Observations on the Role of Charge Clusters in Nuclear Cluster Reactions

Ken Shoulders and Steve Shoulders*

Note entered 2/19/03 John Dash has requested the removal of data relating to his work on the grounds that his samples were likely contaminated during a metallurgical rolling process thus weakening the claims of transmutation. Although adequate warning of such an effect is included in this paper, the authors gladly comply with the request of John Dash and leave the data intact but add this additional warning as to the interpretation of the data. John Dash is not to be held responsible for any data presented.

Abstract -- Deuterium loaded palladium foils, produced by both electrolytic and ultrasonic processing, have been micro-analyzed for nuclear reactions. The characteristic strike marks of charge clusters, known as EVs, have been found to occur concurrently with nuclear reactions in micrometer-sized areas. In the electrolytic case, the reaction is attributed to charge clusters generated from mechanical energy, first stored and then suddenly released, from a brittle metal lattice through the mechanism of fracto-emission of electrons. For the acoustic case, EVs are generated by charge separation in a collapsing bubble. When areas previously free of low energy nuclear reactions are bombarded in either vacuum or air by externally generated charge clusters, nuclear reactions are produced at the bombardment site. Charge clusters are considered to function as a collective accelerator capable of injecting a large group of nuclei into a target with sufficient energy density to promote the nuclear cluster reactions observed.

I. BACKGROUND

Highly organized, micron-sized clusters of electrons having soliton behavior, along with number densities equal to Avagadro's number, have been investigated by K. Shoulders since 1980 [1] [2] for use in electronic systems. To facilitate daily discussion of the entity, a short Latin acronym has been adopted and the structure is called an EV, for *strong electron*. Their organizational properties have been theoretically studied and reported by P. Beckmann [3] and R. Ziolkowski [4].The origin of an explosive emission process capable of producing this extreme state of matter has recently been described by G. Mesyats [5].

What is seen in the laboratory is an extremely energetic entity capable of being transformed into a wide range of action-producing variations. Measurements have been made showing there are no included ions to a limit of at least one ion per million electrons. The total number of electrons in a one micrometer diameter EV is 10^{11}. This number allows for inclusion of about 10^5 nuclides that would escape detection by measuring the charge-to-mass ratio of the structure in such a primitive way as time-of-flight. For all practical purposes, the entire ensemble of electrons and nuclides would be collectively accelerated to the velocity of electrons. This gives the effect of a very simple and efficient nuclear particle accelerator. Nuclides can be added to the basic EV to such a high level that the net charge becomes positive. Under this condition there is no valuable collective acceleration, although other interesting effects occur.

Over time, a number of observations have been made showing that the characteristically high energy density of EVs are enhanced further by interaction with certain target materials. The simplest observation method is to allow an EV to strike a metal electrode and note the magnitude of the plasma plume arising due to the explosive decomposition of the EV order. On some strikes there is copious X-ray production, very energetic plasma plumes and a "wildfire" effect to be discussed later. Conversely, other strikes cause a normally energetic micro plasma plume without the higher energy output. The cause for some of these differences, as seen on palladium foil, is the subject of this paper. In the interest of brevity, we will use the term, NEV, to designate EVs containing nuclides. In the scenario being developed here, the NEV acts as an ultra-massive, negative ion with high charge-to-mass ratio. This provides the function of a simple nuclear accelerator.

It is not the intent of the observations presented here to either add to or take away anything from the ongoing discussions of low-energy nuclear reactions. Rather, it is the intent to show a similarity between electrolytic, sonic, and gaseous discharge methods for producing the effects observed. However, it is difficult to explain the observations without some extraordinary means for introducing "foreign" material.

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II. STRIKE MARK INTERPRETATION

As a reference to what a normal EV strike on a metal foil target looks like, Fig. 1 shows an example produced on an aluminum target having a thickness of about 6 µm. In this case, the EVs were produced by a very simple external power source consisting of a hand-held Tesla coil applied in air. The backside of a typical strike on the same material is shown in Fig. 2. It can be seen that the energy of the strike is sufficient to penetrate the aluminum. Using a higher resolution, chromium film-on-glass type of witness plate, Fig. 3 shows more detail of the energy center for the same kind of strike without having much lateral thermal transfer through the target. The strike is about 3µm in diameter and this should serve as a reference for the core size of energy that is delivered to the Pd sample being investigated.

