INVESTIGATION OF COLD NUCLEAR FUSION
IN CONDENSED MATTER

Final Report

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Introduction

Our research on fusion phenomena near room temperature extends back a full decade. The research began with intensive studies of muon-catalyzed fusion in 1982 [Jones 1983]. Fusion induced by negative muons, without the need for high temperatures, was investigated at Los Alamos Meson Physics Facility, at the Rutherford-Appleton Laboratory in the United Kingdom, at TRIUMF in Canada and at the KEK National Laboratory in Japan. We uncovered a number of surprises relating to muon-catalyzed nuclear fusion [Jones 1986, Leon 1991] and demonstrated skills in detecting neutrons and charged particles.

These studies led several of us in 1985-86 to consider the possibility of achieving room-temperature fusion of hydrogen isotopes without muons. Clinton Van Siclen and Jones wrote a treatise on this process which was called "piezonuclear" fusion to distinguish the idea from thermonuclear fusion and from muon-catalyzed fusion. [Van Siclen & Jones 1986] In March, 1986, BYU Professor Paul Palmer hypothesized that such a process occurring naturally inside the earth could account for helium-3 production in the earth and its emanation at terrestrial hot spots, and called it "cold fusion" [Palmer 1986]. We retain a strong interest in geological fusion and its implications. In early 1986, we began experiments at BYU to search for the possible fusion in metals charged with deuterium in both electrolytic cells and deuterium-gas-filled cylinders. Detector development for this purpose also proceeded at BYU with a suitable neutron spectrometer available in 1988. [Czirr & Jensen 1989].

Our first experimental paper on the subject appeared in Nature in April 1989 [Jones et al. 1989a] amidst widespread uproar over a press announcement by B. S. Pons and M. Fleischmann on March 23, 1989. We will not review this particular history here, but refer interested parties to reviews [Close 1990, Mallove 1991, Huizenga 1992, Peat 1989, Lewenstein & Baur 1991]. It suffices to say that our work and that of others generated interest and controversy that motivated further research and careful checking. So with continued DOE support, we repeated our experiments in the Gran Sasso Laboratory [Bertin et al. 1989] and at the Los Alamos National Laboratory [Menlove et al. 1989] and in a deep mine in Colorado [Jones et al. 1991], and participated in other experiments [see Jones et al. 1991, AIP Proceedings 228].

Our goal in recent experiments has been to find a means to produce neutron emissions at will, to demonstrate reproducibility and to permit in-depth studies of the origins of the neutron emissions. We posited that without clear reproducibility, progress in understanding cold fusion or indeed in assuring ourselves and others of its existence in nature, would be stifled. As we report here, our goal has been pursued in the Kamiokande detector in Japan [Ishida 1992] and has led to the development of a deep underground laboratory in a tunnel in the Wasatch mountains near BYU (see Figure 1). This work was supported by the U.S. Dept. of Energy, and partly by the Electrical Power Research Institute and Brigham Young University. The Provo Canyon Laboratory now includes three state-of-the-art counters for low-level neutron emissions with noise and gamma rejection, along with charged-particle, gamma and x-ray detectors. Calorimetric tools have also been developed, and are available at BYU. Thus, we are in a position to pursue cold-fusion studies and to examine claims made by other researchers (most recently, several Japanese scientists).

Principal Accomplishments Since March 1990

1. Colorado Mine Experiments

Our original experiments on cold fusion, beginning in May 1986, were conducted in an underground laboratory at BYU under approximately two meters of earth and 15 cm of concrete. In order to further preclude interference from cosmic-ray influences, we have conducted experiments in deep underground locations. During the summer of 1990, we moved the helium-3-type detector into the Blackcloud mine in Leadville, Colorado. The detector was then shielded by an overburden of approximately 600m of rock including lead and zinc ores. Both the singles and correlated-count rates dropped dramatically in this location (Table I). Similarly low background rates were observed when the detector was run in the Kamioka mine in Japan, with about 1000 m of overburden. A comparison of rates in various locations is given in Table I. Note that singles rates are the same in the mines in Japan and in Colorado. This supports our calculations that observed singles rates are due almost entirely to decay of radioactive trace elements in the counter-tube walls. Such decay results in a Poisson distribution of counts, consistent with our observations in the deep-mine environments.

