes of mature kelp plants.

Distribution

On the coast of southern Africa, from Cape Agulhas to Swakopmund (Wynne 1986, Figs. 1 and 2), there are three genera of kelp: *Ecklonia*, *Laminaria*, and *Macrocystis*.

Ecklonia maxima is most abundant between Cape Agulhas and Cape Columbine (Anderson and others 1987, Bolton and Levitt 1987, Field and others 1980) and forms dense beds in rough water with a depth of 10 m or less (Fig. 2A). This species is characterized

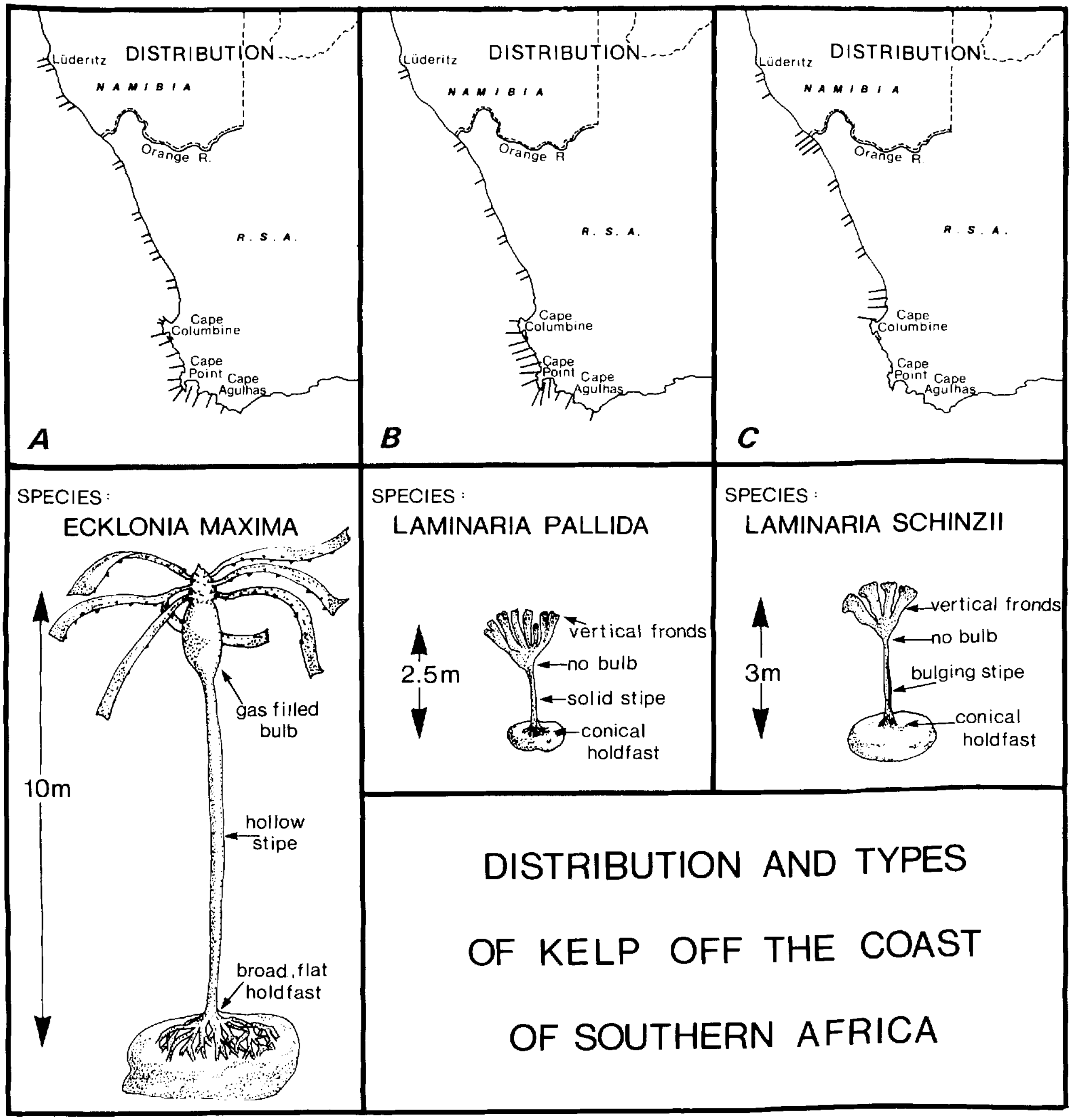

Figure 2. Distribution of the three main varieties of kelp off the coast of southern Africa namely: (**A**) *Ecklonia maxima*; (**B**) *Laminaria pallida*; (**C**) *Laminaria schinzii*.

by a long, hollow stipe with a gas-filled bulb at the top. The large fronds emanate from a short primary blade on the bulb (Fig. 2A). The stipes of mature plants may be up to 10 m long and the gas-filled bulb at the top provides buoyancy to hold the fronds at the sea surface. Approximately 15 percent of the *Ecklonia* plants are wrenched from the sea floor annually during storms and either drift out to sea or are washed ashore (Anderson and others 1987, Simons and Jarman 1980).

