Geomagnetic Map of Field Camp Geophysics in Karangsambung using Data Acquisition 2005-2017

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Abstract. The implementation of field activities in Karangsambung by geophysical engineering ITB has been done since 1996 until 2017. During the field study activities, students conducted acquisition activities with several geophysical methods, one of the most consistent is the acquisition of geomagnetic data. Compilation of geomagnetic data during Karangsambung field activities will be presented in this work. There are 3 data categories during 22 years of geomagnetic survey: data compilation 1996-1999, 2000-2004, and 2005-2017. In this work, we use survey 2017 as references (datum) for other surveys (2005-2016). Geomagnetic observation around the base (LIPI campus) consists of 3632 data showing geomagnetic field trends that decreases with a rate of change of -11 nT/year. Merge data provide geomagnetic map in the range of total intensity from 41371 to 46799 nT. Data distribution from field camp surveys already cover some geological surface map (Diabas Intrusion, Totogan Formation, Karangsambung Formation, and Luk-Ulo Melange Complex). The pattern of total intensity curve shows higher noise of magnetic properties in the Karangsambung Formation and Luk-Ulo Melange Complex that close to the Diabas Intrusion.

1. Introduction
Field camp course is an important subject for geoscience students, and it has been conducted worldwide in many universities of Africa, America, Asia, Europe, and Australia. Several field camp course report that we found [1-8] describe many advantages for students in order to understand materials that the students have been studied in the class/campus. Exploration geophysicist souls with energetic curiosity started to be waken-up during field camp course. Team work, communication skill, and friendship during field activities can be emphasized for the students by the scheme of field camp that conducted far away from campus. During our field camp course, the students will get valuable experience to practice mapping skills in the field. More practice in the field will help an improvement of technical skills and personal confidence of the students as future exploration expert.

Geophysical engineering study program/department of ITB have been conducted field camp course in Karangsambung since 1996. Geophysical methods that have been implemented during 1996 to 2017 are: geomagnetic, gravity, resistivity, ground penetrating radar, and seismic refraction. The most consistent geophysical methods conducted for more than 2 decade in Karangsambung is geomagnetic and gravity. Most geomagnetic and gravity methods are implemented by the students togerther with geological mapping in the same location.

In this paper, we would like to show our summary from geomagnetic in Geophysical Engineering ITB field camp course activities since 1996 to 2017. We would like to merge geomagnetic data from 22 surveys that covered in Karangsambung area by students. The map compilation will shows coverage of all data and provide sugestion for next survey in field camp course.
2. Overview of Karangsambung Field

Geology field camp campus that located in Karangsambung was built in 1964. This campus is known as Balai Informasi dan Konservasi Kebumian Karangsambung LIPI. Karangsambung area also declared as geoconservation area through Indonesian Ministry of Energy and Mineral Resources (Keputusan Menteri Energi dan Sumber Daya Mineral) No: 2817-K/40/MEM/2006. In Karangsambung area we can find several outcrops of various rocks (location shown in figure 1) that associated with subduction of Indo-Australian plate beneath Eurasian plate around 120 million years ago. Schematic plate tectonic model are studied by several researchers [9-14] to explain the appearance of outstanding outcrops in this relatively small area.

Simplified geological map of Karangsambung area is shown in figure 2. Several formations that can be found in Karangsambung area are: Luk-Ulo Melange Complex, Karangsambung Formation, Totogan Formation, Waturanda Formation, Diabas Intrusion, and Alluvium. Panasogon Formation is also can be found about 6 km in the South of LIPI campus (outside of geological map figure 2).

![Figure 1](image1.png)  
**Figure 1** Situation map of LIPI Campus at Karangsambung area with outcrop location based on KEPMEN ESDM No: 2817-K/40/MEM/2006.

