for x-ray emission by the synchroton process. As Felten points out in a recent discussion (*8*), the lifetime problem is already difficult to explain, even for the optical emission.

If the identification of the x-ray source with 3C 273 is correct, the x-ray luminosity is 500 times as great as that of M 87. The addition of the x-ray luminosity to the existing spectrum of radio, infrared, and visible luminosity does not significantly change the total energy budget of radiation. Most of the luminosity still appears in the infrared. The existence of at least three additional sources in the region scanned, at flux levels comparable to 3C 273 but without evidence of radio emission, is suggestive of radio-quiet and invisible quasars as proposed by Shklovsky (*9*). Both Shklovsky (*9*) and Burbidge, Burbidge, and Sandage (*10*) have remarked upon the quasar-like properties of Seyfert galaxies. Shklovsky has proposed that the high-excitation optical-emission lines may be x-ray excited and that those Seyfert galaxies, which are weak at long radio wavelengths have an "invisible quasar" luminosity in the sub-millimeter and infrared range. The x-rays may be produced by inverse Compton scattering of the relativistic electrons on the synchrotron radiation. Osterbrook (*11*) has also considered x-rays as the source of optical excitation in M 87, but attributed the x-ray emission to stellar coronas.

Byram, Chubb, and Friedman (*4*) had suggested, on the basis of their 1965 survey, that the so-called diffuse background was due to unresolved sources. The present survey of a limited region does not permit any clear resolution of the question of the existence of a truly diffuse background. It is surprising to find several x-ray sources as bright as 3C 273 in a region where no radio sources within a factor of 10 of the brightness of 3C 273 exist. Despite the statistical uncertainty of deductions from this small sample, it would not be inconsistent to consider the unresolved background underlying the observed sources to be composed of a host of weaker sources. The discrete sources, exclusive of M 87, constitute about 30 percent of the total flux, and there are suggestions of weaker unresolved features in the residual background. Inclusive of the discrete sources (except for M 87), the background flux (1 to 10 Å) is 9×10^{-8} erg cm^{-2} sec^{-1} $ster^{-1}$ if we assume a synchrotron spectrum of index −1. This is identical with the results obtained in 1965 with a pair of counters —one equipped with a 1-mil Mylar window, the other with ¼-mil Mylar. The counters with ⅛-mil Mylar windows, which were used in the present measurement, had a spectral efficiency (1 to 10 Å) 70 percent greater than the combination used in 1965. Most of the increased efficiency falls in the range 6 to 15 Å. We conclude that there is no evidence for interstellar absorption in the 6- to 15-Å range toward high galactic latitudes.

The question of the existence of a diffuse x-ray background is relevant to several major astrophysical concepts. It has been pointed out (*7, 12*) that evidence of such a background would test estimates of the density of intergalactic gas, the existence of the 3°K blackbody radiation, and the universality of the cosmic rays. It is, therefore, essential to survey additional regions of the sky and to improve resolution and sensitivity still further with a view to detecting the existence and level of a truly diffuse background. Unfortunately, it is difficult to achieve further gains in resolution and sensitivity with the Aerobee system. Larger rocket payloads and particularly the longer observing times of satellites are essential.

Before it is possible to do much more than speculate on the nature of the x-ray sources, tentatively identified with 3C 273 and M 87, it will be necessary to obtain evidence of the x-ray luminosities of other representative objects, to monitor their intensity variations, and to obtain more definitive spectral data. Again, progress can best be made with satellites affording pointing capabilities for the prolonged observation of discrete sources.