Laminaria pallida forms an understory beneath the *Ecklonia* canopy but it also forms its own community in depths between 10 m and 20 m. This species has a stiff, solid stipe, 2.0 m–2.5 m long, supporting a hand-shaped blade of similar length (Fig. 2B).

North of Cape Columbine the shallow (<10 m) kelp beds are co-dominated by *Ecklonia maxima* and *Laminaria schinzii*. *Laminaria schinzii* has a similar appearance to *L. pallida* but the stipe, apart from being taller (2.5 m–3.0 m), has a hollow swelling in its midsection which makes it buoyant; the frond is proportionally larger, too (Fig. 2C).

Macrocystis angustifolia is found only in very sheltered situations; nowhere is it extensive.

Modes of Transport

Transportation of rocks by algae depends on the relative positive buoyancy and amount of drag exerted by the attached plants relative to the mass, and hence the size, of the rock (Kudrass 1974). Due to the gas-filled stipe, *Ecklonia* plants are particularly buoyant, however all of the kelp species described above can be expected to have a high drag coefficient as a result of the large surface area of their fronds.

The initiation and mode of transport are determined by a number of contributing factors. Cobbles and boulders may be transported by floating (Fig. 3) if the positive buoyancy of the plant exceeds the negative buoyancy of the attached rock. For example, the positive buoyancy of a juvenile plant may, with growth, exceed the negative buoyancy of the cobble or boulder to which it has attached and eventually will float to the surface with the rock still connected. The same effect occurs when a number of plants attach to the same cobble or boulder thereby forming a composite holdfast, which may eventually lift the attached cobble or boulder as the plants grow to maturity and in so doing increase their cumulative positive buoyancy. Similarly, during storms algae are wrenched free and may become entangled around a single plant whereupon their combined buoyancy exceeds that of the attached cobble or boulder, which is then floated away. Such floating masses of entangled kelp have been referred to as kelp rafts (Emery 1963). Depending on the prevailing winds and surface currents, the floating kelp may be carried onshore and out to sea.

Friable chunks of bedrock or large boulders may also become dislodged through continual agitation due to the drag exerted by the movement of algae during storms. If the dislodged piece of rock is small, it may be floated away. However, if the positive buoyancy of the plant is approximately equal to the negative buoyancy of the rock, transport will probably take place by means of jumping (Fig. 3). In this case a combination of the lifting motion of the passing swell and the drag of the attached kelp would bounce the cobble or boulder across the sea floor.

If the negative buoyancy of the attached rock exceeds the positive buoyancy of the plant, the cobble or boulder would be transported by dragging (Fig. 3) as forces exerted on the kelp by passing swells drag the attached rock across the sea floor. Transportation by jumping or dragging is usually directed shoreward but may occasionally be out to sea (Emery 1960).

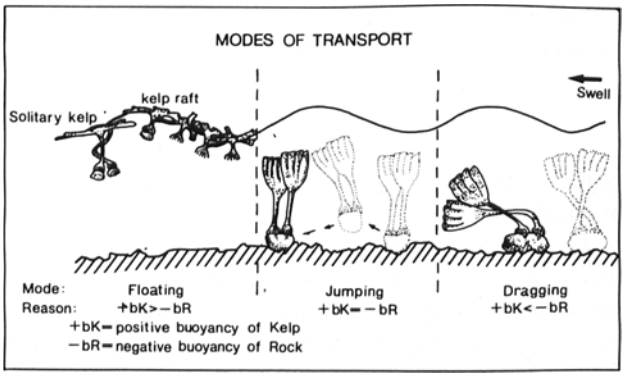

Figure 3. Modes of transport operative during kelp-rafting.

Observations

Intertidal zone

It was the chance observation of an algal-rafting event at Port Nolloth on the coast of Namaqualand (Fig. 4) that prompted a closer investigation of the phenomenon. On May 22, 1985 large waves generated by a northwesterly storm system carried a great quantity of kelp (*Laminaria schinzii*) from an extensive kelp bed on the outer reef 100 m–300 m offshore, onto the 150 m-long stretch of beach immediately north of the main jetty within Port Nolloth Harbour (Fig. 5). The beach was inspected at low tide that morning and, amongst the numerous holdfasts, 12 were found carrying rocks which varied in size from large cobbles (12.8 cm–25.6 cm) to medium boulders (51.2 cm–102.4 cm) according to the Modified Wentworth Grade Scale. A selection of these kelp-rafted rocks is shown in Figure 6.

