southerly stations within the province of left coiling. They are abundant, however, in the tops of cores from the province of dextral coiling. The same association is maintained in the time dimension of cores from the province of dextral coiling; species of *Globorotalia* are well represented in sediments layers where the coiling of *Globigerina pachyderma* is dominantly dextral, but they are absent or rare where the coiling is sinistral.

By determining similar vertical changes in coiling percentages of *G. pachyderma* in cores from more southerly stations not shown on the chart it will probably be possible to determine approximately the former position of the boundary between right and left dominant populations, and by inference the most southerly position of the April 7.2°C isotherm during the peak of the last glaciation. This information will make possible an estimation of the amount of temperature lowering that occurred in this part of the North Atlantic during the last ice age.

In the meantime, the present data are at least suggestive. The absence of any zone of right coiling at lower levels in the cores from the province of left coiling implies that this part of the North Atlantic during the late Pleistocene has not at any time been much warmer than it is now. Evidence that the boundary between right- and left-coiling populations was farther south during the last ice age favors the conclusion that continental glaciation was accompanied by general cooling of North Atlantic waters, and particularly within this critical region, rather than by marked change in pattern of circulation. This conclusion supports the hypothesis that Pleistocene refrigeration was a result of reduction in total radiation from the sun and not a consequence of some purely terrestrial cause (6).

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References and Notes

1. H. Bolli, *Contribs. Cushman Foundation for Foraminiferal Research* 1, 82 (1950); *ibid.* 2, 139 (1951).
2. M. Vašíček, *Sborník ústred. ústravu geol.* 20, 345 (1953).
3. D. B. Ericson, G. Wollin, J. Wollin, *Deep-Sea Research* 2, 152 (1954).
4. Y. Nagappa, *Micropaleontol.* 3, 393 (1957).
5. "World Atlas of Sea Surface Temperatures," U.S. Hydrographic Office Publ. No. 225 (1944).
6. This report is Lamont Geological Observatory contribution No. 355. The investigation is being supported by National Science Foundation grant No. NSF-G6540. I am grateful to Maurice Ewing, director of the Lamont Geological Observatory, who made available the material described in this communication. O. L. Bandy, University of Southern California, has informed me that he has a paper in press which also deals with the coiling of *Globigerina pachyderma*. According to Bandy our respective papers will supplement rather than duplicate each other.

9 April 1959

Virus versus Gene Change in Maize

In maize the *Rrr* kernels from a standard RR ♂ × rr ♀ (*R*, self-colored aleurone; *r*, colorless aleurone) are dark-colored. However, Brink (*1*) has found that when plants of genotype RR^{st} (R^{st}, stippled aleurone) are test-crossed on rr ♀, the resulting kernels which receive *R* (from their RR^{st} parent) have aleurone which is weakly-colored mottled. We might indicate these kernels as *R'rr*; the prime indicates *R* of RR^{st} origin, without commitment whether *R'* is different from *R*.

Brink explains the weakly-colored mottled phenotype of *R'rr* kernels on the assumption that in the RR^{st} parent the R^{st} gene causes *R* to mutate, at a 100-percent rate, to a gene ($R^{r:st}$) for weakly-colored mottling (an effect referred to by Brink as "paramutagenesis"). The R^{st} gene itself is apparently unaffected in RR^{st}. When weakly-colored mottled kernels (*R'rr*) from the test cross of the RR^{st} parent are again test-crossed, the resulting *R'rr* kernels are again weakly-mottled. Brink has therefore concluded that *R* is actually altered in the original RR^{st} parent, since the test-cross progeny (*R'rr*) maintain their light color from one generation to the next. On the other hand, when RR^{st} is self-fertilized, the resulting kernels which have at least two doses of *R'* in their aleurone ($R'R'R^{st}$ or $R'R'R$; $R^{r:st}R^{r:st}R^{st}$ or $R^{r:st}R^{r:st}R^{r:st}$, according to Brink's hypothesis), have aleurone almost as dark as that of standard RR plants. Brink has therefore concluded that in the kernels under discussion, his $R^{r:st}$ gene reverts, at a 100-percent rate, almost completely to *R*.

In order to rule out the theory that a virus (or other plasmid element) is causing the changed expression in the *R'rr* kernels, Brink crossed the plants grown from these kernels to standard RR ♂. The resulting *Rrr* kernels would, of course, be the product of an *R* gamete from the RR parent and an *r* gamete from the *R'rr* parent. If the latter (*R'rr*) carried a virus, its *r* gametes might also be expected to carry the virus and to transmit it to the *Rrr* kernels in the cross *R'rr* ♀ × RR ♂. However, these kernels are dark, like *Rrr* of standard origin. Brink has therefore concluded that no virus is involved in the changed expression in *R'rr* kernels (weakly-colored mottled).

