

Subject: Tectonic Strain and UFOs (VERY LONG)
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The following is a long treatise and analysis of the Tectonic Strain Theory. The TST is widely purported to explain UFOs, ghosts, psychic events, religious ecstasy, spontaneous combustion and pretty well anything else you might name. Literally hundreds of papers have appeared in scientific journals, assuming its real existence and reality. However, there have been very few critical works about the TST, and when such works have surfaced, the critics have been dismissed with commentary or discussion about how complicated the issue is and why it cannot be quantified easily. In short, its proponents appear to invoke almost identical reasons as defendants of the reality of psychic phenomena, and this in itself raises concern among some researchers.

This paper was originally written as a geophysical thesis in 1983, and although more than 10 years old, is still relevant as a critical look at the TST which is still being invoked as a scientific explanation of purportedly paranormal phenomena.

The paper has recently been converted into ASCII by David Thacker of AUFOSG and provided online by Chris Rutkowski.

The Tectonic Strain Theory of Geophysical Luminosities

by

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Abstract

A new hypothesis, explaining unidentified luminosities, has been proposed which has received wide attention and general acceptance. It incorporates both geophysical and physiological mechanisms in an attempt to explain the wide variety of characteristics of the phenomenon. This study examines the feasibility of the theory from an objective standpoint, and tests the tenability of the interrelations of its interdisciplinary mechanisms.

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Chapter I

INTRODUCTION

Since their entry into the scientific and lay literature in the late 1940's, few topics have caused such controversy as that of UFOs (Unidentified Flying Objects). While traditionally ignored or lightly treated by the scientific community, the persistence of the phenomenon over 30 years has led some researchers to consider them more seriously (Jacobs, 1976).

It is recognized that the phenomenon has drawn to it a large contingent of unscientific and unprofessional "believers", many of whom fail to objectively view UFOs without bias. This is not necessarily surprising, given science's stance on the matter, but a Catch-22 situation has resulted. Because the subject is not "reputable", few scientists have spent adequate time considering the problem in detail. This

has left the study of the phenomenon to laymen, and often to cult believers. This has kept the "reputation" of UFOs at a low level, and the circle has been completed.

But probably because of the relatively long history of UFO reports, some scientists have proposed theories to explain them. Some scientists advocate the ETH (Extraterres-

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trial Hypothesis), which states the most popular UFO explanation: that they could be spacecraft from extraterrestrial civilizations. Unfortunately, though most astronomers believe that extraterrestrial civilizations exist, there is no scientifically-acceptable evidence that such civilizations have in fact contacted mankind (Hendry, 1979).

Other explanations proposed for UFOs include: "lost" terrestrial civilizations; "secret" terrestrial devices; spiritual entities; "natural" phenomena; and mass hallucinations (Jacobs, 1976). None have withstood scrutiny as of this date.

It should be noted at the outset that one of the few facts known about UFOs is that about 90 to 95 percent of all UFO reports are misidentifications of conventional or natural phenomena (Hendry, 1979). It is the remaining, significant percent that is regarded when discussing UFOs - the "real unknowns". It is generally felt by skeptics that this percentage of UFOs can be explained if strong effort is made, or it can never be explained other than in terms of a "background noise" of spurious data. Proponents of the UFO phenomenon as a much more complicated mystery disagree with the skeptics. They argue that the remaining percentage of reports is unexplainable even after attempts to explain them have been made. This disagreement is the prime focus of the UFO controversy.

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Natural phenomena have been suggested as an explanation for UFOs many times (e.g. Klass, 1966). The main drawback to natural phenomena theories is that UFO reports offer such a wide variety of characteristics that natural phenomena fall short of explaining all UFO traits. Recently, however, a theory has been proposed which seems capable of explaining many UFO characteristics based on a mixture of mechanisms and processes. This theory, called the TST (Tectonic Strain Theory), begins with the suggestion that strain fields within the Earth's crust can produce an electromagnetic discharge that may manifest itself in one of two basic ways. One way is by the electric discharge becoming visible as a moving body of light. The other way is by the discharge affecting the human brain so that the observer will "believe" he or she is viewing a moving body of light. Both scenarios are consistent with the theory, and are used to explain the reported appearances of UFOs.

So far, only statistical evidence has been presented in support of this theory. This has been in the form of covariation of the number of reported UFOs in an area and the level of seismic activity in that area. Whether this is a "real" relationship or an artifact is not clear at the present time.

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Chapter II

THE TECTONIC STRAIN THEORY AND UFOS

The Tectonic Strain Theory (hereafter referred to as the TST) is a relatively new explanation for the reported appearance of inexplicable luminosities, sometimes UFOs. Papers dealing with certain aspects of the theory have been published in several journals, covering various disciplines (Persinger, 1975, 1976, 1979a, 1979b, 1980a, 1981, 1982, 1983a, 1983b, 1983c, 1983d, 1983e, unpubl, unpub2). The proposed mechanism is interdisciplinary in nature, and carries with it some necessary qualifications to enable it to cope with a poorly-understood phenomena in terms of better-known phenomena. The theory is best explained by its major proponent, Michael A. Persinger:

"Essentially,...normal geophysical processes applied in unusual space-time configurations are responsible for electromagnetic phenomena that have direct physical and biological consequences. These processes involve normal alterations in tectonic (structural) stresses within the Earth's crust and are mediated by

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piezoelectric-like effects. The primary natural analog of this putative phenomena would be earthquake lightning...Whereas earthquake-related luminosities appear contingent upon large releases of structural strain (seismic activities), the luminosities and electromagnetic correlates of alleged close encounters with UFOs are associated with HIGHLY LOCALIZED, less intense changes in crustal structures not necessarily involving major seismic activity." (Persinger, 1979b)

(author's emphasis)

The TST draws upon several processes for its mechanism, and it is best to examine each of them in some detail. The physical processes are linked implicitly by logical arguments, although the basis for these arguments needs careful examination. The major steps involved are:

- 1) Strain is produced in the Earth's crust.
- 2) Strain produces an electromagnetic discharge.
- 3A) The electromagnetic discharge produces a luminosity.
- 4A) The luminosity is observed as a UFO.

Alternatively, steps 3A and 4A may be replaced by:

- 38) The electromagnetic discharge affects human perception.
- 4B) A person believes that he/she has seen a UFO.

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In order to understand the TST, each of these steps will be considered in systematic sequence, in effect testing the links in the chain.

2.1 CRUSTAL STRAIN

Through various processes, strain can be built up in the Earth's crust. These include tectonic activity, tidal action and human activity.

Strain is described in terms of dilational and distortional strain tensors, as it is a vector in three dimensions (Bath, 1973; Kasahara, 1981; Richter, 1958). The strain tensor is defined by the equation:

[NOTE: In this ASCII version, CX represents the Greek symbol alpha, ^2 means squared, _u represents mu, _[is the integration symbol, pi is the pi constant, _B is the symbol for beta.]

$$E(i,j) = e(i,j) - (1/3)e(k,k)CX(i,j)$$

and similarly, the stress tensor is:

$$P(i,j) = p(i,j) - (1/3)p(k,k)CX(i,j)$$

where the arrays $e(i,j)$ and $p(i,j)$ each consist of nine component vectors which define the stress and strain across any small plane area containing the point in question. The release of tectonic elastic strain energy is the cause of major earthquakes. This energy can be expressed in a function and form such that:

$$U = \int \int \int \mu E^2(i,j) \, dV$$

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where μ is the rigidity modulus (the measurement of the resistance of an elastic solid to shearing deformation) and U is the distortional strain energy, taken through the volume (Bullen, 1963).