The size classification of the rafted boulders is based on *in situ* measurements of the primary axes (X, Y, and Z). The largest of the boulders was 55 cm long and its estimated weight was in excess of 30 kg. By comparison, the largest reported clast to date was 40 cm long and was photographed by R. F. Dill off the Coronado Islands, Mexico (Emery 1964, Fig. 1). The heaviest kelp-rafted rocks observed on beaches weighed up to 10 kg (Emery 1963). Thus the kelp-rafted rocks which were carried onto the beach at Port Nolloth during the described storm event are the largest and heaviest yet reported.

The boulders comprised locally derived feldspathic

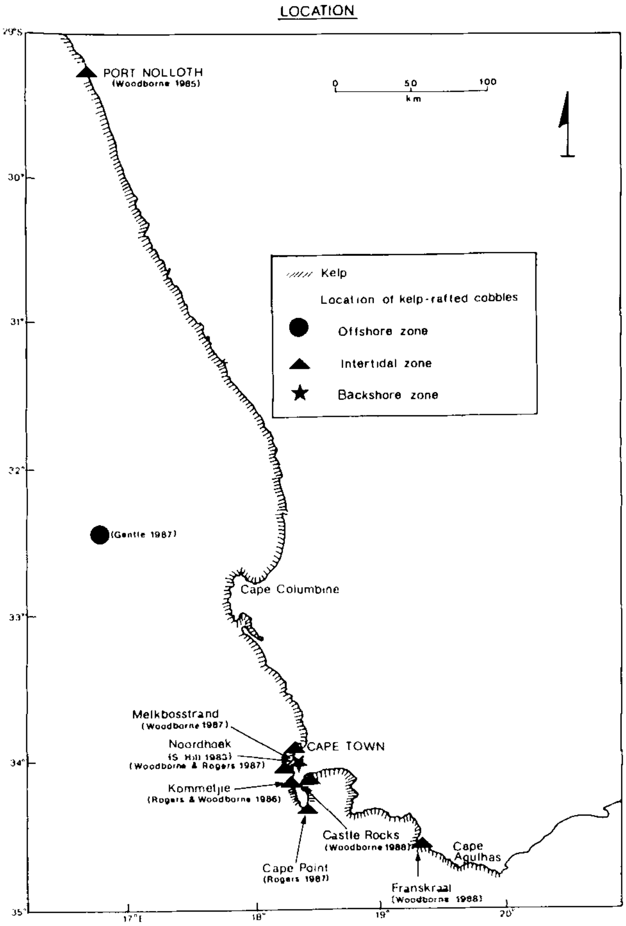

Figure 4. Locations at which kelp-rafted cobles have been found on the South African coast.

Figure 5. The beach north of the jetty at Port Nolloth Harbour littered with kelp (*Laminaria schinzii*) after the storm on May 22, 1985. Some of the kelp holdfasts were still attached to cobbles, the largest of which was 55 cm long and can be seen lying to the left of the 1-liter bottle (height 35 cm).

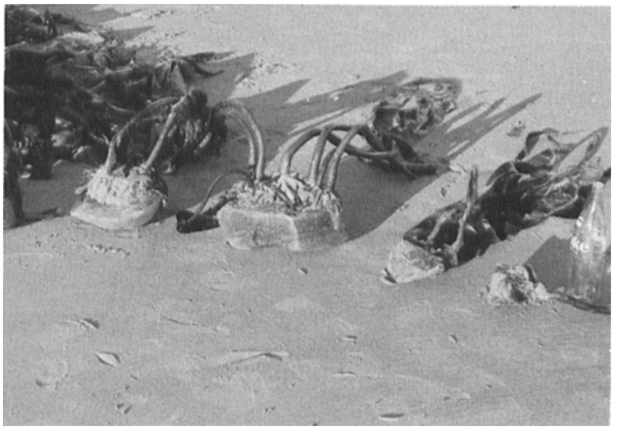

Figure 6. A selection of angular to sub-angular kelp-rafted cobbles of Stinkfontein Formation quartzites found on the beach at Port Nolloth on May 22, 1985.

quartzites of the Late Precambrian Upper Stinkfontein Formation which crops out along the coast at Port Nolloth (Joubert and Kröner 1971). The rafted boulders were randomly scattered across the beach up to about 15 m from the low water mark. Depending on the size, the cobbles and boulders had either single holdfasts or composite holdfasts (Fig. 6) consisting of up to 11 kelp plants, which ranged in length from 1.6 m to 3.1 m.