However, in my opinion this finding relative to the cross *R'rr* ♀ × RR ♂ does not exclude the possibility that a virus is changing the aleurone from dark red to light in the *R'rr* kernels (those derived from RR^{st} ♂ × rr ♀). Conceivably, two substances, *A* and *B*, are necessary for the continued existence of the virus.

Gene R^{st} produces both and supports the virus; *R* produces *A* but not *B*; *r* produces *B* but not *A*. Moreover, we must assume that the virus rapidly disappears in a cell which lacks *A* but that it may live for a longer time in a cell which lacks *B* but has *A*, or may even linger on for several generations, largely in an inactive state, in plants which have only *A*. The virus therefore could not be transmitted by the *r* gametes of a plant that grew from an *R'rr* kernel, but it could be transmitted by the *R'* gametes. If the latter fertilized an rr ♀ (giving *R'rr* kernels), gene *R* would supply the *A* element and *r*, the *B*. The virus would therefore persist, and the kernels would be light (instead of dark, as they would be in the absence of the virus).

Until further tests, involving properly marked chromosomes have been made, it might be well to suspend judgment on the significance of Brink's RR^{st} case in maize (*2*).

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References and Notes

1. R. A. Brink, *Genetics* 41, 872 (1956); ———, *Records Genet. Soc. Am.* 26, 362 (1957); ——— and W. H. Weyers, *Proc. Natl. Acad. Sci. U.S.* 43, 1053 (1957); R. A. Brink, *Science* 127, 1182 (1958).
2. This study was supported by a grant (C-2393) from the National Institutes of Health, U.S. Public Health Service.

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Reflectivity Spectrum and Optical Constants of Bituminous Coal; Estimation of Aromaticity

Abstract. The spectra of reflectivities, refractive indices, and absorption indices of a bituminous coal vitrain have been determined for the ultraviolet-visible spectral region. The low values for these quantities support the premise that polynuclear condensed aromatics may be present in coal only in small amounts. Aliphatic and amorphous carbons may predominate.

The spectra of specular reflectivities have been determined in the ultraviolet-visible region for Bruceton coal vitrain (*1*), which is 84 percent carbon. Previously, the absorption spectrum in this
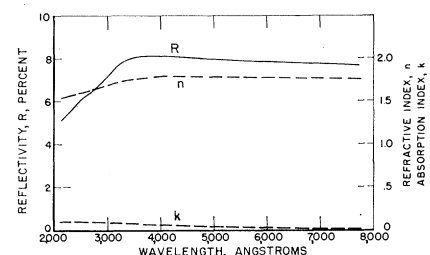

Fig. 1. Ultraviolet-visible spectrum of specular reflectivity and the optical constants, n and k; Bruceton vitrain.

Table 1. Reflectivities (R), specific extinction coefficients (K), and the optical constants, refractive index (n), and absorption index (k), of Bruceton vitrain.

λ (A)	K	k	R (%)	n
7750	0.8	0.006	7.66	1.766
7000	1.2	0.011	7.69	1.767
6000	2.5	0.020	7.75	1.771
5461	3.7	0.026	7.88	1.779
5000	5.4	0.035	7.93	1.781
4000	10.0	0.052	8.11	1.788
3500	14.5	0.066	8.02	1.778
3000	20.0	0.079	7.17	1.715
2750	23.0	0.088	6.49	1.664
2500	24.0	0.086	6.04	1.633
2200	28.0	0.093	5.37	1.583
2150	29.0	0.093	5.13	1.563

region was reported along with calculated absorption indices, k (2); the value for k at 5461 A was found to be appreciably smaller than published values obtained from reflectivity measurements (3, 4). From the reflectivity spectrum (Fig. 1), refractive indices, n, over the entire spectral region have been calculated (Table 1) by Fresnel's equation

$$R = \frac{(n-1)^2 + n^2 k^2}{(n+1)^2 + n^2 k^2}$$

Because of the low magnitude of the absorption indices, this quantity is nearly insignificant in the calculation of refractive indices. However, the interdependence of the two indices was taken into account by successive alternate calculations of refractive indices from the above equation and of the absorption indices from

$$k = \frac{2.303 \, \lambda \, A}{4\pi x n}$$

where λ is the wavelength of light in centimeters, A is the absorbance, and x is the sample thickness in centimeters.

The experimental reflectivity curve remains smooth throughout the spectrum, with no sharp discontinuities. One weak, broad shoulder appears at 2650 A. The reflectivity and refractive index spectra decrease appreciably at short wavelengths in the ultraviolet region. This decrease may be due to changes in absorption properties in this region, but it is more probably due to increased scattering of the coal substance at these wavelengths.

Reflectivity measurements were made on polished pieces of Bruceton vitrain with a Cary spectrophotometer equipped with a specular reflectance attachment; a front-surface aluminized mirror was used as the comparison, and reflectivity values for fused quartz were used as spectral standards.

