The measuring technique for diffusion coefficients which is outlined in this work is beleaved to be very suitable for routine analyses of many binary systems. It is of course necessary that $(\partial\mu/\partial c)$ is not too small as in most isotopic mixtures. If the "dropped crystal technique" cannot be used it may be possible to design an apparatus where the diffusing substance is transferred by other means to the bottom of the cell even at high temperatures.

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On Noble Gas Anomalies in the Great Namaqualand Troilite

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The abundances and isotopic composition of the stable noble gases were measured in a troilite nodule from the Great Namaqualand fine octahedrite. Helium, neon and argon show a significant spallation component. The major anomalies in krypton and xenon are from neutron capture on selenium and tellurium and from the decay of extinct I^{129}. The abundances of tellurium, iodine and uranium in the troilite were determined by neutron activation analyses and compared with the xenon anomalies. The results indicate that part of the excess Xe^{129} is from neutron capture on tellurium and the remainder is due to the retention of radiogenic Xe^{129} from the decay of extinct I^{129}, about 200 million years after an initial $I^{129}/I^{127}=3\times10^{-3}$.

Although there have been many reports on the isotopic composition of the heavy noble gases in stone meteorites, relatively few studies have been reported on the abundances of the heavy noble gas isotopes in iron meteorites. Reynolds [1] reported the abundances of four xenon isotopes in Sardis troilite and three xenon isotopes in Sardis iron. Only recently have complete xenon and krypton spectra been reported for two iron meteorites; Costilla Peak iron [2] and Canyon Diablo graphite [3].

The isotopic anomalies observed in these two samples showed remarkably few similarities. Both the xenon and krypton spectra in Costilla Peak were characterized by a large spallation component. Radiogenic Xe^{129} could not be positively identified, but an upper limit of 2.2×10^{-13} cc STP radiogenic Xe^{129} per gram of Costilla Peak iron was established. In contrast to this the xenon and krypton spectra in Canyon Diablo graphite showed only a small spallation component but contained major anomalies due to neutron capture reactions on bromine and iodine. The amount of radiogenic Xe^{129} in Canyon Diablo graphite, 8.5×10^{-10} cc STP per gram, was greater than had been reported in any stone meteorite except Renazzo and Abee.

The iodine abundance have been measured for both the Sardis troilite [4] and the Canyon Diablo graphite [5]. The ratio of radiogenic Xe^{129} to iodine in the graphite is about 350 times the value of this ratio in the troilite. This suggests that the Canyon Diablo graphite began to retain the gaseous decay product of 17 million year (m. y.) I^{129} about the same time as the chondrites, but almost 150 m. y. before the Sardis troilite.

Due to the scarcity of noble gas data on the iron meteorites and the great differences in the krypton and xenon anomalies in the above-mentioned reports, it was decided to investigate the noble gases and the tellurium, iodine and uranium abundances from a single troilite nodule. The sample used for this study was provided by the museum of the University of Missouri at Rolla.

Hey [6] lists fifteen synonyms which have been used for the Great Namaqualand meteorite. Wasson [7] determined the concentration of Ga and Ge in this meteorite (under the synonym, Gibeon) and classi-

[1] J. H. Reynolds, J. Geophys. Res. **68**, 2939 [1963].
[2] M. N. Munk, Earth Planetary Science Letters **2**, 301 [1967].
[3] E. C. Alexander and O. K. Manuel, Earth Planetary Science Letters **2**, 220 [1967].
[4] G. G. Goles and E. Anders, Geochim. Cosmochim. Acta **26**, 723 [1962].
[5] J. H. Bennett and O. K. Manuel, Earth Planetary Science Letters **2**, November 1967.
[6] M. H. Hey, Catalogue of Meteorites, Alden Press, Oxford 1966.
[7] J. T. Wasson, Geochim. Cosmochim. Acta **31**, 161 [1967].

fied it as a member of the Group IVa fine octahedrites. According to VOSHAGE [8] most members of this group were produced in a single collision about 400×10^6 years ago.