The undisturbed holdfasts on the beach were inspected again at low tide the following morning (May 23, 1985). Within the two tidal cycles that occurred after the initial observation, the kelp-rafted boulders had been completely buried in the foreshore sands with only parts of the kelp fronds being still exposed. Continued observation over a period of eight days revealed no significant change in this status other than a gradual decomposition of the kelp by the combined action of amphipods, bacteria, and kelp-fly larvae (Branch and Branch 1981, Field and others 1977).

Along the Western Cape coast, kelp-rafted cobbles and boulders have been observed by the authors between 1985 and 1987 in the rocky, intertidal zone at Melkbosstrand, Kommetjie, Cape Point and Franskraal (Fig. 4). In this area *Ecklonia maxima* is the dominant transporting kelp species. At Melkbosstrand (Fig. 4), a partially decomposed holdfast attached to a small boulder of locally derived Late Precambrian Malmesbury Group shale was found in a gully just below the low-water mark. The rafted rocks at both Kommetjie and Cape Point (Fig. 4) comprised locally derived Palaeozoic Table Mountain Group sandstone and were found on cobble beaches well above the low-water mark. While Scuba diving off Kommetjie and off Castle Rocks in False Bay (Fig. 4), one of the

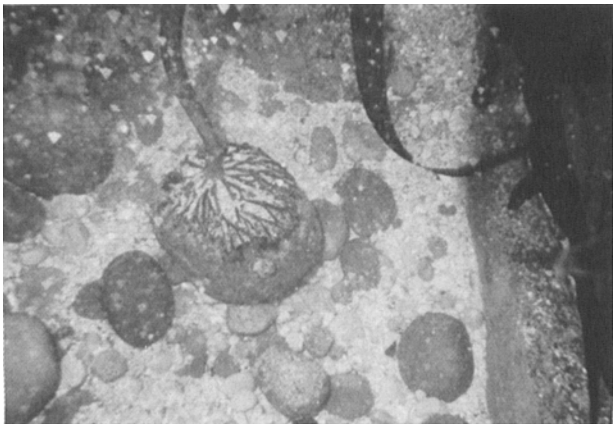

Figure 7. Kelp-rafted (*Ecklonia maxima*) rounded cobble of Table Mountain Group sandstone at a depth of approximately 1.5 m in the subtidal zone at Castle Rocks, False Bay. The cobble measures 25 cm in diameter.

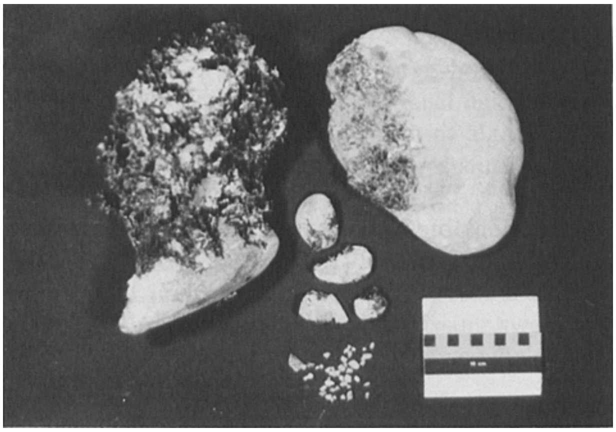

Figure 8. View of the cobble-, pebble-, and gravel-size rock clasts carried by the kelp holdfast found at Frankskraal.

authors observed *Ecklonia* plants attached to cobbles and small boulders at a depth of about 5 m (Fig. 7). The cobbles were easily lifted by pulling gently upwards on the stipe of the plant, thereby giving an indication of their transport potential during storm conditions.

At Franskraal, near the southern limit of the kelp distribution (Fig. 4), a partially decomposed composite holdfast containing a number of pebbles and cobbles was found lying submerged in a gully backed by a cobble beach. The kelp plants were identified on the basis of the holdfast morphology as being *Ecklonia maxima*. Close examination of the holdfast (Fig. 8) revealed that it contained 2 large cobbles, 7 pebbles ranging in size from medium to very coarse pebbles, and a substantial quantity of very fine pebbles.

The cobbles were composed of well-rounded, oblate pieces of locally derived Palaeozoic Table Mountain Group sandstone. The pebbles, also composed of sandstone, were mainly well-rounded but 3 were angular. The holdfast was in an advanced stage of decomposition when found and, judging from the presence and size of rounded cavities in the holdfast, it had probably contained at least another 2 cobbles. This holdfast had thus lost part of its original load in the course of transport and decomposition. Holdfasts, particularly composite ones, are therefore not limited to single large clasts but may also incorporate a number of smaller clasts.

