Conference Paper

GRAVSYS Software Based on Scratch Programming for 2D Gravity Anomalies Source Responses and Its Implementation in Trangkil Gunungpati

Supriyadi[1], Jefta Heparona[1], Sugiyanto[1], Mahardika[1], Rini Kusumawardhani[2], and Togani Cahyadi Upomo[2]

[1]Department of Science, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang
[2]Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Semarang Sekaran Gunungpati, Semarang 50229

Abstract

Gravsys software was created with the aim to overcome student's problems which have difficulty in understanding the concept of gravity. This software was developed using Scratch programming which has features to make a simple appearance in the form of images, animations and simulations. Therefore, an innovation of software products can be established as a learning media for students who take gravity method courses. Broadly speaking, Gravsys has several main features, namely data input of parameter model, creating 2D simulation of uniform object, and displays the response of the gravitational field anomaly in graphical form, so that it can help students to understand the concept of anomalous source objects and response to gravity anomalies caused by source objects for various subsurface cases, seawater intrusion, water pollution, natural resource potential (coal, iron ore), prediction of bunker existence, decrease and increase of ground water level. In the implementation stage of Ayodya, Trangkil, Gunungpati, the subproject layer showed that 3 layers were sandy clay with density 1,4 gr/cm^3, sand with density of 2.3 gr/cm^3, bedrock with density 2.6 gr/cm^3, each at a depth of 0-30 meters, 30-60 meters, and over 60 meters.

Keywords: gravity method, gravity anomaly, Scratch, simulation.

Corresponding Author:
Supriyadi
supriyadi@mail.unnes.ac.id

Received: 21 May 2019
Accepted: 26 June 2019
Published: 7 July 2019

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the UICRIC Conference Committee.

1. Introduction

One method that is often used in mineral exploration activities is the Gravity Method (Santoso, 2001). The Gravity Method is used to detect an anomaly of local or residual gravity values. Gravity Anomalies are due to lateral rock layer density contrasts (Reynold, 1997). The process of proving a theory or understanding of the gravitational field anomaly requires a clear picture of the case being studied. One of the steps to making an illustration is to make a modeling with computer simulations (Jacoby, 2009). Gravity modeling is one method of interpreting gravity data to describe subsurface geometry structures based on rock density distribution (Rahmanto, 2009). The following is an illustration of anomaly of a gravitational field (Figure 1).

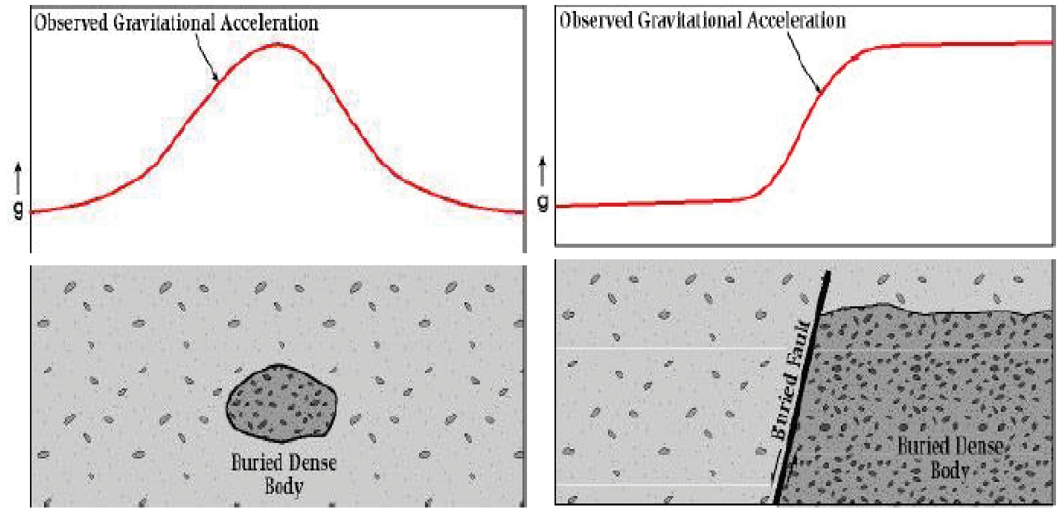

Figure 1: The illustration of anomaly of a gravitational field.