Table I. Comparison of background counting rates
in dual-ring segmented counter

<u>Location</u>	<u>singles rate</u>	<u>Correlated-count rate in 128 μs window ("reals")</u>
BYU underground lab	400/hr	7/hr
Leadville, CO		
Above ground	23,400/hr	300/hr

Figure 1.
Door into the BYU Tunnel Laboratory,
located in mountains 7 miles from BYU.

Dr. Bart Czirr inserts sample into
burst-mode detector inside tunnel.
CAMAC/pulse digitizer/PC system.

The light at the end of the tunnel:
looking toward entrance from near
experimental area in BYU Tunnel Lab.

600 m underground 75/hr*

1/20 days

Kamioka, Japan

1000 m underground 75/hr*

(not enough running time
yet to see any burst-like
events in background)

*For counts accumulated in 60 second bins. Background rate is about 70/hr for 10-second bin collection intervals due to computer dead-time.

Operation of the detector underground provided an opportunity to scrutinize sources of spurious signals in the detectors. These tests complement extensive tests by H. Menlove and colleagues at Los Alamos showing very high immunity of the counter to gamma-rays, temperature changes, microphonics, and electrical noise pickup as well as long-term stability [see 9,10].

When the detector was first run in the humid environment of the Colorado mine, it was not sufficiently protected from penetration of humidity into the high-voltage circuitry. As a result, we observed a dramatic increase in both the singles and the correlated-signals rates. We accumulated data in this condition in order to characterize the moisture-induced noise. We found that the singles rate was dominated by counts in one segment, that is, segment 4 was counting an order of magnitude faster than the other three segments. Thus, segmentation of the counter allowed us to identify the spurious counts. Apparent bursts had the characteristic that counts in singles scalar were much larger than counts in the "reals" or correlated counts register, typically by a factor of 5 to 30, consistent with expectations for high-voltage breakdown or electrical noise induced by high humidity. Again, redundancy in the electronics allowed us to identify spurious burst-like signals. The detector was then dried out, loaded with dessicant, and protected from humidity; a humidity indicator was also monitored. The detector quickly returned to low-count behavior with counts balanced as expected in the four segments. These spurious results due to humidity in the Menlove-type counter warn us that artifactual burst events can occur, and that segmentation is needed to avoid such artifacts. Early runs by Menlove in Los Alamos did not have such segmentation as we now demand at BYU, making the early results suspect.

Results of these experiments are described in AIP Proceedings 228 [Jones et al. 1991a]. Figure 2 shows a major result, data acquired in the Leadville, Colorado, mine using our helium-3-type neutron counter and three electrolytic cells operated by our colleague Kevin Wolf. Following the Dunnett procedure, the value of each observation under foreground conditions was compared with the average background count. The background variability was

Fig. 2. Data acquired 600m underground in Leadville mine using 16-tube helium-3 type counter and three electrolytic cells operated by K. Wolf. Neutron-singles rates are shown in 90 minute bins, except for 30-minute bin to right of arrow representing time to remove cells and refill with electrolyte. A small ($R=1$) burst occurred during time marked by arrow, while the rate was high.

used as the error term for the comparison. The probability that the most extreme observation (120 counts per hour, nearly double the background rate) would be this high if there were no signal is less than 0.005, as determined by statistician Dennis Tolley [in Jones et al. 1991a].

2. Conference on "Anomalous Nuclear Effects in Deuterium/Solid Systems"

In October 1990, an international conference was held on the BYU campus to scrutinize observations of possible low-level nuclear effects associated with deuterium-loading in various materials.

