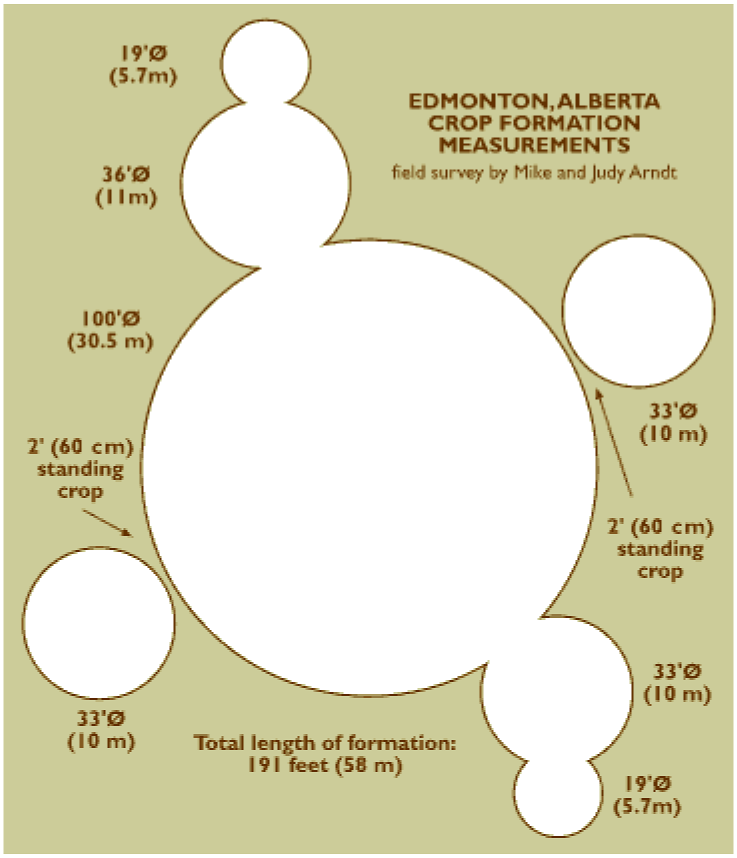
BACK

# CLAY-MINERAL CRYSTALLIZATION CASE STUDY: 1999 EDMONTON, ALBERTA, CANADA CROP FORMATION




**BLT Research Team Inc.**
**Cambridge, Massachusetts (USA)**
**March, 2004**

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## STUDY OBJECTIVES:

1. To determine through x-ray diffraction examination (XRD) and measurement of the consequent Kubler Index (KI) whether changes in crystalline structure exist in specific clay minerals (illite/smectites) in surface soils inside crop circles, as compared to control soils from outside the flattened-crop perimeters;

2. To determine the statistical significance of the KI data;

3. To determine whether changes in crystallinity of the illite/smectites in crop circle soils (as demonstrated by changes in the KI) are correlated with apical node-length changes in crop circle plants sampled at the same sampling locations as the soils;

4. To determine if the XRD/KI results rule out direct mechanical flattening of the crop circle plants;

5. To determine if the XRD/KI results offer support for the hypothesis that an atmospheric plasma vortex system, emitting microwave radiation, is involved as a causative agent in the crop-circle formation process.

## STUDY RESULTS:

1. A sharpening of the mica 001 peak [a decrease in the Kubler Index (KI) value, indicative of growth of the illite/mica crystals] was observed in the crop circle soil samples, as compared with their controls;

2. This increase in crystalline structure was found to be statistically significant at the 95% level of confidence;

3. A correlation was found between this sharpening of the mica 001 peak (KI) and increases in plant stem node-length (NL), a correlation which is statistically significant at a greater than 99% level of confidence;

4. The increase in the KI of the mica 001 peak cannot be attributed to mechanical flattening of the crop circle plants since (in the absence of any evidence of geologic pressure) temperatures of at least 6-800℃ over several hours of exposure would be required to produce such increased crystal growth;

5. Because the temperatures needed (a minimum of 6-800℃ over a period of several hours) to cause mica crystal growth would have incinerated any plant material present at the site (as well as causing other measurable soil effects), and because we know of no energy which can selectively affect soils to one degree and plants at the same locations to another (as is documented here), we suggest that we may be observing a new--as yet undiscovered--energy source at work. It does appear that heat is involved, but more research is needed to determine its precise nature.

## STUDY BACKGROUND:

In 1996 local geologist Diane Conrad visited a crop circle which had occurred near her home in Logan, Utah. The formation, the first one reported in the general area, caused quite a stir locally and resulted in a local radio interview with Nancy Talbott about the BLT Research Team's previous crop circle research and results. In that interview Michigan scientist W.C. Levengood's hypothesis that some sort of atmospheric plasma system might be involved was discussed at length--in particular the fact that plants and soils at cropcircle sites had been shown by Levengood et al. to exhibit abnormalities consistent with their exposure to brief bursts of intense heat. Also pointed out was the fact that plasmas are known to emit microwaves when they spiral, and thus could be a possible source of this heat.

Having written her Master's Thesis on heat effects on clay minerals, Ms. Conrad reasoned that certain expandable clays in the soils at cropcircle sites might provide additional evidence of this heating action. If the soils, and these expandable clay minerals (illites/smectites), had been exposed to unusual heating it was possible that a change in the degree of crystallinity might have occurred. Since Ms. Conrad was familiar with both the particular measure of crystallinity (the Kubler Index) and the X-ray diffraction (XRD) methodology utilized to obtain this information, she decided to carry out preliminary testing on the 1996 Logan, Utah crop circle soils.

Ms. Conrad's results from this preliminary XRD investigation were intriguing. The soil sample from within the crop circle showed a pronounced decrease in the Kubler Index of the illite peak, as compared to the control (S=0.11; C=0.25), indicating increased crystallinity in the circle sample. Ms. Conrad then took the 3 remaining aliquots of the control sample and heated the first in a conventional oven for ten minutes at 93ºC and the second for ten minutes at 287ºC; the third was microwaved for two minutes to determine the effects of energy of different wavelengths on the crystal structure. In these three heated control samples the Kubler Index consistently decreased (from 1.0 to 0.07), with the microwaved aliquot producing a Kubler Index most similar to that of the circle sample.

**It must be kept in mind that this increase in degree of crystallization (greater ordering of the atoms) in clay minerals has not been documented in surface soils before. Such changes are typically seen in sedimentary rock which has been exposed--for hundreds, if not thousands, of years--to both heat from the earth's core and the massive pressure of tons of overlying rock. If such a change were to be demonstrated (with statistical significance) in surface soils in an in-depth study at crop circle sites, it would certainly inspire increased academic interest in the causative mechanism behind the crop circle phenomenon.**

In 1999 New York philanthropist Laurance S. Rockefeller provided BLT Inc. with the funds needed to implement this in-depth XRD examination of expandable clay minerals (illites/smectites) in crop circle soils.

For details of the 1996 Logan, Utah cropcircle report, click on BLT Lab Report #79 (left).

## STUDY CASE SELECTION:

A number of crop circles in several countries were considered as potential candidates for this study, and there were multiple factors which guided our final choice. We relied heavily on the research published by W.C. Levengood et al. (1994; 1995; 1999) over the years to help us choose a productive study case, and paid specific attention to BLT Lab Report #79 (see above) which states that both multiple expulsion cavities and statistically significant apical node-length increases were documented in the plants in the Logan, Utah crop formation. Additionally, we noted that the crop-lay in the upper-most plants in both circles in the Logan formation had been more radial than spiral (radial crop-lays are less common than spiral lays).

Four crop circles (one in Holland, one in the U.S. and two in Canada) were evaluated preliminarily as candidates for this study. All of these cases provided statistically significant apical node-length increases in the plants, as well as the presence of expulsion cavities, and two had the radial lay in evidence. Preliminary XRD examination of the soils in all but the Holland case also suggested increases in the crystalline structure of the illite/smectites in the soils.

In the Holland event we had a reliable eye-witness to the circle forming underneath a disc-shaped light which had hovered over the field, but the soils from this field were extremely rich, containing very little clay, and it became apparent that the extraction of the clays in preparation for X-ray diffraction was not cost-effective for this study. The U.S. case not only had node-length increases and expulsion cavities present, it also was one of the first cases where the massively twisted and spiraled stem at the base of the seed-head was observed. However, the field-team in this instance had misunderstood the sampling protocol and there were not enough controls available. And, in one of the two Canadian cases, the farmer had mowed quite a bit of the field surrounding the formation prior to the BLT field-team' s sampling, thus making it impossible to obtain both plant and soil samples at all the required locations.


The fourth case, a seven-circle formation (overall length 191 ft.) in barley at Edmonton, Alberta, Canada in September, 1999 was the only case of the four which could be examined within our budget and which also met all of our basic criteria and, so, it was chosen for the in-depth XRD study. Unknown to us at the time, this Edmonton formation would turn out to be one of the most interesting crop circles we have studied so far.


The apical node elongation was so extreme at Edmonton that it was clearly visible in the field (and subsequently confirmed to be statistically significant by W.C. Levengood), and the sampling-team found massive numbers of expulsion cavities all the way down the barley stems, in some instances involving the apical node also. The lay of the crop in all seven circles was complex, with an uppermost layer chaotically laid in varying directions, a radially-laid layer beneath that, with an underlying, narrow, counter-clockwise ring of flattened crop around the perimeter of each of the seven circles.

