Geoenvironmental and Geoengineering Research Study By Application of Integrated Techniques In Determining, monitoring the potential of sinkholes geohazard, the Geological model of laying sediments, Environment Changes, the Development of Sinkholes and Karst Phenomenon after the Global flood in Sungai Perak Basin - Peninsular Malaysia

Riyadh R. Yassin¹, Samsudin Haji Taib¹, Dhiya Aldin Almashiky²

¹Department of Geology, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia

²Department of Geology, Faculty of Science, University of Baghdad, Iraq, Email: dhiya55@yahoo.com

Correspondence: Riyadh R. Yassin, Department of Geology, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia. Email: riyadh.geophsea@gmail.com

ABSTRACT:

This geoenvironmental and geoengineering research study focuses on the integrated geological, geophysical, geochemical, physical, structural, environmental, archaeological, aerial photographs and satellite images techniques in determining and monitoring the potential of sinkholes geohazard, the geological model of laying sediments, environment changes and the development of sinkholes and karst phenomenon after the Global flood (Noah flood).

These techniques have joint with engineering surface and subsurface remediation techniques and performed across three (3) selected construction sites distributed over a region of carbonate karst environment located in the Sungai Perak Basin (Kinta Valley). The study region has a length of 145 km and width of 30 km, extends from Tapah city located to the south of Ipoh city, the capital of Perak state, to Chemor city, which is located to the north of Ipoh city over (Kinta valley), in Perak state, Peninsular Malaysia.

This region includes several construction sites. Three of these construction sites have selected for this study. The first study construction site located at Taman Klebang Putra region, Klebang Green to the north of Ipoh city. The second study construction site located at Gunung Rapat region, Taman Gunong View. The third study site located at Kampung Kunsila estate in the northwest of Kampar city and south of Ipoh city.

During the geological field survey and site inspections, several active sinkholes were discovered and identified in these sites and along the study region. Those sinkholes are ranged from narrow-to-medium and medium-to-wide sizes, some with exposed throats. On average, the diameter of the sinkholes in the study region ranged from 1.0 m to more than ~ 30.0m. Some of these sinkholes have approximately the corresponding range in depth. Surface water induces erosion along the frame of the sinkhole, which causes enlargement to several meters long. Some of those sinkholes were selected for this study by applying high-resolution geophysical techniques in order to classify his sinkholes.

Geophysical site characterization by applying Winner's Electrical Resistivity Tomography (ERT) technique has used along with many profiles in these three-selected construction sites in order to capture the image of the subsurface across and in proximity to various types of sinkholes as a primary stage. This technique will allow the recognition of their shapes and the estimation of their depths. In addition, it will assist to know the origin of these sinkholes.

The electrical resistivity data from the multi-electrode measurements have collected from several profiles and processed to generate the 2D resistivity models of the subsurface by using RES2DINV ver.3.54 inversion software. The electrical resistivity images show many active karst cavities and sinkholes having different shapes and origins. Some of these were identified as karst features (sinkholes and cavities) as well as water, clay or air in-fill. Additionally, the transmission of the material from the top (soil surface) down to the bedrocks via the solution showed enlarged joints, drainage systems or pipes, which is expected.

The geological model is clarified via the geophysical data, consists of a basal marbleized limestone unit, which has widely karstified and constitutes the bedrock of the study area. This bedrock unit appears to have been dissected or intervened by solution-widened joints and fractures. Enclosed by overburdened layers consisting of sand, containing lenses of stiff, non-stiff moisturized clay and covered with soil mixed with friable sand and rock fragments scattered throughout in certain places. This karstified limestone bedrock is intervened by sinkholes and cavities in-filled with clay or sandy clay and sand. These features invariably interpretative as created due to the karst process.

The field study identified the types of sediments in the sub surface's layers and estimated its approximate depth and thickness. Moreover, the depth of the limestone bedrock was generated for all sites. The tomography data from different profiles were interpreted using the existence of the extracted boring samples to improve the results of the ERT. When comparing the interpretations from individual profiles with the boring data, a discrepancy was detected in the depth values, speculated to be resulting from variations between the normal subsurface geology and the data from the electrical resistivity survey profiles. Most of the data points contain errors of less than 1 m, with some data points containing errors of less than 3.0 m.

Extensive studies for the sinkholes formations have shown that sinkholes are likely to form in regions mostly located in the southern part of the western belt of limestone hills and an east-west line across Ipoh. Within the region of carbonate karst environment, extended from Tapah city, located in the south of the valley, until Kuala Kangsar city, located in the north of the valley. In the cities such as Pulai, Gopeng, Rapat, Batu Gajah, Kampar, Ipoh, Taman Tasek, Putra Klebang, and Klebang Restu, in (Kinta Valley), Perak state. All of these cities in over carbonate karst environment are former tin mines. Some of these sinkholes spotted and marked in satellite images and found distributed within two zones. The first zone has trended from the south to the north-northeast of the valley. However, the second zone has trended from the south to the north-northwest of the valley. Therefore, sinkholes developments are more common in pure limestone with a high content of calcium carbonate. While the more dolomitized karst areas with a high content of magnesium carbonate have found with less level for the sinkholes to developments.

Certain varieties of sinkholes with differing origins have identified in the study region via the information acquired from the geological and geophysical site characterization survey in the study region. The first types of sinkholes are; a few meters in diameter and depth and have referred to as (cover-layers or material subsidence). The second type was wider than the first type in terms of diameter and depth, referred to as (cover-collapse sinkholes). The third kind of sinkholes are a (slump depression) produced on the ground surface. Finally, the fourth types of sinkholes are an opening with a funnel shape depression or sink, referred to as pipes. There are several causes for the occurrence of sinkhole collapse in the Kinta Valley; the primary reason among them is the irregular distribution of unconsolidated material on the bedrocks surface. The secondary reason is the running of heavy rainwater on the ground surface. The third reason is the heavy acidic rainfall in this region. The fourth reason is the earthquakes and the subsidence movement. The fifth reason is the heavy loads of buildings or

foundations. The sixth reason is the human influence. The seventh reason is the vibration from traffic. The eight reasons are the weather patterns. The ninth reason is the groundwater movement. The tenth reason is the water quality. The eleventh reason is Air high pollution. All these reasons after the development of the sinkholes and other karst feature rapidly in this tropical area of Peninsular Malaysia.

Moreover, this study discovered that the most geohazardous area in construction site #1 found extended underneath the resistivity profile no.5 and no.6, with sinkholes extending over 55.0m and reaching depths of more than 28.7m. Once the excavating work over resistivity profile #5 was started, the under groundwater gushed out immediately; which confirms the result of geotechnical survey, that there was a high conductivity and very low resistivity source representing sinkhole in-fill with water under these profiles.

This study also discovered that the study sites no.3 and other sites with similar specifications are hazardous vis-à-vis constructing accommodation for habitation or animal sheds. There is a possibility of collapse or subsidence of the soil cover or the material and underlying layers due to the load at any time in the near future. Moreover, this study identified an area of on-going subsurface dissolution erosion in this site that may eventually lead to a collapse in the future. Several solutions of engineering surface and subsurface remediation techniques are recommend using in the plan to minimize the risk of problem areas in these sites.

Due to operating of the Permanent Geo-Hazard Incident Scale (PGHIS) that completed by Yassin, R.R. & Haji, Taib, S., (2013) to assess the geo-hazard in construction sites along with karst areas in Malaysia. This scale has many levels, which are determined based on three factors. There are eight (8) levels in this scale to assess the geohazard in the construction sites as described below:

In construction site #1, one level of the scale shown in this site is Level 5: present in high hazard incidents with wide-ranging between traverse no. 1 and traverse no.6. In construction site #2, one level of the scale has shown in this site, Level 4: medium hazard incident record up from the normal values, between traverse no. 1 and traverse no.5. In construction site #3, one-level of the scales has shown in this site, Level 5: High hazard incident with wide-ranging consequences, between traverse no.1, and no.5.

Besides, this study discusses many considerations about the important elements that play major roles in the development of karst phenomena and the dissolution process that effects the increasing of carbonate karst features in the Sungai Perak Basin (Kinta valley). One of these elements first, is the effects of climate change and second is the events that happened during the Holocene period, third the mining and human activities, fourth air and water high pollution, fifth the effects of heavy and acidic rainfall on the environment and climate change. All these elements directed to the rapid development of the karst features in this tropical area of Peninsular Malaysia.

Additionally, this research study also shows the impact factors that arise together and played major roles in the causes of global flood (Noah's Flood) (3300-3100) BCE. In addition, this study shows that Non- terrestrial impact factors lead the global flood to happen.

Furthermore, this study focuses on an important point that is the protection of the open area near the coastline around Malaysia from the sudden change in sea level in the near future. Any flood could happen in the near future is due to an increase in pollution, and due to human activity, which led to climate and environmental change. From that reason in this study, the researches recommended constructing earth dam with a concrete core at least 6.0-8.0 m height from currently, as some the other countries completed it for their side of seashores before the sudden change in sea level happening in the next few years

The geotechnical survey in this research study recognizes; thin red cover that contains different sizes of granite rocks and minerals with thickness is mostly about (5.0cm - 12.0cm). This red cover over a layer of lateritic clay with different thicknesses from site to

another between (1.0m - 1.25m), (2.0m - 5.0m) and to maximum depth (6.0m - 9.0m) are mostly returns to the period of a global flood (Noah's Flood) (3300-3100) BCE.

The appearance of this red cover and the layer of lateritic clay is due to runoff of heavy rains that have deeply eroded and washed both the highest granite ranges around the Kinta valley and then carried away by the new rivers and canyons that formed due to the erosion. The thin layer of carboniferous organic material with different thicknesses of (3.0cm-5.0cm), (8.0cm-10.0cm) have seen beneath the lateritic clay.

In accordance with the geotechnical classification of karst ground conditions presented by Yassin, R., R. & Haji, Taib, S. (2012). Which describe the subsurface karst features that come upon in engineering works on the carbonate karst environments, after the applying of the geotechnical survey, The karst class in construction site#1 found between profile no.1 and profile no.6 is a mature karst KaIII to Complex karst KaIV, due to presence of huge sinkhole, lenses in-fill with clay or water, pinnacles. The karst class in construction site #2, found between profile no.1, profile no.4 is a mature karst KaIII, due to presence of numerous type of sinkholes with different sizes, voids, soil fissures, and pinnacles. The karst class in profile, no.5 is adult KaII to mature karst KaIII. The karst class in construction site#3 found between profile no.1 and profile no.4, is a mature karst KaIII, due to the presence of various types of soil covers collapse sinkholes, lenses, voids, cavities, and pinnacles. The karst class in profile, no.5 is adult KaII.

Besides, the Geophysical site characterization observing that the radon gas existing in the water that in-fill the sinkholes and the cavities in most ER Tomography sections of the construction sites understudied.

Therefore, the construction of structures needs to designing and developing new processes to remove radon from the out-door and in-door air stream in the buildings and housing complex that constructed over carbonate karst environment. Then could contaminated with radon gas in greater levels and other contaminants affect the breathing existing in the air within these buildings, these contaminants include the Hydrocarbons, CO, CO₂, Ozone, Olefins, Nitrogen oxides, and Sulfur. These steps comprising contacting of out-door and in-door air stream with an adsorbent device for the removal of radon.

Furthermore, its requirements for applying a new process of engineering subsurface remediation technique, such as chemical grouting techniques to fill the channel pipes, conduits, cavities, and voids. One of the steps of environmental management, can uses of Bentonite drilling mud and the rock cutting from the drilling operation in oil and gas exploration, after the water and other liquids have removed to re-fill all the types of sinkholes in the karst regions.

KEY WORDS: Geoenvironmental and geoenvironment, Integrated techniques, Geological model, Environment Change, development of Sinkholes, Global flood, Sungai Perak Basin - Peninsular Malaysia

1. INTRODUCTION

The position and condition of carbonate bedrocks such as limestone, dolomite, dolomitic limestone, marbleized limestone, and its appearance are important for geoenvironmental, geological engineers and civil engineers in Perak state. The carbonate karst bedrock in the area represents one of the most complicated ground conditions, its riddle with various solution features, which might be detrimental to any overlaying structures in its vicinity. These karst features such as sinkholes, caves, voids, cavities, channel pipes, depressions, conduits, internal drainages system, solution-widened joints, intensely fractured zones and faults. Thus, creating problems can directly or indirectly affect the foundation of structures when overlapping carbonate karsts sites.

The substantial damage resulting from carbonate dissolution features such as sinkholes was resulting from the construction works could cause massive losses all over the region. It will be directly or indirectly affect the construction structures. Indirectly have the potential to cause catastrophic damages in the near future or perhaps many years after the project has ended. It can precipitate cracking in the building and halt the construction project totally. In addition, it will maximize the cost of the project overall. Other problems also may cause in the area such as the settlement of the houses or the buildings. In addition, the negative consequences that could precipitate years after the project has completed will result in massive losses that lead to enormous financial costs, to both the developers and the lands.

Several subsurface karst features were recognizing in these construction sites, during the utilization of high-resolution geophysical site characterization, by applying of Two-dimensional (2D) Winner's Electrical Resistivity Tomography (ERT) technique. To capture the images of the subsurface in order to pinpoint evidence for near-surface karst features such as caves, cavities, sinkholes, depressions, enlarged joints, fractures, and internal drainages. This technique employed across these construction sites in order to realize the research objectives and to capture the images of the subsurface to various types of sinkholes as a primary stage.

Resistivity traverses have conducted along the survey area at each construction site. The orientation, extension, and the degree of inclination of those traverses have shown in the location map. The resistivity data from the multi-electrode measurements collected from several profiles corrected. Then the correct resistivity data was interpreting by using the (res2dinv software) and plotted in the tomography sections.

The tomography imaged shows many features in the anomaly of different shapes. Many active karst features (sinkholes and cavities), having different shapes and origins. In addition, water, clay, air-infill cavities, and sinkholes have shown as well. Additionally, it showed the transmission of the material from the top (soil surface) down to the bedrocks via the solution enlarged joints, drainage systems or pipes.

This study also proved that high-resolution Electrical Resistivity Tomography (ERT) can effectively be employed to reflect the bedrocks. It is also completely suitable for differentiating surficial soil, clay, weathered rocks, compact or intact rocks, and air-filled karst voids or cavities, and intensely fractured rocks. The interpretation of geophysical techniques can help civil engineers to identify the irregularity in subsurface karst topography of marbleized limestone bedrocks in Perak, the degree of karst level, and identify what causes these karst features. Three (3) construction sites have chosen from numerous sites that are being studied.

Karst in carbonate terrains is a distinctive landscape and hydrology, which occurs from a mixture of high-rock solubility and a well-developed secondary porosity. The carbonate rocks (limestone, dolomite, marble) are often characterized by a group of landforms, which includes an extensive range of closed surface depressions, underground drainage, well-developed systems and sinkholes. These depressions form the key focus of this research.

Sinkholes appear due to many reasons, such as being the result of the runoff of heavy rains channeled towards the bedrock from the flow of groundwater; irregular distribution of unconsolidated material over the bedrock surface; or subsidence movement. Many carbonate rocks contain various amounts of insoluble materials and solution-enlarged joints. When the

soluble components are dissolved and removed by groundwater, the insoluble materials remain, which include sedimentary material such as gravel, sand, silt, and clay. Sediments such as alluvial or marine sediments may also mantle the bedrock. Regardless of their supposed origin, the sediments protect the limestone bedrock and prevent any solution-related features in/on it.

Due to the elevation of the limestone/soil interface being location dependent, defining the depth to the carbonate bedrock with the boring data is time-uncontrollable and expensive, and maybe misleading due to insufficient data density. On the other hand, the boundary between rock and soil is often sharply defined as Sowers, G.F. (1996). The overburdened soil differs from the underlying carbonate rock, whether it is residual soils produced by mechanical and chemical breakdown of rocks from the ground surface, or it's transported from its origin. This contrast provides the basis for applying geophysical techniques to represent sinkholes, the carbonate bedrocks, and the overburdened soil surface in covered karst terrains.

Geophysical site characterization by applying (ERT) has used along with several resistivity profiles in the proximity of active and non-active sinkholes at three sites, situated in north and south of Ipoh city. The location of study sites and region in the Google normal, Google terrain maps (2013) of Kinta Valley, Perak state, peninsular Malaysia highlight in figure 1.

Forty-one steel electrodes in 2D arrays has employed in these surveys, with a spacing of 5 m. The length of the electrical survey lines is 200 m, and it depends on the size of the area and the placement of the wire arrays. The space between the two lines was on average 10 m at this site.

The electrical resistivity data acquired from the survey is constructive for several reasons, among them the fact that karstic features can be delineated by a completed closely spaced parallel resistivity profile; and the subsurface can be immediately imaged across and in proximity to many sinkholes in order to determine the karstic features. The provided images were reliable, and support the interpretation about the study area, if it's underlain by several varieties of karst features (sinkholes, cavities and voids). The survey shows sinkholes, in many different sizes and shapes can be recognized in the study area. It is capable of characterizing the subsurface bedrock in covered karst terrains.

In this research, identify that the subsurface of limestone bedrock was widely karstified by providing reliable images of the karstified limestone bedrocks. In the top of the subsurface, the image identified that the type of sediment that layering and estimating its approximate depth and thickness. The overlaid cover consist of soil clay with varies thickness from one site to another, and friable sand with the remnants of limestone rock and other rock fragments. This is due to the high resistivity recorded in most of the overburdened cover. Furthermore, it also allows an understanding and expectation if the area surrounding this study area could be a hazard in the near future.

This study also discusses many considerations about the important elements, which play major roles in the environment change and the development of karst phenomena and the dissolution process that effect the increasing of carbonate karst features in Sungai Perak Basin (Kinta Valley). In addition, this study discussed the impact factor that arises together and plays major roles in the causes of global flood to happened and cover the study area in Kinta Valley, Peninsular Malaysia between (3300 -3100) BCE.

Early planning of applying engineering subsurface remediation techniques are required to mitigate or minimize the potential of geo-hazard of karst features in these construction sites over carbonate karst bedrock. Several techniques are available to repair any construction site threatened by cover-collapse sinkholes. An effective procedure can rapidly use to fill the sinkhole by using of reverse graded filter technique. In the case of great sinkholes, the graded

filter construction is essentially the same, but the final layers are fine gravel, coarse sand, and fine sand. The uppermost layers are Bentonite clay, which blocks water seepage.

Figure 1: Google normal, Google terrain maps (2013) viewing the location of construction sites in (Kinta valley), Perak state, peninsular Malaysia, by (Yassin, R.R., 2013)

Furthermore, it's a need for applying a new process of grouting method in the study areas as chemical grouting techniques to fill the channel pipes, conduits, cavities, and voids. Long skin friction piles had driven into the layers containing non-stiff materials (soil, clay, silt, sand). Finally, drive off long piles down to the sound bedrock due to the difference in the depth of bedrock from one side to the other. One of the steps of environmental management, can uses of Bentonite drilling mud and the rock cutting from the drilling operation in oil and gas exploration, after the water and other liquids are removed to re-fill all the types of sinkholes in the karst regions.

2. OBJECTIVE OF STUDY

The integrated of geophysical site characterization (ERT) and other techniques such as geological, physical, environmental, archeological, aerial photographs, satellite images, engineering surface, and subsurface remediation techniques in this geoenvironmental and geoengineering research study was conducted at fundamental sites in order to determine the following objectives:

- I. Imaging the subsurface immediately across and in proximity to many sinkholes and determine other karstic features such as voids, cavities.
- II. Estimate the depth of sinkholes in the study area.
- III. Recognize the shape of the sinkholes in the study area.
- IV. Understand the origin of these sinkholes.
- V. Determine the type of sediments and the subsurface layering, including its depth and thickness.
- VI. Generate the geological model of laying sediments of the study area.
- VII. Pinpoint air-filled karstic voids or cavities present in the subsurface.
- VIII. Understand if this study region and its sites will create any probable threat for construction projects in the near future.
- IX. The effects of climate change on the study region.
- X. The important elements, which play major roles in the environment change and the development of karst phenomena and the dissolution process after the global flood and led to the increasing of, carbonate karst features in the Sungai Perak Basin.
- XI. The impact factors that arise together and play major roles in the causes of a global flood

(Noah flood) to happened. In addition, the geo-environmental Change that happens in Sungai Perak Basin, Peninsular Malaysia, between (3300 -3100) BCE.

3. LOCATION OF THE STUDY AREA

The study region located with a covered carbonate karst environment situated in Sungai Perak Basin (Kinta Valley). This study region includes three main study construction sites.

3.1 CONSTRUCTION SITE #1

This study construction site located at Taman Klebang Putra – Klebang Green to the north of Ipoh city (Kinta Valley). This site is located in the West flank of Kinta valley, situated over a high topographic area and a flat terrain of marbleized limestone rocks, covered with soil. It locates to the north of the main series and east of the Kledang series. It's positioned with GPS coordinates at latitude N 4°40' 47.86"- N 4°41'26.96"and longitude E101°05'55.68"- E101°06'21.6" as appeared in figure 2.

Figure 2: Location Map, Satellite images and land photograph viewing the location of the study site #1 on Klebang Putra, north west of Ipoh city, Kinta valley, Perak state, peninsular Malaysia

3.2 CONSTRUCTION SITE #2

This Construction site located at the Gunung Rapat region, the site is visible from the express highway from Simpang Pulai to Ipoh, about 5.0 km south-east of the city center. The site under study located within Kinta Valley and to the south of Taman Rapat Damai, it's positioned with GPS coordinates at latitude 4° 34' 17.34" N - 4° 34'25.5"N and longitude 101° 08' 35.7" E -101° 08' 29.46" E, as appeared in figure 3.

Figure 3: Location Map, Satellite images and land photograph viewing the location of construction site #2 in Gunung Rapat, Kinta valley, Perak state, peninsular Malaysia

3.3 CONSTRUCTION SITE #3

The study region is located at Sungai Perak Basin (Kinta Valley) and the study sites located at place called Kampung Kunsila estate, east of Kledang series, as shown in (Fig. 4), with GPS coordinates of latitude N 4°23' 44.16" - N 4°23'56.88" and longitude E101° 07' 52.46" - E101° 08' 6.78". It is situated northwest of Kampar and south of Ipoh, the capital of Perak, Peninsular Malaysia. Figure 4 viewing the location of the study area in land use map, satellite image, and land-photographs.

Figure 4: Location Map, Satellite images and land photograph viewing the location of study site #3 in Kunsila estate, North West of Kampar City and south of Ipoh City the capital of Perak state

4. GEOLOGY OF THE STUDY REGION

4.1 LIMESTONE OF KINTA VALLEY

Kinta Valley, located in western Peninsular Malaysia, forms a V-shaped valley open to the south and bounded by the granitic massif of the Main Range to the east and of the Western or Kledang Range to the west. The granite that forms the mountains has dated to the Triassic age Cobbing et al, (1992). Kinta Valley karst has made up of steep-sided limestone hills that stick out above enormous floodplain with moderate rolling hills of metasedimentary rocks.

The plain has enclosed by alluvium with variable thickness and underlain with rugged and jagged subsurface limestone platform. The limestone hills are the remnants of extensive limestone beds, which are part of large Palaeozoic carbonate platform complexes that covered parts of South-East Asia. Paleozoic limestone outcrops are scattered intermittently throughout Peninsula Malaysia.

Geologically, most of the study area is underlain by Kinta's limestone, whose origin was pinpointed to be somewhere between the Devonian to Permian periods, Suntharalingam (1968). The original limestone beds of Kinta valley, presumed to be Carboniferous, Ingham & Bradford (1960) and Hutchison (2007) or possibly Permian in age, Fontaine (1995) have been severely eroded and karstified.

Deposit more than 250 million years ago and buried to great depths, lithified and eventually brought to the surface by tectonic forces, presumably in the Mesozoic, the Palaeozoic limestone of the Kinta Valley has exposed to a humid tropical to equatorial climate for very long periods of time, which slowly dissolves the limestones. The hills are the only remaining visible part of the Palaeozoic limestone layers underlying the Tertiary to Recent alluvial deposits over the entire expanse of Kinta Valley and beyond.

The limestone of Kinta Valley overlay extensive younger granite bodies, which affects the texture and composition of the limestone via contact metamorphism at the time of granite intrusion, dated as originated from the Triassic age Cobbing et al (1992). Initial observations reveal that the degree of metamorphism of the limestone varies from hill to hill, from low (practically intact limestone) to high (limestone entirely turned to marble). Most of the Kinta Valley limestone has undergone contact metamorphism from Sungei Siput in the north to Tapah in the south. The less metamorphosed limestone is located in the northern part of Kinta Valley.

Active tin mines have covered the subsurface karstic bedrocks up to 20 m. Only 30% of limestone in Kinta valley occurs as limestone hills, while the rest are subsurface karstbedrocks, Muhammad, R. F. (2003). Rivers from the two highlands provide an uninterrupted supply of allogenic water to the foot plain and consequently create wet and swampy conditions. Studies using Micro Erosion Meter give the assessment of limestone deprivation rates for standing water, running and under the sub-aerial condition and the values are 224 mm/ka, 369 mm/ka and 134 mm/ka, Muhammad, R. F.(2002) correspondingly.

The surface geology of the Ipoh region is well documented by, Yin, (1976); Ingham, & Bradford (1960). The limestone bedrock in the area rises above the alluvial plains to form limestone hills with steep to vertical slopes (Mogote or Tower karst). Granitic uplands are flanking the limestone of the valleys on the eastern and western sides. This geologic setting has given rise to alluvial deposits rich in tin content. Therefore, it is getting on the growth and development of the area as mining towns since the last century.

The subject of foundations in limestone was one of the main subject matter in many studies. A review of borehole data by Tan (1988) showed that the depth of limestone bedrock in the Ipoh area is generally less than 20 m. The review of the borehole data showed the size of the cavities in the limestone bedrock, were mostly < 3 m across.

Yassin, R., R. (2009;2010), applied of Electrical Resistivity Tomography (ERT) geophysical technique in several construction sites of housing complex and shopping mall projects in Perak state, pointed out that the depth of marbleized limestone bedrock rugged and jagged or uneven contains numerous Pinnacles and Gutters. The depth marbleized limestone bedrock ranging between 3.0m to more than 28.0m in the same site. Furthermore, he pointed out that the overburden layer has comprised of alluvium deposits and/or with tailings of mines in some locations.

4.2 LITHOLOGY OF THE STUDY AREA

Kinta Limestone named after Kinta Valley in Perak. It has believed that the age of the Kinta Limestone is Silurian to Middle Permian, Lee (2004).

The lithology of the Kinta Valley had made up of four main types, each producing a different landscape, they are:

1. Carbonate rocks forming Kinta Limestone in which has been going through tropical karstification to form steep-sided tower and cockpit towers protruding across the enormous plain.
2. Granite bodies of the Main Range and Kledang Range (series), that flanks the plain in the east and west respectively were forming rugged ranges of up to 1000 m above mean sea level.
3. Schist, which made up the rolling landscapes of the Kinta Valley.
4. Quaternary alluvial deposits that have extended across the valley and formed an enormous plain.

The limestone in the study area is always calcitic, granular and homogeneous though some dolomite and mica do occur in some places. The Silurian to Lower Devonian rocks mainly are pure cream-colored dolomite, while the lower to upper Devonian rocks consist of massive grey recrystallized calcitic limestone.

The Carboniferous rocks here mainly are thin-bedded grey recrystallized calcitic limestone with dolomitic beds and also pyritiferous black shales and argillaceous sandstone, Lee (2004). The Permian rocks of Kinta Limestone consist of grey to black crinoidal limestone overlain by impure carbonaceous brachiopod-polyzoan limestone. Besides, grey to white bioclastic and fusuline limestone overlain by biothermal limestone, Lee (2004).

The depositional environment of these Paleozoic units is in shallow marine shelf carbonate build-up with shelly flanks. The limestones found in this area are restricted and most of its metamorphosed to marble, Lee (2004).

The Kinta Valley Schist found underneath as well as interbedded with the limestone. Its age is probably shorter and most of it could be older than Devonian. The limestone and schist have probably folded about the end of the Permian. These have also metamorphosed at the same time forming mainly the quartz-mica schists and the fine to medium to coarse-grained white to dark-grey calcitic marble and some minor black and reddish colored dolomites. The GIS geological map of the Perak state displays the lithology of the study region (Kinta Valley) in figure 5.