Nearly seventy papers were presented, with discussions divided into five broad categories with chairs indicated:

1. Neutron Emission Studies: W. Meyerhof (Stanford), K. Nagamine (U. Tokyo), A. Vitale (U. Bologna), K. Wolf (Texas A&M), F. Scaramuzzi (Frascati), H. Menlove (LANL), V. Tsarev (Lebedev Physical Inst.)
2. Charged Particle Detection: J. Ziegler (IBM), E. Cecil (Colorado School of Mines)
3. Tritium/Helium Studies: G. Miley (U. Illinois), . Hoffman (Rockwell Int'l.), M. Srinivasan (BARC, India)
4. Fusion in the Planets: F. Goff (LANL), E.P. Palmer (BYU), G. McMurtry (U. Hawaii)
5. Theory: J. Rafelski (U. Arizona), V. Belyaev (Dubna), Y. Kim (Purdue), E. Tabet (INFN, Italy)

The conference was co-sponsored by the Department of Energy. The 1000+ page proceedings were published in 1991 by the American Institute of Physics [Jones et al. 1991a].

3. Kamiokande (Japan) Experiments

In 1991, a series of cold-fusion experiments were conducted in the giant Kamiokande detector in Kamioka, Japan. Collaborators include scientists from BYU, Los Alamos National Laboratory (H. Menlove and M. Paciotti), Texas A&M (K. Wolf) and several universities in Japan. The Japanese evinced a keen interest in these studies. Important conclusions from this collaborative experiment were: "some burst neutron emissions were observed especially from the electrolytic cells. The event rate (about 0.06 bursts per hour) was comparable to that of Menlove et al. (1990)... [Furthermore,] we have found a clear random neutron emission from the Portland cement mixed with D2O at the level of 1×10^{-3} neutrons/second, which is ... difficult to explain based on radioactivity contamination in the cement..." These quotations are from the Master's Thesis of Taku Ishida, a Japanese graduate student who worked with us on the project; his thesis is appended to provide further detail.

4. Provo Canyon Laboratory Facility

With the support of the Department of Energy, the Electric Power Research Institute and Brigham Young University, we have outfitted an underground laboratory with high-sensitivity detectors, in a tunnel seven miles from the BYU campus. Suggestions from a panel of nuclear scientists assembled by EPRI in December 1991 (S. Koonin, C. Barnes, A. Mann, P. Bond, and others) resulted in improvements in this facility, realizing finally a state-of-the-art laboratory which is dedicated to exploring so-called cold fusion phenomena. In one neutron detector, we approximate the neutron-detection sensitivity of the Japanese Kamiokande detector, with the added ability to discriminate against low-energy neutrons produced, for example, by deuteron photodisintegration. Our Kamiokande collaborators and the nuclear experts assembled by EPRI in December 1991 have strongly urged us to pursue our studies in this new facility. We are doing just this, focussing on the neutron-detection approach we pioneered, and adding heat, x-ray, charged-particle and gamma measurements to complement our neutron measurements. Researches include electrolytic cells, gas-loaded solids, fusion during sonoluminescence in D₂O (other isotopic waters will be employed also), ion-implantation, cement+D₂O, and piezoelectric samples incorporating deuterium. Our goal is to find definitive answers using multiple, integrated detection systems. The electronics is based on fast (100 MHz) waveform digitization to facilitate signal identification and noise rejection, with data acquisition by small computers.

The BYU Tunnel Laboratory responds to the challenge of making multiple, simultaneous measurements to permit conclusive studies. Our assembled team has expertise in nuclear measurements, electron microscopy, data analysis, calorimetry and acoustical measurements. Moreover, we have invited other researchers to check their results in this laboratory, which was initially funded after all by the U.S. Department of Energy. In January 1993, we have planned visits by scientists from the Los Alamos National Laboratory and from Canada. Photographs of the laboratory and associated gear are provided in Figure 1.

A brief discussion of high-sensitivity neutron detectors recently developed and in operation in our tunnel laboratory follows. Patent number 4,931,649 was issued to Bart Czirr and Gary Jensen of our group for a "neutron coincidence calorimeter," described in Appendix B. Its development was instrumental in research described in Nature in 1989 [Jones et al. 1989]. A new spectrometer is designed with a central cavity to accommodate test samples, and provides a neutron detection efficiency for 2.5 MeV neutrons of about 18.7%.

