References and Notes

1. M. Sonenberg, *Vitamins Hormones* **16**, 205 (1958).
2. A. Albert, *Ann. N.Y. Acad. Sci.* **50**, 466 (1949).
3. J. B. Field, I. Pastan, P. Johnson, B. Herring, *J. Biol. Chem.* **235**, 1863 (1960).
4. J. B. Field, I. Pastan, B. Herring, P. Johnson, *Biochim. Biophys. Acta* **50**, 513 (1961).
5. J. B. Field, I. Pastan, P. Johnson, B. Herring, *Biochem. Biophys. Res. Commun.* **1**, 284 (1959).
6. J. A. Pittman, W. E. Martindale, C. E. Pierce, *Clin. Res.* **9**, 52 (1961); I. Pastan, B. Herring, P. Johnson, J. B. Field, *J. Biol. Chem.* **236**, 340 (1961).
7. J. A. Pittman, W. E. Martindale, C. E. Pierce, unpublished data.
8. I. Pastan and J. B. Field, *Endocrinology* **70**, 656 (1962).
9. Supported by an NIH special research fellowship to F.A.Z.

13 February 1963

Glauconite from the Precambrian Belt Series, Montana

Abstract. *Glauconite from the upper part of the Missoula Group of the Belt Series, Flathead County, Montana, has been dated at 1070 million years by potassium-argon and rubidium-strontium analyses. This is the first glauconite of Precambrian age reported in North America.*

The assignment of the Belt Series to the Precambrian has been generally accepted. The age of the uppermost beds of the Missoula Group of the Belt Series in Montana, however, has been questioned by Nelson and Dobell (*1*), who suggest that these beds may be Cambrian.

Glauconite from the upper part of the Missoula Group and within a few thousand feet of the Middle Cambrian Flathead Quartzite, the oldest known Paleozoic formation in the section, gives similar K-Ar and Rb-Sr ages that average 1070 million years (Table 1). This is considered a minimum age for the Precambrian Missoula Group.

The glauconite occurs as dark-green pellets in a pink and dark-green spotted, medium-grained, feldspathic quartzite that was sampled (Fig. 1) at an elevation of 6000 feet on the east flank of the ridge between Ringer and Cruiser mountains in the southeast corner of the Marias Pass quadrangle, Flathead County, Montana.

The glauconite pellets are typical aggregates of crystallites that show low order interference colors. Structurally the mineral is a partially disordered 1M-mica polymorph, as is shown by the broadness of the x-ray peaks and by the poor resolution of some principal peaks of ordered 1M-mica. Interlayering of the mica-montmorillonite type is suggested in the x-ray pattern of a sample treated with ethylene glycol. Expanded layers are estimated at 10 to 15 percent, based on Weaver's (*2*) method and data. The partially disordered 1M-mica structure is considered a good indication that the rock has not undergone severe metamorphism.

The principal minerals in the glauconite-bearing quartzite are quartz, K-feldspar, plagioclase, chlorite, and barite. Minor constituents include hematite, apatite, and a carbonate. Chlorite occurs in pellets and appears to be an iron-rich type. Barite is a secondary mineral and apparently is fairly widely distributed in the rocks of the Missoula Group in the Flathead region.

Analytical data for the K-Ar and Rb-Sr ages are given in Table 1. The Ar^{40} and Sr^{87} reported are radiogenic. The glauconite, outgassed overnight at 75°C, required a correction for atmospheric Ar^{40} of about 1 percent. The Sr^{87} represents approximately 40 percent of the total Sr^{87}. The analyzed sample contains chlorite, quartz, and K-feldspar as impurities. The K-feldspar is estimated at 1 to 2 percent, and should not affect the determined age appreciably.

Although the Belt Series occurrence is the first Precambrian glauconite reported in North America, a number of glauconite samples dated at 1000 million years or more have been reported from the U.S.S.R. and China (*3*). No mineralogical data are given for these glauconites; however, the K-Ar ages given by Polevaya, Murina, and Kazakov (*3*) range to 1260 million years. A sample from the Sinian of Hopei Province, China, was dated at 1040 million years. Three samples from the Murmansk-Kola region range from

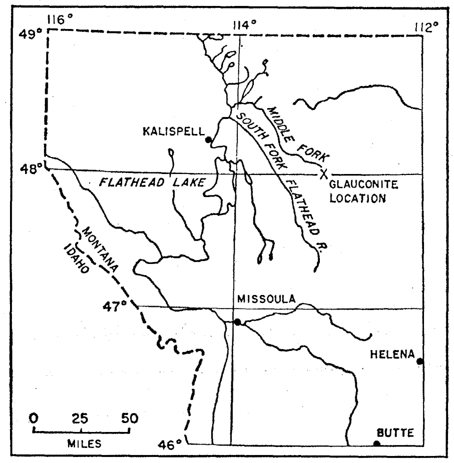


Fig. 1. Map of western Montana showing location of glauconite sample.