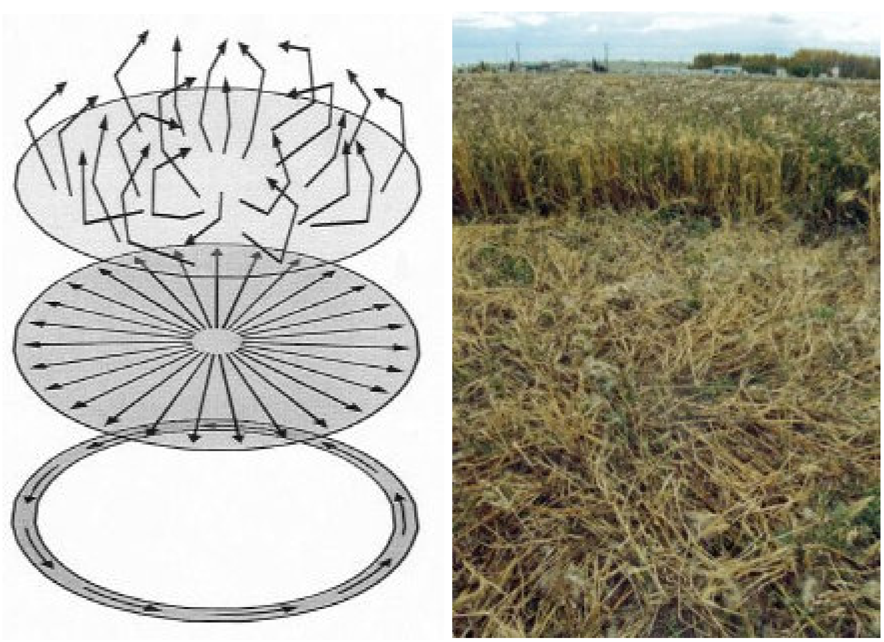
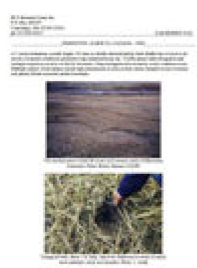


**Diagram and Photo:** J. Arndt

This formation was found by the farmer (who subsequently reported that he had observed multiple circles the previous year in an adjacent field, which he had thought might be caused by deer bedding down) at harvest, and was not visible from the nearest roads. The fact that the field was infested with Canadian thistle, which made it almost impossible to walk in the field without high protective boots, tended to further rule out the possibility that this formation had been mechanically produced.

Photo: J. Arndt

Finally, fieldworkers Mike and Judy Arndt--in spite of the Canadian thistle--carried out a thorough, comprehensive sampling and precise documentation of the field situation, thus making this Edmonton case overall the best candidate. For those knowledgeable about the crop circle phenomenon it is interesting to note that, during the sampling work, cell-phone failure inside the circles was observed by the Arndts and unusual aerial light phenomena was reported by the farmer and his wife and at least one other unrelated individual during the time-period when this formation was thought to have occurred.



To read the entire original BLT Lab Report #122

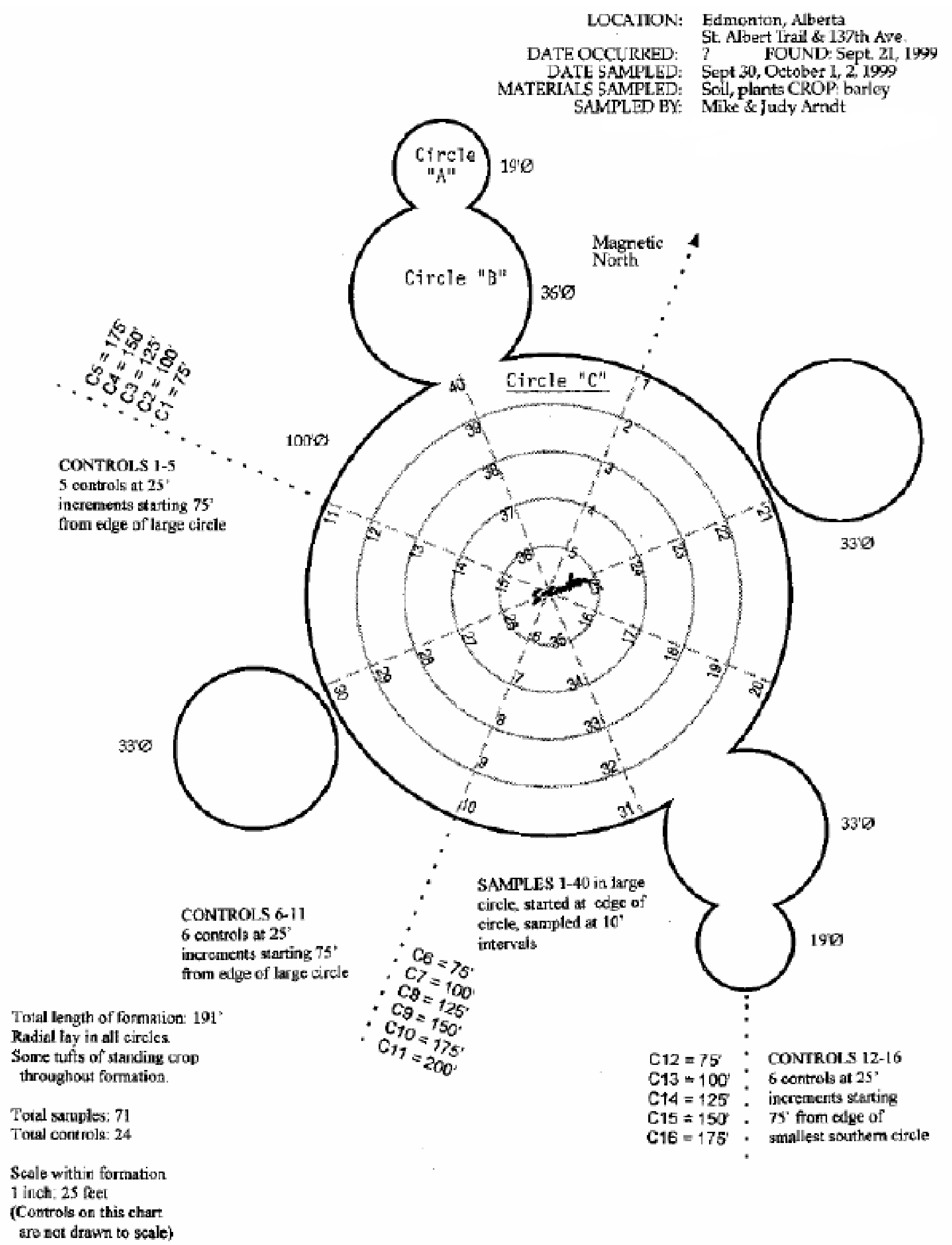
on the Edmonton case, click on diagram at left.

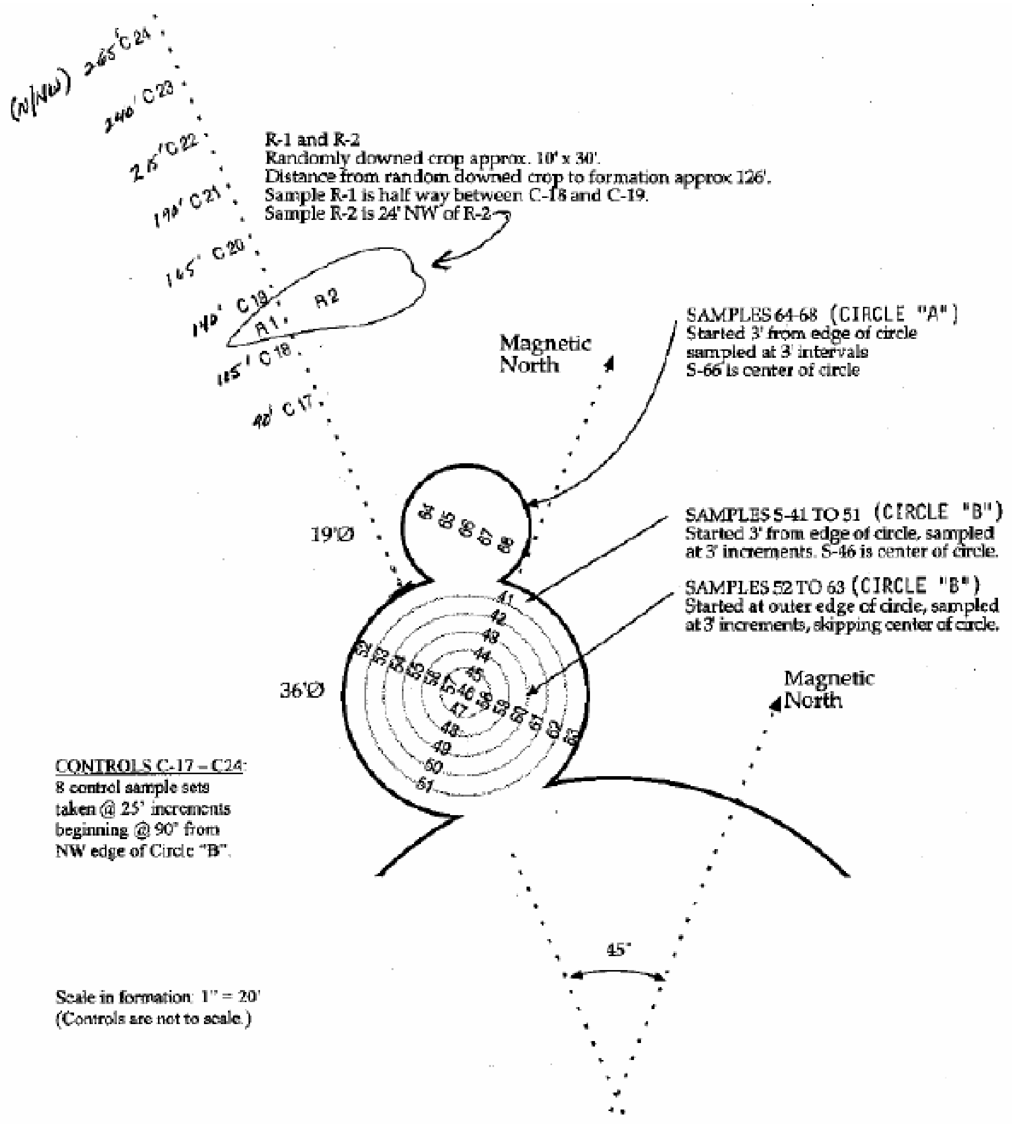
## SAMPLING PROCEDURE:

Plant samples, consisting of 15-20 plants/sample, cut off at just above the soil level, were taken along multiple diameters at precise intervals (which varied, depending upon overall circle size) in three of the seven circles that made up the Edmonton crop formation. In some samples the number of plants/sample varies because of the heavy infestation of thistle, which made it impossible in every sampling location to obtain 15-20 plants adjacent to each other. Magnetic North was determined by the field-team and, in two of the sampled circles, this diameter was sampled.

