

December 6, 1988

Professor Steven E. Jones
Department of Physics and
Astronomy
Brigham Young University
Provo, Utah 84602

Dear Steve:

This will acknowledge, with thanks, the receipt of your comments on Professor Pons' rebuttal on the proposal entitled, "The Behavior of Electrochemically Compressed Hydrogen and Deuterium."

Your kind assistance in our evaluation process is genuinely appreciated.

Sincerely,

Ryszard Gajewski, Director
Division of Advanced Energy Projects
Office of Basic Energy Sciences, ER-16

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Further Comments on the Proposal: "The Behavior of Electrochemically Compressed Hydrogen and Deuterium"

Frankly, I was disappointed by the response to my original comments on this proposal. The contention that neutrons from fusion will be "rapidly thermalized" and that an "increase of (beta + gamma) radiation ... must presumably be attributed to the reactions of thermal neutrons with components of the Dewar" indicates, I fear, a lack of understanding of the penetrating power of 2.5 MeV neutrons, and of nuclear reactions in general. For example, energetic neutrons are much more penetrating than beta particles of comparable energy, and fusion neutrons are not difficult to detect. (There are numerous papers on this subject in papers on muon-catalyzed fusion, for instance.) And why are not gammas from proton-deuteron fusion considered? Furthermore, a background rate of 175 counts per minute in a small scintillation counter points to a dearth of shielding and a rather cavalier attitude toward detecting radiation associated with nuclear fusion. I also feel strongly that jumping from current results to experiments involving large and expensive palladium rods, requiring "about one year to charge" with deuterium, would be premature. First, smaller scale experiments of an exploratory nature are clearly needed to establish the phenomenon of fusion in metals.

However, in spite of these glaring defects, I do not recommend that all support for this project be denied. I find that the proposers have demonstrated expertise with electrochemistry and calorimetric methods. Although the proposed experiments clearly fail to demonstrate the existence of fusion processes in metals, there indeed exists some evidence that such does occur.

I think the proposers should be informed that exploratory research on fusion in metals (and other compounds) has been pursued under the auspices of the Advanced Energy Projects Division since 1985. (See our annual report dated May, 1986.) Our initial interest in the possibility of fusion in minerals stemmed from our related work on muon-catalyzed fusion in which fusion is induced as isotopic hydrogen nuclei are held closely together by a negative muon, and the correlation of this research with observations of anomalously large heat and helium-3/helium-4 ratios associated with earth's geology. We realized both could be explained by the occurrence of proton-deuteron and/or deuteron-deuteron fusion in the earth. (In particular, water is entrained in minerals in subducting zones, where excess helium-3 relative to helium-4 is common. Internal Brigham Young University reports by Profs. S.E. Jones and E.P. Palmer dated March-April 1986 discuss our early thoughts on this process. We now call the alleged process "piezonuclear fusion" in contradistinction to thermonuclear fusion, or "metal-catalyzed fusion" by analogy to muon-catalyzed fusion.) In discussing our idea with geochemists (H. Craig and A. Nier), we learned that they had seen inexplicable excess helium-3/helium-4 ratios in a number of minerals—they were considerably intrigued by our possible explanation, which they had never before heard of. Finally, we uncovered a paper by Mamyrin, Khabarin and Yudenich which formally reports the occurrence of high helium-3/helium-4 in metals and semiconductors (Sov. Phys. Dokl. 23:581 (1978)). Since then, our research has accelerated. We have looked for p-d and d-d fusion in a number of compounds, including palladium foils, under various conditions since Spring 1986. Our methods involve both neutron and gamma detectors, followed by measuring helium-3/helium-4 ratios. It would not be appropriate to discuss our results here. However, there is enough evidence to warrant further studies, in my view.