Most of the limestone has found beneath the general surface covered with the tin-ore bearing alluvium for which the Kinta Valley is famous. The (Mogote) or isolated residual limestone hills that are seen along the valley constitute less than 10 % of the actual surface limestone in Kinta Valley, Muhammad, R. F. & Yeap, E.B. (2003).

The study area has limestone caves due to the surrounding karst formations especially the Tempurung Cave that is the largest and deepest in Peninsula Malaysia. The limestone hills extend 20 km north of Ipoh and 20 km to the south. There are many caves in these hills; cave temples are built in some of these caves such as Kek Lok Tong Perak cave near Gunung Rapat south of Ipoh city. And others is a show cave open to the public such as Gua Tempurung near Gopeng south of Ipoh city, Salim, S. (2009).

The outcrop of limestone hills can found widespread in the eastern part of the study area. These limestone hills of Silurian to Permian age that mostly metamorphosed to marble. Limestone hills found have covered by a huge amount of vegetation.

The limestone bedrock in the area rises above the alluvial plains to form limestone hills with steep to vertical slopes (Mogote or Tower karst). Flanking the limestone on the eastern and western sides of the valleys are granitic uplands. This geologic setting has given rise to alluvial deposits rich in tin content – hence, the growth and development of the area as (mining town) since the last century. The eastern part of the area was made up of limestone hills of Silurian to Permian age that mostly metamorphosed to marble. Limestone hills found covered by a huge amount of vegetation. The outcrops of limestone hills can found widespread in the eastern part of the study area.

Yassin, R. R., have shown that the surface was cover with red layer of lateritic clay with different thickness from site to another, between (1.0m -1.25m), (2.0m - 5.0m) and maximum (6.0m - 9.0m), containing different size of granite rocks and minerals are mostly between the size of (0.5cm-1.0cm). This red cover layer returns to the period of global flood (3300-3100) BCE. Under this layer very thin layer of carbonaceous deposits of few centimeters, after that came the different layers of soil.

Figure 5: TheGIS geological map of Perak state display the lithology of the study region (Kinta Valley)

5. CARBONATE KARST TERRAINS

Karst in carbonate terrains is a type of landscape found on carbonate rocks (limestone, dolomite, marble), and is characterized by a group of landforms, including an extensive range of closed surface depressions, underground drainage well-developed system, and a lack of surface streams Cooper, A. H. et al. (2011). Limestone or dolomitic carbonate karst terrains are generally active and diverse in characteristics and exhibit low solubility, high mechanical strength and in some cases, low ductility. The dissolution process happens very slowly; a few millimeters could be dissolved within a hundred years, which has the potential to create a cavity of 1 m or more across in more than a hundred years. Its highly irregular depths of bedrock, residual red clay-rich soil, and surface drainages usually characterize the carbonate karst terrains, which fade away in the underground.

Karst develops on soluble rocks, both at the surface and subsurface, due to the rate of dissolution processes that work in rapidly developing limestone rocks. This depends on a number of factors, such as the power of rainfall, availability of surface water, and its form of reviving as well as groundwater. Other factors include the distribution of soil-cover, temperature and biological activity, diffusion rate, autogenic content, structural weakness and lithology of the carbonate sub-layers.

Most sinkholes in carbonate karst rocks have formed via the dissolution processes with acidic water, which occurs when rainwater absorbs carbon dioxide from the air and decomposing organic material in the soil. It becomes more acidic and penetrates into the cracks, which dissolves the rocks. Carbonate karst can be a part of the global carbon cycle, in which carbon has an exchange between the atmosphere, surface, underground water and the carbonate minerals. The dissolution of carbonates via the presence of acid in water combines the carbon derived from the rock and from dissolved CO_2 as aqueous HCO_3^- .

The deposition of dissolved carbonate minerals has accompanied and usually generated by the release of some of the Carbon as CO_2 . When the bedrock is water-saturated, the dissolution continues along the bedding planes through the horizontal cracks between rock layers and joints, or fractures in the rock itself. These conduits enlarge over time, and the water moving by means of combination of gravity and hydraulic pressure will further enlarge the conduits via a combination of dissolution and abrasion of the surrounding rocks. The

communication varieties among chemical, physical and biological processes have a broad range of geological effects, including dissolution, precipitation, and sedimentation and ground subsidence. Diagnostic features such as sinkholes (Dolines), sinking streams, caves, and large springs are the result of the dissolution actions of circulating groundwater, which could dispersed to entrenched effluent streams.

Initially, most of the underground water moves by laminar flow within narrow fissures, which gradually become enlarge at or below the water table to form subsurface caves. Once a certain conduit-size threshold has exceeded, which is typically around 10 to 20 millimeters, the flow becomes turbulent. The caves contain a variety of dissolution features, sediments , and Speleothems (deposits with various forms and mineralogy, chiefly calcite), all of which may preserve a record of the geological and climatic history of the area, surface and subsurface, due to the solution and associated processes.

Most of the sinkholes have created on soluble carbonate rocks (marble, limestone and dolomite) because of greater dissolution related with the difference in composition. The sinkholes developed at both the surface and subsurface are due to the solution and associated processes.

6. PAST EFFECTS OF CLIMATE CHANGE IN THE DEVELOPMENT OF KARST PHENOMENON IN KINTA VALLEY:

There are number of important elements that play major roles in the development of the karst phenomenon in the Sungai Perak Basin (Kinta Valley). These elements were working together under several conditions in the geologic past. The karst in the Sungai Perak Basin has developed under the following conditions:

- The situation of tectonics activities during the past period.
- The variables of climate conditions throughout the past periods from ice age to humid tropical to seasonal savanna and then arid seasonal.
- The conditions of water supplying, from rainfalls, isconstant in most of the seasons.
- The conditions of the flood plain in Kinta valley such as an area with fluvial activities and the availability of large amounts of allogenic water passing through the subsurface limestone rocks.

The limestone of the Kinta valley has affected by intense fracturing. Several lineaments have recorded, and their main orientation appears to be in the NNW-SSE, the vertical and sub vertical joints and faults in the marbleized limestone provide the main lines of the weaknesses zone, by Yassin, R.R. (2012) as shown in Google terrains map, figure 6.

Several geologists have suggested that major karstification controlled by the structures in the areas when it has occurred. The structural geology of the limestone in the Kinta valley region have controlled by faults and folds that oriented in the direction of NNW-SSE. It gives noticeable grains to the landscape especially to the orientation of isolated, steep-sided and residual hills (Mogotes). Which are composed of either limestone, marble, marbleized limestone or dolomite and surrounded by nearly flat alluvial plains that locate in the central part of the Kinta Valley.

The subsurface karst has characterized by the formation of rounded top or sharp rock head pinnacles and irregularly shaped sinkholes that had previously referred to as (Dolines). One important aspects of the subsurface karst in the study region particularly in Kinta valley is the presence of one or more concordant levels of the rounded top pinnacles that had referred to as plat forming levels.

It is believed that the sub-surface karst is developed below a cover alluvial sediments during the geologic past Yeap (1998); Dian (1996). The opinions that, the early stage of pinnacle development is due to the differential resistance of physical weathering of the rocks and the role of geological structures (bedding planes, joints, faults, etc.) lead to the formation of pinnacles under the cold climates of Tibet to developed.

Figure 6: Google terrains map shown several lineaments have recorded with main orientations appears to be in the NNW-SSE, the vertical and sub vertical joints and faults in the marbleized limestone provide the main lines of the weaknesses zone, by Yassin, R.R. (2012)

The researcher, be certain of; that most of the biggest caves and channels in the marbleized limestone of Kinta valley is due to the reaction of sulfuric acid (H_2SO_4) with carbonate rocks this can also be one of the corrosion factors in karst formation. This mechanism could also play one of the major roles that in the past the water from precipitation, deluge and surface waters was O_2 -rich seep into the ground, brings oxygen that reacts with sulphide present with Cassiterite into the ground surface of Kinta valley area. The oxidization of sulfide is leading to the formation of sulphuric acid. Sulfuric acid then reacts with calcium carbonate causing an increase of erosion within the limestone formation.

The cover layers of alluvial deposits over marbleized limestone of Kinta valley contains soil pipes or channels features. The Tin (Cassiterite) was accumulated in these alluvial channels or pipes having been washed down from the granite ranges and carried by rivers as mentioned previously, which contain Sulphuric in its chemical deposits, have a large impact on the quick dissolving process of carbonate rocks and development of karst phenomenon.

The satellite images show that numerous limestone hills exposed over the valley which effected by the dissolution process of the water within geological time. Two groups of tower karst define depending on the complexity of their forms, which are composed of either limestone, marble, marbleized limestone or dolomite and surrounded by nearly flat alluvial plains in the central part of the valley.

The depth of limestone with few meters from the ground surface can be identified from the depth of pinnacles that determined in ex-mines and sinkholes that distributed in the study area, figure7.

Figure 7: Pinnacles identified in ex-mines and sinkholes that distributed in the study area presenting that the depth of limestone with few meters from the ground surface

The (cockpit tower) or isolated tower with the steep-sided walls are separated from other hills and contain a single peak represent the remnants of much larger hills that had dissolved away by mainly meteoric water which percolates vertically or subs vertically through the joints or faults. The steep slopes in the tower and cockpit in the tropics formed due to the collapse of the walls. The other type is the (complex tower) that consists of one group of hills with a few peaks and is partially separate from one another by a sinkhole. A further type is the Cone - shape capped by steep-sloped tops of carbonate rocks with gentle slopes from almost the top of the hill to the bottom.

The cockpit towers and isolated towers, the complex towers and cone- shape towers with the steep-sided walls in the study area presenting in figure8.

The researchers believe that this basin mostly filled with water until the mid-division of the Holocene era (the period that follows the last glacial period) around (11500-11000) BCE. Probably is due to the result of predictable changes in the Earth's orbit that provided more solar radiation to the Northern Hemisphere, tending to cause greater heating at that time and cause (the end of the last glacial period) due to a sudden warming of the climate that includes a relatively rapid melting of the ice sheets.

In the early division of the Holocene era, ice sheets melt caused to a sudden rise to world sea levels led the sea to induce the flood that leading to a certain extent catastrophe. Sea levels have risen considerably submerging a large portion of the seashores including the major of (Malaya lands). However, ice melt caused world sea levels to a rise in the early division of the Holocene era and continued to rise till mid division between (6000 - 4000) BCE, through that submerging (Sunda Shelf), low coastal plains and deltas resembling the (Chao Phraya delta) in Thailand.

Furthermore, it submerges the (Mekong delta) in Vietnam, (Sathiamurthy E; Voris H K, 2006). Then afterward between (4000 - 3500) BCE, the sea level becomes 5.0m high from the present- day causes huge disturbances to the seas and tidal waves that run onto the land. These events all happened before the global flood.

Baumgrander, J. (1990a; 1990b; 1994); Austin et.al. (1994) proposed that due to an increase in seawater level, all the original lithosphere became subducted; the rising magma from the hot spate will raise the ocean floor.

Figure 8: The cockpit towers and isolated towers, the complex and cone - shape tower hills that are composed of either limestone, marble, marblized limestone or dolomite and surrounded by nearly flat alluvial plains in the central part of the valley

Due to the El Nino cycle that connects to a spate of undersea quakes and lava eruptions as reported by Walker, D. A. (1994), which has proposed a connection between underwater earthquakes and the incidence of El Ninos. If the volcanic heat were to reach the ocean surface, this would warm the air surrounding it and could generate an El Nino Southern Oscillation (ENSO) event. Scientists reported now a day that the effect of lava eruptions and a spate of undersea quakes had led to the start of the El Nino cycle. The seismic activity was the most unusual it had been in 30 years and apprehensively linked it to El Nino. Some of the under studies records of the past climate variability across the tropical Pacific Ocean, either due to the changes in sea surface temperature (SST) or due to the exposed changes in the frequency and intensity of individual El Niño events through time, Shulmeister & Lees, (1995); McCulloch, et al. (1996); Gagan, et al. (1998); Fontugne, et al. (1999); Sandweiss, et al. (2001); Tudhope, et al. (2001); Andrus, et al. (2002); Koutavas, et al. (2002); Moy, et al. (2002); Riedinger, et al., (2002); Cole, et al. (2003); Loubere, et al. (2003); Stott, et al. (2004); Carre, et al. (2005); Rein, et al. (2005); Lea, et al. (2006). Their studies indicate that the frequency and the intensity of (ENSO) have varied through the Holocene. The majority of these records suggest that ENSO frequency has significantly reduced during the early to mid-Holocene, and there was an increase in frequency for a while in the last few thousand years of Holocene.

The researchers believe that there are many impact factors that cause the global or the great flood to happen, started during the period of between (3500 - 3000) BCE and mostly between (3300-3100) BCE (according to recent recalculation for the period (archeology and geological study of the main flood region, Yassin R. R. (2006).

In the following, some of the impact factors that arise together and playing the major roles in causing the global or the great flood to happen, and then cover the study area in Kinta Valley, Peninsular Malaysia and all other parts of the planet earth :

6.1 THE PRIMARY IMPACT FACTOR; MASSIVE METEORITES AND COMETS HIT THROUGHOUT THE PLANET EARTH

The primary impact factor is due to hit or bombarded throughout the planet earth heavily with massive meteorites and comets and smashes into the flat planet earth surface as shown in various satellite images taken of the planet earth. The geological structure formed due to that

named (Terrestrial Impact Craters). This happens due to giant cosmic electric lightning hit and sculpting the surface of planet Mars and push the rocks to fall to the direction of planet earth. Another scientist from NASA believes that the origin these meteorites are the Kuiper belt. The masses meteorites and comets that hit the surface of flat planet earth in the Holocene period between (3300-3100) BCE display in figure 9-A.

Figure 9-A: Display the masses meteorites and comets that hit the surface of flat planet earth in Holocene period between (3300-3100) BCE.

This impact might lead to activate the movement over the faulting zone in some places of earth crust and consequently, it has led to happened intense sets of fracturing. The authors believe that the collision of these large asteroids or comets that hit the surface of flat planet earth at the Holocene period between (3300-3100) BCE, contributed in shock metamorphic features named ring -like structures or Terrestrial Impact Craters.

The collision of these masses meteorites and comets have an impact on the events of environmental catastrophe and climate change to happen.

Several of known impact craters on planet earth are with small size; the well-preserved craters are an extremely important resource for understanding the impact phenomena. Earth's impact craters also provide important data currently available to extensive geological, geophysical and geochemical study and on the structure of such landforms in all three dimensions, Grieve, R. A. et al (1988).

Since the 1960s, several studies have revealed another physical marker of impact structures, shock metamorphism. Certain shock metamorphic effects have shown to be uniquely and clearly associated with meteorite impact craters. No other earthly mechanism, including volcanism, produces the extremely high pressures that cause them. They include shatter cones, multiple sets of microscopic planar features in quartz and feldspar grains and high-pressure mineral phases. All known (terrestrial impact structures) exhibit some or all of these shock effects.

On the Earth, however, heavily impacted, craters continually removed by erosion as well as by volcanic rising and tectonic activity. About one hundred and twenty (120) terrestrial impact craters have been recognizing. The majority of it in geologically stable cratons of North America, Europe, and Australia where most exploration has taken place. The Spacecraft orbital imagery has helped to identify these terrestrial impact structures in more than isolated locations for further investigation.

The first-recognized terrestrial impact crater, the year 1920s Meteor Crater or Barringer Crater of the iron meteorite, was observed in Arizona, USA, It was discovered fragments of the meteorite impactor within the crater itself.

When celestial bodies tenth of meters or bigger in size, collisions with the earth, due to their high velocity (average impact velocity is 25 km per second), had a kinetic energy equivalent to that contained in approximately fifty megatons of TNT. Upon impact, the bulk of this energy transferred to the target rocks, leading to both the excavation of a crater and the production of diagnostic shock metamorphic effects, Grieve, R. A. et al (1988).

Some of the Impact Craters due to collision of masses meteorites and comets that hit the surface of flat planet earth at the Holocene period between (3300-3100) BCE is display in various satellite images in figure 9-B.

Figure 9-B: Display the satellite images that shows some of the impact craters due to the collision of masses meteorites and comets the surface of flat planet earth at the Holocene period between (3300-3100) BCE

Several other relatively small craters were also founds contain remnants of impactor fragments. These remnants only accepted as evidence for impact origin. In the Western parts of the main global flood area (Iraq), Tenth of this terrestrial impact structures or rings like structure are developed into circular and oval depressions called (Faidhah), with different sizes. Some of the terrestrial impact structures interpreted by geophysicists in their study and gives the names of (rings like structure). However, scientists have come to realize that pieces of the impactor often do not survive the collision area undamaged, due to the excavation process. In massive events caused by a large impactor, great pressures and temperatures are generated that may evaporate the meteorite altogether or may completely melt and mix it with melted target rocks Yassin, R. R. (2006; 2009). Any detectable meteoritic through the several thousands of years possibly eroded away. Some cases, the presence of the remaining large quantity of (**Siderophile non-terrestrial elements**) can be detected in the impact melt rocks within large craters and it signifies a chemical signature of the meteorite collision.

The archeological study of the global flood in the Sumerian text (Gilgamesh flood myth) in the Epic of Gilgamesh, which articulates that the planet earth attacked by non-terrestrial heavy rocky storms for 7 days frequently, before the approaching of the black smoke and darkness, Yassin, R. R. (2006; 2009).

The Impact craters divided into two groups based on morphology:

- Simple craters
- complex craters

On the planet Earth, the basic types:

Simple craters are relatively small with depth-to-diameter ratios of about 1:5 to 1:7, up to 2.0-5.0 km in diameter, with a smooth bowl shape uplifted and overturned rim rocks, surrounding a bowl-shaped cavity. Simple crater forms are typical of structures with rim diameters of less than about 4.0 km; central uplifts, shallow floor depths.

In larger craters, however, gravity causes the initially steep crater walls to collapse downward and inward, forming a complex structure with a central peak ring and a shallower depth compared to diameter (1:10 to 1:20). The diameter at which craters become complex forms depends on the surface gravity of the planet: The greater of the gravity, is the smaller the diameter that will produce a complex structure.

Slumped rims characterize complex craters with diameters larger than about 4.0 km. The surface expression of the central uplift is typically a single peak in craters with diameters between approximately 4.0 and 50 km. larger impact structures can have complex ring-shaped uplifts. Complex impact structures and basins, generally 3.0 km or more across, with a distinct central uplift in the form of a peak and/or ring, an annular trough, and a slumped rim.

The central peak ring of the complex crater formed as the initial (transient) deep crater floor rebounds from the compressional shock of impact. The slumping of the rim further modifies and enlarges the final crater. Complex structures in crystalline rock targets will also contain coherent sheets of impact melt upon the shocked and fragmented rocks of the crater floor.

On Earth, this (transient) diameter is 2.0 to 4.0 km (depending on target rock properties); on the Moon, at 1/6 at one-sixth Earth's gravity, the transition diameter is 1.50 to 2.0 km (0.93 to 1.24 miles), Grieve, R. A. et al (1988).

Geologically, on the active earth surface, this complex crater, weathering, and erosion of the target rocks quickly alter the surface expression of the structure. Despite the crater's preliminary morphology is, crater rims and ejecta blankets that are quickly eroded, and concentric ring structures can be formed as the weaker rocks of the crater floor are removed. While on the non-active lunar surface, this complex crater form and will be well preserved until the subsequent impact events alter it.

The large size of impact craters are requires orbital imagery and observation to provide a view of their structure and large-scale geologic situation. Photographs with various look angles, fields of view, and sun angles are all potentially valuable.

Aerial photographs that took under the low sun angles mostly useful for delineates the subtle structural and geomorphic features. The extra resistant rocks of the melt sheet could left as plateaus overlooking the surrounding structure. Large terrestrial impacts are of greater importance for the geologic history of our planet. The satellite images survey in Malaysia for these impact craters, not successes to find these craters, due to past high mining processes in the land by chines and Japanese led to excavate all these craters.

6.2 THE SECONDARY IMPACT FACTOR; THE WEAKNESS ZONE IN THE AREA OF PACIFIC RING

The secondary impact factor is due to the weakness zone in the area of the pacific ring and due to an increase in seawater level. This pushes down the lithosphere (ocean floor). Consequently, causing it to sinks under the underlying mantle, due to high pressure. Because of this, the mantle will be a squeeze. This in turn leads to the rising up of magma and then released from the entire hot spates through the catastrophic ruptures and covered the entire

ocean floor. Thus, it will grow and rise up and causing the water of the Pacific Ocean to heat up and the sea level to increase.

The energy required to bring the entire of the Earth's oceans to boiling without a change of state is calculated to be (5.33×10^{26}) joules. Magma is a complex silicate mixture, of high-temperature and a fluid substance. Temperatures of most magma when it first released from a volcanic vent, called lava, can vary between the range 1300 °F to 2400 °F or 700 °C to 1300 °C.

The release of heat from magma is enough to boil off all the water of the Pacific Ocean and cause enough water vapor to produce more than (150) days of precipitations. That was the response to heavy rainfall in mid-Holocene round the world in the period about (3300-3100) BCE. Moreover, that is one impact factor led to the global flood (Noah's Flood) to happen. The rainfalls led to sea level getting higher again and hit Malaya land, covering all Kedah land and Kinta valley area. Due to heavy rains that have deeply eroded and washed both the highest mountains of granite ranges and the high lands around the Kinta valley, and new canyons and rivers formed.

The rising of magma with greater viscosity covered the ocean floor, causes ocean water to heat up, expand, rise and boil off. The Vapors produced from ocean boiling was enough to cause more than 150 days of rain.

This is the hypothesis by the authors of how the global rain occurred, when the ocean in the area of the pacific ring boiled off all the water. The boiling point of water is 100°C (212°F) degrees at sea level. It is much greater deep in the ocean, the boiling point rises.

This is due to the increase in pressure. At sea level, the pressure equals one atmosphere. However, for every 10 meters deep, the pressure increases by one atmosphere. At depth of (10) ten meters, the pressure would equal (2) two atmospheres. The hydrothermal vent is about 2500m-2600m deep. The pressure here would equal (250 -260) atmospheres. For ocean (saltwater), the boiling point is further raised, and the melting point lowered. For a 0.5 molar solution of salt, there is a 1.0 molar concentration of ions. The boiling point is raised by 0.5 degrees Celsius for water with 29.2 grams of salt dissolved in each kilogram (kg) of water.

Base on the equilibrium relationship between boiling point and pressure, reducing the pressure causes water to boil at lower temperatures than normally at sea level. Hence, 100°C (212°F) +/-, due to the salt content. Moreover, deeper down the pressure makes it boil at a higher temperature.

The boiling point will be raise by about 0.5°C for each 30 gram/kilogram of salt/water. Salts like NaCl, KCl, LiI, Sr, Br etc., thus the boiling point of the ocean must be greater than the standard boiling point of water. That number may perhaps start at 100.556°C (213°F) to boil off the ocean water in ring of fire. However, then the salinity would increase. It has required a definitive temperature of 107.778°C (226°F) → 110°C (230°F) to reach the state of saturated brine. Energy depends on the measurement system and characterized with many unit types, defined, as the amount of energy (heat) needed to increase the temperature of one gram of water by 1°C.

The Specific heat is a physical property of a material used to describe the heat transfer. It's defined as the amount of energy needed to heat one gram of the substance by 1 degree Celsius. The amount of heat needed to increase the temperature of any object can figure by using the relationship below:

Heat in calories = mass in gram x temperature change °C x specific heat (Cal / gram °C).

The formula has four terms in it and can calculate any of the term when it has the other three. (This is hypothetical demand enables projection to see if it is even possible. Theoretical calculations of many calories needed to heat up and boil the ring of fire in the pacific oceans, from temperature at 4°C to 110°C).

The unit of Specific heat = calories / grams °C.

The specific heat for water = 1 Cal / g °C.

Temperature change in degrees °C = T final - T initial = 110°C - 4°C = 106°C

At the bottom of the pressure over 1000 times than the standard atmospheric pressure, at sea level. The water column above employs a pressure of 1086 bars (15750 psi). At this pressure, the density of water has increased by 4.96%, the same mass as 100 liters at the surface making 95 liters of water under the challenging deep pressure. The temperature of the water at the bottom of the ocean is 1 to 4 °C.

1 Cal = 4.184 J, kilocalorie (kCal) = 4184 J kilojoule (kJ)

KJ = 1000 J, 1000 Cal = 4184J

Joules 1 J = 1 kg m² s⁻²

Sea water is a fluid with temperature of (25°C) and Specific Gravity (SG) = 1.027

To boil the water oceans, need to change the total energy of a substance (Water), by using of a few numbers to a raise the temperature of 1.0 kg of water from 4°C to 110°C.

To raise/lower (Water) temperature:

$$\Delta E = C_p M \Delta T$$

Where:

ΔE = change in energy

ΔT = temperature change

M = mass

C_p = specific heat

To change its state:

$$\Delta E = LM$$

L = latent heat

Energy must add to increase the temperature, to change the state, to evaporate it.

$$C_p^{\text{water}} = 4.2 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$C_p^{\text{steam}} = 2.0 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$$

$$L^{\text{vaporization}} = 2.3 \times 10^6 \text{ J kg}^{-1}$$

$$\Delta E = C_p^{\text{water}} M \Delta T + L^{\text{vaporization}} M + C_p^{\text{steam}} M \Delta T$$

E = energy to heat water to boiling point + energy to change state + energy to raise temperature of steam

Where; M = 1 kg

$$\begin{aligned} \Delta E &= (4.2 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}) (1 \text{ kg}) (106^\circ\text{C}) + (2.3 \times 10^6 \text{ J kg}^{-1}) (1 \text{ kg}) + (2.0 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}) (1 \text{ kg}) (106^\circ\text{C}) \\ &= 2.9572 \times 10^6 \text{ J (it's the energy to boil 1 kg of the ocean water then change the state to the steam)} \end{aligned}$$

The temperature of magma when erupted = 1300°C

Melting point 1200°C

Temperature of sea water = 0°C - 4°C

In total, one kilogram of molten basalt at a temperature of 1350 °C releases 2.190 million joules of heat into the surrounding atmosphere.

The Basaltic magma releases 1,000 joules (per kilogram per degree Celsius) of heat energy for every degree it cools until it transforms into a solid.

$C_p \text{ magma} = 1.0 \times 10^3 \text{ J kg}^{-1} \text{ }^\circ\text{C}^{-1}$

A kilogram of **molten rock** at 1350 degrees Celsius, therefore gives off 250,000 joules of heat as it cools to its crystallization temperature of 1100°C. Passing through that phase from liquid to solid, that kilogram will releases another 400,000 joules of heat.

Then as the solid rock cools from 1100 °C to 0C°, it releases another 1,400 joules per degree, or 1,540,000 joules.

(Multiplying the weight of a cubic mile of lava by the heat energy released per kilogram and we find that a sized underwater).

Sized underwater = (the weight of a cubic mile of lava) x (the heat energy released per kilogram)

1cubic meter =1000 liters

1 Cal = 4.184 J

1mile =2.58999 km²

1 mile = 5280 ft., so (1 mile) ³ = (5280 ft)³

1.00g = 8.30 gal

1cubic meter = 1000 liter

A cubic mile of molten rocks converts to 4.186 billion cubic meters. At a density of 3,000 kilograms per cubic meter, that much molten rock works out to be approximately 1.25 x 10¹³ kg.

The Underwater eruption releases 2.739 x 10¹⁹ joules of heat into the sea.

The geologic record includes roughly 8 x 10²⁴ grams of lava flows and igneous intrusions.

Assuming this magma would release 5.4 x 10²⁷ joules while cooling 1100 degrees C.

In addition, **(the heat of crystallization)** as the magma solidifies would release more heat 5.6 x 10²⁶ joules; **(it is enough to heat the oceans to the boiling point).**

Its seams there is **two types of heats have release from the magma:**

- The first type has release from magma eruption
- The second type has release, while the magma is cooling, then this will lead to (vaporize the ocean water completely).

The idea of the way that magma rising up and released from all the hot spate through the catastrophic ruptures and cover the entire ocean floor which consequently leads to the growth of the ocean floor and raised up causing the seawater levels to increase. the idea of the way that magma rising up and released from all the hot spate through the catastrophic ruptures and cover the entire ocean floor present in figure 10.