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References and Notes

1. S. Bowyer, E. T. Byram, T. A. Chubb, H. Friedman, *Science* **146**, 912 (1964); *ibid.* **147**, 394 (1965).
2. Manufactured by Space General Corporation.
3. *COSPAR International Reference Atmosphere 1965* (North-Holland, Amsterdam, 1965).
4. E. T. Byram, T. A. Chubb, H. Friedman, *Science* **152**, 66 (1966).
5. F. J. Low and H. L. Johnson, *Astrophys. J.* **141**, 336 (1965).
6. I. S. Shklovsky, *Soviet Astron.—AJ* **11**, 45 (1967); H. M. Johnson, *X-Radiation Fields in Cas A and Vir A*, preprint, 1967.
7. R. J. Gould *Amer. J. Phys.* **35**, 376 (1967),
8. J. E. Felten, *Astrophys. J.*, in press.
9. I. S. Shklovsky, *Soviet Astron.—AJ* **9**, 683 (1966).
10. G. R. Burbidge, E. M. Burbidge, A. R. Sandage, *Rev. Mod. Phys.* **35**, 947 (1963).
11. D. E. Osterbrock, *Astrophys. J.* **132**, 325 (1960).
12. G. G. Fazio, F. W. Stecker, J. P. Wright, *ibid.* **144**, 611 (1966); J. E. Felten and P. Morrison, *ibid.* **146**, 686 (1966); K. C. Anand, R. R. Daniel, S. G. Stephens, *Int. Conf. on Cosmic Rays, Calgary, Canada*, June 1967 (sponsored by the University of Calgary and the National Research Council of Canada). R. Berganini, P. Londrillo, G. Setti, *The Cosmic Black Body Radiation and the Inverse Compton Effect in the Radio Galaxies: The X-ray Background*, preprint (Univ. of Bologna, 1967); L. Maraschi, G. C. Perola, S. Schwarz, *X-Ray Flux and Anisotropy Produced by Galactic Cosmic Ray Electrons*, preprint (Univ. of Milan, 1967).

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Indium Variations in a Petrologic Suite of L-Group Chondrites

Abstract. *Indium concentrations have been determined by neutron activation in four members of each of the L3, L4, L5, and L6 chondritic meteorite classes. The range of concentrations is found to be from 0.14 to 22 parts per billion, with the highest values in L3 chondrites and the lowest values in the L5 and L6 classes. Plots of indium concentration versus relative mean deviation of pyroxene iron content, total carbon concentration, and primordial argon-36 concentration show positive correlations to varying degrees. Indium concentration appears to be a valuable parameter relating to variable formation conditions of the chondritic meteorites during the early history of the solar system.*

Van Schmus and Wood (*1*) have proposed a new classification of chondritic meteorites, in which they divide the various chondritic classes into subclasses based on petrologic type. The L-group ordinary chondrites are assigned by these authors to the four grades L3, L4, L5, and L6. We have determined indium by neutron activation in four members of each of these subclasses (*2*). The concentration of indium is found to range from 0.14 to 22 parts per billion, and to correlate well with such sensitive indicators of thermal history as primordial argon-36 concentration, carbon concentration, and the spread in composition of silicate minerals.

Results are listed in Table 1, as are the names and petrologic types of the chondrites (*3*). Each result is the mean of two or more replicate determinations made on separate 0.6-g chips of the chondrites (with the exception of Knyahinya and New Concord). The relative standard deviation of an individual determination is about 15 percent, except for the chondrites having very low indium concentrations, where a variable blank causes a small increase in the errors. Our results (*2*) show good agreement with those of Smales (*4*) and Schmitt and Smith (*5*).

The division by Van Schmus and Wood of isochemical chondritic classes into petrologic subclasses is based mainly on mineralogical and textural evidence. Type-3 stones contain primary isotropic glass, whereas glass is turbid or absent in type-4 stones, and nonexistent in higher types. Textural integration is advanced in types 5 and 6, in the latter to the extent that chondrules are no longer sharply defined.

One of the most useful criteria for distinguishing L3 and L4 from each other and from L5 and L6 is the variability of iron content in olivine and pyroxene. Chondrites in group L3 have relative mean deviations of olivine composition which are greater than 5 percent, L4 chondrites have mean deviations in the range 2.5 to 5 percent, and L5 and L6 chondrites show mean deviations which are less than or equal to 2.5 percent. The value of 2.5 percent is set by the precision limits of the electron microprobe technique which was used to determine the compositions (*6*). The deviations of pyroxene are somewhat larger than those for olivine in a given chondrite. This results partly from a precision poorer by about 5 percent, and partly from the fact that higher temperatures are necessary to homogenize initially variable pyroxene.

