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Modeling and Simulation of Geo-Thermal Electricity to Probe the Volcano-Seismic Prediction

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ABSTRACT

Model of the earth was constructed and magma chamber was created in outer core-mantel region. A spherical magnet is put in the centre. Sealing sticks was put fully in a deep stele cup and it was layered by clay soil paste for making magma chamber, then, it was rounded up electric heater coils, dipped into clay soil layering, and terminals were connected to the power plug. A junction of thermocouple wires of copper and nickel coated iron was put at distance of about 1.0 cm of magma chamber. Globe was fully filled making mantel with lithosphere and upper most hydrosphere and model was made fully dry. Another junction of thermocouple wire was dipped fully in ice bath. Volcano was created by heating magma chamber and produced geo thermo electric current was measured with micro ammeter. Thermoelectric current of earth was increasing with the time and then remained stable. The ratio and proportion and scope of the study had been discussed.

1. INTRODUCTION

Reda et al. [1] constructed a dynamic model to study seismic faults applying magnetically coupled coils to simulate the behavior of eccentricity faults in induction motor. They used indirect field oriented control (IFOC) fuzzy logic based controller to ensure the robust speed regulation and to compensate the fault effects. Zhang et al. [2] studied the fault depression basin having abundant petroleum resources and they identified eleven third-order seismic sequence boundaries in Wenchang. They described the formation of fault-depression period and Enping formation of fault-sag period and 10 third-order sequences of type- I are divided based on the seismic data.

The maximum depth of root of high tree is 200m [3]. While, tectonic seism and volcano activities happen at depth of 20 km. This gave me an idea in the modeling of seismic prediction to be applied supper conductor wires for so sensitive study, not the most resistant roots of tree [4, 5]. Since there are affinities between volcano and seismicity [6], geo-thermo-electric probe would be more predictive.

Study on volcanic prediction technology is divided in to four parts.

1.1 Thermal imaging geological topography

An earth scope technology is available having USARRAY, a magneto telluric array, the plate boundary observatory and San-Andrea's fault observatory [7, 8] These technologies need to develop for the magma observatory and volcano fault to be seen on screen. Studies are going for modeling and simulation of geo-electric, geomagnetic, gaseous measure, wave's measure, seismic parameters record of earth changes during volcano-seismic times and to estimate earth's internal structure [9-11]. Abrams et al. [12] studied a thermal imaging INSAT to land surface topography. They assume data relating to thermal properties during separation of rock [13]. Kimberly [14] dealt with magnetic and gravitational data and chemo physics of rocks and minerals to estimate earth's internal structure in her study. Simmons [15] stated that there is a gradual change in temperature and pressure with the depth of earth, while she studying differences between the upper and lower mantel.

The structure of deep earth is studied deeply [16, 17] and internal structure is shown by mirageoscience.com, so clearly that coal, petroleum, and minerals mining companies apply accurately [18]. Mirageoscience provides software and engineering for the implementation of geological data [19]. Deborah Byrd provides X-ray of earth by her space science technology and now internal structure could be known exactly [20].

1.2 Fine deep drilling technology

Jakkula et al. [21] studied an improvement of overall equipment performance of underground mining machines. Bram et al. [22] have deep drilling company at *Windischenbach* in Germany, entitled as "The KTB Borehole – Germany". Now it is called as Geo - Forschungs - Zentrum (GFZ Germany). They have fine deep drilling technology applied by petroleum companies. They have super deep telescope into earth's crust and they drill deep up to 10 Km proving with information of the temperature and passing earth profiles images. Temperature profile is recorded in KTB–HB technology and the geological temperature is estimated for 'Bore Hole Temp. Profiles. The estimated 'Bottom Hole Temp' (BHT) is found in between 260°C and 270°C, at 9.10 Km in deep earth. They have done drilling up to maximum depth of 12.26 Km [23].