Figure10: Sketch display the idea of the way that magma rising up and released from all the hot spate through the catastrophic ruptures and cover the entire ocean floor

6.3 THE THIRD IMPACT FACTOR; MEGATHRUST EARTHQUAKE STRUCK THE PACIFIC OCEAN

The third impact factor is that Megathrust Earthquake struck the Pacific Ocean. At the same time as the magma raised up, the high pressures of the additional water cause (Megathrust Earthquake) with magnitude of (9) degree in the Richter scale struck the Pacific Ocean with size 400 -500 mile. Generated in the subduction zone of the Pacific Ocean and resulted in the creation of a huge tsunami with energy four times stronger than the tsunami that attacked Japan in 2011. Moreover, this energy carried with the waves reached the Atlantic and North America east coast within two days. The idea of how megathrust earthquakes and the Tsunami with magnitude of (9) degree in the Richter scale struck the Pacific Ocean. The researchers investigated many studies and researches between the years (2007 -2009) completed to the coastlines of the Arabian Gulf and Arabian Ocean.

Through the study of the core samples shown as the sea lay into the area also equal 4000 years much higher slightly than the propose period. Consecutively, perhaps the flood caused the normal production of (carbon-14) to extremely alter and look like a different, possibility as much higher than normal, or wildly fluctuating at the time of the Flood. The study proves that this area was a coastal line during the Holocene Period (3400-3200) BCE, and then it submerges with seawater. This lead the researchers to conclude that this area was hit suddenly by high sea waves during the Holocene period and gave the author strong evidence that a Mega Tsunami reached this region of the Middle East at the same time happened of the (**global rain**).

In addition, the other time period about (70 - 50) BCE, the geologists have found evidence that a megathrust earthquake happened at the West Coast of North America, and Tsunami hit the West Coast several times through the last 2500 years. The idea of how megathrust earthquakes and the tsunami with a magnitude of 9 degree in the Richter scale struck the Pacific Ocean present in figure 11.

Furthermore, fieldwork has done in the Middle East region, in Dora city, which located in the south of Baghdad capital of Iraq (**the center of the Mesopotamian Plain**). The fieldworks represent in the drilling of eleven (11) boreholes. The soil samples were collected and examined both mineralogical and paleoecological, through thin sections. Dinoflagellate of marine fossils origin found within a thin bed of 230.0 cm clearly indicated (the transgression of the Arabian Sea northward through Tigris and Euphrates valleys) or high marine waves reached to Baghdad, approximately between 5000-3000BCE, Almashaiky A. D.(2009).

Figure 11: sketch shown, the idea how the megathrust earthquakes and the tsunami with a magnitude of 9 degree in the Richter scale struck the Pacific Ocean

This means that the marine sediments were also an additional source of the Mesopotamian Plain. Three specific climatic features identified via paleoecological interpretation; The Wet climate period, extended from 10000 to 3500 BCE.

- Followed by Dry period, extend from 3500 to 3100 BCE.
- Moreover, the last climatic feature characterized by oscillation of wet to dry periods that is dominant since 3,000 BCE until now.

Additionally, through the archaeological investigation projects, that applied magnetics and electromagnetic techniques (1999-2000). Found that many archaeological sites in the Middle East (**the main area of global flood**) consist of various villages were submerged underwater thinking in begging, that these villages submerged during the Global Flood (Noah's Flood) because it has covered with a thick layer of unconsolidated, material with different thicknesses varying in height, from (6m-8m-10m). After the digging operation, the observation found that most of the skeletons were still lays in different places of the structures. In addition, Small skeletons found inside big vases or pots, the considerations concluded that the second tsunami was happened between (75 – 50) BCE, and led to submerging all the entire cities of the Sumerian empire in the south and middle of Mesopotamian Plain. The seawater of the Arabian Gulf moved up and progression through both of the revers valleys in the area from the south to the north and lead to submerge the central part of Mesopotamian Plain.

6.4 THE FOURTH IMPACT FACTOR; OCCURRED OF ARTESIAN SPRING

The fourth impact factor is due to the heavy rainfalls, the sea level became higher. On the lands, after the earth surface materials saturated with heavy rainfalls, and then the water percolated through organic material in the soil to the aquifers. At the same time, artesian springs occurred because the underground water table level was too high and nearly reached the surface. These considerations concluded that the reservoir of water became more considerably in-fill since the high amount of rainfall that percolated was more than the size of the reservoirs within the rocks to store it and this was the fourth impact factor.

Due to the high water pressures in the aquifers, the water runoff from the underground aquifers and occurred erosions to the sides of the fissures (joints, fractures, and faults), and

widened it. Then released all the way through to the earth's surface and caused the water to flow out from the underground aquifers through spring waters that flowed from the ground and above to the air then fell on the ground surface and resulted in completing the flooding process.

6.5 THE FIFTH IMPACT FACTOR, WATER CAME FROM HIGH HEAVEN

The fifth impact factor is the rain waters that mixed with the water approached from high heaven due to; (**monster electric wind**) removed the oceans from planet Venus, planet Mars and there two satellites or moons, Phobos and Deimos. In addition, from planet Jupiter and their two satellites Io and Europa. In addition, approach from planet Saturn and its rings, from their two satellites Enceladus and Tethys. Besides, approach from planet Mercury located near the sun, but discovers that there are empty valleys over all the places, old lakes, and oceans on this planet.

The events that happened before found through the archeological studies that discussed:

- First, by Sumerian in their tablets that found in the ruins of Ashur Banibal library in Nineveh, an ancient Assyrian city of Upper Mesopotamia, located on the borders of Mosul state, in the north of Iraq.

- Second, the authorized journeys of spacecraft to the planets in our solar system such as by Pioneer 10 and Pioneer 11 then Voyager I and Voyager II space crafts, in the years 1979, 1980, 1981. These space ships visit these planets and took numerous photographs for its.

In addition, the Sumerian discuss in there tablets, that planet Uranus and planet Neptun are watery planets. All those information has taken from the geological study of the main flood region, the archeological studies of Sumerian tablets, Sumerian Texts about the global flood and the authorized journeys of spacecraft to the planets in our solar system, Yassin R.R., (2006; 2009).

All those types of waters have to mix to complete the water of the flood. The floodwaters were rose up to cover all planet earth about 2000 ft. or 609.6 m high. The naked limestone hills and Tropical lifeless high tress have still seen from that period in the Kinta valley area, (the study region). Furthermore, from archeological study of the Sumerian texts about the global flood in (Gilgamesh flood myth) in the Epic of Gilgamesh, that all the human bodies and animals have melted in the flood water and become clay, this mean that waters which came from the space or high heaven and mixed with pacific rainwater, both of (**high acidity**).

After the volcanic activity stopped, there would be a transition period, the magma cooled down, the ocean floor lowered again, and the floodwaters began to recede. The climatic activity decreased and lesser affected the areas of the extreme north and south continents.

After a time there is a greatly increased moisture in the atmosphere, it is would return to frosty climates and theorized that a second ice age will result. It is clear that the topsoil is wetter soil corresponds to higher rainfall in mid- Holocene. This type of soil has washed due to the running off heavy rains and drains into the features (fractures, sinkholes, and cavities) in the lower layers of sand and can estimate the consideration that these features were formed due to the heavy rains in mid- Holocene. This was determined in electric resistivity tomography sections of the geophysical survey in Kinta valley by (Yassin, R, 2009; 2012) in most of the sites under survey. In addition, the survey determines that most of the soil found drained into the features under the covering layer. The authors believe that these features were difficult to proceed in Tertiary because of Miocene uplift tectonic movement and thick Tertiary limestone plateau that overlies by the sandstone.

The geotechnical survey in this research study recognizes; thin red cover that contains different sizes of granite rocks and minerals with thickness is mostly about (5.0cm -12.0cm). This red cover over a layer of lateritic clay with different thicknesses from site to another

between (1.0m -1.25m), (2.0m - 5.0m) and to maximum depth (6.0m - 9.0m) are mostly returns to the period of a global flood (Noah's Flood) (3300-3100) BCE.

The appearance of this red cover and the layer of lateritic clay is due to runoff of heavy rains that have deeply eroded and washed both the highest granite ranges around the Kinta valley and then carried away by the new rivers and canyons that formed due to the erosion. The thin layer of carboniferous organic material with different thicknesses of (3.0cm-5.0cm), (8.0cm-10.0cm) have seen beneath the lateritic clay. The thin red cover that containing different sizes of granite rocks and minerals over the layer of lateritic clay found covering different sites in Kinta valley present in figure 12.

Figure 12: The Red cover over the layer of lateritic clay containing different size of granite rocks and minerals found covering different sites in Kinta valley

For some time, the runoff floodwater and erosion continues, the seabed slowly settling down. The pressures of the additional water caused earthquakes and movements of the surface and the sea bottom resulting in both sinking and rising of land surfaces. Mostly this movement hit Malaya basin in the direction of (West - East and South West - North East) as shown in the figure 4, which found little lineaments in these directions, leading the water to escapes through the faults, fractures, joints, and cavities in the basin of Kinta valley and lead to widen it to become (**Sinkholes**).

In the main flood area and to the west direction of the flat planet earth, huge sinkholes have an opening depending on the thickness of the sedimentary layers. Afterward, many earthquakes movements occurred in the direction of (West-East) and (South West-North East) led to the developments of these sinkholes and creating them to swallow the greatest capacities of the floodwaters. New geophysical study (2014) in USA discovered that; huge size of reservoir contains massive ocean of water with three times the volume of all the oceans in the earth, hidden beneath the ground surface 700km., in the mantle toward earth core, in layers names as the transitional zone, mostly this water return to the period of global flood.

The lowest capacities of the floodwater have regression to gulfs and oceans. Afterward, the climate conditions changed from wetter to drier and the strong rainfall decrease gradually and the atmosphere starts to clear. At the same time as the effect of global rains become lesser and the seafloor, temperatures start to return to normal. The seawater regression progressively between 3100 BCE until 2700 BCE, and in 1000 BCE, the sea level becomes equal to the

present-day sea level based on the regional topography and bathymetry (Hanebuth, et al., 2000).

This evidence of the past events supports that the Kinta valley basin has in full with floodwater until the end of mid-Holocene. Besides, through the archeological study discovering that what they proposed before about (Perak old man) whose age some between (10000-5500) BCE. His Skelton has found in a small cave at mountain name; (Gua Gunung Runtuh), located in Lenggong area in Ulu Perak to the north of Kinta valley, and not found any indications for the living of Perak old man in the huge caves in the Kinta Valley (the study region).

Besides, archeological studies indicate that the seawater covers all Gunung Runtuh Mountain and in the west covers all Kedah land as mentioned before at the same time cover all Kinta valley from the south. This means that not all the humans' skeletons that live before the global floods have discovered. Because mostly of Giant humans origin and those skeletons that found in many graves returns to the period after the global flood in between (3100-2900) BCE, mostly from Indonesian origin. The reason that; the geological time scale that scientists put due to human origin theory by Darwin give a long period to the age of humans and not have confidence in global flood occurred, they believed it was just a legend.

Growth starts again from the roots and seeds that remain on the ground or near the land surface and the lands spotted with lakes and swamps. Thinlayer of peats from the organic remainshas found beneath the cover soil. The occurrences of spots of organic gray clay deposits give the considerations that the development of swamps and marshes in the regions after the flood. Several positions were identifying as a swampy areas from the spots of organic gray claydeposits presents in figure 13.

Figure 13: Land Photographs viewing several positions that identified as a swampy area from the deposits of organic gray clay

7. THE RESENT EFFECTS OF POLLUTION IN ENVIRONMENT AND CLIMATE CHANGE IN MALAYSIA AND SOUTH EAST ASIA

Air pollution is the phenomenon that contaminates the environments by particles in solids, in liquids and in gases. In Malaysia and other countries in Southeast Asia, air pollutions increased and led to an increase the amounts of liquefied carbon dioxide and other pollutants. The air pollution index (API) levels recorded the reading that ranging between (112 to 300) in the sky of various states in Malaysia peninsular.

Acid rainfall is one of the environmental problems in the world and in the Pacific region and Southeast Asia country. These areas with the highest acid rainfall, some of these countries have the most sensitive natural resources. Rainfall is the most acidic due to several factors such as human-caused (Anthropogenic) or natural (Non-anthropogenic).

The researchers investigated many studies on the acidity of the rainwaters completed by many researches in the last fourteen years. After that, they touch to the most authoritative conclusion that the heightening of the elevated of the acidity of rainwater in the last few decades in Malaysia and other countries in Southeast Asia is due to many impact factors that contributing to the increase of acid rain on these regions. These factor some natural (Non-anthropogenic), such as the climate, the geology, the topography of the area and air movements.

7.1 THE FIRST IMPACT FACTOR; THE INCREASE OF ACIDIC DEPOSITS IN BOTH DRY AND WET

In the twenty and twenty-first-century, scientists increase the study of acidic deposits in both dry and wet. It is a Tran's boundary nature and one of the most serious environmental problems that cause a variety of damages. Bowman, et al. (2002), Atmospheric acid deposition in the form of rain, fog or snow was identified as major environmental problems for the countries in East Asia.

Acid rain is the term widely recognized, for the precipitation that more acidic falls in the ground surface from the atmosphere. It is the result of multiple, complex chemical reactions in the atmosphere between emissions of polluting species or types such as sulfur dioxide (SO_2) producing from fossil fuels, fired power stations and smelters. Furthermore, Nitrous oxide (N_2O) producing from all types of motor vehicle exhausts with water and oxygen to produce corrosive substances.

Sulfur dioxide (SO_2) can react quickly with hydroxyl radicals in the atmosphere to produce (SO_3) which reacts with water to become sulfuric acid, or moved hundreds of kilometers with wind before reaction. Sometime, it is absorbing in clouds to become sulphuric acid via various chemical pathways to liquid phase. These chemicals converted to sulphuric acid and nitric acid in the atmosphere and can carried by the winds for many miles from where the original emissions took place then fall via precipitation, or alteration into the gas phase via evaporation.

Other chemicals contributing to acid rain include (volatile organic compounds, VOCs). These are carbon-containing chemicals that easily become vapors or gases. VOC sources include paint thinners and other solvents and burning fuels such as coal, natural gas, gasoline, and trees wood. Wet deposition occurs when the acid falls in rain, snow, or ice. Dry deposition is caused by tiny particulates in burning emissions that could stay dry and fall in the ground surface or polluted the cloud water and precipitation. Moist these depositions occur when the acid has trapped in the cloud. This is most common in coastal areas. Whatever its form, acid rain can create dangerously high levels of acidic impurities in seawater, rivers water, soil, and plants.

The acidity of acid rain solution is measure on a potential hydrogen (pH) scale numbered from zero to fourteen, with a pH value of seven considered neutral. The pH scale is a logarithmic measure. This means that every pH change of one is a tenfold change in acid content. A decrease from pH seven to pH six is a tenfold increase in acidity; a drop from pH seven to pH five is a one hundred-fold increase in the acidity, and a drop from pH seven to pH four is a one thousand-fold increase in the acidity.

Acid rain has a pH of less than 5.6 considered by Evans, (1984). The pure, distilled or refined water has a neutral pH of seven. Normal rainfall has a pH value of about 5.6 proposed Galloway et al. (1982). The pH of normal rainwater is acidic for the reason that the water

reacts to atmospheric carbon dioxide (CO_2) to produce carbonic acid (H_2CO_3). In addition, a small amount of nitric acid (HNO_3) responsible for the acidity of normal rainwater, which is produced during lightning, storms by the oxidation of nitrogen in the presence of water. It is slightly acidic because it accumulates naturally occurring sulfur oxides and nitrogen oxides as it passes through the atmosphere. The values higher than seven (7) are considered more alkaline or basic.

The values lower than seven are considering acidic. Low pH levels will kill many kinds of fish, their eggs, and the organisms (fish food). When the pollutants of giant smoke emitted into the atmosphere, molecules or particles of (SO_2) and (N_2O) have caught up in the dominant winds. A reaction will happen with O_3 in the presence of sunlight with vapors to form Sulphuric acid and Nitric acid fogs.

In the major high-Temperature conditions, it will be in vapor state. If the temperature drops, it will take the form of droplets, called (acid smut) which is black, unburnt carbon particles, acidic and carbonaceous in nature. The Natural sources of sulfate pollutants in the atmosphere include:

- The volcanic emissions
- The volcanic eruptions
- Ocean sprays and readily oxidized hydrogen sulfide, which is released from the decomposition of organic matter found in the Earth
- Sulfate pollutants from various industrial processes, Cullis, C. F. & Hischler, M. (1980), Such as the smelting of, iron Ore, Zinc Ores and Cuppers Ores
- The manufacturing of sulphuric acid concentrators in petroleum industries

The natural sources of nitrogen or nitrates pollutants in the atmosphere include:

- The (biological processes) produced by Microorganism in the soils.
- From the lightning during thunder storms
- Volcanic eruptions
- From the forest fires

Generally, acid rain is believed to diminish or destroy fish populations in flowing water or lakes; affect soil bacteria and fungi, increase uptake of heavy metals such as cadmium; and make worse other pre-existing stresses such as insecticide contamination. However, Large-scale forest with dreadful conditions has attributed to acid rain.

As well as more confined impacts on urban structures, the best example for acidic rain problem in the Asian region is the building's cement corrosion; the colors of paints change to black and need yearly maintenance and paint. Acid rain also has major consequences for commercial and cultural values including forests, agriculture, and tourism. In addition, it affects land use, urban cities, and transport lines.

Continuous exposure to (SO_2) acidic rain causes serious damage to materials such as marble, limestone. An eroded in the surface will results in carbonates in rocks such as limestone (CaCO_3) that will be replaced by sulfates (CaSO_4) that are water-soluble and maybe washed away easily by rain.

The estimation of measure to the emissions due to (Anthropogenic) or man-made factors is one-third of the

Sulfur and nitrogen emissions in South East Asia. The others originate from natural sources. Moreover, the impacts of construction projects, Vehicle productions and fuel combustion in power plants were another major source.

The lesser sources included industrial processes and waste disposal and recycling. Highway vehicle transportation was the primary source of nitrogen oxides emissions. Transports

systems included the movement of air masses emitted with pollutants of sulfuric and nitric acid by mixing with clouds of water vapor for several miles. Air pollutions in South East Asia, the API levels recorded reading ranging between 201 to 300 (very unhealthy), and 301 and above (hazardous) present in figure 14.

Figure 14: present Air pollutions in south East Asia, the API levels recorded reading ranging between 201 to 300 (very unhealthy), and 301 and above (hazardous)

7.2 THE SECOND IMPACT FACTOR; THE CONSEQUENCE OF VOLCANIC AND TECTONIC ACTIVITY

The second impact factor is the consequence of volcanic and tectonic activity in the most creative volcanic systems on Earth that hidden beneath the pacific oceans. The Pacific Ocean covers an area of 161,760,000 km² and the Ocean Volume about 660,000,000 km³. The Pacific Ring of Fire is a horseshoe shape string with a 40,000 km area, and its volume about 307, 160, 000 km³. It has associated with a nearly continuous series of volcanic arc, volcanic trench, plate movements and approximation of 4000 submarine volcanoes per million square kilometers The locations map of the pacific ring of fire and real photographs that show the submarine smoker and Volcano eruption in the ring seafloor Displays figure 15.

Figure 15: Displays the location map of pacific ring of fire and real photographs that shown the submarine smoker and Volcano eruption in the ring sea floor

In addition, it is 452 volcanoes of overactive and dormant volcanoes eruptions that occurring on the earth. It has yearly produces approximately 75% of the magma of all over the earth. About 3.0 km³ of lava is erupted (0.7 cubic miles). The magma and lava create the edges of new oceanic plates and its resources the heat and chemicals to the ocean floor. Volcanic

activity also produces sulfuric dioxide, and particulate pollution derives by wind-blown several of miles. Several of active volcanoes in the Pacific Rim region such as the Philippines and Indonesia presents figure 16.

Figure 16: Present the presents several of active volcanoes in the Pacific Rim area such as Philippines, Indonesia

The volcanoes located in the Philippines such as, Bulusan and Mayon volcanoes that located in the southeast of Manila. In Indonesia such as the Kelud volcano located in East Java, Mount Sinabung volcano in North Sumatra, Mount Merapi volcano located on the border between Central Java and Yogyakarta, Indonesia, being the most active volcanoes. A spectacular sub-marine volcanic eruption spews out huge columns of ash, smoke, gas and vapors thousands of feet into the Pacific Ocean sky. It is a site of seismic activity or earthquakes, around the edges of the Pacific Ocean basin. Approximately 90% of the world's earthquakes and 81% of the world's largest earthquakes occur along the ring of fire.

7.3 THE THIRD IMPACT FACTOR; AIR POLLUTION DUE TO BURNING LARGE JUNGLES AREA

Air pollution is a complex collection of serious problems that can occur either within a relatively small area or over a wide region. It contaminates the air, due to the activities of burning large jungles area and clearing it, for construction or mining projects. Furthermore, the practice by farmer on burning of large-scale tropical peatlands and forest areas to plants palm oil trees in Indonesia and Malaysia. This burning of tropical peatlands is so significant for greenhouse gas emissions because these areas store some of the highest quantities of carbon on Earth, accumulated over thousands of years.

Using of satellite images data to estimate the emissions arising from Indonesian fires in the past few years. It has calculated that the (96,937) fires in Indonesia detected and the emitted cumulatively about (1,043) million metric tons of carbon dioxide emissions. Based on the fire emissions models, that modeled the relationship between the numbers of the fires occurring on a specific day to the estimation of daily emissions.

These activities resulted in the emission of large volumes of (smoke and haze pollutants) into the atmosphere. These events have a large impact on the development and quick increase of liquefied carbon dioxide and effective of the dissolving process of carbonate rocks. The impact of peat fires on global warming may be more than 200 times greater than any fires on other lands. Burning and draining these lands for agricultural expansion or conversion to oil palm or pulpwood plantations leads to a huge confound in greenhouse gas emissions.

Fires also emitted methane (CH_4) is a greenhouse gas (21) times is more powerful than carbon dioxide (CO_2). The (**Peat fires**) could emit 10 times more than the (CH_4) emitted from fires occurred on different types of land. Emissions of CO_2 leading mostly to climate change

continue risks to the health in both of the land and Ocean. In the ocean, CO₂ will become an alarm that is more conspicuous.

Each year the oceans absorb emissions of carbon dioxide. Most of it transfers to the deep ocean and led to an exponential increase in the net amount of CO₂ being dissolved in the ocean over this and past decades. Dissolved CO₂ creates carbonic acid, which reduces the ocean pH level, making it more acidic. The activities of burning large tropical peats lands for constructions, mining projects or for plants oil palm trees in Indonesia and Malaysia presenting in figure 17.

Ocean acidification; is a significant and harmful consequence, its effects are happening underwater. The decrease in ocean pH would affect marine life. The most direct impacts of ocean acidification will be on lowering the amount of calcium carbonate which is the substance used by many marine organisms including shellfish, corals, mollusks, and crustaceans that build their shells.

If the pH drops by the expected 0.5 during this decade, the resulting would affect the amount availability of calcium carbonate in the ocean. Such a decrease would put the production and even the survival of thousands of marine kinds at the risk. At least one-quarter of the carbon dioxide (CO₂) released due to the burning does not stay in the air but instead dissolves into the ocean. Mass death of tenth of thousands of fish washed up miles and stretch along the coastal shoreline. The environmental studies are blaming the deaths on low oxygen levels and the excessively acidic.

Figure 17: Presenting the activities of burning large tropical peats lands for constructions, mining projects or for plants oil palm trees in Indonesia and Malaysia

The other studies have claimed that these incidents resulted due to the sudden change in water temperature and become higher cause a dead zone and deformities among fish. Samples of the dead fish washed up along coastal shoreline were taken, which included, catfish and pufferfish, carp, perch and suckers. Mass death of thousands of fish suddenly along Malaysia, Singapore, and Indonesian islands (Sumatra and Java) coastal shoreline due to environment change displays inland photographs figure 18.

Figure 18: Land photographs display mass death of thousands fish suddenly along Malaysia, Singapore, and Indonesian islands (Sumatra and java) coastal shoreline due to environment change

8. THE API (AIR POLLUTANT INDEX) AND HEALTH IMPLICATIONS

To assess the air quality of these selected construction sites and to understand if, these sites have effected by any pollution. In this study practicable of (API) (Air Pollutant Index) or in Malay as (IPU) is a simple and generalized way to describe the air quality. It has calculated from several sets of air pollution data in Malaysia. This index shows that API reading of the study construction sites between 51-100 means and the Air Pollution Level (APL) is goods with no health implications.

8.1 API MECHANICS

The API was based on the level of six (6) atmospheric pollutants, namely sulphuric dioxide (SO_2), nitrogen dioxide (NO_2), resizable suspended particulates, carbon monoxide (CO), ozone (O_3), lead (Pb), measured at all the monitoring stations throughout the terrain. The pollutants can be measure quite differently. SO_2 , NO_2 , and Pb10 concentration are measures as average per day. CO and O_3 are more harmful and are measure as average per hour. The final API value has calculated per day. The scale for each pollutant is non-linear, as is the final API score. Thus, an API of 100 does not mean twice the pollution of API at 50, nor does it mean twice as harmful. While an API of 50 from day 1 to 182 and an API of 100 from day 183 to 365 do provide an annual average of 75, it does not mean the pollution is acceptable even if the benchmark of (100) has considered as (safe). This is because the benchmark is a **24-hour target**. The annual average must match against the annual target. It is entirely possible to have safe air every day of the year but still fail the annual pollution benchmark.

9. FIELD SURVEY METHOD

9.1 GEOLOGICAL FIELD SURVEY

During the ground inspectionssurrounding these sites, several varieties of active sinkholes have founded and identified; it manifested as a narrow to medium-wide exposed throat. On average, sinkholes in the study area are from 1.0 to 24.0 m in diameter, with some having approximately the same range in depth.

These sinkholes have not spotted in the satellite image of Perak at a scale of 1/5000. Moreover, they cannot observe in the satellite image of Google Earth for many reasons; first, the chosen satellite image may be older than the age of these sinkholes. This meaning that

these sinkholes not created yet or recently result for many reasons and developed. Secondly, sinkholes with smaller sizes have engulfed by plants, which in this case, compromised their visibility vis-à-vis satellite imagery. Furthermore, the lakes, which is a former tin mines, are clearly visible in the study area in the satellite images of Google Earth.

A few of these sinkholes have selected to analyze by a high-resolution geophysical technique in order to achieve the case objectives. ERT in Wenner configuration was useful, which allows the imaging of the subsurface across and in proximity to many sinkholes as a primary stage to speculate on the origin of these sinkholes, recognize their shapes, and estimate their depths.

Several empty (air-infill) sinkholes were discovered at these sites which supports the assumption that the emptying or infilling of these sinkholes was from the foundation of the stripping of the portion of the topsoil and granules of sand that drops down (in almost all of the study area). This is likely because there are heavy runoff rains in the study area. In addition, there is a difference in the topography of the exposed rock, or due to the subsidence movement in the area. The result is the channeling of materials towards the sinkhole in order to fill the void in the layer beneath, or to fill the cavity through an existing joint/fracture in the limestone bedrock.

These sinkholes measure only a few feet or meters in diameter and depth, respectively. Their small size is due to the fact; that the cavities in the limestone cannot develop to considerable sizes before they are in-filled with the sand. Several varieties of small sinkholes describe as empty, sand in-fills and crammed with vegetations were identified during the site groundwork inspection presenting in figure 19.

Figure 19: Presenting several varieties of small sinkholes describe as empty, sand in-fills and crammed with vegetations were identified during the site groundwork inspection

Through sinkhole observation, standing water remained or stayed in the sinkhole days after the feature formed, suggesting that the flush or the migrating has stopped. This occurs when the conduit or the pipe that was formed due to solution-widened joints become choked or blocked with clay or other material to these drainage because the size of the cavities in the limestone bedrock are in-filled or loaded with clay-based and sandy material. Otherwise, in the rainy season, the meteoric water flushing down through the sinkhole will cause the water table to increase if the sinkhole spreads laterally and intersects the water table. The dissolution is reduced because there is less vertical difference between the water table and meteoric water surface and here, the flush or migrates will be less.