The stress tensor is defined as:

$$P(i,j) = 2\mu E(i,j)$$

Now, we can also define the stress tensor in terms of the Mises function:

$$P^2(i,j) = (CXS)^2$$

where S is the value P would have if the material was near the breaking point. CX is a constant that has a value between 0 and 1, and sometimes assigned a value of $(\sqrt{3})^{-1}$

We can then find E in terms of S such that:

$$E(i,j) = (CXS)/(2_{\text{u}})$$

we can substitute into our equation for U and find:

$$4_{\text{u}}U = CX^2S^2Q$$

where Q is the volume of the strained region near breaking point.

The total energy released in an earthquake can be roughly calculated by a modified Gutenberg-Richter formula:

$$\log E = 11.8 + 1.5 M$$

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The total energy released in an earthquake of magnitude 8.9 (the greatest on record) is thus about 5×10^{24} ergs (Bullen, 1955; Kasahara, 1981).

The strain energy, U , will be some fraction of the total energy, E , since there are other forms of energy release such as the dilational strain energy, heat and sound, etc. Thus, we can replace U by qE , where q lies between 0 and 1. Our new equation is then:

$$z_{\text{u}}E = S^2Q$$

where $z = 4q$ (= approximately 2).

Experimental results have provided estimates for $_{\text{u}}$ and S :

$$0.4 \times 10^{12} \text{ dyne cm}^{-2} < _{\text{u}} < 1.5 \times 10^{12} \text{ dyne cm}^{-2}$$

$$S \text{ is approximately equal to } 10^9 \text{ dyne cm}^{-2}$$

We can then use our equation to calculate Q . The volume of the region near breaking point prior to an earthquake is therefore about 10^{19} cm^3 , with a radius of about 20 to 50 km in extreme cases (Bullen, 1953, 1955).

But this radius is only for the overloaded crustal region. The actual volume of rock in which significant strain exists is obviously much greater than this, but can not be known precisely.

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However, reasonable estimates of the size of the total strained region can be made by comparing the distances between earthquake epicentres and precursory effects, indi-

rectly using the magnitudes and energies involved (Brown and Reilinger, 1983). It is extremely difficult to judge the actual extent of precursory effects, since they will intuitively vary in type, depth and strength for each earthquake. The determination of the size of the strained region will be discussed further, at a later point in this paper.

2.2 STRAIN-PRODUCED RADIATION

There are many types of reported Earthquake precursors on record, including ground deformation, change in the levels and chemistry of well-water and the unusual behavior of animals (Buskirk et al., 1981; Rikitake, 1976; Wyss, 1983). A form of precursor that has received relatively little attention is that of the emission of electromagnetic radiation. Although many such reports are spurious or represent other natural or man-made causes, a significant number are well-documented, and the existence of earthquake-related EM effects must be seriously assessed.

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On 31 March, 1980, anomalous EM emissions were recorded thirty minutes before a deep-focus (depth = 480 km) magnitude 7 earthquake 250 km from an observatory near Tokyo (Gokhberg et al., 1982). These emissions were widely-separated at 10 Hz and 81 kHz. Other similar emissions were recorded for a magnitude 7.4 earthquake in Iran, 1200 km from the epicentre, at 27 kHz and 1.63 MHz. Other examples of such emissions have also been reported (Gokhberg et al., 1980; Sadovskiy et al., 1979).

It has been known for some time that the strain loading of rocks and minerals produces electromagnetic emission. The strength of the emission varies with the different types of substances; the strongest emission arises from quartz and other minerals with a high crystal lattice energy, while rocks such as sandstone have a very low ability to produce emission under strain. It has been reported that there is a shift to high frequency with an increase in grain size. The actual mechanism for the production of the emission is not definitely known, although several theories have been proposed (Lockner et al., 1983; Mizutani et al., 1976).

It has been shown that a rapid drop in the piezoelectric field when stress is released (i.e. when fracturing occurs) can produce EM emission. Experiments have shown that the peak frequency for such a piezoelectric pulse is at about 1.7 kHz, and that the energy release from the fracture of a

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small rock specimen with a volume of 50^3 cm is about 10^{-18} J. However, there is some doubt that piezoelectricity can produce earthquake lights because of its rapid decay and the possibility of its self-cancelling nature (Finkelstein et al., 1973; King, 1983).

An alternate theory for EM emission during fracturing is that of RF (radio frequency) emission caused by a charge buildup across microcracks. During strain processes, there will be discharges between walls of the microcracks which can give not only RF emission, but also IR (infrared) and visible light as well. The energy released by these small cracks has an average spectral range of between 1 and 10^3 MHz (Perel'man and Khatiashvili, 1981).

The most plausible proposed mechanism involves the propagation of an elastic wave within rock, following fracture. Demin et al., (1981) have speculated that the wave would induce the growth of microcracks, and, in the case of semiconducting and piezoelectric minerals, the cracking would produce electrical discharges. But the piezoelectric field might also create transistors within the rock, using as barriers the layers of semiconducting minerals occurring naturally in the ore. These transistors could be coupled into circuits, and an EM emission caused by the formation of microcracks could be amplified, in theory, by these piezoelectric and semiconducting minerals. It is immediately obvious

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that in this mechanism the frequency of the amplified EM wave would be dependent on several variables, especially the composition of the rock. This frequency could, depending on these variables, be represented at many points in the EM spectrum, including radio, infrared, visible and x-ray wavelengths. As a point of note, it has been shown that ultrasonic pulses can also be generated by rock fractures (Demin et al., 1981).

2.3 LUMINOSITY FROM ELECTROMAGNETIC DISCHARGE

As was mentioned in section 3.2, EM emission by rock fracture will probably also include visible wavelengths. The actual size of the luminosities thus produced is difficult to ascertain. While luminescence has been reported in the literature, this has only been in the form of "comet tails" and sporadic outbursts detected on photographic film in close proximity to the rock outcrop undergoing fracture. However, it has been claimed that small, luminous bodies have been detected on the film of the fracturing of a core sample in the laboratory (Brady, private communication).{1}

{1} A description of the experimental conditions under which the luminosities were observed is given by Brady et al(unpub).

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These bodies have the reported appearance of sparks caused by the impact of rocks upon one another, but are believed to be fracture- and not impact-related. It has been suggested that if the processes which produce EM emission during rock

failure are scale invariant, then in nature, luminosities will be produced by the strain and fracture of large or bodies beneath the Earth's surface (Brady et al., (unpub)). These luminosities produced outside the laboratory will, it is thought, be much larger than those observed in the laboratory, perhaps reaching 1 m or more on diameter.

2.4 UFOS AS FRACTURE-RELATED LUMINOSITIES

If it is indeed possible that large luminosities can be produced in nature by crustal stress, then it would seem likely that they would have been observed and reported. Many reports of seemingly inexplicable lights in the sky have been made throughout history, many given the name "UFO" by default (Jacobs, 1976). But there do exist rare, natural phenomena that appear as lights in the night sky. These in-

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clude ball lightning and earthquake lights, both of which are still not fully understood by scientists, but progress is being made in unravelling their mysteries (e.g. Charman, 1979).

In general, earthquake lights are luminous hemispheres, 20 to 200 m in diameter, with a duration following an earthquake of 10 seconds to 2 minutes. In addition, radio interference is reported to occur after the luminescence, strongest at about 15 kHz, which is an order of magnitude from the peak emission for strain release under laboratory conditions (Derr, 1973,1977; Finkelstein and Powell, 1970).

It has been suggested that the release of stress before an earthquake could generate large electric potentials, creating fields of 10^5 V/m (Demin et al., 1981). If rocks can possess a high enough resistivity (about 10^9 ohm - m), then earthquake lights might be explainable in this manner (Gokhberg et al., 1980).

