the presence of ferromanganese deposits in the sediments is not necessary, although in some cases in the deep sea it may be sufficient. The low iron content (< 1 percent) and the fact that the iron is dispersed throughout the diatom-held spheres clearly indicates that manganese can be deposited in the deep ocean independently of iron. This observation differs considerably from the reported precursor iron layer found in some other samples (*11*). If the sediment interstitial fluids are near thermodynamic equilibrium, the small percentage of iron in the embryo concretions suggests either that the iron concentration in the solution is extremely low compared to that of manganese or that there is some catalytic process that is precipitating manganese preferentially. The relative enrichment of manganese versus iron in surface sediment fluids seems tenable, but then so does the probability of bacterial agents being involved in the manganese deposition. Further, it seems reasonable that the process responsible for manganese infilling of diatom frustules may well be the process responsible for manganese infilling of biotic structures recently reported to exist on the surface layer of large manganese nodules (*12*). The microenvironment within the voids of diatom frustules and other planktonic skeletal debris certainly have characteristics that are very similar to those of a vacant structure built on a large nodule's surface, that is, the presence of decaying organic materials, the exclusion of sedimentary particles, and permeability by ambient solutions.

I have stated the genetic relationship between the concretions I term embryos and those I call juveniles. It might be contested whether there exists any such relationship between these two types of smaller concretions and those larger ones that I would like to refer to as adults. Adult nodules are those of a size such that they may exhibit evidence of numerous benthic organisms having resided on their surfaces ($\gtrsim 1$ cm). The small and large concretions are at least related in that some benthic organisms actively add juvenile concretions to the surface of adult concretions (*12*). In addition, all three sizes of concretions are related if by nothing other than the fact that all have manganese as their principal component.

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1. This sediment was collected with a box corer during the Scripps Institution of Oceanography Benthiface Expedition in June 1973, at 14°35.2′N and 117°20.2′W and a water depth of 3980 m. The sediment is a radiolarian clay with a substantial diatomaceous component. The surface sediment is of Recent age. Ferromanganese nodules of centimeter size and larger are abundant in this region, and many were recovered. Many of these nodules were among those I examined for biotic structures and are discussed in (*12*).
2. Sample preparation techniques were designed to be as simple and gentle as possible so as to avoid alteration or elimination of interesting particles, particularly the ferromanganese phases. The generalized procedure involves dispersing the sediment in filtered (pore size, 0.2 μm) seawater, freeze-drying it, and then directly examining the individual particles. Some crushing or embedding and sectioning of larger particles was necessary for the TEM and microprobe studies.
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Baring High-Albedo Soils by Overgrazing: A Hypothesized Desertification Mechanism

Abstract. *Observations are reported of high-albedo soils denuded by overgrazing which appear bright, in high contrast to regions covered by natural vegetation. Measurements and modeling show that the denuded surfaces are cooler, when compared under sunlit conditions. This observed "thermal depression" effect should, on theoretical grounds, result in a decreased lifting of air necessary for cloud formation and precipitation, and thus lead to regional climatic desertification.*

Trewartha (*1*) has raised the question of why there can be sharp contrasts in the amounts of rainfall in regions with similar climatic controls, both dominated by the surface flow of maritime air. The possibility of regional aridity alongside regions of higher rainfall is ascribed here to a desertification mechanism in which overgrazing, which bares inherently high-albedo soils and lowers surface temperatures, is the underlying cause.

Aridity can arise from three general causes: (i) the separation of the region from oceanic moisture sources by distance or topography; (ii) the existence of dry stable air masses that resist convective currents; or (iii) the absence of influences that cause convergence, create unstable environments, and provide the lifting of air necessary for precipitation (*2*). A decrease in lifting is invoked in the mechanism discussed here.

A striking case of baring high-albedo soils can be observed in the Sinai-Negev region. In images of southwestern Israel and northern Sinai from the Earth Resources Technology Satellite (ERTS-1) (Fig. 1), one can discern a sharp demarcation line, with pronounced contrast, between the relatively dark Negev and the very bright Sinai and Gaza Strip. The line coincides with the 1948–1949 armistice line between Israel and Egypt, along which a fence was erected some 5 years ago.