A neutron burst monitor depicted in Figure 3 is also available in the tunnel laboratory. Energetic neutrons produce prompt signals in an optically isolated plastic scintillator. These neutrons are then further moderated in mineral oil, and some are eventually captured in one of several ⁶Li-glass scintillators distributed in the mineral oil volume. For neutrons produced

Fig. 3a Construction details of the burst-mode detector and the spectrometer.

DETECTOR COMPONENT PARTS DESCRIPTION

- A. ALUMINUM HOUSING
- B. PLEXIGLASS BOX; CLEAR ENDS; MIRRORED SIDES, TOP AND BOTTOM
- C. ORGANIC PLASTIC SCINTILLATOR CYLINDER
- D. CLEAR CAST ACRYLIC PLASTIC TUBE
- E. LITHIUM GLASS SCINTILLATOR PLATES (QUANTITY OF EIGHT)
- F. PHOTOMULTIPLIER TUBES (QUANTITY OF THREE)
- G. CENTRAL WELL
- H. PHOTOMULTIPLIER TUBE HOUSING

Top View,
Lid Off

Figure 3b
Vertical Section,
Midplane

simultaneously in a burst, the above process results in time dispersal of the capture signals (half of the signals arise in the first 11 us), so the number of capture events can be counted and the total number of neutrons in the burst can be estimated. The capture of the slow neutrons proceeds by the reaction $n + {}^6\text{Li} \rightarrow \alpha + t$ with an energy release of 4.86 MeV, providing a distinctive light pulse in the scintillator. The optical signals from the plastic and the glass scintillators are monitored separately by independent photomultiplier systems.

Using large quantities of copper and rock salt as shielding, we have reduced backgrounds in the tunnel. Cosmic-ray muons are quite readily identified as narrow Cherenkov pulses in the mineral oil, and these are rejected off-line. Thus, the background is reduced to about 1 correlated single per three hours while the efficiency for MeV-energy neutrons is about 8.4%. This counter has a sensitivity approaching that achieved in the Kamiokande detector in Japan, when that neutrino counter is modified for use as a neutron detector.

Our latest development involves augmentation of a helium-3-type counter (as developed originally by H. Menlove at Los Alamos National Laboratory). The core of the detector is a large plastic scintillator (8.9 cm O.D. X 30 cm long, with 4.7cm diam central hole to admit samples) to provide prompt registration of neutrons and to allow rejection of slow neutrons (e.g., from $d(\gamma, n)p$ reactions induced by Tl-208). Neutrons are moderated in polyethylene and captured in He-3 where the reaction $n + {}^3\text{He} \rightarrow p + t$ results in ionization picked up in proportional counter tubes. Now in place underground in the tunnel laboratory, the scintillator/ ${}^3\text{He}$ -type counter has a sensitivity for MeV-energy neutrons (12.1% efficiency, 0.45 counts/h background) comparable to that of the Kamiokande (20% efficiency, 0.25 counts/h background). We believe that ours is now the most sensitive detector for MeV-energy neutrons in the Western Hemisphere.

All pulses are digitized at 100 MHz using a LeCroy waveform digitizer over 160 us (typical) and data are stored using 386 PC/CAMAC systems. Thus, one can analyze pulses off-line and differentiate genuine pulses from (rare) noise sources with high efficiency. The use of redundant detectors also increases data surety. It will be very difficult to fool all three energy-discriminating neutron counters.

The direct measurement of energetic charged particles emanating from thin films is far more sensitive than measurement of changes in tritium or helium or isotopic levels in samples. Moreover, the energy of any observed particles carries crucial information regarding the reactions which generated them.

A charged-particle spectrometer (CPS) built at BYU is pictured in Figure 4. The CPS incorporates a very thin plastic scintillator (0.0157 gm/cm²) glued (0.0073 gm/cm² silicon glue) onto a thicker

Figure 4.

Coupled Charged - Particle Detector / Neutron Spectrometer at BYU

glass scintillator (0.375 gm/cm²) which is glued on the face of a 12.7-cm diameter photomultiplier tube (PMT). Pulse-shape analysis of digitized signals allow us to distinguish plastic pulses from glass pulses which are broader in time. The integrated area in each pulse reflects the energy of the incident charged particle. The detector is calibrated using Am-241, Co-60 and Th sources.