Surface water can induce erosion along the frame of a sinkhole and cause its enlargement, reaching several meters long. Due to the interconnected nature of the karst features system, a

group of small sinkholes observed in the study area is also capable of bonding to create an appearance of a larger sinkhole. This might enforce the thought that the small active sinkholes might be connected to one or more of the larger sinkholes (in diameter) by a series of groundwater conduits. There may be a seep of water at the subsurface, with conduits for seep-water to a local lake, snaking along the base of the slope to the east side. Tubular voids of visually undetermined depth in-filled with clay or air karst cavities were present, which could potentially threaten the integrity of these sites.

Originally, sinkholes are made of steep or nearly vertical sidewalls. The portions of the sidewalls can break off over time, and fall into the sinkhole. This continuous process will enlarge the sinkholes, and it might invariably deepen if water has continuously added into it. This phenomenon confirms that the size of the sinkholes varies over time.

In some of these sinkholes, observed that one-side remains steep, and the opposite side forms a gentle slope. The sinkhole looks like a funnel that has cut into half along its length, with a curvature of soil being apparent along the sidewall. This arch forms over the throat of the sinkhole and represents the roof of the void. The area above the soil arch, throat and the steep side is the most stable. Over time, the sides of the sinkhole will continue to fall and fill in the hole. The sinkhole may reach a point that it will appear as a depression on the land surface, or it may be indistinguishable on a surface relief from the surrounding area.

However, if there is a constant supply of water entering a sinkhole, a sinkhole can theoretically stay open for many years. Several varieties of sinkholes have found and identified surrounding the site during groundwork inspection, some of it shown in figure 20.

Figure20: Present several varieties of sinkholes found and identified surrounding the sites during the groundwork inspection

Throughout the ground site inspection in construction site#1, more than four big black spots and covered with bushes imply it to be old swamps with organic gray clay deposits were recognized which might contain sinkholes in the subsurface.

On the other hand, the aerial photographs of the area viewing the positions of four big black spots, three of them circular to semi-circular shapes and the others are with longitudinal shape. However, due to human activity and excavating work as ex-mining areas, most of these features were packed with sand and other material and among them; three areas with deposits of grey swamp clay in circular shape were recognized. The clay seems to sink down due to numerous causes.

In addition, numerous soil covers collapse sinkholes have found surround the study area and small depress filled with rock fragment and sand, may its soil cover collapse sinkholes in the past then filled by human activity. Besides, in the satellite image of the area which shown as one large-size black spot extended widely with more than 200 m. indicate that this area as before was swampy. This provides a consideration that sinkhole, karstic cavities, tubular voids clay or air in-filled were present in the subsurface that could threaten this construction site in the future.

Throughout the ground site inspection in construction site #2, several soil pipes and pits were found and were marked as narrow to medium extends in diameters. Many small sinkholes have observed distributed in this site referred to soil covered collapse. In addition, several small pits observed in the ground surface with depth between 1.0m-2.0m. This gives the idea that the small cavities or sinkholes might be connected to one or more of larger channels in diameter. Clay or air-filled karst cavities may present that could threaten the integrity of this site.

Through the direct ground inspections in the (3) three construction sites authorized to finding an indicator for the presence of sinkholes and other karst features could affect the construction projects. Many soils covered collapse sinkholes have found distributed surrounding the study area and holes crammed with sand and other materials that are not particular on aerial photographs and satellite images due to many reasons for many reasons, the area may be enclosed by vegetation, sinkholes definite size or their depth is too small to detect.

The recorder's needs including the diagram of the sinkholes are used for the description of each sinkhole. These recorders will supply information on the activity and the periods of the sinkholes and provide as indicators of the probable location of the future sinkholes in proximity to human structures and other observations.

The existence of features like muddy areas or the expansion of vegetation and holes crammed with materials may help detect shallow subsidence depressions. Generally, the application of geophysical surveys has chosen to establish whether these irregular characteristics are interrelated to sinkholes or not.

9.2 DESCRIPTION OF THE SINKHOLES THAT DISCOVERED IN THE STUDY AREA

Several varieties of sinkholes have discovered in the study area through the information and data record of geological and geophysical surveys. Diagrammatic cross-sections illustrating the type of sinkholes in the study are present in figure 21- (A-B-C) and 21 (A-B).

The first kind of sinkholes; that discovered was a few meters in diameter and depth, and are refers to as a **(soil cover- subsidence or collapse)**. This type of sinkhole has formed where the overburden is relatively thin in some regions; the limestone rocks have covered by a thin layer, more permeable and composed of a greater percentage of silt and sand, with a possible thickness between 15.0m to 30.0 m, with the slight presence of clay below it.

These layers have covered with soil. These layers are designed with lack of cohesiveness between the particles to form a significant **(bridge)** across the void where it occurs. The limestone rocks, which are sensitive to both physical and chemical and the natural dissolving processes, will eventually break down. When it collapses, a cavity or void usually forms. The

dissolving granules of sand will drop down to fill this cavity or void. The small diameter and depth of these kinds of sinkholes are due to the fact that the open cavities were smaller, and cannot expand in order to reach the considerable size before they were in-filled with sand as illustrated in figure 21-A.

Figure 21: Diagrammatic cross-sections illustrating the type of sinkholes in the study area, **A:** The soil cover- collapse sinkhole was within overlain cover soil as a result of a thick section of weakly unconsolidated sand and clay. **B:** The cover layer - subsidence sinkhole as a result of a bridge collapses and thick section of clay. **C:** the cavern roof collapse within the cap rock that has overlain by a thick section of unconsolidated or weakly compacted sands and mudstones

The second kind of sinkholes; which discovered was depending upon the size of the cavity; it refers to as (**cover layers- subsidence sinkholes**). Occasionally, if the sediments were more clay-based, the upper cover will lean towards becoming more inclined. This bridge will provide some dependence on the clay above. However, if this bridge collapses, the material acts as a conduit to any vacant cavity in the limestone bedrock. Some of the sinkholes appear due to an essential variance in the behavioral strength of the soil above the cavity, and the fact of whether this subsides slowly or has collapsed. The size of the sinkhole depends upon the size of the cavity, and whether or not it spreads efficiently and intersects the water table. The dissolution processes are possibly reduced in order to reduce the perpendicular difference between the phreatic water table and prospective meteoric surface, and consequently, reducing the percolation processes, as illustrated in figure 21-B.

The third kind of sinkholes; that discovered in the study area was (**sinkhole-like slump depression**), produced at the ground's surface. This kind distributed in different sizes and diameter from 5.0 m to more than 35.0 m in the study area. Mostly this kind of sinkholes formed after the Indonesia tsunami on 26 December 2004 in which (**it cannot observe in satellite images before 2004**). These kinds of sinkholes are present in weak sediments or when unconsolidated layers lie above the limestone Caprock.

The displacement may result in plastic deformation for the space located immediately higher than the collapsed area, depending on the lithology and the amount of water associated with these sediments. Due to the upper strata collapsing on the roof of the cavern, which is part of an extensive cavern, the network itself will collapse. The clay-based sediment shall be transported and deposited a considerable distance away from the cavern via the continuous removal of material entering from the channel or conduit area, allowing the upward

development of the conduit, diverting the occurrence of collapse to the surface, as illustrated in figure 21-C.

The fourth type of sinkholes; that discovered was a (funnel-shape depression or sink) openings with a funnel shape depression or sink that might develop in the future, generally referred to as (**pip**ing). This occurs when the rain in-fill is on an impermeable surface layer. During the infiltration process, the water passes through the soil and migrates towards a widened fracture caused by the dissolution process. Water then moisturizes the soil in the area around the opening hole of the conduit or fracture. As a result, the moistened soil begins to lose its cohesive properties, and begins to break apart and falls into the opening drain. The water began to erode the sediment from around these opening and migrate or move down toward the drain, with the sediments under the influence of gravity; it leaves a void or open area in the soil. Around the opening, a funnel-shape depression or sink has the potential to develop in the near future. The downward passage of the conduit or fracture can be enlarged with the passage of time by erosion or dissolution.

For the **pip**ing to occur, two basic geologic conditions must be encountered: first, there must be a considerable quantity of materials (sediments or rocks) between the ground surface and the water table; and second, the condition of that sediments or rocks above the water table is capable of maintaining open fractures. Most of the site in the study meets these conditions, as there are high quantities of sediments between the ground surface and the water table. The piping process without the effect of the water table is illustrated in the diagrammatic cross-section in the figure, 22-A.

Figure -22: Diagrammatic cross-sections illustrating the type of piping in the study area, **A:** the piping process without the effect of water table. **B:** the piping process when the water table has been lesser to a lower position below the top of the limestone cap rock

The piping is the processes that include infiltration and dissolution, and both can be active along the same fracture system. Although these processes are in hydraulic communication specified by a sufficient time, the two individual processes can be combining to produce a collapsed-pipe sinkhole.

The emergence of a sufficient volume of material dissolution processes can take place in widening conduits or fractures in the cap rocks of limestone, which overlain on the water table. However, if these processes result in fractures below the water table, it could allow meteoric water to penetrate downward along these fractures, and freely mix with phreatic water. The piping process when the water table has been reduced to a lower position below the top of the limestone cap rock is illustrated in the diagrammatic cross-section in the figure,

22-B.

9.3 FACTORS AFFECTED THE SINKHOLES TO COLLAPSE AND EVOLUTIONS IN KINTA VALLEY REGION, PERAK STATE

The collapses sinkholes are occurring mainly in the region of covered limestones bedrocks in Kinta Valley, Perak state. While the regions of covered marbleized limestone bedrocks with less degree of collapse sinkholes to occurring. The study region tends to have fewer noticeable surface water sources of ponds and streams and can easily drain downward through joints and fractures in the marbleized limestone bedrock.

Yassin R.R, (2013) mentioned in his research study that there are several causes for the occurrence of sinkhole collapse in the Kinta Valley, as in the following:

- The primary reason among them is the irregular distribution of unconsolidated material on the bedrocks surface.
- The secondary reason is the running of heavy rainwater on the ground surface.
- The third reason is the heavy acidic rainfall in this region.
- The fourth reason is the earthquakes and the subsidence movement.
- The fifth reason is the heavy loads of buildings or foundations.
- The sixth reason is the human influence.
- The seventh reason is the vibration from traffic.
- The eight reasons are the weather patterns.
- The ninth reason is the groundwater movement.
- The tenth reason is the water quality.
- The eleventh reason is Air high pollution.

All these reasons after the development of the sinkholes and other karst feature rapidly in this tropical area of Peninsular Malaysia. However, it still requires more studies to provide sufficient results to conclude the relationship between sinkholes and subsidence.

10. IDENTIFYING KARST FEATURES BY EMPLOYING AERIAL PHOTOGRAPHS AND SATELLITE IMAGES TECHNIQUE

Old aerial photographs are usually very helpful for the recognition of karst features such as sinkholes that are now enclosed by buildings or human structures. Using low sun-angle photographs with apparent shadows can emphasize subtle topographic features.

Large-scale color stereoscopic aerial photographs are very helpful for identifying sinkholes. The key limitation of aerial photographs and satellite images is that, depending on the scale and description of the images, it may not be feasible to pin down small or shallow sinkholes. The methodical analysis of photographs taken on different dates allows the chronology of freshly formed sinkholes to be inhibited. The interpretations help to gain minimum estimates of the possibility of sinkhole occurrence and permit the study of the spatial-temporal allocated patterns of the subsidence phenomena.

Interpretation of the aerial photographs of the study area and its surroundings to determine the fracture system, topography and drainage pattern has carried out. These old aerial photographs was operational in 1965 under the Colombo Plan have a scale of about 1: 25,000. Table -1 show the list of aerial photographs used in this study.

Location	Roll no.	Line no.	Print no.
Ipoh - Perak	C10	L35N	215-235
	C109	L34N	162-180
	C24	L33S	45-60
	C-12-A	L32N	35-20
	C-6	L31N	60-40
	C-5	L30N	30-20
	C-5	L29S	80-100
	C-5	L28N	130-110
	C-4	L27N	170-190
	C-4	L26N	80-70
	C-4	L25S	40-55

Table1: The list of aerial photographs that employed in this research study

The further technique is the investigation of airborne and satellite multispectral and thermal images which may be used to distinguish the surface terrain patterns and acquire the variations in moisture, vegetation, colors, heat-related to subsidence areas and sinkholes. In this current work, usage of (2010) five layers satellite spot images of Perak state in scale 1/5000 to locate the study region and the construction sites covered by combined survey techniques in Kinta Valley, Perak state.

In addition, the Global Position System (GPS) and Geographic Information System (GIS) technologies have helped the examination considerably. The common methods of mapping land utilizing the changes are typically high in cost and low in precision. The remote sensing provides updated information on land by using these methods. Natural events and human meddling can observe also by using current and archived distantly sensed data. The GIS map of Perak state viewing the location of the study region and construction sites covered by combined survey techniques in Kinta Valley, Perak, by Yassin, R.R. (2012) present in figure 23.

The technique for this aerial photographic interpretation of the karstic features such as limestone isolated and residual hills (mogotes), the cliffs and the lineaments. The significance of the karstic features and their possible origin in relation to the geologic features are concluding. In addition, identify the developments of the forests, the plantations and the urban areas. The old aerial photographs used in this study display in figure 24.

Besides, the interpretation showed that the orientation of lineaments from Main Range and Kledang Range is far from irregular but shows the dominant strike of northwest to Southeast with a subsidiary set, striking east-northeast to west-southwest. Conclusion made that these lineaments also observed clearly cutting the marbleized limestone of Kinta valley and the hills above it. The drainage in this study area is rather straight and angular and aerial photographs show that stream courses have controlled by the direction of lineaments (joints, fractures and fault systems) in the marbleized bedrock.

The old aerial photographs showed that the area of construction site #1 is a swampy area and covered with bushes. The Aerial photographs indicate that this construction site (Ipoh City - Taman Klebang Putra) made up of old swamps area and covered with bushes, which might contain sinkholes on its subsurface.

Moreover, the satellite image of the study area detects more than four big black spots distributes and extends widely with from 50m to more than 200 m in the north of this site and in profile 5 &6. Three of these spots circular to semi-circular in shape while the others possess a lengthy shape. During the ground worksite inspection, this large-size black spot areas represent by organic grey clay shown over the ground surface in the places mentioned above.

This provides a consideration that sinkhole, karstic cavities, tubular voids clay or air in-filled were present in the subsurface that could threaten this construction site in the future. This indicates that the area before was an old swampy area. Several of small -size black spots distributes and extend with from 10m to more than 15 m in the south of this site and in profile 1&2.

Figure 23: GIS map of Perak state viewing the location of the study region and construction sites that covered by combined survey techniques in Kinta valley, Perak, by Yassin, R.R. (2012)

Besides, water flow-up, from the ground in the area between, traverse# 5 and # 6, Due to the presence of large sinkhole in the subsurface of this site. However, due to human activity and excavating work being prepared there which was an ex-mining area, most of these features packed with sand and other material. Among them, three areas with deposits of grey swamp clay in circular shapes acknowledged. The clay seems to sink down due to numerous factors. This area is identified and demonstrates as an area that's includes a medium to large sinkhole, extended in the subsurface along this site of visually uncertain depth. This might point to the presence of clay or water in-filled karst sinkhole or cavities that could compromise the reliability of this site.

The ground site inspection also identifies that this area was much lower down from the main level of the ground surface about 2m. In the south part of the study area, a collapsing happening that was not visible in the aerial photographs and satellite images due to many factors, such as the area certainly enclosed by vegetation. The areas (dark brown color) represent the parts under excavating for the development. The areas (light brown) represent the parts under soil improvement operation.

Figure 24: Display the old aerial photographs that operating in 1965 under the Colombo Plan with a scale of about 1: 25,000

The old Aerial photographs of this construction site#2 (Gunung Rapat –Taman Gunong View) showed that this area was swampy area before and covered with bushes. Isolated residual limestone hills detected distributed in the south and southwest of this construction site. In addition, some ponds due to ex-mining activity detected separated on the west side of this construction site.

The recent satellite image map of the study area showing that there is one (1) large-size black spot extends widely more than 300 m in this construction site. During the ground inspection at site #2, large areas with organic gray clay shown over the ground surface along the site, this indicates that the area before was swampy covered with bushes and plants.

In addition, direct ground inspections in this construction sites resulted in the discovery of environmental karst features such as several varieties of small soil cover collapse sinkholes, soil pipes and pits discovered distributed over the site, but not recognized in aerial photographs and satellite images, due to many factors. For example, the area may enclose by vegetations, sinkholes with definite size or their depth is too small to detect as adjacent small plants enclose it. One of these sinkholes has a diameter from ~3m to less than ~10m, a few with water in-filled, visually undetermined depth, are recognized and proven.

The old aerial photographs showed that site #3 (Kampar – Kampung Kunsila estate) was before part of a huge forest area. Most of the forest trees removed for mining projects in the area. Several Pits due to mining activity observed in the south of this site.

The recent satellite images show, that some of the trees of the forest still everywhere surrounding this site. Mining pit with medium size observed in the south of this site. Hills of sand due to excavation operation, observed over the surfaces in white color in the image. In addition, the satellite images show brown areas with black points, that the area develops to palm oil and coconut oil plantation, some bushes and old trees can observe separated surround the site. In the big size images, many spots in camel color can see separated in the site could represent soil pipes or covers collapse sinkholes.

During the groundwork site inspection, several varieties of cover layers subsidence sinkholes recognized in this site and describe between medium and great size with~ 2.5 m - ~50.0 m in diameters. In addition, many soil covers collapse sinkholes discovered with depth about a few meters, and some of the dissolution sinkholes. Some sinkholes packed with vegetation and others with sand or water in-fill. Several empty subsidence sinkholes also determined in this site. Direct ground inspections in this site resulted in the discovery of environmental karst features such as several types of sinkholes that were not visible in aerial photographs and satellite images due to many factors.

For example, the area possibly enclosed by vegetation, sinkholes with a small size or their depth is too small to detect. These sinkholes are new opening compare to the date of the image. The existence of surface features such as muddy areas, or the increase of vegetation

in holes and holes crammed with materials may help to detect shallow subsidence depressions or sinkhole.

Besides the information from aerial photographs and satellite, images together shown that Kinta valley resembling a huge basin with a triangular-shaped or V-shaped valley bounded by the Main Range on the east, and Kledang Range in the west. The northern tip of the triangle starts at around Chemore town in the north.

The valley in this region extends to about 7 km and extends in the south around Kampar town to reach this region, at about 20 km. This valley is extending over a distance of 45 km from extended from Sungai Sepot in the north of Kinta valley to Tapah in the south. The first tower karst observed in Kinta Valley is Gunung Kanthan in the north, and the last is Gunung Tempurung in the south. The alluvial plain has situated over the valley area with active tin-mining pits separated over the study area. The major rivers originating from the granitic Main Range highland drains into most of the karstic land in the study area.

11. SITE CHARACTERIZATION BY APPLYING OF GEOPHYSICAL FIELD SURVEY

11.1 INSTRUMENTATION AND MEASUREMENT PROCEDURE

The survey has carried out using an SAS1000 system, manufactured by ABEM Inc. of Sweden. Generally, this resistivity tool provides a greater combination of spatial resolution and depth of the investigation on the karst terrain than any other geophysical technique. The resolution provided by the resistivity technique is a function of the electrode spacing and other factors, including subsurface heterogeneity and conductivity contrasts. The depth of investigation is a function of the length of the employed two-dimensional arrays.

Two-Dimensional (2-D) electrical resistivity imaging/tomography surveys have carried out and employed a large number of electrodes using 41 channels and an array of Wenner configurations has displayed at the site. These consisted of five traverses or profiles, spaced at 10-m intervals, oriented in (NE 25°SW) perpendicular to the trending of sinkholes in the study area. The length of each profile is 200 m. Normally, a constant spacing between adjacent electrodes is used. The electrode spacing of 5 m is deemed adequate in this case.

These electrodes have connected to multi-core cable, Griffiths, D.H. & Barker, R. D. (1993), configured in a Wenner array. The multi-core cable has attached to an electronic switching unit and used automatically to select the applicable four electrodes for each measurement. The typical setup for a 2-D survey with a numbers of electrodes along a straight-line attached to a multi-core cables and the instrument type SAS300, which has used in the survey is demonstrate in figure 25.

The field systems have a built-in microprocessor system, which codes the sequence of measurements to take the type of array to use, while other survey parameters such as the current to use is normally entered into a text file. A computer program in a field system's computer reads this. Different resistivity meters use different formats for the control file, which means that it will need to refer to the system's manual. After reading the control file, the computer program automatically selects the appropriate electrodes for each measurement, which is the very advantage of this system, especially in the context of a rugged terrain.

In a typical survey, most of the fieldwork involves laying out the cable and electrodes. After that, the measurements have automatically taken and stored in the computer device. To obtain a good 2-D picture of the subsurface, the coverage of the measurements must all correct. In order to get the best results, the measurements in a field survey should carry out in a systematic manner so that all the possible measurements have made as far as possible. This

will affect the quality of the interpretation model obtained from the inversion of the apparent resistivity measurements Dahlin, T. & Loke, M.H. (1998).

Figure 25: Demonstrate the instrument type SAS300 used in the survey and the typical setup for a 2-D survey, with a numbers of electrodes along a straight-line attached to a multi-core cables.

As the electrode spacing increases, the number of measurements decreases. The number of measurements that can be obtained for each electrode spacing from a given number of electrodes along the survey line depends on the type of array used. The Wenner array provides the smallest number of possible measurements, compared to the other common arrays that use in 2-D surveys.

11.2 DATA COLLECTION

When the successful measurements were done. Electrical resistivity data were acquired from the two dimensional (2-D) electrical resistivity traverses which function via 41-channel and 81 arrays in Wenner configuration in order to image the subsurface in sites with and without evidence of subsurface karst features, and in proximity and adjoining to active and non-active sinkholes.

The resistivity measurements for each profile or traverse with lengthwise of 200 m and electrode spacing of 5m, the total 190 data points have collected for each (41-electrodes) in one traverse. For the resistivity measurements for each profile with a length of 300 m and electrode spacing of 5.0m, the total (320) data points were comprising from each (61-electrodes) in one profile. For the resistivity measurements for each profile with 400 m and electrode spacing of 5.0m, the total (340) data points were comprising from each (81-electrodes) in one profile.

The controlling of electrical resistivity (ER) Traverses and the data collection from ER- Tomography survey for the (3) construction sites in this research presented in the following:

11.2.1 DATA COLLECTION IN CONSTRUCTION SITE #1 (TAMANPUTRA KLEBANG)

Six "6" electrical resistivity traverses, traverse no.1 to traverse no.6 were controlled over and along the survey area in construction site #1 which located in Putra Klebang to the northwest of Ipoh city. The direction of these profiles is (N90°W) and the level of those traverses are viewing in the Google earth satellite images of construction site #1 in figure 25.

Two dimensional (2-D) Electrical resistivity tomography (ERT) survey has carried out in this

site by using 41-channel array in winner configuration. The length of each traverse was 200 m, with an electrode spacing of 5.0m, and a space interval of about 25.0m between each traverse. The total length of all traverses in this site was 1200 m, covering an area of 30000 m². About 190 data points have composed for each (41-electrode) in one traverse, and on average, and about 1140 data have collected for six traverses in this site.

Figure 26: Google earth satellite image viewing the location of resistivity traverses in in construction site #1 (Putra Klebang)

11.2.2 DATA COLLECTION IN CONSTRUCTION SITE #2 (GUNNING RAPAT–TAMAN GUNONG VIEW)

Five “5” of 2D electrical resistivity traverses, traverse no.1 to traverse no.5 were controlled over and along the survey area in construction site #2 which located in gunning Rapat area to the southeast of Ipoh city. The orientation of these traverses in the direction of (NW10°SE) and the level of those traverses are viewing in the Google Earth satellite images of construction site #2 in figure 27.

Figure 27: Google earth satellite images viewing the location of resistivity traverses in construction site #2 (Gunung Rapat –Taman Gunong View)

Two dimensional (2-D) Electrical resistivity tomography (ERT) survey has carried out in this site by using 41- channel array in winner configuration. The length of each traverse was 200 m, with an electrode spacing of 5.0m, and a space interval of about 25.0m between each traverse. The total length of all traverses in this site was 1000 m, covering an area of 25000 m². About 190 data points have composed for each (41-electrode) in one traverse, and on average, and about 950 data have collected for a total five traverse in this site.

11.2.3 DATA COLLECTION IN SITE #3 (KAMPUNG KUNSI LA ESTATE) NORTHWEST KAMPAR CITIES

Five “5” of Two dimensional (2-D) electrical resistivity traverses, traverse no.1 to traverse no.5 were controlled over and along the survey area in construction site #3 which located in (Kampung Kunsila estate) northwest Kampar cities. The orientation of these traverses in the direction of (NE104°SW) and the level of those traverses are viewing Google Earth satellite images of construction site #3 in figure 28. Electrical resistivity tomography (ERT) survey has carried out in this site by using 41- channel array in winner configuration. The length of each traverse was 200 m, with an electrode spacing of 5.0m, and a space interval of about 25.0m between each traverse. The total length of all traverses in this site was 1000 m, covering an area of 25000 m². About 190 data points have composed for each (41-electrode) in one traverse, and on average, and about 950 data have collected for five traverses in this site.

Figure 28: Satellite image of Google Earth viewing the location of resistivity traverses in construction site #3 (Kampung Kunsila Estate) Northwest Kampar Cities

11.3 DATA PROCESSING

After the geophysical field survey, the resistivity measurements are usually concentrated on the apparent resistivity values. Practically all of the commercial multi-electrode system comes equipped with computer software RES2DINVver.3.54. This inversion software has developed by Loke, M.H., Barker, R.D. (1994). The SAS instrument is connect to a laptop computer via a special cable, which enables data transfer that was process to generate the 2D resistivity models of the subsurface. It assumes that the subsurface are homogeneously layered. consequently, lateral smoothing will occur in non-layered strata. This step converts the apparent resistivity values into a resistivity model section, which can used for geological interpretation. The data has already inputted into RES2DINVver.3.54, Format. The conversion program has provided in a bundle with many commercial systems.

The bad data points, caused by different problems such as poor ground contact for a few number of electrodes, should contain significantly higher errors than the excellent data points. The bad data points, with the error distribution might show a more complicated pattern, and as general rule, data points with errors of 100% and above can be removing.

In this survey, the computed root mean square (RMS) errors indicated that the difference between the measured resistivity values and those calculated from the true resistivity model was less than 10% of the RMS value, indicating a close match, as defined by the convergence limit. The default value with the average RMS error of 6.46% is the change in the RMS error between iterations, with a minimum of 4.0%, and a maximum of 8.3%. Most of the error in

data reading may be due to the difficulty in penetrating the electric current through the ground surface, which may be due to the presence of large amount of friable sand and rock fragments due to mining activity in the surface of this site.

12. ANALYSIS AND INTERPRETATION OF ELECTRICAL RESISTIVITY TOMOGRAPHY/ IMAGES SECTIONS

The ER Tomography technique applied in this geo-technical survey in order to imaging the shallow subsurface from a depth of less than 2.0 m, to a maximum depth of 61.0m. This technique was use in the carbonate karst region as a function to investigate karst features such as sinkholes, cavities, depressions and channel pipes. The survey found that this tool is suitable for differentiating surficial soil, clay, sand; weathered marbleized limestone bedrocks, intact marbleized limestone bedrocks and water- and air-filled cavities. In addition, it was applying due to its requiring less effort and more time effective. This technique based on the application of electric current into analysed bedrock and measuring the intensity of electric resistivity to its passage. Fundamentally, it gives information of electric resistivity properties through the analysed of material towards electrical current passage, Telford W.M. et al. (1990).

Several reports and researches on application of geophysical techniques in many karst terrains, in several countries around the world, were reading. These reports and researches are done by; Anderson, N. L. et al. (2007) in the (Assessment of Karst Activity at Highway Construction Sites Using the Electrical Resistivity Method, Missouri, USA). Furthermore, additional research was doing by Louis I.F. et al. (2002) of (Accurate subsurface characterization for highway applications by using of resistivity inversion methods).

Moreover, the study of mining area in the research of (Evaluating the presence of karst Bauxitic clays in parts of Western Desert of Iraq, by the application of VLF - electromagnetic and Electrical resistivity techniques) by Yassin, R. R. (2002). In addition, the research by Zhou, B.F.et al. (2000) in the Reliability of dipole-dipole Electrical resistivity tomography for defining depth to bedrock in covered karst terrains. Also, the research on ; The application of complex geophysical techniques to detecting and locating the weakness zone and the water seepage in the body of the AL-Tharthar dam , Samara town, Salahuddin province / Iraq by Yahia, N. A., Yassin, R. R., Hijab, S. R. (1994).