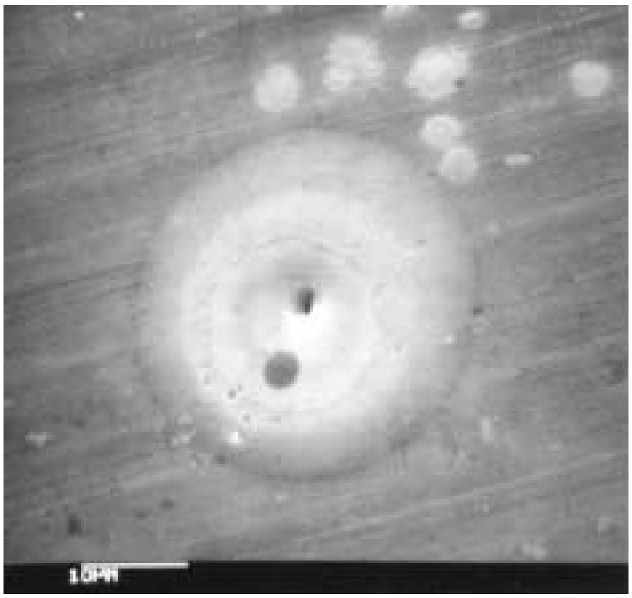


Fig. 1

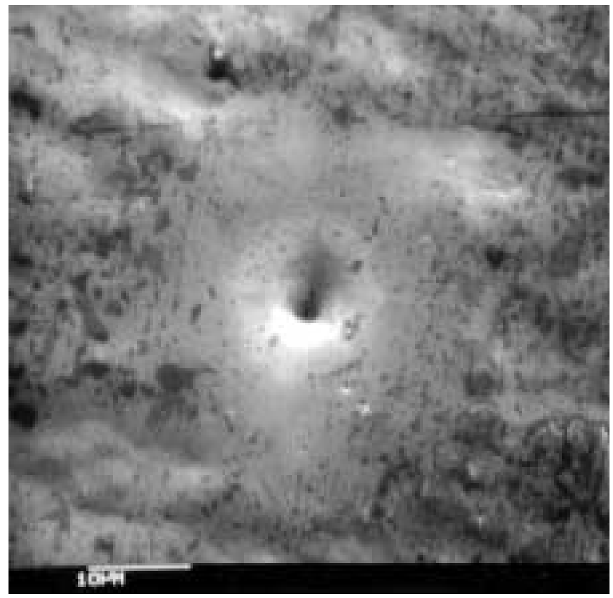


Fig. 2

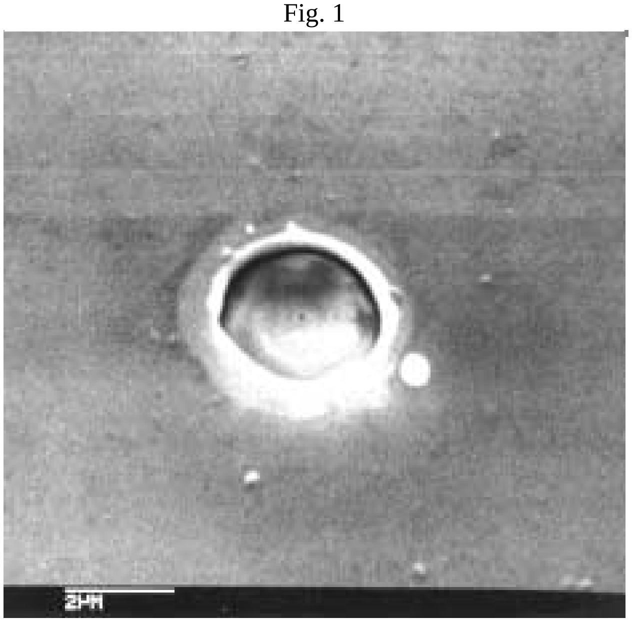


Fig. 3

When higher melting point materials are struck in vacuum by an EV, the craters change in both size and shape. Fig. 4 is an example of a strike on a stainless steel metal foil 13 µm thick. The back side of the foil is shown in Fig. 5. Once again, there is adequate energy for penetration. The peculiar splash pattern of ejected material on the back side is caused by using an aluminum back-up plate to help suppress charge accumulation on the high resistance stainless steel foil. Without this plate, the negative charge density can be so high that the EV is unable to land and it will skip away to deposit energy elsewhere.

The arc literature has many examples of this type of strike mark, often called cathode craters, but there is difficulty in distinguishing between cathode and anode craters on bulk materials by appearance alone. This point is often complicated by not being able to tell which electrode is a cathode and which is an anode. Further exasperation results by studying work done on unipolar arcs where a laser beam strikes a surface having a single potential and produces a miniature thunderstorm of charge that, first, separates into positive and negative clouds, and then forms an EV destined for the electrode that appears positive to this newly-formed negative entity.

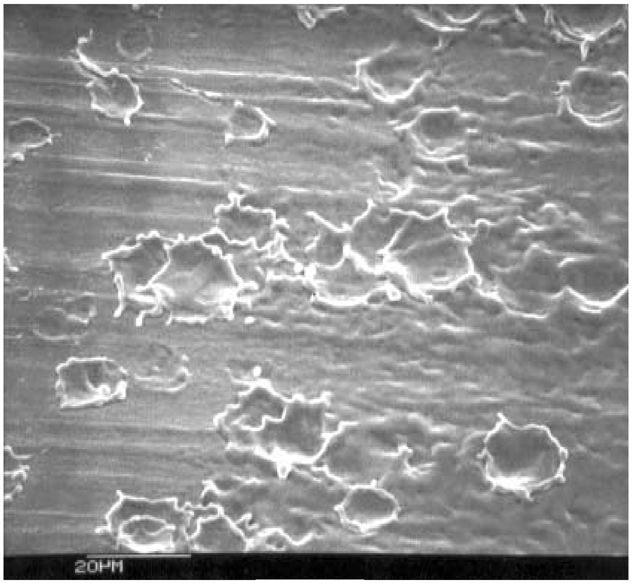


Fig. 4

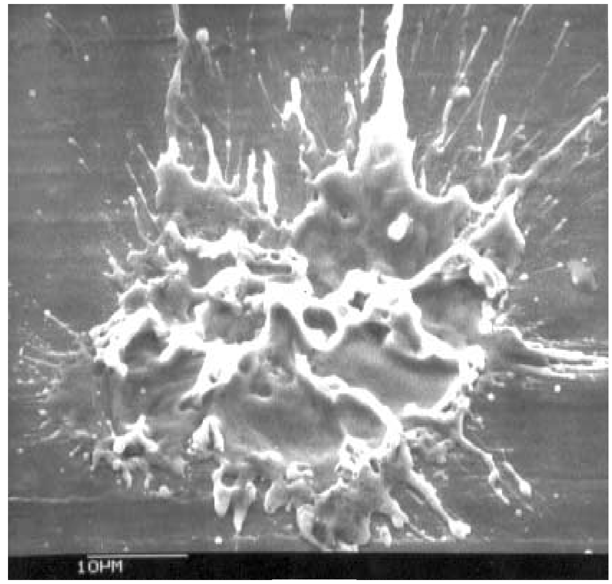


Fig. 5

In fact, both cathode and anode craters do appear very much alike unless analyzed at high resolution. This analysis is not easy to do on most bulk materials, such as those used here. The craters seen on both sonically processed and electrolytically processed surfaces share the enigma of the unipolar arc. Cathode and anode marks are largely indistinguishable. Fortunately, for externally generated EVs, where the distance is large and filtering is possible, the polarity problem is largely overcome. The target is the anode.