1.3 Super conductor high temperature thermo couple wires

Meklid et al. [24] studied lead zirconate titanate (PZT) based ceramic materials have been largely used for piezoelectric applications due to their excellent potential properties especially at the morphotropic phase boundary (MPB). International Business Machines Corporation (IBM) is an American multinational information technology company in Armonk, New York. USA. From where, noble laureates Bednorz and Müller [25] discovered high-temperature super conductors (high - T_c or HTS) superconductivity in ceramic materials [26]. Superconductors cannot be penetrated by magnetic flux lines due to Meissner–Ochsenfeld effect. Elementary superconductors, such as aluminum and lead are typical Type-I superconductors. [27] This type of superconductivity is normally exhibited by pure metals, e.g. aluminum and lead [28]. High temperature superconductors are potentially of great practical importance. Superconducting cable is expected as one of the solutions for the shortage of transmission capacity. It's merits are: - 1-Large transmission capacity. 2- Small transmission loss. 3- No leakage of electro-magnetic field to the outside of the cable, and 4- Small impedance. Omega.com supplies high temperature thermocouple [29].

1.4 Liquid nitrogen observatory establishment

Liquid nitrogen is an extremely low temperature, colorless clear liquid with a density of 0.807 g/ml at its boiling point (−195.79°C (77 K; −320 °F)) and a dielectric constant of 1.43. Nitrogen was first liquefied at the Jagiellonian University on 15 April 1883 by Polish physicists, Zygmunt Wróblewski and Karol Olszewski [30] Suzhou Xinglu Air Separation Plant is developed by Science and Development Co. Ltd (China) focused on the research and development, design and manufacture of cryogenic technical field. It is a natural gas purifier plant at Chengbo Road, Xiancheng district Suzhou, China. Liquid nitrogen could be component of cooling bath used for very low temperature to create a thermal gradient for generation of geo thermoelectric current. A liquid nitrogen storage tank must be permanent and strong structure, since the liquid nitrogen expansion ratio is 1:694 at 20°C. A tremendous amount of force can be generated if liquid nitrogen is rapidly vaporized in an enclosed space [26, 27].

Since, during volcanic activity nearer to the tectonic plates, temperature increases prior to volcanic eruption, in the form of an enthalpy of volcanic drum beat, gas emission, seismicity, and piezoelectric effect. An increased temperature shall increase geo-thermo-electricity in the proportion of the temperature gradient. Therefore one junction of thermocouple super conductor wires is recommended to be dipped in liquid nitrogen bathing medium and another junction in deep volcanic region inside earth. Prototype observation was done by copper and Ni coated iron conductor wires as a thermocouple and temperature gradient was made by a lamp flame /hot water and ice and finally with model's magma and ice.

Objective of the study is to construct a model to simulate volcanic prediction by an increase of geothermal electric current to be observed by super sensitive nanoammeter, micro-volt-meter, or galvanometer. In this study, there was experimental measure with micro ammeter.

2. METHODOLOGY

2.1 Thermoelectric experimentation

Seeback effect (1821) was tested with experimentation at lab. Thermoelectric current was produced by using copper and iron couple conductor wires with heating a junction and cooling another junction. One thermocouple junction put on flam of a candle, and another into an ice-glass. Figure 1 represents thermoelectric effect observation. Before experiment its micro ampere was adjusted zero. When another junction was put in candle's flame thermoelectric current 40 µA current was observed. It was reconfirmed temperature gradient by hot water rather than flam. The heating junction was dipped fully in to boiled water in a stele pot at 80°C. Figure 2 represents the experimentation and the generated thermoelectric current was 50.00µA, which decrease gradually with the cooling was water of heating junction and about 10.00 µA current remains due to room temp. 20°C.