The subject proposal approaches the measurement with calorimetric methods, which complements our methods outlined above. I think there is room for the proposed work in addition to the ongoing effort and would encourage funding. Indeed, I recommend a joint effort, with cooperation between the presently-funded project and the complementary work now being proposed. Such a joint effort would be facilitated by the close proximity of two of the universities involved (Brigham Young and Utah).

000490

002624

SHARP FO-700
(801) 378-2800

BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
Communication Systems (801) 378-7311

TO: Ryszard Grzenski
ER-16
DOE

() FACSIMILE NUMBER

Country Code:

City Code:

Number: 301-353-3870

FROM: S E Jones
BYU

COMMENTS:

MESSAGE CENTER

1	2	3	4
<u>Leida</u>			
<u>9/10/88</u>			
<u>mm.</u>			

CONTACTED

DATE/TIME

OPR. INI

Phone (801) 378-2749

Sending Instructions: () RUSH () CONFIDENTIAL () SEND ACKNOWLEDGEMENT
Additional Message:

1988 DEC - 5 PM 5:03

For office use only - DO NOT write on this portion of the form

Sent/Received by: Levelia
Time: 2:55 p Date: 12-5

Originals: () Dispose
() Wait
() Pick up
(x) Send to:
2916 ESC

Billing Information:

Number of pages: 3

Long Distance Charge to:

Cash (if applicable)

Amount: \$ _____

() CID number:

() Sender's number:

Received by: _____

000620

002656

SHARP FO-700
(801) 378-2800

BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
Communication Systems (801) 378-7311

TO: Ryszard Grojewski
Doc, ER-16

() FACSIMILE NUMBER

Country Code:

City Code:

Number: 301-353-3870

FROM: S. E. Jones
BYU

COMMENTS:

MESSAGE CENTER

1	2	3
<u>Linda</u>		
<u>6/4/88</u>		
<u>mad</u>		

1988 DEC - 04 PM 3:27

CONTACTED

DATE/TIME

ERR. INI

Phone (801) 378-2749

Sending Instructions: () RUSH () CONFIDENTIAL () SEND ACKNOWLEDGEMENT
Additional Message:

For office use only - DO NOT write on this portion of the form

Sent/Received by: Jewellia

Originals: () Dispose

Time: 1:20p Date: 12/10/88

() Wait
() Pick up
(x) Send to:
Linda PSC

Billing Information:

Number of pages: 4

Long Distance Charge to:

Cash (if applicable)

() CID number:
() Sender's number:

Amount: \$ _____

Received by: _____

state the procedure of obtaining the best equation of state on the basis of a system of equivalent equations and to estimate the degree of reliability of calculation of any thermodynamic function from experimental p, v, T data but also to ascertain the advisability of incorporating one group of data or other into the calculations and thus to optimally plan further experiments.

G. A. Spiridonov, A. D. Kozlov, and V. V. Sychev, in: *Thermophysical Properties of Substances and Materials (in Russian)*, Vol. 10, Izd. Standartov, Moscow (1976), p. 35.

V. V. Sychev, A. A. Vasserman, et al., *Thermodynamic Properties of Nitrogen (in Russian)* Izd. Standartov, Moscow (1977).
 R. D. Goodwin, *Nat. Bur. Stand. Techn. Note No. 653* (1974).
 R. T. Jacobson and R. B. Steward, *J. Phys. Chem. Ref. Data* 2, No. 4, 157 (1973).

Translated by Eugene Lepa

Anomalously high isotope ratio $^3\text{He}/^4\text{He}$ in technical-grade metals and semiconductors

B. A. Mamyrin, L. V. Khabarin, and V. S. Yudenich

A. F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad

(Presented by Academician V. M. Tuchkevich, February 24, 1978)

(Submitted February 16, 1978)

Dokl. Akad. Nauk SSSR, 241, 1054-1057 (August 1978)

PACS numbers: 82.90.+j, 35.10.Bg

The helium isotope ratio in any object carries information about processes leading to their formation.

