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Geocomputation and Spatial Analysis Applied for Geological Mapping: A Case Study in Palopo, South Sulawesi, Indonesia

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ABSTRACT
In searching for a track record of earth formation, people tend to interpret field data in a way that limits the potential of history and explanation, which is often less influenced by theory and available facts, this requires valid data gathered intellectually. Geocomputing, which is the digital processing of geographic data, is a relatively recent field that reflects a wide range of research methodologies and their application to help solve problems in machine learning, geostatistics, image processing, and spatial analysis, among other areas. The purpose of this study was to assess the effectiveness of using geocomputational methods with Avenza Map and ArcGIS. This study uses geocomputation and spatial analysis to carry out geological mapping at a scale of 1:25,000 located in the Battang area, West Wara District, Palopo City, South Sulawesi. Two aspects are the main focus in implementing this research method, namely when mapping by relying on Avenza with a base map sourced from the Rupa Bumi Indonesia (RBI) map and on data management using the ArcGIS application to become a 3D map. Lithological of the study area showed basalt, porphyry basalt, and phyllite. The geological structure that develops in the research area is joint and fault. Avenza Map work with spatial analysis in ArcGIS is obtained cognitively, involving the relationship between individual conditions, tools, and terrain conditions. It can be stated that the use of avenza on smartphones in this modernization condition is more effective. This research allows for a review of the practical level of use of computer methods ranging from mapping to data management. Regarding implementing cognitive mapping, Avenza Map and ArcGIS can be recommended tools in geo-computation techniques as more effective support for recording and managing data while still paying attention to noise that may occur as a barrier to data accuracy.

Keywords: Geocomputation, Geological Mapping, ArcGIS, Avenza Map

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1. INTRODUCTION

Geocomputational models can be developed with the aid of three-dimensional rock structures, temporal correlations, and causal processes that can be derived from the interpretation of geologist field data(Wang et al., 2021). In geocomputational modeling, the interpretive element contributes significantly (Qin et al., 2014). Geocomputational modeling is often difficult to identify and represent with non-human systems (Franklin, 2019). Geocomputational modeling is considered to be part of art, part of science, and an approach to artificial intelligence (Murray, 2019). The development of previous research and the interpretation of field observations are several factors that contribute to geocomputational modeling (Yuan, 2020).

Individual geo-computational methods have become accepted as practical solutions to specific spatial analysis problems and appear as functional elements embedded in more commonly used software (Fontanella & Xiao, 2018). For example, digital geological maps have become a means of artificial intelligence from geological aspects in decision-making considerations and other scientific and social endeavors (Murray, 2019; Xu et al., 2021). However, it remains a fact that digital geological maps are often difficult to use effectively (Sang et al., 2020). The widespread use of data models is an important requirement for digitally distributing geological information (Wu et al., 2015).

According to Simandjuntak et al. (1991), the geological conditions of the study site consist of two rock formations and intensive tectonic processes (Figure 1). The two rock formations are; 1) Latimojong Formation (KLs). 2) Lamasi Volcanic Rocks (Tplv). According to the tectonics process, joints are seen in nearly every form of rock. This connection's pattern and direction depend on the diagonal axis' type.