Finally, earlier research completed by Yahia, N. A., Yassin, R. R., Abdal-Qadir, S. O.(1992) in the application of 2D electrical resistivity and electromagnetic survey in study karst features and its deposits. These reports enabled the determination of the electrical variables associated with the nature of sediments.

Conclusions has made based on the variations in electrical resistivity values related to the nature of sediments. The geological classification permits the successful imaging of the bedrock and subsurface karst features, because soil, sand, clay, carbonate rock, and air-filled cavities can normally be differentiated and mapping.

Clay

It is usually distinguished by low apparent resistivity and variables, which are dependent on moisture, mineral content, purity, and unit shape/size, usually from 5 Ohm-m to less than 60 Ohm-m. In this case, the clay has divided into many types with different colors, which has used in this resistivity section as:

- Highly moisturized soft clay is usually distinguished by insufficient low apparent

resistivity, with water-filled porosity or very high mineralized, usually from 3 Ohm-m to 5 Ohm-m. In addition, sometimes contains radon gas in water. It has giving pink color in this study.

- Soft clay with pond water content is usually distinguished by extremely low resistivity and has very high conductivity or highly mineralized usually from 5 Ohm-m to 10 Ohm-m. Moreover, has giving dark blue color in this study.
- Moderate moisturized soft clay is usually distinguished by very low apparent resistivity and has very high conductivity or moderate mineralized, usually from 10 Ohm-m to less than 20 Ohm-m. In addition, has giving light blue color in this studying.
- Clay with low-moisturized are usually distinguished by low apparent resistivity or with low mineralized content, usually from 20 Ohm-m to less than 50 Ohm-m. Moreover, has giving yellow color in this study.

Sand:

It is usually characterized by medium apparent resistivity and variables, depending on the moisture content, purity and unit size, usually from 70 Ohm-m, to less than 160 Ohm-m. The sand is also dividing into many types; its coloring scheme described below:

- Sand, distinguished by medium apparent resistivity, usually from 100 Ohm-m to less than 160 Ohm-m. Moreover, has giving dark green color in this study.
- Sandy clay, distinguished by its low medium apparent resistivity, usually from 70 Ohm-m to less than 100 Ohm-m. Moreover, has giving light green color in this study.

Weathered limestone rock:

- Comparatively weathered limestone rock is typified by high apparent resistivities, typically more than 200 Ohm-m, to less than 400 Ohm-m, has given gray color in this study.

Intact limestone rock:

- Is distinguishing by higher apparent resistivity, naturally from more than 400 Ohm-m to more than 3000 Ohm-m, and varies depending on layer thickness, its impurities and moisture content. It has given a light purple colour in this study.

Intact pure marbleized limestone or dolostone rocks:

- Is distinguishing by higher apparent resistivity, naturally from more than 4000 Ohm-m to more than 8000 Ohm-m, and varies depending on layer thickness, its impurities and moisture content. It has given a dark purple colour in this study.

Air-filled cavities or voids :

- Have generally characterized by very high apparent resistivity, usually more than 3000 Ohm-m to less than 6000 Ohm-m, but varies depending on the conductivity of the nearby strata and size/shape of void or cavity. Classically, it has given a black color in this study.

Transitional zone:

- Mostly high-apparent resistivity (160) Ohm-m – (200) Ohm -m, consists mostly of rock fragments and sand and or marly limestone. Classically, has given a Khaki color in this study.

Radon :

- Radon gas has mostly found in karst area with unground features such as buried sinkholes, that containing water or underground caves and channels. Mostly has

extremely very low -apparent resistivity from (1) Ohm-m – (3) Ohm –m. it has given a pink color in this study.

Therefore, the electrical resistivity values were resolute for each rock unit. The results have tabulated in Table 2. This table was suitable for investigation karst features and its deposits within karst terrains. Also at the same time was suitable for detecting any mineral deposits within the sediments in the area but it need experience for that. The geological classification is utilized in this geoelectrical survey that was described above it permits the successful imaging of mapping and differentiated bedrocks and subsurface karstic features.

Because there is a crossing point between the value of resistivity data of intact limestone and the value of resistivities data to define karst features infill with air such as a cave, cavity, and sinkholes. The table above can be used for two times, one with resistivity from 3000 - 6000 Ohm -m to define the cave, cavity, and sinkhole with air-infill, table 2. In addition, to define rock fragments of limestone with friable and coarse grains sand which containing high porosity with air.

In the second time with resistivity from 3000- 6000 Ohm -m as intact limestone, showed in table 3, without mentioning the void or cavity with air-infill.

No.	Range of resistivity values	Expected geological units deposits	Color of Res. units in ERT model
1.	0 Ω -m – 5 Ω -m	Insufficient low resistivity, Soft clay with water filled porosity, very high mineralized.	
2.	5 Ω -m – 10 Ω -m	Extremely low resistivity and very high conductivity, soft clay with ponded water, highly mineralized.	
3.	10 Ω -m – 20 Ω -m	Very low resistivity and very high conductivity, Clay moderate mineralized.	
4.	20 Ω -m – 50 Ω -m	Clay low mineralized, low resistivity and very high conductivity.	
5.	50 Ω -m – 70 Ω -m	Below average resistivity, soil, silty or sandy clay.	
6.	70 Ω -m – 100 Ω -m	Average resistivity, clayey or silty sand.	
7.	100 Ω -m – 160 Ω -m	Above average resistivity, sand friable, coarse grain.	
8.	160 Ω -m – 200 Ω -m	Mostly high resistivity, transitional zone consists of rock fragments and sand.	
9.	>200 Ω -m – 400 Ω -m	high resistivity, weathered limestone, probably consisting of wet joints or fractures and/or clay in-fill, higher resistivity	
10.	>400 Ω -m – >3000 Ω -m	Very high resistivity, Compact or intact limestone.	
11.	>3000 Ω -m – 6000 Ω -m	Extremely high resistivity, Voids or cavity, air in-fill.	
12.	>6000 Ω -m – 8000 Ω -m	Extraordinarily high resistivity, Intact pure marbleized limestone or dolostone rocks.	

Table 2: Describes the range of resistivity values with expect geological unit deposits to define the cave, cavity and sinkhole with air-infill.

No.	Range of resistivity values	Expected geological units deposits	Color of Res. units in ERT model
1.	0 Ω -m – 5 Ω -m	Insufficient low resistivity, Soft clay with water filled porosity, very high mineralized.	
2.	5 Ω -m – 10 Ω -m	Extremely low resistivity and very high conductivity, soft clay with ponded water, highly mineralized.	
3.	10 Ω -m – 20 Ω -m	Very low resistivity and very high conductivity, Clay moderate mineralized.	
4.	20 Ω -m – 50 Ω -m	Clay low mineralized, low resistivity and very high conductivity.	
5.	50 Ω -m – 70 Ω -m	Below average resistivity, soil, silty or sandy clay.	
6.	70 Ω -m – 100 Ω -m	Average resistivity, clayey or silty sand.	
7.	100 Ω -m – 160 Ω -m	Above average resistivity, sand friable, coarse grain.	
8.	160 Ω -m – 200 Ω -m	Mostly high resistivity, transitional zone consists of rock fragments and sand.	
9.	>200 Ω -m – 400 Ω -m	high resistivity, weathered limestone, probably consisting of wet joints or fractures and/or clay in-fill, higher resistivity	
10.	>400 Ω -m – >3000 Ω -m	Very high resistivity, Compact or intact limestone.	
11.	>3000 Ω -m – 6000 Ω -m	Very high resistivity, Compact or intact limestone.	
12.	>6000 Ω -m – >8000 Ω -m	Extraordinarily high resistivity, Intact pure marbleized limestone or dolostone rocks.	

Table 3: Describes the range of resistivity values with the expected geological unit deposits to define the weathered, intact limestone and intact marbleized limestone

In the following the analysis and interpretation of the data collected from resistivity profiles. The acquired data was interpreted by applying the geological classification originating from the variations in electrical resistivity values, which describes the range of resistivity values with the expected geological units' deposit. These classifications are the key interpretations of the geoelectrical data in order to understand the resistivity profiles and the function of sinkholes and other subsurface karstic features that investigated at these sites. In addition, this classifications has successfully used before for the exploration of mineral deposits in the karst area, Yassin, R.R. (2002). The interpretation of resistivity data identifies the points illustrated in the objective of the study.

The smoothing that observed in the subsurface limestone bedrock is the result of employing the RES2DINV ver.3.54. Software, which assumes that the subsurface is uniform, layered; and consequently lateral smoothing will form in a non-layered stratum. Some of the boreholes have completed by auger to the depth of 10 m at some point, facilitating in the interpretation of covered sediments in these sites. The high contrast in resistivity values between the carbonate rocks and the clayey soil is favorites to the use of the geo-electrical resistivity method to delineate the boundary between bedrocks and overburden. The Wenner arrays provide the highest resolution, and are most sensitive to vertical resistivity boundaries found at pinnacles and gutter interfaces.

However, the data collected from the Wenner array are sensitive to near-surface resistivity variations, Griffiths & Barker, (1993), and therefore can produce noisy data.

Computerized instrumentation permits automatic selection of four electrodes from a multiple-electrode array to use for each measurement, which significantly expedites the data collection process. The measuring of apparent resistivity is volume-averaged values that had affected by all the geologic layers, through which the induced electric current flows. An inversion program converts the array of apparent resistivity data into a model of the geology that would yield the observed distribution of the apparent resistivity values. The product of the data inversion process is a 2-D image.

The extensive description of the classification described above is the key to the interpretations of the geological survey that had carried out to understand the resistivity profiles and the function of sinkholes and other investigated subsurface karstic features. The interpretation of the resistivity data in the absence of borehole control in the area was relatively complex. Some of boreholes has completed by auger reaching the depth of ~10m. At some point, it facilitates the interpretation of covered sediments in these sites.

12.1 INTERPRETATION OF (E.R.T) SECTIONS IN CONSTRUCTION SITE #1 (TAMAN KLEBANG PUTRA)

The electrical resistivity data of this construction site has built up in electric resistivity tomography sections. The interpretations of Tomography or image sections have clarified by applying table 2 and table3. The inverse model of electrical resistivity section form traverse no.1 to traverse no.6 present in figure 29(A-F), viewing the interpreted location of shallow karst features (sinkholes and cavities) in Construction site #1 (**Taman Klebang Putra**).

Figure (29 - A): Inverse model of electrical resistivity section for profile no. 1 (Klebang Putra)

Figure (29- B): Inverse model of electrical resistivity section for profile no. 2 (Taman Klebang Putra)

Figure (29 - C): Inverse model of electrical resistivity section for profile no. 3 ((Taman Klebang Putra)

Figure (29- D): Inverse model of electrical resistivity section for profile no. 4 ((Taman Klebang Putra)

Figure (29- E): Inverse model of electrical resistivity section for profile no. 5 ((Taman Klebang Putra)

(Figure29 - F): Inverse model of electrical resistivity section for profile no. 6 (Taman Klebang Putra)

Figure 29(A-F): Inverse model of electrical resistivity section form traverse no.1 to traverse no.6, viewing the interpreted location of shallow karst features (sinkholes and cavities) in Construction site #1(Taman Klebang Putra)

The database of karst features from (2-D) E R Tomography sections in construction site #1(Taman Klebang Putra) is viewing in table 4.

Data base of karst features from (2-D) E. R. Tomography sections in construction site #1 (Klebang Putra)						
TRAVERSE NO.	KARST FEATURES	QUANTITY	LOCATION	SIZE	APPROXIMATE DEPTH	DESCRIPTIONS
Trav.#1	Sinkhole	1	E17-E28	Diameter~55.0m	1.25m->28.7m	Subsidence sinkhole, in-fill with stiff, non stiff clay, silty and sand.
	Lens	1	E30-E36	Width 30.0m	>2.25m-12.4m	Oval shape lens in-fill with non stiff clay and ponded water.
Trav.#2	Sinkhole	1	E15-E28	Diameter ~65.0m	~1.25m->28.7m	Subsidence sinkhole in-fill with stiff clay, non stiff, silty and sand.
Trav.#3	Sinkhole	1	E10-E27	Diameter ~85.0m	~1.25m - ~24.0m	Subsidence sinkhole in-fill with stiff clay, non stiff, silty and sand.
	Small Depress	1	E23-E30	Length~35.0m	~1.5m - ~9.0m	In-fill with non stiff and stiff clay.
Trav.#4	Sinkhole	1	E12-E23	Diameter ~55.0m	~1.25m ->24.0m	Subsidence sinkhole in-fill with stiff clay, non stiff, silty and sand.
	Small Depress	1	E24-E31	Length~35.0m	~1.5m - ~11.0m	In-fill with stiff and non stiff clay with ponded water.
Trav.#5	Sinkhole	1	E16-E26	width ~50.0m	~1.25m ->28.7m	Subsidence sinkhole in-fill with stiff clay, non stiff, silty and sand.
	Small Depress	1	E27-E34	Length ~35.0m	~0.0m - ~12.4m	In-fill with stiff and non stiff clay with ponded water.
Trav.#6	Sinkhole	1	E18-E26	Diameterter~35.0	~1.25m ->28.7m	Subsidence sinkhole in-fill with stiff clay, non stiff, silty and sand.
	Lens	1	E10-E18	width~40.0m	~1.25m - ~23.0m	Oval shape, packed with non stiff clay and ponded water.
	Lens	1	E24-E27	width~15.0m	~ 4.50m - ~18.0m	Oval shape, packed with non stiff clay and ponded water.
	Cavity	1	E25-E34	width~45.0m	~11.0m - ~15.0m	Packed with rock fragments.
	Depression	1	E26-E35	Length~45.0m	~0.0m - ~9.0m	In-fill with stiff clay.

Table 4: The Database of karst features from (2-D) E R Tomography sections in construction site #1(Taman Klebang Putra)

12.2 INTERPRETATIONS OF (ERT) SECTIONS IN CONSTRUCTION SITE SITE#2 (GUNUNG RAPAT –TAMAN GUNONG VIEW)

The electrical resistivity data of this construction site has built up in electric resistivity tomography sections. The interpretations of Tomography or image sections have clarified by applying table 2 and table3. The interpretation confirms that a variety of karst features that are present in this site, mainly the soil covers collapse sinkholes and lenses, can clearly be observed in the image section of the subsurface along resistivity traverses.

The inverse model of the electrical resistivity section from traverses no.1 to traverses no.4 in figure 30(A-D), viewing the interpreted location of shallow karst features (sinkholes and cavities) in Construction site #2 (Gunung Rapat –Taman Gunong View).

(Figure30 - A): Inverse model of electrical resistivity section for Traverse no.1 (Gunung Rapat –Taman Gunong View)

(Figure30 - B): Inverse model of electrical resistivity section for Traverse no.2 (Gunung Rapat –Taman Gunong View)

(Figure30 - C): Inverse model of electrical resistivity section for Traverse no.3 (Gunung Rapat –Taman Gunong View)

(Figure30 - D): Inverse model of electrical resistivity section for Traverse no.4 (Gunung Rapat –Taman Gunong View)

Figure (30- E): Inverse model of electrical resistivity section for Traverse no.5 (Gunung Rapat –Taman Gunong View)

Figure 30(A-E): Inverse model of electrical resistivity section from Traverses no. (1 -5), viewing the interpreted location of shallow karst features (sinkholes and cavities) in construction site#2(Gunung Rapat –Taman Gunong View)

The Database of karst features from (2-D) E R Tomography sections in construction site#2(Gunung Rapat –Taman Gunung View) are viewing in table 5.

Data base of karst features from (2-D) E. R. Tomography sections in Construction site #2 (Gunung Rapat –Taman Gunung View)						
TRAVERSE NO.	KARST FEATURES	QUANTITY	LOCATION	SIZE	APPROXIMATE DEPTH	DESCRIPTIONS
Tran.#1	Semi round Lens	1	E7- E11	Width ~ 20.0m	0.0m ~ -17.0m	In-fill with extremely non-stiff moisturized clay
	Irregular Lens	1	E16- E23	Width ~ 35.0m	3.0m ~ -14.0m	In-fill with extremely non-stiff moisturized clay
	Semi round Lens	1	E26- E27	Width ~10.0m	3.0m ~ -14.0m	In-fill with extremely non-stiff moisturized clay
Tran.#2	Mold lens	1	E9- E17	Length ~ 40.0m	2.5m ~ -12.4m	In-fill with extremely non-stiff moisturized clay
	Mature sinkhole	1	E21- E24	Width ~18.0m	0.0m ~ -17.0m	In-fill with stiff and extremely non-stiff moisturized clay
	Mature sinkhole	1	E26- E32	Width ~ 60.0m	0.0m ~ -17.0m	In-fill with stiff and extremely non-stiff moisturized clay
Tran.#3	Soil cover collapse sinkhole	1	E8- E10	Diameter ~ 10.0m	0.0m ~ -15.0m	In-fill with meteoric water and nonstiff clay
	Soil cover collapse sinkhole	1	E12- E17	Diameter ~ 26.0m	0.0m ~ -14.0m	In-fill with meteoric water and nonstiff clay
	Soil cover collapse sinkhole	1	E19- E21	Diameter ~ 10.0m	0.0m ~ -17.0m	In-fill with meteoric water and nonstiff clay
	Soil cover collapse sinkhole	1	E26- E30	Diameter ~ 25.0m	0.0m ~ -19.0m	In-fill with meteoric water and nonstiff clay
	Lens	1	E33- E34	Diameter ~ 5.0m	2.5m ~ -15.0m	In-fill with stiff clay
Tran.#4	Soil cover collapse sinkhole	1	E9- E11	Diameter ~ 15.0m	0.0m ~ -18.0m	In-fill with meteoric water and nonstiff clay
	Full-size Lens	1	E16- E18	Width ~ 10.0m	1.5m ~ -17.0m	In-fill with very non-stiff moisturized clay
	Normal Lens	1	E26- E27	Width ~ 10.0m	3.0m ~ -14.0m	In-fill with stiff and extremely non-stiff moisturized clay
Tran.#5	Soil cover collapse sinkhole	1	E8- E11	Diameter ~ 15.0m	0.0m ~ -19.0m	In-fill with meteoric water and nonstiff clay
	Full-size Lens	1	E16- E19	Width ~10.0m	2.5m ~ -17.0m	In-fill with very non-stiff moisturized clay
	Minute Lens	1	E20- E21	Width ~ 5.0m	3.0m ~ -7.0m	In-fill with non - stiff moisturized clay
	Minute Lens	1	E22- E23	Width ~ 5.0m	3.0m ~ -7.0m	In-fill with non - stiff moisturized clay
	Normal Lens	1	E26- E27	Width ~ 10.0m	2.5m ~ -12.5m	In-fill with non-stiff moisturized clay

Table 5: Data base of karst features from (2-D) ER Tomography sections in construction site#2 (Gunung Rapat –Taman Gunung View)

12.3 INTERPRETATIONS OF (ERT) SECTIONS IN CONSTRUCTION SITE #3 (KAMPUNG KUNSILA ESTATE) NORTHWEST KAMPAR CITIES

The electrical resistivity data of this construction site has built up in electric resistivity tomography sections. The interpretations of Tomography or image sections have clarified by applying table 2 and table 3. The inverse model of the electrical resistivity section from traverses no.1 to traverses no.4 present in figure 31(A-D), viewing the interpreted location of shallow karst features (sinkholes and cavities) in site #3 (Kampung Kunsila estate) northwest Kampar cities.

Figure (31 - A): Inverse model of electrical resistivity section for profile no.1(Kampung Kunsila estate)

Figure (31 - B): Inverse model of electrical resistivity section for profile no.2(Kampung Kunsila estate)

Figure (31 - C): Inverse model of electrical resistivity section for profile no.3(Kampung Kunsila estate)

Figure (31 - D): Inverse model of electrical resistivity section for profile no.4 (Kampung Kunsila estate)

Figure (31 - E): Inverse model of electrical resistivity section for profile no.5(Kampung Kunsila estate)

Figure 31(A-E): Inverse model of electrical resistivity section from profiles no. (1-5), viewing the interpreted location of shallow karst features (sinkholes and cavities) in construction site#3 (Kampung Kunsila estate) northwest Kampar cities

The Database of karst features from (2-D) E R Tomography sections in site#3(**Kampung Kunsila estate**) northwest Kampar cities are viewing in table 6.

13. THE DEPTH OF MARBLEIZED LIMESTONE BEDROCK AND PINNACLES IN THE STUDY CONSTRUCTION SITES

The area under study is a division of Kinta Valley's karst topography. Commonly it is approximately complex ground conditions. It is often insufficient understood, except by those geologists and geological engineers who are familiar with soluble rock and understand the type of irregularities and problems associated with it. For civil engineers, the development in limestone karst terrains normally creates various difficulties and problems. Through increase, the expansion of construction in the area means the increases in the scale of complexity.

The data of the depth for the weathered, intact or sold marbleized limestone bedrock and pinnacles summarize in tables 7,8 and 9. These tables present an outline or portrayal of some selected points regarding the limestone bedrock depth of the three construction sites that will be advantageous for engineers to recognize the depth of limestone in these selected construction sites understudies.

This will be beneficial in understanding the probable topography conditions of the limestone bedrock. These are, however, incomplete and can only provide common suggestions of expected ground conditions if there was enormous variation occurring with the depth of marbleized limestone bedrock and the local features in the limited region.

The 2D geophysical site characterization surveys show that the depth of marbleized limestone bedrock in these construction sites was uneven or asymmetrical and have possessed several pinnacles and gutters. Tables 7, 8 and 9 described the approximate depths of weathered, intact marbleized limestone bedrock and pinnacles in these selected construction sites through the interpretation of inverse model sections.

In construction site #1, the depth of weathered limestone bedrock mottled between 3.00 m and >28.0m. The depth of intact limestone bedrock varied between 8.0 m and >28.0m, and the depth of pinnacles varied between 3.0 m and 19.0 m, as shown in table 7.

In site #2, the depth of weathered limestone bedrock mottled between 20 m and >28.0m. The depth of an intact limestone bedrock varied between 21.0 m and >28.0m, while the depth of its pinnacles varied between 20.0 m and 27.0m, as shown in table 8.

DATA BASE OF KARST FEATURES FROM (2-D) E. R. TOMOGRAPHY SECTIONS IN (KAMPUNG KUNSLA ESTATE) NORTH WEST KAMPAR CITY						
TRAVERSE NO.	KARST FEATURES	QUANTITY	LOCATION	SIZE	APPROXIMATE DEPTH	DESCRIPTIONS
Profile no.1	cover-collapse sinkhole	1	E14 -E17&188	7.5m Diameter	0.0m - 9.0m	In-fill with non stiff and moisturized clay.
	cover-collapse sinkhole	1	E7&8-E9&10	4.5 - 5m Diameter	0.0m - 5.0m	The bottom half comprises of sand and other remnant of rock fragments. The top half was air in-fill.
	cover-collapse sinkhole	1	E32 - E33	3m Diameter	0.0m - 3.0m	
	cover-collapse sinkhole	1	E36 - E37	5m Diameter	0.0m - 6.0m	
	semi-lens or a wetter area of moisturized clay	1	E2 - E8	30m Wide	<1.25m - >12.4m	Clay saturated with water.
	Depression	1	E8 - E14	30m Wide	1.25-5.5m	Packed with dry sand and friable and remnants of limestone rock.
Profile no.2	Semi- tabular shaped anomaly	1	E2 - E19	30m Wide	<1.25m - >14.0m	Remnants of surface soil or silty clay due to water activity.
	Soil cover-collapse sinkhole	1	E23&24 - E25	7.50 m Diameter	1.25m - ~13.50m	Lower part with water in-fill and moisturized clay. The upper part with air or unfilled.
	Moderate size lens	1	E26& E28	10m Wide	6 m - ~13m	Contain stiff clay, silty clay or remnant surficial soil.
	Big size Lens	1	E29&30 - E37	27.50m Wide	6.36m - ~17.5m	Contain stiff clay, silty clay or remnant surficial soil.
Profile no.3	Cavity	1	E20 - E23	Size 10.4 x 15m	2m - ~12.4m	Bagged with stiff clay, soil or silty clay, silty sand due to Karst processes.
	cover-collapse sinkhole	1	E24 - E28&29	22.5m Diameter	1.25m -12.5m	In-filled with moisturized clay, stiff clay, soil or silty clay.
	cover-collapse sinkhole	1	E29&30 - E31	7.5m Diameter	1.25m- 9m	Clay and remnant surficial soil or silty clay and silty sand.
	cover-collapse sinkhole	1	E33 - E34&35	7.5m Diameter	1.25m - 12.4m	Clay and remnant surficial soil or silty clay and silty sand.
	cover-collapse sinkhole	1	E 28 - E29&30	7.5m Width	1.25m - 9.5m	In-filled with friable sand and remnant rock fragments.
	Void	1	E29 - E30	2.5m x 3.25m	1.25m - ~4.5m	air in-fill.
Profile no.4	semi-tabular shaped anomaly	1	E2 - E20	Extent 90m	1.25m - ~17m	Clay in-fill, due to Karst processes.
	longitudinal channel	1	E23 - E39	Extent 80m	4m - ~19m	High moisturized clay, stiff clay, soil or silty clay and silty sand.
	cover - collapse sinkhole and pipes	4	E17 - E18 E25 - E26 E28 - E29 E35 - E36	2-3m Diameter	1.25m - ~3m 1.25m - ~4m	The bottom half comprises of sand and other remnant of rock fragments.
	Depression	1	E40 - E56	width ~130m	0.0m - ~17.0m	Due to Karst processes.
Profile no.5	Semi- tabular shaped anomaly	1	E8 - E14&15	~ 32.50 m wide	~2m - ~21m	Soft and moisturizing clay and less moisturized clay and remnants of Dispersive surficial soil.
	Cavity	1	E8 - 14&15	~ 32.50 m wide	~2m - ~21m	Soft and moisturizing clay and less moisturized clay and remnants of Dispersive surficial soil.
	Cavity	1	E14&15 - E19	~ 22.50 m wide	~6m - ~14m	Stiff clay and remnants of Dispersive surficial soil or silty clay.
	Depression	1	E7 - E12	~25m wide	1.25m - ~ 6.36m	Packed with stripped dry and friable sand and remnants of limestone rock or other rock fragments.
	cover-collapse sinkhole and pipes	5	E8 - E9 E16 - E20 E23 - E24 E31 - E32 E36 - E37	~1m - ~5m.	~3m - ~5m	The bottom half comprises of sand and other remnant of rock fragments
	Lens or cavity in pear shape	1	E8 - E14&15	~ 32.50 m wide	~2m - ~21m	soft and moisturizing clay and less moisturized clay, and remnant surficial of Dispersive soil or silty clay
	Lens in oval shape	1	E14&15 - E19	~ 22.50 wide	~6m - ~14m	Stiff clay, remnant of Dispersive surficial soil or silty clay.
	Channel Pipe/Conduit	1	E28 - E30	5m wide	1.25 - ~19.8 m	in-filled with sand
	Depression	1	E11 - E23	Length ~ 60.0m	0.0m - ~ 9.50m	Packed with stripped dry and friable sand, with remnants of limestone rock and other rock fragments Due to Karst processes.
	Depression	1	E26 - E43	Length ~160.0m	0.0m - ~11.50m	Packed with stripped sand dry and friable, with remnants of limestone rock and other rock fragments Due to Karst processes.

Table6: TheDatabase of karst features from (2-D) E. R. Tomography sections in (Kampung Kunsila estate) northwest Kampar cities

In construction site #3, the depth of weathered limestone bedrock mottled between 11.0 m and 22.0 m. The depth of intact limestone bedrock varied between 13.5 m and 26.0m, and the depth of pinnacles varied between 10.5 m and 15.5 m, as shown in table 9.