Ball lightning has been reported infrequently, but enough cases are on record that some characteristics have been determined (Barry, 1968). It is spherical, with a diameter of about 30 cm, and may have a contained energy of 10^3 to 10^7 J (with an average of about 10^5 J) and an energy density between 10^2 and 10^3 J cm⁻³.

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2.5 ELECTROMAGNETIC EFFECTS ON THE HUMAN SYSTEM

Rather than creating a physical luminosity through the production of visible photons, an alternate method to produce a UFO in the TST is the direct effect of EM radiation upon the human brain.

It has long been understood that both electric and magnetic fields affect physiological systems in various ways.

Effects range from dizziness and irritation in weak fields to severe disruptive effects such as induced epilepsy in strong fields. Basically, it appears that the electrochemical responses within the body are interfered with by external fields, causing the confusion of signals received and originating from the brain. Experimental tests have shown that headaches are frequently reported by individuals exposed to electric fields of 15-25 kV/m for extended periods of time (Sheppard and Eisenbud, 1977). As well, fatigue and sleepiness are also reported to be symptoms of prolonged exposure to electric fields, although other studies fail to support this, possibly due to differing experimental conditions. Medical examinations of individuals exposed to electric fields have found changes in blood composition and cardiovascular function (Persinger, 1973).

Since the human body behaves as a conductor, external electric fields will be internally attenuated except in the upper-layers of the skin.

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The perception of electric and magnetic fields by human beings has been a topic of interest for many years. Electric fields of 50-60 Hz, of >10 kV/m can be consciously detected by humans, probably by the erection of body hairs. Weaker fields of <5 V/m are claimed to produce behavioral effects, although the physiological mechanism for this is not fully understood (Sheppard and Eisenbud, 1977).

The problem of magnetic field exposure is not an easy one, as few studies have been conducted on this topic. So far, the actual effects are not known, although the strength at which magnetic fields are thought capable of influencing biological functions may be as low as 1 Gauss. Magnetic fields are not attenuated within the body, and also will tend to induce currents within the body, so their effects might be construed as being of more significance than electric fields. Experiments have shown that magnetic fields may be perceived as low as 10 Gauss in strength (Becker, 1969). It has even been proposed that the detection of weak magnetic gradients can explain the "art" of dowsing in humans (Rocard, 1964).

Actual changes in the electrical activity of the brains of animals have been found using low-frequency electric fields of 100 kV/m. Biological cycles (circadian rhythms) have also been reported as being affected by exposure to electric fields, and there is evidence of effects on blood

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cell counts in humans following exposure.{2} In all probability, the mechanism for the changes is due to the production of stress from the influence of electric and magnetic fields upon the human metabolism, encouraging an increase in the production of steroids within biological systems. There is also some evidence that electric fields may operate directly

upon the central nervous system, interfering with the normal transmission of information to and from the brain (Beal, 1974).

Interestingly, there are phenomena known as magnetic phosphenes which may be relevant to the subject of UFOs. Under the influence of an alternating magnetic field with a strength >100 Gauss and at frequencies between 10 and 100 Hz, an individual will observe flashes of light. The peak frequency for this effect is at about 20 Hz. Whether this has any bearing on the reporting of UFOs is not known (Shepard and Eisenbud, 1977).

{2} Because of the potential danger in exposure to EM radiation, limits were recently proposed for the maximum recommended level of human irradiation (Cahill, 1983).

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2.6 TEMPORAL LOBE EXPERIENCES

Under extreme conditions, it has been speculated that at high voltages, individuals might experience rather severe alterations in normal brain functions (Persinger, 1983c). "Dreamy conditions" and temporary paralysis might be experienced. Other suggested sensations are out-of-the-body experiences (OOBEs), religious "awakenings" and feelings of "cosmic significance", since these emotions can be produced by stimulating the limbic structures of the brain (including the hippocampus) with electric currents. Such stimulation apparently may induce "false" memories of dreamed events, making a person "believe" he or she has experienced something which has not occurred. These "artificial hallucinations" would seem "real" to the individual thus influenced. In this way, the "bizarre" aspects of UFO experiences such as seeing an alien entity, conversing with it, etc., might be explained in terms of an interference in brain functions (Persinger, 1983e).

The stimulation of the temporal lobe is perhaps the most interesting of all the effects noted. This stimulation could produce disorientation and epileptic-like experiences that might include actual seizures and loss of consciousness. Upon recovery, the individual might well have amnesia regarding certain parts of his or her experience, all due to electrical interference within the brain (Persinger, 1979b).

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The suggestion is that the behavior of the individuals is not unusual in any way. Rather, it is the interpretation of the experiences which is unusual, and thus, the UFO phenomenon can be reduced to a poor interpretation of the experiences of individuals who have actually been in contact with geophysical electromagnetic emissions. However, the reasons for the consistent description of such experiences in terms of UFOs are not elaborated upon in the TST.

The TST includes some consideration of the separation between the observer and the geophysical luminosity. At a distance, only the optical effects would be reported. As a person approached the emission, it would have increasingly greater effect upon the human system, until finally, in the event an actual physical contact was made, the unfortunate individual might be electrocuted, and death would be attributed by an unsuspecting coroner to lightning or contact with power lines (Persinger, 1979b).

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Chapter III

STATISTICAL CORRELATIONS OF THE TST AND UFO OBSERVATIONS

In several papers on the TST, its major proponent offers statistical arguments in support of the theory. The conclusions reached by some authors (e.g. Persinger 1983a, 1983b, 1983c) seem to show that the variations in numbers of UFO reports vary with numbers of earthquakes:

"In general, UFO report numbers [tend] to increase two to three years after decreases in geomagnetic activity and the year after increases in the number of local, low intensity earthtremors." (Persinger, 1981)

The disquieting aspect of the TST is that the correlation is said to be due to "as yet unspecified processes associated with tectonic strain (Persinger, 1981)", but the factors creating the variance are described as existing YEARS before an actual detectable seismic event. While this might be true in the sense that stresses leading up to an earthquake build over long periods of time, this suggests characteristics for the "unspecified processes" without clearly understanding the processes themselves.

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In one paper, yearly totals for UFO "flaps" were taken from Fate magazine, tabulated earlier by the author (Persinger and Lafreniere, 1977). Yearly totals for earthquakes of various intensities (MM: <III, III, IV, V, VI and >VI) were taken from U.S. Department of Commerce earthquake publications, and yearly means for sunspot numbers were taken from the Journal of GeoPhysical Research. The total number of UFO reports used for analysis over a 15-year period was 214, while the sunspot numbers ranged up to values near 1000 per year, so their values were substituted by their square roots. Outliers of variables with a skewness greater than 1.00 were recoded (i.e. given alternate values).

The end result was that both the r and the r^2 values were generally high, with the r^2 values between 0.53 and 0.70 for the UFO/earthquake correlations (the r value is often called the "Pearson Product", which is the correlation coefficient

and is an indicator of the dependence of one variable upon another). It was noted that although there was an overall trend in the data, some variables did not fall into the same pattern, showing regional differences. The results provided a pattern by which UFO report numbers were predicted for years beyond the study{3} (see figure 1; Persinger, 1981).

{3} More predictions were made, based on studies of UFO reports from the years 1950-1975. "Missed" predicted UFO flap years were explained from a sociological perspective (Persinger, 1983d).

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Figure 1: A comparison of observed versus predicted values for total numbers of UFO reports and their square roots. Reproduced from Persinger (1981).

