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^{24} 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*).

J. G. SPARROW
E. P. NEY
School of Physics and Astronomy, University of Minnesota, Minneapolis

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17 May 1968

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*).

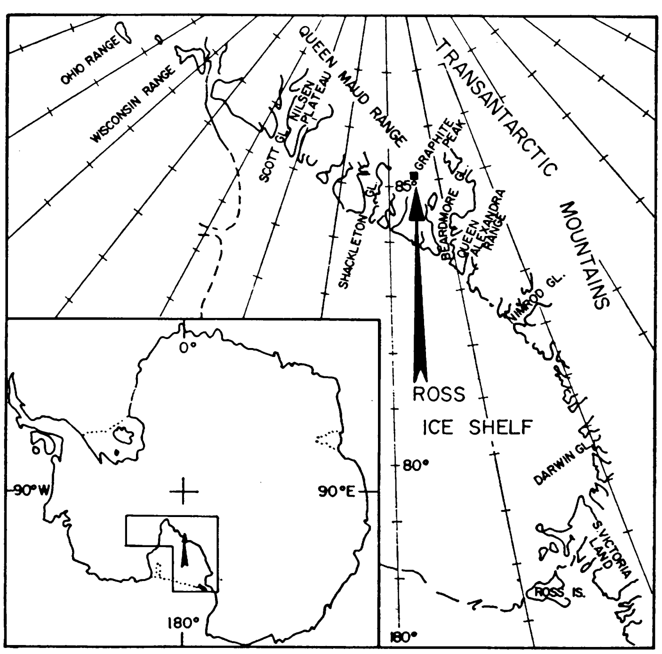
The sedimentary section near Graphite Peak, which had previously been visited briefly and described (*4*), begins above a 200-m slope of dolerite rubble with the Buckley Formation, which here includes 60 m of sandstone containing plant stems and silicified wood, overlain by 230 m of mainly medium gray (weathers very light gray) claystone with minor sandstone, siltstone, and graphitic coal. *Glossopteris* leaves, which in the absence of Triassic plants may be taken to indicate a Permian age, were found at a number of levels and as high as 4 m from the top of the formation.

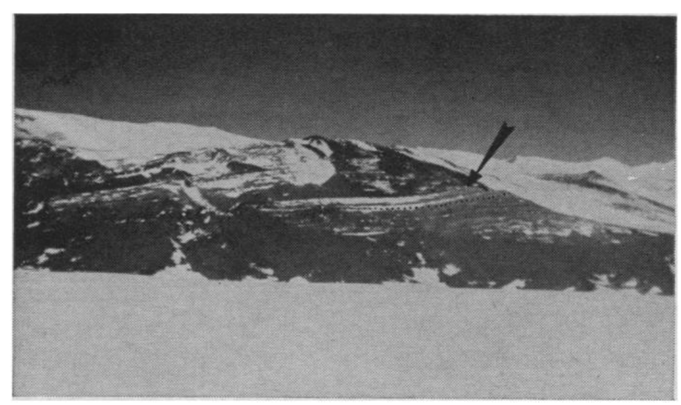
The Fremouw Formation, in which the bone fragment was found, overlies the Buckley Formation at Graphite Peak with a sharp, probably disconformable contact, and is truncated 420 m above the base by the dolerite sill that caps Graphite Peak. The formation throughout the Beardmore area is characterized by greenish gray mudstone, although quartzose sandstone (like that in which the bone was found) dominates the lower 50 to 150 m, and lithic sandstone the upper 200 to 300 m. The mudstone and associated beds are noncarbonaceous in the lower part of the formation, in marked

Table 1. Stratigraphy of the Beardmore Glacier area, based on sections in the Queen Alexandra Range.

Age	Formation	Description	Thickness (m)
		Ferrar Group	
Jurassic	Kirkpatrick basalt	Tholeiitic flows, rare shale lenses with conchostracans, ostracods	600
	Ferrar dolerite	Numerous sills and a few dikes	Circa 1000
	Prebble * †	Volcanic mudflows, agglomerate, tuff and tuffaceous sandstone	0–500
		Beacon sequence	
Triassic	Falla ‡	Sandstone, light and dark gray shale, *Dicroidium*; tuff dominates upper part	160–530
	Fremouw *	Quartzose and lithic sandstone, greenish gray mudstone; logs, coal, and *Dicroidium* near top of unit	620
Permian	Buckley ‡	Lithic sandstone, light and dark gray shale, coal, *Glossopteris;* rounded white quartz pebbles at base of unit, and at several higher levels	Circa 750
	Fairchild *	Massive arkosic sandstone	160
	Mackellar	Dark shale and fine sandstone	90
	Pagoda	Tillite, sandstone, shale	120
Devonian (?)	Alexandra	Orthoquartzite, sandstone	Circa 400
Lower Paleozoic and Precambrian		Thick, folded, low-grade, metasedimentary sequence intruded by granite	

* New formation, not yet defined. † Possibly Late Triassic in age. ‡ Formation to be redefined.