Previous plant research had indicated that, in crop formations comprised of multiple-sized circles, the most significant plant changes often occur in the smaller-diameter circles. The field-team was unable to complete the full sampling of the smaller circle in this case, in spite of which the plant data revealed interesting results.

Plant controls, also consisting of 15-20 plants/sample cut off at the base, were taken along four different control lines beginning at 75 ft. away from the flattened edges of various sections of the formation and continuing to between 175 ft. - 265 ft. away from the flattened edges, at 25 ft. intervals. (*Click on sampling diagrams below to see in full size.*)



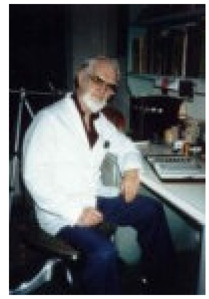



All plant samples and controls were wrapped in newspaper, secured and labeled with the appropriate sample or control number, and dropped in situ until the soil sampling had also been completed. Each sample and control location was registered on the field sampling diagram.

Soil samples and controls, consisting of approximately 1/2 cup of surface soil at each location (down to a depth not exceeding 1/2 inch), were taken immediately around each plant sampling location and then placed in plastic bags and labeled.

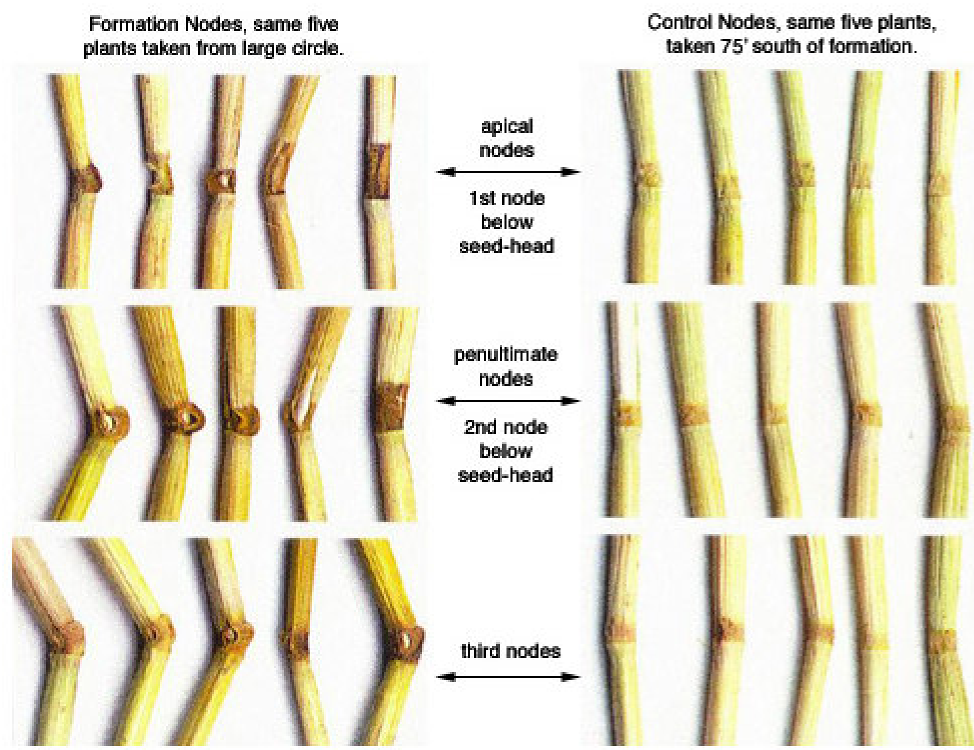
The fieldwork took three days to complete (September 30, October 1 & 2, 1999), after which the plant samples were allowed to dry for an additional three weeks, prior to shipping to Michigan for the initial plant and soil analyses.

**PLANT RESULTS:**



Twenty-three control sets (approx. 230 plants) and seventy-one sample sets (approx. 710 plants) were examined by Michigan biophysicist W.C. Levengood. Two of the most reliable indicators (node-length increase and the presence of expulsion cavaties) that an unusual energy system had impacted the plants inside the flattened circles were found. [Both of these abnormalites are thought to be caused by a rapid, intense exposure of the plants to heat (microwaves?) which turns the internal stem moisture to steam. Depending on (a) the elasticity of the plant fibers (younger tissues are more elastic), (b) the amount of moisture inside the plant stems, and (c) the intensity and/or duration of the heating agency itself, the steam either stretches the apical node of the plant and/or bursts holes through the lower nodes as it escapes. See published papers, 1994; 1995; 1999.]

(1) Expulsion cavities (holes blown out at the plant stem nodes) were found in 68% of the 71 plant sample sets; none were found in the 23 control sets. These expulsion cavities were found not only in the apical node (1st node beneath the seed-head) and in the penultimate node (2nd node beneath the seed-head), but also in the third node beneath the seed-head--with multiple expulsion cavities observed in many of the plant stems, the first time that this had been documented in the laboratory.




(2) Apical node-elongation levels in all of the 71 plant sample sets were significantly higher (p <0.01) than the overall control level. All three sampled circles disclosed very significant node-length increases, with the plants from the smallest circle showing the greatest node-elongation (+109%). The 5 tables below contain the complete plant data obtained by W.C. Levengood.

Table 1:
**Plant Data - Controls**
Edmonton, Canada Crop Circle
September, 1999

| CONTROL LOCATION | | CONTROL NUMBER | MEAN APICAL NODE LENGTH (%) | EXP. CAVATIES/ SAMPLE SET (APICAL NODES) | NUMBER OF PLANTS PER SET* |
|---|---|---|---|---|---|
| 75' | W | C-1 | 3.22 % | 0 | 9 |
| 100' | W | C-2 | 3.13 % | 0 | 9 |
| 125' | W | C-3 | 2.97 % | 0 | 11 |
| 150' | W | C-4 | 3.18 % | 0 | 10 |
| 175' | W | C-5 | 3.33 % | 0 | 10 |
| 75' | S | C-6 | 2.93 % | 0 | 10 |
| 100' | S | C-7 | 3.09 % | 0 | 10 |
| 125' | S | C-8 | 3.44 % | 0 | 10 |
| 150' | S | C-9 | 3.44 % | 0 | 10 |
| 175' | S | C-10 | 3.72 % | 0 | 10 |
| 200' | S | C-11 | 4.91 % | 0 | 10 |
| 75' | SE | C-12 | 3.72 % | 0 | 10 |
| 100' | SE | C-13 | 3.34 % | 0 | 10 |
| 125' | SE | C-14 | 3.32 % | 0 | 10 |
| 150' | SE | C-15 | 2.97 % | 0 | 10 |
| 175' | SE | C-16 | 2.73 % | 0 | 11 |
| 90' | NW | C-17 | 3.21 % | 0 | 10 |
| 115' | NW | C-18 | 3.05 % | 0 | 11 |
| 140' | NW | C-19 | 3.35 % | 0 | 10 |
| 165' | NW | C-20 | 3.44 % | 0 | 10 |
| 190' | NW | C-21 | 3.23 % | 0 | 10 |
| 215' | NW | C-22 | 3.92 % | 0 | 10 |
| 240' | NW | C-23 | 3.71 % | 0 | 8 |
| 265' | NW | C-24 | - | - | - |

*Notes:

(1) Number of plants/set in this chart reflects the number of plants which arrived at the laboratory fully intact and, thus, usable for the study.

(2) No plant data was presented for Control #24 (C-24).