Technological developments provide more and more applications that offer various conveniences to create and design a modeling or simulation (Resnick, 2009). One of them is Scratch, a program developed by the Massachusetts Institute of Technology (MIT). The advantages of Scratch software are freeware so that it does not burden usage fees for its users or derivative program makers and can be embedded into HTML files which are the programming languages used on the internet. Another advantage of Scratch is its capabilities and compatibility on various Operating System platforms such as Windows, Mac, and Linux (Kadir, 2011). Scratch is a new programming language that can be used to create games and animations (Martanti, 2013). Because its function can be used as an animation so it can be used also to make a simple simulator regarding the anomaly of the gravitational field. In this study, researchers created an anomaly simulator gravitational field named GRAVSYS.

2. Theory

2.1. Ball

An anomalous spherical object applies an approach where the length dimension from the anomaly source is << its depth from the surface. The following is an anomaly component of spherical objects.

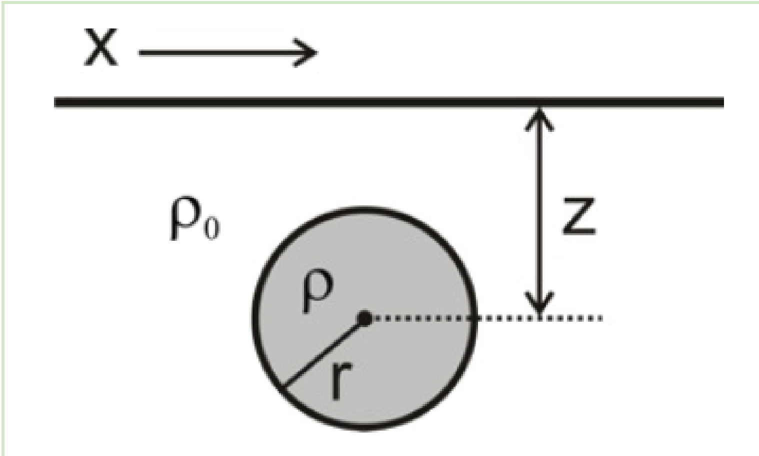

Figure 2: An Anomalous of Spherical Object.

Components of gravity on the axis vertical of spherical objects (Figure 2) at one point mass can be given by the equation:

$$g = \frac{4}{3}\pi G\rho \frac{R^3}{\left(x^2 + z^2\right)^{\frac{3}{2}}}$$

2.2. Horizontal cylinder

Components of gravity on the axis vertical of horizontal cylinder objects (Figure 3) at one point mass can be given by the equation:

$$g_z = \frac{2Gmz}{r^2}$$

where m is the mass of the cylinder, G is Newton's constant of gravitation field, z is the depth of the object and r is the distance of objects with point P on the surface. If the cylinder has a mass density ρ, it will be obtained:

$$g = 2\pi G\rho R^2 \frac{z}{x^2 + z^2}$$

2.3. Vertical cylinder

Response of gravity on the axis of a vertical cylinder (maximum value) is easy to calculate. First we get the g on the axis of a disc with a thickness *dl* (Figure 4) The calculations start with a ring width dr. δm = 2πρr dr dl.