Table I lists natural objects containing helium with sharply differing isotope ratios and also indicates the main processes leading to the formation of helium with the corresponding isotope ratios.

It is shown in the present paper that in a number of commercially-pure metals and semiconducting materials helium is found to be present in a $^3\text{He}/^4\text{He}$ ratio of close to 1, i.e., several orders of magnitude higher than the values given in Table I. This would indicate that the origin of helium isotopes in the materials studied was due to some processes, nuclear or physicochemical, other than those enumerated in Table I. A high $^3\text{He}/^4\text{He}$ ratio in aluminum was reported by Alimova et al.⁸

I. It turned out that our investigations, as those in Ref. 9, could be carried out by employing a sensitive mass-spectrometric technique¹⁰ and a low-background gas-liberating apparatus.¹¹

The gas was extracted from the samples by heating them in a vacuum unit with a corundum crucible. The helium was then purified by removing the accompanying gases with liquid-nitrogen-cooled carbon traps and a titanium getter heated to $T \sim 400^\circ\text{C}$, after which the helium isotopes were analyzed in a magnetic resonance mass spectrometer. The minimum measureable quantities of ^3He and ^4He were $\sim 10^6$ and 10^9 atoms, respectively.

We studied samples of 18 elements from all groups of the Mendeleev periodic system (Ni, Cu, Al, Ti, Au, Mo, Ta, Ag, Zn, Pb, Bi, Pd, Pt, Re, Ir, Ge, Si, and InSb). Three to five samples of each element were studied; more thorough investigations were made of Ni (~ 200 samples), Cu (~ 30), Ta (~ 20), Ti (~ 20), Au (10), and Al (40). In most cases the samples were foil ribbons measuring $(0.05-0.1) \times 10 \times 125$ mm. The impurities in the samples corresponded to the standard commercially-pure metals.

II. The results of the investigations, based on analysis of more than 300 samples, reduce to the following. Many

TABLE I

Object	Processes	$^3\text{He}/^4\text{He}$	Source
Earth's crust	α -decay of radioactive elements, reactions of type $^6\text{Li}(n, \alpha)^3\text{He}$, $nT, T^2 \rightarrow ^3\text{He}$	$10^{-6}-10^{-8}$	(1)
Uranium-thorium minerals	Ditto	$10^{-6}-10^{-8}$	(1)
Lithium-beryllium minerals	" "	$10^{-6}-10^{-7}$	(1)
Upper mantle of Earth	Ditto, presence of primary helium captured during formation of Earth	$3 \cdot 10^{-6}$	(1, 2)
Atmosphere	Diffusion of helium isotopes from mantle to crust, dissipation of helium isotopes into outer space, nuclear reactions in upper atmosphere with formation of $T, ^3\text{He}$	$1.4 \cdot 10^{-6}$	(1, 7)
Outer soil	Spallation reactions, implantation of solar wind	$3 \cdot 10^{-6}$	(1)



FIG. 1. Distribution of ^3He in segment of nickel foil: n is the number of atoms in a sample measuring 0.05-10-125 mm, N is the ordinal number of the sample. The vertical segments characterize the error of measurement.

samples contain a considerable quantity of ^3He . These quantities vary markedly both from element to element (10^{10} - 10^7 atoms/g) and from sample to sample (from 10^{10} atoms/g to a background value of $\sim 10^6$ atoms/g).

The values of $^3\text{He}/^4\text{He}$ vary from 10^{-3} to 1. These values of the isotope ratio, are, apparently, underestimated since the quantity of ^4He , as a rule, should not exceed the threshold of instrument sensitivity (10^7 atoms) and in most cases this was the value taken for calculations.

The ^3He distribution was found to be spotty in character. In nickel foil (Fig. 1) samples with a comparatively high ^3He content are frequently next to samples with a comparatively low content. It may be said on the basis of the results that the spots in which ^3He is contained have a size of less than 1 mm. Next to a relatively large bunching of these spots is the practically complete absence of these spots along the length of the foil up to several tens of centimeters. The results of measurements of the ^3He content in other metals also indicate a pronounced nonuniformity in the ^3He distribution.