III. PALLADIUM SAMPLE PREPARATION

Two samples of palladium, treated by different processes, were contributed from other laboratories. A sample was sent by John Dash of Portland State University. A slightly similar sample was used by Dash [6] in an early cold fusion paper showing nuclear conversion in micrometer-sized areas. The particular sample we received was about 100µm thick and had been electrolytically treated in heavy water, using sulfuric acid electrolyte, on 7-26-93. According to Dash, "the sample was immediately washed in deionized water and stored in a covered plastic dish."

A second sample, treated by ultrasonic process, was contributed by Roger Stringham of E-Quest Sciences. The sample was run in D_2O on April 29, 1996 in reactor M 11 B and was originally a foil 100µm thick. The received sample consisted of bits of palladium that were energetically detached by cavitation from the main palladium foil and had fallen to the bottom of the ultrasonic apparatus. The samples analyzed were about ½ millimeter in extent across their diameter. They were tested in the as-received condition.

IV. TESTS ON THE DASH SAMPLE WITHOUT EXTERNAL STIMULATION

Initial tests on the surface morphology of the sample were done in the authors' laboratory using a SEM to see if EV strike marks could be located that would likely arise from fracto-emission. Such strike marks were found, although they differed slightly from standard EV marks produced using the aforementioned methods. A typical example is shown in Fig. 6. Although the small bright mark in the center is somewhat characteristic of an EV strike, the one on the extreme right is more typical. This mark is magnified in Fig. 7. The size of the strikes are smaller than is usually seen by external EV generation methods and the brittle structure of the base Pd has altered their appearance slightly, sometimes producing a molten, elongated cavity aligned with some metallographic feature. In all likelihood, the main strike hit the large black area in Fig. 6 and was blown away with it. A slight, light colored decoration of the lower edge of the crater shows the effects of evaporated material as the ejected fragment left.

Fig. 6

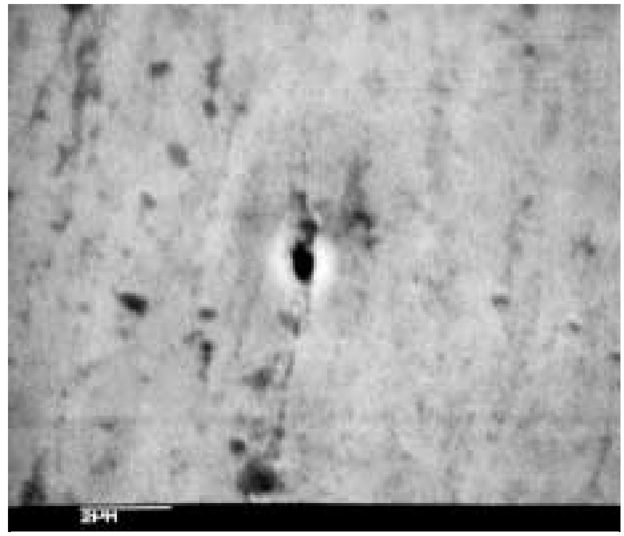


Fig. 7

The brittle nature of the material shown in Fig. 6 is apparent from the shape of the fracture lines. Also, there are melted regions showing that testify to an intense heating process. An X-ray microanalysis of almost any area of the surface that has not been subject to a disruptive process is shown in Fig. 8 and is basically pure palladium. On the other hand, an X-ray microanalysis of a typical fractured region, like that shown in Fig. 6, is shown in Fig. 9 and depicts quantities of Mg, Ca, Si, Ga and Au, along with the base Pd signature. Many examples similar to the one shown appear on the substrate, although, on this particular sample, they are widely separated. It is possible that these new materials were produced by nuclear reactions involving the two major materials initially present, namely, palladium and deuterium, although they could have conceivably migrated into the region along grain boundaries.

Taking the nuclear reaction view, it is the authors' contention that the craters on the surface are caused by a locally created, fracto-emission site that then produces a NEV strike and that, in turn, this nuclear cluster input is