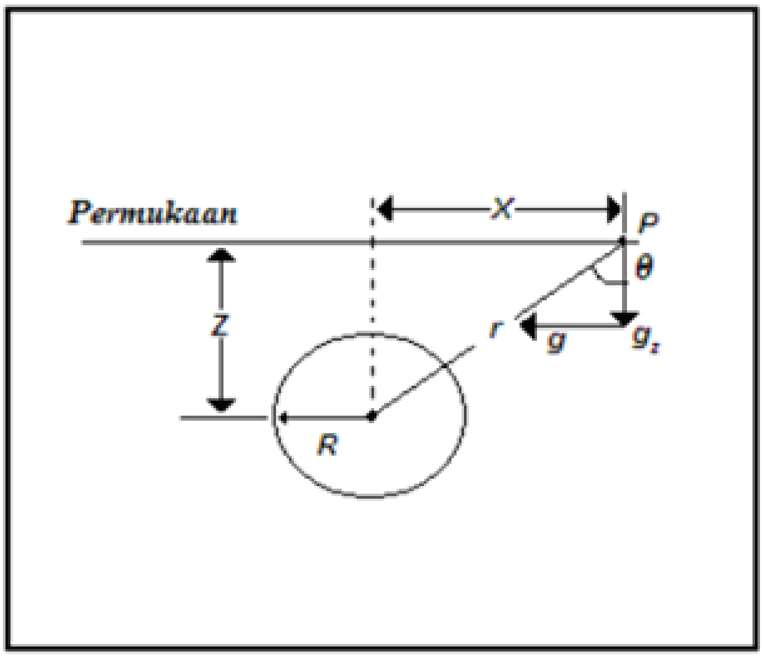

Figure 3: Components of gravity on the axis vertical of horizontal cylinder objects (Nettleton, 1976).

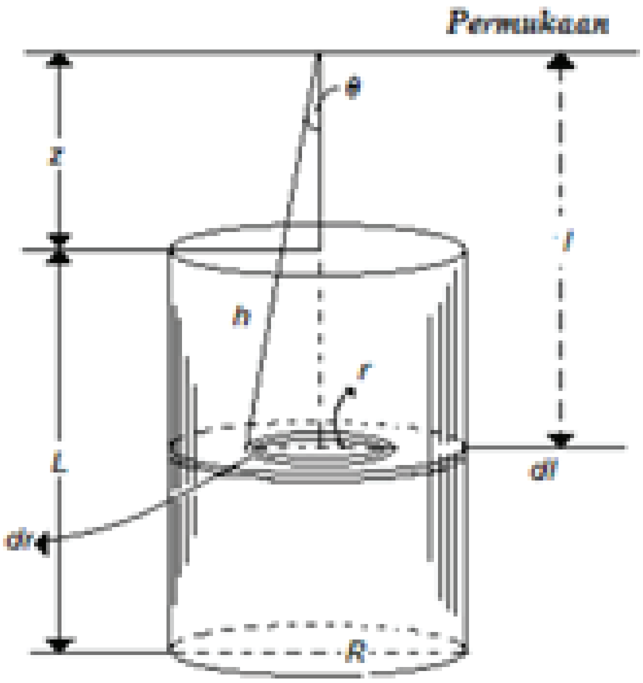

Figure 4: Components of gravity of vertical cylinder objects (Telford,1976).

here is to be calculated is the gravity anomaly on the z axis only to obtain:

$$\delta g_z = G\frac{\delta m cos\theta}{r^2+l^2}$$

$$= 2\pi\rho G\ dl sin\theta\ \ d\theta$$

Equation (11) is initially integrated from θ = 0 to $\tan^{-1}$ (R/L) for the ring disk then *l*=*z* to *z*+*L*, then the gravity value on the cylinder axis is:

$$
\begin{aligned}
g &= 2\pi G\rho \int_{z}^{z+L} \left\{ 1 - \frac{l}{\left(l^2+R^2\right)^{\frac{1}{2}}} \right\} dl \\
&= 2\pi G\rho \left[L + \left(z^2 + R^2\right)^{\frac{1}{2}} - \left\{(z+L)^2 + R^2\right\}^{\frac{1}{2}} \right]
\end{aligned}
$$

2.4. Angled cylinder

Component on the object with a certain slope at an angle equal to the object is in an upright position. The formulation of response to gravity on the body angle (Figure 5**)** can be given as:

