

# PROCESSES OF SELECTIVE GRAIN TRANSPORT AND THE FORMATION OF PLACERS ON BEACHES<sup>1</sup>

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## ABSTRACT

Placers are found on many beaches of the Oregon coast. In the beach that is the focus of this study, the principal placer minerals are ilmenite (22.0%), epidote (20.0%), garnet (18.7%), augite (15.5%), hypersthene (8.1%), hornblende (5.8%) and zircon (2.0%), the "ilmenite" fraction actually being partly chromite. A series of beach-face sand samples was obtained along a profile when sand was being eroded from the upper beach and transported to offshore bars, since the processes of grain-selective sorting leading to placer formation were probably most active at such a time. The landward-most sample contained 96% heavy minerals, being part of the placer. This concentration systematically decreased offshore to a 6% heavy-mineral content in the seaward-most sample (54 m offshore). Determinations of individual heavy mineral concentrations revealed that, although they all tended to become concentrated within the placer with light quartz and feldspar dominating the offshore transport, the sorting processes were most effective in concentrating the ilmenite (concentration factor = 1403) and least efficient in concentrating the hornblende (factor = 5). All of the minerals form a pattern of increasing efficiency of concentration within the placer with an increase in grain density and decrease in mean grain size. Thus the sorting processes are most effective in concentrating the ilmenite, which is both the densest and finest-grained of the minerals present in the beach, least efficient for the hornblende, which has the lowest density and is the coarsest of the heavy minerals. Measurements of grain settling velocities indicate that this parameter cannot account for the observed selective grain sorting. Instead, evaluations of the selective entrainment and transport rates of the mineral grains yield trends which exactly parallel their observed concentration factors within the placer, indicating the probable dominance of these grain-sorting processes in placer formation. Shear sorting of the light and heavy minerals may also be an important process, but its role could not be determined in the present study.

## INTRODUCTION

Placers within beach deposits often contain valuable concentrations of minerals, yet the conditions which produce this heavy-mineral enrichment remain imperfectly understood. What are the physical processes responsible for the grain-by-grain selective sorting leading to a concentration of heavy minerals? In developing the concept of hydraulic equivalence, Rubey (1933, p. 5) hypothesized that the various minerals would be transported and deposited according to their settling velocities, the assumption being that "whatever the conditions may have been which permitted the deposition of quartz grains of a certain size, these conditions would also permit the deposition of magnetite grains that had the same settling velocity." Under this concept of hydraulic equivalence, one might envision that placers form due to the con-

trasting settling velocities of light minerals (principally quartz and feldspar) and heavy minerals. Subsequent studies, however, have demonstrated the general inapplicability of this concept; light and heavy minerals deposited together do not generally have the same settling rates (Rittenhouse 1943; Lowright et al. 1972; Slingerland 1977). This casts doubt on the role of comparative settling velocities in forming placer concentrations.

More recent investigations, such as those of Slingerland (1977, 1984), have focused on the role of processes of selective grain entrainment and transport in the formation of placers. This approach attempts to consider a sediment of mixed grain sizes and densities, evaluating which grains can be most-easily entrained and transported. Accordingly, a placer forms because the heavy minerals are both denser and finer-grained than the quartz and feldspar grains. The role of higher grain densities in producing a placer lag is readily apparent; the studies also indicate that the smaller grain sizes of the heavy minerals permit them to "hide" within the interstices among the larger grains such that these smaller grains are less-readily entrained by

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