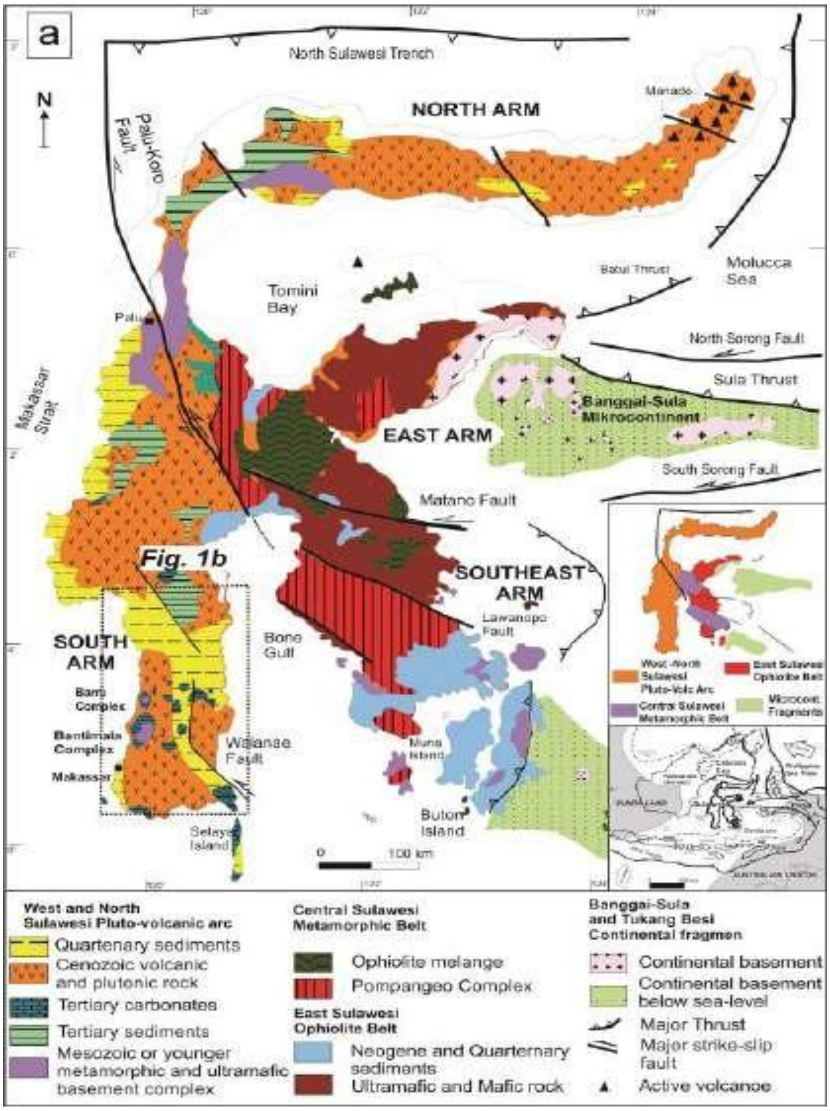

Figure 1. Geological Map of Sulawesi and its tectonic order (modified) (Hall & Wilson, 2000).

2. METHOD

In to produce a geological map based on data collection activities in the field, it was carried out for six days with a map scale of 1: 25,000 in the Battang area, West Wara District, Palopo City, South Sulawesi Province (Figure 2). Data retrieval focuses on updating information and then synchronizing field observation data and existing data (previous researchers). However, with pre-existing data, whether it was recorded with detailed accuracy and is still relevant is used today. Therefore, in this study, mapping was carried out using geocomputation with two application bases, namely Avenza Map version 4.1.4 (172) on Poco F3 smartphone and Arc GIS version 10.8, which can later be a recommendation in the future for other researchers to explore.

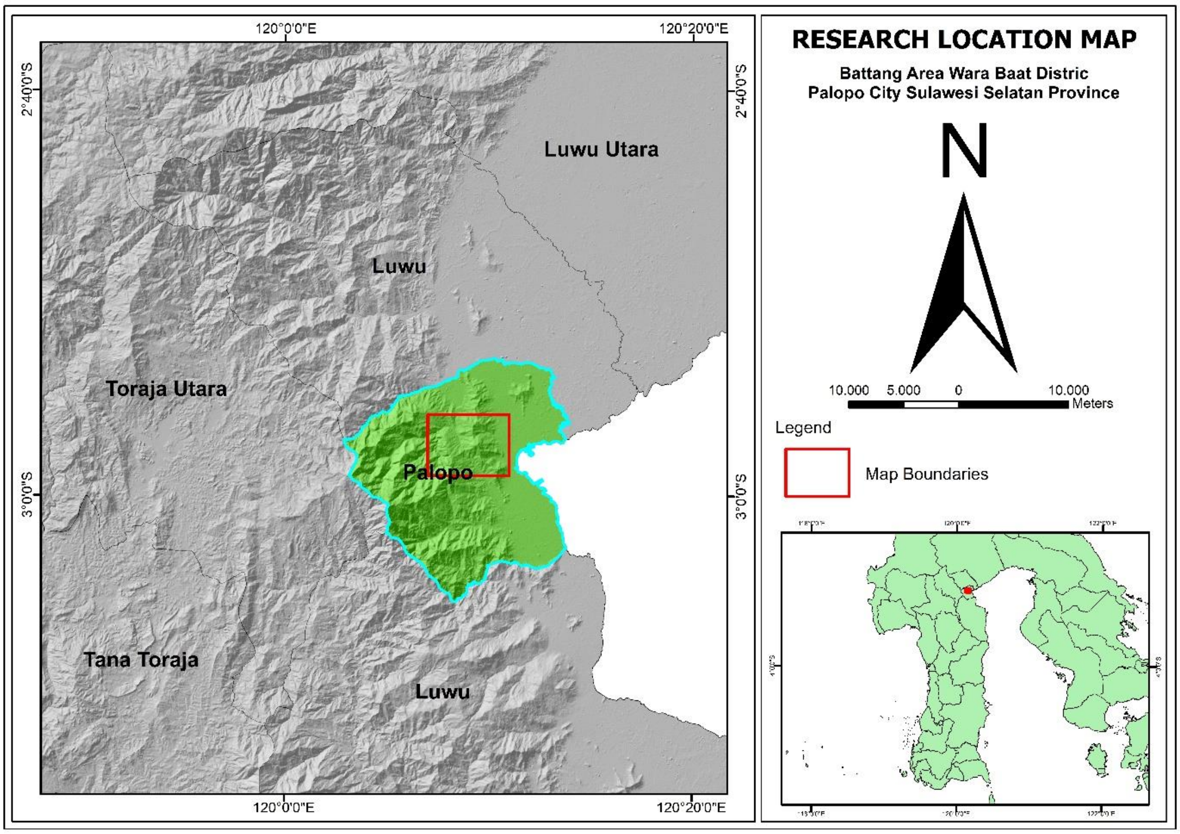

Figure 2. The map shows the location of the research area.

The implementation of research methods focuses on three stages, namely preparation, field research, and data processing. 1) Stage of preparation; before carrying out the study, it is necessary to prepare the equipment, especially the basic map sourced on the Indonesian Terrain

Map. 2) Stage of field research; the implementation of field research is the first step in the performance of this research to obtain field data using Avenza map version 4.1.4 (172) on the Poco F3 smartphone. Smartphone specifications can affect the details of the data because it allows access to the latest version of Avenza (Figure 3), 3) Stages of data processing; at this stage, the data that has been previously exported from the Avenza map (Figure 4), and then processed into Arc GIS 10.8 to produce a geological map (Figure 5 and 6).