Table 2:
**Plant Data - Samples, Circle "C"**
Edmonton, Canada Crop Circle
September, 1999

| SAMPLE # | MEAN APICAL NODE LENGTH (%) | EXP. CAVITIES/ SAMPLE SET (Apical Nodes Only) | NUMBER PLANTS/SET |
|---|---|---|---|
| [Circle "C," 100' diameter center circle] | | | |
| S-1 | 4.51 % | 3 | 8 |
| S-2 | 5.54 % | 0 | 11 |
| S-3 | 5.92 % | 4 | 9 |
| S-4 | 5.20 % | 5 | 9 |
| S-5 | 6.19 % | 2 | 10 |
| S-6 | 5.62 % | 3 | 10 |
| S-7 | 5.51 % | 2 | 9 |
| S-8 | 7.56 % | 0 | 7 |
| S-9 | 5.89 % | 1 | 9 |
| S-10 | 5.36 % | 1 | 10 |
| S-11 | 4.35 % | 1 | 10 |
| S-12 | 4.84 % | 4 | 10 |
| S-13 | 5.04 % | 6 | 10 |
| S-14 | 4.92 % | 3 | 10 |
| S-15 | 6.46 % | 3 | 10 |
| S-16 | 5.71 % | 1 | 11 |
| S-17 | 5.34 % | 0 | 8 |
| S-18 | 5.15 % | 2 | 10 |
| S-19 | 5.34 % | 0 | 9 |
| S-20 | 6.98 % | 1 | 10 |
| S-21 | 4.61 % | 2 | 9 |
| S-22 | 5.86 % | 0 | 12 |
| S-23 | 5.34 % | 3 | 10 |
| S-24 | 4.89 % | 0 | 10 |
| S-25 | 5.83 % | 0 | 10 |
| S-26 | 6.60 % | 0 | 11 |
| S-27 | 6.81 % | 0 | 10 |
| S-28 | 5.62 % | 4 | 10 |
| S-29 | 4.70 % | 1 | 10 |
| S-30 | 5.86 % | 0 | 10 |
| S-31 | 5.28 % | 0 | 9 |
| S-32 | 6.06 % | 4 | 10 |
| S-33 | 6.44 % | 4 | 12 |
| S-34 | 6.26 % | 7 | 8 |
| S-35 | 4.97 % | 4 | 10 |
| S-36 | 4.91 % | 1 | 7 |
| S-37 | 7.17 % | 2 | 9 |
| S-38 | 4.58 % | 4 | 10 |
| S-39 | 4.59 % | 0 | 9 |
| S-40 | 4.93 % | 0 | 10 |
| "C"-Center | 5.50 % | 1 | 9 |

Table 3:
**Plant Data - Samples, Circle "B"**
Edmonton, Canada Crop Circle
September, 1999

| SAMPLE # | MEAN APICAL NODE LENGTH (%) | EXP. CAVITIES/ SAMPLE SET (Apical Nodes Only) | NUMBER PLANTS/SET |
|---|---|---|---|
| [Circle "B," 36' - diameter NW circle] | | | |
| S-41 | 5.77 % | 0 | 9 |
| S-42 | 6.90 % | 0 | 9 |
| S-43 | 6.92 % | 0 | 9 |
| S-44 | 6.14 % | 0 | 10 |
| S-45 | 4.93 % | 3 | 11 |
| S-46 | 5.47 % | 3 | 7 |
| S-47 | 5.09 % | 5 | 10 |
| S-48 | 6.38 % | 0 | 12 |
| S-49 | 5.88 % | 2 | 10 |
| S-50 | 5.96 % | 3 | 10 |
| S-51 | 4.43 % | 0 | 11 |
| S-52 | 5.98 % | 4 | 10 |
| S-53 | 5.96 % | 2 | 10 |
| S-54 | 5.92 % | 2 | 10 |
| S-55 | 5.64 % | 0 | 11 |
| S-56 | 6.45 % | 0 | 10 |
| S-57 | 3.40 % | 10 | 10 |
| S-58 | 4.95 % | 5 | 11 |
| S-59 | 6.45 % | 2 | 10 |
| S-60 | 5.30 % | 3 | 9 |
| S-61 | 6.04 % | 2 | 9 |
| S-62 | 6.52 % | 4 | 8 |
| S-63 | 4.87 % | 0 | 10 |

Table 4:
**Plant Data - Samples, Circle "A"**
Edmonton, Canada Crop Circle
September, 1999

| SAMPLE # | MEAN APICAL NODE LENGTH (%) | EXP. CAVITIES/ SAMPLE SET (Apical Nodes Only) | NUMBER PLANTS/SET |
|---|---|---|---|
| [Circle "A," 19'-diameter NW circle] | | | |
| S-64 | 7.08 % | 2 | 11 |
| S-65 | 6.74 % | 2 | 9 |
| S-66 | 6.94 % | 2 | 10 |
| S-67 | 6.71 % | 3 | 11 |
| S-68 | 7.62 % | 0 | 9 |

Table 5:
**Plant Data - Samples, Randomly Downed Area**
Edmonton, Canada Crop Circle
September, 1999

| SAMPLE # | MEAN APICAL NODE LENGTH (%) | EXP. CAVITIES/ SAMPLE SET (Apical Nodes Only) | NUMBER PLANTS/SET |
|---|---|---|---|
| R-1 | 4.77 % | 1 | 9 |
| R-2 | 5.12 % | 3 | 9 |

## X-RAY DIFFRACTION ANALYSIS:

Dr. Sampath S.Iyengar, a geochemist/minerologist and X-ray diffraction and materials science specialist, carried out the clay mineral extractions and X-ray diffraction (XRD) analysis at his analytical materials laboratory (Technology of Materials) in San Diego, California (now located in Wildomar, CA). Dr. Iyengar was recommended by a colleague because of his acknowedged expertise in the XRD technique; it was a further bonus that he was also totally unacquainted with the crop circle phenomenon or any of the controversy surrounding it, thus further protecting this analysis from any experimenter bias.

XRD is regularly used to evaluate degree of crystallinity in specific clay minerals. As x-rays are refracted from the sample mounts printed graphs are produced with multiple peaks which represent specific clay minerals--it is the width of these peaks, at half-height, which produces the value known as the Kubler Index (KI), a known indicator of degree of crystallinity in the sample. As the width of the peak narrows, the KI value decreases.

Decreases in KI are indicative of increased crystallinity and, when this change is subtle, large number of samples are required to prove that the change is statistically significant--and therefore meaningful. Illite/smectites (because they are the most expandable of clay minerals and therefore thought to be the most likely to provide evidence of having been exposed to heat), and specifically the mica 001 peaks, were examined.

Dr. Iyengar' s full report follows below.

**Introduction:**
Eighty-five soil samples were received at the laboratory for complete mineralogical work. Clay fraction in these soils was analyzed by X-ray diffraction (XRD). The following report summarizes the findings:

**Materials and Methods:**
Soil and control samples listed in Tables 1-4 were received for analysis:

*X-ray analysis (XRD):*
*Clay analysis*:
The samples were gently ground to break up the aggregates, and were suspended and shaken in distilled water to promote dispersion. The time required to separate < 2 um fraction was calculated from the Stocks law and the suspension was allowed to stand for appropriate time. The supernatant (with colloids) solution was decanted into a separate beaker. The process of adding water and settling was continued till the supernatant became clear.

A portion of the clay suspension in the beaker was used to make oriented clay mounts on a Millipore filter. The suspensions were filtered through a 45 um filter paper on a Millipore filter set-up using vacuum. They were then washed thoroughly with distilled water to remove excess salts. The clay cake on the filter paper was transferred, while still wet, onto a glass slide and kept in an ethylene glycol chamber for 24 hours. A drop of glycol was placed on the edge of each slide before placing them in the chamber. For heat treatment, the oriented slides were heated at 95 C in an oven for 12 hours.

Oriented and glycolated clay mounts were scanned from 2 to 30 degrees two theta using a Scintag X-ray diffractometer and were scanned from 2 to 50 degrees two-theta using Cu K-alpha radiation at 45 kV and 35 ma.

## Results and Discussion:

Clay analysis by X-ray Diffraction:

X-ray diffraction (XRD) is a crystal structure analysis method using the atomic arrays within the crystals as a three-dimensional diffraction grating to diffract a monochromatic beam of x-rays. The angles at which the beam is diffracted are used to calculate the interplanar atomic spacings (d-spacings) giving information about how the atoms are arranged within the crystalline compounds. These patterns are compared to over 65000 data entries in the International Powder Diffraction File (PDF) database. By this method, identification of the crystalline compounds and minerals, even in a complex sample, can be made.

X-ray patterns of oriented (glycolated) clay fractions for all soil samples are shown in attached Figures. Appropriate peak positions for various minerals are marked. The clay fraction (<2 um) contains predominant amounts of **smectite (an expandable clay), mica/illite**, **kaolinite** and accessory minerals such as **quartz, feldspar** and **amphibole**. The peaks responsible for these minerals are marked. Two scans were made on clay fraction from each sample. They are room temperature (RT) and glycolated (Gly) samples

**Clay minerals** are fine-grained (< 0.002 or 0.005 mm) hydrous aluminum silicate phyllosilicate minerals with a layered structure. They consist of sheets of $SiO_2$ tetrahedra linked to sheets of Al or Mg octohedra forming a layer. When the ratio of silica tetrahedra to Al or Mg octohedra is 1 : 1, it forms **kaolin** group of minerals; when the ratio is 2 : 1, one octohedra sandwiched between two sheets of silica tetrahedra, it forms **mica** (mica/illite), **smectite**, **vermiculite** or **chlorite**. The space between layers is called interlayer space. **Smectite group of minerals (includes montmorillonite)** are expandable *clay minerals* with Ca, Mg, Na, etc. in the interlayer region. Water molecules surround these ions. They expand upon intercalation with water or organic compounds such as ethylene glycol and glycerol. They are sensitive to heat and lose water when heated. They have large surface area and are highly reactive. **Mica/Illite** is a non-expandable mineral (with K ion in the interlayer space holding the layers together) and is slightly reactive. **Vermiculite** is a non-expandable mineral with Mg ions (with water) or islands of partially developed hydroxy-Al polymers in the inter-layer region. They also have a large surface area and are highly reactive. **Chlorite** is a non-expandable mineral with a fully developed brucite ($Mg(OH)_2$) in-between the layers, preventing any separation. They are moderately reactive.