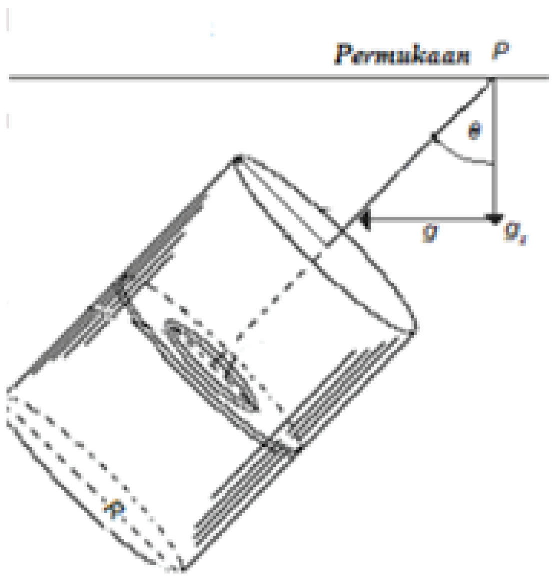

Figure 5: Components of gravity on the axis vertical of angled cylinder objects (Melvyn and Boniwell, 1989).

$$gz = g\cos\theta.$$

$$g = 2\pi G\rho \left[L + \left(z^2 + R^2\right)^{\frac{1}{2}} - \left\{(z+L)^2 + R^2\right\}^{\frac{1}{2}} \right] \cos\theta$$

3. Method

The design of this program uses the SCRATCH programming language. Scratch is a programming language developed by Lifelong Kindergarten Group at MIT (Massachusetts Institute of Technology) Media Lab, United States. Scratch is a visual language that is the creation of projects using intermediaries in the form of images (Resnick, 2009). The pattern of programming with images is a differentiator between Scratch and other text-based programming languages such as PHP, C, and Pearl which seem more complicated. Here is the Scratch application interface (Figure 6).

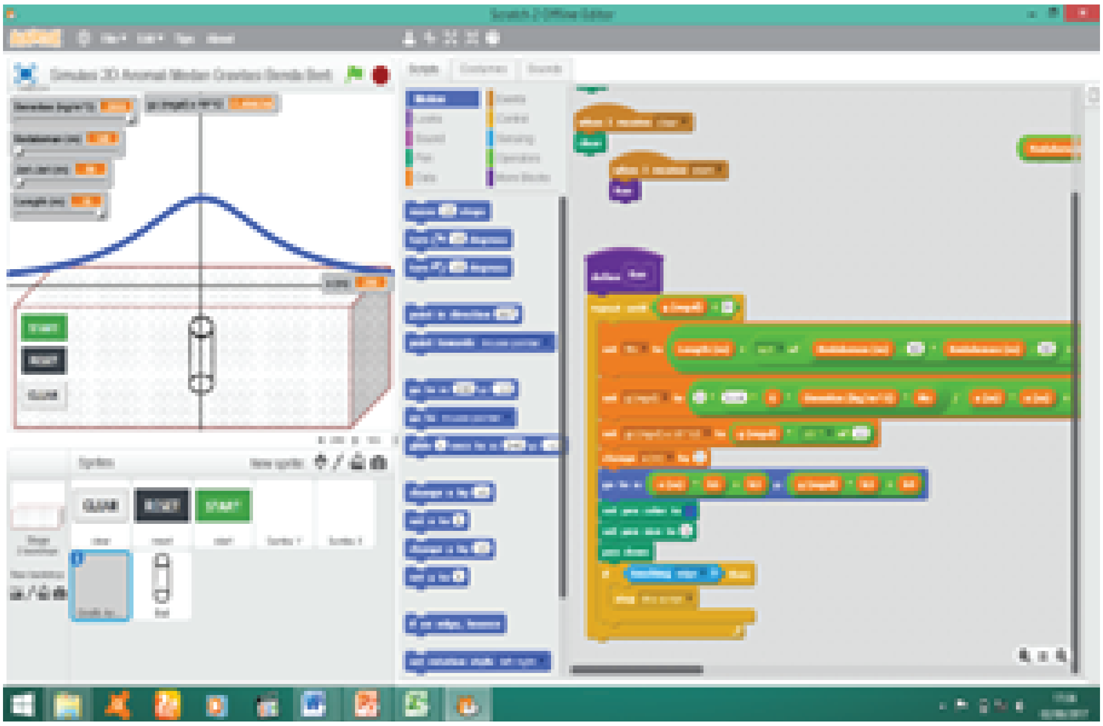

Figure 6: Interface of Scratch Applications.