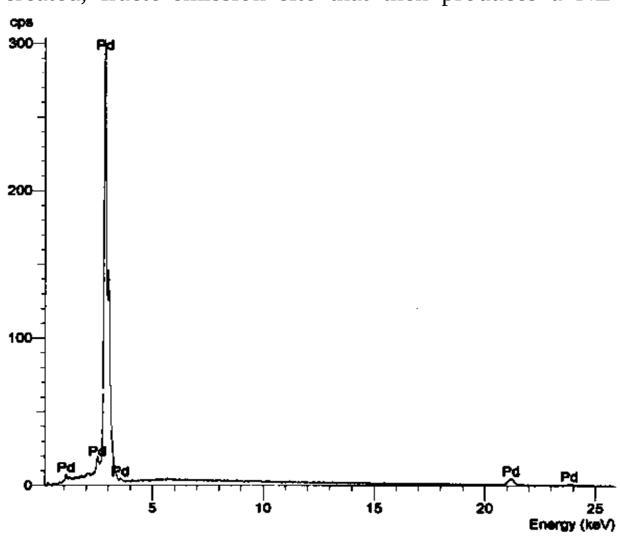
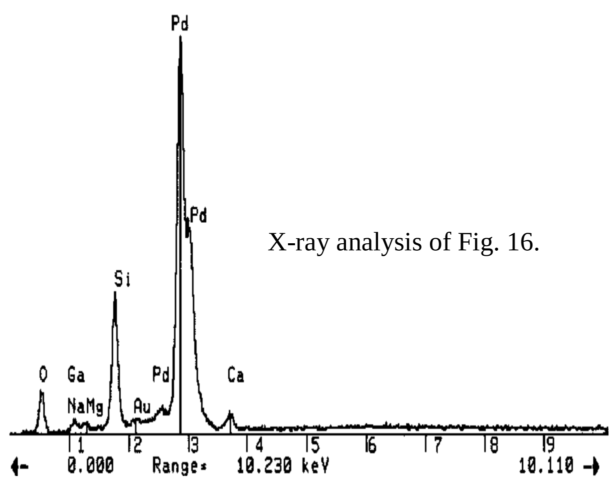


Fig. 8



X-ray analysis of Fig. 16.

Fig. 9

responsible for the nuclear cluster reaction produced. A wide variety of crater shapes would be expected on such an active surface. That some of the most energetic strike marks would be carried away with the ejection of a brittle material chunk would be expected as well. In fact, brittle chunk ejection is the *sine quo non* of the surface. In this case, most of what remains to be seen would be the ineffective strikes. The ejection of incompletely-used nuclear fuel material is not a desirable trait, but it is commonplace in this sample. In the next section, an example will be shown of more complete retention of material using an external initiation method.

V. TESTS ON THE DASH SAMPLE WITH NEV STIMULATION

A primitive EV generator was used to bombard a localized region of the same sample just discussed. It consists of a hand-held Tesla coil of the type designed to locate vacuum leaks in glass apparatus. A region of the sample was masked off by a dielectric shield, and then, with the sample grounded, sparks were allowed to strike the surface from a distance of about 1 centimeter. Small flashes are produced wherever the spark terminates on the surface. This is the signature of an EV strike and it dependably produces the kind of marks shown in Fig. 1 and Fig. 3, provided there is no added energy from the surface itself.

Although the strike mark produced by the above method of generating an EV is very consistent on the standard witness plates discussed, there is no assurance as to the kind and number of nuclides loaded into the structure. When this EV loading is an important parameter of a nuclear reaction produced by a NEV, as it may be when working with deuterium loaded Pd, such a chance method of loading may be found insufficient for consistent work.

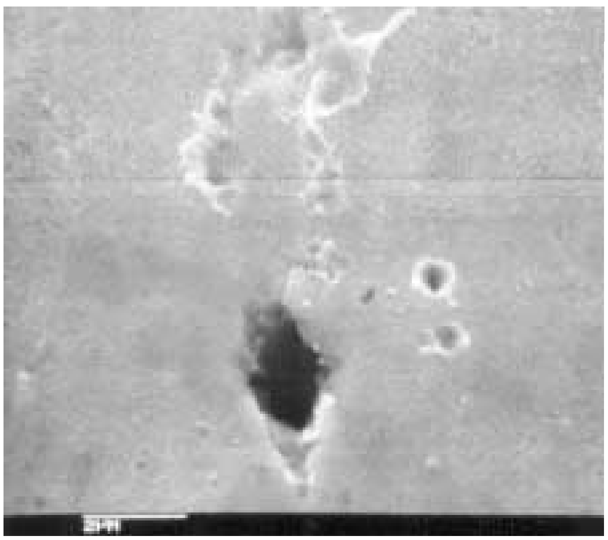


Fig. 10

Occasionally, one of the strikes on the material being analyzed produces a result that is uncommon to the low energy EV strikes shown in either Fig. 1 or 3. An example of this shows in Fig. 10 on a region of the surface that includes a brittle fracture on a thin surface layer. This layer has been effectively peeled back by throwing molten material sideways along the path of propagation. Although the NEV strike may have initiated the process, continuation appears to be self-propagating due to locally added energy. This is the Hallmark of an exothermic process, and if the active material extends to a great depth, complete runaway can occur.

In the center region shown in Fig. 11, and magnified in Fig. 12, the X-ray analysis shown in Fig. 13 defines the production of either new material or something foreign included in the substrate along the boundary defined by the dark marks. Although an inclusion of dirt is easily