Experimental

1. Noble Gases

A troilite nodule weighing about five grams was taken from a cut surface of the meteorite. A piece of this nodule weighing 218.4 mg was mounted in a side-arm chamber so that it could be dropped into a molybdenum crucible for gas extraction. The sample was heated at ≈ 100 °C overnight to remove surface contamination and then dropped into the previously outgassed molybdenum crucible. The sample was melted by radiofrequency induction heating and the evolved gases cleaned on titanium at 850 °C. The noble gases were separated into four fractions by adsorption on charcoal and analyzed in the following order: helium and neon, argon, krypton, and finally xenon.

The gases were analyzed statically in a Reynolds' type 4.5 inch 60° sector mass spectrometer [9]. The spectrometer was calibrated before and after the experiment by subjecting air spikes of approximately 0.01 cc STP to the same procedure of analysis as used for the sample. The amount of each noble gas in the sample was obtained by comparing the peak heights from the sample with those from the air spikes. The isotopic compositions reported here were corrected for mass spectrometer memory by extrapolating the observed ratios to the start of the analysis. The errors reported in the isotope ratios are one standard deviation (σ) from the least squares line through the observed ratios and do not take into account any systematic error from background. Results from blank analyses using the same procedure for the hot molybdenum crucible showed no significant contamination peaks in the noble gas region, except at mass 78.

2. Tellurium, Iodine and Uranium

The tellurium, iodine and uranium contents of Great Namaqualand troilite were determined by neutron activation analyses. The chemical procedure was essentially identical to that reported by GOLES and ANDERS [4] and by CLARK, ROWE, GANAPATHY, and KURODA [10]. The samples were irradiated with two aqueous monitors of each of the following salts: KI, $Te(NO_3)_4$ and $UO_2(NO_3)_2$. The irradiation was conducted in a local reactor at a flux of about 5×10^{12} n/cm²/sec.

Approximately 20 mg of iodine carrier was added to each sample and monitor. Following several cycles of iodine extraction into carbontetrachloride and back-extraction into aqueous $NaHSO_3$, the iodine was precipitated as Ag I, filtered, dried and mounted on 2 inch stainless steel planchets for proportional counting. Blanks containing distilled water sealed in the same polyethylene capsules as used for samples and monitors were analyzed with each experiment.

The Ag I precipitates were counted for gross β-activity in a gas-flow end window proportional counter having a background of 12 counts per minute. The abundances of iodine and uranium were determined from two samples irradiated for 25 minutes. Due to the relatively small neutron capture cross-section of Te^{130} and the long half-period of I^{131}, the tellurium abundance was determined on a separate sample which had undergone a two hour irradiation.

Results and Discussion

1. Helium, Neon and Argon

The abundances and isotopic composition of helium, neon and argon are shown in Table 1. The He^3/He^4, Ne^{22}/Ne^{21} and Ar^{38}/Ar^{36} ratios are similar to those observed in the iron phase of meteorites and attributed to cosmic-ray induced spallation reactions [11, 12].

The Ar^{38}/Ar^{36} ratio in the troilite is slightly smaller than any of the values reported by SIGNER and NIER [11] in an analysis of 23 different iron meteorites. This may be due to atmospheric contamination or to secondary neutron capture reactions on chlorine [13]. The Ar^{40}/Ar^{36} value is appreciably larger

noble gas	concentration of standard isotope 10^{-8} cc STP/gm	isotopic composition
helium	$He^4 = 576$	$He^3 = 0.1833 \pm 0.0050$ $He^4 = 1.000$
neon	$Ne^{21} = 40.8$	$Ne^{20} = 1.54 \pm 0.01$ $Ne^{21} = 1.000$ $Ne^{22} = 1.236 \pm 0.007$
argon	$Ar^{36} = 43.5$	$Ar^{36} = 1.000$ $Ar^{38} = 1.455 \pm 0.008$ $Ar^{40} = 12.57 \pm 0.28$

Table 1. Helium, neon and argon in Great Namaqualand troilite.