**Kubler Index** for all the samples from **Edmonton crop circle** is tabulated in Tables 1-4.

The following comments describe some of the other minerals that are present in these soils.

**Quartz** is usually the major constituent of most rocks and sediments, and is one of the common crystalline forms of silicon dioxide ($SiO_2$). This is a fairly *hard and non-reactive mineral*. **Cristobalite** is another form of $SiO_2$

**Feldspar** is a group name for a large number of aluminum silicate minerals of variable composition. The general formula is **X** $Al(Al,Si)Si_2O_8$, where **X** may be Na, K, Ca or Ba. The most common mineral names mentioned from this group include K-feldspars (orthoclase, adularia, microcline) and plagioclase (Na-Ca) feldspars (albite, anorthite). They are major constituents of most rocks and sediments. These minerals *are softer than quartz and slightly reactive.*

**Amphibole** is a chain silicate with a formula $A_{2\text{-}3}\ B_5(Si_\cdot Al_4)O_{11}(OH)_2$, where A is mainly Mg, Fe, Ca and Na; B is mainly Mg, $Fe^{2+}$, Al and $Fe^{3+}$

Table 1: Kubler (KI) Index or Full Width Half Maxima (FWHM) of Illite/mica (~10 A) peak in "Control" Samples

| Sample # | RT | Glycolated |
|---|---|---|
| C-1 | 0.18 | 0.18 |
| C-2 | 0.17 | 0.18 |
| C-3 | 0.18 | 0.16 |
| C-4 | 0.16 | 0.19 |
| C-5 | 0.16 | 0.20 |
| C-6 | 0.10 | 0.16 |
| C-7 | 0.16 | 0.14 |
| C-8 | 0.19 | 0.20 |
| C-9 | 0.22 | 0.20 |
| C-10 | 0.21 | 0.22 |
| C-11 | 0.18 | 0.20 |
| C-12 | 0.27 | 0.26 |
| C-13 | 0.23 | 0.24 |
| C-14 | 0.19 | 0.20 |
| C-15 | 0.24 | 0.20 |
| C-16 | 0.25 | 0.40 |
| C-18 | 0.20 | 0.20 |
| C-19 | 0.29 | 0.20 |
| C-20 | 0.17 | 0.22 |
| C-21 | 0.18 | 0.22 |
| C-22 | 0.15 | 0.16 |
| C-23 | 0.22 | 0.16 |

Table 2: Kubler (KI) Index or Full Width Half Maxima (FWHM) of Illite/mica (~10 A) peak in Circle "A"

| Sample # | RT | Glycolated |
|---|---|---|
| S-64 | 0.12 | 0.20 |
| S-65 | 0.13 | 0.21 |
| S-67 | 0.15 | 0.19 |
| R-2 | 0.14 | 0.11 |

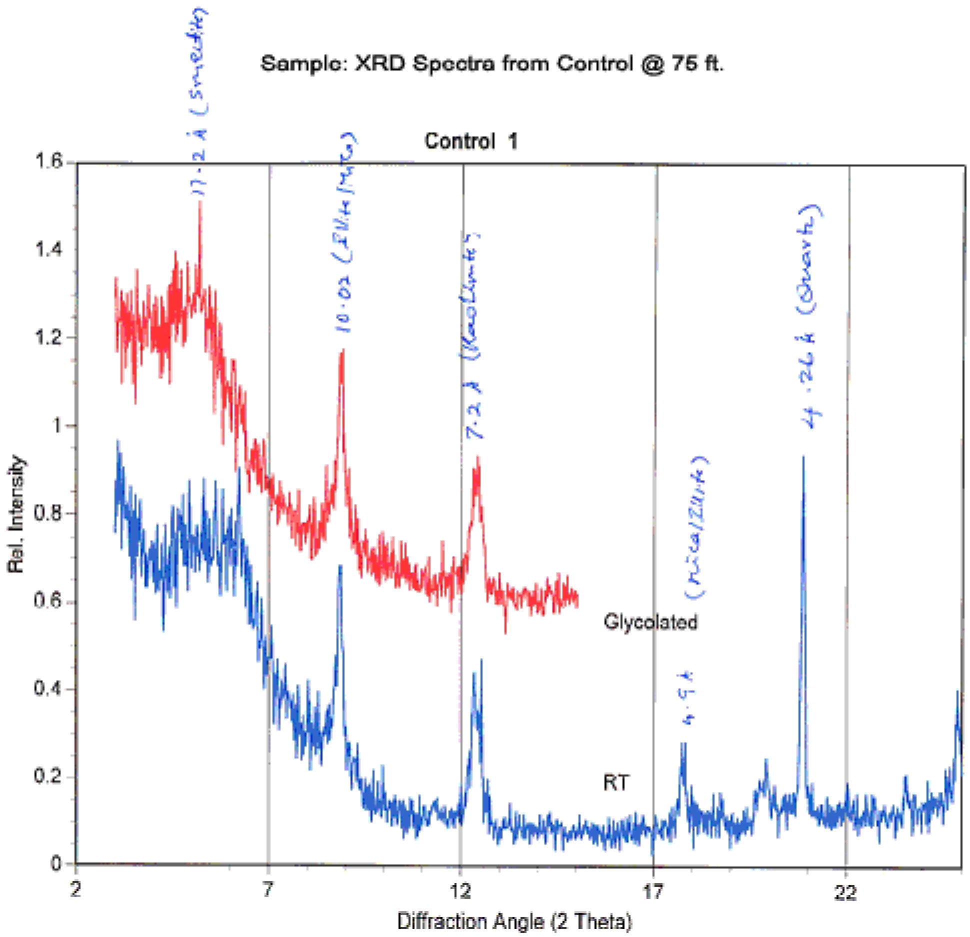
Table 3: Kubler (KI) Index or Full Width Half Maxima (FWHM) of Illite/mica (~10 A) peak in Circle "B"

| Sample # | RT | Glycolated |
|---|---|---|
| S-41 | 0.30 | 0.20 |
| S-44 | 0.17 | 0.22 |
| S-45 | 0.14 | 0.17 |
| S-46 | 0.14 | 0.18 |
| S-47 | 0.13 | 0.14 |
| S-49 | 0.17 | 0.18 |
| S-50 | 0.17 | 0.14 |
| S-51 | 0.23 | 0.23 |
| S-52 | 0.15 | 0.16 |
| S-53 | 0.12 | 0.14 |
| S-54 | 0.17 | 0.22 |
| S-55 | 0.17 | 0.20 |
| S-56 | 0.20 | 0.22 |
| S-57 | 0.17 | 0.17 |
| S-58 | 0.17 | 0.15 |
| S-59 | 0.19 | 0.23 |
| S-60 | 0.19 | 0.38 |
| S-61 | 0.17 | 0.23 |
| S-62 | 0.13 | 0.27 |
| S-63 | 0.15 | 0.13 |

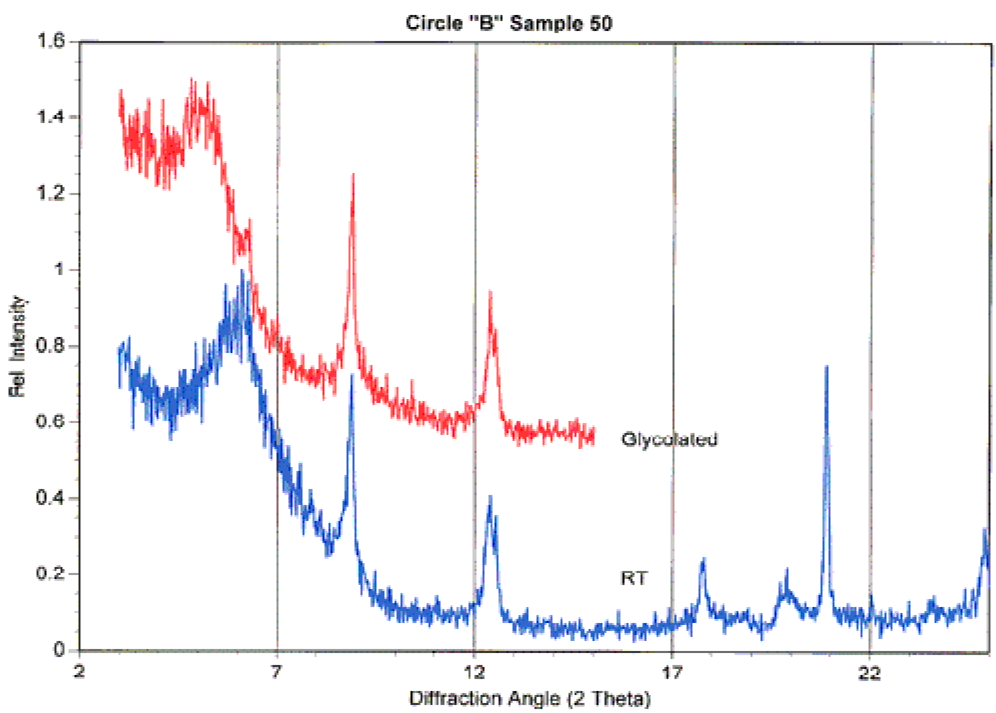
**Table 4: Kubler (KI) Index or Full Width Half Maxima (FWHM) of Illite/mica (~10 A) peak in Circle "C"**