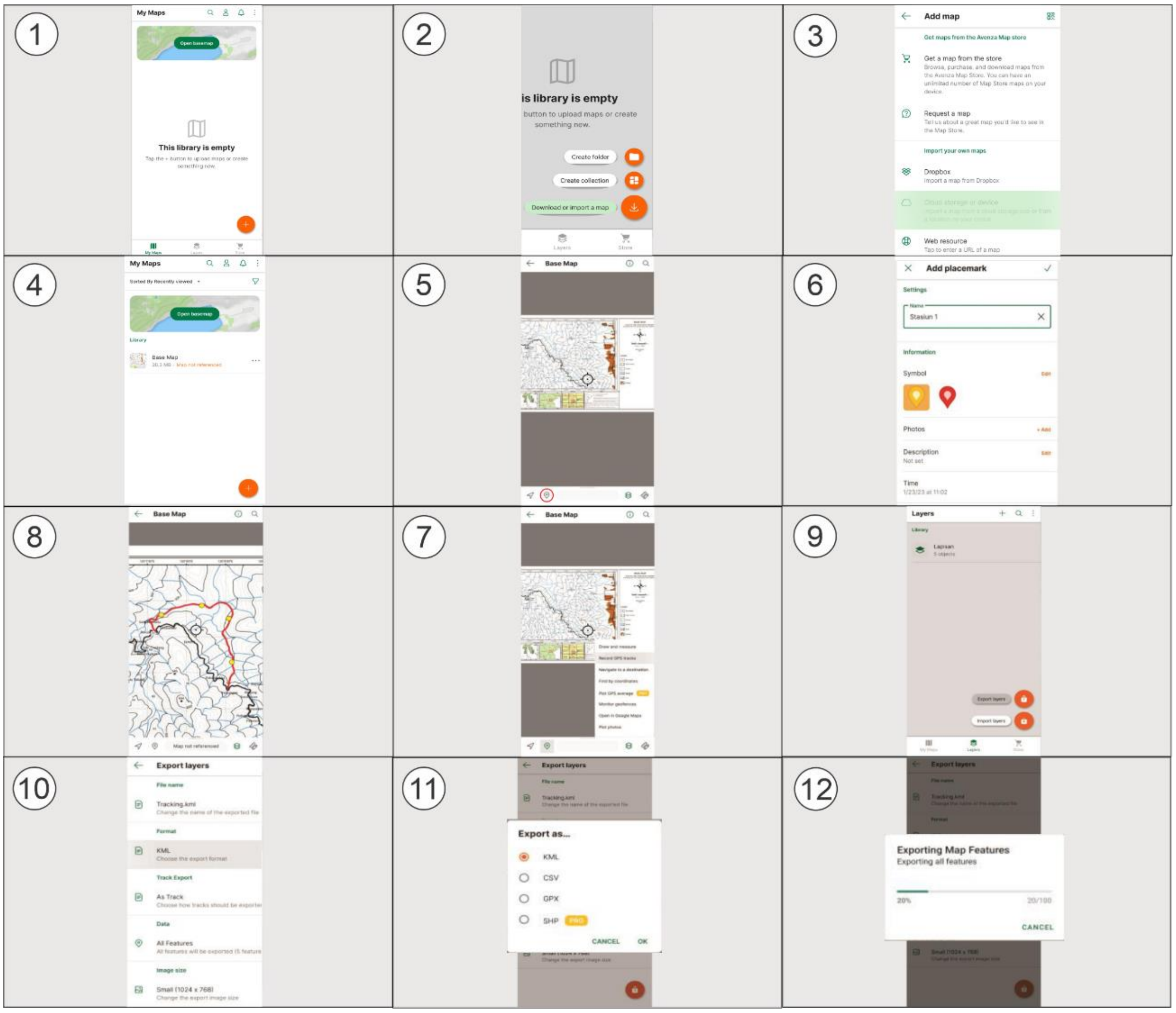

Figure 3. Data Collecting Procedural using AvenzaMap. 1) Start page. 2) "+" icon page then tap "Download or import map" to importing a map. 3) "Download or import map" page. 4) Map importing complete. 5) Map page then tap placemark icon to adding a placemark. 6) Placemark icon page. 7) Toolbar page (bottom right) then tap "Record GPS tracks" to record a tracking. 8) Tracking result. 9) Layers icon page then tap "Export layers" (bottom right) to exporting a layer. 10) "Export layers" page then tap "Format" to select a file format. 11) "Format" page. 12) Exporting on process.