One implementation of the detector which allows simultaneous charged-particle and neutron registration is depicted in Figure 4. For further information, see Jones et al. 1991 from the proceedings of the Provo meeting on "Anomalous Nuclear Effects in Deuterium/Solid Systems."

A surface-barrier detector is also in operation for charged-particle detection and energy evaluation, simultaneously with neutron detection (see Fig. 5). We have successfully used such detectors in a deuterium atmosphere in muon-catalyzed fusion experiments for detection of energetic alpha and alpha-muon ions [Paciotti 1988, Jones 1988]. An electrolytic cell with a thin Pd window viewed by a surface-barrier detector has been built at BYU. The apparatus is small enough to fit inside a neutron counter. The Pd cathode foil is thin enough to permit transmission of p,d,t and He ions from reactions occurring near the active cathodic surface or in the thin metal. Other experimental searches have used a similar technique but sometimes with too much intervening material to be sensitive to fusions occurring on the active surface of the cathode [Suddquist 1989, Ziegler 1989].

A 12.5-cm diameter X 12.5 cm long sodium iodide detector is available at BYU for gamma detection, along with a multichannel analyzer. Fast electronics are in hand to allow us to look for gammas correlated with detection of neutrons or energetic charged particles. To date, detection of 5.4 MeV gammas expected from proton-deuteron fusions has not been convincing. However, we have arranged to use the segmented bismuth-germanate detector (BGO Ball) at the Los Alamos Meson Physics Facility if needed.

We currently use a Beckmann-II Scintillation Counter with Aquasol as the scintillation cocktail for tritium detection at BYU. This equipment is satisfactory for observing tritium production at rates reported by some [Bockris 1989, see Jones, Scaramuzzi & Worledge 1991], although we have not seen tritium above ordinary electrolytic-enrichment levels. [Harb 1990] To detect tritium at very low levels, as required in geological studies, we send samples to Gote Ostlund at the University of Miami and to a group at the University of Berlin. Indeed, small but significant levels of tritium have been reported from magmatic waters of both Mt. Saint Helens and Kilauea volcanoes by the team of Fraser Goff (Los Alamos) and Gary McMurtry (Univ. Hawaii). [Goff 1991]

Electrolytic cell with Pd foil cathode/window, placed inside vacuum vessel; surface barrier detector (gold) detects ions.

Glow-discharge cell with Pd cathode, filled with deuterium.

FIG. 5

New BYU neutron spectrometer, showing assembled electrolytic cell placed into core. (Neutron and charged-particle detection.)

In addition, BYU has several mass spectrometers which can be used for this research, including a high resolution double focussing mass spectrometer. Dr. Nate Hoffman of ETEC/Rockwell International has offered to analyze samples for changes in helium-3 and helium-4 content.

BYU has recently acquired a state-of-the-art scanning tunnelling electron microscope and scanning force microscope which will be used for this research. Examination of the metal surface before and after deuterium-charging will show changes in the morphology and grain size and reveal void formation. [Murr 1990] The size of the voids can be used to evaluate the effective hydrogen pressure which formed the voids. [Doremus 1985] The composition of the metal will be determined using electron-induced x-ray fluorescence.

BYU has an x-ray diffractometer to permit diffraction studies on the metal before and after deuteriding. This will disclose changes in the crystal structure. [Yamamoto, Osaka] The deuterium content can also be calculated from the change in the lattice constant. Stresses in the metal can be studied also by x-ray diffraction.

BYU has a state-of-the-art x-ray fluorescence spectrometer which will be available for this research. Fluorescence spectroscopy performed on the metal before and after deuteriding will show changes in the composition. Rutherford back-scattering is also available at BYU.

CALORIMETRY. To our knowledge, no experiments have been reported in the literature where sophisticated calorimetry has been conducted at the same time nuclear particles were being detected with state-of-the-art sensitivity. We have considered the failings of simple calorimeters and designed an isothermal, integral system to provide reliable data while it is inserted in our neutron counter. (The design is due primarily to Lee D. Hansen of the BYU Chemistry Department.)

