ON TRANSGRESSIONAL WARMING
AND DEGLACIATION

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Sea level is an important—perhaps the most important—master variable of the marine stratigraphic record. Whether we study facies distribution, climatic indices, or biogeography through time, we usually invoke sea level changes as part of the physical explanation for the observed variations. For many purposes we can consider the sediment-producing machine of erosion, transport, and accumulation, as a system driven by sea level fluctuations. Feedback mechanisms are part of this system. Negative feedback tends to slow down sea level changes, once it has started, and positive feedback tends to accelerate them.

Positive feedback is of great interest, because it can produce run-away situations accompanied by rapid change and resulting in extreme conditions. Global reduction of sensitive organisms, and extinctions, may result from such run-away phenomena. I will consider three types of positive feedback (Figure 1): albedo feedback, greenhouse feedback, and feedback from collapse of transient reservoirs.

Systemic analysis of the stratigraphic record ("systemic stratigraphy," Berger and Vincent, 1981) may be illustrated by analyzing the feedback associated with the last deglaciation. This event, which lasted from about 14,000 years to 8,000 years ago, represents an extremely fast and large rise of sea level (about 120 m in 5,000 years). Albedo changed markedly from glacial to postglacial conditions (CLIMAP, 1976). There are several reasons: (1) water covered land area, changing an average albedo of 20 percent to one of 10 percent (Table 1); (2) snow-covered areas became snow-free (albedo of 50 percent to 25 percent); (3) dry regions (steppe and desert) became forests and even wetlands (albedo of 25 percent to 12 percent). The overall change is computed by weighting these changes according to area involved (for example, land to sea—5 percent; snow and ice to bare soil—2 percent; dry to moist—10 percent of Earth). An overall albedo change near 2.5 percent results. Additional changes in the same direction are from the decrease in sea ice cover and from the lowering of the fertility of the ocean. To be sure, these changes refer to surface albedo only. We do not know how the planetary albedo reacted: it depends to a large extent on cloud cover. We may assume that cloud cover was reduced during cold, dry periods, providing a negative feedback element within the albedo mechanism.

Assuming that the surface albedo changes proceed parallel with sea level change, in a linear fashion, we can then calculate the temperature effect according to the convention that a change of 1 percent in surface albedo corresponds to a change of about 1°C in global temperature (Hummel and Reck, 1978). The total change in global temperature is between 4 and 5°C (Figure 2). CLIMAP (1976) gives a value of 2.3°C for the global ocean. If this is accepted, the average change on land had to be much greater, near 8 to 9°C.

The CO₂ content and the moisture of the atmosphere is crucial for the "greenhouse effect". The concept was introduced by J. Tyndall and S. Arrhenius a century ago. It has been elaborated by Plass (1956), and by many others since, in connection with the industrial CO₂ buildup. The term "greenhouse effect" refers to the heating of the lower