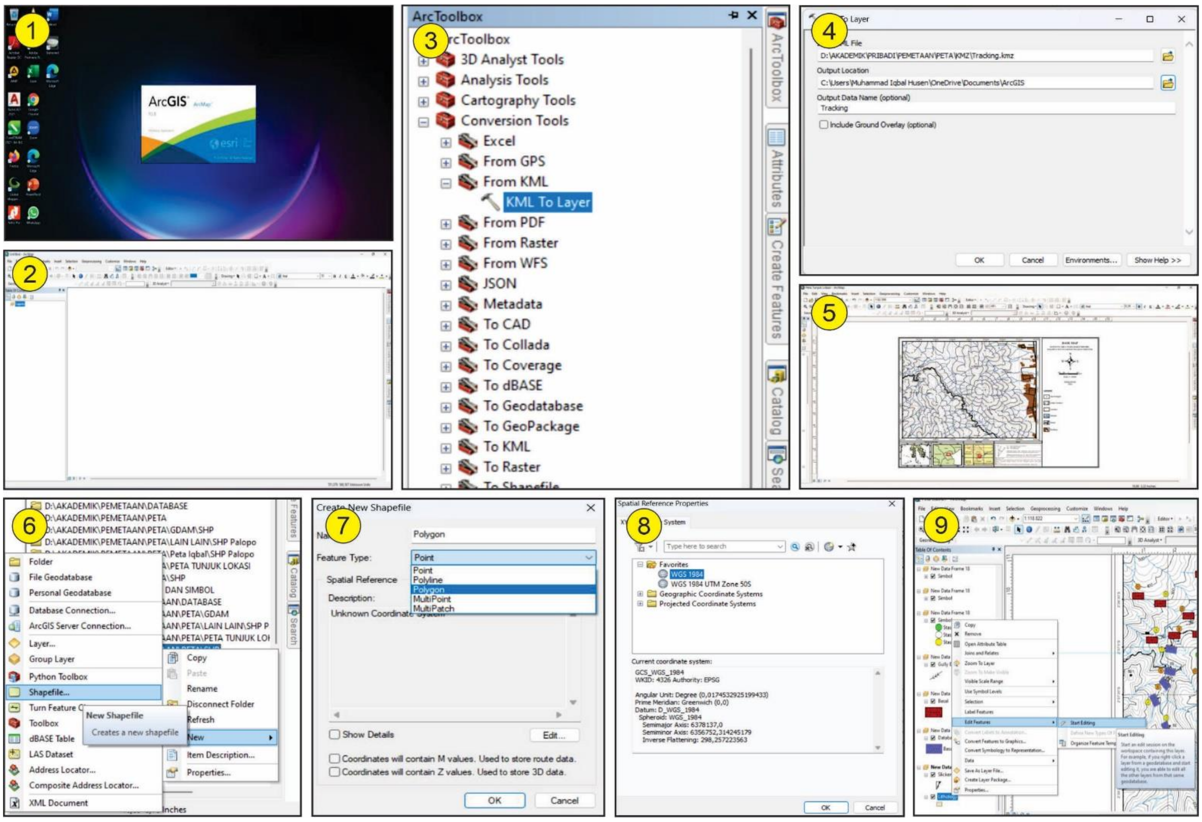

Figure 4. Data Processing Procedural using ArcMap. 1) Opening ArcGIS. 2) Start page. 3) “ArcToolbox” page then click “KML to Layer” to importing a layer. 4) “KML to Layer” page. 5) Open a previously created basemap. 6) “Catalog” page then click New Shapefile to creating a lithological boundary shapefile. 7) New Shapefile page then click “Edit” to select a spatial reference. 8) “Spatial Reference Properties” page. 9) “Table of Contents” page then click “Start Editing” to editing lithological boundary.

