



Identification of potential mineral Zircon ($ZrSiO_4$) rare earth metal in Indonesia as raw material for electric tactical motorcycle battery

Dimas Prayogo *

Indonesia Defense University,
INDONESIA

Riri Murniati

Indonesia Defense University,
INDONESIA

Chutiwat Likitaporn

Chulalongkorn University,
THAILAND

Article Info

Article history:

Received: November 5, 2023

Revised: February 11, 2024

Accepted: March 13, 2024

Published: April 30, 2024

Keywords:

Electric Tactical Motor Bike

Rare Earth Metal

Zircon Battery

Abstract

Rare earth metals are associated minerals that are magnetic used as the main component in providing power to most electronic devices. Rare earth metal (REM) as a material that has 14 chemical elements. These elements are grouped according to their molecular weight, namely light rare earth metals (Ce, Pr, Nd, Pm, Sm, Eu) and heavy rare earth metals (Gd, Tb, Dy, Ho, Tr, Tm, Yb, Lu). The use of this REM includes electric cars, health identification devices, LCDs and computer hardware. From some of the benefits and contents of REM, its development is not only in the industrial world but also in the world of defense, one of which is as a battery for motorized vehicles developed by the ministry of defense (Electric Tactical Motor Bike) that uses lithium batteries as a source of electrical energy. However, the use of lithium batteries which have shortcomings in terms of charging makes lithium batteries look for other alternatives so that they can be charged optimally, one of which is using REM. REM is one type of material that can be utilized optimally, given its ability to produce electrical energy that can replace lithium batteries.

To cite this article: Prayogo, D. & Murniati, R. (2024). Identification of potential mineral Zircon ($ZrSiO_4$) rare earth metal in Indonesia as raw material for electric tactical motorcycle battery. *International Journal of Applied Mathematics, Sciences, and Technology for National Defense*, 2(1), 29-36

INTRODUCTION

Rare earth metal is one type of material that is being developed to be used en masse. The potential that exists in Indonesia is found in several areas, including South Bangka and North Sumatra. From these two areas, rare earth elements as co-minerals are found in the main commodities, especially alluvial gold and tin, which can be cultivated as by-products that can add value to all mineral potentials ([Rohmana & Gunradi, 2006](#)). The potential for alluvial gold deposits is relatively abundant and can be spread over several large islands of Indonesia ([Aryanto & Widodo, 2008](#)). Seeing this condition, the development was carried out by the ministry of defense in collaboration with PT LEN (Lembaga Elektroteknika Nasional) by making electric motors which was named the Electric Tactical Motor Bike (ETMB). This vehicle has been mass-produced for the purposes of troops in reaching hard-to-reach areas. This vehicle uses a lithium-ion with a charging time of 1.5 – 3.4 hours to be able to fully charge the battery ([Widhiyatna et al., 2006](#)). The duration of this battery charging has an impact on the mobilization of troops if needed suddenly, so further studies are needed to be able to find alternative charging so that the battery can be charged quickly ([Djunaedi & Putra, 2006](#); [Gunradi & Djunaedi, 2003](#))

Kementerian Pertahanan RI (Kemhan) is developing an electric vehicle in the form of a military motorcycle called a tactical electric motorcycle. The military electric motor, which is still in the prototype stage, was developed by Eltran Indonesia, a subsidiary of Len Industri ([Kemhan, 2022](#)).

***Corresponding Author:**

Dimas Prayogo, Indonesia Defense University, Indonesia, Email: dimasprayogo888@gmail.com

Figure 1 is the shape of an electric motorbike that has a fast charging function of 1200 A and can be used for a distance of 80 kilometers. However, one of the problems with this car is that it takes a long time to charge, which requires a charger that can charge quickly so that it can be used in emergency situations.



Figure 1. Electric Tactical Motor Bike

This motorbike already has two variations, namely the Type s and Type R variations. Both have specifications that are not much different. Table 1 is the similarity of the two types of motors developed, however, they still have different specifications in terms of gearbox, battery pack and charging duration which can be seen in Table 2.