4. Results and Discussion

4.1. Spherical objects

Profile of anomalies produced by the GRAVSYS modeling program with positions spherical objects and references taken from Telford (1967) can be seen in the (Figure 7).

4.2. Vertical cylinder

Profile of anomalies produced by the GRAVSYS modeling program with positions vertical cylinder objects and references taken from Telford (1967) can be seen in the (Figure 8).

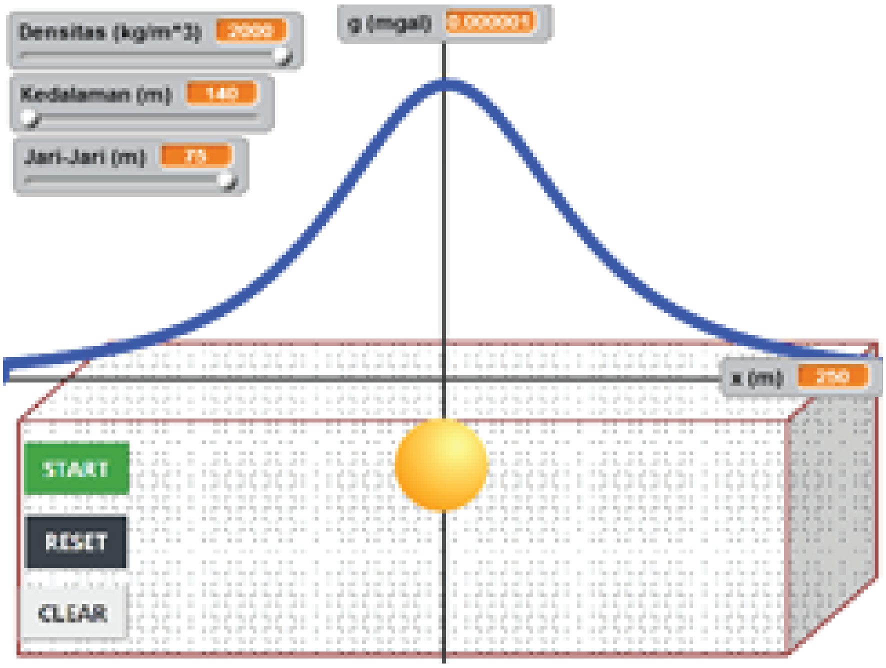

Figure 7: Gravity Anomalies of Spherical Objects (Telford, 1967).

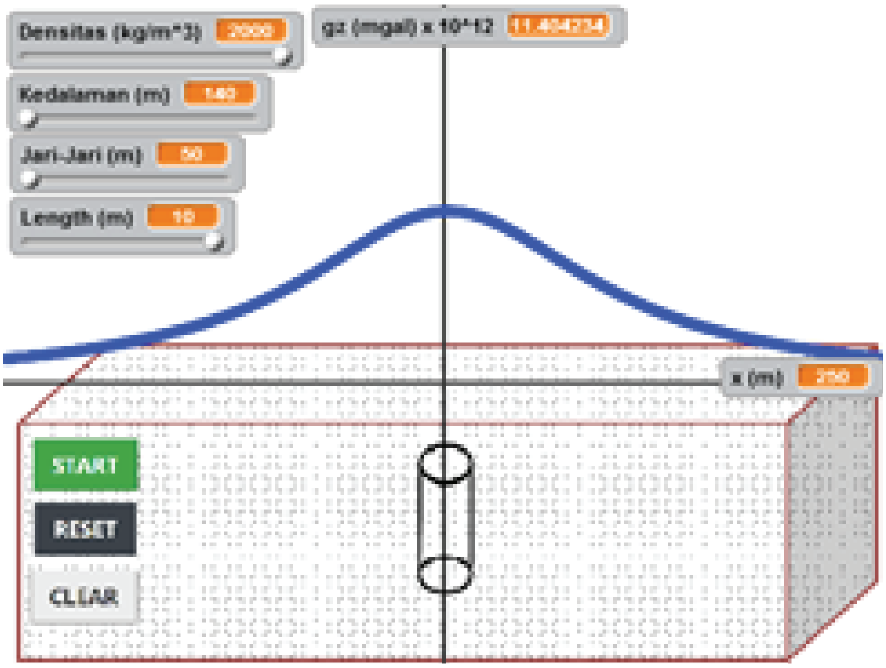

Figure 8: Gravity Anomalies of Vertical Cylinder (Telford, 1967).

