PERSISTENCE OF FELDSPAR IN BEACH SAND

James H. C. Martens, *West Virginia University.*

Although the amount of detrital feldspar in a sand, and the degree of alteration of the feldspar are considered some indication of climatic and topographic conditions during deposition, comparatively few quantitative analyses showing amounts of feldspar in recent sediments seem to have been published.[1] This paper gives the results of a study of the feldspars in a series of beach sands for which the source of material and conditions of transportation and deposition are fairly well known, and attempts a discussion of some of the factors affecting the proportion of feldspar present.

The samples used were collected from the Atlantic beach between Charleston, South Carolina, and Miami, Florida, while the writer was in the employ of the Florida Geological Survey. There was no particular reason except that of convenience for limiting the investigation at Charleston on the north, but no grain counts were made on the sand from south of Cape Florida, near Miami, because the beach sand is almost entirely calcium carbonate, and detrital grains of either quartz or feldspar are scarcely to be found.

Source and Transportation of Sand

The rivers entering the Atlantic ocean in North Carolina, South Carolina and Georgia carry large amounts of sand, part of which is derived from the weathering of the crystalline rocks of the Piedmont Plateau, and part from the sedimentary Coastal Plain formations. Since the rocks of the Piedmont region are largely feldspathic, the sand coming directly from them as a source contains more feldspar than that from the Coastal Plain formations which have been subjected to weathering and leaching through a long period of time. In addition to the sand carried to the sea by rivers, there is some on the beaches which is derived directly from marine erosion of sand formations mostly of Pleistocene to Recent age. Southward from the mouth of Altamaha River near Brunswick,

[1] A few references on detrital feldspar in sediments are: Milner, H. B., *Sedimentary Petrography*, second edition, pp. 217, 432, 448. Mackie, W., Feldspars in Sedimentary Rocks as Indicators of Climate: *Trans. Edinburgh Geol. Soc.*, **1898**, p. 443. Reed, R. D., Recent Sands of California: *Jour. Geol.*, vol. **38**, pp. 223–245, 1930.

Georgia, all the way to Miami there is very little contribution of sand by the rivers draining into the Atlantic, and none at all from beyond the limits of the Coastal Plain. All the way along the shore in the region under consideration the movement of sand is to the southward. The sand is transported by wave action on the beach and by shore currents in shallow water. Except for shell fragments and grains of calcium phosphate, the beach sand on the east coast of Florida comes from the north, and has essentially the same source as the sand on the coast of Georgia.

In the northern part of the region from which the beach sands were studied, that is, in South Carolina and Georgia, the proportion of feldspar in the sand may be considered some indication of how this mineral is able to stand weathering and stream transportation in a humid, warm-temperate climate. The proportion of feldspar in the beach sand farther to the south in Florida may show something regarding the resistance to abrasion and solution during alongshore transportation in sea water.

Collection of Samples

While the method of collecting at all of the localities was not absolutely uniform, in most instances the sample represents a vertical cut through a depth of ½ foot to 2 feet at or near the ordinary high tide line. With the exception of sample No. 8094 from Tybee, Georgia, which contains 4.6 percent of minerals of specific gravity above 2.85, sands in which heavy minerals were very much concentrated were avoided in selecting material for the study of the feldspars.

Laboratory Procedure

The sands containing an appreciable amount of shell fragments were treated with dilute hydrochloric acid; this was necessary for all samples from Melbourne southward, and for some of those from north of there. The relative amounts of quartz and potash-feldspar were determined by microscopic examination of the light portion floated in bromoform of specific gravity 2.85. Grain counts were made on temporary mounts in a liquid of refractive index 1.530, and in some instances also, on permanent mounts in Canada balsam. The potash-feldspar was distinguished from quartz by its lower refractive index. All of the potash-feldspar grains in the slides examined were counted, but the quartz grains were counted in fields uniformly spaced so as to cover systematically a certain fraction of the slide, usually between ¼ and ½, and the total number of quartz grains was estimated from that. The number of grains examined was generally between 2000 and 7000 for each sample. In some of the sands a very little plagioclase may have been counted with the quartz.