[8] H. VOSHAGE, Z. Naturforsch. **22 a**, 477 [1967].
[9] J. H. REYNOLDS, Rev. Sci. Instrum. **27**, 928 [1956].
[10] R. S. CLARK, M.W. ROWE, R. GANAPATHY, and P. K. KURODA, Geochim. Cosmochim. Acta **31**, 1605 [1967].
[11] P. SIGNER and A. O. C. NIER, Researches in Meteorites, ed. by CARLTON MOORE, J. Wiley & Sons, New York 1962.
[12] D. E. FISCHER and O. A. SCHAEFFER, Geochim. Cosmochim. Acta **20**, 5 [1960].
[13] P. EBERHARDT, J. GEISS and H. LUTZ, Earth Science and Meteorites, compiled by J. GEISS and E. D. GOLDBERG, North-Holland Publ. Co., Amsterdam 1963.

than the ratio produced by spallation [14]. This excess Ar^{40} may result from the decay of K^{40} in the troilite or from atmospheric contamination.

The likelihood that atmospheric contamination is responsible for the excess Ar^{40} can be examined by comparing the amount of Ar^{40} with that expected from the potassium content of the troilite. As will be noted later, the troilite has retained radiogenic Xe^{129} from extinct I^{129} and may therefore be expected to have retained an appreciable fraction of its radiogenic Ar^{40}. By assuming that all of the radiogenic Ar^{40} has been retained in the troilite and that the potassium has the same isotopic composition as terrestrial potassium [15], it can be shown that the troilite would have to contain a minimum of 70 ppm K in order to have produced the observed Ar^{40} over the past 4.55 billion years. Since this minimum potassium content is sizeably larger than the potassium content in troilite [15] from Canyon Diablo, Odessa or Xiquipilco, it seems likely that atmospheric contamination is responsible for most of the Ar^{40} shown in Table 1.

A maximum spallation Ar^{38}/Ar^{36} ratio for the troilite can be obtained by asuming that all of the Ar^{40} is due to atmospheric contamination. When corresponding amounts of atmospheric Ar^{38} and Ar^{36} are subtracted from the values shown in Table 1, there results a maximum value of spallation $Ar^{38}/Ar^{36} = 1.51$. Since this value is equal to the lowest spallation Ar^{38}/Ar^{36} value reported by SIGNER and NIER [11], an argon component due to neutron capture on chlorine cannot be positively identified.

The Ne^{21}/Ar^{38} ratio in the troilite is about a factor of three larger than that observed in iron meteorites [11, 12]. This is due to the contribution of both iron and sulfur to the production of cosmogenic neon. If the troilite is assumed to be pure FeS, then the difference in the Ne^{21}/Ar^{38} ratios in the iron and the troilite phases can be used to calculate the relative cross sections of sulfur and iron for the production of Ne^{21}, $\sigma_{S^{21}}/\sigma_{Fe^{21}}$.

$$(Ne^{21}/Ar^{38})_{\text{Troilite}} = (\sigma_{S^{21}} + \sigma_{Fe^{21}})/\sigma_{Fe^{38}}. \quad (1)$$

In the analyses of 21 iron meteorites, SIGNER and NIER [11] found $(Ne^{21}/Ar^{38})_{\text{Iron}} \approx 0.20$. This value of $\sigma_{Fe^{21}}/\sigma_{Fe^{38}}$ in Eq. (1) yields $\sigma_{S^{21}}/\sigma_{Fe^{21}} = 2.2$, i. e., cosmic rays on sulfur in this troilite nodule were 2.2 times as effective in producing Ne^{21} as were cosmic rays on iron.