Ground truth observations show that the effect stems from the denuding of the bright sandy soil, predominantly as a result of overgrazing by goats, camels, and sheep, on the formerly Egyptian-held side. Additional contributing causes include picking by the Bedouin of the prevalent inedible shrub *Artemisia* for the construction of their habitats and shallow ploughing by the Bedouin of some small isolated areas (*3*). On the protected dark side of northwestern Negev, only a few herds graze and the natural vegetation grows in relative abundance. The natural vegetation is definitely rain-limited, and the weakening of the contrast between Sinai and Negev in the inland direction can be attributed to the weakening of the natural vegetation cover in the Negev as a result of decreasing rainfall.

The contrast between the denuded bright side and the protected dark side has been measured with a Joyce-Loebel microdensitometer. The space contrast, that is, the contrast as seen in the satellite by the multispectral scanner (MSS) in its various bands, is presented in Table 1. The weaker contrast in the MSS-4 band is attributed in part to a higher-contrast attenuation by the atmosphere at the shorter wavelengths. Considering the contrast-attenuating effects of the atmosphere in all the bands, the contrast ratio of the surface reflectivities averaged over the solar irradiation can be estimated to be about 1.5.

The albedo of the bright desert sandy soil has not been measured but, based on published results, can be estimated to be 0.37 (*4*). Applying as an approximation the contrast ratio 1.5 of upward reflectivities to the albedos, the albedo of the same soil with appreciable vegetation cover would be 0.25, for a difference in albedo of 0.12.

Such large differences in surface reflectivities can have important environmental implication, which are under study. An aircraft instrumented with a Barnes precision radiation thermometer (PRT-5 radiometer) has been flown across the Sinai-Negev demarcation line, in the area where the contrast is the greatest. The radiometer measured the ground radiation temperature in the spectral interval between 8 and 13 μm. The measurements, carried out at 1400 hours on 29 August 1973, showed that surface radiation temperatures were about 45°C on the dark side and dropped abruptly to 40°C on the bright side. The PRT-5 measurements were repeated on 22 February 1974. This time the instrument was hand-held above the ground, and there was much scatter in the individual measurements.

Table 1. Contrast between the Sinai and the Negev measured from ERTS-1 images.

Band	Wavelength (μm)	Sinai/Negev
MSS-4	0.5 to 0.6	1.27
MSS-5	0.6 to 0.7	1.49
MSS-6	0.7 to 0.8	1.41
MSS-7	0.8 to 1.1	1.45

The measurements carried out between 1300 and 1400 hours averaged about 33.5°C on the dark side and about 30°C on the bright side.

The appropriate data for the region were fed into a simulation program which is being developed for the thermal flux through the ground (*5*). It appears that such radiation temperature differences for early afternoon—of 5°C in late August and 3.5°C in late February—are quite consistent with the albedo ratio (1.5), and that considerably greater differences, depending on the meteorological conditions and sun elevations, can be encountered, always assuming clear skies, sunlit conditions.

A National Oceanic and Atmospheric Administration satellite (NOAA-2) thermal image of the area, 11 September 1973, shows the Negev warmer than Sinai, but no quantitative assessment of the temperature difference was possible from this image. In the same image, the cultivated and irrigated Nile Delta (which appears very dark in the visible) is cooler than the surrounding desert. Here, as expected, the evaporation and thermal inertia are more significant than albedo.

The regional climatic effects that can result from surface temperature differences have been studied by Malkus and Stern (*6*) and Black and Tarmy (*7*). In an area where the ground temperatures are higher, there is more heating of the atmospheric boundary layer. The air has more tendency to rise, and to form clouds, as in the case for air flow over a mountain. The amount of cloud cover and rainfall can thus be expected to be higher above the areas with warmer ground temperatures. Black and Tarmy refer to such warmer regions as "thermal mountains" and compute, for a given ground surface temperature difference, the height of the equivalent thermal mountain. It can be said that the western Negev forms such a thermal mountain, or that the Sinai forms a "thermal depression." A cloud cover conforming closely to the extent of the dark area of the Negev has been observed on a Gemini 11 image of the region, taken on 14 September 1966.