The approximate depth of Weathered, Intact marbleized limestone bedrock and Pinnacles in construction site#1 (Taman Klebang Putra)							
No.	Traverse No.	Electrode No.	Approximate depth of Weathered marbleized lst.	Electrode No.	Approximate depth of Intact marbleized Lst. bedrock	Electrode No.	Approximate depth of Pinnacles
1	Res Trav. #1	7	11.0 m	8	15.0 m	16	7.0 m
		11	13.0 m	11	18.0 m	28	19.0 m
		16	8.0 m	15	14.0 m		
		18	19.8 m				
		19 - 24	>28.0 m				
		28	19.0m				
2	Res Trav. #2	5	10.0 m	10	19.0 m		
		9	12.4 m	16	24.0 m		
		17	24.0 m	17	> 28.0 m		
		18	> 28.0 m				
3	Res Trav. #3	4	6.5 m	4	10.0 m	10	6.0 m
		12	18.0 m	9	8.5 m		
		16 - 25	> 28.0 m	14	> 28.0 m		
		31	9.0 m				
4	Res Trav. #4	4	8.5 m	6	8.0m	10	6.0 m
		9	6.38 m	10	8.0 m		
		13	18.0 m	12	19.8 m		
		15	> 28.0 m				
		23	9.0 m				
		33	12.0 m				
5	Res Trav. #5	4	7.0 m	5	8.0 m	12 26	3.0 m 11.0 m
		10	10.0 m	9	10.0 m		
		12	3.0 m	10	18.0 m		
		15	> 24.0 m	15	> 28.0 m		
		26	12.0 m	24	> 28.0 m		
		30	22.0 m	26	> 26.0 m		
6	Res Trav. #6	15	26.0 m	16 - 17	26.0 m	19	12.0 m
		19	12.0 m				
		20	> 28.0 m				

Table 7: Describe the approximate depth of weathered, intact marbleized limestone bedrock and pinnacles in construction site#1(Taman Klebang Putra)

Description of the depth of weathered, intact marbleized limestone bedrock and pinnacles in construction site#2 (Gunung Rapat –Taman Gunung View)							
No.	Traverse No.	Electrode No	Approximate depth of weathered marbleized limestone bedrock	Electrode No	Approximate depth of intact marbleized limestone bedrock	Electrode No	Approximate depth of pinnacle
1	Res Trav. #1	9	>28.7m	9	>28.7m		
		17	23.0m	17	26.0m	15	23.0m
		25	25.0m	25	>24.0m	26	27.0m
		33	>28.7m	33	>28.7m		
2	Res Trav. #2	9	>28.7m	9	>28.7m		
		17	21.0m	17	22.0m	17	21.0m
		25	20.0m	25	21.0m	26	20.0m
		33	>28.7m	33	>28.7m		
3	Res Trav. #3	9	>28.7m	9	>28.7m		
		17	24.0m	17	26.0m	16	23.0m
		25	25.0m	25	27.0m	23	26.0m
		33	>28.7m	33	>28.7m		
4	Res Trav. #4	9	>28.7m	9	>28.7m		
		17	21.0m	17	23.5m	16	23.0m
		25	24.0m	25	26.0m	25	24.m
		33	>28.7m	33	>28.7m		

Table 8:Describe the approximate depth of weathered, intact marbleized limestone bedrock and pinnacles in construction site#2(**Gunung Rapat- Taman Gunung view**)

Describe the approximate depth of weathered, intact marbleized limestone bedrock and pinnacles in construction site#3(Kampung Kunsila estate)							
No.	Profile no.	Electrode no.	Approximate depth of weathered Limestone Bedrock	Electrode no.	Approximate depth of Intact Limestone bedrock	Electrode no.	Approximate depth of pinnacles
1	Profile no.1	14	19	14	22	27-28	10.5
		20	17.5	20	20		
		27	11	27	13.5		
2	Profile no.2	14	22	14	25	21-22	12
		20	16.8	20	19.8		
		27	17.8	27	20		
3	Profile no.3	14	21.8	14	23	18-19	12.5
		20	13.5	20	15.7	23-24	14.5
		27	15.4	27	18.5	31-32	11
		30	11	30	16.5		
4	Profile no.4	14	23	14	26	22-23	15.5
		20	21.8	20	24		
		27	18.5	27	20.5		
5	Profile no.5	15	21.8	15	24	21-22	-
		20	17.4	20	18		
		27	16	27	19.8		

Table 9: Describe the approximate depth of weathered, intact marbleized limestone bedrock and pinnacles in site#3 (Kampung Kunsila estate) northwest Kampar city

14. DESCRIPTIONS OF BOREHOLES FROM THE GEOLOGICAL BORING REPORTS

In this survey, the drilling of boreholes has done in the study area by hand Auger, portable Auger with motor and mobile drilling machine for environmental study. The boring report by auger clarified that the auger has penetrated until the maximum depth of 12.0m in layers described as; Soil, clay, silty sand, sand, rock fragments, and marbleized limestone. Sometimes it has penetrated faster in layers described as soil and very non- stiff clay highly moisturized. In addition, the boring report by auger clarified that the auger for several times has terminated in a Boulders and fragment of marbleized limestone rocks.

Through the comparison between the boring data by auger and geophysical data found that there is a small difference in the depth between the depth from geophysical interpretation sections and the depth from the geological report of drilling by auger about 2.0m to maximum 5.0m if the ground surface cover with sand and/or rock fragments. Some of the boreholes that drilled by auger in construction site#1, #2, described in tables 10(A, B).

In construction site #1, the boring report by auger clarified that the auger penetrated until maximum depth of 12.0m. Sometimes it was penetrating faster in layers described as soil and very non- stiff clay highly moisturized. In addition, the boring report by auger clarified that the auger many times was terminate in a Boulders and fragment of marbleized limestone rocks. The description of boreholes drilled by auger in construction site#1 (Taman Klebang Putra) has clarified in table 10-A.

Description of boreholes drilled by Auger in construction site #1 (Taman Klebang putra)						
Borehole no.	Traverse no.	Drilling point	Depth from drilling by Auger	Depth from ER Tomography sections	Description	Check points
1	1	E-22	12.0m	12.4m	Stiff clay, silty clay.	Stiff organic gray clay
2	3	E-17	6.0m	6.36m	Soil, silty sand, silty clay.	Stiff organic gray clay
3	5	E-21	12.0m	12.4m	Soil, stiff clay, silty clay, highly moisturized clay.	Lens
4	6	E-11	6.3m	5.6m	Soil, stiff clay, silty clay, highly moisturized clay.	Lens with highly moisturized clay

Table 10-A: Clarified the description of boreholes that drilled by auger in construction site#1(Taman Klebang Putra)

In construction site #2 The boring report by auger clarified that in borehole 1 in traverse no.1, placed in electrode no. E-8, the Auger penetrated few meters in layers described as soil, stiff clay, non-stiff clay.

Borehole 2 in traverse no.2, placed in electrode no. 22, penetrated few meters in layers described as Soil, stiff clay, non-stiff clay. Borehole 3 in traverse no.3, positioned in electrode no. 23, the Auger penetrated few meters in layer described as very stiff silty sand and sand. Borehole 4 in traverse no. 4, placed in electrode no. 17, penetrated few meters of layer described as Silty sand, silty clay, non-stiff clay, very non-stiff highly moisturized clay. The description of boreholes that drilled by auger in construction site #2 (Gunung Rapat – Taman Gunong View) describes in table 10-B.

Description of boreholes drilled by Auger in construction site #2 Gunung Rapat –Taman Gunong View						
Borehole no.	Traverse no.	Drilling point	Depth from drilling by Auger	Depth from ERT sections	Descriptions	Check point
1	1	E-9	16.0m	16.0m	Cover soil, stiff clay , highly moisturized non stiff clay and silty sand	Layer of silty sand
2	2	E-17	20.0m	20.50m	Sand, silty sand, silty clay, non-stiff clay, very non stiff highly moisturized clay, silty sand, sand, rock fragment	Boundary of carbonate bedrock
3	3	E-8	16.5m	17.0m	thick clay, highly moisturized clay, silty clay ,silty sand	Depth soil clay
4	4	E-17	17.5m	19.0m	Silty sand, silty clay ,non-stiff clay, very non stiff highly moisturized clay	Depth soil clay
5	5	E-21	20.0m	19.0m	Silty sand, silty clay, non-stiff clay, very non stiff highly moisturized clay, silty sand, sand, rock fragment	Boundary of rock fragment between sand and carbonate layer

Table 10-B: The description of boreholes that drilled by auger in construction site #2 (Gunung Rapat –Taman Gunong View)
Table -10(A-B): Viewing the descriptions of boreholes that drilled by Auger in construction site#1, #2

In construction site #3, Tenth boreholes opened, with a maximum depth of 12 m. The borings are complete in the unconsolidated material of soil, clay, sandy clay and sand over karstified limestone. This boring was used to define the limestone/clay boundary and a few of the sinkholes spatially. The depth of the boreholes was approximately ranging from 3, 6, 9, 10 to 12 m.

The depth of the boreholes to bedrock has defined as the depth that refuses auguring in the borings. The mistake found in the boring data is the result of the borings recording the top of the weathered limestone zone, instead of the top of the intact or unweathered limestone bedrock. Numeral of borings has stopped by residual boulders in the overburden layers, or by limestone fragments.

The limestone dipped approximately toward the southwest in this site. When comparing the interpretations from individual profiles with the boring data, it was discovered that more of the data points have fewer errors of less than 1 m, and some of the data points have errors of less than 3 m. When the boring penetrate deeper in order to reach one of the limestone pinnacles beneath electrode no. 27 in profile no.1, the auger became very problematic in the borings when it reaches a depth of 9 m, which represent the transitional zone that contains limestone rock fragments and sand. The boreholes that drilled in the study area by hand Auger, portable Auger with motor and mobile drilling machine for environmental study in the study sites present in figure 32.

Figure 32: Present the boreholes that drilled in the study area by hand Auger, portable Auger with motor and mobile drilling machine for environmental study

15. PLANNING TO MITIGATE THE RISK IN CONSTRUCTION SITES DEVELOPING OVER THIS ENVIRONMENT CARBONATE KARST TERRAIN

Variety of foundations that function for these construction sites over the environments carbonate karst region depends upon two criteria, first to assume foundation loading, second the degree of development of the karst features. The most dangerous site was the occupied foundation over sinkholes which affected by two controlling factors, the first factor is the overloading and second, the water seeps through the cover soil.

If the level of engineering classification of karst ground conditions in these carbonate region has known and classified, the most economical point of view in developing these site is to minimize the risk of structures that have founded over the area by determining the safest route in changing the plan's location far from the problem site over the karst features. If

possible, the most important part with great size and type of construction structures has to place in the safest region, while the problem areas can be, allocate for non-critical facilities, such as grass field, golf or football playing field, roadway pavements, etc. The variety of foundation that functional for these construction sites over environment carbonate karst region depends upon two criteria, first to assume foundation loading, second the degree of development of the karst features.

The most dangerous site was the occupied foundation over sinkholes which affected by two controlling factors, the first factor is the overloading and second the water seep through the cover soil. If the level of engineering classification of karst ground conditions in these carbonate region has known and classified, the mostly economical point of view in developing these site is to minimize the risk of structures that have founded over the area by determining the safest route in changing the plan's location far from the problem site over the karst features. If possible, the most important part with great size and type of constructions structures has to place in the safest region, while the problem areas can be, allocate for non-critical facilities, such as grass field, golf or football playing field, roadway pavements, etc.

16.1 FOUR SOLUTIONS WERE MOST GENERALLY USED IN THE PLAN IN ORDER TO MITIGATE OR MINIMIZE THE RISK OF THE PROBLEMATIC AREAS IN CONSTRUCTION SITE # 1 (KLEBANG PUTRA):

16.1.1 First Solution Method In Minimize the Risk of the Problematic Areas, Sinkholes Remediation by Using of Reverse Graded Filter Technique

Sinkhole remediation has achieved by utilizing the reverse graded filter technique. To fill this huge sinkhole, the hole must be excavated, and its throat plugged by concrete block, sealed with a thick grout of cement. Fill the hole with larger boulders or rocks at the bottom, followed with cobbles, then gravels or Bentonite mixed with rock fragments, then by sand and finally, the top must covered with 8-12 inches of soil. The placement of larger materials directly on the bedrock at the bottom of the sinkhole is done in order to provide support and prevent another collapse, while the smaller materials stops water from moving the soil downward into the void, and then to the bedrock. Sinkhole remediation has achieved by utilizing the reverse graded filter technique is presenting in figure 33.

Figure 33: Sinkhole remediation has achieved by utilizing the reverse graded filter technique in construction site # 1 (Klebang Putra)

16.1.2 Second Solution Method In Minimize the Risk of the Problematic Areas, By of Using Concrete Bridge Beam

Sinkhole remediation through using concrete bridge beams, in order to transfer a load of construction structures to both sides of the massive subsidence sinkhole. The applying of this method has consisted of four main stages. The first stage is, driving along bearing pile or column down to a point that is resting on sound rock strata.

This column or the pile will transfer the loaded weight of the concrete bridge beam to the ground. The second stage is the setting of the concrete support block or abutment that is the connection between the end of the bridge and the earth that providing support to the two end parts of the bridge. The third stage is, filling the hole with larger boulders or rocks at the bottom, followed with cobbles, then gravels. If the sinkhole is very dangerous to designed foundations, it must be packed with concrete. The fourth stage is the setting of the superstructure of the concrete bridge beam, which is the horizontal platform that spans the space between two abutments or concrete support block over the first and second elements. The Sinkhole remediation by using a concrete bridge beam in construction site # 1 is present in Figure34.

Figure 34: Sinkhole remediation by using concrete bridge beam in construction site # 1(Taman Klebang Putra)

16.1.3 Third Solution Method in Minimize the Risk of the Problematic Areas, By Using Bentonite / Cement Grouting Compaction Technique

Soil stabilization by using the Bentonite / Cement grouting compaction technique can be utilized to fill the small voids and fissures in the soil. This technique is best appropriate for the granular silty, sandy and clayey soil with significant fine sand content that strengthens the ground and prevent excessive movement in the future. First, the grouts have injected into drilled holes then the grouts are compacted into the joints and gaps in the surrounding soil, where it solidifies with the soil to make it appear relatively impermeable and hard. Soil stabilization using Bentonite / Cement grouting technique is one of the engineering subsurface remediation techniques in construction site # 1 (Taman Klebang Putra) is present in figure 35.

16.1.4 The Fourth Solution Method In Minimize the Risk of the Problematic Areas, By Placed the Project in the Safest Region

If it is possible, relocation the most important part with great size and type of construction structures to be place in the safest region, may prove to be more cost-effective in certain cases. While the problem areas can be, allocate for non-critical facilities, such as grass field,

playing football area, pavementsroadway.

Figure 35: Soil stabilization by using Bentonite / Cement grouting technique is one of engineering subsurface remediation technique in construction site # 1(Taman Klebang Putra)

16.2 THE FOLLOWINGS ARE THREE SOLUTION METHODS USED MOST FREQUENTLY IN THE PLAN TO MITIGATE OR MINIMIZE THE RISK OF PROBLEM AREAS IN CONSTRUCTION SITE# 2(GUNUNG RAPAT)

16.2.1 The First Solution Method in Minimize the Risk of the Problematic Areas by Remediation of Small Sinkholes Using of the Bentonite Drilling Mud and the Rocks Cutting

Preparing the land for the future development of construction project consists of many stages. The first stage is cleaning the land from the plants and bushes. The second stage, small sinkholes remediation by using Bentonite drilling mud and the rock cutting from the drilling operation as one of the steps of environmental management in oil and gas exploration after the water and other liquids are removed to refill the small sinkholes in this construction site would be the ideal solution.

To fill these small sinkholes, first excavate the holes, then filling it with Bentonite drilling mud and the rocks cutting. After that, if possible to spray the filling sinkholes with a geopolymer a chemical solution to fill the gaps between the rocks fragments. In the third stage, the uppermost of the sinkhole area completed with a layer of Bentonite clay with a thickness of about 4.0/5.0 inches to preventing water seepage from occurring. After that, the final layer of the ground surface must cover by a layer of soil with a thickness of about 6.0/7.0 inches.

The Surface soil needs improvement in this construction site by rolling and compaction processes to increase the stiffness by decreasing the permeability of surface soil in this construction site. Small sinkholes remediation by using Bentonite drilling mud and the rock cutting from the drilling operation is present in figure 36.

16.2.2The Second Solution Method to Minimize the Risk of the Problem Areas by Using Of Deep Grouting Chemical Solution

Deep grouting by using of geopolymer chemical grouts (urethane) is a form of penetration grouting. A cost-effective professional process uses chemical solution forms to fill the small voids and fissures in the soil. The best type of soils suited for this technique are granular soils, with significant fine sand content, that strengthen the ground and prevent excessive movement. Chemical grout has injected through the joints and gaps in the surrounding soil,

where it solidifies with the soil to making it appears relatively impermeable and hard. The deep grouting by injection of chemical solution is one of the engineering subsurface remediation techniques as presented here below in figure 37-A, and figure 37-B.

Figure 36: Small sinkholes remediation by using of Bentonite drilling mud and the rock cutting from the oil and gas drilling operation

Figure 37-A: Presenting the deep grouting by injection of geopolymer chemical grouts (urethane) is one of engineering subsurface remediation technique

Figure 37-B: Presenting the geo-polymer chemical grouts (urethane) in the subsurface

16.2.3 The Third Solution Method to Minimize the Risk of the Problem Areas by Using of Raft Foundation Also ThisType it'sknownas Floating Foundation

Raft foundation or mat(also known as floating foundation) is required and necessary where soils have low bearing capacity and have to hold up heavy structural loads on swampy land, soft clay, and unconsolidated soil material. Raft foundation is necessary where an area that subsidence may occur from different reasons such as due to the alteration in groundwater level or due to the change in the climate especially in area with extended soil or in mining area. Raft foundation is the economical solution in this site where the deep pile foundations are not possible and not economical. The type of Raft foundations that convenient in construction site#2 is present in figure38.

Figure38: Presenting the Raft foundations or floating foundation that convenient in construction site #2

16.3 TWO SOLUTION METHODS THAT ARE MOST FREQUENTLY USED IN THE PLAN TO MITIGATE THE RISK OF PROBLEMATIC AREAS IN CONSTRUCTION SITE #3 (KAMPONG KUNSLA – NORTH KAMPAR) COULD BE DEMONSTRATED AS FOLLOWS

16.3.1 The First Solution Method Is To Minimize the Risk of the Problem Areas by Remediation of Small Sinkholes Using ofthe Bentonite Drilling Mud and the Rock Cutting

The first solution is small sinkholes remediation by using Bentonite drilling mud and rock cutting. In this process, the first stage is cleaning the land from the plants and bushes. The second stage, small sinkholes remediation by using Bentonite drilling mud and the rock cutting from the drilling operation as one of the steps of environmental management in oil and gas exploration after the water and other liquids are removed, to re-fill the small sinkholes in this site would be the ideal solution. To pack these small sinkholes, first excavating the holes of these sinkholes, then were filling it with Bentonite drilling mud and the rock cutting. After that, if possible to spray the filling sinkholes with a geopolymer chemical solution, to fill the gaps between the rocks fragments. In the third stage, the uppermost of the sinkhole area must complete with a layer of Bentonite clay about 4.0/5.0 inches, to prevent water seepage from occurring. After that, the final layer of the ground surface covers with soil about 6.0/7.0 inches. Surface soil needs to improve in this construction site by rolling and compaction processes to increase the stiffness by decreasing

the permeability in this site. Small sinkholes remediation by using of Bentonite drilling mud and the rock cutting is present in figure 39.

Figure39: Presenting the small sinkholes remediation by using of Bentonite drilling mud and the rock cutting

16.3.2 The Second Solution Method To Minimize the Risk of Problematic Areas in Site #3 using the Deep Grouting Technique by Injecting of Geopolymer Chemical Solution Grouts (Urethane)

The second solution using the deep grouting technique by injecting of Geopolymer chemical solution grouts (Urethane) is a form of penetration grouting. A cost valuable specialized process uses chemical solution forms to fill the small voids and fissures in the soil. The granular soils with a considerable amount of sand with fine and medium size contents are the best appropriate for this technique. That will strengthen the ground and prevent excessive movement. Chemical grout has injected through the joints and gaps in the surrounding soil and sand, where it solidifies with the soil making it appear relatively impermeable and hard. Using the deep grouting technique by injection of geopolymer chemical solution grouts (Urethane) is present in figure 40.A and, 40.B.

Figure 40.A: Presenting the deep grouting technique by injection of geopolymer chemical solution grouts (Urethane)

Figure 40.B: Presenting the geopolymer chemical grouts (urethane) in the subsurface

17. MITIGATE THE HAZARD OF RADON GAS EMISSION IN KARST AREA

17.1 Introduction

Carbonate Karst environments its geologic condition is everywhere around the planet earth. Its rocks characterizing by features contain fluids such as cavities, sinkholes, and underground streams. Also, caves, and channels pipes. When the groundwater has dissolved a geologic formation of sedimentary rocks located over carbonate karst environment bedrocks, high in uranium or radium, radioactive radon gas will produce by those formations can more freely move into the houses and the buildings that located above this geologic formation. Besides, the most dangerous area in karst regions are the housing complex and high-rise building that constructed rounds these karst lakes and the mining pits that developed in the region to become lakes for tourism. The radon emission is so strong and can affect the people who stay around these lakes and create lung problems to them.

Karst causes jaggedness; Fissures assist as conduits that channel radon gas to the surface, causing irregular flow rates and patterns of movement that can vary with the seasons and outer environmental conditions. Weather and seasonal conditions can cause spikes and dips in radon levels. The radon measurements in the internal seasonal variations are greater in karst areas than in non-karst areas.

Variability has shown in the environmental experimental study by many scientists, in the karst regions of Tropical and semi-tropical regions. In a yearlong test of radon will give the best picture of the actual radon level than a short test in one day or in one week. The study has shown that; short-range in-door and out-doors testing for the houses and buildings around these karst sites have higher radon levels. However, there are structures in karst areas that give wrong or negative results in the hot morning and when tested in the night become colder give positive results or high radon problem.

In addition, in colder areas, Short-term tests often show that houses have higher radon levels in colder months (November through February). However, there are houses that do test higher in warmer months (May through September). To account for the variability of problems, a yearlong test will give the best picture of the houses actual radon level.

The unpredictability of studies shown that the karst has approximately one-third of the homes tested (with short-term tests) in karst areas in the summertime had (False) negative results and when tested in the winter had a radon problem.

17.2 The Hazard of Radon Gas Emission in Karst Area

Radon also is a potential health hazard in karst areas. The accumulation of radon gas beneath the ground floors of buildings can be harmful to humanity. Particularly those who existing

adjacent to rock types which are relatively rich in radon and where open fissures exist such as karst lake.

In an area where the limestone is closely to a granite body, the radon problems can improve by ventilation. Distinctive plants associated with karst features which their life cycle or at least part of it depending on upon the distinctive environment of these systems. Even slight alterations or disturbances can have significant impacts upon these plants.

The buildings and housing complex constructed in karst regions contaminated with greater levels of radon and other contaminants that affect the breathing and present in the air within the buildings and housing complex in these regions. It will be contaminated with radon of two pico-curies per liter (2 pCi/l) or the greater levels four pico-curies per liter (4 pCi/l) and other contaminants that affect the breathing and present in the air within these housing and buildings. These contaminants include hydrocarbons, CO, CO₂, ozone, olefins, and nitrogen oxides, sulphuric. Many areas with karst bedrock are composed of limestone; phosphate minerals that occur naturally in limestone contain small amounts of uranium. Uranium is a radioactive, toxic element that easily oxidized.

Because of the uranium degrading into lead, small amounts of radon are producing as a byproduct. The dissolved rock on top of a geologic formation is high in uranium or radium, radioactive radon gas produced by those formations can more readily move into houses and buildings above. Over a period, this radon gas can accumulate within solution-derived through Joints naturally occurring in the limestone bedrock that allows for fissures and cavities to form through solution processes. Over a period of time, and heavy rain events this radon gas can accumulate within solution that derived through these fissures and released into water reservoirs beneath the following surface, Savoy, L. et. al., (2011).

The structures that built above karst cavities are likely to the diffusion of radon due to fluctuations in atmospheric pressure (Ruthven, C. et. al., 2002). Extensive amounts of radon are producing within the soil overlying karst bedrock. This radon is released into water reservoirs beneath the surface after heavy rain events (Savoy, L. et. al, 2004). These potential geologic hazards can identify by geologists in order to mitigate the risks that are present by the karst bedrock.

A short-range test often shows that the houses have higher radon levels. However, there are houses that do test higher in a yearlong test will give the best picture of the actual radon level. A karst variability study has shown that approximately one-third of the homes tested (with short-term tests) in karst areas is (false) negative results. In addition, when making (with long-term tests), they had a radon problem.

Radon infiltration is a problem to take seriously. Prolonged exposure to the gas can result in serious health problems and even death. The radon gas is an environmental hazard associated with areas of karst topography, is known as deadly gas cause of lung cancer. These steps involving get in touch with an indoor air stream with an adsorbent device for the removal of radon. Additionally, when the design of buildings and housing structures needs the development of a new process to remove radon from the out-door, in-door air stream and other contaminants. Levels process greater than 4.0 picocuries are cause alarm. Houses in the karst area with this category, such as allow for more ventilation of basements and crawl spaces in the houses, as well as sealing crawl spaces with plastic. The geophysical techniques viewing that radon gas existing in the water that in-fill the sinkholes and the cavities in most ER Tomography section of the sites under study. This led to the conclusion that there is an effect and put the solution in these sites. Some of the ERT Sections from construction site #1, site# 2 and site#3 displays the radon (pink color, 1-3 Ohm-m) detected in the underground water of the cavities and the sinkholes present in figure 41(A-C).

Radon infiltration is a problem to take seriously. Continued exposure to the gas can result in serious health problems and even death. Radon is the second leading cause of lung

cancer variability in radon concentrations within individual homes. This variability seemed related to differences between ground and outdoor air temperatures, and the ability of these temperature differences to move air through caves and channels of the underlying karst geology.

This air movement can alternately infuse the soils around a building with radon from the earth. Changing the concentration of radon in the soil gas surrounding a building can dramatically change the indoor radon levels in a matter of hours. Short-term radon measurements are not reliable indicators of the long-term radon concentration in buildings in karst areas. An agreement of a new testing procedure was developing that (recommends 12-month testing in karst areas, warns against using shorter-term testing, and calls for periodic retesting). Similar situations have since been identifying in both Canada and Europe.

Figure 41.B: ERT Sections from construction site#1, display the radon in the underground water of the cavities and the sinkholes

Figure 41.A: ERT Sections from construction site# 2 display the radon in the underground water of the cavities and the sinkholes

Figure 41.C: ERT Sections from construction site#3, display the radon in the underground water of the cavities and the sinkholes

Figure 41 (A-C): ERT Sections from construction site #1, site#2, and site#3, displays the radon in the underground water of the cavities and the sinkholes

17.3 Preventing the Radon Gas From Enters Into Our Houses

The radon gas is an environmental hazard associated with areas of karst topography, is a known deadly gas cause of lung cancer. Radon is a radioactive gas. It comes from the natural decay of uranium that is found in nearly all soils. It typically moves up through the ground to

the air above and into the house through cracks and other holes in the foundation. The house traps radon inside, where it can build up. Any house may have a radon problem, new houses and the olds, well-sealed and draft homes, and homes with or without basements. Radon from soil gas is the main cause of radon problems. Sometimes radon enters the home through well water. Many studies discover that in some homes, the building materials can emit radon also. Radon gets into the homes or the buildings through the cracks in the solid floors and in the walls, construction joints, gaps in suspended floors, gaps around service pipes, cavities inside the walls, and the water supply.

Uranium can generate radon gas by fission. The radon gas will itself undergo further fission to produce radioactive (daughters). The alpha particles produced by radon daughters are not powerful enough to penetrate the human body from outside it. However, if radon draws in, the alpha particles generated by the daughters can cause harm to cells in the lungs and in a different place. This may result in an increased risk of cancer. The level of radon is often highest in the lower part of the building. Radon moves through the homes by diffusion and natural air movements and it can be distributed by mechanical equipment, such as a forced-air ventilation system. As radon moves away from the house's foundation or other entry points, its combinations and is diluted into a greater volume of air.

In addition, more reduction often occurs in the upper levels of the home because there is more fresh air ventilation there. Greater reduction and less home vacuity may also occur when the home is more open to the outdoors during the non-heating season. The gas exposure in houses could be reducing through impermeable casing could install at floor level. In addition, fans could suck air-containing radon from underneath the ground floor and expel it directly into the atmosphere, where it goes away (Agius, R., 2009).