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A similar series of reported calculations was used in the study of UFO reports from the pre-Arnold period (pre-1947; specifically, 1820-1920), originally chronicled by a historical researcher (Charles Fort) and compiled by the study's author (Persinger and Lafreniere, 1977). The yearly UFO report numbers were compared with yearly numbers of sunspot numbers and earthquakes. Once again, the correlation was reported as being very high, and that the relation "accurately classified more than 90% of the luminosity events (Persinger, 1983a)." In dealing with the UFO data, several methods were used to correlate geophysical data. In one method, "all solar and seismic variables were lagged from 1 to 6 [years]", while the "luminosity variables were not lagged or lagged 3 [years] (Persinger, 1983a)." The UFO data was also in a peculiar form: the number of reports per year was usually less than three, "although [that] type of year was not very frequent (Persinger, 1983a)." Essentially, correlations were found between significant numbers of earthquakes (and sunspots) and one or two UFO reports in a particular year. Interestingly, the historical UFO reports took on various forms, including accounts of "phantom armies" in the sky. All the data were selected from Central western Europe in this study, including only the countries Germany, Austria, France, Italy and Switzerland, a geographical span of over 1000 kilometres. The correlation results of this study are shown in figure 2.

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Figure 2: Predicted relative yearly levels of UFO activity compared with years of actual reports of "odd luminosities" (arrows). The years within the bar were used in the calculation of the prediction function. Reproduced from Persinger (1983a).

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Yet another study involved the correlation of different types of UFO reports, according to the classification system employed by Saunders (1978). In this system, UFO reports are categorized by increasing levels of "strangeness" for types I to IX. A type I UFO report, for example, is merely a strange light in the sky, with a high probability of a conventional explanation such as that of a meteor, while a type IX report is a Close Encounter of the 3rd Kind, involving a reported contact with alien entities. Most UFO reports fall into types I, II or III.

Each type of report was compared to levels of seismic activity with a "temporal increment" of six months, taken through the specific years examined for the study (Persinger, unpubl). The results are shown in figure 3:

"All of the major types of [UFO report] classes were significantly correlated with consequent increases in V or less intensity earthtremors." (Persinger, unpubl)

But the maximum r value is only near 0.50, so that the corresponding r^2 value is near 0.25. This means that only 25% of the variance in UFO reports can be attributed to seismic events in this study. Even its author admits:

"This may indicate that a significant portion of the [UFO report] variance for all types of classifications may still involve non-seismic factors." (Persinger, unpub2)

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Figure 3: r-values for the correlation between UFO reports and earthquakes, by UFO type. Reproduced from Persinger (unpub2).

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Chapter IV

ANALYSIS OF THE TST

The TST proposes that many UFOs are produced by a strain field that is caused by crustal stress. This strain field is visibly indicated by a fracture (earthquake) that might occur many kilometres distant and many days or even months separated in time and space from the point where the UFO was observed. It has been claimed that there is a statistical correlation between the numbers of UFO reports and earthquake activity. In effect, an increase in earthquake activity means an increase in UFO reports (Persinger, 1983a, 1983b, 1983c, 1983d).

But the statistical correlation works best when UFO reports from large distances are included. This is described as choosing an "optimal space and time increment". In a UFO/earthquake correlation study in the New Madrid earthquake area, not only were the recognised New Madrid states

included, but also those surrounding them as well. The statistical study did find a good correlation for some years, but also found a "lag" for others (Persinger, 1983b).

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Hence, this is the source of the suggestion that UFO reports are related to earthquakes through a common strain field that may cover a large area, so that the UFO may be observed hundreds of kilometres from the epicentre of an earthquake and still be related.

But what exactly is the strain field responsible for the UFOs and the earthquakes? We know that crustal stress can build within rock through various processes, including tectonic and tidal force-related activities. This stress will accumulate in a certain area within the crust, the exact structure and dimensions of this area being dependent upon the local geology and the physical composition of the rocks involved. The actual mechanisms of crustal deformation is beyond the scope of this review, although some basic elements have been considered in Chapter 2.

Most sources agree that the size of the region strained to its breaking point prior to a fracture (earthquake) is about 20-50 km in radius, but this depends on the magnitude. Naturally, however, rock outside this area will be under some strain, but not enough to cause failure. There is no practical method for determining the exact extent of the strained region,{4} since the strain will never quite be zero,

{4} There do exist some methods for estimating crustal stress from core samples, such as using the Kaiser effect to monitor acoustic emission, but underground conditions have been shown to be capable of altering stress determinations (Yoshikawa and Mogij 1981), so that these measurements will have their limitations.

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even at large distances from the earthquake epicentre. Therefore, the determination of a "strain field" is quite arbitrary.

If a "strain field" is in existence, then the TST implies that its major visible indicator is an earthquake. If this field is also responsible for the appearance of a UFO, then one can wonder why the UFO would not appear adjacent to the fracture site, where the most energy is released.

Earthquake lightning is often observed concurrently with earthquakes, and although it may be theorized that UFOs are indicators of smaller fractures, the use of "optimal temporal increments" to associate UFOs and earthquakes in a strain field tends to point out a lack of similarity between the two phenomena. Specifically, earthquake lightning is essentially simultaneous with an earthquake, while according

to the TST, UFOs can appear much before or later. Therefore, earthquake lights are probably not upscaled versions of UFOs.

4.1 ENERGY CONSTRAINTS

In terms of energy involved, we can estimate the energy required to support a luminous, ball-like UFO. Assume that there is a luminous ball with a diameter of one meter. Suppose it radiates energy at a frequency near 1×10^{14} Hz, corresponding to a wavelength of 5700 Å, or yellow light.

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Let us also suppose it has the power of a common 60-watt light bulb.

To an observer 100 metres away, the object will have a flux of:

$$S = L / (4 \pi r^2) = 4.7 \times 10^{-4} \text{ W m}^{-2}$$

This value is considerably more than that of the threshold intensity of the human eye, which is about $10^{-14} \text{ W m}^{-2}$ (Haines, 1980). If the object is seen for ten seconds, then abruptly disappears, its energy radiated is 6 J in the observer's direction.

Now, since the object will subtend an angle of 1.146 degrees, which is equivalent to 1.26×10^{-3} steradians, its total energy output would have been about $6 \times 10^4 \text{ J}$:

$$(4 \pi E) / W = E = 6 \times 10^4 \text{ J}$$

and its energy density would have been $1.42 \times 10^4 \text{ J m}^{-3}$.

We can see, then, that even a relatively dim object 100 metres from an observer will still be quite visible, but the energy requirements for such an object are not insubstantial. Even if an object radiated just at the threshold level for our 100 metres distance (about $1.25 \times 10^{-9} \text{ W}$), its contained energy would be $1.25 \times 10^{-6} \text{ J}$. These calculations assume an entirely efficient energy radiation mechanism, under ideal conditions. Any mechanism which aims to produce a vis-

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ible luminous body will need to overcome the obstacles of energy requirements.

Several researchers have reported on their results of experiments upon the fracturing of rock. They have consistently found that electromagnetic emission is produced when rock is subjected to strain. However, the frequency of this emission varies greatly (Gol'd et al, 1975; Kuksenko et al., 1981; Perel'man and Khatiashvili, 1981; Sobolev et al., 1980; Volarovich et al., 1959).

According to Demin et al (1981), the peak frequency of the piezoelectric pulse in a fracturing rock is 1.7 kHz. This would mean an energy of 1.12×10^{-30} J. Its luminosity would be about 10^{-31} W, and its flux would be (at 100 m) about 9×10^{-33} W m⁻².

Nitsan (1977) calculated the radiated power of a piezoelectric emission as about 10^{-15} W at 5×10^6 Hz, and this would yield 8×10^{-21} W m⁻² at 100 m.