BEGEMANN [15a] has measured the abundances of cosmogenic helium, neon and argon in troilite nodules of Sardis, Mt. Edith and Odessa. As in this troilite nodule from Great Namaqualand, the He^3/Ne^{21} and Ar^{38}/Ne^{21} ratios were appreciably smaller than in the iron phase, but the $\sigma_{S^{21}}/\sigma_{Fe^{21}}$ ratios were larger than in Great Namaqualand. In Table 2 the relative abundances of He^3, Ne^{21} and Ar^{38} in these troilite nodules are compared with the relative cross sections for the production of Ne^{21} from sulfur and iron.

Although the low He^3/Ne^{21} ratio in the Great Namaqualand troilite may be due to preferential loss of helium during the twelve hour preheating of the sample to $\approx 100\,^{\circ}C$, the correlation of the He^3/Ne^{21} ratio with the ratio of the Ne^{21} production cross sections, $\sigma_{S^{21}}/\sigma_{Fe^{21}}$, suggests that the relatively low helium content may reflect the depth of the sample below the surface during exposure to cosmic rays. HEY [6] indicates that over 14,600 kg of Great Namaqualand have been recovered. This suggests that the preatmospheric mass may have been large enough to have shielded part of the sample from the primary cosmic ray flux and thus alter the relative production rates of the different noble gases.

The cosmic ray exposure age of the Great Namaqualand meteorite has not been reported. VOSHAGE [8] has determined the K^{41}/K^{40} exposure age on 60 iron meteorites and shown that most of the fine octahedrites of the Ga-Ge-Group IVa were produced in a single collision about 4×10^8 years ago. This exposure age together with the noble gas abundances listed in Table 1 indicate that the production rates

	He^3/Ne^{21}	Ar^{38}/Ne^{21}	$\sigma_S^{21}/\sigma_{Fe}^{21}$
Trolite Phase			
Great Namaqualand	2.8	1.53	2.2
Sardis [15a]	11.6	—	4.3
Mt. Edith [15a]	15.3	0.57	7.4
Odessa [15a]	15.9	—	9.4
Iron Phase			
Sardis [15a]	—	4.63	
Mt. Edith [15a]	71	4.57	
Odessa [11]	93	5.4	

Table 2. Cosmogenic gases in troilite and the cross sections of sulfur and iron for producing Ne^{21}.

[14] P. LÄMMERZAHL and J. ZÄHRINGER, Geochim. Cosmochim. Acta **30**, 1059 [1966].

[15] W. KEMPE and J. ZÄHRINGER, Geochim. Cosmochim. Acta **30**, 1049 [1966].

[15a] F. BEGEMANN, Z. Naturforsch. **20 a**, 950 [1965].

of He^3, Ne^{21} and Ar^{38} in the troilite were 26×10^{-10}, 10.2×10^{-10} and 15.8×10^{-10} cc STP per gram per million years. This production rate for He^3 is not exceptionably low compared to production rates calculated by SCHAEFFER and FISHER [16] and by SIGNER and NIER [11], but the production rates of both Ne^{21} and Ar^{38} are much higher than the production rates reported in the iron phase of meteorites [11, 12, 16]. It should be noted, however, that the exposure age of Great Namaqualand could be substantially greater than 400 million years since one member of the IVa group studied by VOSHAGE [8] had an exposure age of 745 million years.

A determination of the Cl^{36} activity in the Great Namaqualand would make it possible to determine the actual cosmic ray flux on this sample and would also test the hypothesis of SCHAEFFER and FISHER [16] that the meteorites with low Cl^{36} activity have low He^3/Ar^{38} ratios.