Backshore

Holocene progradation of the backshore environments beside Noordhoek beach (Fig. 4) has allowed coastal dunes to advance seaward over sediments originally deposited in a backshore lagoon (Fig. 9). This was inferred on the basis of abundant barnacles and bivalves between vegetated coastal dunes up to a kilometer inland from the seaward edge of the modern backshore dunes. However, the association of well-rounded, isolated cobbles of Table Mountain Group sandstone (Fig. 10) found together with the barnacles and bivalves was puzzling until it was proposed that the cobbles may have been kelp-rafted into an earlier backshore lagoon.

Periodic examination of the abundant kelp that washed over into the modern backshore lagoon at Noordhoek during onshore northwesterly storms in winter led to the observation of a cobble still attached to a holdfast (Hill 1983, personal communication). Isolated cobbles are, nevertheless, fairly abundant in the modern sandy lagoon (Fig. 11) and it is concluded that although these cobbles are statistically rare, their preservation potential is very high. In contrast, the kelp itself decomposes rapidly.

In a recent study of Noordhoek Beach, trench excavations revealed decomposing clast-free holdfasts buried 0.5 m–1.0 m below the surface within the parallel-laminated, fine-sand, washover deposits beneath the modern backshore environment (White 1987, Figs. 5 and 6).

Offshore

Gentle (1987) describes kelp-rafted clasts that were recovered by dredging from a depth of 350 m, about 120 km offshore to the northwest of Cape Columbine (Fig. 4). The sample consisted of "Rounded pebbles, up to 10 cm in diameter, of greenish, fine-grained

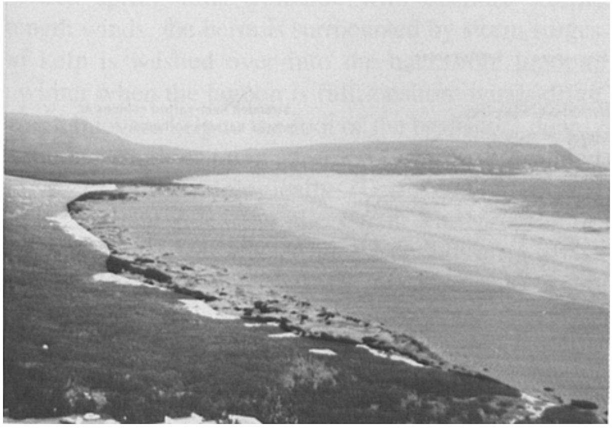

Figure 9. Winter view of Noordhoek Beach (11/8/87). Note the full backshore lagoon extending to the base of prograding backshore dunes. Landward of the dunefield is a marshy, palaeo-backshore-lagoon environment.

subgreywacke all held together by a loose mat of seaweed in which there are also shells" (Gentle 1987, p. 104). According to the Modified Wentworth Grade scale, material of this size can be classified as small cobbles. The presence of the holdfast is the only way Gentle (1987) could positively identify the transporting agent. Once the organic material has decayed there is no lasting impression of the holdfast on the rocks (Dr. R. Simons, personal communication, in Stewart 1974).

There are no reports of cobbles being recovered from free-floating kelp plants or kelp rafts in the deep sea off the coast of South Africa. However, after the storm event on May 22, 1985, described earlier, one of the authors observed two large kelp-rafts of *Laminaria schinzii* approximately 5 m–8 m wide floating about 2 km offshore just south of Port Nolloth (Fig. 12). Such kelp rafts off the west and south coasts of South Africa have often been observed by local yachtsmen. Floating kelp can be carried far offshore and Arnaud and others (1976) report finding *Ecklonia* plants off St. Helena Island, a distance of 2,700 km from the nearest shore area off southern Africa.

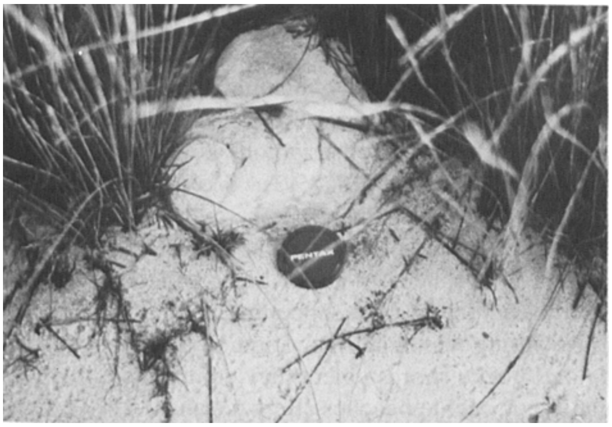

Figure 10. Stranded, sub-rounded cobble of Table Mountain Group sandstone in the palaeo-backshore-lagoon environment.