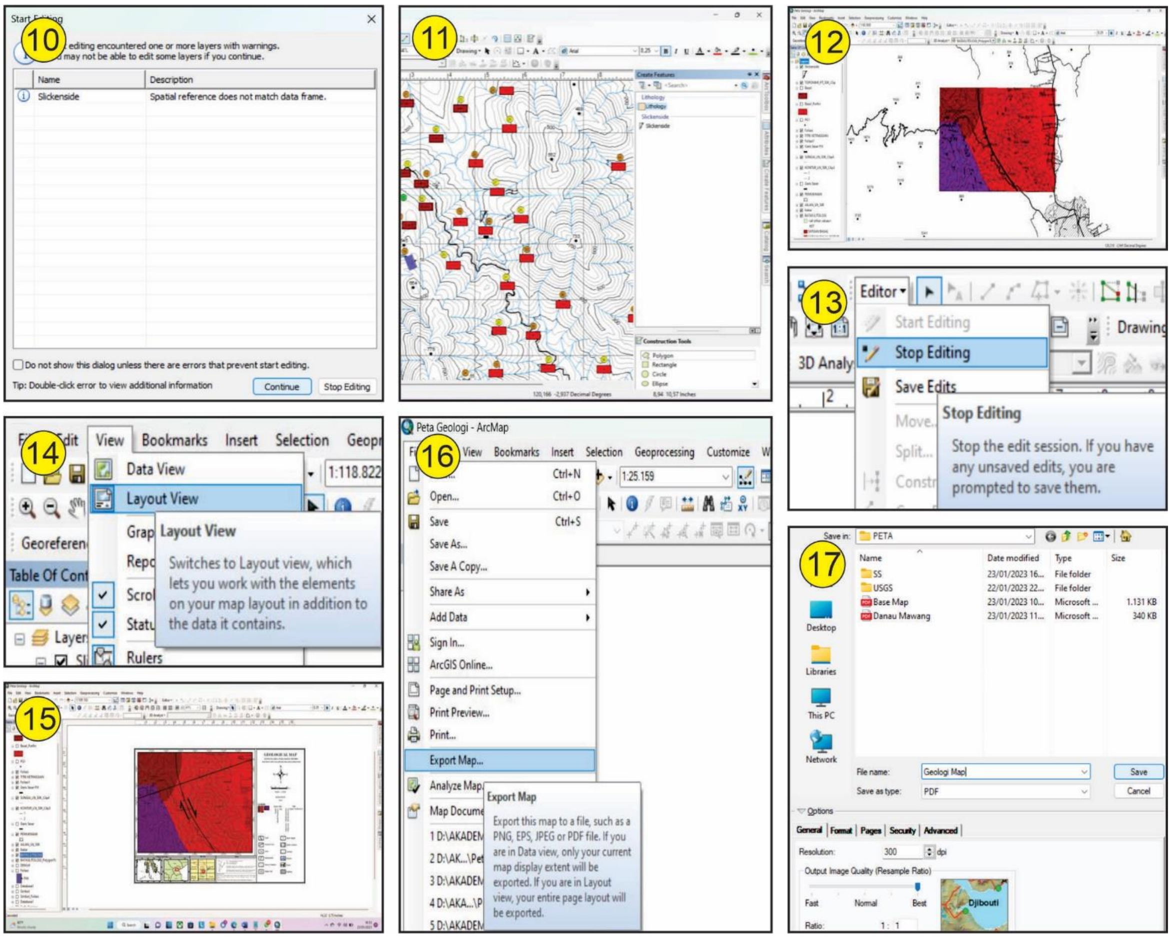

Figure 5. Continue Procedural using ArcMap. 10) "Start Editing" page. 11) "Create Features" page then click "Polygon" to start a editing. 12) Creating a structure line with the same way. 13) "Editor" page then click "Stop Editing" to finish a editing.14) "View" page then click "Layout View" to entering a layout view mode. 15) Fixng a layout as standard procedure. 16) "File" page then click "Export Map" to exporting a map. 17) "Export Map" page.

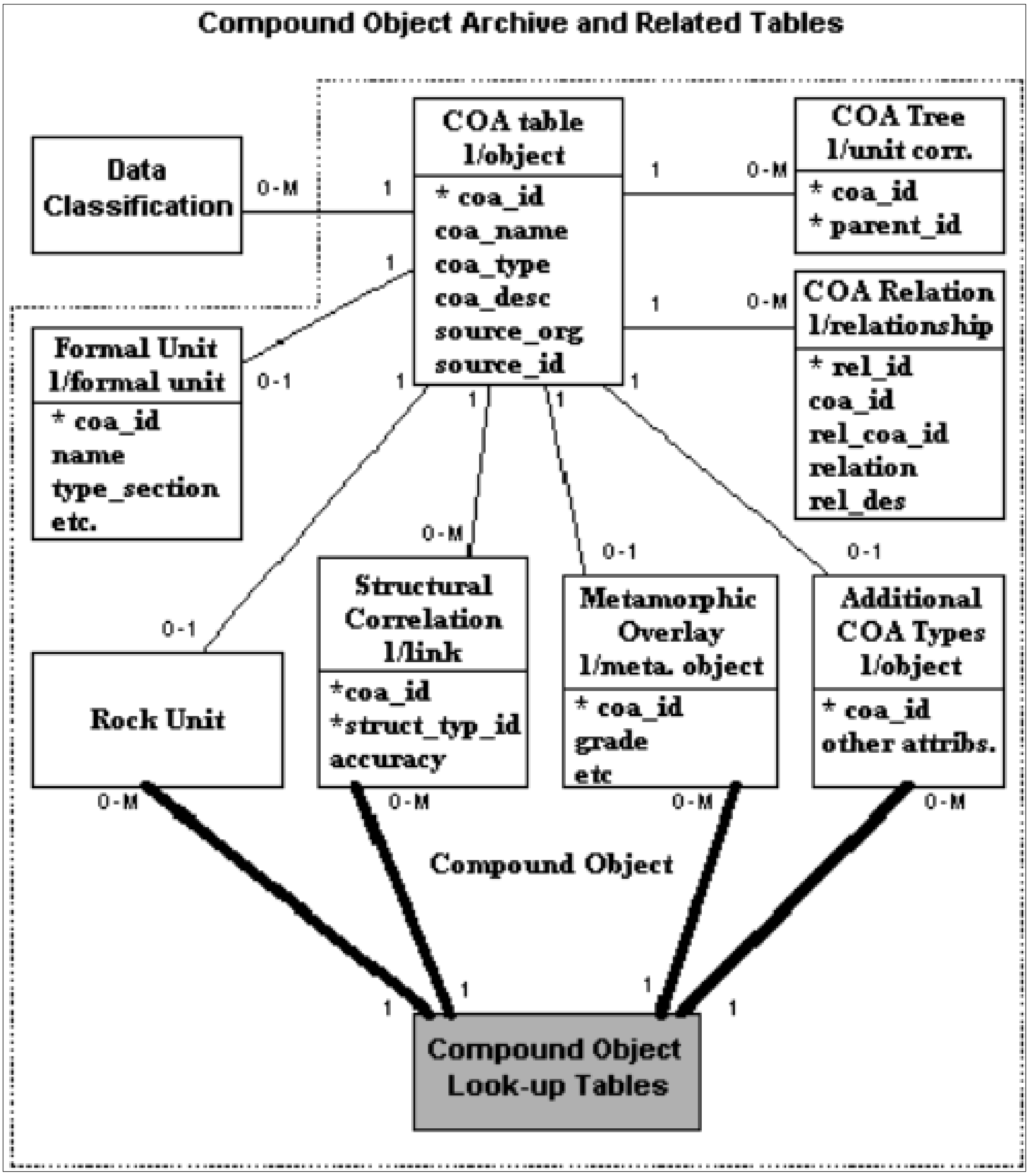

Figure 6. Portion of the data model of Johnson et al. (1997).