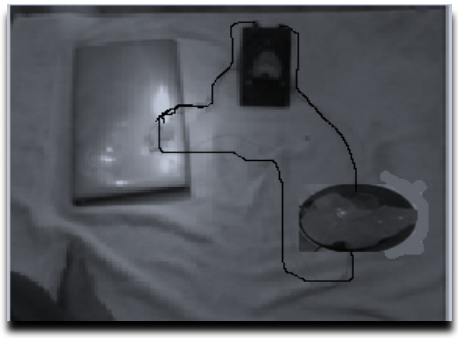


Figure 1. Seeback effect on flame

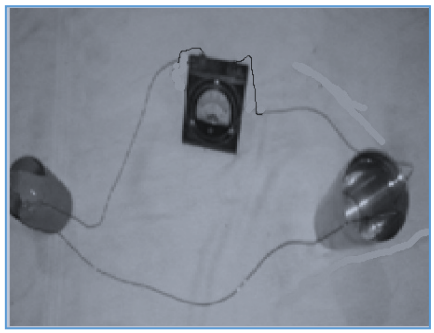


Figure 2. Seeback effect on hot water

2.2 Construction of model

All requirements were arranged, Basket ball was taken from Game Dept. "Nivia moisten India" Model No. 107-91BS. Grit from railway site and compact soil from road filling site, and all required material were collected from local sources. A model of the earth was constructed using a basket ball, spherical magnet, glycerin, grits, compact soil, common soil, NaCl solution, water, polythene packets, children's balloons, electric heaters wires etc.

The spherical projections of the structure of the earth presented by Peter [16] and concentric layers of the earth by Christopher and Armstead [17], were kept in mind to modify previous earth model [3]. Modifications were made with consideration of geodetic data from Clarks Table of science data book [28].

The basket ball having diameter of 23.6 cm and volume of 6881 ml^3, was bifurcated up to quarter depth *i.e.* 05.5 cm. vertically using fine Shaw blade. Again, at the same place, it was bifurcated vertically on different axis till the same depth. The cut four foldings were opened outside as a rising of lotus flower making a large gap in the centre, through which, cherished materials inside the ball could be put (Figure 3).

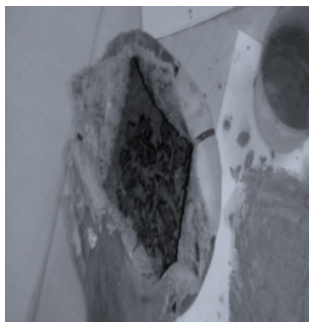


Figure 3. Construction of model

2.3 Filling of earths model

Compact soil was made paste and made an inner layer of basket ball.

Grits were shown in a layer on compact soil and fixed by soft hand pressing and left to dry for 24 hrs in room temp. 20°C and fan was made 'on'.

Inner layer of ball was made a sands layer of about two cm to make grits covered and again made a layer of grits which were further covered by a past of compact soil. Then it was again left to dry for 24 hrs in room temp 20°C and fan 'on'.

The bottom of globes model was checked to have a furrow (pressed inner, therefore it was mad round by putting in an empty pot.

Inner surface of half filled model was made possible concave smooth surface with sand filling.

2.4 Geomagnetism

Figure4 represents magnetic measurement of applied magnet. The magnetic power was equal to holding five articles 1. Hollow iron pipe=78 gm, 2. black watch =62 gm, 3. Yellow watch=64 gm, 4. Seizer =28 gm and 5. Nail cutter=34 gm. Total 266 gm.

It was tested that magnetic flux could pass through balloon.

Then it was put in to the balloon made airtight by rubber band and threads.

Then it was put into the center of balloon and made a sand layer to be smooth surface as depicted in Figure 5.

Figure 4. Magnetic deflection measurement

Figure 5. Magnet (inside balloon) into the model

2.5 Creation of magma chamber

A circular sand bed of about 2.0 cm thick and 15cm diameter was made.

About 2-3 cm thick layer of paste of clay soil was made on sand bed.

It was left for 24 hrs. to be tight (hard semi solid) in fan 'on'.

A stele cup of depth 4.0 cm and diameter 4.0 cm was over filled vertically with sealing wax rods up to upper of top.

The cup overfilled with sealing wax was put on the center of clay bed (Figure 6).

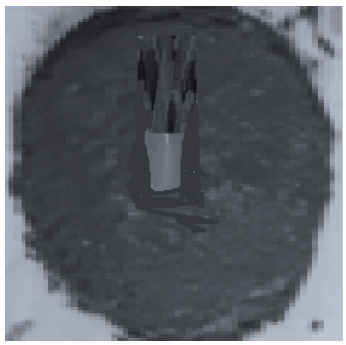


Figure 6. Construction of magma chamber

Then from all sides it was covered by clay bed.

It was again left for 24 hrs but without 'on' fan. Now it was magma chamber.

An electric heater's coil of 150W was expanded to increase 25% more long, then it was dipped in the periphery of semi solid magma chamber all around three rotations .and made smoothly hidden by pasting external paste of clay soil, making out both terminals.