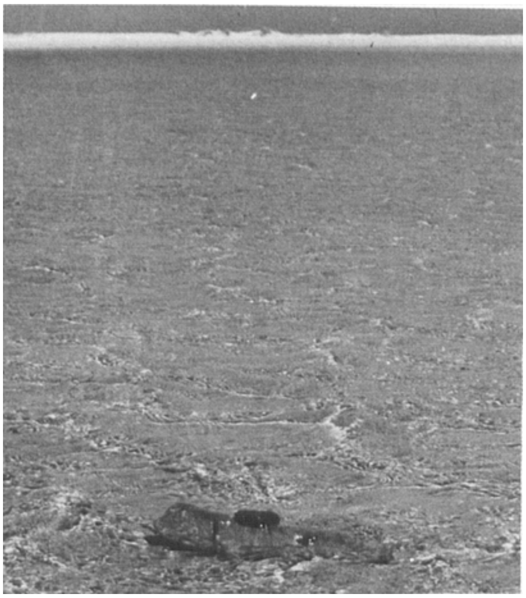

Figure 11. Sub-angular cobble of Table Mountain Group sandstone in the modern backshore lagoon at Noordhoek. Camera lens cap (5 cm diameter) is resting on the cobble.

Discussion and Summary

In this study we report observations of kelp-rafted rocks in several environments. Such rocks have been found on rocky shores of the South West Cape between Franskraal and Melkbosstrand as well as on sandy

Figure 12. Large kelp-raft (*Laminaria schinzii*) floating about 2 km off the coast at Port Nolloth. The raft is approximately 5 m to 8 m wide.