The most extensive collection of data on the variability of olivine and pyroxene composition is given by Dodd, Van Schmus, and Koffman (*6*). Figure 1 shows a plot of indium concentration versus relative mean deviation of pyroxene, expressed in percent. As noted above, any variations in L5 and L6 chondrites are below the detection limit of the microprobe technique; we have arbitrarily plotted L5 indium data at a mean deviation of 2 percent, and L6 data at 1 percent. The plot shows a strong correlation between indium concentration and variations in pyroxene composition. A plot of indium versus olivine composition would be quite similar.

Another variable which has been found to be correlated with petrologic type is the concentration of carbon (in all chemical forms). Figure 2 shows a plot of indium concentration versus total carbon concentration data reported by Moore and Lewis (*7*) for 11 of the 16 chondrites which we have studied. A correlation is observed, but one which is relatively weak. The range of carbon concentration in these chondrites is almost exactly a factor of 10. It is of interest to note that the increased carbon contents of the black chondrites, Farmington and Ergheo, are not paralleled by similarly high indium contents.

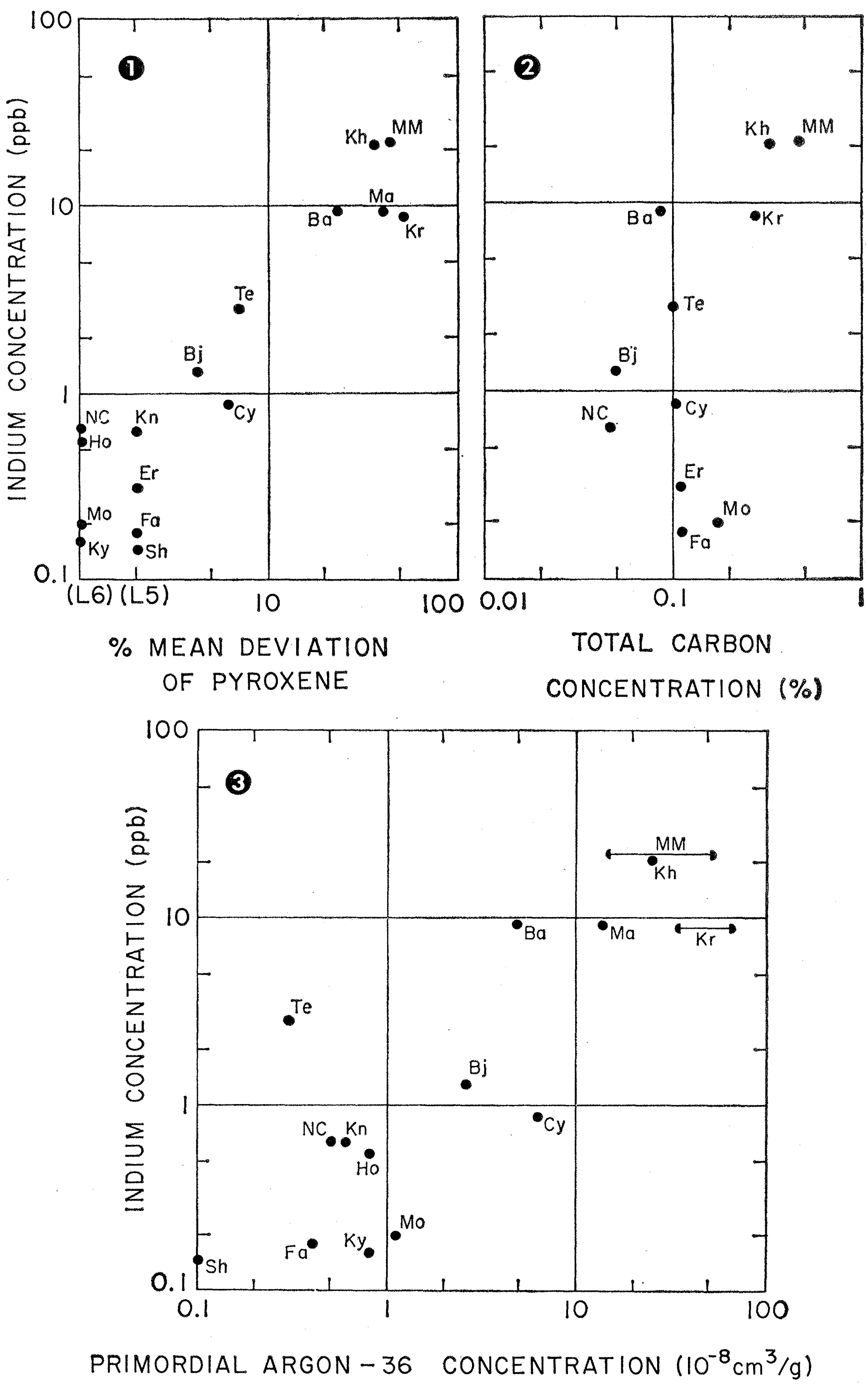

Fig. 1. Indium concentration versus relative mean deviation of pyroxene composition in a petrologic suite of L-group chondrites. For abbreviations, see Table 1. Fig. 2. Indium concentration versus total carbon concentration in a petrologic suite of L-group chondrites. For abbreviations, see Table 1. Fig. 3. Indium concentration versus primordial Ar^{36} concentration in a petrologic suite of L-group chondrites. Argon-36 concentrations are measured at standard temperature and pressure. For abbreviations, see Table 1.

Table 1. Petrologic types and indium concentrations (in parts per billion, ppb) in a suite of L-group chondrites.

Type	Chondrite	Abbreviation	Indium (ppb)
3	Khohar	Kh	21
3	Krymka	Kr	8.5
3	Manych	Ma	9.1
3	Mezö-Madaras	MM	22
4	Barratta*	Ba	9.1
4	Bjurböle	Bj	1.3
4	Cynthiana	Cy	0.86
4	Tennasilm	Te	2.8
5	Ergheo*	Er	0.31
5	Farmington	Fa	.17
5	Knyahinya	Kn	.62
5	Shelburne	Sh	.14
6	Holbrook	Ho	.54
6	Kyushu	Ky	.15
6	Modoc (1905)	Mo	.20
6	New Concord	NC	.63

* These meteorites are fresh-appearing finds; we do not believe it likely that weathering has altered their indium contents, but this possibility cannot be ruled out.