The problem here, though, is that this energy is produced within the crust at unknown depths. Radio wave propagation through rock is of the order of a few meters, unless one includes such things as "natural circuits" and energy tunneling. Even assuming that this energy could find its way to the surface, the method by which it would discharge into the atmosphere and exhibit UFO-like characteristics may not be possible.

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Speculations have been made that the monitoring of EM emission could be used to predict earthquakes, interpreting an anomalous reading as a precursor. Although this may one day be a useful supplement to other precursory indicators, at the present time the parameters and the actual mechanism are both unresolved, so that it can only be regarded as a possible factor for consideration (Gokhberg et al., 1983; King, 1983; Sardarov, 1981).

4.2 GEOGRAPHICAL IMPLICATIONS OF UFO SIGHTINGS

A persuasive argument presented in favor of the TST is that seismic activity and UFO reports appear to be statistically correlated in space and time. That is, seismically active areas will have accompanying high numbers of UFO reports. In the TST, however, a "lag" is sometimes introduced to compensate for the lack of a direct one-to-one correspondence within the data. An earthquake in an area is not expected to be directly associated with a particular UFO report. This makes the theory neatly unaffected by complaints that UFOs might not be observed near an earthquake epicentre at the time of the event (of course, since the reporting of UFOs is related to psychological and sociological processes, the number of variables influencing the eventual reporting of a UFO over a period of many months and within a large radius is going to be considerable).

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Actually, the existence of UFO reports within a large radius of an epicentre need not be surprising. UFO reports appear to be generally related to population density in some ways, and, as they are a significantly subjective phenomena, one would expect them to be related to other phenomena that involve similar subjective limitations. After all, Persinger

(1983b) noted that the best results for the New Madrid area, for example, were strongest when states surrounding the New Madrid states were included. Is this because of a real seismicity-UFO correlation or because a larger radius means a larger population to report UFOs?

It has also been said that: "the more intense the quake, the longer the lag back" (Persinger, 1980b), when referring to the TST, consistent with the theory and its strain field mechanism. But one can wonder, then, if a low intensity event will really imply a short lag between the event and the UFO observation. How well-defined is this relationship? How well are UFOs actually related to seismic activity? Since attempts have been made to demonstrate statistically that UFOs are related to seismically active areas, a logical step would be to determine if this is physically the case. Can we test the TST using other data? In particular, consistent with the TST is the suggestion that a seismically-inactive area should not be burdened with a plethora of UFO reports. Therefore, a seismically-inactive area, such as Manitoba, should not have a history of frequent UFO sight-

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ings. But this is not the case, as there are a large number of UFO reports on record for the province (Rutkowski, 1983).

The studies of Persinger (unpubl) show that all but the very-high-strangeness UFO cases could be correlated to seismic activity. The report sample of Ufology Research of Manitoba should therefore show some sort of relationship to seismic activity in the province and/or the surrounding area.

Manitoba, however, is not known to be a seismically-active province, and there have been no earthquakes within its borders (Wilson and Brisbin, 1962). Yet, over 500 Manitoba UFO reports are on file with UFOROM. How can this be reconciled with the TST?

Persinger (1983b) includes a radius of up to 200 km between earthquakes and UFO reports in his studies of statistical correlations. we must therefore incorporate this distance into any comparative map of UFO reports and seismic events for Manitoba, including the surrounding provinces and states. However, within a radius of 200 km from the Manitoba border (not necessarily from UFO report sites), there have been only eight recorded earthquakes over the last 100 years.{5} These earthquakes are listed in Table 1.

{5} For the sake of completeness, we can include one additional event which occurred in 1880.

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Table 1

Earthquakes in and Around Manitoba, 1880-1984

28 Dec 1880*	49.0 N	97.2 W		III	Pembina
16 May 1909	49.0 N	104.0 W	5.5	VI	Westby
8 Aug 1915	48.2 N	103.6 w		IV	Williston
6 Feb 1917*	47.9 N	95.0 w		IV	Red Lake
23 Dec 1928	47.6 N	93.9 w		IV	Bemiji
26 Oct 1946	48.2 N	103.7 w		IV	Williston
7 Nov 1976*	50.8 N	102.0 w	3.0	IV	Esterhazy
4 Nov 1978*	50.7 N	101.8 w	3.1	V	Esterhazy
10 Jan 1981*	51.9 N	103.4 w	3.1	V	Canora

Of these, only five (*) were considered near enough to UFO-prone areas to be consistent and viable through the TST (Gendzwill et al., 1982; Horner and Hasegawa, 1978; Reagor et al., 1981; Stover et al., 1981) (See Map 1).

With regard to the year-by-year distribution of UFO reports for Manitoba, there were three major "flap years", namely 1952, 1967 and 1975, when report numbers climbed considerably above the normal background level. These years coincide with "flap years" in other parts of the world, as agreed upon by other researchers, and are considered part of a world-wide trend (Rutkowski, 1983) (See Figure 4).

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Map 1

Earthquakes Near Manitoba

Compiled and Plotted by C. Rutkowski (1983)

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Figure 4: Tabulation of Manitoba UFO reports by year. Reproduced from Rutkowski (1983).

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The first observation that we can make is that there were no earthquakes within real "range" of Manitoba during these "flap" periods. Only one earthquake (7 Nov 1976) occurred within a 2-year interval of a flap year (1975), and this occurred 300-400 km away from the area which experienced the bulk of the reports (Carman). This means that no earthquake was related to a surge of UFO reports, even through the action of a moveable strain field, with the exception of one event that is more than likely a coincidence. Secondly, these were all low-intensity events, and highly-localized, so that they were not felt beyond a small radius.

Given the large number of UFO reports in the province, it is not conceivable that they are related to seismic activity. No statistical study is necessary in this case, since the lack of seismic events and the contrasting abundance of

UFO data are not conducive toward conditions for analysis. In Manitoba, there can be no "optimal" temporal or spatial increment in analogue to the New Madrid area studied by Persinger (1983b).

In Map 2, the geographic locations of UFO reports in Manitoba have been plotted. These represent more than 150 places where over 500 reports have been made within the province since 1900 (Rutkowski, 1983). Map 3 exhibits the rural population distribution for Manitoba (Weir, 1960). It is immediately obvious that, in general, the distribution of

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Map 2

MANITOBA

UFO Report Distribution

Compiled and
Plotted by

C. Rutkowski (1983)

- -

Map 3

MANITOBA

RURAL POPULATION

- -

UFO reports within the province is similar, if not identical, to the distribution of population. This is because the reporting of UFOs is through a human system. Since UFOs are reported by people, there will be a strong relationship between the two elements.

What do these maps tell us about the occurrence of UFOs in Manitoba? Since there are very few populated areas in Manitoba north of 52 degrees latitude, the lack of UFO reports means only that few people are present to observe UFOs if and when they appear. In fact, there seems more evidence for a UFO-demographic relationship than a UFO-geologic one. Determining a relationship between faults and/or seismic events and UFO reports appears geographically untenable, at least in Manitoba.

We see, then, that UFO reports do not necessarily indicate seismic activity (this is, in fact, stated in the TST). In the TST, it is even possible that UFOs may be associated with unknown or undiscovered faults in the Earth's crust. In considering this possibility, a map of the faults in Manitoba needs to be examined as well.

Map 4 is a representation of major geologic fault systems in the province, showing that with the exception of two faults in the Whiteshell area, all are well over 200 km from the bulk of UFO report sites (Manitoba Mineral Resources Division, 1979).