It was left to dry for 48 hrs. in fan 'on'.

At the tip of magma chamber, a furrow of about 1.0 cm was made by sharp Shaw knife.

Two wire of copper and simple iron were jointed and the junction of that thermocouple was inserted in the furrow of the top of magma chamber. This furrow was filled half and till it's level again a second furrow was made on its 90^0 (cross) and up to about 0.5 cm and junction of another thermocouple of nickel coated iron wire and copper wire was inserted and it was finally over filled by semi solid compact soil. 10 gram NaCl was poured on it for increase geo - electricity.

Then magma chamber was left for 48 hrs. to dry in room temp. and fan 'on'.

Magma chamber was supported from all four sides by black strong electric tape.

Wires of both thermocouples were pressed in a line to be about straight and not intermingled be separately.

Both terminals of electric heater coil (150W) dipped into mama chamber was searched by screeching carefully and both terminals were connected strongly to the thick high voltage connection wires of power plug.

And these both connections were made fixed with Tape,

Magma chamber was inserted into model carefully upright so that all both wires of thermo couple be remain unbroken and be fixed in cut furrows of globe and power plug connection wire on top of globes mouth, as represented in Figure 7a.

A layer of small grits around magma chamber was put one by one slowly all around and it was made hidden by semisolid paste of compact soil.

It was left to dry for 24 hrs. in fan 'on'.

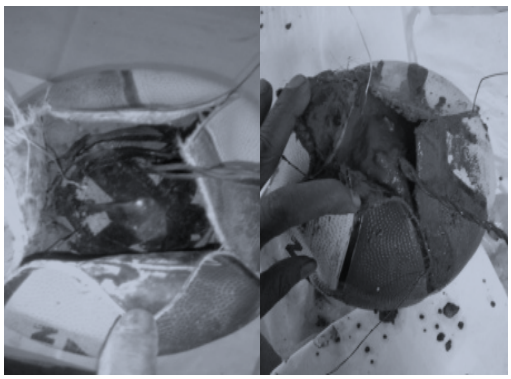
2.6 Hydrology and final filling

Three pouches of drinking water were taken and from those 200ml was measured. 70 gram NaCl was dissolved, and were again packed in same pouches.

Two saline water pouches were inserted into the model's outer periphery.

About 50gram salt was mixed with 100 gm of compact soil and made its paste to fill neck of globe.

Then finally the globe was filled full the globe with loose paste of clay soil.



(a) (b)

Figure 7. (a) Magma chamber (b) final filling

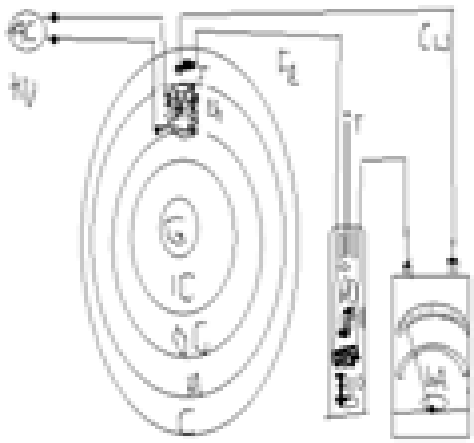


Figure 8. Diagrammatic representation

2.7 Drying of model

Figure 7b, represents final filling into the model. Fully filled globe was left for 96 hrs in fan on and before electric heater to be completely dry slowly, so that hydrology was not disturbed but magma chamber and lithosphere were completely dry with electric hot air flow system. Since, 150 W electric heater was put in magma chamber, therefore completely and slowly dried of earth's model. It was a need for safety to operate the model, to make magma boiled and its geo thermal electrical measurement.

