scribing objects at right angles to the direction of transport reached at least 15 cm—a limit fixed by the size of the available sandstone blocks. The dimension parallel to the direction of transport, as indicated by the spread of turning points of separate grooves within curved sets (Fig. 1), attained at least 3 cm. The pattern of the grooves within a set does not reflect any regular structure in the scribing objects. Rigid transparent overlays fitted to the points of inflection of grooves in curved sets cannot be moved along the sets, which shows that they were scribed by nonrigid objects (*4*), even though the approximate parallelism of the grooves suggests some degree of rigidity. The short length of some sets, as well as a 10-cm gap in one set where it crosses a trough 2 cm deep in the bedding surface, indicates that the scribing objects were semibuoyant and had a specific gravity at most only slightly higher than that of sea water. The scribing objects were apparently not heavy stones in the holdfast of seaweeds, but drifting organisms—probably algae, perhaps with small stones or sand grains attached. The variety of orientations of intersecting sets, as well as the changes of direction of individual sets, indicate that the objects were moved by random currents or, more probably, waves. Irregular oscillation ripple marks on the upper surface of the sandstone bed suggest wave action. Unlike similar drag marks described by Kuenen (*5*), these marks were not scribed by objects moved by turbidity currents, the absence of which is indicated by lack of either graded bedding or fluted soles in the sandstone bed.

The formation in which these markings occur has been mapped as the Winnall Beds (*6*), which near Henbury are laterally transitional into the Pertatataka Formation. These beds unconformably underlie the Pertaoorrta Formation, which contains Cambrian fossils. A potassium-argon age of 760 ± 33 million years has been obtained on a shale sample of the Pertatataka Formation (*6*). About 200 km from Henbury, Barghoorn and Schopf (*1*) found actual preserved microorganisms (interpreted as filamentous green and bluegreen algae) in the Bitter Springs limestone, several hundred meters stratigraphically below the Pertatataka Formation.

The markings described here fit the definition of drag mark casts (*7*), if the association with turbidites emphasized in the original use of the term (*5*) is not considered essential. They have also been given a variety of Linnaean names by those who regarded them as fossils. The reported range of these forms extends from Cambrian to Recent time (*8*). This find extends the range into the Precambrian and indicates that before the beginning of the Paleozoic era life had evolved beyond the microscopic forms described by Barghoorn and Schopf into organisms as large as much of the seaweed in modern seas.

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1 April 1966

Absence of Short-Term Variability of CTA 102

Abstract. *Short-time variations in intensity of about 40 percent, with a period of the order of 100 days, have been reported for the quasistellar radio source CTA 102 at 32.5-centimeter wavelength. We have observed CTA 102 at 25.5-centimeter wavelength over a 67-day period and have detected no significant variations of intensity.*

Sholomitskii (*1*) has measured rapid variations in the 32.5-cm wavelength emission of CTA 102 during the period from August 1964 to February 1965. The observations indicated that the intensity varies periodically over at least the range 1.39 to 1, with a period close to 100 days. However, Maltby and Moffet (*2*) found no evidence for variations in the intensity of CTA 102 at 31.3-cm wavelength in a number of observations from August 1959 to September 1961. Also, Caswell and Wills (*3*) observed no significant difference in intensity at 168-cm wavelength in measurements in July and August 1964 as compared to measurements in September and October 1964, where the central dates for the two periods differed by only a few days from times of minimum and maximum predicted by Sholomitskii's observations. CTA 102 has been identified with a quasistellar object by Sandage and Wyndham (*4*).

We observed 135 sources, including CTA 102, at 25.5-cm wavelength between 7 October and 13 December 1965 in a program to measure their linear polarizations. Twenty of the sources, including CTA 102, were observed on nearly every day of the 67-day observing period. The remaining sources were observed during either the first or last half of the period.

The measurements were obtained with the National Radio Astronomy Observatory 300-foot (90-m) transit telescope at Green Bank, West Virginia. Two identical radiometers were connected to orthogonal, linearly polarized outputs of a rotatable circular-waveguide feed antenna at the focus of the reflector. The radiometers were the same ones used previously for polarization in the 300-foot reflector (*5*) except that the center frequency for our observations was 1175 Mcy/sec. Each radiometer accepted power in two bands 3.5 Mcy/sec wide, separated by 20 Mcy/sec.

The observations consisted of simultaneous measurements of source antenna temperatures at orthogonal polarizations once each day with the feed antenna orientation fixed. The averages of the uncorrected antenna temperatures measured on two polarizations are plotted in Fig. 1 as a function of date (U.T.) for CTA 102 and the comparison sources 3C 205, 3C 418, 3C 436, and 3C 444. The straight lines in Fig. 1 are least-square fits. Similar plots and least-square fits have been made for all of the sources. Inspection of these plots indicates no change in the intensity of any source that is significant compared to the measurement errors over this relatively short time base. The observations are not sensitive to relatively long period variations such as have been observed in the quasistellar sources 3C 273B, 3C 279, and 3C 345 by Dent (*6*), and in 3C 273B by Maltby and Moffet (*7*).