The first type is focused on existing cartographic documents (Kraak & Fabrikant, 2017; Otto et al., 2011). The latter type is focused on field observations (Kraak & Fabrikant, 2017). The development of a comprehensive data model is underway in the US (Johnson et al., 1999). One notion of model complexity is the entity-relationship diagram l called the "Joint Object Archive" or "COA".

A simple query language is required in extracting data for spatial analysis (Supavetch & Chunithipaisan, 2011). Many relational databases that are highly structured in other fields are identical to comprehensive databases for geological maps, making data extraction problematic (Dodge et al., 2011).

3. RESULT AND DISCUSSION

The mapping process is done using RBI map source with geocomputation method and analysis also using geocomputation method. RBI map uses the basis of the map of the terrain of Indonesia (RBI). However, the data is not real-time, but still possible to be used with the condition: not in the area of activity of the structure, But in the area of active mining and development. These areas are certainly not updated on the RBI map database, and it is recommended to use Real-Time sources from the USGS if the research is carried out in these areas.

The categorization of the field involves theories, data, and biases that are individual, tool, and situational. Further work considering multiple mapped categories and multiple time sequences is needed to confirm and extend the results. The results also demonstrate the development of geo-computing systems for other geoscience fields and information, and highlight the usefulness of geo-computing data sources for their study and processing. Future work will also address the expansion of geo-computing frameworks to accommodate the greater variety of reasoning, representation, and visualization techniques that can be brought to geoscience data and other space-time information (Bergmann & Sullivan, 2019).

Avenza Map data is obtained cognitively, involving the relationship between individual conditions, tools, and terrain conditions. It can be stated that the use of avenza on smartphones in this modernization condition is more effective than the use of old GPS models that are limited to one tool and require other devices, such as cameras, to support photo taking in the field. It's just that the use of avenza which only has an accuracy of 8 m, less than GPS, which is capable of up to 3 m (Figure 9). The presence of noise in the form of dense trees and weather aspects can affect the accuracy of the Avenza Maps. Avenza map collaboration with a smartphone has more accurate data results for an urban environment than forested conditions (Merry & Bettinger, 2019).

Smartphone power can also be affected due to the use of multitasking, which also takes photos. Avenza map also requires a smartphone with GPS accuracy that can be adjusted because it can affect the level of data accuracy other than the previous noise factor (Huang et al., 2022), as in this study using Poco F3 (smartphone). In this case, avenza can be recommended for geologists in this era if they consider the inhibiting factors explained previously.

Figure 7. a) Basalt outcrops in the study area with photo direction N 305^{O} E. b) Porphyry basalt outcrops in the study area with photo direction N 56^{o} E. c) Philyte outcrop in the study area with photo direction N 137^{o} E.

The grouping and naming of rock units in the research area are based on the division of lithodemic units intended to classify igneous, metamorphic, and other rocks that are powerfully converted into named units joined to lithological characteristics (IAGI, 1996). In general, the lithology of the research area is composed of metamorphic and igneous rocks. It can be seen from the differences in lithological characteristics in the field Physical properties, chemical composition, and rock contact when the contact boundary may be located on an actual plane are the lithological qualities in question; in the event of an ambiguous change, the edge is an estimated plane. The research area's rock units are arranged lithologically from youngest to oldest, with the following compositions:

a. Basalt occupies about 8% of the total area of the study area or about 6.97 Km2. This unit covers the Bambalu River and the northern part of the Battang area.
b. Porphyry basalt occupies about 61% of the total area of the study area or approximately 25.01 Km2. This unit spread in the northwestern part of the research area and covers the East Bambalu River and the Balandai area.
c. Phyllite occupies about 22 % of the total area of the study area or about 9.02 Km^2. This unit is spread from the west to the southwest of the research area. This unit covers the area of Sungai Tabang and the southern part of Battang.

The geological structure of the research area was identification of the type of structure, the structure's age connected with the research area's stratigraphy, and the interpretation of the mechanism of forces that cause the structure to occur in the research area. Determining geological structure is based on data obtained in the form of primary and secondary data and interpretation of topographic maps of the research area.

Based on observations in the field, primary geological structure characteristics data were obtained in the form of slickenside, minor faults, and changes in rock position. The secondary geological structure characteristics data include topographic alignment, the joint, river turns, and ridge shifts/offset ridges. The geological structure that develops in the research area is joint and fault.