2.8 Experimental set up

Figure 8 is diagrammatic representation of experimental set up showing G= Spherical Magnet, IC= Inner Core, OC = Outer Core, M= Mantel , C= Crust H= Hydrosphere of NaCl Solution packets , ⏚ = AC Source Power Plug , V= Volcano magma, J =Junction of thermo couple , Eh= Electric heater coil, 150W, Fe= Nickel coated Iron wire , Cu = Copper wire, I= Ice bath, T°C Thermometer, µA= Meu ammeter. The outer junction of thermocouple was dipped fully in an ice-bath and µ ammeter was connected for geo thermo electric current measurement. Power plug of heating magma chamber was on and current was noted along with the time. Figure10 represents photograph of experimentation. A feeble result was found as it is represented in table one, so that there was also externally boiled the magma of sealing wax and heating junction of boiling wax condition was measured and verified correct the geo thermo electric current of model as depicted in Figure 10.

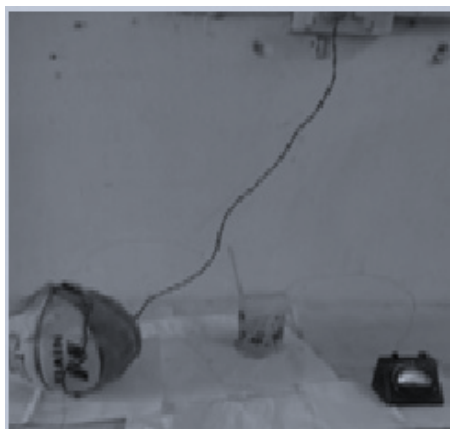


Figure 9. Experimental set up

Figure 10. Externally boiling magma

Table 1. Observation of geo-thermo- electricity due to magma eruption in model at Room temperature 15℃ and humidity 35%

Sr.	Time Of volcanic action	µAmmeter reading	Cold Temperature
1	01.00 pm	0µA	$0^{\circ C}$
2	01.30 pm	0 µA	$0^{\circ C}$
3	02.00 pm	5µA	0^0 C
4	02.30 pm	5 µA	1^0 C
5	03.00 pm	10 µA	1^0 C
6	03.30 pm	10 µA	2^0 C
7	04.00pm	15µA	2^0 C
8	04.30pm	15 µA	3^0 C
9	05.00pm	15 µA	3^0 C

3. RESULT AND DISCUSSION

Table1 represents the geo thermo electric current along with time. After the electric heater coil of 150W, was made 'on', so that the magma got melted and finally boiled. It took 30m, to reach its temp. to the junction of thermocouple inside mantel, producing 10 to 15 µA, Geo thermoelectricity was increasing with the time up to 15µA in 4.00 hrs. and then remain stable. The cause of feeble result would due to very less melting point of the sealing sticks. In primary observation, with hot water between 90℃ and 80℃, thermal gradient (with ice bath dipped a junction) generated thermoelectric current was 45 µA. The boiling sealing wax sticks generated (with ice bath of another junction) only 10 to 15 µA, due to minimum melting point. But result simulated to observation of magma activity by thermocouple probes. Since melting point and boiling point of magma would be high about to melting point of Silica is 1,200℃, as states in Clark Table [28]. The selection of thermocouple wires is suggested to be having high melting point like Fe =1810^0k and Cu 1380 °K. While Al and Mg are not suggested to have MP 932°k and 924°k. Since, the junction wire would be melted at volcano temperature.

Experimentation with model of the earth for the condition to touch a junction of thermo couple wires with boiling magma to produce electric current with the ice bath dipped another junction, seen a feeble result of 10 µA to 15 µA. It created confusion, if magma of model was properly boiled? Therefore, further in another cup, sealing wax was melted to create external magma dipped with a junction of thermo couple, gave the same result of 10 µA to 15 µA. as represented in Figure 11, Since sealing wax has melting point, 55℃ to 60℃ [33].

3.1 Scope of the study

Whether micro ammeter is replaced by Nano- ammeter and thermocouples junction would dip into liquid nitrogen like super cryopreservation and if, thermocouple wires would be of super -conductor. Observation in three- four digits would be observed with super computer at volcano observatory centre. Whether, we can predict volcanism and control the volcanic thermal energy and convert in electrical energy, the curse of volcano may change into a great energy source and beneficial for human kind by application in technology, as it is hypothesised as Dei Vulcan [31].

3.2 Ratio and proportion

Table 2 represents the comparative physical parameters taken from Clarks table for earth and measured the model. Weight of model was taken at the last**.** The ratio between earth and model made of basket ball didn't match with other parameters. Therefore, another ball of small size was taken and compared with the basket ball and was found that those too were not being matched due to different chemistry.