Description of Feldspars Present

Microcline is the most abundant feldspar present throughout the whole length of the beach under consideration. In making the grain counts, no attempt was made to distinguish between orthoclase and microcline, the two being counted together as potash-feldspar (Kf). In sample No. 8079 from Folly Beach near Charleston, S. C., there is some plagioclase as basic as labradorite, and the total plagioclase is estimated to amount to about half as much as the potash-feldspar, which, after allowing for the presence of minerals

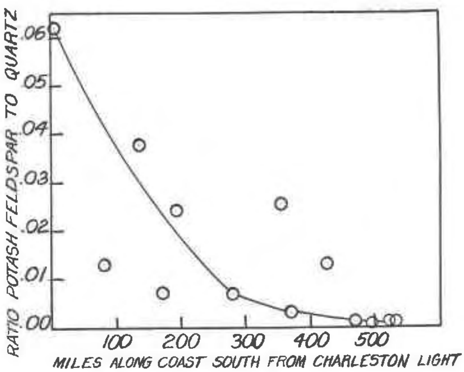

Fig. 1. Variation in ratio of number of potash feldspar to number of quartz grains in beach sands of the Atlantic coast.

other than quartz and feldspar, brings the total feldspar content of that sand to about nine percent. Plagioclase was noted in the other samples in which potash-feldspar is most abundant, and occasionally in some where it is rather scarce. A single grain of oligoclase was observed in sample No. 8049 from Riviera, near West Palm Beach, this being the farthest south that any plagioclase was found.

The diameter of the feldspar grains varies from a few hundredths of a millimeter up to 0.5 mm. They average a little smaller than the quartz grains in the same sand, and are mostly angular to subangular in shape.

The degree of alteration shown by the feldspar grains is usually slight. The largest proportion of grains turbid from alteration, or having surfaces coated by other minerals, was observed in the sands from Georgia and South Carolina; to the south the proportion of such grains decreases, presumably because the softer altered grains are more easily destroyed by the shocks received in transportation along the beach toward the south. Most of the feldspar grains from the beach sands in Florida are clear and practically free from alteration products, either as coatings or as inclusions.

Relative Amounts of Quartz and Feldspar

The approximate localities of the samples analyzed, the number of grains counted, and the potash-feldspar/quartz ratios are shown in table I. I have expressed the amount of potash-feldspar in the sands examined, as a ratio of the number of potash-feldspar grains to the number of quartz grains, because, by doing so, the variations in the amount of shell and of heavy minerals may be neglected. This may be more briefly referred to as the Kf/quartz ratio. On Fig. 1 are plotted the Kf/quartz ratios in relation to the distance along the coast south from Charleston Light, this being a convenient reference point near the most northerly locality. At Folly Beach near Charleston, S. C., this ratio is .062, at St. Simon Island, Georgia, 130 miles to the south it has decreased to .038, at Manhattan Beach near Jacksonville, about 190 miles to the south, it has still further decreased to .024. Several samples from the vicinity of Palm Beach and Miami, 470 to 520 miles along the coast from Folly Beach, have a Kf/quartz ratio of .001 or a little less.

While the sample from nearest the outcrops of igneous and metamorphic rocks shows the largest amount of feldspar and that farthest away shows the least, the decrease toward the south is far from being regular and uniform. When it is considered that usually only one sample from a locality was analyzed, and that not all of the samples were taken in the same manner, this is not at all surprising. In addition to the effects of transportation by which the less resistant minerals are destroyed to a greater extent, local conditions of sorting have much to do with the proportions of the different minerals. The difference in specific gravity between quartz and feldspar is not great enough so that waves and currents will do much sorting if the grains are about the same size and shape, but there is relatively more feldspar in the fine sand than in the medium to coarse. Therefore, where there is coarser sand at about the upper limit of wave action than there is on the lower part of the