Using representative meteorological parameters, Black and Tarmy obtain, for a ground temperature difference of 5°C, 900 m as the height of an equivalent thermal mountain for a heat island 30 km long along the wind direction. Radiation temperature differences of 5° and 3.5°C, measured in the Negev, correspond to actual ground temperature differences of 5.1° and 3.6°C, respectively, for an assumed emissivity of 0.9. The heights of the equivalent thermal mountains are 900 and 650 m, respectively, for the same meteorological parameters and the same length of 30 km.

Black and Tarmy (*7*) discuss the possible amount of increased rainfall that can accumulate on such thermal mountains, by a comparison with real mountains of comparable dimensions in North Africa, along the shores of the Mediterranean. Their conclusion is that the effect could be of the order of hundreds of millimeters of precipitation per year. The accuracy of such an assessment is an open question. One difficulty is that cloud formation over the thermal mountain might actually quench, by its shadowing effect, the ground surface temperature differences. But, it can be guardedly said, based on the work of Malkus and Stern, and that of Black and Tarmy, that quite appreciable effects, in quantities of rainfall, can reasonably be hypothesized on theoretical grounds as a result of ground temperature differences of the order of 5°C. Since, as shown here, the baring of high-albedo soils by over-

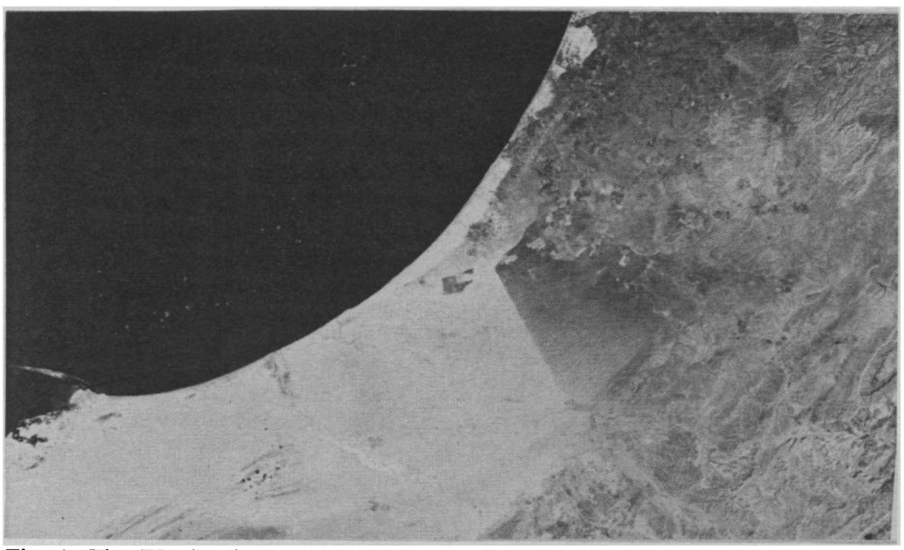

Fig. 1. The ERTS-1 image E-1091-07482, taken on 22 October 1972, band MSS-6, showing the denuded high-albedo regions of the Sinai and Gaza Strip, in contrast to the darker western Negev.

grazing can bring about such ground temperature differences, the regional climatic effects could be appreciable. Such mechanism of regional desertification would be in accordance with the approach to the dynamics of subsidence in desert climate developed by Charney (*8*). The global climatic effects of overgrazing might also be measurable.

The changes in the albedo of polar regions and the climatic consequences of these changes have been discussed by Flohn (*9*). He points out that the albedo of the polar sea ice lies between 0.62 to 0.80, whereas the typical albedo of the sea surface is between 0.04 and 0.10. Thus, the extension of sea ice, and also the extension of snow cover on land surfaces, are powerful climatogenic factors, which have global implications (*9*).