| Sample # | RT | Glycolated |
|---|---|---|
| S-1 | 0.25 | 0.18 |
| S-2 | 0.17 | 0.16 |
| S-3 | 0.20 | 0.16 |
| S-4 | 0.18 | 0.25 |
| S-5 | 0.13 | 0.25 |
| S-8 | 0.09 | 0.12 |
| S-6 | 0.18 | 0.21 |
| S-7 | 0.25 | 0.25 |
| S-9 | 0.22 | 0.20 |
| S-10 | 0.18 | 0.19 |
| S-11 | 0.18 | 0.13 |
| S-12 | 0.15 | 0.11 |
| S-13 | 0.13 | 0.18 |
| S-14 | 0.14 | 0.11 |
| S-15 | 0.15 | 0.15 |
| S-16 | 0.14 | 0.17 |
| S-17 | 0.18 | 0.18 |
| S-18 | 0.16 | 0.18 |
| S-19 | 0.20 | 0.14 |
| S-20 | 0.20 | 0.18 |
| S-21 | 0.18 | 0.19 |
| S-23 | 0.17 | 0.15 |
| S-24 | 0.18 | 0.23 |
| S-25 | 0.19 | 0.18 |
| S-26 | 0.11 | 0.16 |
| S-28 | 0.22 | 0.15 |
| S-29 | 0.21 | 0.21 |
| S-30 | 0.14 | 0.14 |
| S-31 | 0.23 | 0.19 |
| S-32 | 0.16 | 0.18 |
| S-33 | 0.21 | 0.22 |
| S-34 | 0.17 | 0.13 |
| S-35 | 0.19 | 0.20 |
| S-36 | 0.18 | 0.18 |
| S-37 | 0.20 | 0.17 |
| S-38 | 0.13 | 0.13 |
| S-39 | 0.15 | 0.19 |
| S-40 | 0.21 | 0.22 |
| Circle "C" Center | 0.22 | 0.18 |

**Sample: XRD Spectra from Control @ 75 ft.**




**Sample: XRD Spectra from Sample #50**



## STATISTICAL ANALYSIS:

Upon completion of the XRD work the Kubler Index (KI) data was submitted to Ohio statistician, Dr. Ravi Raghavan for analysis. Dr. Raghavan' s first objective was to establish whether there were differences in the KI values between the Edmonton soil samples and controls and, if there were, to determine whether these differences were statistically significant.

As stated at the beginning of this report ("Study Results"), a sharpening of the mica 001 peak (a decrease in the KI, indicating growth of the illite/mica crystals) was found in the cropcircle soils, as compared with the control soils. Further, this increase was found to be statistically significant at the 95% level of confidence.

Dr. Raghavan was then sent W.C. Levengood' s node-length data and asked whether a correlation existed between the plant node-length increases and increase in soil crystallinity at the same sampling locations. The regression analysis indicates that there is a correlation between Kubler Index and Node Length, at more than the 99% level of confidence.

Dr. Raghavan' s statistical report follows below.

## Statistical Analysis of Edmonton, Canada Crop Circle Data

**Objectives**: (a) to verify if the soil controls and samples have different properties, as determined by the Kubler Index evaluation;

(b) to see if there is a correlation between plant node length and the Kubler Index results.

**Method used to determine differences in Kubler Index between controls and samples**:

A grouped t-test was performed in order to verify whether the Kubler Indices for the samples as a group are significantly different from those of the controls as a group, and the results are given below:

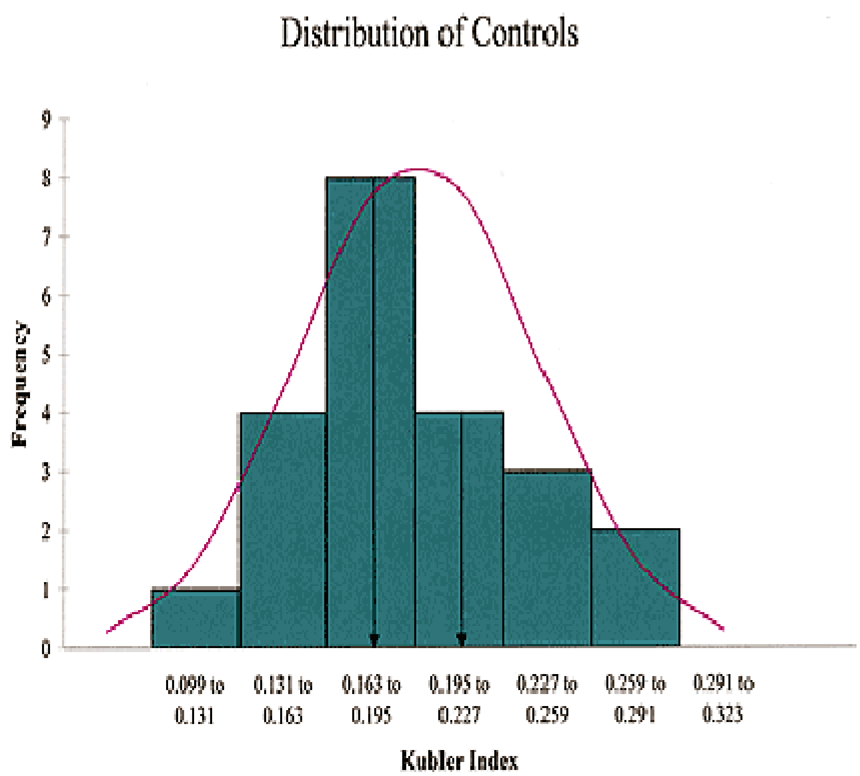
```
Grouped T-test              -   6/2/01  14:02 - File: BLTDATA.STP

Dependent variable: KIRT    (Kubler Index @ Room Temperature)
Grouping variable:  TYPE    (Type 1=Control)

              Mean     Std.Dev.    Minimum    Maximum    N

Controls:   0.1955     0.0433      0.1000     0.2900    22

Samples:    0.1730     0.0377      0.0900     0.3000    63

F-test for equality of variances:
F score: 1.3181 with 21 and 62 df...Two-tail significance=0.3986

Mean of group 1 minus mean of group 2: 0.0224

Pooled variance estimate t-test:
Standard error of difference: 0.0097
t score: 2.3121 with 83 df...Two-tail significance = 0.0210

Separate variance estimate t-test:
Standard error of difference: 0.0104
t score: 2.1619 with 33 df...Two-tail significance = 0.0317

Valid cases: 85  Missing cases: 9
```

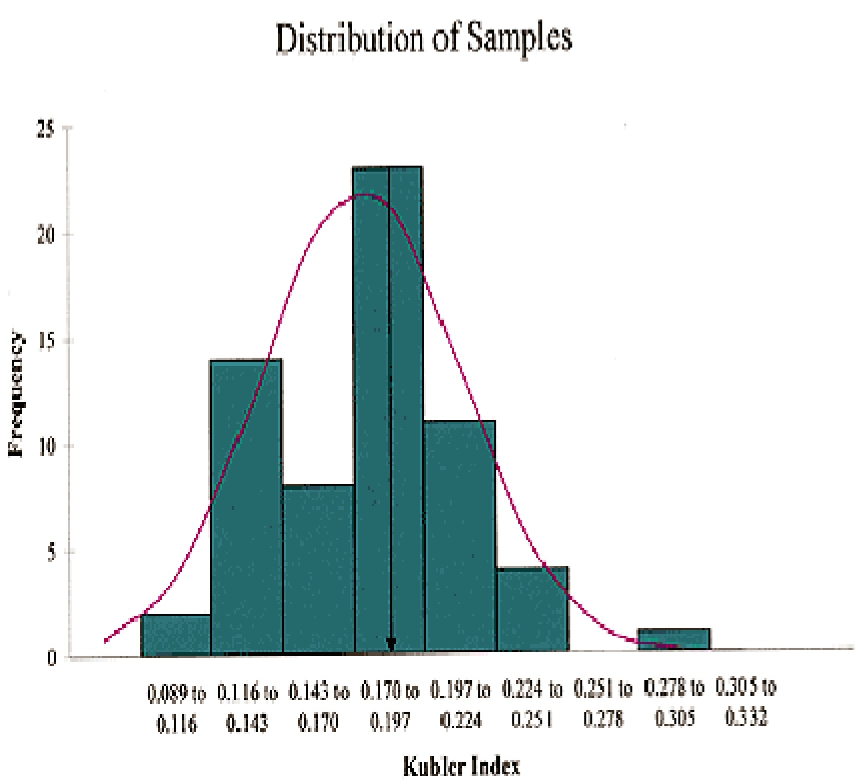
**Analysis:**

Although it appears that there is a significant difference between the controls and the samples (t score two-tail significance < 0.05), one of the requirements of the t-test ( viz., the standard deviations of the two groups should be the same) is not strictly valid here: the F-test for standard deviation has a significance of 0.3986 (a value of 0.05 or less is required). In order to overcome this the non-parametric equivalent of the t-test, the Wilcoxon Rank Sum test, is carried out. The Wilcoxon test requires the assumption that the distributions of samples and controls are similar. Two graphs, attached, show that the distributions <u>are</u> similar (approximately normal), and so this assumption is valid. The results of the Wilcoxon Test are given below:

```
Wilcoxon Rank Sum Test      -  6/2/01  14:03 - File: BLTDATA.STP

Dependent variable: KIRT     (Kubler Index @ Room Temperature)
Grouping variable:  TYPE     (Type 1=Controls,  Not 1=Samples)

Group 1:  TYPE      equals 1  (controls)
   Rank sum = 1167,     n = 22

Group 2:  TYPE      does not equal 1 (samples)
   Rank sum = 2486,     n = 63

Test statistic W=1167, Sig.(two-tail,using Normal approx.)= 0.0266

Valid cases: 85     Missing cases: 9     Cases not selected: 0
```