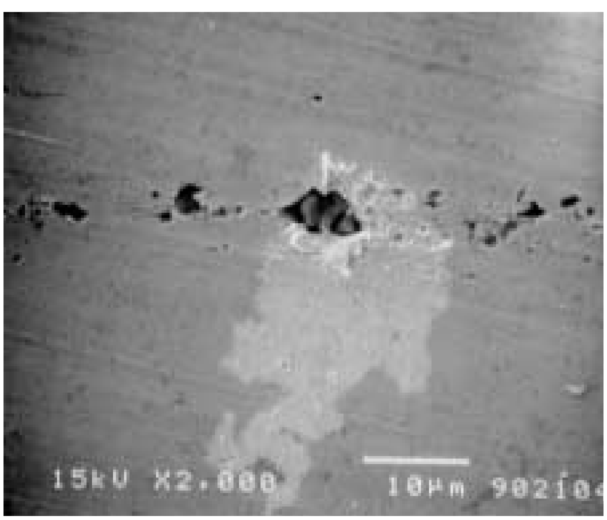


Fig. 11

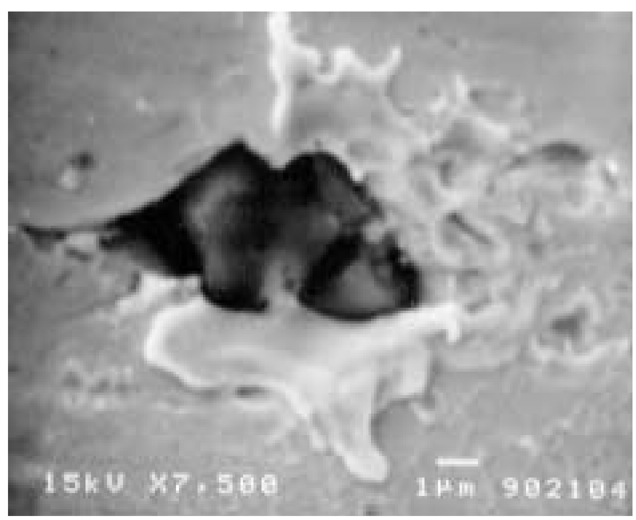


Fig. 12

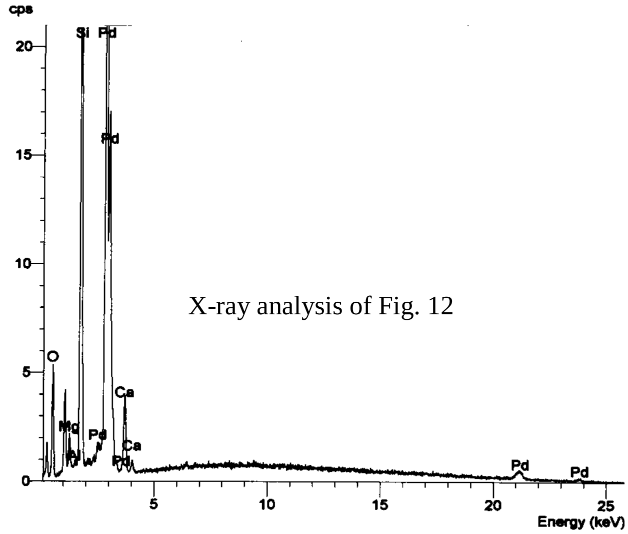


Fig. 13

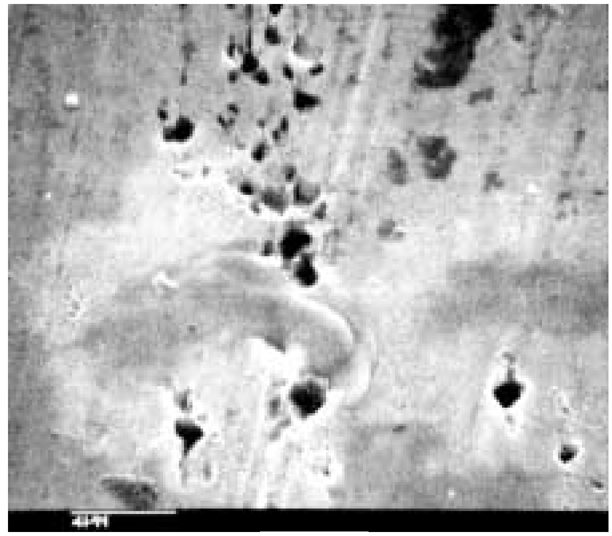


Fig. 14

suspected for the crack shown, no suspect material appears unless the region is involved in an energetic strike.

The explosion in this region was produced by bombardment with an externally produced NEV and the strike mark can be clearly seen. In addition, there is some surface decoration showing that defines an energy release which has scoured the surface, producing a light colored region below the main strike. The cause of this “wildfire” will be discussed later.

In some regions there is an exception to the rule of ejecting a brittle piece of substrate material. Fig. 14 shows a strike region where gross melting occurred in a way that is also very uncommon for EV-only energy deposition on benign substrates. This melted region seems to have been moving sideways at the time it froze in place. Keeping the nuclear fuel bound to the surface, as it is here, is more desirable than losing it through brittle fracture chunks being thrown off. Unfortunately, electrolytic processing needs the brittle structure to serve as the nuclear initiator. Separation of the processes of initiation and fueling would be desirable.