1. Volume of sphere =$4/3\pi r^3$

$$Volume\ of\ Basketball = (4/3)\times(22/7)\times(11.8)^3$$
$$= 1.333\times 3.142\times 1643.0 = 6881.35 ml^3$$

2. Surface area of sphere =$4\pi r^2$

$$Surface\ area\ of\ Basketball\ = 4\times(22/7)\times(11.8)^2$$
$$= 4\times 1.333\times 139.24 = 42.427 cm^2$$

Table 2. Comparative physical properties of the earth (from Clark's table) and the model

Sr.	Property	Earth, from Clarks Table (Ref. 27)	Earth's Model	Ratio
1	Diameter	12,742 Km	23.6 cm	53991525.42
2	Area	510.1 million Km^2	1750.44 cm^2	2914124448110
3	Volume	One trillion Km^3	6881 ml^3	57142857142857
4	Circumference	40,007 Km	42.4 cm	94134117
4	Mass	5.972 x 10^{24} Kg	11.5 Kg	5.139 x 10^{22}
5	Density	5.513 grams/ Cm^3	1.671 gm/ cm^2	3.2992
6	Highest point	8.848 Km.	1.5 mm	5898666.6
7	Deepest marina trench	11.2 K m	1.0 mm	11200000

3.3 Geomagnetism

For the magnetic moment of magnet there were many observations as represented in Table 3. Diameter of the magnet inserted in the centre of the earth's model. d=1.5 cm. and l-3.5 cm and the weight of magnet = 56 gm. It attracts iron keel of 8.0 gm weight from 3.0 cm. Magnetic force, F=d l sin θ/$r^{2.}$ Or a magnetic moment could be calculated by the formula- B=HTanθ. Or $\mu_0 2M/4\pi$=HTanθ (here H=6.24 ergs/m^2).

Magnetic measurement had been made, represented in figure 4, with defluxion magnetometer at it leveled position and north south position, so that the initial defluxion was zero and then magnet was put on various distances and defluxion observation was tabulated in Table 3 with the *sine* value and *cos* value of defluxion by magnet. Average magnetic moment of used magnet was calculated to be 0.6 x 10^{-6} ergs/m^2. This magnetic power was capable to hold weight of 266gm. But one could not create gravity force in model, and difference of both forces of the earth is that, magnetism attracts or reflects only to magnetic mettles while gravity force attracts (only) to all matters except objects of escape velocity.

Table 4 represents model filling layers in regard with the established layer thickness of the earth. Mass of the earth in

the construction of the earth's model, was taken from wave site (34). Table 2 represents miss match ratio due to the shape of earth somewhat elliptical and polar peculiar structure with inclination on its axis, having highest point of 8.848 Km and deepest 11.2 Km, while basket ball has the ridge in gluing mono on a basket ball, furrow for a grip to hand only. Geo diversity, Biodiversity, petrology, hydrological ratio and force of gravity could not be created in this model, Diamonds jewels mine gifts minerals, so that, one can never ditto copy earth. Even earth magnetic force was tried to make by inserting a spherical magnet as depicted in Figure 5, but gravity force and rotation with supersonic sound of the earth could not be made. But the model was concentrated only for study of volcano prediction.

Table 3. Magnetic measurement with deflection magnetometer

Sr	Distance	Deflection	Sinθ	Tanθ
1	5cm	70^0	0.9397	2.7475
2	7 cm	45^0	0.7071	1
3	1°Cm	40^0	0.6428	0.8391
4	11 cm	30^0	0.5	0.7002

Table 4. Ratio of the internal structure of the earth

Sr	Layer of the Earth	Layer Thickness	Model Layer Thickness	Radius in the Model
1	Crust	32 km	0.3 cm	11.8 cm
2	Mantel	2,900 km	5.0 cm	6.0 cm
3	Outer core	2,250 km	5.0 cm	5.0 cm
4	Inner core	1,300 km	0.5 cm	0.8 cm

3.4 Seismic prediction and super conductivity

The earth quake effects on geo-electricity due to an increase of piezo electric effect developed by movement of two tectonic plates. Their mechanical energy ½ mv2+ ½ mv2, when hit two huge masses or one has stress to dissociate, high energy liberates in many forms i.e. geo electric and geothermic energy [30]. Since the third law of energy deals with generation of enthalpy. Thus volcano and earth quake both should increase tectonic plates temperature, and about all radiating energy moves in wave form in string theory. Certainly, experimentation and observation was limited to volcanic modeling and simulation of geo thermo electric prediction. Same situation with semi conductivity wires, further need to study and application.