The BYU calorimeter runs at a constant temperature. Previous calorimeters have measured temperature rise to detect heat production, and excess heat was assumed to flow at a constant rate (proportional to the temperature difference) into a surrounding constant temperature bath. Unfortunately, changes in temperature lead to numerous errors in the calorimetric data. The two most serious problems are irregular (history-dependent) changes in the thermal conductivity of the calorimeter's materials and changes in the viscosity and stirring pattern of the liquid. The result of this is uncontrollable variation in the calorimeter constant, k . In cold fusion work, others have assumed k is constant over an entire run (or a large part of it), but it is clearly not, and this is a source of major error.

Other calorimeters are differential in that they sample

temperature at various times and use this information to reconstruct heat production and leakage as best they can. Our proposed calorimeter is integral in that it automatically adds heat electrically to counteract cooling. Heat produced by chemical or other reactions in the cell calls for less electrical heat to be added. The added heat is integrated. A computer keeps track of this total and computes heat production in the cell. It will also be programmed to account for constantly monitored changes in electrode potentials and electrochemical joule heating.

The conduction calorimeters used in the past have several pathways for the removal of thermal energy. Unfortunately, each of these has a different time constant, and if the temperature changes, the efficiency of these pathways changes in an unpredictable fashion. This is another reason to go to an isothermal calorimeter since precision is required.

5. Theory

An early treatment of cold fusion is given in the June 1985 (submission date) paper by Van Siclen and Jones [Van Siclen & Jones 1986], which suggests that the cold fusion rate is very small even for deuterons separated by half the equilibrium distance in D₂ gas molecules (0.74 Å). In our 1989 paper [Jones 1989], we argued that non-equilibrium conditions are essential for d-d fusion even at the very low rates we deduced. It is possible that under non-static, high-pressure conditions, metallic deuterium may form briefly leading to close proximity of lattice and interstitial deuterons, leading to low-level fusion. [Jones 1990]

Others have argued that high deuteron/metal ion loading ratios are essential to achieving fusion, and that 3- and 4-body reactions may be implicated [e.g. Takahashi 1992]. We have performed computer-based studies of deuteron siting and movement in metallic lattices and have not found evidence for deuterons existing closer than 0.74 Å even with high loading. The notion of fusion reactions involving more than two nuclei on the time and distance scale involved in strong-force (nuclear) interactions is clearly problematical.

Eventually, one must develop a consistent picture for "cold fusion" phenomena, if these are definitively proven to exist. The objectives can best be met by measuring diverse signals such as neutrons and charged particles, simultaneously. Progress in understanding must be slow without a coordinated, comprehensive detection scheme of the type developed here with the support of the Department of Energy.

7. Geophysical evidences for natural fusion in the earth

One of the goals of the research funded by the Department of

Energy was to assess the possibility of natural fusion inside the earth [Jones et al. 1989]. The research was conducted primarily by Prof. Gary McMurtry of the University of Hawaii in conjunction with Fraser Goff, geophysicist at the Los Alamos National Laboratory. BYU scientists also contributed. Tritium was selected as a tracer of nuclear reactions occurring in the earth, since it has a half-life of only 12.4 years which is very short on geologic time-scales. Thorough studies to distinguish tritium from prosaic sources such as hydrogen-bomb tests and neutron capture in lithium, have been carefully conducted. The following volcanoes have been analyzed for tritium content in magmatic waters:

1. Kilauea volcano, Pu'u O'o vent, in Hawaii.
2. Mount St. Helens, in Washington state.
3. Picaya volcano, in Central America.

The conclusion of these studies is that all three show non-zero tritium contents which have resisted diligent efforts at conventional explanation. In particular, deuterium/proton and $^{16}\text{O}/^{18}\text{O}$ ratios have been used to differentiate magmatic water from surface waters. A draft of the geophysicists' paper is included in this report. The geophysicists will next sample the Galeras volcano in Columbia. Our hypothesis of geologically occurring fusion also motivates our search for fusion stimulated by diamond-anvil cells containing isotopes of hydrogen (also lithium and boron).