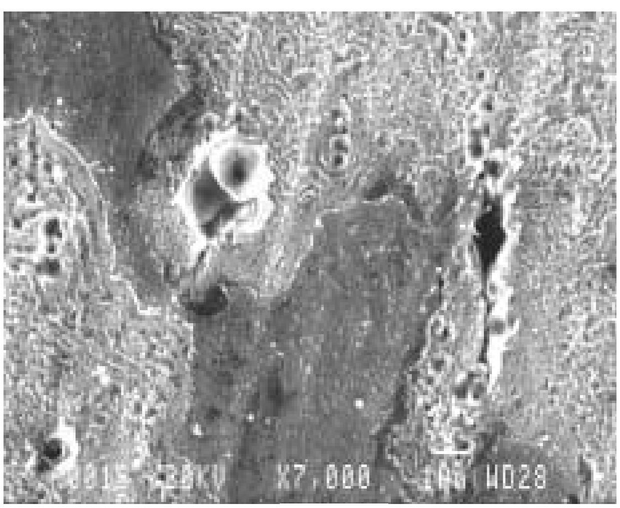


Fig. 15

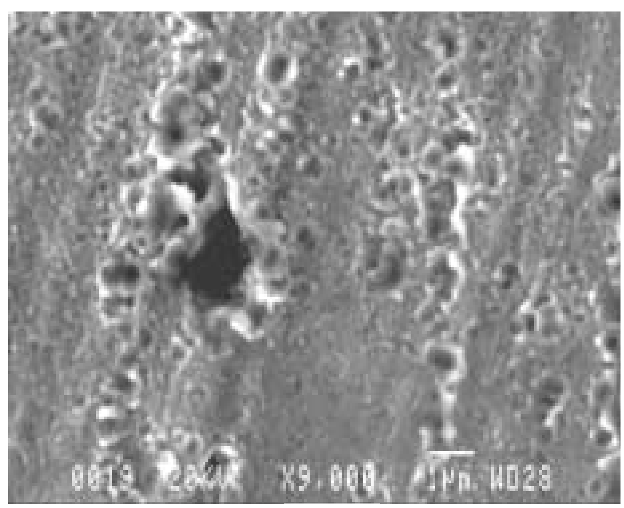
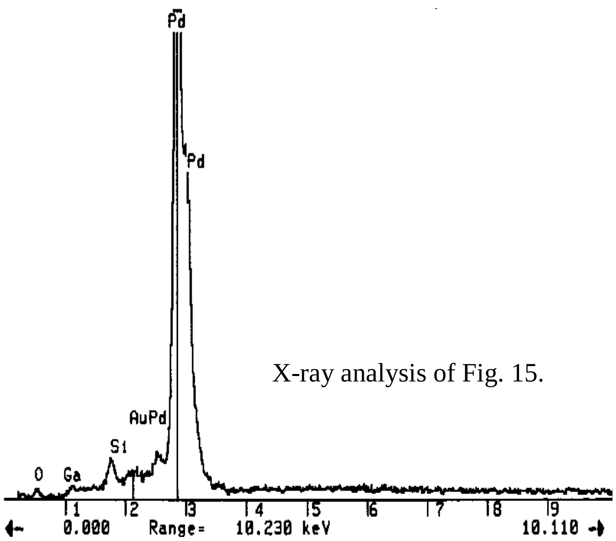


Fig. 16

An example of what appears as a “wildfire” propagation of energy shows in Fig. 15 and Fig. 16. This effect has also been seen on other than Pd surfaces, but it is quite pronounced here. The runaway process was triggered by the arrival of an externally made NEV. The energy feeding the process seems to emanate from cracks formed in the brittle, top layer of Pd. This layer is about 0.1μm in thickness and extends over the entire surface. It would seem incumbent on this highly stressed layer to either peel or otherwise breakaway from the base material in an explosive fashion, producing fracto-emission of electrons. An input shock from an externally supplied EV would likely supply a trigger for this process.

The X-ray microanalyses of Figs. 15 and 16 are shown in Fig. 17 and Fig. 9 respectively. The analysis of Fig. 16 was done while centered on the large, dark crack on the left. Analysis for Fig. 15 was done on the crack on the right side. When the bright, melted area, slightly above center and left in Fig. 15 was analyzed, there was nothing but Pd showing. Apparently this area was below a critical threshold of energy density or size for nuclear cluster reactions.



X-ray analysis of Fig. 15.

Fig. 17

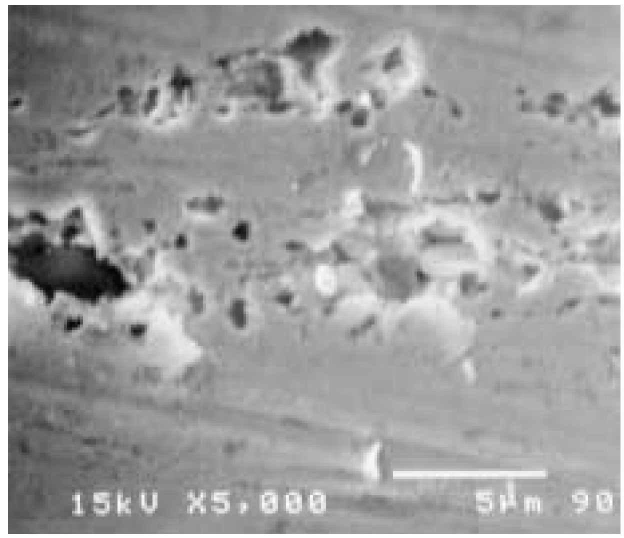
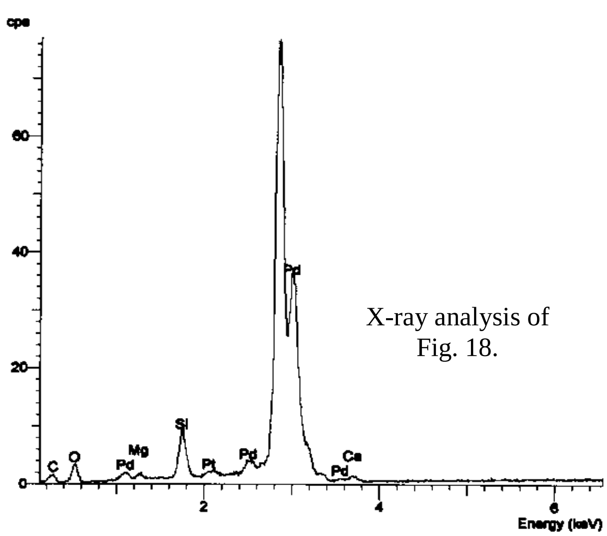


Fig. 18

Fig. 18 shows an area having a mixture of cracks, molten spheres of material and an EV strike that has been partially obliterated by other activity. There is a minimum amount of wildfire activity in this eruption. Fig. 19 is an X-ray analysis of the dark crater on the left side of Fig. 18. Small amounts of "foreign" material show here. With the limited analysis done, the source of this material is unknown.



X-ray analysis of Fig. 18.