Zähringer (*8*) has pointed out that the concentration of primordial (as opposed to cosmogenic) Ar^{36} in chondrites increases as one passes from L6 to L3 grades of chondrites. Figure 3 shows a plot of indium concentration versus primordial Ar^{36} concentration data given by Zähringer (*8*) and Heymann and Mazor (*9*). A strong correlation is observed. Bars are shown connecting the extremes of reported values for Krymka and Mezö-Madaras. The correlation is quite strong.

As pointed out by Urey (*10*) and Anders (*11*), continuous depletion sequences of two trace elements of differing volatility such as shown here cannot be the result of differing degrees of heating of a material of initially uniform composition. Such processes tend to lead to complete depletion or complete retention, partial retention being feasible only over a narrow range of temperatures differing from element to element. Anders (*11*) has proposed that such effects have arisen from selective condensation processes during the early evolution of the solar system, followed by differing admixtures of "low-temperature" and "high-temperature" source materials. An alternative explanation by Wood (*12*) that venting in the chondritic parent body would have removed equal fractions of volatiles such as Ar^{36} and indium seems much less likely, though the issue is by no means settled.

It is curious to note that none of the four parameters which we have plotted are capable of distinguishing L5 and L6 chondrites. It may be that the mineralogical and textural distinctions which are observed between these two classes have resulted from processes distinct from those which have caused the variations in concentration of indium and other substances. Perhaps the latter processes originated in the condensing solar nebula, whereas the former processes reflect different degrees of heating within the parent body, under closed-system conditions.

Indium concentration appears to be an excellent indicator of differences in the evolutionary history of L-group chondrites. The indium contents of these objects vary over a factor of at least 150, and mean contents can be measured to a precision of about ± 20 percent at a 95 percent confidence level. The ranges of measurable variations in mean silicate-mineral deviations and in carbon content are considerably smaller. Primordial Ar^{36} shows a similar range, but the concentration data on this substance show somewhat more scatter, perhaps partly as a result of losses by diffusion. Recent data on primordial Xe^{132} suggest that it may show variations similar to those found for Ar^{36}, but with less evidence of diffusion losses (*13*).