4.3. Horizontal cylinder

Profile of anomalies produced by the GRAVSYS modeling program with positions horizontal cylinder objects and references taken from Melvyn and Boniwell (1989) can be seen in the (Figure 9).

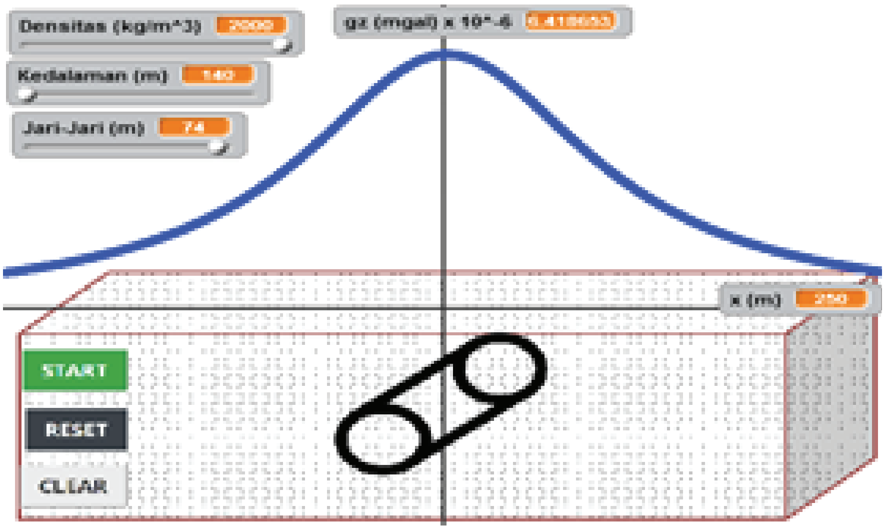

Figure 9: Gravity Anomalies of Horizontal Cylinder (Melvyn and Boniwell, 1989).

4.4. Angled cylinder

Profile of anomalies produced by the GRAVSYS modeling program with positions angled cylinder objects and references taken from Melvyn and Boniwell (1989) can be seen in the (Figure 10).

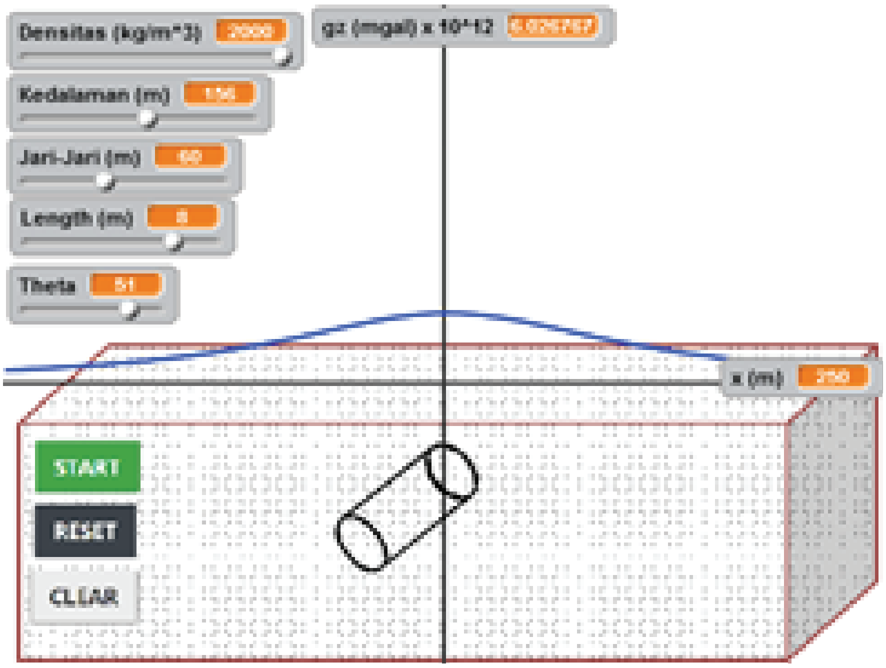

Figure 10: Gravity Anomalies of Angled Cylinder (Melvyn and Boniwell, 1989).