17.4 Impact of Radon Gas

Radon is present approximately in entirely air. Usually, everyone breathes radon every day at very low levels. However, people who breathe in high levels of radon are at an increased risk of developing lung cancer. Radon deteriorates quickly, giving off tiny radioactive particles. When breathing in, these radioactive particles can damage the cells that line the lung. Long-term exposure to radon can lead to lung cancer, the only cancer proven associated with breathing in radon. According to Yamada (2003), radon's half-life of 3.8 days is long enough for it to enter into indoor and cause an increase in the indoor concentration. However, this half-life is relatively too long to enter into the breathing territories and to expose the cells.

Radon gas that appears from the cracked in the buildings could affect the health of humans. Radon cited as the second leading cause of lung cancer after cigarette smoking. This study is important, as it will be beneficial to people who live in karst area to understand more about radon and its effect on human health.

Radon-222's half-life of 3.8 days is long enough for it to enter into indoor and can cause the indoor concentration to increase but it is too long for it to enter into the breathing zones and to treat the cells. Poor indoor air quality in homes and office buildings has recognized as a primary factor that leads to lung problems in people. Radon is a primary contributor and levels above four pico-curies per liter (4pCi/l) have statistically shown to increase the risk of cancer in personalities. Radon gas, which is a radioactive decay byproduct of radium, constantly seeps from subterranean radium deposits and out through the surface of the earth's crust, into the atmosphere surrounding the earth. It has a relatively short half-life, in the order of four days.

Thus, the radon gas concentration never reaches significant levels upon escaping into the earth's atmosphere. Radon gas does not reach sufficient concentration levels, e.g., above (4pCi/l) to pose a human health hazard. When an enclosed structure, such as a building, is located in an area of significant radon contamination, the radon seeps into the structure

through cracks or other openings in parts of the foundation, basement or other parts of the building that are in contact or near contact with the earth. If there is a poor exchange of interior and exterior air within the building, significant radon concentrations can develop within a building, which is above current limits (4pCi/l).

17.5 The Physical Properties of Radon Gas

Radon is a chemical element with symbol Rn and atomic number 86. It is a radioactive, colorless, odorless, tasteless, noble gas, occurring naturally as a decay product of radium. Its most stable isotope, ^{222}Rn , has a half-life of 3.8 days. Radon is one of the densest substances that remain a gas under normal conditions. In addition, the only gas under normal conditions has a radioactive isotope and is considered as a health hazard due to its radioactivity.

Because of that gas specification, therefore not detectable by human senses alone. At standard temperature and pressure, radon forms a monatomic gas with a density of 9.73 kg/m³, about 8 times the density of the Earth's atmosphere at sea level, 1.217 kg/m³. Radon is one of the densest gases at room temperature and is the densest of the noble gases. Although colorless at standard temperature and pressure, when cooled below its freezing point of 202 K (−71 °C; −96 °F), radon emits a brilliant radio luminescence that turns from yellow to orange-red as the temperature lowers. Radon radiates because of the intense radiation it produces. Radon is sparingly soluble in water, but more soluble than lighter noble gases. Radon is noticeably more soluble in organic liquids than in water. Being a noble gas, radon is chemically not very reactive. However, the 3.8-day half-life of radon-222 makes it useful in physical sciences as a natural tracer.

Radon is members of the (zero-valence elements) that are called noble gases. It is inert to most common chemical reactions, such as combustion, because the outer valence shell contains eight electrons. This produces a stable, minimum energy configuration in which the outer electrons are tightly bound. 1037 kJ/mol is required to extract one electron from its shells (also known as the first ionization energy).

In accordance with periodic trends, radon has a lower electronegativity than the element one period before it, xenon, and is therefore more reactive. Early studies concluded that the stability of radon hydrate should be of the same order as that of the hydrates of chlorine (Cl₂) or sulfur dioxide (SO₂), and significantly higher than the stability of the hydrate of hydrogen sulfide (H₂S). Because of its cost and radioactivity, experimental chemical research is seldom performed with radon, and as a result, there are very few reported compounds of radon, all either fluorides or oxides. Powerful oxidizing agents such as fluorine, thus forming radon difluoride, can oxidize radon. It decomposes back to elements at a temperature of above 250°C. It has low volatility and thought to be RnF.

It has not possible to study of radon and the radioactivity of its compounds, Because of the short half-life. The theoretical studies on this molecule predict that it should have a Rn-F bond distance of 2.08 Å, for that the compound is thermodynamically more stable and less volatile than its lighter counterpart (XeF). The octahedral molecule RnF₆ has predictable to have an even lower enthalpy of formation than the di-fluoride. The higher fluorides RnF₄ and RnF₆ have claimed, and are calculated to be stable, but it is unsure whether they have yet been produce. The (RnF) + ion have considered forming by the following reaction:

17.6 The Development of Process for Removal of Radon Gas

This development provides a process for removal of radon and/or other contaminants from indoor air comprising the step of contacting of indoor air with an adsorbent, adsorbent comprising a silver-exchanged zeolite. In another representation of the process, other impurities, which may affect breathing, are sometimes present in the air within buildings and

these include hydrocarbons, CO, CO₂, ozone, olefins, nitrogen oxides, sulfur oxides, water, and microorganisms.

These impurities can remove, in addition to radon, if present, via a layering of adsorbents that are designed for selective removal of the impurities within the adsorption system. One refinement is providing a process for the removal of impurities from indoor air contaminated with radon of 2 pCi/l or greater. Within a building comprising the steps of contacting the indoor air stream with a porous material that releases silver ions upon contact with water for removing bacteria and molds; contacting the indoor air with a desiccant under conditions for removing moisture; and, contacting the indoor air with a silver exchanged zeolite capable of removing radon.

The process and device provide an ability to remove radon from indoor air in buildings; which may be competent at generally ambient conditions if desired. Using an adsorbent having an affinity and capacity for radon. Radon is substantially or partially removed from the moisture-free air bypassing the moisture-free air through the absorbent comprised of (Ag exchanged zeolite) to create (cleaned air), and is returned to the indoor air atmosphere. The manifestation (cleaned air) describes as, the air stream that occurs by the absorber.

Radon formed as one intermediate step in the normal radioactive decay chains through which thorium and uranium slowly decay into lead. Thorium and uranium are the two most common radioactive elements on earth; they have been around since the earth formed. Their naturally occurring isotopes have very long half-lives, approximately billions of years. Thorium and uranium, their decay product radium, and its decay product radon will therefore continue to occur for tens of millions of years at almost the same concentrations as they do now. As radon itself decays, it produces new radioactive elements called radon daughters or decay products. Unlike the gaseous radon itself, radon daughters are solids and stick to surfaces, such as dust particles in the air. If such contaminated dust inhaled, these particles can stick to the airways of the lung and increase the risk of developing lung cancer.

Different from all the other intermediate elements in the aforementioned decay chains, radon is gaseous and easily breathes in. Thus, naturally occurring radon is responsible for the majority of the public exposure to ionizing radiation. It is often the single largest contributor to an individual's background radiation dose, and is the most variable from location to location. Despite its short lifetime, some radon gas from natural sources can accumulate to far higher than normal concentrations in buildings, especially in low areas such as basements and crawl spaces due to its heavy nature. It can also found in some spring waters and hot springs.

.17.7 The Potential Entry of Radon Gas in the Houses

The potential entry points of Radon gas in the housing construct over Carbonate Karst environment is:

- 1- Cavities inside the walls
- 2- Cracks in the footing and solid floor
- 3- Construction joints
- 4- Cracks in walls
- 5- The water supply pipes
- 6- Cracks round surface pipe
- 7- Cracks in suspended floor
- 8- The floor drain

The potential entry points of Radon gas in a home construct over Carbonate Karst environment and Gas emission purifications instrument display in figure 42.

Figure42: Display the Potential Entry Points of Radon Gas in a Home Construct over Carbonate Karst environment and the Design of Gas Emission Purifications instruments by Yassin, R. R (2012)

18. RESULTS AND DISCUSSION

In the following the results and discussion of the integrated techniques in this geoenvironmental and geoenvironment research study:

1. As a result of applying the ERT technique in this research, the 2-D Survey demonstrates that ERT is a useful geotechnical tool that is appropriate for imaging the bedrock, overburden layers and to determine the subsurface karst features in cover karst terrains. The electrical resistivity tomography data acquired from the survey is constructive for several reasons:
 - a) The complete data analysis and suitable design of profiles arrangement are important factors to determine the karstic features and to ensure the achievement of the project objectives. In order to delineate the karst features such as (sinkholes, voids, and cavities) can organize by complete closely spaced parallel ERT profiles and imaging the subsurface immediately across and in-proximity to many sinkholes. in order to determine the karstic features such as (sinkholes, voids and cavities).
 - b) It has provides dependable images and supported the interpretation that the study area is underlain by several varieties of karsts features such as (sinkholes, cavities, and voids).
 - c) It can be useful for characterizing the subsurface bedrock in covered karst terrains. In this study, it is recognized that the subsurface limestone bedrock was widely karstified and it has provides dependable images of the karstified limestone bedrock.
 - d) It has identified the type of sediments in the subsurface layer, including estimation for its approximate depth and thickness.
 - e) It has indicated that the ground surface overlain in various places by friable sand and remnant of limestone rock and other rock fragments due to high resistivity recorded in most of the overburden cover.
 - f) It has provides a sufficient resolution to pinpoint the locations of packed and empty sinkholes and other geophysical anomalies such as cave and cavities.
 - g) It has identified an area of ongoing subsurface erosion that may eventually collapse in the near future. A potential collapse may be due to the presence of longitudinal anomalies in the shape of lenses or cavities filled with rainwater and thick clay. Other materials of sandy or silty clay might also collapse when it is subject to a piping under load, and threaten the site in the near future.

2. This study also displayed the reliability of electrical resistivity tomography (ERT) as a high-resolution technique was very favorable vis-à-vis locating underground cavities and sinkholes. In addition, water channels, due to the dissolution in fractured zones. It is also completely suitable for differentiating surficial soil, clay, weathered rocks, compact or intact rocks, and air-filled karstic voids or cavities, and intensely fractured rocks. These features affect many construction sites position in the area extended over carbonate karst rocks, causing a disturbance in construction works, which can increase the overall cost of the projects.
3. The geological model is clarifying via the geophysical data, consists of a basal marbleized limestone unit and constitutes the bedrock of the study area. This bedrock unit appears to have been dissected or intervened by solution-widened joints and fractures, enclosed by overburdened layers consisting of sand, containing lenses of stiff, non-stiff moisturized clay and covered by soil mixed with friable sand and rock fragments in certain places. Intervened by sinkholes and cavities in-filled with clay or sandy clay and sand; it is interpreted as created due to karst process.
4. The interpretation of the inverse model section in construction site #1 (Klebang Putra) indicated that the area has been exaggerated by a numerous of sinkholes and thus contains stiff, non-stiff clay and saturated with water. These features are harmful and making the area hazard as it has packed with material such as sandy or silty clay, which could collapse when subjected to piping under the load of the construction structures. The interpretation of the inverse model section in construction site #2 (Gunung Rapat) indicated that the area have been affected by a thick cover of alluvium deposits contain several lenses contain both stiff and non-stiff clay highly moisturized, making the area hazard.
5. The geophysical data indicated that the depth of limestone bedrock topography was asymmetrical or uneven, containing many pinnacles and cutters. In construction site #1, the depth of weathered limestone bedrock mottled between 3.0m and >28.0m. The depth of intact limestone bedrock varied between 8.0 m and >28.0m, and the depth of pinnacles varied between 3.0 m and 19.0 m. In construction site #2, the depth of weathered limestone bedrock mottled between 20.0 m and 28.0m. The depth of an intact limestone bedrock varied between 21.0 m and >28.0m, while the depth of its pinnacles varied between 20.0 m and 27.0m. In construction site #3, the depth of weathered limestone bedrock mottled between 11.0 m and 21.8m. The depth of an intact limestone bedrock varied between 13.5 m and 24.0m, while the depth of its pinnacles varied between 10.5 m and 15.5m.
6. Several varieties of sinkholes with different origins were discovered in the study area through the information of the geological and geophysical survey data records. The first types of sinkholes discovered were a few meters in diameter and depth, referred to as **cover-layers or material subsidence sinkholes**. The second type was wider than the first type in terms of diameter and depth, and it's referring to **cover-collapse sinkholes**. The third type of sinkhole resembles a **slump depression** produced on the ground surface, and the fourth type is an opening with a funnel-shape depression or sinks, which is referred to as pipes.
7. Many empty (air in-fill) sinkholes were found at this site, which supports the assumption that the emptying or infilling of these sinkholes were due to the stripping of the portion of the topsoil and granules of sand that drops down (in almost all of the study area). This is likely because there are heavy overspill rains in the study region. In addition, there is a

difference in the topography of the exposed rock, or because of the subsidence movement in the area. The result is the channeling of materials towards the sinkhole in order to fill the void in the layer beneath, or to fill the cavity through an existing joint/fracture in the limestone bedrock. These sinkholes measure only a few feet in diameter and depth, respectively. Their small size is because; the cavities in the limestone cannot develop to considerable sizes before they are in-filled with sand. Several small sinkholes empty and some seals with sand were identifying during the site groundwork inspection in the region.

8. The overlying sand found in many places on the surface in the area of study is mostly characterized by high resistivity; interpreted as sand dry and friable with remnants of limestone rock or other rock fragments, had been stripped by earth-moving equipment from the pits of mine, due to ex-mining excavating operation.
9. Through sinkhole observation, standing water remained or stayed in the sinkhole days after the feature formed, suggesting that the flush or migrate were stopped. This occurred when the conduit or the pipe that was formed due to solution-widened joints become choked or blocked with clay or other material to these drainages because the size of the cavities in the limestone bedrock are in-filled or loaded with clay-based and sandy material. Otherwise, in the rainy season, the rainwater flushing down through the sinkhole will cause the water table to increase if the sinkhole spreads laterally and intersects the water table. The dissolution is reduced because there is less vertical difference between the water table and rainwater surface and here, the flush or migrates will be less.
10. Sinkholes in many different shapes and sizes were recognizing in the study area. They are generally circular in outline, conforms to similar shapes such as elliptical or irregular configuration, or look like a funnel. A tunnel or throat is visible within the hole, representing a soil pipe that leads to the bedrock drain.
11. The group includes 10 small sinkholes found in site #3 representing the daughters, while the big sinkhole represents the mother. Due to the interconnected nature of the karst features system, this group of small sinkholes can also bond to form a larger sinkhole, with its shape-changing over time, from steep to nearly vertical sidewalls, and portions of this sidewalls can be break off over the time and fall into the sinkhole. As this process continues, the sinkhole gets larger. If water continues to add into the sinkhole due to precipitation or due irrigating, it can also get deeper.
12. In accordance with the geotechnical classification of karst ground conditions presented by Yassin, R., R. & Haji, Taib, S. (2012). Which describe the subsurface karst features that come upon in engineering works on the carbonate karst environments, after the applying of the geotechnical survey, The karst class in construction site#1 found between profile no.1 and profile no.6 is a mature karst KaIII to Complex karst KaIV, due to presence of huge sinkhole, lenses in-fill with clay or water, pinnacles. The karst class in construction site #2, found between profile no.1, profile no.4 is a mature karst KaIII, due to presence of numerous type of sinkholes with different sizes, voids, soil fissures, and pinnacles. The karst classin profile, no.5 is adult KaII to mature karst KaIII. The karst class in construction site#3 found between profile no.1 and profile no.4, is a mature karst KaIII, due to the presence of various types of soil covers collapse sinkholes, lenses, voids, cavities, and pinnacles. The karst classin profile, no.5 is adult KaII.

13. There are several causes for the occurrence of sinkhole collapse in the Kinta Valley; the primary reason among them is the irregular distribution of unconsolidated material on the bedrocks surface. The secondary reason is the running of heavy rainwater on the ground surface. The third reason is the heavy acidic rainfall in this region. The fourth reason is the earthquakes and the subsidence movement. The fifth reason is the heavy loads of buildings or foundations. The sixth reason is the human influence. The seventh reason is the vibration from traffic. The eight reasons are the weather patterns. The ninth reason is the groundwater movement. The tenth reason is the water quality. The eleventh reason is Air high pollution. All these reasons after the development of the sinkholes and other karst feature rapidly in this tropical area of Peninsular Malaysia
14. This study discusses many considerations about the important elements that play major roles in the development of karst phenomena and the dissolution process that effects the increasing of carbonate karst features in the Sungai Perak Basin (Kinta valley). One of these elements first, is the effects of climate change and second is the events that happened during the Holocene period, third the mining and human activities, fourth air and water high pollution, fifth the effects of heavy and acidic rainfall on the environment and climate change. All these elements directed to the rapid development of the karst features in this tropical area of Peninsular Malaysia.
15. This research study also shows the impact factors that arise together and played major roles in the causes of global flood (Noah's Flood) (3300-3100) BCE. In addition, this study shows that non- terrestrial impact factors lead the global flood to happen.
16. This study focuses on an important point that is the protection of the open area near the coastline around Malaysia from the sudden change in sea level in the near future. Any flood could happen in the near future is due to an increase in pollution, and due to human activity, which led to climate and environmental change. From that reason in this study, the researches recommended constructing earth dam with a concrete core at least 6.0-8.0 m height from currently, as some the other countries completed it for their side of seashores before the sudden change in sea level happening in the next few years.
17. The geotechnical survey in this research study recognizes; thin red cover that contains different sizes of granite rocks and minerals with thickness is mostly about (5.0cm - 12.0cm). This red cover over a layer of lateritic clay with different thicknesses from site to another between (1.0m -1.25m), (2.0m - 5.0m) and to maximum depth (6.0m - 9.0m) are mostly returns to the period of a global flood (Noah's Flood) (3300-3100) BCE. Besides, this study shows that known- terrestrial impact factors lead to happen of the global flood.
18. The appearance of this red cover and the layer of lateritic clay is due to runoff of heavy rains that have deeply eroded and washed both the highest granite ranges around the Kinta valley and then carried away by the new rivers and canyons that formed due to the erosion. The thin layer of carboniferous organic material with different thicknesses of (3.0cm-5.0cm), (8.0cm-10.0cm) have seen beneath the lateritic clay.
19. The study region is with covered carbonate karst environment situated in Sungai Perak Basin (Kinta Valley). The first study sites located at Taman Klebang Putra, Klebang Green to the north of Ipoh city. The second study site located at the Gunung Rapat region.

The third study site located at Kampung Kunsila estate, situated northwest of Kampar city and south of Ipoh city the capital of Perak, Peninsular Malaysia.

20. The interpretation of aerial photographic and satellite image techniques observed clearly that the orientation of lineaments (fractures and fault systems) from the Main series and Kledang series was cutting the marbleized limestone of Kinta valley and the hills above it. These give a consideration that there is a significant relationship between the geologic features and the origin of the karstic features and the possibility of its development in the study area. In addition, the interpretation showed that the drainage in the study area is rather straight and angular and the stream courses are controlled by the direction of lineaments (fractures and fault systems) in the marbleized limestone bedrock.
21. Through direct ground inspections in the sites, various types of sinkholes were found distributed surrounding the study area that was not observed in the satellite images because it contained modest evidence in the study area with regards to the presence of sinkholes. These sinkholes might be due to various factors such as the minuscule size of the sinkholes or their depth is too small to be detected in the satellite images, or concentrate plants might cover it, or its formation and development occurred after the satellite images have taken.
22. The analyses led to the conclusion that the origin of Karst features in construction site #1 appears to be a collapse sinkhole created by a small-scale collapse in the surface that occurred due to the presence of subsurface structural features. Then, the earliest collapse sinkhole was packed with soil, sediment and fragments due to the modifications to the surroundings, and finally resulting in the sinkhole being buried. Another Surface subsidence may then take place, due to compaction of the soil.
23. The origin of Karst features in construction site #2 appears to be new. The early stages of a soil-cover karst collapse may appear as a soil-piping feature; most soil cover collapse sinkholes locations are soil materials dominated by porous layers, with thickness of $\geq 9\text{m}$, highly weathered condition of underlying karstified carbonate bedrock, with positions adjacent to a main active sinkhole.
24. The origin of the sinkhole in construction site #3 is due to the sudden appearance of a Soil cover collapse sinkhole. It has initiated when a small void developed at a depth of a few meters in the soil. Otherwise, unconsolidated cover overlaying karst bedrock are enlarged by the loss of cohesion and loading of the arch-forming material, which is in turn caused by either saturation of the soil by rainwater precipitation or by the rapid draining of a submerged void, which also increases pore pressure.
25. In construction site #1, the most geohazardous area found to underneath resistivity profile no.5 and no.6, with sinkholes extending over 55.0m and reaching depths of more than 28.7m. Once the excavating work over resistivity profile #5 was started, the underground water gushed out immediately; which confirms the geophysical survey that there was a high conductivity and very low resistivity source representing ground water body under this profile
26. The most geo-hazardous area in construction site #2, found to be beneath resistivity traverse no.1, between E 7 and E 33. Extended also in resistivity traverse no.2, traverse no.3 and traverse no.4 which affected by various types of soil cover collapse sinkholes, soil

pipes, and lenses. Several of these features reaching depths range between 12.0m to 15.0m, while others reaching the maximum depth of ~19.0 m. These features are harmful because some were in-filled with water, while others with thick clay or with sandy or silty clay, which could collapse when subjected to piping under a load of structures.

27. Due to operating of the Permanent Geo-Hazard Incident Scale (PGHIS) that completed by Yassin, R.R. & Haji, Taib, S., (2013) to assess the geo-hazard in construction sites along with karst areas in Malaysia. This scale has many levels, which are determined based on three factors. There are 8 levels in this scale to assess the geohazard in the construction sites as described below:

In construction site #1, one level of the scale shown in this site is Level 5: present in high hazard incidents with wide-ranging between traverse no. 1 and traverse no.6, have and have an impact on people and the environment. It could affect creates collapsing in houses, roads, highways, and pavements. Is requiring the application of field measurements. The geological survey found large karst features on the upper surface such as large sinkhole, or huge depression, water flows up from this sinkhole, numerous of black spots of gray color clay represent the old swampy area. The geophysical survey showed large karst features extended in the subsurface deep and wide with a tenth of meters, representing in a buried sinkhole or large depression, lenses water infill and relief pinnacles.

In construction site #2, one level of the scale has shown in this site, Level 4: medium hazard incident record up from the normal values, between traverse no. 1 and traverse no.5. It's can possibly have an impact on the environment, the people, and the animals. Due to the presence of numerous types of soil covers collapse and subsidence sinkholes in this site. It's could affect in creates fracturing in the houses, roads, and pavements. It's requiring of the application of geological, geophysical field surveys and topographic field measurements. The geological survey shows numerous types of medium size of soil cover collapse, subsidence sinkholes and water pools present on the surface of this site. The geophysical survey showed karst features extended a few meters in the depth and width in the subsurface and relief pinnacles.

In construction site #3, one-level of the scales has shown in this site, Level 5: High hazard incident with wide-ranging consequences, between traverse no.1, and no.4, could have an impact on the people, environment, and the animals. It's requiring the application of geological and geophysical field surveys and Topographic field measurements. The geological survey found numerous types of soil cover collapse, soil pipe and subsidence sinkholes on the surface. The geophysical survey has shown numerous types of soil cover collapse, soil pipe, and subsidence sinkholes extended the subsurface. In addition, has shown many karst features in the shape of the body in- fill with water and lenses extended in the subsurface with a tenth of meters.

28. Through the comparison between the boring data by auger and geophysical data found that there is a small difference in the depth between the depth from geophysical interpretation sections and the depth from the geological report of drilling by auger about 2.0m to maximum 5.0m if the ground surface cover with sand and/or rock fragments.
29. The geophysical site characterization observing that the radon gas existing in the water that in-fill the sinkholes and the cavities in most ER Tomography sections of the construction sites understudied.

30. The construction of structures needs to designing and developing new processes to remove radon from the out-door and in-door air stream in the buildings and housing complex that constructed over carbonate karst environment. Then could contaminated with radon gas in greater levels and other contaminants affect the breathing existing in the air within these buildings, these contaminants include the Hydrocarbons, CO, CO₂, Ozone, Olefins, Nitrogen oxides, and Sulfur. These steps comprising contacting of out-door and in-door air stream with an adsorbent device for the removal of radon.
31. Early engineering subsurface remediation techniques needed to mitigate or minimize the potential geohazard of karst features in these construction sites over karst carbonate bedrock. Initial consideration is, utilizing the reverse graded filter technique to seal the huge sinkhole in construction site #1.also, Skin friction piles driven into the layers containing non-stiff materials (soil, clay, silt, sand). Driven off, long piles down to the sound bedrock due to the difference in the depth of bedrock from one side to the other. Besides, the need for a new grouting method in the study areas such as chemical grouting techniques and controlling surface and subsurface water drainages. All of these plans must put into operation in these sites when the project is beginning at these respective sites. One of the steps of environmental management in oil and gas exploration uses the Bentonite drilling mud and the rock gutting from the drilling operation after the water and other liquids have removed to fill-up the depression and sinkholes in these karst regions.

19. THE EFFECTS OF ALTERATIONS IN THE ENVIRONMENT OF THE LAND USE IN THIS KARST REGIONIN NEAR FUTURE

The alterations in the Karst Region's environment occur on both the surface and subsurface. The actions that are responsible for these alterations are possibly direct or indirect in nature. The variation in karst environments may maneuver the karst situation toward or away from its boundaries, Williams PW (1993).

There is an urgent need for a better understanding of the association between primary actions that affect the karst situation in both, short or long-term periods, such as agriculture, irrigation, and mining, on top of soil erosion and its movement, the rates of sedimentation, and groundwater contamination.

The presence of underlying fissures and joints is likely to facilitate the migration of soils from the surface. These features can deepen and disturb the surface of the soil.

Sources of contamination include fertilizers and manure disbursed to fields for crop production. The failure to supervise areas and unfortunate management in storing the manure and fertilizers and the application of liquid fertilizers using irrigation techniques may increase the erosion of the surface's soil.

In addition, the inappropriate tillage techniques, such as before heavy rainfall may facilitate the emergence of sinking streams, cavity, and sinkholes. This can cause rapid subsurface runoff and likely lead to increased sediment loads due to erosion in the subsurface emergent streams. Leaving crops residue cover on the soil surface can increase infiltration, and cause the loss of soluble nutrients to groundwater.

20. RECOMMENDATION

This geo environmental and geo engineering research study focuses on the integrated several techniques in determining and monitoring the potential of sinkholes geohazard, the overlaying sediments model, environment changes and the development of sinkholes and karst phenomenon. The application of ERT as usefulness geotechnical tool to capture the images of the bedrock and overburdened layers in order to determine the subsurface karst features located in the selected sites situated over carbonate karst environment in Kinta Valley

north and south of Ipoh, the capital of Perak, Peninsular Malaysia.

In this study several varieties of sinkholes were discovered through the information and data record of geological and geotechnical surveys; and there are more than a few of it of hazard origins, which are assumed cover-layers or material subsidence, cover-collapse sinkholes, sinkhole-like slump depression, and piping. So the researchers recommended using an ERT technique with a 5.0 m electrode spacing providing sufficient resolution to pinpoint the locations of filled sinkholes, cavities, voids, and other geophysical anomalies.

The ERT identified an area of ongoing subsurface erosion, which may eventually collapse in the near future in site #3, due to the presence of longitudinal anomalies in the shape of lenses or cavities in-filled with meteoric water. These sinkholes contain thick clay and other materials consisting of sandy or silty clay that could collapse when subjected to piping under load, creating a latent site threat in this case in the near future.

The failure to supervise this areas and unfortunate management in the storage of manure and fertilizers and the application of liquid fertilizers via irrigation techniques may increase surface soil erosion.

In that case, this area and other areas with similar specifications are hazardous for constructing accommodation for habitation or creating animal sheds by farmers, as well as manure storage facilities, feed storage, and poultry production. There is a possibility of collapse or subsidence of the soil cover or material sinkholes or its underlying layers due to the load at any time in the near future. This study also identified that the presence of an area with undergoing subsurface erosion that may eventually collapse in the near future in this site.

In addition, the inappropriate tillage techniques, such as before heavy rainfall may facilitate the emergence of sinking streams, cavities, and sinkholes. This study discovered that this area was hazardous to farmers seeking living spaces, or animal's shades or horses stables over the area. This is due to the fact that a collapse or subsidence for the cover soil or material and underlying layers (due to load) might occur at any time in the near future. This study will enable an understanding that an area with specification approximating to this study area will create future threats.