4. CONCLUSION

Volcanic prediction can be made using Geo thermo electric increase. Two different fine wires having minimum electric resistance can be applied as thermo couple conduction wires fixed with electrodes. A junction of the thermo couple of connected to the liquid nitrogen in the observation center. Another junction of thermo couple should be inserted up to most possible depth makes micro hole at volcanic land. Volcanic eruption will increase temp. at certain rate. This Geo thermo electric circuit can be observed with meu-am-meter. Volcanic waves must have geothermic waves to increase meu-am-meter's readings. Contribution of this modelling is yet to be union of geosciences like earth scope, earth drilling science, geo thermoelectricity, and liquid nitrogen observatory in the study of volcano prediction.

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REFERENCES

[1] Reda, R., Fayçal, A., Tahar, B. (2017). Fault Eccentricity Diagnosis in Variable Speed Induction Motor Drive Using DWT. AMSE Journals, Series: Modeling C, 72(3): 181-202. https://doi.org/10.18280/ama_c.720301

[2] Zhang, Z., Guo, J.H., Wang, Y. (2017). Sedimentary Reflection of Tectonic Activities of Fault Depression Basin-taking Lufeng Depression as an Example. AMSE Journals, Series: Modeling C, 78(2): 191-209.

[3] Mahar, H.D. (2001). Modeling and simulation of seismic prediction using phytoelectric method "Proc. MS Int. Conf. National University of Defense Technology Changsha China, on Modeling and Simulation in Distributed Applications, 841-845.

[4] Asebedo, B. (2018). The Deepest Roots. https://www.goodreads.com/book/show/37677999-the-deepest-roots, retrieved on 2018.10.

[5] Becerril, L., Galindo, I., Gudmundsson, A., Morales, J. M. (2013). Depth of origin of magma in eruptions. Scientific Reports, 3(1): 2762-2762. https://doi.org/10.1038/srep02762

[6] (2018). How are volcanoes and earthquakes related? Volcano World http://volcano.oregonstate.edu/how-are-volcanoes-and-earthquakes-related.

[7] (2018). Earth scope From Wikipedia, the free encyclopedia https://en.wikipedia.org/wiki/Earthscope Jump to navigation Jump to search.

[8] http://www.usarray.org/http://www.usarray.org/researchers/obs/magnetotelluric.

[9] Laboratory Simulation of Volcano Seismicity. Science science.sciencemag.org/content/322/5899/249.

[10] Volcano-DCmobility Holdings LLC Sep 9, 2018 https://www.dcmobility.com/volcano/.

[11] Model Volcanoes-Science Net Links sciencenetlinks.com/lessons/model-volcanoes/.

[12] Abrams, M., Kahle, A.B., Palluconi, F.D., Schieldge, J.P. (1984). Geologic mapping using thermal images. Remote Sensing of Environment, 16(1): 13-33. https://doi.org/10.1016/0034-4257(84)90024-5

[13] Mcmillan, N., Larson, P.B., Fairley, J.P., Mulvaneynorris, J., Lindsey, C.R. (2018). Direct measurement of advective heat flux from several Yellowstone hot springs, Wyoming, USA. Geosphere, 14(4), 1860-1874. https://doi.org/10.1130/GES01598.1

[14] Kimberly, Y. (2018). How Do Scientists Know the Structure of the Earth's Interior?" www.kimberlyyavorski.com. Updated April 23, 2018, https://sciencing.com/do-scientists-structure-earths-interior-8695198.html Retrieved on 19.10.2018.