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Map 4

MANITOBA

Geologic Faults

Compiled and
Plotted by

C. Rutkowski (1983)

Adapted from

Manitoba Mineral Resources
Division. Geologic Map of
Manitoba, Map 79-2. (1979)

- -

In an early TST study (Persinger and Lafreniere, 1977), UFO report numbers were compared with "gravity anomalies", showing a reported correlation. Map 5 gives the relative intensities of gravity anomalies in the province. There are relative gravity highs in the densely-populated prairies, with large low anomalies in the extreme north and west parts of the province (Davies et al., 1962).

It is apparent that there is a poor geographic relationship between faults and UFO report areas in Manitoba. This must mean, then, that there exist undiscovered faults in the UFO report areas, according to the TST. This is permissible in the TST, since it is the strain field which is the production mechanism for luminous phenomena. It has been proposed that these luminous ball-like UFOs may be earthquake lights associated with very small, local seismic events, with a magnitude less than 2 and perhaps even less than 1 on the Richter scale (Simon, 1983). Since there is always some amount of subsidence, release and buildup of small strains within the Earth's crust, the TST might be broadly embraced to explain all UFO phenomena. Not only could all luminous lights be explained by strain-related EM emission, but also all close-encounters where witnesses report bizarre experiences. This is so because EM emission has been shown to be capable of affecting the human brain, causing hallucinations. It appears that, at face value, the TST can be used to explain a phenomenon with a wide variety of characteristics.

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Map 5

MANITOBA

Gravity Anomalies

Compiled and
Plotted by

C. Rutkowski (1983)

- -

But why, then, if the strain produces UFO reports, is there not a more direct relationship between earthquakes and UFOs? Why would there not be a flurry of reports during seismic activity in the area near the epicentre?

4.3 EARTHQUAKE LIGHTS AND DILATANCY HYPOTHESES

The dilatancy model of strain precursors explains that it is the movement of water into microcracks within a strained area that causes dilation. Rikitake (1975) suggests it is even possible to calculate the size of the dilated area as crustal deformation. The formula for calculating this is:

$$M = 1.96 \log r + 4.45$$

where r is the radius measured in kilometres. Therefore, an (unmeasurable) event with a magnitude of 1 will have a radius of about 17 metres.

$$r = 10^{_B}$$

where $_B = (M - 4.45) / (1.96)$

(a magnitude 4.45 event will have a dilatancy radius of 1 km)

The problem of UFOs being small, "local" earthquake lights is basic: their differing characteristics. Earthquake lights are stationary and of very short duration, be-

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ing associated with events at the time of the fracture, and appear at that time. UFOs, on the other hand, come in a myriad of colors, move erratically and are not visibly associated with any crustal movement.

The TST argues that UFOs move as they do because the strain field they "belong to" moves in the same manner. However, since UFOs have been reported to move with great speed, one wonders if a strain field could move with such velocity. Even fracture propagations (the earthquake mechanism) often take several days to travel short distances.

TST proponents believe that the strain field could, in fact, react to geophysical processes including lunar tidal effects and geomagnetic field changes. These reactions could provide a moving force for the strain field, according to corollaries of the TST. The exact mechanism is not proposed, although it is assumed that it involves crustal movement associated with gravitic and magnetic attraction. In effect, the ground beneath a UFO is said to be affected (probably dilated) and as the strain field reacts, the dilation shifts, carrying the UFO with it. These microdilatory effects are essentially too small to detect (and, in fact, there are no reported cases in geophysical literature), so that the only evidence we could have for their existence would be a visible UFO.

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4.4 OTHER CONSIDERATIONS

While it is true that there have been precursory dilations associated with shallow earthquakes, a major factor for consideration is the focal depth of the events. One would expect, naturally, that shallow earthquakes would show more precursory crustal deformation than deep events. One indication is the fact that at depths below 200 km, the nature of the earthquake focal mechanism itself is modified, so that dilation cannot easily occur (Kasahara, 1981).

If in fact luminous effects caused by emissions are produced by strain, then their association with deep-focus events would be very puzzling. Since attenuation of electromagnetic waves through rock is often of the order of only a few metres, it is difficult to explain how emissions within a strained area could reach the surface and produce detectable effects.

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Chapter V

OTHER TST-RELATED THEORIES

5.1 VESTIGIA

A group whose work supports that of Persinger and parallels his research on the TST is Vestigia, a group of individuals who have conducted independent studies into so-called "spook lights".{6} The group has often set up field experiments in areas frequented by these lights, using equipment such as geiger counters, methane detectors, infrared sensors and radio detection equipment with several thousand feet of wire attached to an amplifier and an oscilloscope. They have reported the detection of radio emission of 40 kHz during the observation of yellowish-white lights along railroad tracks in areas with small faults or alluvial soils (Wagner et al., 1978).

Their theory for the phenomenon is nearly identical to the TST:

"When quartz-bearing rock is subjected to stress...an immense electrostatic charge is generated. At the maximum periods of lunar tidal stresses (sic) this

{6} It appears that Persinger has drawn upon Vestigia's results and theories to some degree.

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effect would be more pronounced. If sufficient electrical fields are created close to the surface, a portion of the spherical field would be above the surface. In a region where either faults or loose-packed alluvial soils are present, radon gas would be emitted into the air at the surface. This radioactive gas would create partially "ionized" pockets of air which would be enhanced by the highly electrified fields in the region. This would, in turn, start a low-energy plasma of small size which would be predominantly near railroad tracks or power lines that traverse the terrain." (Wagner et al., 1978)

The Vestigia group goes on to describe details such as colors of the lights, the effect of changes in atmospheric and the effect on humans in the proximity.

Although the theory is well-described, little in the way of supporting physical mechanisms is given, showing more similarity with the TST. Vestigia has produced photographs of the lights and records of the instrumental detection of the events, as well as numerous witnesses' accounts. In support of Vestigia, it should be noted that although many "spook lights" have been reported around the world, no scientific investigation of them has been conducted by the scientific community. Vestigia has gone to considerable length to document the phenomenon, and has produced a theory which

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is consistent with the observations, although a quantitative assessment is certainly in order. The theory is subject to considerable constraints.

Once again, it would be desirable to know the relationship between stress and energy production, and the energy requirements involved. Also, one would have to question the observations themselves, since Vestigia has described in one instance a "spook light" that was visible and detectable from only one direction (Wiedemann, 1977). The TST would here invoke the influence of EM emission upon the human brain to explain the appearance of a UFO to one person and not another, but the Vestigia theory leaves this question unanswered, although it has commented on animal precursors of earthquakes (Wagner et al., 1978).

The Vestigia group has also expressed its view that electrostatic fields of the order of 10^5 V m^{-1} could be generated in quartz-bearing rock under stress. They include piezoelectricity in their approach as well, and describe a relationship between earthquakes and "spook lights". Specifically, they found that 80% of recorded "spook lights" correspond to "regions of extensive earthquake activity". But they realized that the other 20% would constitute a problem. They were encouraged, however, by the finding that a light in South Carolina not on a previously recognized fault was in fact on a fault discovered after the light's documentation.

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In April of 1978, some of Vestigia's consultants presented a paper to the American Geophysical Union meeting on "earth stress lights", and as a result of their studies, announced: "we now [have] introduced to the scientific community a realistic explanation for luminous occurrences in earthquake regions" (Wagner and Visvanathan, 1978).

As well, based on their "spook light" research and probably also due to the success of a light "predicting" a fault, Vestigia commented that:

"Possibly within the next 10 years, THERE WILL BE AN EARTHQUAKE in Florida, S.E. Texas and S.E. Maryland."
(Wagner et al., 1978)

(emphasis in original)

Vestigia's theory is actually preferable to the TST in some ways because it focusses on only one type of UFO, the "spook light", which has its own individual characteristics. Statistical studies involving the TST have used raw UFO data from UFO report catalogues, incorporating a wide variety of characteristics, and hence may involve several different phenomena.