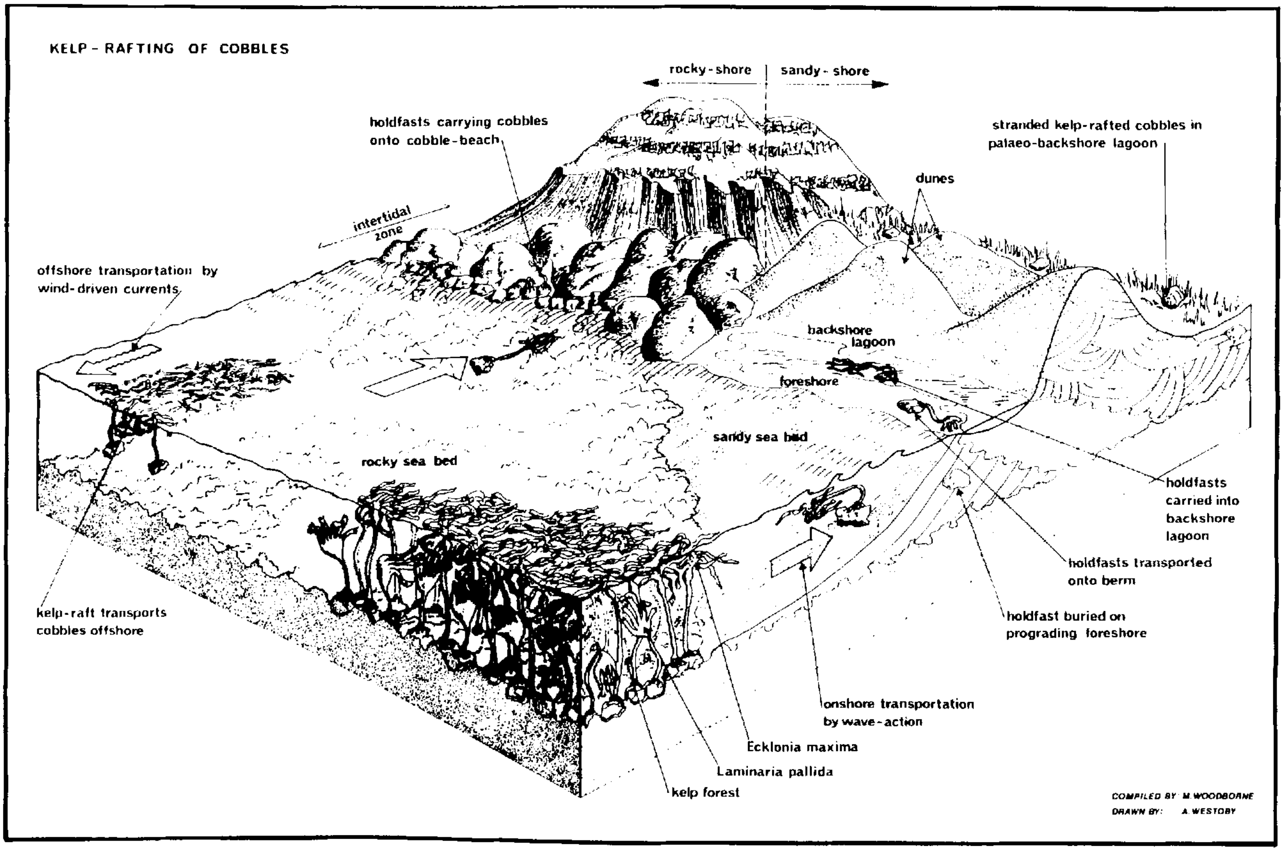

Figure 13. Conceptual model depicting the course of kelp-rafted rocks from the initiation of movement up to the final point of deposition in both high energy (beaches) and low energy (backshore lagoon, outer shelf) environments.

beaches at Noordhoek and at Port Nolloth (Fig. 4). However only at Noordhoek have we observed them in a backshore lagoon environment. No reference to a similar occurrence has been found in the literature. The only definite evidence of kelp-rafting on the outer shelf is reported by Gentle (1987) who described a holdfast dredged off Cape Columbine from a depth of 350 m.

Although Huggett and Kidd (1983/84) report the possibility of kelp-rafting of relatively soft and sometimes pholad-bored lithologies, we have only observed rafting of well-consolidated, pre-Mesozoic sedimentary or metasedimentary rocks. The clasts were derived from Late Precambrian Stinkfontein Formation quartzites off Port Nolloth, and from Precambrian Malmesbury Group shale and Palaeozoic Table Mountain Group sandstones off the Western Cape.

From the available evidence it would appear that kelp-rafting off the South African coast is less prevalent and that the clasts are from more resistant, older formations than those from the northeast Pacific coast. A major botanical difference is the abundance of *Macrocystis pyrifera* off California which grows to lengths of 200 m (Frye and others 1915 in Emery and Tschudy 1941), twenty times the length of our largest species, *Ecklonia maxima* (Field and others 1980). In addition, the South African coastline terminates southward at latitude 35°S. In contrast the kelp off the west coast to the Americas ranges from California to Alaska (70°N) and from Peru to Tierra del Fuego (about 50°S).

We have obtained, albeit sparse, evidence of exotic kelp-rafted rocks in two distinct, low-energy sedimentary environments, namely a backshore lagoon and the outer shelf. Our observations are summarized in a conceptual model (Fig. 13). We propose that on coasts exposed to southern ocean southwesterly swells, where eastern-boundary-current upwelling supports extensive kelp beds, a minor but geologically significant proportion of clast-supporting holdfasts are ripped loose during winter storms. Some of these are washed up onto rocky shores where they contribute to the formation of cobble beaches (Ben-Avraham 1971). Others are washed onto sandy shores where they are rapidly buried in the foreshore sediments.

When spring tides coincide with onshore storm-strength winds, the berm is surmounted by storm surges and kelp is washed over into the backshore lagoon. In winter when the lagoon is full, onshore winds drive the still buoyant kelp to the foot of the backshore dunes. As the lagoon dries up in summer, the kelp is stranded and decomposes biologically (Griffiths and others 1983), thereby releasing the clast. The prograding backshore dunes bury the clast for a period, after which it is exposed and appears as a stranded cobble in the palaeo-backshore-lagoon environment.

Coastal currents are responsible for the distribution of clasts floated out onto the continental shelf within kelp rafts. The clasts are only released when the grip of the holdfast is broken by decomposition. Due to the high sedimentation rate that often prevails on the inner shelf, kelp-rafted rocks deposited there are probably buried soon after deposition. Therefore kelp-rafted rocks are more likely to be dredged on the middle to outer shelf.

In all cases, the final point at which the kelp-rafted clasts are deposited lies somewhere between the initial mobilization during storms and the subsequent complete decomposition of the kelp. The holdfasts leave no permanent impressions on the clasts; consequently, positive identification of kelp-rafted rocks is difficult once the kelp has decomposed.

Emery and Tschudy (1941) and Ben-Avraham (1971) conclude that kelp rafting is a significant sedimentary process. Our observations off South Africa's western coast support their opinion. It is known that every year, about 15 percent of the *Ecklonia* plants off the South African coast are torn free during storms and are either washed up as wrack or carried out to sea (Anderson and others 1987, Simons and Jarman 1980). If only 1 percent of these carry rock clasts, this would result in a significant quantity of rocks being transported over geological time.