[15] Simmons, A.E. (2017). What Are Three Differences Between the Upper & Lower Mantle? April 25, 2017 Science, U.S. Geological Survey: The Interior of the Earth. https://sciencing.com/three-between-upper-lower-mantle-8516951.html.
[16] Peter, C.B. (1976). Structural methods for the exploration geologists. Oxford Book Company Kolkata, India, 8: 187-190.
[17] Chhristopher, H., Anderson, D.B. (2016). The Structure of the earth in Geothermal energy. John willey and Sons Publication, 3: 19-22.
[18] Hasim, R., Jaiswal, A., Shrivastva, B. (2018). Estimation of rock load height during development operation in bord and pillar coal mine using numerical simulation method. MMC., AMSE Journal; 79(2): 24-35.
[19] http://www.mirageoscience.com/Retrievedon24.10.2018.
[20] Deborah Byrd in Earth | Science Wire | Space | January 26, 2016 X-ray view of Earth's aurora. (wave site) http://earthsky.org/space/x-ray-view-of-earths-aurora, Retrieved on 19.10.2018.
[21] Jakkula, B.R., Mandela, G., Chivukula, M.S. (2018). Improvement. AMSE Journals, Modelling; 79(1): 06-12.
[22] Bran, K., Draxler, J., Hirschmann, G., Zoth, G., Hiron, S. (2018). Scientific Drilling, The KTB bore hole, Germany's Super Deep Telescope in to Earth's Crust.
[23] Risch, M.H. (1990) Example for advanced drilling Technology. 16(4): 16-20.
[24] Meklid, A., Boutarfaia, A. (2018). The effects of sintering temperature and titanium ratio on structural and electrical properties of new PZT-CNS ceramics. MMC, AMSE, Journal; 79 (1): 01-06.
[25] Bednorz, J.G., Müller, K.A. (1986) Possible highT c superconductivity in the Ba−La−Cu−O system. Z. Physik B-Condensed Matter, 64: 189–193. https://doi.org/10.1007/BF01303701
[26] The Nobel Prize in Physics 1987: J. Georg Bednorz, K. Alex Müller Archived 19 September 2008 at the Wayback Machine. Nobelprize.org. The Nobel Prize in Physics 1987 https://www.nobelprize.org/prizes/physics/1987/summary/, Retrieved on 28.10.2018.
[27] Paulsen, C., Hykel, D.J., Hasselbach, K., Aoki, D. (2012). "Observation of the Meissner Ochsenfeld Effect and the Absence of the Meissner State in UCoGe"Phys. Rev. Lett. 109: 237001. https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.109.237001 Retrieved on 28.10.2018.
[28] Russell, W.S. (2014). Clarks Table of Science Data Book Orient Longmann Group Pvt. Ltd., Oliver & Boyd Corytha RN House 23, "Revillston Terrace, Edinburgh EH4, 3JJ, Scotland, 2014, Chap. 21, Terrestrial and Geodetic Data, pp 78-79.
[29] https://en.wikipedia.org/wiki/BCS_theory. Retrieved on 28.10.2018.
[30] https://www.omega.com/pptst/XC_XS_XT_XL_WIRE.html, Retrieved on 28.10.2018.
[31] https://en.wikipedia.org/wiki/Liquid_nitrogen. Retrieved on 28.10.2018.
[32] https://www.airseparation-plant.cn/products/?gclid=CjwKCAjw9sreBRBAEiwARroYm_LvFQV5xTQDUdxvCBV1XiIV8YgOBiAGJI8J6cIRRRiNGEoV6TGaGxoClUQQA DBwE; Retrieved on 28.10.2018.
[33] About sealing wax–Nostalgic Impression/ what temperature does sealing wax melt at? https://www.nostalgicimpressions.com, Retrieved on 25.12.2018.
[34] https://www.google.co.in/search?q=how+to+make+a+scale+model+of+earth%27s+layers&sa=X&ved=0ahUKEwil6ref0dPeAhXBL48KHThvDckQ1QIInwEoAQ&biw=1015 & bih=488.
[35] Mahar, H.D. (2001). Geoelectricity' in "Investigation on electrical properties of plants and their application" Ph.D. thesis, Guru Ghasidas Central University Bilaspur CG India, 8: 350-352.
[36] Mahar, H.D. (2018). Ad Majorem Dei Gloriam, Sonnet song, (2018) Notion press publication Chennai, India 69.