Fig. 19

Mechanical storage of energy is thought to be the source for the small EVs produced. It has been determined, both experimentally by the authors and theoretically by G. Mesyats [5], that the size of an EV structure is a function of the high specific energy delivered to the metal. Higher energy density produces smaller structures. The locally obtained energy from micrometer-size sources gives a higher input energy density than the best external power sources used for EV generation, usually limited to the one micrometer size range.

This wildfire process appears to have little value in the mode seen because it is below the threshold level for triggering the main nuclear cluster reaction we seek. So far, there have been no nuclear transitions observed that are associated with wildfire action. Its principal function has been to more accurately point to mechanical, fracto-emission as the local source of stored energy to trigger a cluster nuclear reaction through the instrument of NEVs.

VI. TESTS ON THE E-QUEST SAMPLE

The ultrasonic processing method produces a different surface morphology from samples processed electrochemically. The ultrasonic method tends to wipe out its past surface history more rapidly than does the electrochemical method. It does this by both adding colloidal particles of the parent metal to the surface, and at the same time, removing material by mechanical shock. EV craters that would normally look very sharp on unmolested surfaces show a fuzziness characteristic of repeated pummeling. Nevertheless, Fig. 20 is a view that shows 4 classic EV witness marks, similar to those shown in Fig. 4, and characteristic of most bulk material surfaces having a high-melting point. Fig. 21 shows a crater produced in a protected region. Brittle fracture is evident here. There is evidence of melting shown deep down in the crater, signifying an energy

Fig. 20

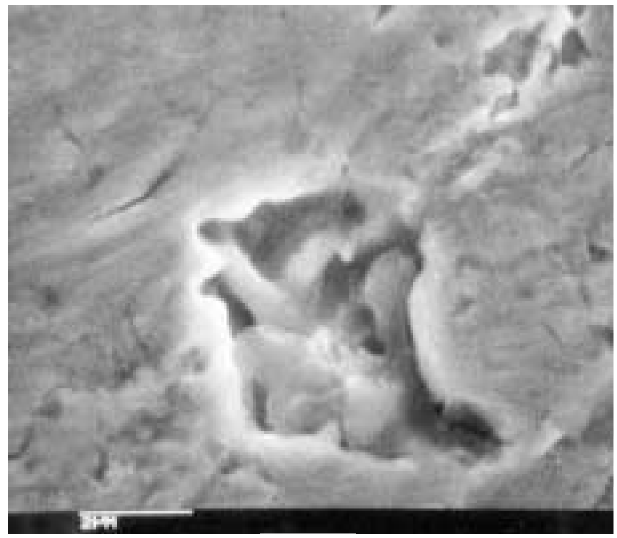
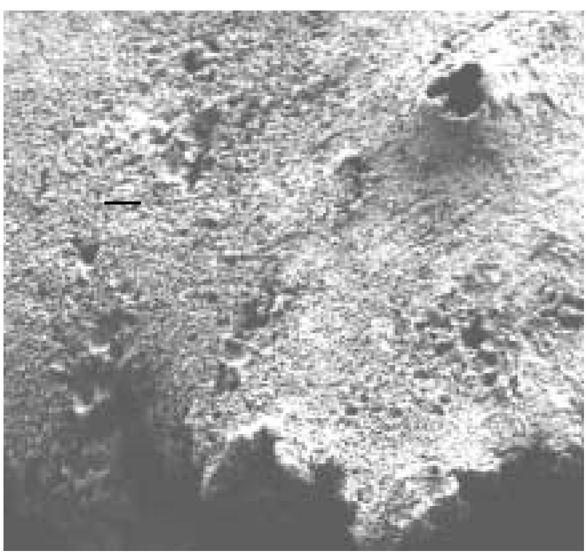


Fig. 21



100 μm — Fig. 22

production process at work that is not strictly surface related. In a private discussion, Roger Stringham has stated that the edges of such craters are usually the location of transmuted material. This is in accordance with what is found in electrolytically treated samples where it is easier to view the undisturbed residue of a reaction.

The origin of the observed strikes has not yet been clearly delineated in any theory known to the authors. However, work has been done on EVs produced under water by electrical methods, and the results give the same witness marks as those shown earlier from gaseous production methods. The fact that light shows as 50 ps flashes in the sonoluminescence process associated with cavitation, and that this corresponds to the time known to occur in EV formation processes, points to the possibility of sonically produced EV structures made through cavitation charge separation.

Fig. 22 shows a SEM photo taken of a foil prepared by R. Stringham and photographed by J. Dash and R. George. The micron mark in the photo has been restored by the authors and is only approximate. The most obvious thing that can be seen at this low magnification is the large impact craters generated by a few strikes from some unknown energy concentration process, probably having to do with momentum transfer from the fluid bath to the surface. These strikes both totally penetrate the foil and also knock out trumpet-shaped, brittle fragments on the reverse side of the strike. These strikes are more like driving a nail through the material and, according to the notions being presented here, would not likely yield nuclear reactions. In the nuclear cluster reaction theory, the energy density is the all-important parameter to maintain. Large, low-energy-density strikes represent a loss of energy gain in the process of nuclear conversion. The measure of energy density might be found most expeditiously by the number and type of nuclear transitions produced.

The main point to be made here is that marks are made on the ultrasonically processed surfaces that are very similar in both size and shape to those made by EVs under more controlled conditions. Examples of sonically bombarded surfaces taken from the literature show many classic EV-like witness marks.

VII. DISCUSSION OF OBSERVATIONS

The nuclear reactions produced in the observations made have many things in common, but the most outstanding of these is the clustering effect. All reactions found occur in regions of only a few square micrometers in extent. This is also the size realm of the NEVs used to either fuel or trigger the events. From this observation it is necessary to conclude that such nuclear reactions are fundamentally an intense event involving large numbers and not one of widely isolated events working individually at an atomic level.