In particular, inspection of Fig. 1 shows no change in the intensity of CTA 102 for a single observation greater than ± 4 percent from the

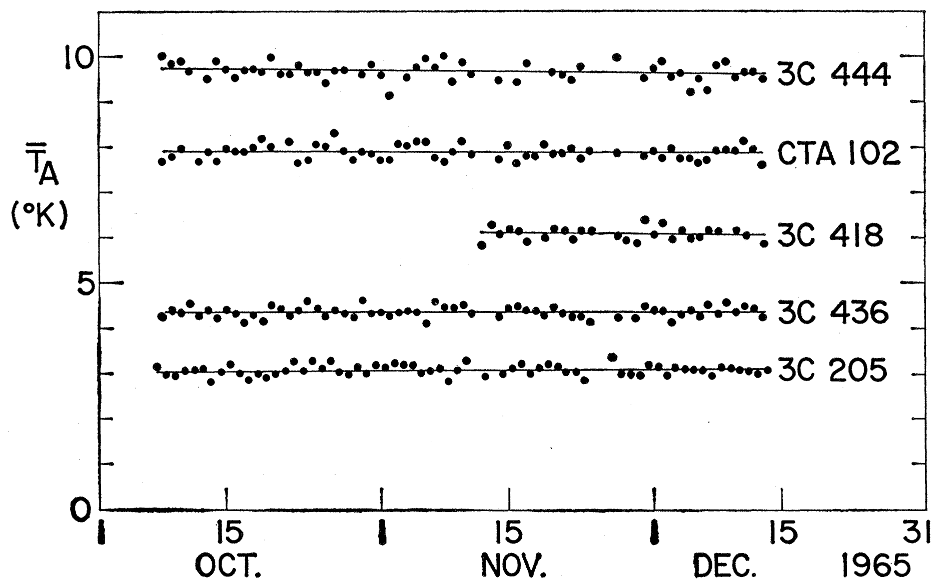

Fig. 1. Averages of antenna temperatures measured on two orthogonal polarizations plotted against date (U.T.) for the sources CTA 102, 3C 205, 3C 418, 3C 436, and 3C 444.

mean, and the least-square results indicate no linear change greater than 1.4 percent per 30 days. The standard deviation of the measurements about the least-square fit is 2 percent of the mean antenna temperature. We consider this proof that there were no significant changes in the intensity of CTA 102 during the 67-day observing period at 25.5-cm wavelength. Our observing period was not long enough to rule out completely changes of intensity of the type reported by Sholomitskii. However, Sholomitskii has shown that his intensity variations can be fitted by a sinusoidal law with a period of about 100 days and an amplitude of ± 23 percent, and our measurements would be sensitive to such variations. Our observations put an upper limit of about ± 4 percent on the amplitude of variations having a 100-day period. Based on Kellermann's flux-density scale (*8*) the observations correspond to a flux density for CTA 102 of (7.2 ± 0.4) × 10^{-26} watt m^{-2} $(cy/sec)^{-1}$, where the error is estimated standard error.

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6 April 1966

Strontium Isotopes in Deep-Sea Sediments

Abstract. *Recent deep-sea sediments, leached of carbonate, have $Sr^{87}:Sr^{86}$ ratios ranging from 0.7044 to 0.7394. Strontium in the detrital sediment has not equilibrated isotopically with seawater strontium. Amounts of strontium-bearing authigenic material in the clay-mineral assemblage are not great enough to mask strontium-isotope ratios inherited from source areas.*

Isotopic studies have provided significant information about the geologic provenance of deep-sea sediments. Chow and Patterson (*1*), measuring $Pb^{206}:Pb^{207}$ ratios in lead, leached with HCl, from deep-sea sediments, found regional variations within the major ocean basins. They suggest that the lead is extracted biogenically from overlying water before complete oceanic mixing occurs; hence, soluble lead supplied to the oceans from each major drainage basin retains its isotopic identity in the marine realm.

Hurley *et al.* (*2*) obtained K-Ar "dates" from deep-sea sediments of the North Atlantic that range from 200 to 400 million years—ages compatible with the old ages of rocks in adjacent continental areas. A Pacific deep-sea sample "dated" at 80 million years reflects the generally younger rocks rimming the Pacific basin.

The purpose of investigating strontium-isotope ratios in deep-sea sediments is threefold: (i) to establish geologic provenance for deep-sea sediments, (ii) to distinguish between authigenic and detrital components of deep-sea sediments, and (iii) to explore the possibility of dating material recovered from deep penetrations of the marine sediment column, such as the Mohole, by the Rb-Sr method.

The $Sr^{87}:Sr^{86}$ ratios herein reported were obtained from the tops of cores raised by Lamont Geological Observatory. Chow and Patterson's lead-isotope provenance maps and Biscaye's (*3*) clay-mineral distribution data for Recent sediments were used to select the samples for this reconnaissance study. Biscaye's work indicates that continental weathering, rather than authigenic mineral formation, is the dominant factor controlling the mineralogy of Atlantic deep-sea sediments. Strontium-isotope differences in the detrital, aluminosilicate fraction of deep-sea sediments, therefore, must result from differences in provenance unless equilibration with sea-water strontium has occurred. The long residence time of strontium in the sea results in a nearly homogenous $Sr^{87}:Sr^{86}$ ratio of about 0.709 for sea water (*4*). If any component of the aluminosilicate fraction is authigenic, diagenetically altered, or otherwise modified isotopically by sea-water strontium, its presence will subdue differences due to provenance.

Calcium carbonate was dissolved from the sediments with a buffered solution of acetate and acetic acid (*5*). Calcium carbonate–rich sediments of the deep sea contain about 2200 parts per million strontium, whereas the non-carbonate or "clay" fraction contains about 50 to 250 ppm (*6*). Biogenically deposited calcium carbonate incorporates strontium that is isotopically identical with strontium in sea water; thus a small amount of calcium carbonate analyzed with the sediment