Table 1. Similarity of the E-Tactical Motorcycle - Type S and Type R

	E-Tactical Motor Bike - Type S	E-Tactical Motor Bike - Type R
Flow Control	Electric power control	Electric power control
Cell Battery	Li-Ion	Li-Ion
Battery IP	65	65
Charger	Input 180-264 VAC 50Hz; Output 84 VDC \pm 1% max A = 12 Ampere	Input 180-264 VAC 50Hz; Output 84 VDC \pm 1% max A = 12 Ampere
Fast Charger (Optimal) 0-80%	1 hour 30 minutes - 3000 Watt (A=35 Ampere)	1 hour 30 minutes - 3000 Watt (A=35 Ampere)

Table 2. Specifications of the Electric Tactical Motor Bike obtained by the Ministry of Defense Balitbang at the Indo Defense 2022 event.

	E-Tactical Motor Bike - Type S	E-Tactical Motor Bike - Type R
Gearbox	There isn't	There is
Battery Pack	72V 40Ah	72V 50Ah
Normal charging	3.4 hours - 1000 Watt	4 hours - 3000 Watt

In Table 2, it is known that what is used is lithium batteries, but the availability of lithium batteries is currently decreasing even though in Indonesia itself the availability of lithium batteries is very large, but of course other alternatives are needed that can be used if the reserves of lithium batteries are getting less at a time. So, one of them is to examine the ability of zircon batteries which are quite abundant in Indonesia as an alternative to lithium batteries ([Aryanto 2022](#)). An assessment of the utilization of REM is needed, one of which is to see the opportunity to turn it into a battery. One type of mineral that can be utilized for electricity is zircon. The availability of zircon as a mineral containing rare earth metals in nature reaches 58 percent, so it is unfortunate if it has not been widely

utilized ([Tain et al., 2003](#)). Therefore, it is necessary to re-test zircon batteries so that they can be utilized as batteries that can be used by electric vehicles, especially Tactical Electric Motors.

METHOD

This research uses the literature review method, both national and international about zircon batteries. The stages of making this journal begin with looking for problems that will be raised then looking for references that will be used to make this journal. The principle used in this research is to explore the existence of zircon in Indonesia based on previous journals which can later be used as a reference in finding zircon materials in Indonesia. The selection of zircon minerals because this mineral is a mineral that has better electrolyte power and the material is widely available in Indonesia, so to replace lithium batteries this mineral can be an alternative. In addition, I also conducted interviews with competent sources in the field of Electric Tactical Motor Bike as a supporter of the ability of the zircon material that I used in this study.

RESULTS AND DISCUSSION

REM Potential in Indonesia

Rare earth metal is one type of material that is being developed to be used en masse. The potential that exists in Indonesia is found in several areas, including South Bangka and North Sumatra. From these two areas, rare earth elements as co-minerals are found in the main commodities, especially alluvial gold and tin, which can be cultivated as by-products that can add value to all mineral potentials. The potential for alluvial gold deposits is relatively abundant and can be spread over several large islands of Indonesia .

Properties of Rare Earth Metals (REM) is a group of lanthanides which are group 111B transition metals in the periodic table. The lanthanide group consists of 15 elements, ranging from lanthanum (atomic number 57) to lutetium (atomic number 71) and three other elements namely yttrium, thorium and scandium. The inclusion of yttrium, thorium, and scandium in the rare earth group because of their similar properties. Rare earth elements are highly reactive with water and oxygen, they form stable compounds under oxidizing conditions, they have relatively high melting points and are good conductors of heat ([Suprpto, 2008](#)).

The types of minerals present in rare earths are more than 100, and 14 of them have high oxide content. Of the 100 types, they are grouped into several types of minerals including carbonate, phosphate, fluoride, silicate and oxide minerals. As for the metallic minerals, they are bastnaesite ($CeFCO_3$), monazite ($(Ce, La, Y, Th)PO_3$), Xenotime (YPO_4), and Zircon. Rare earth metals are irreplaceable ([Kok et al., 2019](#)). The reason for this is the very unique properties of rare earth metals, which have not been replaced by other materials. If anything, the yield potential is not as good as that of rare earth materials. The nature of rare earth metals that are used as high-tech materials and have no substitute materials make rare earth metals an important material and have strategic potential. Rare earth elements are found in low concentrations (10 – 300 ppm) in many rock formations ([Setiady et al., 2008](#)). A greater number of rare elements are found in granite rocks than in alkaline rocks. High concentrations of rare earth elements are found in alkaline and carbonate igneous rocks.