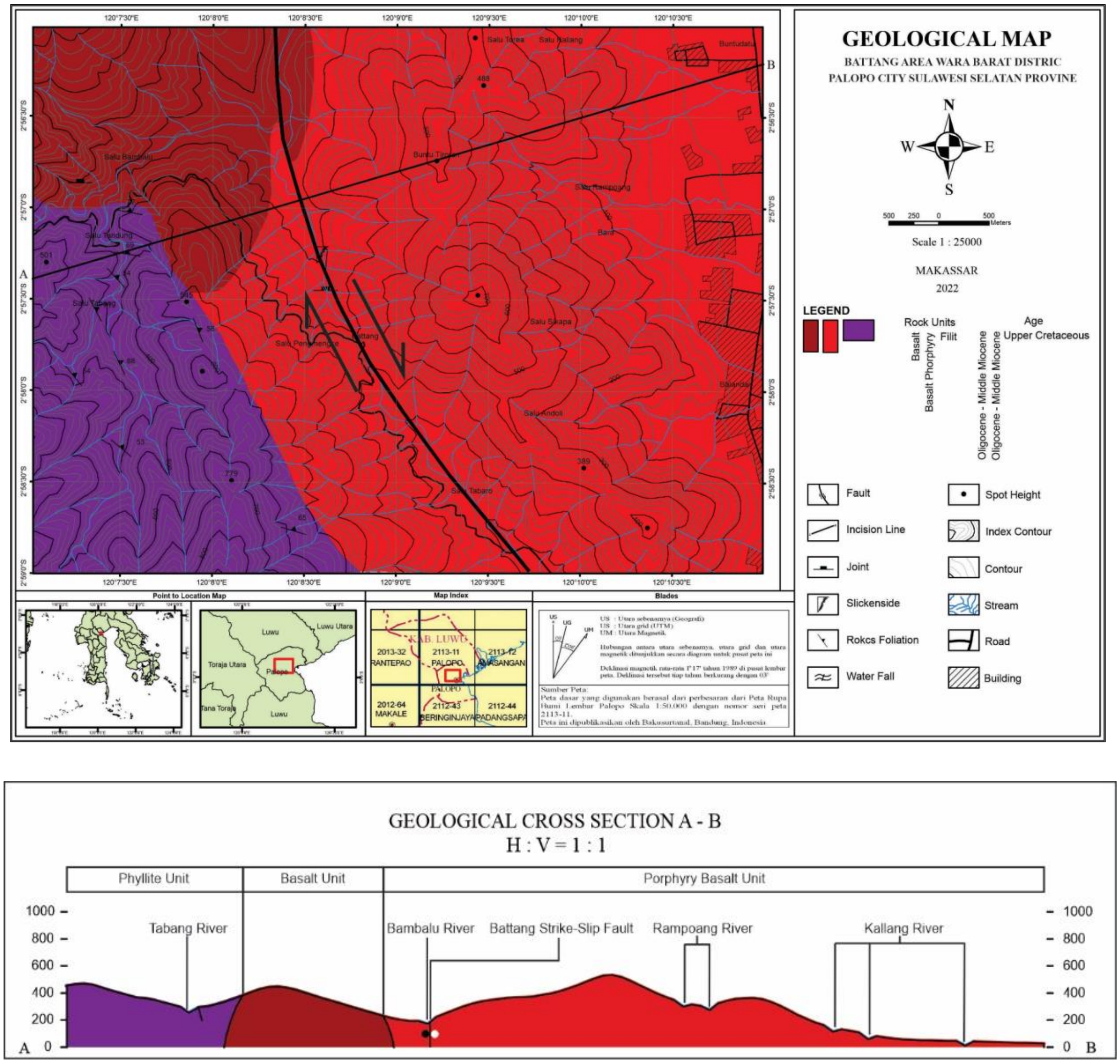

Figure 8. Geological Map of The Research Area.

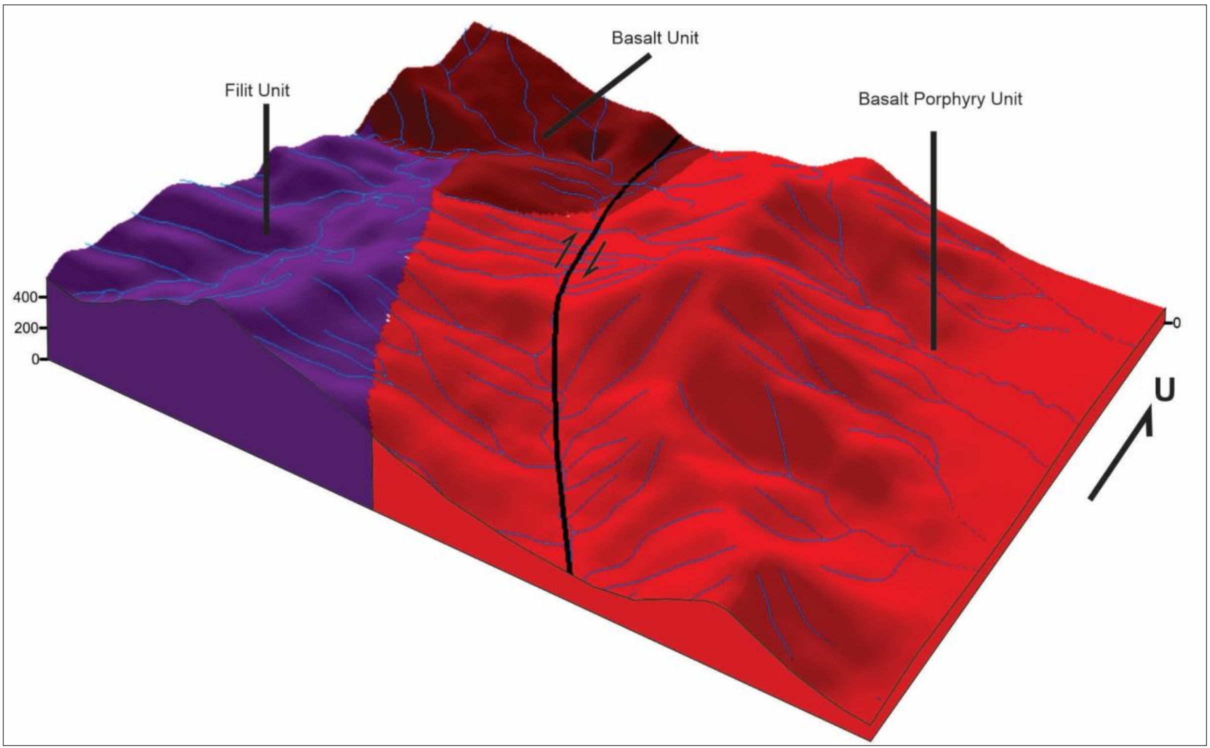

Figure 9. Geological Map of The Research Area.