**This non-parametric analysis shows that there is a statistically-significant difference between the two sets of Kubler Index data (controls and samples) <u>at the 95% level of confidence</u>.**


Distribution of Controls
Frequency
0
1
2
3
4
5
6
7
8
9
0.099 to 0.131
0.131 to 0.163
0.163 to 0.195
0.195 to 0.227
0.227 to 0.259
0.259 to 0.291
0.291 to 0.323
Kubler Index


Distribution of Samples
Frequency
0
5
10
15
20
25
0.089 to 0.116
0.116 to 0.143
0.143 to 0.170
0.170 to 0.197
0.197 to 0.224
0.224 to 0.251
0.251 to 0.278
0.278 to 0.305
0.305 to 0.332
Kubler Index

**Method Used to verify whether there is a correlation between the Kubler Index (soil crystallinity) results and Node Length (plant) changes:**

A regression analysis, with the Kubler Index data as the dependent variable and the Node Length data as the independent variable, was carried out and the results are given below:

Regression Analysis - 5/6/01 10:29 - File: BLTDATA.STP

Dependent variable: KIRT (Kubler Index @ Room Temperature)

Independent variable: NODELEN (Node Length)

| Variable | B | Std.Error | t Score | 2-tail Sig. |
|---|---|---|---|---|
| Intercept | 0.2256 | 0.0180 | 12.5441 | 0.0000 |
| NODELEN | -0.0093 | 0.0035 | -2.6751 | 0.0075 |

Valid cases: 85 Missing cases: 9

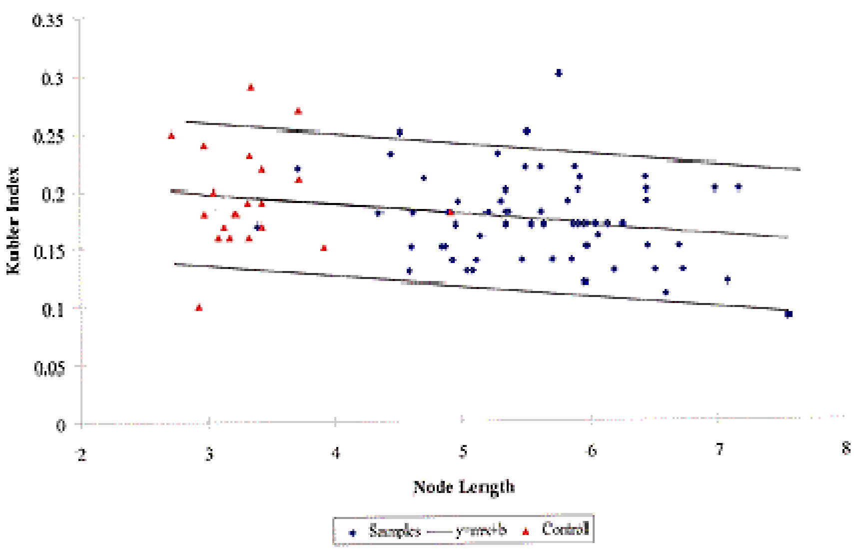
Analysis of Variance

| Source | SS | DF | MS | F | Sig. |
|---|---|---|---|---|---|
| Regression | 0.0108 | 1 | 0.0108 | 7.1563 | 0.0090 |
| Residual | 0.1249 | 83 | 0.0015 | | |
| Totals | 0.1357 | 84 | 0.0016 | | |

R-squared = 0.0794
R-squared adjusted for DF = 0.0683

**Based on the 2-tail significance and the significance of the F-test (analysis of variance), there is a definite correlation between Kubler Index and Node Length <u>at more than the 99% level of confidence</u>. A scatter plot showing the Kubler Index and Node length data and the regression line are attached.**

Regression - Kubler Index vs. Node Length (Controls & Samples)




Ravi Raghavan, Ph. D
Raghavan & Associates, Inc.

## MINERALOGICAL REVIEW:

We were extremely fortunate, at this time, to be able to consult with Dartmouth College geologist/minerologist Robert C.Reynolds, Jr., described by his colleagues as "a brilliant scientist and without any exaggeration ... the best known expert in the world of X-ray diffraction analysis of finely-dispersed layer compounds, and first of all, of clay minerals" (D.M. Moore, "Presentation of the Roebling Medal of the Mineralogical Society of America for 2000 to Robert Coltart Reynolds, Jr., Am. Mineralogist 86:943-45, 2001).

Currently Frederick Hall Professor of Geology and Mineralogy, Emeritus, Dr. Reynolds examined our work and stated that he was

> *"...convinced that the sample preparation methods and the X-ray analytical procedures used were consistent with sound, standard methods of analysis. In short, the data have been obtained by competent personnel using current equipment."*

Reynolds, however, wondered whether the observed sharpening of the mica 001 peak might be caused by the dehydration of inter-stratified smectite layers in the crystals and asked that additional statistical work be carried out to evaluate this possibility. A paired t-test was then conducted, comparing the KIs in both the RT and glycolated conditions, but no significant difference was found with, or without, glycolation, again at the 95% level of confidence. This was true for each of the sampled circles individually and all of the sampled circles combined.

## Supplemental Statistical Analysis of Edmonton, Canada Crop Circle Data

(June, 2001)

**Objective:** To determine whether the Kubler Index differs significantly with and without glycolation.

**Method Used:** A paired t-test was conducted using the data for each of the sampled circles (A, B and C) and for all of them combined, as compared to all controls. The results obtained were further confirmed using the Wilcoxon Rank Sum (nonparametric) test. The results are given below:

### Paired t-test:

```
Variable 1: KIRT       Kubler Index, Room Temperature
Variable 2: KIGL       Kubler Index, Glycolated
```

### Circle A:

| | Mean | Std.Dev. | Minimum | Maximum | N |
|---|---|---|---|---|---|
| KIRT | 0.1350 | 0.0129 | 0.1200 | 0.1500 | |
| KIGL | 0.1775 | 0.0457 | 0.1100 | 0.2100 | |
| Difference | -0.0425 | 0.0519 | -0.0800 | 0.0300 | 4 |

Correlation coefficient:
Pearson's r = -0.3670   One-tail significance = 0.3165

Standard error of mean difference: 0.0259

t score: -1.6384 with 3 df...Two-tail significance = 0.1999

Valid cases: 4   Missing cases: 0

### Circle B:

| | Mean | Std.Dev. | Minimum | Maximum | N |
|---|---|---|---|---|---|
| KIRT | 0.1715 | 0.0400 | 0.1200 | 0.3000 | |
| KIGL | 0.1980 | 0.0578 | 0.1300 | 0.3800 | |
| Difference | -0.0265 | 0.0598 | -0.1900 | 0.1000 | 20 |

Correlation coefficient:
Pearson's r = 0.2947   One-tail significance = 0.1036

Standard error of mean difference: 0.0134

t score: -1.9802 with 19 df...Two-tail significance = 0.0624

Valid cases: 20   Missing cases: 0

Supplemental Statistical Report
p. 2

## Circle C:

| | Mean | Std.Dev. | Minimum | Maximum | N |
|---|---|---|---|---|---|
| KIRT | 0.1777 | 0.0365 | 0.0900 | 0.2500 | |
| KIGL | 0.1769 | 0.0367 | 0.1100 | 0.2500 | |
| Difference | 0.0008 | 0.0396 | -0.1200 | 0.0700 | 39 |

Correlation coefficient:
Pearson's r = 0.4153 One-tail significance = 0.0028

Standard error of mean difference: 0.0063

t score: 0.1214 with 38 df...Two-tail significance = 0.9044

Valid cases: 39 Missing cases: 0

## All Circles:

| | Mean | Std.Dev. | Minimum | Maximum | N |
|---|---|---|---|---|---|
| KIRT | 0.1730 | 0.0377 | 0.0900 | 0.3000 | |
| KIGL | 0.1837 | 0.0453 | 0.1100 | 0.3800 | |
| Difference | -0.0106 | 0.0491 | -0.1900 | 0.1000 | 63 |

Correlation coefficient:
Pearson's r = 0.3091 One-tail significance = 0.0057

Standard error of mean difference: 0.0062

t score: -1.7174 with 62 df...Two-tail significance = 0.0877

Valid cases: 63 Missing cases: 0

## Wilcoxon Rank Sum Test:

## Circle A:

Group 1: Kubler Index Room Temperature
Rank sum = 14, n = 4

Group 2: Kubler Index Glycolated
Rank sum = 22, n = 4

Test statistic W = 14 (Not significant at .10 level, two-tailed)

Valid cases: 8 Missing cases: 0

Circle B:

```
Group 1:  Kubler Index Room Temperature
Rank sum = 347.5000,    n = 20

Group 2:  Kubler Index Glycolated
Rank sum = 472.5000,    n = 20

Test statistic W = 347.5000  Sig. (two-tail, using Normal
                                          approx.) = 0.0909
Valid cases: 40    Missing cases:  0
```

Circle C:

```
Group 1:  Kubler Index Room Temperature
Rank sum = 1560.500,    n = 39

Group 2:  Kubler Index Glycolated
Rank sum = 1520.500,    n = 39

Test statistic W = 1520.500  Sig. (two-tail, using Normal
                                          approx.) = 0.8416
Valid cases: 78    Missing cases:  0
```

All Circles:

```
Group 1:  Kubler Index Room Temperature
Rank sum = 3710,    n =  63

Group 2:  Kubler Index Glycolated
Rank sum = 4291,    n =  63

Test statistic W = 3710  Sig. (two-tail, using Normal
                                      approx.) = 0.1564
Valid cases: 126    Missing cases:  0
```

**Based on the paired t-test, the data show no significant difference in the Kubler Index with, or without, glycolation at the 95% level of confidence. This is true for each of the circles and all circles combined.**

Dr. Ravi Raghavan, Ph.D.
Ravi Raghavan & Associates, Inc.