2. *Krypton*

The abundance and isotopic composition of krypton in the troilite are compared with krypton from troilite and graphite nodules of Canyon Diablo in Table 3. The isotopes are normalized to Kr^{86} because this isotope has essentially no spallation component [2, 17]. The excess of each of the light krypton isotopes relative to atmospheric krypton are shown in Table 4, where

$$\delta_i = (Kr^i/Kr^{86})_{\text{Meteorite}} - (Kr^i/Kr^{86})_{\text{Atmosphere}}. \quad (2)$$

Eq. (2) will yield negative anomalies for samples such as Canyon Diablo graphite which contains an excess of Kr^{86} and a relatively small spallation component.

mass number	Great Namaqualand troilite	Canyon Diablo troilite	Canyon Diablo graphite	Earth atmosphere
80	0.288 ± 0.007	0.1769	0.4329	0.1296
82	0.706 ± 0.031	0.692	0.7720	0.6616
83	0.980 ± 0.013	0.730	0.6500	0.6599
84	3.344 ± 0.022	3.234	3.211	3.273
86	1.000	1.000	1.000	1.000
Kr^{86}	3.00×10^{-11} cc STP/gm	3.4×10^{-11} cc STP/gm	7.3×10^{-10} cc STP/gm	1.6×10^{-4} cc STP/gm
investigator	this work	CLARK and THODE [18]	ALEXANDER and MANUEL [3]	NIEF [19]

Table 3. Krypton from Great Namaqualand troilite and other inclusions in iron meteorites. Krypton spectrum for Canyon Diablo troilite has not been corrected for mass discrimination.

Relative to the excesses of other krypton isotopes, the troilite samples display a large excess of Kr^{83}. For example, the δ^{83}/δ^{82} ratio in Great Namaqualand troilite is more than five times as large as the δ^{83}/δ^{82} ratios in spallation krypton from the iron phase of Costilla Peak or from the Stannern achondrite. CLARKE and THODE [18] suggested that the excess Kr^{83} in Canyon Diablo troilite was produced by neutron capture on Se^{82}. This appears to be the most likely mechanism to account for the large δ^{83}/δ^{82} ratio in the troilite. The high tellurium content and the excess Xe^{131} in the troilite, as will be discussed in the next section, suggest that the troilite contains sufficient selenium to account for the Kr^{83} anomaly.

It is more difficult to assign an origin to the smaller krypton anomalies at Kr^{80}, Kr^{82} and Kr^{84}. The δ^{80}/δ^{82} ratio is similar to that in Canyon Diablo graphite, which has been attributed to neutron capture on bromine [3]. However, the δ^{84}/δ^{82} ratio in the troilite is larger than the spalation ratio observed

meteorite	Kr^{80}	Kr^{82}	Kr^{83}	Kr^{84}	investigator
Great Namaqualand troilite	0.158 ± 0.007	0.044 ± 0.031	0.320 ± 0.013	0.071 ± 0.022	This work
Canyon Diablo troilite	0.046	0.023	0.064	-0.052	CLARK and THODE [18]
Canyon Diablo graphite	0.302	0.100	-0.010	-0.062	ALEXANDER and MANUEL [3]
Costilla Peak iron	0.423	0.535	0.617	0.082	MUNK [2]
spallation krypton	0.495	0.765	$\equiv 1.000$	0.63	MARTI et al. [17]

Table 4. Excess krypton isotopes in meteorites relative to the atmosphere as calculated from the equation: $\delta_i = (Kr^i/Kr^{86})_{\text{meteorite}} - (Kr^i/Kr^{86})_{\text{atmosphere}}$. Meteorites with negative δ_i values contain an excess of Kr^{86}.

[16] O. A. SCHAEFFER and D. E. FISHER, Nature **186**, 1040 [1960].
[17] K. MARTI, P. EBERHARDT, and J. GEISS, Z. Naturforsch. **21 a**, 398 [1966].
[18] W. B. CLARKE and H. G. THODE, J. Geophys. Res. **69**, 3673 [1964].

in either Stannern or Costilla Peak, and the assignment of part of the excess Kr^{82} to neutron capture would require an even higher δ^{84}/δ^{82} spallation ratio in the troilite.