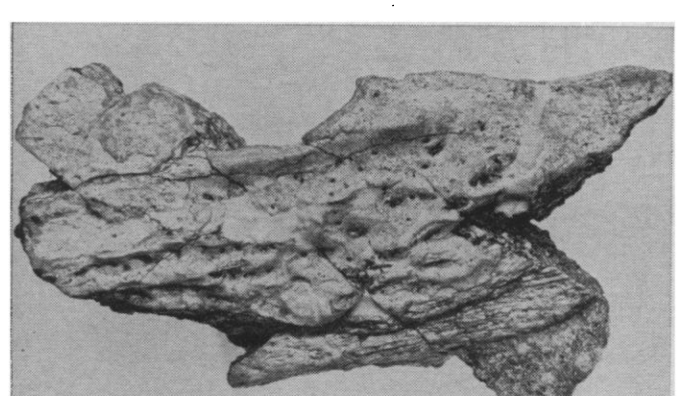


Fig. 1 (left). Central Transantarctic Mountains, with area of fossil site indicated by arrow. Fig. 2 (upper right). Section near Graphite Peak, looking south. Dotted line is the Buckley-Fremouw contact. Fossil site is shown by arrow. Fig. 3 (lower right). Posterior part of left mandibular ramus of labyrinthodont amphibian, external lateral view (1.3 times natural size). [American Museum of Natural History, New York] contrast to the mudstone and shale in the underlying Buckley Formation, but from about 300 m above the base of the Fremouw Formation at Graphite Peak, as at most other sections, the remains of stems (possibly *Neocalamites*) and roots are common. At the proposed type section (Fremouw Peak, central Queen Alexandra Range) 30 m below the top of the formation, the plant assemblage includes *Dicroidium odontopteroides* (*5*), indicating a Triassic age.

From the paleobotanical evidence an Early or Middle Triassic age for the bone-bearing strata is thought most likely, although a Late Permian age is possible.

The fragment of bone with which this report is concerned is not very large, being about 7 cm long, 3 cm high, and 2 cm wide. It is identified here as the back portion of the left mandibular ramus of a labyrinthodont amphibian.

The external surface of the bone, in this fragment composed of the surangular, is very rugose, with a pattern quite typical for a labyrinthodont. There are two discernible grooves with pits, one running from the dorsal edge of the bone forwardly and down, the other branching from this beneath the glenoid and running more or less horizontally to the front of the bone fragment. The obliquely directed groove is identifiable as the sulcus mandibularis, according to an earlier nomenclature (*6*), the other one being the sulcus oralis. The glenoid articulation of the articular bone is preserved on the outer surface of the bone; its inner portion is, however, missing. Along the ventral edge of the surangular, externally, is the squamous articulation for the angular bone.

There is a very large retroarticular process, partially preserved, and on the internal surface of this part of the bone are the lines of sutural articulation of the prearticular bone. At the very posterior edge of the bone fragment, internally, is a part of the foramen chorda tympani, evidently placed along the junction between the prearticular and surangular.

Anterior to the semicircular glenoid is the posteriormost part of the adductor fossa. This contains two, large, deep surangular foramina, in front of the glenoid and directed back beneath the articular. There is a small foramen lateral to each of these large foramina. This empirical description of the bone outlines briefly its salient osteological characters. The importance of the discovery of a Triassic tetrapod on the Antarctic continent can hardly be overemphasized. It bears upon the past relations of that continent to other southern land masses, as well as upon the zoogeographical relations of Triassic tetrapod faunas. Now, for the first time, there is direct evidence of land-living vertebrates inhabiting the Antarctic continent in a rather remote geologic period. And where one fragment has been found, there is every reason to think that, with diligent search, more fossils can be obtained.

In larger aspect, an assemblage of Antarctic Triassic tetropods, if found, will strengthen the evidence, now foreshadowed by this first discovery, of a land connection permitting Triassic tetrapods to migrate between Antarctica and some of the other southern continents. Its bearing upon the Triassic zoogeography of the Southern Hemisphere, and the very close affinities now recognized between the Triassic tetrapods of southern Africa and those of Brazil and Argentina, is obvious. Moreover, such an assemblage, if found, will be viewed against the background of Antarctic Gondwana plants (*7*).

PETER J. BARRETT
RALPH J. BAILLIE
Institute of Polar Studies, Ohio State University, Columbus 43210
EDWIN H. COLBERT
American Museum of Natural History and *Columbia University, New York*

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31 May 1968

Meteoroid Hazard near Moon

Abstract. *The meteoroid experiments by five Lunar Orbiters have provided direct measurements in the near-lunar environment of the rate of penetration of 0.025-millimeter beryllium copper by meteoroids. Each experiment used 20 pressurized-cell detectors having a total effective exposed area of 0.186 square meter. The spacecraft carrying the cells were in both equatorial and polar orbits; altitudes ranged between 30 and 6200 kilometers. Data collected continuously for 17 months indicate that the rate of penetration in the lunar environment is approximately half the rate in the near-Earth environment as measured by detectors of the same type aboard Explorers 16 and 23.*

Penetrations by meteoroids were measured by five Lunar Orbiters for assessment of the hazard to the pressurized camera system, and for comparison of the rate of penetration (of a metal skin) in the vicinity of Moon with rates measured near Earth. Such measurements would also help to determine the protection required for spacesuits, instruments, and spacecraft on the Apollo mission.

Estimates of the hazard near Moon have varied by several orders of magnitude; they have ranged from somewhat less to greater by several orders of magnitude than the hazard near Earth. A major uncertainty is the contribution by secondary meteoroids created by impacts of primary meteoroids on Moon.

Before the Lunar Orbiters the only measurements by satellites of meteoroid flux near Moon were made by Luna 10 with piezoelectric detectors that were sensitive to particle impacts; impacts were recorded at altitudes between 355 and 1050 km, the average rate of 4×10^{-3} m^{-2} sec^{-1} exceeding the average for interplanetary space by about two orders of magnitude (*1*).

The Lunar Orbiters carried pressurized-cell detectors like the ones flown near Earth aboard Explorers 16 and 23. Each is a pressurized semicylinder with a pressure-sensitive switch; the cylindrical surface of the detector is the test material, 0.025-mm beryllium copper. Gas pressure holds the switch closed, but when the pressure is released by puncture of the test material the switch returns to open and stays in this position as a permanent record