Following this additional statistical inquiry into the possiblity that loss of interstitial water might account for the subtle sharpening of the mica 001 peak, Reynolds concluded that

> *"The possibility of smectite dehydration seems ruled out by the fact that the data show no systematic increase in peak breadth upon ethylene glycol solvation of the samples."*

Finally, because Diane Conrad' s preliminary work suggested that microwave exposure (the Kubler Index of her control aliquot decreased from 0.25 to 0.07 after having been exposed to microwaves for two minutes) might produce a decrease in the Kubler Index similar to the decrease she observed in the Logan, Utah circle samples, we asked Dr. Iyengar to expose a few of our control samples from the Edmonton formation to microwaves for varying periods of time to see if we could replicate this effect.

Eight controls (C-3, C-9, C-12, C-13, C-15, C-16, C-19 and C-23), for which the KI values were already known, were placed in a commercial microwave oven for one minute, then ten minutes, and then 60 minutes, and their KIs again determined. From the results below it is clear that microwaving produced no consistent or significant change in KI in these Edmonton control samples.

**Kubler Index (KI) or Full Width Half Maxima (FWHM) of Illite/Mica (~10 A) Peak in Microwaved Controls**

| Control # | | RT | 1 Minute | 10 Minutes | 60 Minutes |
|---|---|---|---|---|---|
| C-3 | (0.18) | 0.17 | 0.16 | 0.17 | 0.19 |
| C-9 | (0.22) | 0.23 | 0.17 | 0.23 | 0.27 |
| C-12 | (0.27) | 0.22 | 0.22 | 0.25 | 0.18 |
| C-13 | (0.23) | 0.20 | 0.19 | 0.22 | 0.26 |
| C-15 | (0.24) | 0.25 | 0.21 | 0.18 | 0.23 |
| C-16 | (0.25) | 0.21 | 0.21 | 0.19 | 0.16 |
| C-19 | (0.29) | 0.21 | 0.19 | 0.20 | 0.20 |
| C-23 | (0.22) | 0.21 | 0.20 | 0.20 | 0.18 |

Numbers in parenthesis are previously obtained RT values for these controls.

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ROBERT C. REYNOLDS JR.
*Frederick Hall Professor of Geology and Mineralogy, Emeritus*

The people at BLT Research Team Inc. have made available to me 9 X-ray diffraction mounts that were analyzed for the data base in their study of the crop circle in Edmonton, Alberta. I have their report on this study which contains X-ray diffraction patterns from these slides as well as peak width data on the mica 001 reflection from each of them.

After analysis of these samples in my laboratory, I am convinced that the sample preparation methods and the X-ray analytical procedures used were consistent with sound, standard methods of analysis. In short, the data have been obtained by competent personnel using current equipment. But this brings up the question of the meaning of their results.

A sharpening of the mica 001 peak could be caused by the dehydration of interstratified smectite layers in the crystals. Alternatively, crystal growth of the mica crystals would cause decreases in peak breadth. The possibility of smectite dehydration seems ruled out by the fact that the data show no systematic increase in peak breadth upon ethylene glycol solvation of the samples. The possibility of crystal growth seems remote. Temperatures of 600-800°C are required in the laboratory for such growth, and these conditions would have incinerated any plant material present. In short, I believe that our present knowledge provides no explanation for the observed decrease in peak breadth with respect to proximity to the center of the crop circle.

Sincerely,

R.C.Reynolds.

## DISCUSSION:

The study reported here examined both the barley plants *(Hordeum vulgare)* and specific clay minerals (illites/smectites) extracted from surface soils at a 1999 Edmonton, Alberta, Canada 7-circle crop formation. Both plant and soil samples were taken at each of 69 sampling locations within three of the circles (plus two additonal "samples" taken from a randomly-downed area outside the main formation), and at 24 control locations 75-265' away from the flattened edges of the formation.

In the plants, statistically significant ($p < 0.01$) apical node-length increases were found in **all** of the 71 plant sample sets, compared with the mean of the controls. Additionally, 68% of the plant samples contained expulsion cavities in one or several plant stem nodes in each plant, while none were found in the controls. Based on previous research (see "Published Papers"), microwave radiation has been proposed as a possible causative mechanism for the plant stem changes found in this case, and also consistently in many other cases around the world over the last 10-12 years.

Clay minerals (illite/smectites) extracted from surface soils taken at the same sampling locations as the plants, were submitted to X-ray diffraction analysis, resulting in Kubler Index values for both the room temperature (RT) and glycolated condtions. Analysis of the XRD results shows a subtle, but statistically significant (at the 95% level of confidence), sharpening of the mica 001 peak in the circle samples, suggesting crystal growth.

Dr. Reynolds, a world authority in clay minerology, raised the question as to whether this sharpening of the mica 001 peak might have been caused by the dehydration of interstratified smectite layers in the crystals. In response to this possibility, a paired t-test comparing the room temperature (RT) condition to the glycolated condition was conducted, but smectite dehydration seems to be ruled out by the fact that the data show no systematic increase in peak breadth upon ethylene glycol solvation of the samples (again, at the 95% level of confidence).

In Reynold' s words, "the possiblity of crystal growth seems remote." The degree of pressure known to be involved in causing crystal growth in sedimentary deposits would have, had it been present, completely obliterated the plants. And the 600-800ºC temperatures, over a period several hours, known to be necessary to promote such crystal growth in the laboratory would have, in the crop circle field, incinerated any plant material present. Additionally, the very brief bursts of possibly intense microwave radiation thought to be the cause of node-elongation and the creation of expulsion cavities (through heating and expansion of internal stem moisture) could not account for crystal growth.

And yet statistical analysis reveals **both** a subtle decrease in the KI of circle samples as compared to controls, and a **definite** correlation between the KI and Node Length data -- **at more than the 99% level of confidence.** It seems evident that whatever caused the decreased KI (increased cyrstal growth) in the clay minerals in the soils was also responsible for the plant abnormalities.

Our present knowledge provides no explanation for these results. It is unlikely that an atmospheric plasma vortex system could account for the changes observed in the clay minerals. The data, however, rule out direct mechanical flattening of the cropcircle plants by human beings utilizing planks or boards as an explanation for this event. Control studies carried out by BLT over the last several years have shown that significant node-length increase and expulsion cavities do not occur in crop flattened by boards or planks, human feet or cement rollers, or to crop which has been 100% over-fertilized. And, since either geologic pressure and/or intense heat is required to cause decrease in KI of the clay minerals--and neither can be produced by planks, boards, cement rollers, feet, etc.--this, or a similar mechanical mechanism, must be ruled out. It is our intent to carry out additional plant and soil research in an attempt to replicate the results of this XRD study, if funding can be obtained.

It should be mentioned that the farmer/owner of the field and his wife, as well as an unrelated individual, reported dramatic aerial light phenomena in the immediate area of this crop field around the time the formation was discovered, as well as the fact that cell phone failure was observed during sampling inside the formation. Reports of similar events at other cropcircle sites around the world are increasingly common. Whether these incidents are relevant is not known, but it is our opinion that they should not be dismissed without investigation if further scientific study cannot provide an adequate explanation for the data.

## STUDY PERSONNEL:

**MIKE & JUDY ARNDT** .......................................... BLT Inc. Field-Team

**DIANE L. CONRAD** .................................................. Geologist
*M.S. in Geological Sciences and Clay Chemistry,*
*State Univeristy of New York (SUNY)*
[thesis: "Heat Effects on Clay Minerals"]

**DR. SAMPATH S. IYENGAR** .................. Geochemist/Minerologist
*Ph.D in Materials Chemistry/Minerology, VA Tech*
*M.S. in Soil Physical Chemistry, VA Tech*
X-ray diffraction (XRD) and materials science specialist.
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**WILLIAM C. LEVENGOOD** ..................................... Biophysicist
*M.S in Biophysics, University of Michigan*
*M.A. in Bioscience, Ball State University*
Has published three peer-reviewed papers (1994; 1995; 1999) on plant/soil abnormalities found in crop circles.
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**DR. RAVI RAGHAVAN** ............................ Chemical Engineer/Statistician
*Ph.D in Chemical Engineering, Purdue University*
Specialist in mathematical modeling and computer simulation of processes.
President of Raghavan & Associates, Inc., Cleveland

**DR. ROBERT C. REYNOLDS, JR** .............. Geologist/Clay Minerologist
*Ph.D in Geology, Washington University*
Roebling Medal Recipient (Mineralogical Society of America, 2000)
Frederick Hall Professor of Geology and Minerology,
*Emeritus,* Dartmouth College, Hanover, NH

**NANCY P. TALBOTT** ......................................... Study Director
Has co-authored one peer-reviewed paper (1999) on energy dispersion in crop circle plants. President, BLT Research Team Inc., Cambridge, MA