The curve of ^3He extraction from nickel foil (Fig. 2) displays two ^3He peaks much like those presented by Tishchenko et al.¹² who studied the desorption of helium from a silver film with various helium concentrations. Tishchenko et al.¹² showed that when samples with high helium concentrations are heated the helium collects in microbubbles and is desorbed at $\sim 1100^\circ\text{K}$. At low concentrations the desorption occurs by diffusion of individual atoms at a much lower temperature, 400-700 $^\circ\text{K}$. Comparison of our results with those with Ref. 12 shows that the desorbed peaks (Fig. 2) correspond to diffusion of individual atoms and, consequently, there were no bubble formations in our samples.

The certainty of the effect can be confirmed by the following facts:

1. The quantity of ^3He considerably exceeded the background level (100 times) in many samples.
2. Repeated (more than 50-fold) blank tests did not once yield quantities of ^3He which noticeably exceeded the background level of the instrument.
3. Two gas-liberating apparatuses of different construction were used to extract the gas and the picture of the effect was the same in both cases.

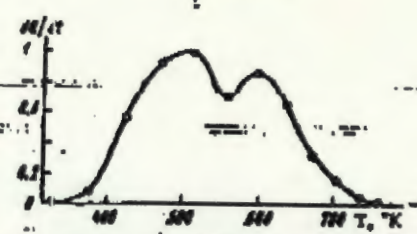


FIG. 2. Extraction of ^3He from nickel foil when temperature is raised uniformly at rate of 3.5 deg/min.

4. In some cases with the effect, the sample was completely melted but in comparison with heating to 600°C (the ordinary procedure) this did not significantly change either the total quantity of ^3He extracted or the $^3\text{He}/^4\text{He}$ isotope ratio.

5. The quantity of ^3He in each sample was determined as the average of the heights of five recorded peaks whose magnitude practically did not change.

6. In our instrument¹⁰ the ^3He line was completely separated from the HD and H_2 lines.

III. Let us consider the possible processes leading to the occurrence of ^3He in metals.

1. Diffusion from the ambient. Any processes of penetration from natural media cannot give the observed helium isotope ratio since there are no helium sources on Earth with such a high $^3\text{He}/^4\text{He}$ ratio. The possibility of the penetrating helium being enriched with the ^3He isotope by several orders of magnitude is apparently excluded because of the difference in the masses of ^3He and ^4He .

2. It may be assumed that ^3He in metals is formed as the result of the β -decay of tritium. Evidence in favor of the T- ^3He bond is given by: the "point" character of the ^3He distribution which is much like the hydrogen distribution in metals¹³; some experimental data indicating the possibility of sharply increased concentrations of tritium in metal. The T/H ratio measured for several aluminum samples¹⁴ was $\sim 10^{-8}$ which exceeds the ratio in possible ambient media by 6 to 8 orders of magnitude.¹⁵ The usual processes of separation of isotopes by diffusion from the ambient medium evidently cannot yield the effects indicated (contamination of the samples with technogenic T was ruled out).

3. There is a hypothesis¹⁴ that the high tritium concentration in aluminum results from the separation of hydrogen isotopes in electrolysis during the production of the aluminum. However, the aluminum should be enriched in the process but this was not detected in the first experiments. Moreover, with this explanation metals produced without electrolysis should not have high T/H and $^3\text{He}/^4\text{He}$ ratios. However, many samples of metals obtained by the blast-furnace process, zone refining, as well as semiconductors obtained by the Czochralski method contain helium with a high $^3\text{He}/^4\text{He}$ ratio.