In construction site #1, the most geohazardous area found to underneath resistivity profile no.5 and no.6, with sinkholes extending over 55.0m and reaching depths of more than 28.7m. Once the excavating work over resistivity profile#5 was started, the under groundwater gushed out immediately; which confirms the result of geotechnical survey, that there was a high conductivity and very low resistivity source representing sinkhole in-fill with water under these profiles. Needs to mitigate or minimize the hazard in this site, Initial consolidations of reverse graded technique. Besides, it needs to apply of new process of grouting method in the study areas as chemical grouting techniques. Moreover, controlling of the surface and subsurface water drainages must put into the operation in these sites.

Furthermore, this study focuses on an important point that is the protection of the open area near the coastline around Malaysia from the sudden change in sea level in the near future. Any flood could happen in the near future is due to an increase in pollution, and due to human activity, which led to climate and environmental change. From that reason in this study, the researches recommended constructing earth dam with a concrete core at least 6.0-8.0 m height from currently, as some the other countries completed it for their side of seashores before the sudden change in sea level happening in the next few years.

Besides, the Geophysical site characterization observing that the radon gas existing in the water that in-fill the sinkholes and the cavities in most ER Tomography sections of the construction sites understudied. Therefore, the construction of structures needs to designing and developing new processes to remove radon from the out-door and in-door air stream in the buildings and housing complex that constructed over carbonate karst environment. Then

these buildings and housing complex could be contaminated with radon gas in greater levels and other contaminants that affect the breathing existing in the air within these buildings. These contaminants include the Hydrocarbons, CO, CO₂, Ozone, Olefins, Nitrogen oxides, and Sulfur. These steps comprising contacting of the out-door and in-door air stream with an adsorbent device for the removal of radon.

21. CONCLUSIONS

This geo environmental and geo engineering research study focuses on the integrated geological, geophysical, geochemical, physical, structural, environmental, archaeological, aerial photographs and satellite images techniques in determining and monitoring the potential of sinkholes geo hazard, the geological model of laying sediments, environment changes and the development of sinkholes and karst phenomenon after the Global flood (Noah flood).

These techniques have joint with engineering surface and subsurface remediation techniques and performed across three (3) selected construction sites distributed over a region of carbonate karst environment located in the Sungai Perak Basin (Kinta Valley).

The study region contains a cover carbonate karst environments situated in Sungai Perak Basin (Kinta Valley), which includes three main study sites. The first study sites located at Taman Klebang Putra, Klebang Green to the north of Ipoh city. The second study site located in the Gunung Rapat region. The third study site located at Kampung Kunsila estate, situated northwest of Kampar city and south of Ipoh city the capital of Perak, Peninsular Malaysia.

Geophysical site characterization by Two Dimensional (2-D) electrical resistivity imaging/tomography (ERT) surveys has conducted by employing a large number of electrodes using a 41- channel and array in Wenner configuration, displayed in many traverses or profiles across many sinkholes or in-proximity to it located at the study sites. The electrical resistivity data have collected and assumed to identify the origin of these sinkholes and their shapes. Furthermore, it generates the geological model of the area under study and the type of overburdened sediments and its thickness. Besides, on top to estimates the thickness of overlying sediments, and in the bottom, to estimates the depth of the (marbleized limestone) bedrock. Several varieties of sinkholes have discovered in the study sites via the information and data records from geological and geophysical surveys.

During the geological field survey and the inspections, several active sinkholes discovered and identified in the study sites and along the study region. Those sinkholes ranged from narrow-to-medium and medium-to-wide sizes, some with exposed throats. On average, the diameter of the sinkholes in the study region ranged from 1m to more than ~ 30m, some having approximately the corresponding range in depth

There are several causes for the occurrence of sinkhole collapse in the Kinta Valley; the primary reason among them is the irregular distribution of unconsolidated material on the bedrocks surface. The secondary reason is the running of heavy rainwater on the ground surface. The third reason is the heavy acidic rainfall in this region. The fourth reason is the earthquakes and the subsidence movement. The fifth reason is the heavy loads of buildings or foundations. The sixth reason is the human influence. The seventh reason is the vibration from traffic. The eighth reasons are the weather patterns. The ninth reason is the groundwater movement. The tenth reason is the water quality. The eleventh reason is Air high pollution. All these reasons after the development of the sinkholes and other karst feature rapidly in this tropical area of Peninsular Malaysia

Besides, this study discusses many considerations about the important elements that play major roles in the development of karst phenomena and the dissolution process that effects the increasing of carbonate karst features in the Sungai Perak Basin (Kinta valley). One of these elements first, is the effects of climate change and second is the events that happened

during the Holocene period, third the mining and human activities, fourth air and water high pollution, fifth the effects of heavy and acidic rainfall on the environment and climate change. All these elements directed to the rapid development of the karst features in this tropical area of Peninsular Malaysia

Moreover, this research study also shows the impact factors that arise together and played major roles in the causes of global flood (Noah's Flood) (3300-3100) BCE. In addition, this study shows that non-terrestrial impact factors lead the global flood to happen.

The geotechnical survey in this research study recognizes thin red cover that contains different sizes of granite rocks and minerals with thickness is mostly about (5.0cm - 12.0cm). This red cover over a layer of lateritic clay with different thicknesses from site to another between (1.0m - 1.25m), (2.0m - 5.0m) and to maximum depth (6.0m - 9.0m) are mostly returns to the period of a global flood (Noah's Flood) (3300-3100) BCE. Besides, this study shows that known-terrestrial impact factors lead to happen of the global flood.

The appearance of this red cover and the layer of lateritic clay is due to runoff of heavy rains that have deeply eroded and washed both the highest granite ranges around the Kinta valley and then carried away by the new rivers and canyons that formed due to the erosion. The thin layer of carboniferous organic material with different thicknesses of (3.0cm-5.0cm), (8.0cm-10.0cm) have seen beneath the lateritic clay.

Furthermore, this study focuses on an important point that is the protection of the open area near the coastline around Malaysia from the sudden change in sea level in the near future. Any flood could happen in the near future is due to an increase in pollution, and due to human activity, which led to climate and environmental change. From that reason in this study, the researches recommended constructing earth dam with a concrete core at least 6.0-8.0 m height from currently, as some the other countries completed it for their side of seashores before the sudden change in sea level happening in the next few years.

In accordance with the geotechnical classification of karst ground conditions presented by Yassin, R., R. & Haji, Taib, S. (2012). Which describe the subsurface karst features that come upon in engineering works on the carbonate karst environments, after the applying of the geotechnical survey, The karst class in construction site#1 found between profile no.1 and profile no.6 is a mature karst KaIII to Complex karst KaIV, due to presence of huge sinkhole, lenses in-fill with clay or water, pinnacles. The karst class in construction site #2, found between profile no.1, profile no.4 is a mature karst KaIII, due to presence of numerous type of sinkholes with different sizes, voids, soil fissures, and pinnacles. The karst class in profile, no.5 is adult KaII to mature karst KaIII. The karst class in construction site#3 found between profile no.1 and profile no.4, is a mature karst KaIII, due to the presence of various types of soil covers collapse sinkholes, lenses, voids, cavities, and pinnacles. The karst class in profile, no.5 is adult KaII.

This research study also found that site#3 and another site with similar specifications are hazardous for constructing accommodation for habitation or creating animal sheds, as well as manure storage facilities, feed storage, poultry farms, etc. There is a possibility of collapse or subsidence of the soil cover or material sinkholes or underlying layers due to the load at any time in the near future. This study also identified the presence of an area of ongoing subsurface dissolution erosion that may eventually collapse in the near future. Two solution methods have recommended using in the plan to minimize the risk of problematic areas in this site.

Due to operating of the Permanent Geo-Hazard Incident Scale (PGHIS) that completed by Yassin, R.R. & Haji, Taib, S., (2013) to assess the geo-hazard in construction sites along with karst areas in Malaysia. This scale has many levels, which are determined based on three factors. There are 8 levels in this scale to assess the geohazard in the construction sites as described below:

In construction site #1, one level of the scale shown in this site is Level 5: present in high hazard incidents with wide-ranging between traverse no. 1 and traverse no.6. In construction site #2, one level of the scale has shown in this site, Level 4: medium hazard incident record up from the normal values, between traverse no. 1 and traverse no.5. In construction site #3, one-level of the scales has shown in this site, Level 5: High hazard incident with wide-ranging consequences, between traverse no.1, and no.5.

Early planning needed to mitigate or minimize the hazard of karst features in these sites over karstified carbonate bedrock. Initial consolidations of reverse graded technique. Drive off long piles to the sound bedrock due to the difference in the depth of bedrock from one side to the other.

In addition, it needs to apply of new process of grouting method in the study areas as chemical grouting techniques. Moreover controlling of the surface and subsurface water drainages must put into the operation in these sites.

Besides, the Geophysical site characterization observing that the radon gas existing in the water that in-fill the sinkholes and the cavities in most ER Tomography sections of the construction sites understudied.

Therefore, the construction of structures needs to designing and developing new processes to remove radon from the out-door and in-door air stream in the buildings and housing complex that constructed over carbonate karst environment. Then could contaminated with radon gas in greater levels and other contaminants affect the breathing existing in the air within these buildings, these contaminants include the Hydrocarbons, CO, CO₂, Ozone, Olefins, Nitrogen oxides, and Sulfur. These steps comprising contacting of out-door and in-door air stream with an adsorbent device for the removal of radon.

REFERENCES

1. Anderson, N., L., Apel, D., P., & Ismail, B., A. (2007). Assessment of karst activity at highway construction sites using the electrical resistivity method. Missouri, USA.
2. Austin, S. A., Baumgardner, J. R., Humphreys, D. R., Snelling, A. A., Vardiman, L. & Wise, K.P. (1994). Catastrophic plate tectonics, a global flood model of earth history, Proceedings of the third international conference on creationism, technical symposium sessions, pp. 609-621.
3. Baumgardner, J. R. (1990a). Changes accompanying Noah's Flood, Proceedings of the second international conference on creationism, vol. II, pp. 35-45.
4. Baumgardner, J. R. (1990b). The imperative of non-stationary natural law in relation to Noah's flood, Creation research society, Quarterly vol. 27(3): pp.98-100.
5. Beck B.F., Herring J.G. (2001) Geotechnical and Environmental Applications of Karst Geology and Hydrology, Balkema Publishers, pp. 341-346.
6. Bouwman, A.F., D.P. Van Vuuren, R.G. Derwent & M. Posch, (2002). A global analysis of acidification and eutrophication of terrestrial ecosystem. Water Air Soil Pollute, 141, 349-382.
7. Chan, S. F. (1986). Foundation problems in a limestone area, of peninsular Malaysia, Geotechnical Engineering Div., IEM, Sep1986, p. 98.
8. Chang K. S., Wong S.L. (2009). The limestone hills and caves of Kinta Valley) Malaysian Nature Society, Kuala Lumpur, Malaysia, p.151.
9. Chow W.S., Jamaludin O., Loganathan P. (1996). Geotechnical problems in limestone terrains with emphases to cavities and sinkholes pp.102-117.
10. Cobbing, E. J., Pitfeld, P. E. J., Derbyshire, D. P. F., & Mallick, D. I. J. (1992). The granites of Southeast Asian tin belt, Overseas Memoir 10, British Geological Survey of London, pp. 78-86.
11. Cooper, A. H., Farrant, A. R. & Price, S. J. (2011). The use of karst geomorphology for

- planning, hazard avoidance and development in Great Britain. *Geomorphology*, Vol. 134, pp 118-131.
12. Cullis, C. F., & M.M. Hirschler: Atmospheric Sulphuric natural and man-made sources. *Atmos. Environ.*, 14, 1263-1278 (1980). Dahlin, T. (1996) 2-D resistivity surveying for environmental and engineering applications, *First Break*, 14(7), pp. 275-283.
 13. Dahlin, T., & Like, M.Y. (1998). Resolution of 2D Wenner resistivity imaging as assessed by numerical modeling, *Journal of Applied Geophysics*, Volume 38: pp.237-249.
 14. David P., Panagiotis T., Konstantinos A. (2008) Electrical resistivity tomography mapping of beach rocks, application to the island of Thassos (N. Greece), *Environ, Earth Science*, (2009) 59:233–240 DOI 10.1007/s12665-009-0021-9.
 15. Fatihah, R. M., Al-Kouri, O. & Yassin, R. R. (2010). Geophysical and Geospatial Database Of Sinkhole Occurrences Distribution After Earthquake Tsunami. Southeast Asia international geological conference, Indonesia.
 16. Fischer J.A., Candace R. (1989) Foundation Engineering Construction in Karst Terrain, In *Foundation Engineering. Current Principles and Practices*, Proc. Conf., Evanston, Illinois, ASCE, USA, 1989, pp. 29-42.
 17. Fontaine H., Ibrahim B. A. (1995) Biostratigraphy of the Kinta Valley, Perak, *Geol. Soc. Malaysian Bulletin*, Vol. 38, pp.159-172.
 18. Gobbett D.J (1964) The Lower Paleozoic Rocks of Kuala Lumpur, Malaysia, *Federation Museum's Journal*, 9, 67-79.
 19. Grieve, R. A., Wood, C. A., Garvin J. B., McLaughlin G., & McHone, J. F. (1988). *Astronaut's Guide to Terrestrial Impact Craters*. LPI Tech. Rpt. 88-03, Lunar and Planetary Institute, Houston. 89 pp.
 20. Griffiths, D. H., & Barker, R. D. (1993). Two-dimensional resistivity imaging and modeling in areas of complex geology. *Journal of Applied Geophysics*, 29, 211-226. [http://dx.doi.org/10.1016/0926-9851\(93\)90005-J](http://dx.doi.org/10.1016/0926-9851(93)90005-J)
 21. Hoover R.A., Saunders W.R. (2000). Evolving Geophysical Standards, in *The First International Conference on the Application of Geophysical Methodologies & NDT to Transportation Facilities and Infrastructure Conference Proceedings*, Missouri Department of Transportation.
 22. Hu, R.L., Yeung, M.R., Lee, C.F., Wang, S.S. & Xiang, J.X., (2001). Regional risk assessment of karst collapse in Tangshan, China. *Environmental Geology* 2001, 40, pp. 1377-1389.
 23. Hussein, I. E., Kraemer, G., & Myers, R. (2000). Geophysical characterization of a proposed street extension in Cape Girardeau, Missouri, *Proceedings of the First International Conference on the Application of Geophysical Methodologies & NDT to Transportation Facilities and Infrastructure*.
 24. Hutchinson C.S. (2007) *Geological Evolution of Southeast Asia (2nd Edition)*, Geological Society of Malaysia" (Publ), 433 p.
 25. Hyatt, J. A., & Jacobs, P. M. (1996). Distribution and morphology of sinkholes triggered by flooding following tropical storm Alberto at Albany, Georgia. *USA Geomorphology*, 17, 305-316. [http://dx.doi.org/10.1016/0169-555X\(96\)00014-1](http://dx.doi.org/10.1016/0169-555X(96)00014-1)
 26. Ingham F.T., Bradford E.P. (1960). The geology and mineral resources of the Kinta Valley, Perak. *Geological Survey District Memoir* 9, Federation of Malaya Geological Survey, Ipoh, p. 347.
 27. Ioannis F. L., Filippou I. L. & Melanie B. (2002) *Accurate Subsurface Characterization For Highway Applications Using Resistivity Inversion Methods*, Geophysics & Geothermic Division, Geology Department, University of Athens, Panepistimiopolis, Ilissia, Athens.
 28. Jamal, S. E. (1986). The winter park sinkhole and central Florida sinkhole type

- subsidence. International Association of Hydrological Science Publication, 151, 585-594.
29. Kachentra, N., & Tanad, S. (2007). Application of resistivity survey to investigate sinkhole and karst features in southern Thailand, Geothai'2007, Bangkok, Thailand.
30. Kochanov, W. (1999). Sinkholes in Pennsylvania (PDF). Pennsylvania Geological Survey, Educational Series 11.
31. Langer, W. (2001). Potential Environmental Impacts of Quarrying Stone in Karst - A Literature Review. U.S. Geological Survey, Open-File Report 01-0484.
32. Lee, C. Y. (1971). Geology, mineralization and some geochemical aspects of the Chenderiang area, Perak, West Malaysia. Unpubl. BsC. Thesis. P 129.
33. Li-Guang, S. Z., & Qing, X. (2008). Hot Cradle of El Niño, Institute of Polar Environment. School of Earth and Space Sciences, University of Science and Technology of China, Hefei, Anhui, 230026, P R China.
34. Loke, M.H., & Barker, R.D. (1994) .Rapid least-squares inversion of apparent resistivity pseudo section using a quasi-Newton method., Extended Abstracts of Papers 56th EAGE Meeting Vienna, Austria 6-10 June 1994, p. 1002.
35. Louis, I.F., Louis, F.I., & Bastou, M. (2002). Accurate Subsurface Characterization for Highway Applications Using Resistivity Inversion Methods. Geophysics & Geothermic Division, Geology Department, University of Athens, Panepistimiopolis, Ilissia, Athens.
36. Muhammad R. F., Yeap E. B. (2002) Estimating Dissolution Rates in Kinta and Lenggong Valleys the Micro Erosion Meter, Geol Soc Bull. V45, pp. 26-27.
37. Muhammad, R. F., Al-Kouri, O., Yassin, R. R. (2010) .Geophysical and geospatial database of sinkhole occurrences distribution after earthquake tsunami, Department of Geology, Faculty of Science, university of Malaya.
38. Neil L. Anderson, Derek B. Apel, Ismail B. A. (2007) Assessment of Karst Activity at Highway Construction Sites Using the Electrical Resistivity Method, Missouri, USA.
39. Newton, J. G. (1987). Development of Sinkholes Resulting From Man's Activities in the Eastern United States. US Geological Survey, Circular 968.
40. Pierson B.J. (2009) The limestone hills of the Kinta Valley a part of Malaysia's geological heritage worth preserving. First Break, vol. 27, pp. 97-100.
41. Psomiadis D., Tsourlos P., Albanakis K. (2008) Electrical resistivity tomography mapping of beach rocks, application to the island of Thassos (N. Greece) Environ". Earth Sci. (2009) 59:233–240 DOI 10.1007/s12665-009-0021-9.
42. Psomiadis, D., Tsourlos, P., & Albanakis, K. (2008). Electrical resistivity tomography mapping of beach rocks, application to the island of Thassos (N. Greece) Environ. Earth Sci., 59, 233-240. <http://dx.doi.org/10.1007/s12665-009-0021-9>
43. Reitz H.M. and Eskridge D.S. (1977) Construction methods which recognize the mechanics of sinkhole development, in Dilamarter R.R., and Csallany S.C. Eds Hydrologic problems in karst regions: bowling green, Western Kentucky University, Department of Geology and Geography, pp. 432-438.
44. Sathiamurthy, E., & Voris H.K. (2006) .Maps of Holocene sea level transgression and submerged lakes on the Sunda shelf. Journal of Chulalongkorn University, Supplement 2: 1-44, August 2006.
45. Seng C. K. , Wong S.L. (2009) The limestone hills and caves of the Kinta Valley, Malaysian Nature Society, Kuala Lumpur, Malaysia, p. 151.
46. Sowers, G. F. (1996). Building on sinkholes,(the Design and construction of foundations in karst terrain),The American Society of Civil Engineers, New York., p115, <http://dx.doi.org/10.1061/9780784401767>.
47. Suntharalingam,T. ,(1984). Quaternary stratigraphy and prospects for tin placer in the Taiping-Lumut area, Perak. Bull. Geol. Soc. (pp. 9-32).

48. Tan, B. K. (1983). Geology and urban development of Kuala Lumpur, Malaysia, 1986, geological society of Hong Kong, Bullten No.3, oct.1987, pp.127-140.
49. Tan B.K. (1987).(Some geotechnical aspects of urban development over limestone terrain in Malaysia), Bulletin of the international association of engineering geologist, pp. 35, 57, 63.
50. Telford W.M., Geldart, L.P., and Sheriff, R.E. (1990), Applied Geophysics, (2nd add). Cambridge University Press, New York.<http://dx.doi.org/10.1017/CBO9781139167932>
51. Mahat, S., & Mohd, S. S. (2001). Characterization, geochemistry and possible usage of the limestone hills in the Kinta Valley area, Perak. In the Proceeding of Geol. Soc. Mal. Annual Geological Conference. Eds. The, G. H., Mohd Shafeea Leman and Ng. T. F. 53-57.
52. Walker,D. A.,(1999). The First Tsunami Symposium Papers –II, the international journal of the Tsunami Society, Volume 17 Number 2.
53. Waltham A.C., Fookes P. G. (2005) Engineering classification of karst ground conditions, Quarterly Journal of Engineering Geology and Hydrogeology vol. 36, pp. 101-118.<http://dx.doi.org/10.1144/1470-9236/2002-33>
54. Waltham, A.C., & Fookes, P.G. (2003). Engineering classification of karst ground conditions. Quarterly White, W. B. (1988). Geomorphology and Hydrology of Karst Terrains. Oxford University Press.
55. William E. D., Jonathan E. N., Carpenter P. J., Kaufmann R. D., Bradley J. C.’(2002) Geophysical Surveys of a Known Karst Feature, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.
56. William, E. Doll’, Jonathan, E. N., Philip, J. C., Kaufmann R. D., & Bradley J. Car-r’(2002). Geophysical Surveys of a Known Karst Feature, Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.
57. Williams B.E.; Robinson R.(1993) Grouting beneath an existing dam founded on karst terrain, pp. 255–258 in Beck, B.F. (Ed.) Applied karst geology. Proceedings of the 4th conference on sinkholes and the engineering and environmental impacts of karst. AA Balkema, Panama City. Science for Conservation, 198-57.
58. Williams P.W. (1993) Environmental change and human impact on karst terrains” an introduction. In Williams, P.W. (Ed.) Karst Terrains, environmental changes, human impact. Catena Supplement 25: 1–19.58 Urich - Land use in karst terrain.
59. Williams, B. E., & Robinson, R. (1993). Grouting beneath an existing dam founded on karst terrain. In B. F. Beck (Ed.), applied karst geology (pp. 255-258). Proceedings of the 4th conference on sinkholes and the engineering and environmental impacts of karst. AA Balkema, Panama City. Science for Conservation, 198-57.
60. Williams, P. W. (1993). Environmental change and human impact on karst terrains, an introduction. In P. W. Williams, (Ed.), Karst Terrains, environmental changes, human impact. Catena Supplement 25: 1–19.58 Urich - Land use in karst terrain.
61. Yahia N. A., Yassin, R. R., Abdel qadir, S. O.(1992) The results of Applying geophysical techniques in Prospecting and Investigation of Bauxite Ore deposits in subsurface karst terrains / Iraqi western desert, Rep.no.2262,geosurv, Baghdad – Iraq.
62. Yahia N. A., Yassin, R. R., Hijab S. R. (1994) The application of complex geophysical techniques to detecting and locating the Weakness zone and the water seepage in the body of the AL-Tharthar dam , samara town, Salahuddin province / Iraq , Geosurv. / Baghdad – Iraq, NI-38-10, SEGSM, 2265.
63. Yahia, N. A., Yassin, R. R., & Abdel Qadir, S. O. (1992). The results of Applying geophysical techniques in Prospecting and Investigation of Bauxite Ore deposits in subsurface karst terrains / Iraqi western desert, Rep.no.2262, Geosurv, Baghdad – Iraq.
64. Yahia, N. A., Yassin, R., R., & Hijab, S., R. (1994). The application of complex

- geophysical techniques to detecting and locating the Weakness zone and the water seepage in the body of the AL-Tharthar dam, samara town, Salahuddin province / Baghdad – Iraq, Geosurv.NI-38-10, SEGSM, 2265.
65. Yassin R. R. (2002) evaluates the presence of karstic Bauxitic clay deposits in parts of western desert of Iraq by the application of VLF – electromagnetic and Electrical resistivity techniques” MsC thesis submitted to Department of Geology, college of science, University of Baghdad– Iraq, p. 293.
66. Yassin R. R., Hj Taib S., Muhammad R. F.(2013) Reliability of Wenner ER Tomography and satellite image techniques in recognizing and assessing the geohazard development of subsurface carbonate karst features in selected construction sites in (Kinta valley) Perak, Peninsular Malaysia” The fifth regional conference on Geological Engineering, Kuala Lumpur, Malaysia.ISBN:978-967-0380-23-0.
67. Yassin R. R., Hj Taib, S., & Muhammad, R. F. (2012). Determine Sinkholes and overburden thicknesses in selected covered carbonate Karst Terrains (Kinta valley), Perak, Malaysia by combining Wenner E.R. Tomography, geological and satellite images techniques. The 8th physics, math and Geosciences conference, Bangkok –Thailand.
68. Yassin, R. R. (2002). Evaluate the presence of Bauxitic clays in selected sites on carbonate karst regions in western desert of Iraq by application of Vlf – electromagnetic and electrical resistivity techniques, Department of geology, College of science, University of Baghdad.
69. Yassin, R. R. (2002). evaluates the presence of karstic Bauxitic clay deposits in parts of western desert of Iraq by the application of VLF – electromagnetic and Electrical resistivity techniques, M.Sc. thesis submitted to Department of Geology, college of science, University of Baghdad, p. 293.
70. Yassin, R. R. (2006). Combined techniques in evaluating the presence of karst features and its deposits in selected part of western desert of Iraq, pp1-60.
71. Yassin, R. R. (2008). Karst terrains, karst phenomenon, karst features and karsts landscape, karst deposits, paleo-climate in selected part of western desert of Iraq, pp1-50.
72. Yassin, R. R. (2009).Astronomy in Ancient Mesopotamian Civilizations: Sumerian, Babylon, and Assyrian, Archeological research pp1-25.
73. Yassin, R. R. , Hj- Taib, S., & Muhammad, R. F.(2013), Reliability of Wenner ER Tomography and satellite image techniques in recognizing and assessing the geohazard development of subsurface carbonate karst features in selected construction sites in (Kinta valley) Perak, Peninsular Malaysia. The fifth regional conference on Geological Engineering, Kuala Lumpur, Malaysia.ISBN:978-967-0380-23-0.
74. Yassin, R. R. , Muhammad, R. F. & Hj- Taib, S., (2014) Determine Sinkholes and overburden thicknesses in selected covered carbonate Karst Terrains (Kinta valley), Perak, Malaysia by combining Wenner E.R. Tomography, geological and satellite images techniques. The Canadian journal of geography and geology, Journal of Geography and Geology; Vol. 6, No. 4; 2014.
75. Yassin, R. R., Hj- Taib, S., & Muhammad, R. F. Geohazard Assessment of Carbonate Karst Features in Construction Sites by Application of Combined techniques in (Kinta Valley) Perak, Peninsular Malaysia. International Journal of Advanced Scientific and Technical Research, Issue 4 volume 6, Nov. - Dec. 2014.
76. Yassin, R. R., Muhammad, R. F. & Hj- Taib, S., (2013). Integrated Techniques to Identify Consequences of Sinkhole Hazards For Constructing Housing Complexes On Carbonate Karst Terrains In Perak, Peninsular Malaysia, July – 2013.
77. Yassin, R., R., Ros, F., M., Samsudin, H., T.& Omer, K. (2013). Application of ERT and Aerial Photographs Techniques to Identify the Consequences of Sinkholes Hazards in Constructing Housing Complexes Sites over Karstic Carbonate Bedrock in Perak,

- Peninsular Malaysia, Journal of Geography and Geology; Vol. 6, No. 3; 2013, ISSN 1916-9779, E-ISSN 1916-9787.
78. Yeap E.B. (1985) Irregular topography of subsurface carbonates bedrock in Kuala Lumpur area, Malaysia” The 8th southeast Asia Geotechnical Conference, Kuala Lumpur, V1, pp.12.
79. Yin, E. H., (1976). New Series Regional geology of Peninsular Malaysia Peninsular Malaysia, 1:63,630 Sheet 94. Kuala Lumpur, Geological Survey of Malaysia.
80. Zhou, W., Beck, B. F., & Stephenson, J. B., (2000). Reliability of dipole-dipole electrical resistivity tomography for defining depth to bedrock in covered karst terrains, Journal of Environment Geology, Vol.39 (7), pp760-766.