The possible variation in albedo in the case of snow or ice cover of polar regions versus clear sea and bare land areas of about 0.60 is higher by a factor of 5 than in the case of the baring of high-albedo soils, for which the computed difference of 0.12 is assumed to be representative. But the solar irradiation at the ground level is typically higher by a factor of 3 to 6 at the latitudes of the Deserts Belt than at the polar latitudes. The extent of some desertified areas, such as Sahel south of the Sahara, can be some 1.5×10^6 km^2, of the same order of magnitude as areas subject to changes in the snow or ice cover (2×10^6 km^2 in the Antarctic and 3×10^6 km^2 in the Arctic, as discussed by Flohn). Thus the global climatic effects of the baring of high-albedo soils can be comparable to the effects of variations in the snow or ice cover in the polar regions.

Vegetation recovers (rather quickly, as observed in some exclosures in the Sinai) when the pressures are removed. Thus, the hypothesized mechanism can be visualized as a cause of cyclical drought: if, because of drought, grazing animals die off or the population moves away in a nomadic migration, the vegetation recovers, the ground albedo decreases, surface temperatures increase, rains return to normal, and, with improved climatic conditions, population increases, which again puts anthropogenic pressures on the vegetation. The natural unit of time for such a cycle would be the age at litter-bearing of goats. As a gross oversimplification, it can be postulated that population explosion in grazing herds during "the seven fat years" is the cause of "the seven lean years."

There is an exact functional parallel between the mechanism of desertification presented here and the desertification mechanism ascribed to the dense pall of dust over the desert, raised by winds from the denuded surface. The dust, dwelling over the denuded areas, affects the radiative transfer, causing a diabatic cooling of the mid-troposphere and a resulting increased mean subsidence rate and increased aridity (*10*). The theory has been developed for the Rajasthan desert in India. Since dust is not a permanent blanket over most deserts, the dust theory does not seem applicable in general to the arid regions of the world.

In presenting here this climatic desertification mechanism, I have tacitly assumed that the basic wind pattern over the region is unchanged. The amounts of rainfall in the desert belt depend heavily on the gross circulation patterns which vary with shifts in position of the main anticyclones (*11*). The question of the extent to which changes in ground temperatures over large areas can bring about shifts in circulation patterns is not addressed here.

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Antarctic Glacial History from Analyses of Ice-Rafted Deposits in Marine Sediments: New Model and Initial Tests

Abstract. *Contrasts between the latitudinal distributions of ice-rafted debris deposited in deep-sea sediments during Pleistocene glacial and interglacial periods are predicted by a new model. The model requires the existence of a restricted zone where rates of deposition of ice-rafted debris are essentially independent of glacial-interglacial cycles. Initial tests and published results show that the concept is valid in the Southern Ocean and that it provides a new means of diagnosing major migrations of climatic zones.*

Deep-sea sedimentary cores are prolific recorders of Earth history, simultaneously providing evidence of past changes in climate, microfauna and flora, sea floor dynamic processes, geomagnetism, atmospheric particulate transport, and other phenomena. In high latitudes, marine sediments also include materials deposited by melting icebergs. Study of the spatial and temporal distribution of such ice-rafted debris (IRD) has long been recognized as a promising means of diagnosing the behavior of the polar ice caps (*1*). The advantage of the method over conventional land-based geological techniques is particularly obvious for Antarctica, where almost all relevant geological evidence (especially that for interglacial periods) remains inaccessible (*2*). Studies of deep-sea sedimentary cores have conclusively shown, for example, that Antarctica was a source of icebergs as early as the Eocene (*3, 4*), whereas similar results from studies on the continent are very difficult to obtain (*2*).

As stressed by Denton *et al.* (*2*), however, analyses of IRD have not provided any substantial advances in understanding the details of past fluctuations of the Antarctic ice cap, and it is