5. Implementation

Implementation for field data is the result of gravity measurements in April 2018 at the location of Nirwana Trangkil in Gunungpati. Overall distribution of gravity points as shown in Figure 11 :

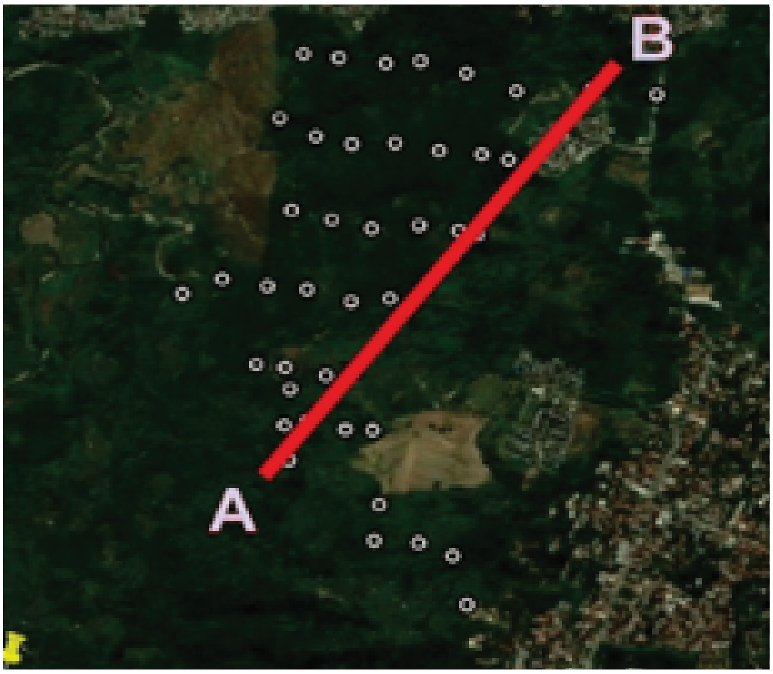

Figure 11: Distribution of gravity force points in the research location.

Modeling the Southwest (SW) - Northeast (NE) direction as shown in Figure 11. Next, the results of the measurement on gravity along the path become the input parameters in 2D modeling. The modeling results are shown as in the following Figure 12.

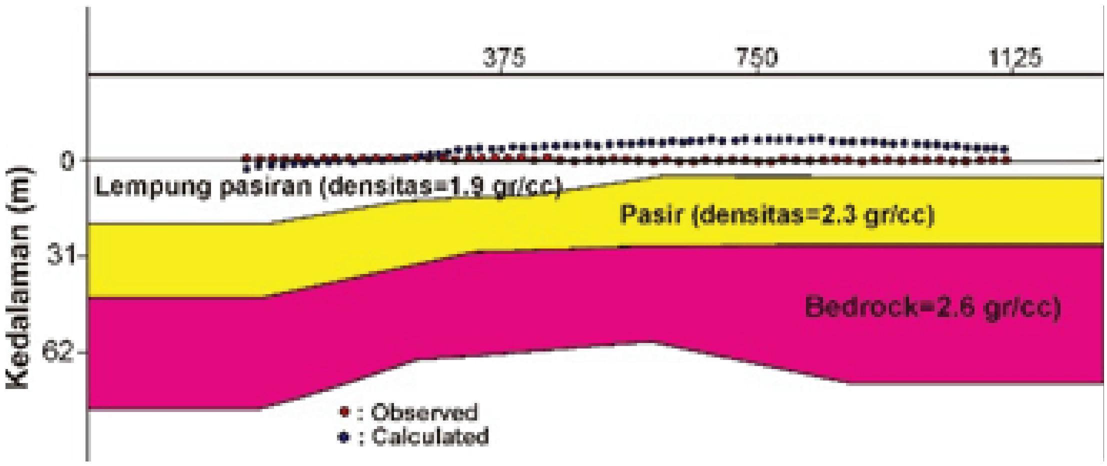

Figure 12: Cross section of subsurface structure for incision A-B.