There appears to be no single mechanism capable of explaining the excess Kr^{80}, Kr^{86} and Kr^{84}. If there are measurement errors above the statistical errors shown in Table 4, these are most likely to effect the δ^{84} value where the excess Kr^{84} amounts to only 2% of the total Kr^{84}. In contrast to this the excess Kr^{80}, Kr^{82} and Kr^{83} are 55%, 6% and 33%, respectively, of each isotope's abundance. Tentatively, it appears that neutron capture on bromine and selenium are responsible for the krypton anomalies in the Great Namaqualand troilite. CLARKE and THODE [18] assigned the krypton anomalies in Canyon Diablo troilite to these same neutron capture reactions.

3. *Xenon, Tellurium, Iodine and Uranium*

The isotopic composition of xenon in the Great Namaqualand troilite is shown in Table 5. The xenon content is approximately equal to that in the iron phase of Costilla Peak, but almost a factor of 10 smaller than that in the troilite phase of Sardis. Within experimental error, the isotopic composition of xenon in the Great Namaqualand troilite is identical to the primordial xenon in Murray [22], except at mass 131 and 129. In order to determine the origin of these anomalies, the abundances of elements most likely to have contributed to the medium-weight xenon isotopes were determined by neutron activation analyses.

The iodine, tellurium and uranium abundances in the troilite are shown in Table 6. The iodine and uranium contents in the Great Namaqualand troilite are similar to those in Canyon Diablo troilite, but the tellurium content of the Great Namaqualand troilite is greater than that reported in any troilite phase by GOLES and ANDERS [4]. In spite of the chalcophilic nature of tellurium, GOLES and ANDERS found the abundances of tellurium in troilite to be about equal to the tellurium content of carbonaceous and enstatite chondrites. The tellurium content in the Great Namaqualand troilite, 18 ppm, corresponds to an atomic ratio $Te/S = 1.2 \times 10^{-5}$ if the troilite is assumed to be pure FeS. This value is in close agreement with the cosmic Te/S ratio reported by SUESS and UREY [23].

Sample	Tellurium (ppm.)	Iodine (ppb.)	Uranium (ppb.)	Investigator
Great Namaqualand	18 ± 5	90 ± 30	2.1 ± 0.5	this work
Canyon Diablo	5.0	62	3.5	GOLES and ANDERS[4]
Sardis	7.8	3590	6.5	GOLES and ANDERS[4]
Grant	2.4	24	6.5	GOLES and ANDERS[4]
Toluca	1.7	1030	10	GOLES and ANDERS[4]
SOROTI	1.2	50	17	GOLES and ANDERS[4]

Table 6. Tellurium, iodine and uranium in the troilite phase of iron meteorites.

mass number	Great Namaqualand troilite	Sardis troilite	Costella Peak iron	Stannern spallation xenon	Pasamonte fissiogenic xenon	Murray carbon aceous chondrite
129	1.86 ± 0.003	1.30	1.14	—	—	1.056
130	0.162 ± 0.003	—	0.152	1.0	—	0.1633
131	0.956 ± 0.002	0.851	0.965	4.3	0.285	0.8207
132	$\equiv 1.000$	$\equiv 1.000$	$\equiv 1.000$	$\equiv 1.00$	$\equiv 1.00$	$\equiv 1.000$
134	0.373 ± 0.008	—	0.389	$\leqq 0.03$	1.05	0.3824
136	0.319 ± 0.008	—	0.320	—	1.14	0.3219
Xe^{132}	1.1×10^{-11} cc STP/gm	1.0×10^{-10} cc STP/gm	7.2×10^{-12} cc STP/gm	—	—	1.1×10^{-9} cc STP/gm
investigator	this work	REYNOLDS[1]	MUNK[2]	MARTI et al.[17]	HOHENBERG et al.[20]	KRUMMENACHER et al.[21]

Table 5. Xenon from Great Namaqualand troilite and other meteorites. Within experimental error the xenon spectrum in the Great Namaqualand troilite is identical to the primordial xenon spectrum in Murray, except at mass numbers 129 and 131.

