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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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* ($> 3.1 \times 10^9$ *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-

Table 1. Averages and ranges of chromium and nickel in various South African sediments, together with comparison with results derived by other workers. Numerals in parentheses are references. All values are given in parts per million.

Source and number of samples	Chromium		Nickel	
	Average	Range	Average	Range
South African argillaceous sediments, 228	120	8–785	49	3–355
Fig Tree shales, 23	860	525–1145	495	280–800
Average shale (*6*)	90		68	
Average deep-sea clay (*6*)	90		225	
Devonian pelites, 63 (*7*)	110		64	
Marine argillaceous sediments, 34 (*8*)	75	30–121	40	20–65
Freshwater argillaceous sediments, 32 (*8*)	50	15–135	23	8–56
Nonmarine noncarbonaceous claystones, 8 (*9*)	59	31–110	32	18–90
Nonmarine carbonaceous shales, 14 (*9*)	52	36–67	19	7–48
Marine nearshore sediments, 32 (*9*)	82	34–110	32	13–51
Marine offshore sediments, 53 (*9*)	106	52–200	53	11–160
Estimated abundance in ultramafic rocks (*10*)	2400		1500	
Average basalt (*6*)	170		130	

laceous sediments, including 23 samples from the Fig Tree series, have been analyzed by x-ray fluorescence spectroscopy for Cr and Ni; results are given in Table 1. Frequency distributions of these metallic elements in the samples studied are depicted in Figs. 1 and 2, respectively. From Table 1 it is evident that the concentrations of Cr and Ni in the Fig Tree shales are considerably higher than those found in argillaceous sediments of younger age from the southern African continent, as well as those from other continents. These large amounts of Cr and Ni are not due to contamination introduced during the grinding process to which all the samples were subjected prior to analysis, and must, therefore, be due either to detrital supply resulting from weathering of material rich in Cr and Ni or to some secondary enrichment process contemporaneous with deposition or subsequent to it.

Since the individual minerals in these rocks have not yet been separated, the precise locations of the Cr and Ni are uncertain. Frölich (*3*) suggests that most of the Cr in sediments is concentrated in the micas and clay minerals, notably illite. Nicholls and Loring (*4*), in their study of British Carboniferous sediments, suggest that much of the Cr in these rocks is detrital, while the Ni appears to be dispersed among several components—a considerable amount being bound in the clay minerals proxying for Fe^{2+} or Mg^{2+}. A qualitative study of the mineralogy of the Fig Tree shales by means of standard x-ray diffraction techniques showed Fe chlorite to be the dominant clay mineral present together with varying amounts of illite and occasional minor goethite.

Von Gaertner and Schellman (*5*) have reported high values for Ni and Cr (200 parts per million and more) in marine clays off Guinea, which have been attributed to the proximity of peridotites in the peninsula of Kaloum. They suggest that the mineral goethite acts as a host for these elements.

If the large amounts of Cr and Ni in Fig Tree shales did, in fact, enter the basin of deposition in lattice positions within the degraded clays, it would appear that the source rocks for these extremely old sediments were either ultramafic or, less likely, mafic in composition. The average Cr and Ni abundances in basaltic rocks (Table 1) would necessitate rather drastic concentration of these elements during weathering and deposition.

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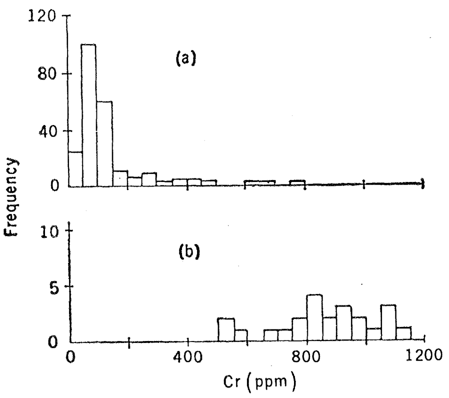

Fig. 1. Frequency distribution diagram of Cr in South African argillaceous sediments. (a) Assorted shales, siltstones, and mudstones (251 samples); (b) 23 Fig Tree shales.

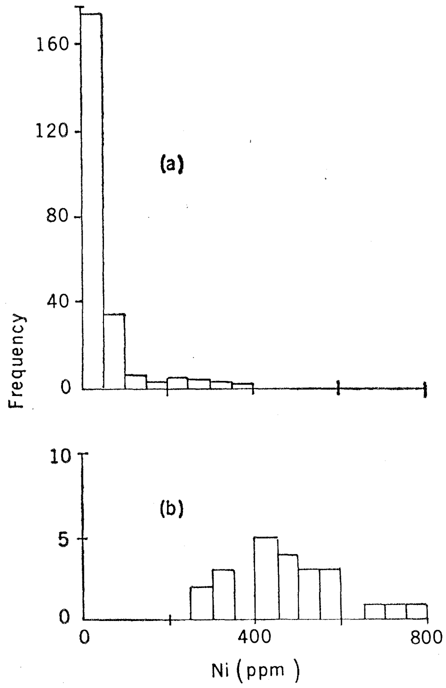

Fig. 2. Frequency distribution diagram of Ni in South African argillaceous sediments. (a) Assorted shales, siltstones, and mudstones (251 samples); (b) 23 Fig Tree shales.

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