4. It can be assumed that ^3He in metals is formed as the result of processes which occur right in the metal and these processes lead to the formation of either ^3He , T, or T and ^3He together. An analog of processes of this type is the nuclear reaction which takes place with the interaction of deuterium mesic atoms with ordinary deuterium atoms at thermal energies $\mu^-d + d \rightarrow ^3\text{He} + n + \mu^-$.

It should be borne in mind that the absolute concentration of ³He and T in metals are low and the build-up time for ³He and T may be quite long. Accordingly, even processes with a very low yield can, in principle, supply the observed quantities of ³He in metals.

Reliable proof of the causes of the effect discovered requires further experiments.

1. K. Gerling, B. A. Mamyrin, et al., *Geokhimiya*, No. 10, 1208 (1971).
 2. G. Khlopis and E. K. Gerling, *Dokl. Akad. Nauk SSSR* 81, 297 (1948).
 3. A. Aldrich and A. Nier, *Phys. Rev.* 74, 1590 (1948).
 4. I. Kozlov, B. A. Mamyrin, et al., *Dokl. Akad. Nauk SSSR* 217, 172 (1974).
 5. N. Tolstikhina, B. A. Mamyrin, and L. V. Khabarja, *Earth Planet. Sci. Lett.* No. 1, 75 (1974).
 6. A. Mamyrin, G. S. Anufriev, et al., *Geokhimiya*, No. 6, 721 (1970).
 7. N. Tolstikhina, L. Ya. Azbel', and L. V. Khabarja, *Geokhimiya*, No. 5, 651 (1975).

8. S. Boltzenkov, V. N. Garmatov, et al., In: *Lunar Soil from the Sea of Plenty* (in Russian), Nauka, Moscow (1974), p. 363.
 9. A. Alimova, B. S. Boltzenkov, et al., Preprint FTI im. A. F. Ioffe Akad. SSSR (A. F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR), No. 241 (1970).
 10. B. A. Mamyrin, B. N. Shustrov, et al., *Fizh. Tekh. Eksp.*, No. 6, 148 (1972).
 11. B. A. Mamyrin and L. V. Khabarja, *Fizh. Tekh. Eksp.*, No. 6, 232 (1976).
 12. L. P. Tishchenko, T. I. Peregona, et al., *At. Energy*, 37, No. 6, 494 (1971).
 13. Z. Solahtin, L. A. Sunin, et al., In: *Processes of Diffusion, Structural Defects, and Properties of Metals* (in Russian), Metallurgiya, Moscow (1972), p. 108.
 14. B. S. Boltzenkov, Candidate's Dissertation, A. F. Ioffe Physicotechnical Institute, Academy of Sciences of the USSR, Leningrad (1973).
 15. A. P. Vinogradov, A. P. Derjuz, and E. I. Dobidna, *Geokhimiya*, No. 1, 1947 (1968).

Translated by Eugene Lepa

check recent list for these authors
- go to library of student

8/88 - E. Jones

Notes:
 - p-p weak → ignore → Proposal
 - 1/10 in / Jumbo - no product (Pegm)
 - ³He / T 10⁻⁴ - correlation of D - some metal alloy or w/ D
 - above 8'5 or 170'5 - natural d-d / f...
 - d-d may be further done to see if...
 - geo. samples... high 3He/4He - no Russian products
 - 2x heat - interesting for geo/chem under...
 - high rates needed for energy
 - large quantities of p+d in...
 - interstitially...
 - extra under way at BPA - low level in year

e is raised
 He was com-
 to 600°C
 ntly change
 He/⁴He
 determined
 peaks whose
 mpletely
 leading
 ases of
 observed
 sources on
 stability of
³He isotope
 xcluded
 and ⁴He.
 formed as
 in r of
 ter of the
 n distrib-
 ting the
 of tritium
 aluminum
 possible
 The usual
 from the
 its indi-
 genetic T
 dum con-
 tion of
 duction of
 e enriched
 as first
 metals pro-
 T/H and
 metals
 ining, as
 tralsid
 formed as
 metal and
³He, T, or
 deuterium