Aromaticity of coal. In regions of strong spectral absorption, an increase is expected in both the refractive index

and the absorption index, and hence in the reflectivity. In coal, such marked increase in absorption does not occur anywhere in the ultraviolet-visible spectrum (3). As can be seen from the data for reflectivity and refractive index, there also is no substantial increase in these values at any place in the spectrum.

These data are of particular significance in view of the recent reevaluation of x-ray measurements (5) which indicate that the ring sizes of aromatics that may be in Bruceton vitrain should be 1-to-3 and 2-to-4 rings. Thus the possible condensed aromatic nuclei are limited to 2-to-4 rings such as are found in naphthalene, phenanthrene, fluorene, chrysene, and other compounds. The strongest absorptions of all of these are confined to a narrow region of the short-wavelength ultraviolet, so that both reflectivity and absorption should show marked increases with definite spectral fine structure in this narrow region, but they do not. Most of the 16 2-to-4-ring polynuclear condensed aromatics, naphthalene through pyrene, have their strongest band in the region 2100 to 2550 A with K values from 205 (fluorene) to 1230 (anthracene). Five of the 2-to-4-ring group have their maximum absorption band between 2550 and 2750 A with K values from 360 (2,3-benzo-fluorene) to 1640 (naphthacene). On the basis of K values, the allowable percentages of these compounds that could be present in Bruceton vitrain varies from 1.4 to 14 percent. These maximum percentages of individual aromatics are not additive owing to considerable overlapping interference in this short spectral region.

If the principal structures in bituminous coal vitrain are not polynuclear condensed aromatic in nature, the predominant structures may be aliphatic and alicyclic and/or benzenoid. The shortage of hydrogen, oxygen, and other elements may require that the saturated structures contain extensive systems of tetrahedral carbon-carbon bonds—that is, quaternary carbon atoms in diamond-like structures of small size or in amorphous carbon structures like the "vitron" suggested for glass (6).

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References and Notes

1. Vitrain (coals). A separable constituent of bright coal, of vitreous appearance (Chambers's Technical Dictionary, 1953 ed.).
2. R. A. Friedel and J. A. Queiser, *Fuel*, in press.
3. R. A. Friedel, *Nature* 179, 1237 (1957).
4. C. G. Cannon and W. H. George, *Conference on the Ultrafine Structure of Coal* (B.C.U.R.A., London, 1944), p. 290.
5. P. B. Hirsch, paper presented at the Conf. on Science in the Use of Coal, spring meeting of the Institute of Fuel (1958); S. Ergun, *Fuel* 37, 365 (1958).
6. *Natl. Bur. Standards (U.S.) Tech. Bull.* 42, 236 (1958).

24 February 1959

On the Presence of Fixed Ammonium in Rocks

Abstract. From one-fourth to one-half of the nitrogen in some granite rocks, and up to two-thirds of that in some paleozoic shales, occurred as ammonium ions held within the lattice structure of silicate minerals. The results provide greater insight into the origin of the earth's atmosphere.

It has been assumed by many scientists that practically all of the nitrogen in rocks occurs in organic combination. Evidence for this assumption has been based on the fact that only a small fraction of the nitrogen in rocks could be recovered as ammonia or nitrate by leaching with base-exchange reagents. Research conducted recently by my coworkers and me (1, 2) has shown that soils contain considerable amounts of fixed ammonium (ammonium ions held within the lattice structure of silicate minerals), and it seemed reasonable to postulate that some of the nitrogen in rocks is fixed ammonium. The purpose of this study was to test this hypothesis (3).

A procedure based on the ability of HF to remove fixed ammonium from clay minerals has been developed by Dhariwal and Stevenson (1) for the determination of fixed ammonium in soils. This method was modified for the determination of fixed ammonium in rocks. The procedure adopted was as follows: a 0.5- to 1.0-g sample of finely ground rock (100 mesh) was treated with 20 ml of boiling $1N$ KOH for 6 hours. The residue was recovered by centrifugation in a polyethylene tube, washed free of KOH with ammonia-free water, and treated with 10 ml of a solution consisting of $7.5N$ HF and $1.0N$ HCl. For granite rocks, the mixture was transferred to a polyethylene beaker and heated on a hot plate at 80°C to near-dryness. The ammonium released by HF was distilled with alkali into standard acid. The ammonia was estimated colorimetrically, by means of Nessler's reagent.

Total nitrogen in the samples was determined by a micro-Kjeldahl procedure. The digestion time was 3 hours.

The specimens included several Paleozoic shales and granite rocks. The shales were from Illinois. Shales A, B, and C were from Mississippian horizons; shale D was from a Pennsylvanian horizon. Granite rocks A, B, and C were from outcrops. Rock A was from New Hampshire, rock B was from Maine, and rock C was from Vermont (from the Rock of Ages quarry). Granite rocks D, E, and F were Pleistocene boulders from glacial till of Wisconsin age. They were obtained from Vermilion County, Ill. (4).

The total nitrogen and fixed ammonium nitrogen contents of the speci-