inhibition against both carbonic anhydrase B and C hydration (CO_2) is noncompetitive, while that against dehydration (HCO_3^-) is competitive. This is not surprising on structural grounds, and although not certain at the time, was used as the base for our discussion of the Haldane relation (*1*). This new situation in enzymology is based on the antipodal qualities of the two substrates. In these experiments, the I_{50} for I^- and Cl^- in the hydration reaction (for enzyme B) are tenfold greater at pH 8.2 than at 7.2, showing direct competition between OH^- and the halides for the protonated (E) form of the enzyme, an effect predicted from earlier binding studies (*4, 5*). Inhibitors thus compete with OH^- and HCO_3^- for E, but not with CO_2.

Bicarbonate as well as OH^- has a high affinity for the B enzyme, as shown by our data (*1*). From inhibition of the hydration reaction (table 1) and the suppression of Cl^- inhibition by 15 mM HCO_3^-, the HCO_3^- K_S may be fairly judged to be less than 5 mM. The K_m of HCO_3^- has been variously reported, but our recent value is relatively low, 15 mM, in agreement with that cited in (*4*). Why then is it surprising that, with 30 mM HCO_3^- as substrate in the dehydration reaction, the I_{50} of other (competitive) anions is relatively high?

Turning specifically to the Haldane equation, we write the catalytic reaction in simplified form

$$EOH + CO_2 \rightleftharpoons EHCO_3 \rightleftharpoons HCO_3^- + E$$

At constant pH (where k_{cat} is the turnover number)

$$\frac{k_{cat}\,HCO_3^- \times K_m\,CO_2}{k_{cat}\,CO_2 \times K_m\,HCO_3^-} = K_{equil} = \frac{(CO_2)}{(HCO_3^-)}$$

The changes on the left side are dictated by the inhibition mechanism. A given concentration of anion will decrease k_{cat} CO_2 but leave k_{cat} HCO_3^- unchanged. K_m CO_2 will be unchanged, but K_m HCO_3^- will rise. We made this point (*1*). Under the present conditions, with initial (HCO_3^-) considerably higher than its K_m or K_S (see above), this latter change may not be readily apparent in our experiments, since there may be only a small effect on velocity.

The effect of anion inhibition will therefore leave the terms of the numerator on the left unchanged, and alter the terms of the denominator in opposite directions. The result is to preserve the Haldane relation.

Finally, a critical error by Koenig and Brown (end of penultimate paragraph) is to speak, presumably of our experiments, as "conditions of low substrate concentration" . . . where "there is no distinction possible between competitive and noncompetitive inhibition." Reference to our report and to the above show that (S) for HCO_3^- is at least as high, and probably much higher than its K_m or affinity constant. The substrates were chosen in attempts to come reasonably close to physiological situations, and still acquire useful biochemical data.

THOMAS H. MAREN
Department of Pharmacology and Therapeutics, University of Florida College of Medicine, Gainesville 32610

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6. I thank Drs. Joseph Coleman, Raja Khalifah, and David Silverman for continuing discussion of this subject. Also, I thank the authors of the foregoing comment for sharpening my perception of this problem, and the editors of *Science* for allowing 2 weeks for my reply. "Depend upon it, Sir, when a man knows he is to be hanged in a fortnight, it concentrates his mind wonderfully." (Samuel Johnson).

22 September 1976

No Desertification Mechanism

Jackson and Idso (*1*) have stated that there is little justification for the desertification mechanism theory proposed by Otterman (*2*). They argued (*1*) that their own "analysis tends to indicate that the denuding of soil may have thermal and climatic effects just the opposite of those that he [Otterman] has postulated" (*3*). Otterman's hypothesis was triggered by a "sharp demarcation line" seen in a Landsat-1 image of southwestern Israel and northwestern Sinai (*2*). The same line was seen on chromatic and achromatic photographs taken by one of the Apollo 7 astronauts in October 1968 (Fig. 1). Otterman suggested that the line, which coincided with the 1948–1949 armistice line between Israel and Egypt, was an indication of a desertification mechanism: namely, that the Sinai side of the