4. CONCLUSION

Geocomputation for smartphone mapping is more effective, and it is vital to know the source of data and their respective uses. Spatial analysis with GIS is needed to add insight into the modeling of the data that has been obtained. From the data collection process, it can be concluded that Avenza can be used in areas with reasonably dense vegetation, coupled with the practical use of Avenza. Avenza's with ArcGIS can be a recommendation for its use in mapping and other exploration processes.

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REFERENCES

Bergmann, L., & Sullivan, D. O. (2019). Enabling spaces by GeoComputation. *Geocomputation 2019: Adventures in Geocomputation*, 1–5.

Dodge, M., Kitchin, R., & Perkins, C. (2011). Technologies of Mapping. In *The Map Reader: Theories of Mapping Practice and Cartographic Representation,* (Section tw, pp. 116–121).

Fontanella, S., & Xiao, N. (2018). Geocomputation: Data, Methods, and Applications in a New Era. In *Comprehensive Geographic Information Systems* (Vol. 3). Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.09600-7

Franklin, J. (2019). Geospatial data for forecasting global change impacts on ecosystems. *Geocomputation 2019: Adventures in Geocomputation*, 1–8.

Hall, R., & Wilson, M. E. J. (2000). Neogene sutures in eastern Indonesia. *Journal of Asian Earth Sciences, 18*(6), 781–808. https://doi.org/10.1016/S1367-9120(00)00040-7

Huang, J., Guo, Y., Li, X., Zhang, N., Jiang, J., & Wang, G. (2022). Evaluation of Positioning Accuracy of Smartphones under Different Canopy Openness. *Forests*, *13*(10), 1–22. https://doi.org/10.3390/f13101591

IAGI. (1996). Sandi Stratigrafi Indonesia Edisi 1996. In *Sandi Sratigrafi Indonesia 1996*.

Johnson, B. R., Brodaric, B., Raines, G. L., Hastings, J. T., & Wahl, R. (1999). *Digital Geologic Map Data Model, version 4.3: AASG/USGS Data Model Working Group Report*. http://geology.usgs.gov/dm/model/Model43a.pdf

Kraak, M. J., & Fabrikant, S. I. (2017). Of maps, cartography and the geography of the International Cartographic Association. *International Journal of Cartography, 3*(S1), 9–31. https://doi.org/10.1080/23729333.2017.1288535

Merry, K., & Bettinger, P. (2019). Smartphone GPS accuracy study in an urban environment. *PLOS ONE*, *July*, 1–19. https://doi.org/10.1371/journal.pone.0219890

Murray, A. T. (2019). GeoComputation and Spatial Analysis. *Geocomputation 2019: Adventures in Geocomputation*, *15*, 1–9. https://doi.org/10.1007/pl00011476

Otto, J. C., Gustavsson, M., & Geilhausen, M. (2011). Cartography. Design, Symbolisation and Visualisation of Geomorphological Maps. In *Developments in Earth Surface Processes* (Vol. 15, Issue December 2011, pp. 253–295). https://doi.org/10.1016/B978-0-444-53446-0.00009-4

Qin, C. Z., Zhan, L. J., Zhu, A. X., & Zhou, C. H. (2014). A strategy for raster-based geocomputation under different parallel computing platforms. *International Journal of Geographical Information Science*, *28*(11), 2127–2144. https://doi.org/10.1080/13658816.2014.911300

Sang, X., Xue, L., Ran, X., Li, X., Liu, J., & Liu, Z. (2020). Intelligent high-resolution geological mapping based on SLIC-CNN. *ISPRS International Journal of Geo-Information, 9*(2), 1–23. https://doi.org/10.3390/ijgi9020099

Simandjuntak, T., Rusmana, E., Surono, & Supandjono, J. (1991). *Peta Geologi Lembar Malili, Sulawesi (Geological Map of Malili Quadrangle, Sulawesi)*. Geological Research and Development Centre.

Supavetch, S., & Chunithipaisan, S. (2011). The SQL-Based Geospatial Web Processing Service. *International Journal of Computer Information Systems and Industrial*

Management Applications, *3*(2011), 119–126.

Wang, C., Wang, X., & Chen, J. (2021). Digital Geological Mapping to Facilitate Field Data Collection , Integration , and Map Production in Zhoukoudian , China. *Applied Sciences*, *11*(5041), 1–18. https://doi.org/10.33115041

Wu, L., Xue, L., Li, C., Lv, X., Chen, Z., Guo, M., & Xie, Z. (2015). A geospatial information grid framework for geological survey. *PLoS ONE*, *10*(12), 1–29. https://doi.org/10.1371/journal.pone.0145312

Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S., Liu, X., Wu, Y., Dong, F., Qiu, C. W., Qiu, J., Hua, K., Su, W., Wu, J., Xu, H., Han, Y., Fu, C., Yin, Z., Liu, M., … Zhang, J. (2021). Artificial intelligence: A powerful paradigm for scientific research. *The Innovation*, *2*(100179), 1–20. https://doi.org/10.1016/j.xinn.2021.100179

Yuan, M. (2020). Why are events important and how to compute them in geospatial research ? *Journal Odf Spatial Infromation Science*, *21*(21), 47–61. https://doi.org/10.5311/JOSIS.2020.21.723