Reports

Discrete Light Sources Observed by Satellite OSO-B

Abstract. *A comparison is made between the intensities, as measured by satellite OSO-B, of various discrete light sources on the earth (lightning, city lights, flare gas from oil wells).*

The experiment on the orbiting solar observatory satellite (OSO-B) was designed primarily to measure zodiacal light and the continuum airglow. Of the four photometers, three monitored in the same direction and were sensitive to astronomical visual, blue, and visual + blue light, respectively; the other photometer, which was sensitive to visual + blue, observed in the opposite direction. The technique has been described (*1*) along with some of the results of the airglow observations. In addition to these observations, the four photometers detected a number of other discrete light sources. We now report on these.

At various times during the 9-month life of OSO-B, other satellites passed through the 10° field of view of the photometers. Although these satellites could only be detected during the few minutes after sunset and before sunrise (as viewed by OSO-B), when the satellite in view was illuminated by sunlight, a total of ten such observations were made. In principle, each satellite could be identified but, as it was improbable that use could be made of the identification (for example, as a calibration source), this was not done. The visual magnitude of these satellites as seen from OSO-B ranged from −1.0 to +2.5, the color index being that of sunlight (0.6).

When the photometers viewed earthward during the night, they often detected the occurrence of lightning storms (*2*). Identification as lightning was facilitated by examination of the exponential decay of the signal after each stroke (amplifier time constant). The lightning was usually associated with large cloud systems which could be seen in the reflected light of the airglow.

The photometers were also sensitive to the lights of cities. The observed cities were concentrated in the United States. The sparsity of cities detected on the Asian continent was unexpected, since the scanning time at each latitude should generally be independent of longitude. The dearth of cities recorded on the eastern seaboard of the United States and in South America arises from the fact that data cannot be recorded during the 5.5-minute telemetry of each orbit. The four NASA STADAN (Satellite Tracking and Data Acquisition Network) stations are located at approximately the same longitude, from Fort Myers, Florida, in the north to Santiago, Chile. The positions of certain isolated cities could be used as a check upon the accuracy with which the satellite orientation is known (1° in right ascension and declination). When the city lights were seen by both telescopes 2 (visual) and 3 (blue), a color index could be obtained. Typical color indices for a city ranged from 1.2 to 1.8. A number of very bright lights were seen in areas where no cities were known, particularly in North Africa and the Persian Gulf. However, the color index of these lights, some of which were as bright as the brightest cities, was in the range of 2.5 to 2.9. That these are the burn-off of waste gases from the oil wells in those areas is now apparent. However, these flare gases are of potential commercial value and, within a few years, liquefaction and export will replace the present burn-off (*3*). The positions of the cities and oil wells detected by OSO-B are shown in Fig. 1. All of the sources that were clearly indicated are now marked as cities unless the color index showed that they were too red for that designation. For this reason some of the points may be falsely indicated as cities. The 10° field represents an uncertainty of only ± 0.5° (latitude or longitude) when the satellite views a source on the earth's surface from directly overhead; when the viewing is oblique the error may be considerably larger.

The Mercury and Gemini astronauts have not reported sighting of such flare gases simply because the orbits of these spacecraft precluded passing over North Africa during the night. The flare

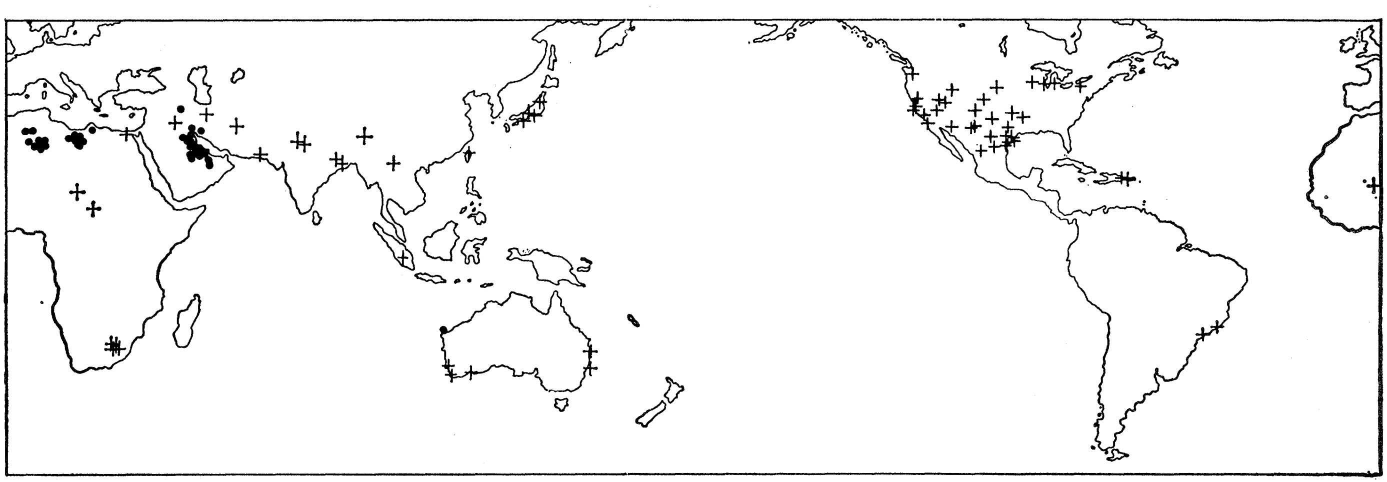

Fig. 1. Positions on the earth's surface of cities (crosses) and flare gases (dots) detected by OSO-B.