TABLE I

POTASH FELDSPAR IN BEACH SAND IN RELATION TO DISTANCE ALONG COAST

Fla. Geol. Surv. Sample No.	Locality	Miles along coast from Charleston Light	Grains Potash Feldspar	Grains Quartz	Ratio of Potash Feldspar to Quartz
8079	Folly Beach, S. C.	4	124	2010	.062
8094	Tybee, Ga.	80	64	4760	.013
8032	St. Simon Island, Ga.	135	100	2630	.038
8028	Amelia Island, Fla.	170	22	3080	.007
8025	Manhattan Beach, Fla.	192	56	2300	.024
8041	Daytona Beach, Fla.	283	39	5410	.007
8050	Cocoa Beach, Fla.	354	101	3450	.029
8053	Cocoa Beach, Fla.	354	38	1740	.022
8020	Melbourne Beach, Fla.	371	10	3280	.003
8014	Ft. Pierce, Fla.	422	77	6000	.013
8049	Riviera, Fla.	469	3	3010	.001
8010	Boca Raton, Fla.	498	1	2000	.0005
8009	Hollywood, Fla.	523	6	7100	.001
8001	Miami Beach, Fla.	535	7	6900	.001

beach there may be a much smaller number of grains of feldspar relative to quartz in the coarser material. Some of the local deviations in the Kf/quartz ratio can be explained by the texture as determined by local sorting. As an example of this we may consider two sands from northeastern Florida, one of which was collected from the upper part of the beach and has a Kf/quartz ratio of .007, while the other is a finer sand from the lower part of the beach and has a Kf/quartz ratio of .024. Sample No. 8094 from Tybee probably has a smaller Kf/quartz ratio than normal for that locality, because it contains 4.6% of heavy minerals and in the concentration of these from the smaller average amount in the sand the coarser quartz would go with the heavy minerals, and the finer feldspar would be carried away with the finer quartz. The two sands from Cocoa Beach, which have a much larger feldspar content than those from the nearest localities sampled to the north and the south, have a very fine texture, since nearly seventy percent will pass a sieve with 0.149 mm. square opening. Comparison of sieve tests of many sands with the grain counts made under the microscope leaves no doubt whatever that the feldspar content is greater in the finer than in the coarser sands.

To get more information about the relation of grain size to distribution of feldspar, counts were made on the several portions into which a sand had been separated by a series of small sieves with openings of 1 mm., 0.5 mm., 0.25 mm., and 0.10 mm., respectively. The results are as given below, showing in another way that the feldspar is distinctly more abundant in the finer sand.

Distribution of Potash Feldspar According to Grain Size
(Sample No. 8020, Melbourne Beach, Florida.)

Size limits	Number of quartz grains	Number of potash feldspar grains	Ratio of potash feldspar to quartz
0.5 to 1 mm.	Many	None	.0000
0.25 to 0.5 mm.	3860	2	.0005
0.10 to 0.25 mm.	4350	15	.0034
less than 0.10 mm.	3160	90	.0285

W. A. P. Graham[2] has recently noted a similar relation between texture and occurrence of feldspar in the Cambrian sandstones of Minnesota.

Conclusions

The decrease in the ratio of feldspar to quartz with increasing distance from the source of the sand is clearly shown by microscopical analyses of sands collected over an interval of more than 500 miles along the beach on the Atlantic coast of the southeastern states. Some feldspar still persists in the beach sand in spite of the low topography near the coast, the fairly warm, humid climate and the derivation of much of the material from sedimentary formations so that it has gone through more than one cycle of erosion. The feldspar in the vicinity of Miami has apparently been transported at least 400 miles along the shore, plus about 200 miles by river. Some of it may have come a much greater distance. The fresh conditions of the few feldspar grains still remaining seems to indicate that the destruction of the feldspar during transportation along the coast has been more by mechanical means than by chemical alteration. Under the conditions prevailing along the Atlantic coast, a fine sand has more feldspar in it than a coarse one which has travelled the same distance.

[2] W. A. P. Graham, A Textural and Petrographic Study of the Cambrian Sandstones of Minnesota: *Jour. Geol.*, vol. **37**, pp. 696–716. 1930.