Figure 2 and 3 is a mine of rare minerals that grow in Indonesia, which are often found in Kalimantan, especially West Kalimantan. Rare earth deposits in South Kalimantan are associated with uranium deposits. Zircon in Kalimantan as a by-product of alluvial gold deposits. Rare gray minerals commonly occur in tin generation in the form of monazite, xenotime, and zircon, which accumulate as byproducts of tin processing during gravity, magnetic, and electrostatic processing.



Figure 2. Zircon mining in gold mine tailings, Central Kalimantan ([Rohmana & Gunradi, 2006](#))



Figure 3. Results of mining and processing gold and zircon at the Katingan gold mine, West Kalimantan ([Djunaedi & Sukaesih, 2007](#))

The Geological Resource Center balance sheet (2007) recorded monazite ore reserves of 185,992 tons. This potential exists in the main tin producing areas, including Bangka, Belitung, Kundur and Kampar ([Djunaedi & Sukaesih, 2007](#)). Meanwhile, recent developments will increase the discovery of monazite resources with intensive exploration activities. Apart from being produced in alluvial and gold ores, rare minerals are also found in uranium ores. Uranium ore in Rirang, West Kalimantan is mined from the upper, middle and lower valleys of Rirang. Figure 4 is the mining results obtained in West Kalimantan which contain elements in Rirang ore that have potential economic value, namely uranium (U) 8528.75 ppm, rare earth elements (UTJO3) 60.85%, phosphate (PO4) 32.84 n thorium (Th) 861.5 ppm which produces uranium in the amount of 178.43 tons per year ([Erni et al., 2004](#)).



Figure 4. Gold and zircon, magnification $\pm 30x$, Katingan, South Kalimantan (Rohmana & Gunradi, 2006).

Zircon Battery

Rare earth metals (REM) are being targeted by many countries around the world. The reason is, these mineral resources can be used to produce various types of technology (Haxel et al., 2005). According to a report from the Center for Mineral, Coal and Geothermal Resources (PSDMBP) of the Geological Agency of the Ministry of Energy and Mineral Resources, LTJ can be used to support the production of lighting technology, computers, cell phones, to automotive components and electric car batteries (Firman & Haya, 2021). Indonesia itself has the potential for rare earth metal wealth which is spread in various regions. Citing data from the Ministry of Energy and Mineral Resources, the largest LTJ potential is in the Bangka Belitung Islands, reaching 207,397 tons with details of 186,663 tons in the form of monazite and 20,734 tons of senotim (Drossel et al., 2015). There is also 19,917 tons of LTJ potential in North Sumatra, then 443 tons of laterite LTJ in Central Sulawesi and 219 tons in West Kalimantan. The Director General of Mining and Coal at the Ministry of Energy and Mineral Resources, Ridwan Jamoluddin, said that the use of rare earth metals in Indonesia is currently in the research stage (Said et al., 2017). Although it is still in the exploration stage, it is necessary to study the use of REM, one of which is by looking at opportunities to turn it into a battery. One type of mineral that can be used for electricity is zircon (Jowitt et al., 2018). The availability of zircon as a mineral containing rare earth metals in nature reaches 58 percent, so it is unfortunate if it has not been widely used. one of them is to see an opportunity to make it a battery. One type of mineral that can be used for electricity is zircon. The availability of zircon as a mineral containing rare earth metals in nature reaches 58 percent, so it is unfortunate if it has not been widely used. Figure 5 is a zircon battery that has been developed by UNS students on a small scale of use.

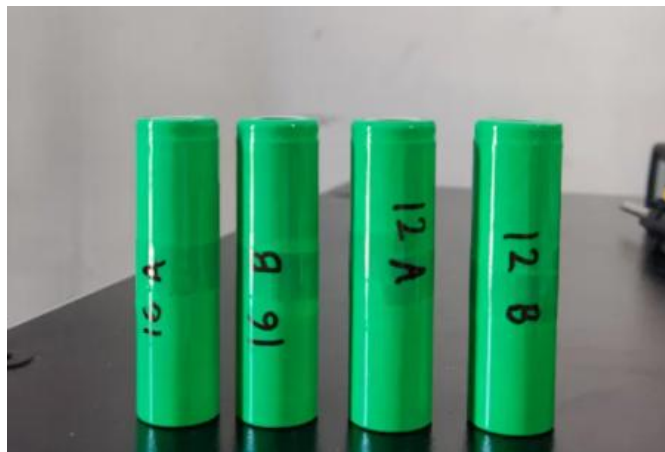


Figure 5. Zircon battery made by UNS students (Source: Adit, 2022)