![Figure 2](image2.png)  
**Figure 2** Geological map at Karangsambung area (simplified from previous study[15-16]).
3. Geomagnetic Data Acquisition

Geomagnetic data are collected using at least two magnetometers that operated in base and field stations. Several types of magnetometers used in the field camp courses are: geometrics proton magnetometer, envi pro proton magnetometer, and gsm-19 magnetometer. Geometrics proton magnetometers are used in field camp course 1999-2009, envi pro proton magnetometers are used in field camp course 2009-2013, and gsm-19 magnetometers are used in field camp course 2014-2017.

Until recent effort of data compilation, we categorize geomagnetic data from Karangsambung field camp course into three groups as follow: (a) data 1996-1998, (b) data 1999-2004, and (c) data 2005-2017. Group c is the main data that will be merge in this paper. The oldest data that we can find is student’s report in 1997 as part of group a (first three years of field camp course). We will not included the data of group a in this paper because we don’t have coordinate information. The next six years are compiled into group b. The coordinate data in group b is considered un-correct, and we have doubt about hand-held GPS precision. Most of the surveys design during field camp 1999-2004 are line survey with some stations location provided by hand-held GPS, while the other stations location provided by estimation using distance measurement. For the purpose of students exercise and comparison, ususally we show these data (figure 3).

Acquisition dates of geomagnetic method during Karangsambung field-camp 1999 to 2017 are shown in table 1. Data acquisition is not yet set-up into grid observation because we consider field stations accessibility from campus. Main focus at early field camp class is to introduce the students with the instruments and standard operational of geophysical methods.

![Geomagnetic map produced using data collection of group b (field camp 1999-2004).](image)

Table 1 Acquisition Date of Geomagnetic Method during Field-camp.

| Year | Month | Date | Base avg sampling | avg | Base Observation (nT) | min. | max. | range | #data | Field sts Interval (m) | Field Group |
|------|-------|------|-------------------|-----|-----------------------|------|------|-------|-------|-----------------------|-------------|
| 1999 | Jun   | 2nd, 3rd | 300 sec. | 45084.20 | 45067.00 | 45107.50 | 40.50 | 292 | 68 | 1
| 2000 | Jun   | 12th | 404 sec. | 45229.42 | 45187.00 | 45253.10 | 66.10 | 47 | 156 | 1
| 2001 | Jun   | 7th | 303 sec. | 45281.82 | 45249.00 | 45296.00 | 47.00 | 90 | 72 | 2
| 2002 | Jun   | 6th, 8th | 320 sec. | 45235.49 | 45130.63 | 45279.70 | 149.07 | 352 | 81 | 2
| 2003 | Jun   | 6th, 9th | 799 sec. | 45244.63 | 45221.95 | 45284.50 | 62.55 | 801 | 131 | 3
| 2004 | Jun   | 6th, 7th | 300 sec. | 45256.48 | 45225.50 | 45274.40 | 48.90 | 188 | 1293 | 1
| 2005 | Jun   | 14th, 16th | 300 sec. | 45145.17 | 45068.00 | 45164.00 | 96.00 | 663 | 119 | 3
| 2006 | Jun   | 18th, 20th | 843 sec. | 45165.90 | 45172.40 | 45172.00 | 14.60 | 84 | 318 | 3
| 2007 | Jun   | 19th | 300 sec. | 45136.21 | 45122.60 | 45158.60 | 36.00 | 359 | 114 | 1
| 2008 | Jun   | 10th, 12th | 550 sec. | 45055.85 | 45020.00 | 45097.00 | 77.00 | 207 | 158 | 3
| 2009 | Jun   | 14th, 15th | 425 sec. | 45160.85 | 45122.00 | 45246.00 | 124.00 | 123 | 76 | 9
| 2010 | May   | 21th, 25th | 300 sec. | 45306.28 | 45219.40 | 45359.40 | 140.00 | 429 | 91 | 5
| 2011 | May-Jun | 30th-3rd | 362 sec. | 45083.12 | 45067.40 | 45107.20 | 39.80 | 275 | 84 | 5
| 2012 | Jun   | 20th, 24th | 493 sec. | 45083.00 | 45061.20 | 45094.40 | 33.20 | 193 | 198 | 10
| 2013 | Jun | 4th, 8th | 685 sec. | 44979.84 | 44936.55 | 44998.09 | 61.54 | 110 | 99 | 2
| 2014 | May | 14th, 17th | 606 sec. | 45047.08 | 45023.41 | 45059.90 | 36.49 | 112 | 144 | 7
| 2015 | May | 7th, 10th | 358 sec. | 45002.39 | 44976.44 | 45022.47 | 46.03 | 283 | 34 | 7
| 2016 | Apr | 25th, 28th | 600 sec. | 45035.61 | 45011.67 | 45063.00 | 51.33 | 229 | 131 | 8
| 2017 | Jun | 15th-18th | 282 sec. | 45006.10 | 44933.48 | 45059.53 | 126.05 | 325 | 59 | 8
4. Base Observation, IGRF, and Diurnal Variation