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5.2 EARTH LIGHTS

Another group of researchers doing independent research into strain-related luminous phenomena are involved in the Dragon Project. Involved are: Don Robins, an inorganic chemist; Paul Devereux, an archaeological researcher and writer about UFOs; and Paul McCartney, a geochemist. The Dragon Project cites the work of Persinger and Brady{7} in support of their own research into the relationship between UFOs and geophysical phenomena. But these two groups of researchers have rather marked distinctions.

Firstly, the Dragon Project is primarily interested in the petroforms of England, including Stonehenge, Rollright and other megalithic sites (Devereux and Forrest, 1982). The researchers believe that they have found that "stone

circles...emit anomalously high and anomalously low levels... of radiation. (Robins, 1982)" Combined with this radiation is also ultrasound production, detected at some sites (Robins, 1982). What has been found is that certain sites give geiger counter readings at levels above the normal background, while at some sites, the background is unusually low. The Dragon Project has put forth the concept of "Earth energy", which is more mystical than mechanical. This "Earth energy" is reportedly detected by dowzers and psychics, and permeates all things in analogy to the famous

{7} Specifically, Persinger and Lafreniere (1977) and Brady et al (unpub).

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"ether" of the ancient philosophers (Robins, 1982).

One of the proponents of this energy, Devereux (1982), combined the concept of radiation emission with that of UFOs. Devereux and his associates carried out several experiments (all with unpublished details and results) in which they crushed a specimen of rock and observed lights produced during the process (Devereux et al., 1983). In this way, they were able to "confirm" the results of Brady et al (unpub).

Frequently referring to Persinger's research, Devereux (1982) found "the best UFO-geology correlations yet published". He found that many UFO sightings in Wales occurred within a few hundred metres of a fault. But he makes a quantum leap from faults to earthquake lights at one point (citing Derr (1977)), and links the TST with his research (Devereux, 1982).

Devereux, however, makes one distinction in that he disagrees that piezoelectricity is the causative mechanism for UFOs. He suggests triboluminescence "as a more likely candidate" (Devereux et al., 1983). The two processes are different mechanisms, but both produce luminous phenomena in minerals. Piezoelectricity is created when certain crystals are subjected to pressure, while triboluminescence is the effect caused by mechanical friction upon two mineral surfaces.

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Devereux, although claiming to have duplicated Brady's experiments, describes a photograph of "triboluminescence in rock crystal...after it has been subjected to friction (Devereux et al., 1983)." But Brady (Brady et al., unpub) subjected his granitic core sample to pressure, a different mechanism. There appears to be a lack of distinction here, and a probable contributing factor to this confusion is the fact that the experimental results of neither Brady nor Devereux have been formally published.

A further similarity between the TST and EL (Earth

Lights) theories is that the latter includes the possibility that the energy that "creates" the EL may effect the human brain. In this regard, the EL theory claims that psychics or "sensitives" might be more apt to perceive these energies than other people (Persinger, 1975). Although no actual mechanism is proposed, the implication is that the "Earth energy" acts upon the brain in a method in agreement with that proposed by the TST.

It is clear, then, that the EL theory parallels the TST in many ways. A significant difference is that the EL theory restricts "Earth energy" effects upon human systems to distances generally less than 1 km, whereas the TST involves faults and/or events up to 200 km away from an observer.

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Chapter VI

CONCLUSIONS

The TST (Tectonic Strain Theory) is a theory with minimal supportive evidence, but with wide appeal for individuals wishing to explain a persistent phenomenon in terms of known mechanisms. While elements of the TST appear to include documented geophysical phenomena, the main thrust of the theory hinges on its unproved relationship with a controversial phenomena, namely UFOs. For a theory of its kind, the TST has received a large amount of publicity and a generally uncontested entrance into published scientific literature. This situation has resulted in an apparent acceptance of the theory's "principles" without proper scientific comment.

Although statistics on UFO reports have been kept for nearly forty years (and much earlier, if we include pre-1947 reports), the data are without many redeeming features. Data sources such as UFOCAT and MANUFOCAT contain many reports with poor investigation or insufficient information due to the methods used in obtaining the data. For example, many entries in UFOCAT are from published articles or newspaper clippings, and not necessarily from an investigator's report. Many reports are therefore anecdotal rather than factual (Rutkowski, 1983).

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Even in the case of entries copied from investigators' files, the problem of consistency remains. The quality of investigative effort is expected to vary, since essentially anyone could call his- or herself an "investigator", regardless of qualifications, and submit reports for entering into the file. Although this is not as true today, with efforts for standardization in preparation, the lack of training could easily account for judgement errors in early case files. Admittedly, this was not always so; the files contain many greatly-detailed reports from good investigators (including law enforcement officials) (Hendry, 1979).

They may, in fact, have been good reason for lower-standard investigations. Most UFO investigators and researchers are not funded for their efforts, so lack of travelling expenses might preclude many investigations. Some might lack the experience to identify high-flying aircraft and their descriptions. Others might include their own personal bias in their report (e.g. by asking a witness: "How big was the craft?" rather than "What was the angular size of the object?"). Still others might just make a judgement error.

All of these problems with UFO data are found in all UFO report listings. It is details such as these which have led one UFO researcher to comment that UFOCAT is not useable for statistical studies of UFO data because of inherent flaws in its design (Hendry, 1979). Yet, the TST uses several UFO

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data sources for statistical correlative studies, with very vaguely-defined parameters.

There is no question that some of the geophysical processes invoked in the TST are sound. Rock undergoing strain can indeed give off EM radiation that can be detected by sensors near the event. Whether this EM emission is scale invariant is an entirely different matter.{8} There is also no question that earthquake lights exist, and that their mechanism is not fully understood. The TST suggests that UFOs are essentially the same phenomenon, and it has been proposed (in a questionable manner) that the statistical correlation between UFOs and earthquakes is supportive of the theory (Persinger, 1983a, 1983b, 1983c, 1983d).

But the existence of UFOs in aseismic areas seems to contradict this correlation. To suggest that the seismic activity exists in these areas with magnitudes less than 2 (or even 1) on the Richter scale is perhaps grasping for straws. Certainly, activity in the range of magnitude 1 can occur frequently in many areas, so that the observation of UFOs should be at a constant value. While it is true that UFO reports have a "background" level, this is more the case of reporting rather than the reports themselves as the main contributors.

{8} Brady (1973, 1974), has given evidence to show that strain itself may be scale invariant. Whether this might include EM emissions is not clear.

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Also, there are different characteristics of earthquake lights and UFOs that need to be considered. Earthquake lights are reported as generally stationary hemispheres of white light, in contact with the ground. They are 20 to 200 metres in diameter, and follow an earthquake, with a duration of 10 to 100 seconds. They do not occur at an epicenter, but in areas around it at varying radii (10 to 50 km), and frequently on mountaintops (Derr, 1973, 1977; Hedervari,

1982). UFOs, by definition, are seen in the air, and are observed in areas where no earthquake is felt. They are most often described as spherical, with the next most frequent shapes reported being point sources, discs and cigars. There are two main distributions of sizes: <1 metre, and >4 metres. Red, white and orange, in that order, are the most frequently- reported colors of UFOs. The duration of a UFO sighting ranges between a few seconds up to an hour or more (Hendry, 1979; Rutkowski, 1983).

A comparison of the characteristics of the two phenomena shows they do differ significantly and that any attempt to reconcile these differences needs to properly address the dissimilar features.