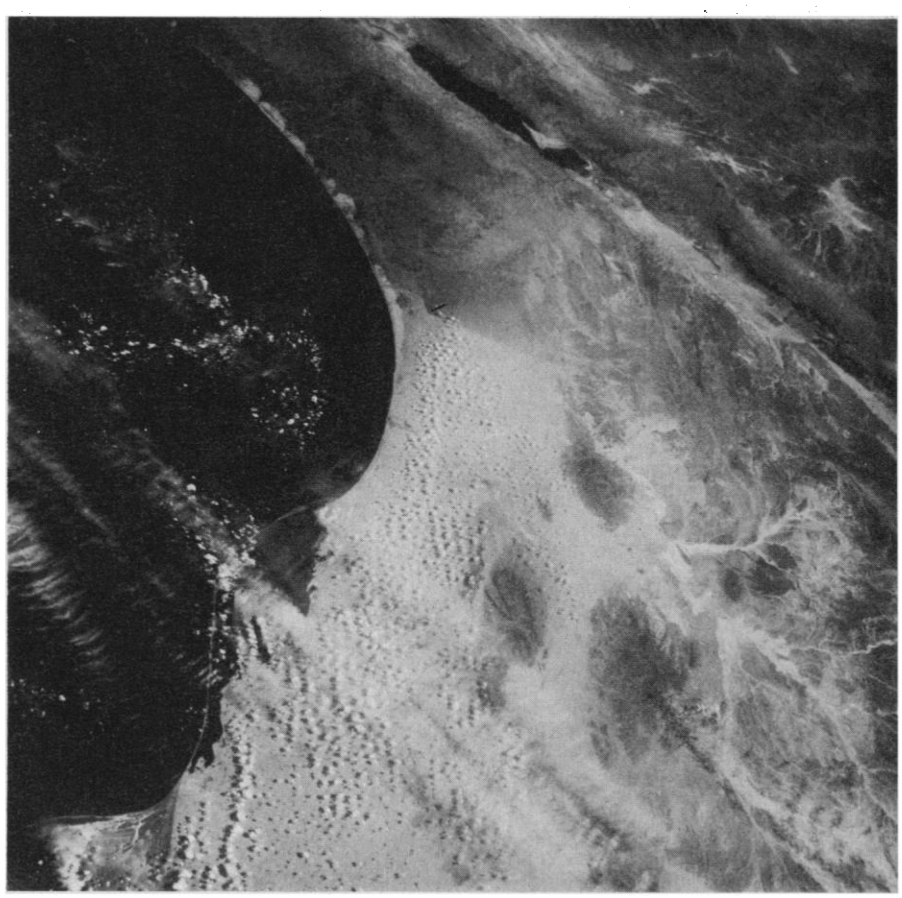

Fig. 1. The Sinai-Negev region: National Aeronautics and Space Administration photograph AS7-6-1696 taken during the 42nd orbit of Apollo 7 at an altitude of 230 km on 14 October 1968 at 11:13 local solar time with a sun elevation of 40°; the demarcation line has the coordinates 30°59′N, 33°55′E.

line is bright on the image because of the reflection of the denuded sandy soil, predominantly as a result of overgrazing by goats, camels, and sheep, on the formerly Egyptian-held territory, whereas the Negev side is dark on the image because of the reflection of soil which has been protected from grazing (there were only a few herds) and because the natural vegetation was relatively abundant (*2*).

Otterman's observation cannot be supported by the local geography (*4*). On the Negev side of that sharp demarcation line, the ground is covered with a thick mobile sand dune complex. These dunes consist of fine to coarse quartz grains (98 to 65 percent fine grains 0.25 to 0.05 mm in diameter; 1 to 34 percent coarse grains 2.00 to 0.25 mm in diameter) (*5*). The topography of the area consists of dune colonies, dune chains, and seif ridges, with sand falls as high as 8 to 15 m (*6*). Holot (sands in Hebrew) Haluza and Holot 'Agur are the local names of these sand dunes which extend over a half million dunams (1 dunam = 1000 m^2) dominated by varieties of *Artemisia monosperma*, with an average ground coverage of less than 5 percent (*7*). The sand dunes were wet on 22 October 1972, the date of the Landsat-1 photo (*8*). The Sinai side of the line, on the other hand, is a typical Hamada limestone-loessy desert pavement, which is the most common type of terrain in the Sinai and the Negev. The Hamadas, El Barth and Atara, consist of limestone rock waste resting on a shallow layer of desert dust loess. Varieties of *Zygophylletum dumosi* dominate this side of the demarcation line, with an average coverage of less than 8 percent (*9*).

The line in question (from 075080 to 036090 Palestine coordinates) (*10*) seems to be just another lithological-ecological natural lineament out of so many that have recently been seen on earth images from space (*11*). This specific lineament was chosen as a political-administrative boundary line as early as 1906 (*12*). In numerous historical circumstances statesmen have perceived physical features as natural boundaries (*13*). The sharpness of the line on the image is a consequence of the photographic generalization, due to the lower limits of the resolution power (*14*).