Table 1. Color indices and intensities (based on a 1000-Å band centered in the visible spectrum) of light sources observed by OSO-B.

Entry	Color index (mean)	Intensity (visual, 1000 Å)
Continuum airglow	1.2	1.2×10^4 photon cm^{-2} sec^{-1} deg^{-2}
5557 Å airglow		7×10^3 photon cm^{-2} sec^{-1} deg^{-2}
Zodiacal light at ecliptic pole	0.6	5×10^3 photon cm^{-2} sec^{-1} deg^{-2}
Integrated starlight, 30° galactic latitude*		7×10^3 photon cm^{-2} sec^{-1} deg^{-2}
City (Johannesburg)	1.5	4×10^{23} photon sec^{-1}
Flare gas (Marada, Libya)	2.7	10^{24} photon sec^{-1}
Lightning stroke		10^{21} photons

* Mean

gases, being so red (the red star Betelgeuse has a color index of 1.85) should easily be identified as such, should there be opportunity to see them in the future. Table 1 gives approximate values of the color index and intensity of the discrete light sources and some diffuse sources also seen by the telescopes.

From observations of the lights from various cities in the U.S. on nights apparently clear of clouds, an estimate may be obtained of the light intensity per unit of population density. The visual light emitted is of the order of 6×10^{23} photon/sec per 10^6 people (0.2 watt per person, compared to the average total consumption of electrical power of 500 watts per American). An extrapolation of this estimate to the light emitted by the entire country (population 2×10^8) gives 10^{26} photon/sec. To an observer viewing the nighttime earth from deep space, the light intensity from U.S. cities would be approximately the same as that from the airglow.

Table 1 shows that the light emitted per second from a typical gas flare is about the same as that from a single lightning stroke. Since there are about ten lightning strokes per second over the nighttime earth (*2*), the total light emitted from these is probably not more than that emitted by all the gas flares in North Africa and considerably less than that emitted skyward from U.S. cities. A typical flare stack issues 10^{24} photon/sec in the visual region or 4×10^5 watts. If we assume an efficiency for light production of 10^{-3}, the total power consumed is 4×10^8 watts. By comparison, the total consumption of electrical power in the State of California in the year 1963 was 9×10^9 watts (*4*).

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References

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Triassic Amphibian from Antarctica

Abstract. *A fossil bone fragment—the first record of tetrapod life from Antarctica—was found near Graphite Peak in the upper Beardmore Glacier area (85°3.3'S; 172°19'E). The fragment was embedded in a pebbly quartzose sandstone, probably of fluvial origin, in the lower part of the Triassic Fremouw Formation (as yet undefined), which contains* Dicroidium *in the upper part. The fossil horizon is only 76 meters, stratigraphically, above the* Glossopteris-*bearing Buckley Formation, a coal-bearing sequence of Permian age. The bone fragment is the back portion of a left mandibular ramus of a labyrinthodont amphibian. This identification is based on the characteristic labyrinthodont external surface sculpturing, with indications of "mucous grooves," as well as on other osteological features.*

Striking similarities in the Upper Paleozoic and Mesozoic geology between continents of the Southern Hemisphere have been noted by numerous geologists over the last 40 years or so, and these similarities have influenced many toward the hypothesis of continental drift. Perhaps the major paleontological difference heretofore remaining between Antarctica and the neighboring continents has been the apparent absence of tetrapod remains in the Paleozoic and Mesozoic Beacon strata of Antarctica. This report records the discovery of the posterior portion of a lower jawbone of a labyrinthodont amphibian in sandstone of probable Triassic age in the upper Beardmore Glacier area of the central Transantarctic Mountains (Fig. 1) by one of us (P.J.B.) on 28 December 1967. Identification of the specimen was confirmed by Donald Baird of Princeton University.

The bone was found at 85°3.3'S and 172°19'E, at an elevation of 2780 m, about three-quarters of the way up a west-facing ridge 4 km west of Graphite Peak (Figs. 1 and 2). Stratigraphically, the bone comes from 76 m above the base of a new unit that will be named the Fremouw Formation, a unit 600 m thick consisting mainly of sandstone and greenish gray mudstone, which disconformably overlies the Buckley Formation and underlies the Falla Formation (Table 1) in the Beardmore area.

The precise location of the find was 1 m below the top of a coarse-grained, quartzose sandstone unit, 16 m thick, in an extensive pebbly lens generally less than 1 m thick. The sandstone unit dips at 23° to the southeast and forms the higher of two hogbacks on the ridge. The bone-bearing pebbly lens is exposed over about 20 m^2; this and other pebbly strata within the sandstone were searched for about 3 hours, and, although no further vertebrate remains were found, the internal mold of a gastropod was discovered at the upper contact of the unit.

In the Beardmore Glacier area subhorizontal strata of the Beacon sequence rest on an erosion surface of low relief cut in a Lower Paleozoic and Precambrian basement complex. The Beacon stratigraphy was first formally defined in 1963 (*1*), but recent field work by expeditions from Ohio State University (*2*) has resulted in a more detailed stratigraphic subdivision into seven formations (Table 1). The sedimentary strata, which are now known to be 2500 m thick in this area, have been intruded by dolerite sills with an aggregate thickness of about 1000 m and are overlain by tholeiitic basalt flows of Jurassic age (*3*).

The sedimentary section near Graphite Peak, which had previously been visited briefly and described (*4*), begins above a 200-m slope of dolerite rubble with the Buckley Formation, which