Our data provide strong support for the validity of the Van Schmus–Wood classification. The only object which seems to be out of place is Barratta. The indium concentration in this object suggests that it should be a member of the L3 subclass. This conclusion is not supported by the data on the other parameters discussed above, however, with the exception of Xe^{132}.

Data that would result from a study of more representatives of the different L-group classes, and from investigations of petrologic suites of other classes of chondrites, if combined with data on other thermal indicators, should lead to a better understanding of events which took place during the early history of the solar system.

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References and Notes

1. W. R. Van Schmus and J. A. Wood, *Geochim. Cosmochim. Acta*, **31**, 747 (1967).
2. S. N. Tandon and J. T. Wasson, *Radiochim. Acta*, in press.
3. The sources and original catalog numbers, where known, of the meteorites are as follows: Academy of Sciences, U.S.S.R., Krymka (1707) and Manych (2331); American Museum of Natural History, Holbrook (586), Knyahinya (1068), Kyushu (1072), Modoc [1905], and New Concord (385); Arizona State University, Khohar (623.1); Australian Museum, Barratta; Field Museum of Natural History, Bjurböle (Me 1426), Ergheo (Me 553), Farmington (Me 345), and Shelburne (Me 2142); Harvard University, Cynthiana; Hungarian National Museum, Mezö-Madaras; U.S. National Museum, Tennasilm (483).
4. A. A. Smales and K. F. Fouché, *Chem. Geol.* **2**, 5 (1967).
5. R. A. Schmitt and R. H. Smith, *Proc. Intern. Assoc. Geochem. Cosmochem. Symp.*, Paris, May 1967, to be published.
6. R. T. Dodd, Jr., W. R. Van Schmus, D. M. Koffman, *Geochim. Cosmochim. Acta* **31**, 921 (1967).
7. C. B. Moore and C. Lewis, *Science* **149**, 317 (1965); *J. Geophys. Res.*, in press.
8. J. Zähringer, *Earth Plan. Sci. Letters* **1**, 379 (1966).
9. D. Heymann and E. Mazor, *Science* **155**, 701 (1967); *Geochim. Cosmochim. Acta*, in press.
10. H. C. Urey, *Astrophys. J. Suppl. Ser.* **1**, 147 (1954).
11. E. Anders, *Space Sci. Rev.* **3**, 583 (1964); J. W. Larimer and E. Anders, *Geochim. Cosmochim. Acta*, in press.
12. J. A. Wood, *Icarus* **6**, 1 (1967).
13. K. Marti, *Earth Plan. Sci. Letters* **2**, 193 (1967); J. Zähringer, private communication.
14. We are indebted to W. R. Van Schmus for suggesting the problem, R. A. Schmitt for an early version of the analytical procedure, and J. Kimberlin for experimental assistance. The meteorite samples were generously supplied by R. O. Chalmers, R. S. Clarke, Jr., C. Frondel, E. L. Krinov, L. Kvasha, D. V. N. Manson, B. Mason, C. B. Moore, E. Olsen, and K. I. Sztrókay. This research was supported in part by USAF contract AF F19(628), 67 C0044, and NSF grant GP-5309.

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Chromium and Nickel in the Fig Tree Shale from South Africa

Abstract. *Exceptionally high contents of chromium and nickel in shales from the early Precambrian Fig Tree series of South Africa (> 3.1 × 10⁹ years old) suggest that the ancient crustal rocks from which these sediments were derived were ultramafic in composition.*

The Fig Tree series of the Upper Swaziland System in the eastern Transvaal comprises several thousand feet of shale, grit, and graywacke together with well-developed horizons of chert, jasper, and ironstone (*1*). Sediments from the Fig Tree series are of considerable interest because of their extreme age; isotopic investigations indicate an age of deposition exceeding 3×10^9 years (*2*).

A total of 251 South African argil-