We collect base observation of Karangsambung field camp start from 1999 until 2017. Table 1 shows the statistics of base observation for each year geophysical field camp class. We have 5162 data of base observation, after sorting bad data we have 4917 data. There are 245 bad data (outliers) that we removed from base observation 2002, 2004, 2009, 2011, and 2015. Bad data can be caused by human activity that used metal material and very close enough to the base location. Base location in LIPI campus is shown in figure 4. The information from figure 4 shows that coordinate of base location from 2005 to 2017 can be differ in the range of 400x400 meter square inside LIPI campus.

Histogram and statistic descriptive of geomagnetic base observation are shown in figure 5. The histogram seems like to shows 2 peaks of normal distribution (bin 45100 nT and 45250 nT) that almost overlaps. Normal distribution of peaks 45100 nT most likely data observation of field-camp 1999, 2005, 2008, and 2011-2017, while the other base data observation represent in second distribution (45250 nT).

Figure 6 shows linear regression of base observation from 1999 to 2017. The total intensity value at base station Karangsambung is decreases about -11.357 nT/year. The figure also provide us comparison of total intensity value from base observation and International Geomagnetic Reference Field (IGRF). The IGRF value is calculated using online magnetic field calculator from National Geophysical Data Center at website https://www.ngdc.noaa.gov/geomag-web/#igrfwmm. The input for IGRF model is base coordinate (109.67462°, -7.54691°, 70 meters from mean sea level) and acquisition dates (table 1). Total intensity of IGRF is decreases slightly from 1999 to 2004, and then decreases more rapidly from 2005 to 2017. Online magnetic field calculator also provide declination and inclination changes at Karangsambung from 1999 to 2017. Declination at Karangsambung is quite stable in the range of 0.8° to 1.2°, while inclination is increases from -34° to -32° for the last 19 years (figure 7).

![Figure 4](image-url) Geomagnetic base station location in LIPI campus during data acquisition from 2005-2017.

![Figure 5](image-url) Histogram and statistic descriptive of geomagnetic base at Karangsambung field-camp 1999-2017.
Diurnal variation can be seen daily from geomagnetic base data observation. Table 1 shows range value from total intensity that recorded at base station. Wide range of total intensity (>100 nT) at base station was observed during field-camp data acquisition in 2002, 2009, 2010, and 2017. Based on our data (table 1), diurnal variation at Karangsambung for the last 19 years are in the range of 14 nT – 150 nT. Figure 8 shows example of diurnal variation during data acquisition in 2002 and 2006. Diurnal variation in 6th of June 2002 shows fluctuation > 100 nT, while 7th of June is quite stable in the range < 50 nT. Diurnal variation during survey 2006 is the most stable that have range < 20 nT.

5. Geomagnetic Map
The analysis of geomagnetic map usually provided using several survey from different instrument that overlapped in study area. Several data from different surveys are used and merged to cover larger area that cannot be covered using single survey only. Several studies that we can find as references for geomagnetic map from merging/compilation are published since 90’s [17-28].