The use of rare earth metals will open Indonesia to the acquisition and development of technology, particularly electronic technology (Adit, 2022; Redaksi, 2008). To improve the quality of Indonesia's metallurgical industry, increase the many benefits that Indonesia derives from the processing of rare earth metals, and especially encourage industrial development (Prameswara et al., 2019). The huge potential of this rare earth metal is very beneficial if Indonesia participates in its development. In addition, rare earth mineral sands as a source of rare earth metals (some of which are only used as waste in tin mines), or earth sands for stockpiling tin root areas are not considered for their rare earth mineral content. The uses of rare earths vary widely in industry (Suharji & Sumama, 2006).

CONCLUSION

The identification of potential zircon ($ZrSiO_4$) in Indonesia as a source of rare earth metals (REMs) could play a significant role in advancing the development of electric tactical motorcycle batteries. Rare earth metals, which include both light and heavy elements, are essential components in various technologies, including electric vehicles and defense-related applications. While lithium batteries are commonly used, they have limitations in terms of charging efficiency. Rare earth minerals in Indonesia are currently produced as by-products of mining activities, leading to their underutilization.

This has sparked further research and exploration efforts aimed at achieving energy independence and transitioning to a zero-fossil energy future in Indonesia. One promising area of development is zircon-based batteries, which have the potential to replace lithium batteries. Therefore, REMs present a promising alternative due to their ability to generate electrical energy more effectively. By exploring and utilizing REMs from zircon deposits in Indonesia, there is potential to enhance battery performance and support the development of advanced electric vehicles, including those used in defense.

AUTHOR CONTRIBUTIONS

Each author of this article played an important role in the process of method conceptualization, simulation, and article writing.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

- Adit, Albertus. (2022). Kompas: Mahasiswa UNS inovasi logam tanah jarang jadi baterai Lithium-Ion Accessed on February 2, 2024: <https://www.kompas.com/edu/read/2022/09/30/132824571/mahasiswa-uns-inovasi-logam-tanah-jarang-jadi-baterai-lithium-ion>
- Aryanto, N. C. J., & Widodo, R. (2008). *Keterkaitan unsur tanah jarang thd mineral berat Ilmenit dan Rutil perairan pantai Gundi, Bangka*. Puslitbang Geologi Kelautan, Bandung. <http://dx.doi.org/10.32693/jgk.1.2.2003.95>
- Djunaedi, E. K., & Putra, C. (2006). *Inventarisasi potensi bahan galian pada wilayah PETI, di daerah Kamipang, Kabupaten Katingan, Provinsi Kalimantan Tengah*. Pusat Sumber Daya Geologi, Bandung. <https://doi.org/10.47599/bsdg.v2i3.214>
- Djunaedi, E. K., & Sukaesih. (2007). *Inventarisasi potensi bahan galian pada wilayah PERL di Kabupaten Lebak, Provinsi Banten*. Pusat Sumber Daya Geologi, Bandung. Accessed on February 2, 2024: https://www.academia.edu/101306194/Tinjauan_Bahan_Galian_Tertinggal_Pada_Wilayah_Bekas_Tambang_DI_Indonesia
- Erni, R. A., Susilaningtyas, H., Sumarni, W., & Rusydi. (2004). *Penentuan kondisi dekomposisi optimal bijih uranium rirang kalan*. Pusat Pengembangan Geologi Nuklir-BATAN. ISBN : 979-8769-12-0
- Firman & Haya, A. (2021). Study on the potential rare earth elements in coal combustion product from Banjarsari power plant, South Sumatera. IOP Conference Series: Materials Science and Engineering, 1125(012003), 1-6. <https://10.1088/1757-899X/1125/1/012003>