In an early study where a form of the TST was first described, not only were geophysical events correlated with UFOs, but also unusual objects falling from the sky, EM effects, unusual human talents, telekinetic events and ghost sightings. In the early study, it was said that:

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"Transient and unusual phenomena should occur in areas where tectonic stress is accumulating. Episodes may not necessarily involve areas of well-known seismicity, since these areas may only reflect structural weakness along the stress axis." (Persinger and Lafreniere, 1977)

It was implied that most unusual phenomena were related to geophysical processes.

Interestingly, Devereux (1982), himself a proponent of a form of the TST, asks of Persinger's research:

"Why attempt to explain other, possibly more complex and perhaps unrelated mechanisms under the same conceptual umbrella?...This approach to the UFO problem cannot sensibly be conducted over the entire USA in any case - the area is so vast that untenable numbers of UFO events would have to be involved. And how would one cope with the detailed geological data of such a continental area, even if it is available?" (Devereux, 1982)

(emphasis in original)

He concludes:

"...despite all the scientific trappings [the] work displays, the conclusions drawn owe as much to intuition as to the computer..."

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This represents perhaps the most succinct published criticism of the TST on record.

One of the few other criticisms of the TST, this time directed at Devereux et al. (1983), was by Campbell (1983). He pointed out that "since Britain is criss-crossed with geological faults, it is not surprising that 'many reports of UFO sightings come from areas close' to them." He cautioned that Devereux "should be as concerned with the UFO data as [he is] with geology," since Persinger's data base was flawed, and that "the geological jargon conceals a poverty of hypotheses."

Devereux quickly countered by saying that surface faulting does not cover Britain as Campbell implies, and that he did not think that the UFO/fault relationship was coincidence. He also came to Persinger's defense by calling his work "meticulous", and saying that:

"If [UFOs are] all hoaxes or hallucinations, then we had better start wondering why figments of the imagination correlate with faulting." (Devereux, 1983)

Of course, the problem is not that UFOs are hoaxes or hallucinations (few are), but that the majority are misidentifications.

In the end, the major problem is that of the data itself. We know that seismic activity exists, and that earthquake

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lights exist, and that UFO reports exist. But the data for these phenomena is taken from a variety of sources and covers a variety of disciplines.

The handling of data has always been a problem, and several statisticians have cautioned against its misinterpretation.

"When...probabilistic considerations seem to be called for, we now feel more hesitant about postulating simple parametric distributions. We are not now so sure that there is a likelihood function, or a set of sufficient statistics, or an exact test of significance...Thus we view data with greater respect, with greater curiosity about what is there; and we have less confidence that we know just what questions should be answered and in what way." (Anscombe, 1982)

While the TST is very appealing in its description of UFO phenomena in terms of "terrestrial", rather than "extraterrestrial" mechanisms, it provides little in the way of supportive evidence that its mechanism actually exists. As a hypothesis, it cannot be discounted; only the evidence in its support can be evaluated as either favorable or not favorable. But using one poorly-understood phenomenon to explain another using an unknown mechanism is perhaps too much to expect at this point (Rutkowski, 1984).{9}

{9} The text of this paper is given in the Appendix.

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It is possible that the TST may explain some aspects of the UFO phenomenon, but the theory needs a great deal of refining and rethinking before it can be applied in general to the phenomena it incorporates.

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Appendix A

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Geophysical Variables and Human Behavior: Some Criticisms

Through statistical studies of geophysical phenomena and UFO (Unidentified Flying Object) reports, it has been suggested that some reports of UFOs might reasonably be understood on the basis of natural phenomena produced by a geophysical process involving tectonic strain (Persinger, 1979, 1980, 1981, 1983a, 1983b, 1983c). This theory, hereafter referred to as the TST (Tectonic Strain Theory) of UFOs, suggests that plasma-like luminosities

can

be naturally created and that these can be reported as UFOs. The TST is laudable in that it attempts to explain the persistent reports of UFOs in terms of "terrestrial" rather than "extraterrestrial" causes.

The theory incorporates luminous effects that are a great distance

from the source and temporarily displaced. This theory also contends that the luminous effects are related to geophysical variables such as the solar wind and geomagnetism. The geophysical

basis for such a theory, however, is not strong and is extremely dependent upon recent reports of luminous effects produced by strain on rock during fracture tests (Demin et al., 1981).³

These

effects are highly localized, of short duration and have not been

demonstrated to be related to other geophysical phenomena such as the solar wind. Despite this, statistical studies using seismic, solar and UFO data as variables have been performed, and it has been proposed that UFO report numbers vary with the seismic and solar data (Persinger, 1981). These correlations are suggested to be consonant with the TST.

There are several problems with obtaining adequate data to test the theory which are worth noting. The statistical studies which suggest a

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correlation between UFO report numbers and geophysical phenomena show the best relationships between the variables only when the optimal Δt and Δs (increments of time and space) are used.

In particular, it has been proposed that the geophysical cause for UFOs in the TST is a strain field which may extend hundreds of kilometers between the locations of the perceived UFOs and earthquake epicenters. Statistical correlations use these UFO report numbers and earthquake numbers to define relationships between the variables, often including a time lag of up to a

year. Essentially, an observed UFO at point p may be the result of a strain field and may be related to an earthquake at point q, two hundred kilometers distant and several months previous to the

time of observation. This is intuitively unsatisfying, since if two variables can occur at any time within a year of observation and anywhere within a large radius, it would be difficult to

determine a time-geography variable in order to arrange a correlation study.

Countless other variables may be present or occur within the strain field's perimeter, and these may influence any correlated effects.

It should be noted that a rare geophysical phenomenon called earthquake lighting displays some reported UFO characteristics such as luminous bodies of light (Derr, 1973). However,

earthquake lightning appears generally within a short time before or after

an earthquake, so it has a more readily-apparent cause. In addition,

there exist several theories as to the origin of earthquake lightning, encompassing geological processes familiar to geophysicists (Finkelstein, et al., 1973). More serious problems concern the actual selection of UFO data. The studies make use

of UFO report numbers from several sources with

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varying degrees of credibility (e.g., Fate magazine and UFOCAT).

In all cases, there is a great difficulty in trying to establish whether an object is actually unidentified or merely misidentified. The two different categories are often within the same data set in the UFOCAT file, for example. The fact remains that UFOs are often reported by inexperienced observers, and the reports are often investigated by inexperienced investigators. Statistical studies of raw UFO data, including the UFOCAT file, have shown that about 90% are misidentifications of ordinary phenomena (Hendry, 1979; Hynek, 1977). It has been stated that the UFOCAT file cannot be used as a source of data because of inherent flaws in its design (Hendry, 1979).

The TST is therefore not supported by the statistical studies involving UFO data. Although geophysical phenomena could account for some UFO reports, a persuasive covariance has not been produced. On a more positive side, while the TST may not predict the presence of plasma-like luminosities, it may say something about the witnesses who report UFOs. In this regard, it has been suggested that geophysical luminosities are related to EM (electromagnetic) radiation, also produced by tectonic strain (Persinger, 1983c). This EM radiation is thought to be capable of affecting the human brain (in particular, the temporal lobe) and creating a variety of effects, including artificial memories. If the theory can show a relationship between misidentifications of ordinary phenomena and geophysical effects, perhaps there is, after all, some interaction between these phenomena and the human brain, causing individuals to report UFOs.

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Care should be taken in further studies of UFO data because their nature is subjective and collection involves several problems. Theories such as the TST are quite valuable in their attempt to explain UFOs from a scientific standpoint. The TST probably could explain some UFO reports and elements of the total UFO problem, but the persuasiveness of an empirical scientific argument can be no better than the acceptability of the data upon which it is based.

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