![Figure 6](image6.png)
**Figure 6** Total intensity of IGRF and geomagnetic base observation at Karangsambung field-camp 1999-2017.

![Figure 7](image7.png)
**Figure 7** Declination and inclination changes at Karangsambung from 1999 to 2017.

![Figure 8](image8.png)
**Figure 8** Example of diurnal variation at Karangsambung during data acquisition (a) 2002 and (b) 2006.
The work was initially (compile the existing data) started since 1st June 2015. In this work, we merge geomagnetic data from TG field camp course from 2005-2017. Histogram geomagnetic data (that observed in field stations from surveys 2005-2017) is shown in figure 9. We use survey 2017 as references (datum) for other surveys (2005-2016). Surveys spacing in average value for each surveys can be seen in table 1. Stations distribution from surveys 2005-2017 are plotted in figure 10.

From stations distribution, we can divide the study area using smaller sectors. Per-sector area is covering (250x250) meter square. Frequency of data number for each sector are shown as colour group (figure 11a). In figure 11b we can see there are only three sectors (red and orange group colour) that observed in the field more than 150 data. The data clustering into sectors help us tracking line between surveys (2005 to 2017). From this three sectors we easily see the overlap line. We will observed the differences from data sample to see the correction for each survey to our datum/reference. We use closes stations in the range of (25x25) meter square as our sample (shown in figure 12). Data samples are considered as observation in the same position (block 25x25 meter square). Several blocks provide data sample that observed in different surveys (between 2005 to 2017).
Figure 11. (a) map showing crowdness of data observation per sector (250x250 meter square), (b) layout of clustering data to get sample for calculation data adjustment using 2017 data as references.

There are no data sample from 2005, 2007, 2015, and 2016. So we plot from average difference from samples (2006, 2008, 2009, 2010, 2011, 2012, 2013, 2014, and 2017) with survey 2017 as datum. We get linear trend with gradient -30.71 nT. As comparison, we also plot (in figure 13) the total intensity changes that predicted by IGRF model as red line (in the range of -28.70 to -30.10 nT). Using the linear relationship, we correct the total intensity of geomagnetic data surveys (2005-2016) to provide data as expected to be observed in 2017 for all stations. After the correction, the histogram data shows higher frequency in the range of 45000-45200 nT (figure 14).

Geomagnetic map that merged using 2017 as datum/reference show the range of total intensity from 41371 to 46799 nT (figure 15). Data distribution from field camp surveys already cover some Diabas Intrusion, Totogan Formation, Karangsambung Formation, and Luk-Ulo Melange Complex. Next surveys can be planed for larger coverage area in Waturanda and Panasogan Formation. The pattern of total intensity curve shows higher noise of magnetic properties in the Karangsambung Formation and Luk-ulo Melange Complex that close to the Diabas Intrusion (figure 16).
Conclusion
Geomagnetic survey 2017 in the Karangsambung as datum/reference of merge data provide geomagnetic map in the range of total intensity from 41371 to 46799 nT. Data distribution from field camp surveys already cover some geological surface map (Diabas Intrusion, Totogan Formation, Karangsambung Formation, and Luk-Ulo Melange Complex). The pattern of total intensity curve shows higher noise of magnetic properties in the Karangsambung Formation and Luk-ulun Melange Complex that close to the Diabas Intrusion.

Figure 12. Tracking data sample to choose several close station in the range of (25x25) meter square.

Figure 13 Summary of data sample and linear plot of datum correction for surveys 2005-2016.

Figure 14 Histogram geomagnetic field data 2005-2017 after corrected to datum 2017 survey.
Figure 15 Geomagnetic map from data 2005-2017 after corrected to datum 2017 survey.

Figure 16 Slice line of geomagnetic map in S-N section to shows zoning of signal patern above surface geological map (no topographic variation included in surface geology).

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