Acknowledgments

The Chief Director of the South African Geological Survey, Dr. C. Frick, is gratefully acknowledged for supporting the publication of this document. Special thanks to Miss. K. Krüger and especially to Mrs. A. Westoby who drafted the illustrations as well as Mrs. G. C. Krummeck for typing the manuscript.

References

Anderson R, Jarman N, Almendro C (1987) Kelp forests. Underwater 5:28–29

Arnaud F, Arnaud P, Intes A, Le Loeuff P (1976) Transport d'invertebres benthiques entre l'Afrique du Sud et Sainte Helene par les laminaires (Phaeophyceae). Bulletin Museum National d'Histoire Naturelle 384:49–55

Ben-Avraham Z (1971) Accumulation of stones on beaches by *Codium fragile*. Limnology and Oceanography 16:553–554

Bolton JJ (1986) Marine phytogeography of the Benguela upwelling region on the west coast of Southern Africa: A temperature dependent approach. Botanica Marina 29:251–256

Bolton JJ, Levitt GJ (1987) The influence of upwelling on South African west coast seaweeds. South African Journal Marine Science 5:319–325

Branch G, Branch M (1981) The living shores of southern Africa. Struik, Cape Town, 272 pp

Dunn EJ (1911) Pebbles. George Robertson & Co., Melbourne, 122 pp

Emery KO (1960) The Sea off Southern California. J. Wiley & Sons Inc., New York, 366 pp

Emery KO (1963) Organic transportation of marine sediments. In: Hill MN (ed) The Sea. Volume 3, The Earth Beneath The Sea. Interscience Publishers, New York, pp 776–793

Emery KO, Tschudy RH (1941) Transportation of rock by kelp. Bulletin Geological Society America 52:855–862

Field JG, Griffiths CL, Griffiths RJ, Jarman NG, Zoutendyk P, Velimirov B, Bowes A (1980) Variation in structure and biomass of kelp communities along the southwest Cape coast. Transactions Royal Society South Africa 44:145–193

Field JG, Jarman NG, Dieckmann GS, Griffiths CL, Velimirov B, Zoutendyk P (1977) Sun, waves, seaweed and lobsters: the dynamics of a west coast kelp bed. South African Journal Science 74:7–10

Gentle RI (1987) The geology of the inner continental shelf and Agulhas Arch: Cape Town to Port Elizabeth. Bulletin Joint Geological Survey/University Cape Town Marine Geoscience Group 20:1–129

Griffiths CL, Stenton-Dozey JME, Koop K (1983) Kelp wrack and the flow of energy through a sandy beach ecosystem. In: McLachlan A, Erasmus T (eds) Sandy Beaches as Ecosystems. Junk, The Hague: pp 547–556

Huggett QJ, Kidd RB (1983/1984) Identification of ice-rafted and other exotic materials in deep-sea dredge hauls. Geo-Marine Letters 3:23–29

Joubert P, Kröner A (1971) The Stinkfontein Formation south of the Richtersveld. Transactions Geological Society South Africa 75:47–53

Kudrass H (1974) Experimental study of nearshore transportation of pebbles with attached algae. Marine Geology 16:M9–M12.

Mann KH (1973) Seaweeds: Their productivity and strategy for growth. Science 182:975–981

McGill JT (1958) Map of coastal landforms of the world. Geographical Review 68:402–405

Menard HW (1953) Pleistocene and Recent sediment from the floor of the northeastern Pacific Ocean. Bulletin Geological Society America 64:1279–1294

Shumway GA (1953) Rafted pebbles from the deep ocean off Baja California. Journal Sedimentary Petrology 23:24–33

Simons RH, Jarman NG (1980) Sub-commercial harvesting of a kelp on a South African shore. Proceedings Tenth International Seaweed Symposium, pp 731–736

Stewart RD (1974) A study of rock samples dredged off the southwestern cape coast. Unpublished Honours Project, Geology Department, University Cape Town, 21 pp

White J (1987) Sedimentary Structures of a High-Energy Nearshore and Backshore Environment, Noordhoek Beach, Cape Peninsula. Unpublished Honours Project, Geology Department, University Cape Town, 38 pp

Wynne MJ (1986) Report on a collection of benthic marine algae from the Namibian coast, southwestern Africa. Nova Hedwigia 43:311–355

Manuscript received 17 August 1988; revision received 12 December 1988.

Note Added in Proof

A paper on the movement of gravel by algae on an Arctic intertidal flat in northern Canada (Gilbert R, 1984, Journal Sedimentary Petrology 54:463–468) came to our attention after final acceptance of the manuscript.