1020 to 1060 million years. Seven samples from the southern Urals range from 570 to 1260 million years, and six samples from Siberia show a similar range of 502 to 1260 million years. The K_2O content of the glauconite samples is variable, ranging from 3.0 to 7.7 percent and averaging 5.9 percent. Argon was determined volumetrically and tested for purity with a mass spectrometer. This method has been abandoned in this country in favor of the isotope dilution technique. The results are particularly interesting in their promise of a method for correlating the Precambrian nonfossiliferous strata.

Although the U.S.S.R. glauconite ages appear to fit the geological time scale (*4*) rather well, such agreement is not common for glauconite samples dated in this country. Summaries of the extensive studies of glauconite in various laboratories are given by Hurley *et al.* (*5*), Folinsbee *et al.* (*6*), and Evernden *et al.* (*7*). Many of the K-Ar ages for glauconites appear to be satisfactory; however, more commonly the ages are too low. Hurley *et al.* (*5*) found that the glauconite results may be 10 to 20 percent lower than ages measured for micas from igneous rocks whose positions can be reasonably determined stratigraphically.

In view of the uncertainty of the isotopic ages for glauconites, the age of 1070 million years for the Belt Series sample should be considered a minimum age. This age, however, is considerably greater than that reported by Goldich *et al.* (*8*) for illite from the Siyeh Limestone of the Belt Series. The 2M-illite from a light-green shale bed near the top of the Siyeh Limestone, Logan Pass, Glacier Park, Montana, gave a K-Ar age of 740 million years.

Table 1. Age determinations for Belt Series glauconite, by K–Ar and Rb–Sr analyses (*13*). Ages are given in millions of years.

K–Ar analysis			Rb–Sr analysis			
K_2O (%)	Ar^{40} (ppm)	Age	Rb (ppm)	Sr (ppm)	Sr^{87} (ppm)	Age
8.36	0.733	1090	294	22.2	1.30	1050

Constants: K^{40}, $\lambda\varepsilon = 0.585 \times 10^{-10}$ per year, $\lambda\beta = 4.72 \times 10^{-10}$ per year. $K^{40} = 1.22 \times 10^{-4}$ gm/gm K. Rb^{87}, $\lambda\beta = 1.47 \times 10^{-11}$ per year. $Rb^{87} = 0.283$ gm/gm Rb.

The Rb-Sr age was originally reported at 780 million years, but if calculated with the constant used in this paper (Table 1) the revised age is 730 million years.

Eckelman and Kulp (*9*) arrived at a U-Pb age of 1190 million years for pitchblende from the Sunshine Mine from the Coeur d'Alene district of Idaho, giving a minimum age of approximately 1200 million years for the Belt Series rocks. The K-Ar age of 1200 million years for phyllites in the Coeur d'Alene district reported by Goldich (*10*) is erroneous and should be ignored. Hunt (*11*) reports some K-Ar ages that were completed recently by H. Baadsgaard for micas and amphiboles from the Purcell sills in Belt rocks in British Columbia, Canada, and in Montana. The mica ages are all considerably less than 1000 million years, the oldest being 844 million years; however, two samples of amphibole and a whole-rock sample of hornfels fall within a narrow range of 1070 to 1110 million years. In addition, two amphiboles give surprisingly high ages of 1400 and 1580 million years. If the latter ages are satisfactory, the glauconite age for the Missoula Group may be considerably low.

A more detailed mineralogic and geochronologic study of glauconite and related minerals of the Belt Series of Montana is now in progress (*12*).

R. A. GULBRANDSEN
U.S. Geological Survey, Menlo Park, California

S. S. GOLDICH
H. H. THOMAS
U.S. Geological Survey, Washington, D.C.

References and Notes

1. W. H. Nelson and J. P. Dobell, *U.S. Geol. Surv. Bull.* **1111-F**, 189–235 (1961).
2. C. E. Weaver, *Am. Mineralogist* **41**, 202 (1956).
3. N. I. Polevaya, G. A. Murina, G. A. Kazakov, *Ann. N.Y. Acad. Sci.* **91**, 298 (1961).
4. J. L. Kulp, *Science* **133**, 1105 (1961).
5. P. M. Hurley, R. F. Cormier, J. Hower, H. W. Fairbairn, W. H. Pinson, Jr., *Bull. Am. Assoc. Petrol. Geologists* **44**, 1793 (1960).
6. R. E. Folinsbee, H. Baadsgaard, J. Lipson, *Rept. Intern. Geol. Congr. XXI Session, Norden*, pt. III, 7 (1960).
7. J. F. Evernden, G. H. Curtis, J. Obradovich, R. Kistler, *Geochim. Cosmochim. Acta* **23**, 78 (1961).
8. S. S. Goldich, H. Baadsgaard, G. Edwards, C. E. Weaver, *Bull. Am. Assoc. Petrol. Geologists* **43**, 654 (1959).
9. W. R. Eckelman and J. L. Kulp, *Bull. Geol. Soc. Am.* **68**, 1117 (1957).
10. Reported in A. Long, A. J. Silverman, J. L. Kulp, *Econ. Geol.* **55**, 645 (1960).
11. G. Hunt, *J. Alberta Soc. Petrol. Geologists* **10**, 438 (1962).
12. Publication authorized by the director, U.S. Geological Survey.
13. Analysts for K-Ar were H. H. Thomas and C. O. Ingamells; for Rb-Sr, C. E. Hedge and F. A. Walthall.