- Gunradi, R., & Djunaedi, E. K. (2003). *Evaluasi potensi bahan galian pada bekas tambang dan wilayah PETI di daerah Monterado, Kabupaten Bengkayang, Provinsi Kalimantan Barat*. Direktorat Inventarisasi Sumber Daya Mineral, Bandung. <http://dx.doi.org/10.13140/RG.2.2.16710.63048>
- Haxel, G. B., Hedrick, J. B., & Orris G.J. (2005). *Rare earth elements-critical resources for high technology*. US: Geological Survey. <https://pubs.usgs.gov/fs/2002/fs087-02/>
- Jowitt, S., Werner, T., Weng, Z., & Mudd, G. (2018). *Recycling of the rare earth elements*. In *Current Opinion in Green and Sustainable Chemistry* (Vol. 13, pp. 1–7). Elsevier BV. <http://dx.doi.org/10.1016/j.cogsc.2018.02.008>
- Kemhan. (2022). *Kemhan garap motor listrik militer karya anak bangsa*. CNN Indonesia. Accessed on February 2, 2024 : <https://www.cnnindonesia.com/otomotif/20220916113314-579-848674/kemhan-garap-motor-listrik-militer-karya-anak-bangsa>
- Kok, M., Qader, N., Dagdelen F, & Aydogdu, Y. (2019). Akıllı malzemeler üzerine derleme: araştırmalar ve uygulamaları. *El-Cezeri Fen ve Mühendislik Dergisi*. 6(3), 755 -788. <https://www.acarindex.com/el-cezeri/akilli-malzemeler-uzerine-derleme-arastirmalar-ve-uygulamalari-293851>
- Prameswara, G., Mulyono, P., Prasetya, A., Poernomo, H., & Trisnawati, D. (2019). Ekstraksi logam tanah jarang (LTJ) dan logam berharga hasil fusi alkali tailing zircon. *Prosiding Seminar Nasional Teknik Kimia "Kejuangan"* (pp1-7). FTI UPN "Veteran" Yogyakarta. ISSN : 1693-4393
- Redaksi. (2008). *Perkembangan sepeda motor listrik dari militer Rusia dan Australia*. Accessed on February 2, 2024 : <https://gpriority.co.id/sejajar-dengan-militer-rusia-dan-australia-indonesia-kembangkan-sepeda-motor-listrik-untuk-militernya/>
- Rohmana, & Gunradi. (2006). *Inventarisasi bahan galian pada wilayah PETI, Daerah Kotarawaringin Barat, Kalimantan Tengah*. Pusat Sumber Daya Geologi, Bandung. ISSN : 2502-6844
- Drossel, W-G., Kunze, H., Bucht, A., Weisheit, L., & Pagel, K. (2015). Smart³ - Smart materials for smart applications. *Procedia CIRP*, 36, 211–216. <https://doi.org/10.1016/j.procir.2015.01.055>
- Said, MIN., Anggraini, M., Mubarak, M., & Widana, KS. (2017). Studi Ekstraksi Bijih Thorit dengan Metode Digesti Asam dan Pemisahan Thorium dari Logam Tanah Jarang dengan Metode Oksidasi-Presipitasi Selektif. *Eksplorium: Buletin Pusat Teknologi Bahan Galian Nuklir*, 38(2), 109-120. <https://10.17146/eksplorium.2017.38.2.3930>
- Setiady, D., Rahardiawan, R., Adam, Y., & Sunartono. (2008). *Kandungan unsur tanah jarang sedimen permukaan dasar laut*. Puslitbang Geologi Kelautan, Bandung. <https://doi.org/10.47599/bsdg.v4i1.173>
- Suharji, N., & Sumama. (2006). *Peningkatan kualitas estimasi cadangan uranium dan unsur tanah jarang sebagai asosiasinya di sektor rirang hulu, Kalimantan Barat*. PPGN-BATAN, Jakarta. ISSN : 0854 - 1418
- Suprpto, S. J. (2008). *Geokimia regional Sumatera: Contoh endapan sungai aktiffraksi -80 mesh*. Pusat Sumber Daya Geologi, Bandung. <https://doi.org/10.47599/bsdg.v3i3.169>
- Tain, Z., Suprpto, S. J., & Suhandi. (2003). *Pemantauan dan evaluasi konservasi sumber daya mineral di daerah Belang, Kabupaten Minahasa, Provinsi Sulawesi Utara*. Direktorat, Inventarisasi Sumber Daya Mineral, Bandung. <https://doi.org/10.47599/bsdg.v2i3.214>
- Widhiyatna, D., Pohan, M. P., & Putra, C. (2006). *Inventarisasi bahan galian pada wilayah bekas tambang, di daerah Belitung, Bangka Belitung*. Pusat Sumber Daya Geologi, Bandung. ISSN : 1693 - 162