It would be practical for Otterman to consult the Palestine Series and the Israel Defense Army aerial photographs and topographical maps to determine the nature of the ground on both sides of the demarcation line (*15*). Short and Marrs have pointed out that "promising 'anomalies' must be examined *in the field* [underlined by the authors] rather than in imagery alone in order to distinguish those defined or modified by topography, soil, . . ." if truly anomalous and meaningful information is to be revealed (*16*).

ERVIN Y. KEDAR
Department of Geography, William Paterson College, Wayne, New Jersey 07470

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4. I have carried out a field investigation of the soil and farming ecology of the Negev. Thirty-five maps on the scale of 1:45,000 were published as an appendix in the book [E. Y. Kedar, *The Ancient Agriculture in the Negev Mountains* (Bialek Institute for Sciences, Jerusalem, 1967)]. Maps 09-04/10-04, 09-03, 09-02, and 09-01/10-01 are closely related to the area under question.
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6. E. Orni and E. Efrat, *A Geography of Israel* (Achiasaf, Jerusalem, 1962), p. 47. For a more detailed description of the nature of sand dunes, see K. W. Glemmie, *Desert Sedimentary Environments* (Elsevier, New York, 1970), pp. 99–119.
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8. On 17 October 1972 the area under discussion experienced a rainfall of almost 1 percent of the total annual precipitation. The sand dunes were saturated at the time of the Landsat-1 overpass (the following stations recorded rainfall: Nir-Yzhak, 1.3 mm; Revivim, 1.0 mm; Gevulot, 1.7 mm; and Zeelim, 1.6 mm). The rainfall also reached to: Sede-Boker, 2.2 mm; Avedat, 1.3 mm; and Mitzpe Ramon, 3.1 mm [Z. Gilboa, Document No. 1/001/z-1.30 (Meteorological Service Department of Transportation, State of Israel, 22 October 1975)].
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15. Topographical maps: 1:100,000 scale, Nos. 13, 14, 17, and 18; 1:250,000 scale, No. 1, Sinai and Israel south (Survey of Israel, Ministry of Public Works, Jerusalem, 1973). It seems obvious that no earth photograph from aerial or space platforms can be interpreted correctly without acquaintance with the analyzed terrain; see E. Y. Kedar, *Photogramm. Eng*. **24**, (No. 5), 821 (1958).
16. N. M. Short and R. W. Marrs, in *Abstracts, Earth Resources Survey Symposium* (L. B. Johnson Space Center, Houston, Texas, 1975), pp. 110–112.

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Kedar's suggestion that the space-visible contrast between the bright Sinai and the dark Negev is an inherently lithological lineament along which the Egypt-Palestine boundary was traced is untenable, because of the following considerations:

1) Starting from the point some 13 km from the Mediterranean where the Gaza Strip, the Negev, and the Sinai meet, the Sinai-Negev contrast extends in a straight line across two pedological areas. The line runs for about 5 km across a flat terrain of fine aeolian sands (see Fig. 1). The highest observed contrast occurs here (*1, 2*). The sand dunes of Haluza start 5 km from the point of intersection of the Sinai–Negev–Gaza Strip.

2) Where the line continues across the sand dunes, the dunes are elongated in an east-west direction, nearly perpendicular to the contrast line. The dunes in this area extend on both sides of the contrast line, in the Negev as well as in the Sinai (Fig. 1). The desert pavement area that, according to Kedar, begins at the border actually occurs only well inside the Sinai. The Sinai-Negev contrast occurs along a straight line, within the limitations of the imagery. (When the imagery is enlarged so that individual picture elements are discernible, the contrast appears as a staircase with one-pixel steps.)

3) The contrast is apparent not only between the Sinai and the Negev but also between the Gaza Strip and the Negev (see the left side of the white area near the top in Fig. 1). The continuation of the supposed Sinai-Negev boundary lineament, after making a sharp corner, along the Gaza Strip–Negev boundary would indeed be a strange coincidence.

I thus attribute the contrast observed around the Negev to the anthropogenic pressures in the Sinai and in the Gaza Strip. Similar sharp contrasts have been observed in other parts of the world, where anthropogenic pressures differ sharply across political boundaries (*2*), for example, the Afghanistan–Soviet Union boundary, where the contrast line conforms to the border between the two countries and runs in sections of straight lines. The contrast ratios across this boundary in the four Landsat multispectral scanner bands are essentially equal to the contrast ratios measured in the Haluza sands region. We attribute the effect to uniform overgrazing by sheep (*2*). Inside the Soviet Union, circular "halos" with radii of 4 to 6 km were found around settlements from which the sheep apparently go out daily to graze.