The picture shows the source of anomaly in the form of 3 layers of soil with the following density : Sandstone clay 0 – 25 m (density = 1900 kg/m^3), sand 25 - 40 m (density = 2300 kg/m^3), and bedrock 40 – 65 m (density = 2600 kg/m^3).

6. Conclusion

From the results of this study concluded that the program has successfully created a gravitational anomaly modeling approach spherical and cylindrical objects. It can be seen from their suitability program output in the form of data anomalies and profile by reference. Also obtained from the modeling that. With the same object, the surface gravity anomaly value of these objects will increase. Long objects will be very influential in the anomalous gravity values, the longer the object then the anomaly value will also increase. The radius of the object bigger then gravity anomaly will also be getting bigger. The position of objects large effect on the shape and gravity anomaly caused.

Acknowledgement

This paper is part of Hibah Pengembangan Keilmuan (HBK) activities. For this reason, the research team thanked the Rector of Universitas Negeri Semarang for giving the opportunity to carry out research activities with the title “**Analisis Longsoran Rayapan pada Lempung Formasi Kerek dengan Geo Complexity Detection dan Geophysics Method** ” funded by the contract number of the Semarang State University Number of Budget Implementation Lists (DIPA) : SP DIPA-042.01.2.400899 / 2018, dated 05 December 2017 in accordance with the Letter of Agreement for the Assignment of Fund Research Implementation of the UNNES DIPA in 2018 Number: 1.26.3 / UN37 / PPK.3.1 / 2018, dated 26 March 2018.

References

[1] Jacoby, Wolfgang and Smilde, Peter L. (2009). *GRAVITY INTERPRETATION– Fundamentals and Application of Gravity Inversion and Geological Interpretation*. Jerman: Springer-Verlag Berlin Heidelberg.

[2] Kadir, A. & Nurcito, L. A. 2011. *Bahasa Pemrograman Scratch*. Yogyakarta : MediaKom.

[3] Martanti, A. P., Hardyanto, W., Sopyan A. 2013. Pengembangan Media Animasi Dua Dimensi Berbasis Java Scratch Materi Teori Kinetik Gas Untuk Meningkatkan

Pemahaman Konsep Siswa SMA. *Unnes Physics Education Journal*. 2 (2) : 19-25.

[4] Melvyn E.B. and Boniwell J.B.,1989, *A Geophysical Handbook for Geologist,* The Canadian Institute of Mining and Metallurgi. Canada

[5] Nettleton, L. L. 1976, *Gravity and Magnetics in Oil Prospecting.* McGraw-Hill, Inc. New York.

[6] Rahmanto, D. dan Yulianto, T. 2009. *Pemodelan Anomali Gravitasi dengan Pendekatan Benda Berbentuk Silinder*. Jurnal Sains dan Matematika volume 17 nomor 3. Artikel Penelitian : 164-171

[7] Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B., Kafai, Y. (2009). *Scratch: Programming for All*. Communications of the ACM, November 2009.

[8] Resnick, Mitchel. et al. 2009. Scratch: *Programming For All*. Communications Of The ACM. Vol.52, 60-67.

[9] Reynold, J.M. 1997. *An Introduction to Apllied and Environtmental Geophysics*. England: Jhon Wiley & Sons, Ltd.

[10] Santoso, J. 2001. *Pengantar Teknik Geofisika. Bandung* : Institut Teknologi Bandung.

[11] Serway, Raimond A. dan Jhon W. Jewett, Jr. 2009. *Fisika untuk Sains dan Teknik*. Jakarta : Salemba Teknika

[12] Telford, M. W., L. P. Geldard, R. E. Sheriff, & D. A. Keys. 1990. *Applied Geophysics*. London: Cambridge University Press.