From only a small set of observations, it is increasingly apparent that there is a threshold effect in which no new or “foreign” material is produced until the physical size of the stressed area is above about 1.5 μm in lateral extent. Additionally, the percentage of new material seems to increase as the size of the reaction grows. The production of high atomic number elements also increases with reaction size. Before the observations made in the course of this work can be taken seriously, many more samples must be tested.

In the search for the validity of this threshold effect, one must consider that the energy density of the initiator sets the threshold size of the nuclear cluster reaction. High energy density in the initiator would produce small clusters, just as it does with high-energy, individual nuclei found in standard nuclear processes. The low energy density of our initiator process would be expected to give rise to larger clusters containing more events with the concomitant low energy by-products. NEV generation is a compression process that blends smoothly with other compression processes, like cavitation excitation, but the maximum density is limited by unknown factors.

From other work done in the area of high-charge-density effects, the timing of the events being studied here occur in scarcely more than a few tens of picoseconds. Even with this short interval of time, there is a series of steps leading to the final result we see in frozen images. For the self-triggered electrolytic process, first, there is a slow loading process that produces a brittle product. Next, there is a very rapid brittle fracture of sufficient magnitude and shape to give rise to a NEV that is loaded with whatever nucleons are most available. In the case considered here, it is likely that over 100,000 deuterons are included. These nuclei are then hurled, with the high energy density afforded by the EV compression process, into the parent material. This is done by a collective acceleration at a low-applied voltage, in the kilovolt range, but having the equivalent velocity of megavolts, due to the acceleration mechanism.

The theoretical basis for a controlled, micro volume, D-T thermonuclear process is described in a paper by V. Skvortsov and N. Vogel [6]. In the model, the authors interact a local, laser-produced, intense micro beam of heavy ions with condensed matter. The extreme state of matter produced, in the Gbar pressure range, is generated by interacting shock waves like those demonstrated in EV technology [7]. Functionally, the two processes are nearly identical with the NEV method being the easier of the two.

At this point in the reaction process there is a void of knowledge, but we will attempt an ad hoc explanation of the observed results. The most outstanding observation of “cold fusion” in general is that the by-products of the nuclear reactions produced have much lower energy than conventional “hot fusion” reactions. In our opinion, this is due largely to a *nuclear cluster reaction* having an unknown form of coherence .

As in any harmoniously coupled reactions, it is easier to dispose of excessively high peak energies by coupling them into an interlocked network of lower energy, coupled states. A supreme example of this is found in the Mössbauer effect whereby a solid lattice of atoms, acting in unison, takes up departing gamma photon recoil energy. In a like fashion, the most energetic components of our nuclear cluster reactions are transferred to multiple, lower energy states through group action. This can be a conversion process without loss. Carried to an extreme, a theoretical conversion could be made in which all of the energy in one class of nuclide is converted to another without any external indications. This super transmutation would be the equivalent of superconductivity and really not that much more surprising.

In the imperfect world in which our process is embedded, the debris of nuclear reaction is transformed into heat and some errant, energetic particles. It is the effect of nuclear cluster reactions, with their propensity for low levels of peak energy output that produce the most desirable properties and not whether the process is either cold, tepid, hot, low energy or high energy. The underlying merit of this unspecified process stems from the salient fact that some still unknown, coherent, group action lies at the root of it.

Electrolytic and sonic processes, occurring in solutions, are difficult processes for extraction of certain operating mechanisms. By bombarding surfaces in vacuum with externally generated NEVs, the brittle fracture requirements become null and nuclear fueling processes can be separately investigated in great detail. What is immediately apparent here is that any area on the surface becomes a willing site for nuclear reactions and concomitant isotopic conversion. However, there remains a requirement for cluster action in which billions of atoms cooperate to produce a more desirable end point.

With the crude method of generating a NEV used here, there can be no accurate determination of either the energy level or the number of nuclides included in the NEV. The critical size must lie between the limits of the successful 3 µm cluster used by the authors and the largest of the ineffective strikes seen, around 0.5µm in diameter.

There is also a contribution of energy from the substrate that cannot be accurately accounted for at this time. Taking advantage of the mechanically-stored energy is mostly a matter of supplying a mechanism for concentrating the available energy of the many small strikes that lie below the triggering threshold. Arranging for a particular fracture geometry would be one such method, but this technique is felt to be impractical because external NEV generation is much easier.

VII. CONCLUSIONS

It has been determined that the electrolysis of Pd in heavy water produces a brittle layer on the surface that fractures in a manner producing fracto-emission of electrons. These electrons are organized into concentrated electron structures containing nuclei, called NEVs, and then collectively accelerated into the surface where they produce a nuclear cluster reaction.

Sonically-treated Pd surfaces in heavy water are also subject to the same dense-electron and ion-cluster treatment that arises from charge separation in a collapsing bubble. A nuclear-cluster reaction is also produced from this process.

Deuterium loaded Pd foils, spark bombarded in air with an electron cluster, incidentally loaded with nucleons, produce nuclear cluster reactions.

Indications are that the cluster type of nuclear reaction is responsible for the limited number and mild nuclear reaction products escaping the reaction site that produced them.

In the limited work done here, there is the appearance of a threshold for the nuclear cluster reactions observed. The threshold is connected to a physical size for the eruption seen and is near 3 cubic micrometers of material. In addition, there seems to be a preferred production of heavier nuclides with increasing size of the disrupted area.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the moral and financial support provided by Tom Shanks.

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[7] For an example of shock wave depiction by surface decoration, see ref. 1, Fig. 2:14, page 2-22.