On one count I agree with Kedar—the need for ground-truth observation. I interpreted a dark area bordered by a highway in Australia, somewhat similar to the Negev in its spectral characteristics, to be an animal exclosure. Ground-truth observations indicated that the area in question was a burnt-out terrain, the brush fire having been stopped by the highway. The semi-protected Negev, which has more abundant vegetation than the Sinai, is relatively dark at high contrasts in all the spectral bands of the Landsat scanner, including the reflective infrared, and surprisingly has characteristics of a burnt-out area, characteristics not expected of natural vegetation. This is due to the dark debris littering the surface (*3*).

Recently, data became available that made possible a more quantitative assessment of the role of the debris in the Sinai-Negev area. Surface reflectivities were derived from the Landsat computer-compatible tapes, with the atmospheric effects calculated under assumed representative clear conditions (*4*). In situ measurements were made of the components of the terrain, that is, crumbled Sinai soil (albedo, 0.46), crusted soil, plant debris (albedo, 0.18), and a prevalent plant (*Artemisia monosperma*), by a ground-truth radiometer, operating in the same spectral bands as the Landsat scanner (*5*). The spectral reflectivity of the Sinai terrain is due primarily to crumbled Sinai soil. As for the Negev, if the effects of shadowing are ruled out, the dark debris in the interstices between the sparse plants (*3, 5*) is the only component of the terrain that can cause the low reflectivities.

Two more points made by Kedar require comment. The first concerns the extent to which the effects of a particular rainfall persist. After 1 mm of rain fell on 17 October 1972, percolation and evaporation would leave the surface dried out by 22 October 1972. Darker areas corresponding to moist surface were not observed at the Sinai-Negev demarcation line on 22 October, and the images from the four Landsat passes in the period from October 1972 to January 1973 are very similar, with no moist spots noticeable.

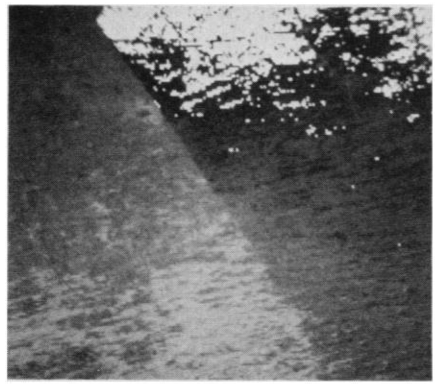

Fig. 1. Landsat multispectral scanner image showing the Sinai-Negev demarcation line (about 15 by 15 km) (photograph of a high-resolution display from the computer-compatible tapes by General Electric Image 100). The white area close to the top is thematic mapping of the darkest part of the Negev, a flat terrain of fine aeolian sands. Sand dunes are visible only in the lower two-thirds of the image as bright streaks from left to right.

The second point is that I do not regard the Landsat imagery as indicating desertification, only as showing a sharp and unexpected increase in the surface albedo as a result of overgrazing and anthropogenic pressures. This observation applies to arid regions where the plants cover only a fraction of the ground area and their direct contribution to the reflectivity of the area is small. Because of the small areal extent and inherently low evapotranspiration of vegetation in the arid regions, the sensible temperatures of protected regions, which have more vegetation but which are primarily debris-covered interstices, can be higher than those of anthropogenically impacted, nearly bare areas, when sun-illuminated (*3, 6*). The increased heating of the atmosphere in the daytime hours, due to the higher sensible temperatures and the more complex debris-covered surface (as compared to the bare crumbled soil), introduces updrafts. The possibility of cloud formation and rainfall then arises if moisture is available. The hypothesized mechanism of desertification, that is, a reduction of rainfall, is thought to have caused a climatic change over most of the Mediterranean region from prehistoric times, especially by reducing the small-scale convection and spotty local rainfall (*7*). Such a desertification mechanism is not directly indicated by the Landsat imagery and as of today remains only a hypothesis.

JOSEPH OTTERMAN*

Department of Geophysics and Planetary Sciences, Tel-Aviv University, Ramat-Aviv, Israel

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* Presently resident research associate, National Academy of Sciences–National Research Council, Goddard Space Flight Center, Greenbelt, Maryland 20771.

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