CONCLUSION

Questions continue to arise regarding cold fusion: Are neutron and heat releases real? Correlated? Triggerable? The BYU/Los Alamos/Texas A&M/Kamiokande experiments point to real neutron emissions, but definitive answers have proven elusive. Tritium emissions from active volcanoes point to natural fusion inside the earth. In order to provide complete answers, we have developed an underground laboratory which permits simultaneous detection of neutral and charged particle emission with heat and acoustical signal registration (as in sonoluminescence; e.g., we are searching for evidence of fusion during SL in D₂O). The real-time data are augmented with electron microscopy and analysis for changes in content of tritium and helium isotopes. The BYU Tunnel Laboratory holds state-of-the-art equipment for these researches. In cooperation with other researchers, including active collaborations with Japanese, American and Russian scientists, we are resolved to settle the matter and see where it leads.

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Papers related directly to this agreement:

1. S.E. Jones, E.P. Palmer, J.B. Czirr et al., "Observation of cold nuclear fusion in condensed matter," Nature, 338:737 (27 April 1989)
2. S.E. Jones, D.L. Decker, H.D. Tolley, Scientific Correspondance, Nature, 343:703 (22 Feb 1990)
3. S.E. Jones, E.P. Palmer, J.B. Czirr et al., "Anomalous Nuclear Reactions in Condensed Matter: Recent Results and Open Questions," J. Fusion Energy, 9:199-208 (Dec 1990)
4. H.D. Menlove, M.M. Fowler, E. Garcia, M.C. Miller, M.A. Paciotti, R.R. ryan, and S.E. Jones, "Measurement of Neutron Emission from Ti and Pd in Pressurized D2 Gas and D2O Electrolysis Cells," J. Fusion Energy, 9:495-506 (Dec. 1990)
5. A. Bertin et al., "First Experimental Results at the Gran Sasso Laboratory on Cold Nuclear Fusion in Titanium Electrodes," J. Fusion Energy 9:209-213 (Dec. 1990), also same authors in Il Nuovo cimento A101:997 (June 1989)
6. AIP Proc. 228, "Anomalous Nuclear Effects in Deuterium/Solid Systems," Provo, UT 1990 conference, S.E. Jones, F. Scaramuzzi, D. Worledge editors, Am. Institute of Physics, NY, 1991.
7. T. Ishida, "Study of the Anomalous Nuclear Effects in Solid/Deuterium Systems," Masters Thesis printed as ICCR-Report-277-92-15, Univ. of Tokyo, Feb. 1992
8. S.E. Jones, "Current issues in cold fusion research: heat, helium, tritium, and energetic particles," Surface and Coatings Tech. 51:283-289 (1992)
9. S.E. Jones, J.B. Czirr, D.L. Decker et al., "Response to queries regarding "Observations of cold nuclear fusion in condensed matter," RAL-90-022, Rutherford Lab., Proc. of Internat. Symposium on Mu-Cat. Fusion, 1990.

APPENDIX: PAPERS NEARING PUBLICATION (AND INTRODUCTION TO AIP
CONFERENCE PROCEEDINGS NO. 228)

1. Anomalous Nuclear Effects in Deuterium/Solid Systems,
Conference held at BYU, Provo, UT, October 1990, published by the
American Institute of Physics, 1991; co-sponsored by U.S. Dept.
of Energy, Electric Power Research Institute, and BYU.
2. Study of the Anomalous Nuclear Effects in Solid-Deuterium
Systems, Master Thesis by Taku Ishida of the Kamiokande
collaboration.
3. Systematic Investigations of Neutron Emissions from Cement
Prepared with Heavy Water, Steven E. Jones (unpublished).
4. Deuterium and Tritium in Primary magmatic Water from Mount
St. Helens and Kilauea Volcanoes, Fraser Goff and Gary McMurtry
(submitted for publication).
5. Is Reported "Excess Heat" Due to Nuclear Reactions?, D.
Buehler, L. Hansen, S. Jones and L. Rees (submitted for
publication)

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