14 March 1963

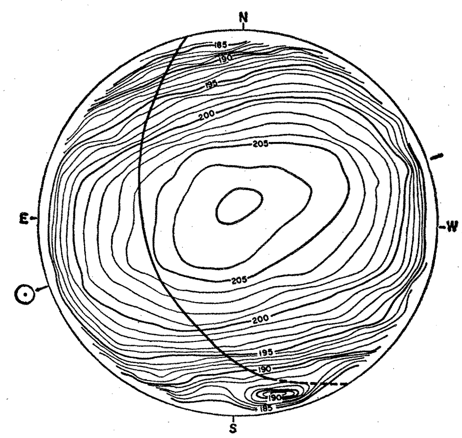
Venus: A Map of Its Brightness Temperature

Abstract. *The 200-inch Hale telescope has been used to make high-resolution maps of the brightness temperature of Venus at wavelengths 8 to 14 microns. Resolution of about 1/30 of the disk reveals a general symmetry about the plane of the orbit, no day-night temperature effects, and a transient temperature anomaly in the southern hemisphere.*

Interest in the planet Venus has been heightened by the successful return of data from man's first planetary probe, Mariner II. Exciting new observations of Venus have also been made recently with large ground-based optical and radio telescopes and radar systems. We now report on high-resolution observations, made with the 200-inch Hale telescope at Palomar Mountain on the mornings of 13, 14, 15, and 16 December 1962, of infrared radiation emitted from Venus.

Infrared radiation is transmitted through the earth's atmosphere in a "window" of wavelengths 8 to 14 microns. We used a special photometer incorporating a mercury-doped germanium photoconductive detector cooled with liquid hydrogen (*1*) to measure the intensity of the 8 to 14 micron radiation emitted from Venus as collected and imaged by the telescope. The photometer was mounted at the *f*/16 focus in the east arm of the yoke. The focal plane aperture we used restricted the circular field of view through the telescope to a diameter of 1.5 seconds of arc, or about 1/30 the planetary diameter. The image of Venus was scanned by moving the telescope in right ascension at successive declination settings and thus building up a series of parallel profiles of output voltage deflections. By using the instrumental calibration curve and allowing for assumed atmospheric transmission losses, we converted the deflections into brightness temperatures. Such brightness temperatures are not unambiguously relatable to the actual kinetic temperature distribution because the sources of opacity and the energy transport mechanisms (time-dependent case) are not well known.

The strong limb-darkening obvious in Fig. 1 and also in the maps made on the other three nights is evidence that the emergent radiation comes from a range in depth over which the temperature increases significantly. This effect alone would produce a radially symmetric pattern rather than the bilaterally symmetric pattern shown. The data thus suggest that there is a real geographic variation of atmospheric boundary temperature. The simplest, but not the only, interpretation of this departure from radial symmetry is as follows. First, there is little or no difference in atmospheric temperature between the daytime and night-time portions of the disk, a result indicated by the previous work of Sinton (*2*) and Pettit and Nicholson (*3*). Gross differences would be expected if there were a significant diurnal temperature variation in the planetary atmosphere. Second, there is an apparent "insolation" effect. The portion of the planetary disk which is intersected by the orbital plane of Venus—that is, the "equatorial" zone if the planet were imagined to be rotating about a spin



DEC. 15, 1962
1334 – 1422 U.T.

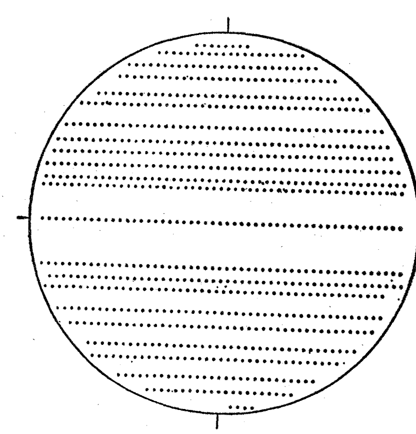


Fig. 1. Brightness-temperature contour map of Venus at wavelengths 8 to 14 microns. The bottom chart shows geographic location of points where the continuous scan records were sampled and reduced. The slightly crenulated pattern running in an east-west direction results from slight uncertainties in positioning the scans.