[19] G. NIEF, National Bureau of Stand. Tech. Note 51 [1960], F. MOHLER, editor.
[20] C. M. HOHENBERG, M. N. MUNK, and J. H. REYNOLDS, J. Geophys. Res. **72**, 3139 [1967].
[21] D. KRUMMENACHER, C. M. MERRIHUE, R. O. PEPIN, and J. H. REYNOLDS, Geochim. Cosmochim. Acta **26**, 231 [1962].
[22] J. H. REYNOLDS, Phys. Rev. Letters **4**, 351 [1960].
[23] H. E. SUESS and H. C. UREY, Rev. Mod. Phys. **28**, 53 [1956].

From the data in Table 5 it appears that the xenon in the Great Namaqualand troilite has been enriched in Xe^{131} and Xe^{129}. Relative to the xenon spectrum of Murray, there are 1.5×10^{-12} cc STP excess Xe^{131} and 8.8×10^{-12} cc STP excess Xe^{129} per gram of troilite. Since fission would also produce excesses at Xe^{132}, Xe^{134} and Xe^{136}, the anomalies in the troilite are probably the result of nuclear reactions on tellurium and/or the *in situ* decay of extinct I^{129}.

Thermal neutron capture on tellurium of terrestrial isotopic composition would produce excess Xe^{129} and Xe^{131} in the ratio $Xe^{129}/Xe^{131} = 0.63$. Since the anomalous xenon in the troilite occurs in the ratio $Xe^{129}/Xe^{131} = 5.9$, this origin of the Xe^{131} would suggest the presence of 7.9×10^{-12} cc STP radiogenic Xe^{129} per gram of troilite or 8.8×10^{-5} cc STP radiogenic Xe^{129} per gram of iodine.

For the continuous synthesis model described by KOHMAN [24], KURODA [25] has calculated the I^{129}/I^{127} ratio, β, at the end of galactic nucleosynthesis to be $\beta = 3 \times 10^{-3}$. This corresponds to a maximum of 0.52 cc STP radiogenic Xe^{129} per gram of iodine for meteorites which start to retain the gaseous Xe^{129} decay product immediately after nucleosynthesis. Since the Great Namaqualand troilite contains 8.8×10^{-5} cc STP radiogenic Xe^{129} per gram of iodine, this nodule began to retain radiogenic Xe^{129} about 216 million years after an initial I^{129}/I^{127} ratio of 3×10^{-3}.

The above is probably a minimum $I^{129} - Xe^{129}$ age for this sample since fast neutrons may produce a larger Xe^{129}/Xe^{131} ratio than thermal neutrons. From the presently available cross section data on tellurium [26], it appears that nonthermal neutrons will produce a maximum $Xe^{129}/Xe^{131} \approx 3$. Excesses of Xe^{129} and Xe^{131} have been found in tellurium ores [27, 28] in the ratio $Xe^{129}/Xe^{686} = 1.5 - 3$. These anomalies have been attributed to neutron capture on tellurium [27] and to negative muon reactions [29] on Te^{130}, $Te^{130}(\mu^-,n)\,Sb^{129}(\beta^-)\,Te^{129}(\beta^-)\,I^{129}(\beta^-)\,Xe^{129}$. If the excess Xe^{131} was produced in some reaction which produced $Xe^{129}/Xe^{131} \leqq 3$, then the radiogenic Xe^{129} in the troilite nodule of Great Namaqualand could amount to as little as 4.3×10^{-12} cc STP per gm. In this case the $I^{129} - Xe^{129}$ formation interval would be 231 million years.

Thus the $I^{129} - Xe^{129}$ formation interval for the Great Namaqualand troilite appears to be in close agreement with the $I^{129} - Xe^{129}$ age of the Sardis troilite [1], but appreciably longer than the $I^{129} - Xe^{129}$ age of Canyon Diablo graphite [3]. The presence of excess Xe^{129} from neutron capture reactions on tellurium in the troilite phases of both Sardis and Great Namaqualand are consistent with the proposed synthesis of I^{129} in the solar system [30] and $Te^{128} - Xe^{129}$ dating of meteorites [31].

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