Characteristic study of SiO₂ content of quartz rock as a raw material for making silicon metal for solar cells

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Abstract Studies on the characterization of quartz rock have been carried out at three locations, namely on the shores of Lake Poso, the Poso River and the location of sand mines has been done using XRF and XRD methods. The results indicate that the SiO₂ mineral content obtained from the Poso Lake, Poso River and Poso sand mining locations are 99.4%, 99.34% and 99.30%, respectively. The XRD data showing that the Miller index value obtained in all three samples is [101] with a trigonal crystal structure (hexagonal axes).

1. Introduction
Quartz sand or also known as silica sand is a material that can be developed for the manufacture of solar panel materials. Quartz sand has a complex compound formed between SiO₂ silica crystals and impurities containing iron oxides, aluminum, titanium, calcium, magnesium and others [1]. Quartz sand contains impurities so the quality improvement process needs to be carried out to produce silica concentrations with a purity of 98-99% to achieve the minimum requirements for silicon purity standards [2]. On a large scale, silicon material resulting from the purification of quartz is very useful to supply the increasingly human needs in the energy field. The use of silicon as a raw material for making solar panels requires a high level of purity [3].

Silicon is very rarely found in pure form, silicon can be found in the form of silica compounds (SiO₂), so to produce pure silicon, high silica purity is needed. Silica that is used for raw materials for making solar panels must have a purity of 99.99% [1]. Quartz sand cannot be used as a raw material for pure silicon for the manufacture of solar panels with ordinary washing processes. This requires a breakthrough in the process of processing quartz sand into pure silica as a raw material for making silicon with high purity that reaches the standard.

The potential of quartz sand in the Pasir Putih village of South Pamona District is very abundant. Previous studies have carried out studies on the purification of quartz sand silica in Pamona Selatan District, Poso Regency using purification methods that produce 99.9% purity [4]. Besides the form of sand, silica potential in South Pamona District is also much in the form of rock. In this research, studies on the characteristics of quartz rock have been carried out at three locations, namely on the shores of Lake Poso, the banks of the Poso River and the location of sand mines.
2. Methods
Quartz rocks are obtained from three different locations, namely on the coast of Lake Poso, Poso River and the Sand Quartz Mine in Poso. After cleaning, the samples were mashed using ball milling. Characterization of SiO$_2$ content was carried out using the XRF and XRD methods. XRF characterization produces information about the types of elements contained and the amount of elemental concentration in each sample. While the XRD characterization in the form of peaks is the relationship between the angle and intensity of the X-ray. Then these peaks are matched using Search Match software to obtain the crystal structure in the purification of each sample and use JCPDS data to determine the crystal plane.

3. Results and discussion
The XRF measurement results for the three samples can be seen in Table 1.

| Analyze  | Analysis Unit | Poso Lake | Poso River | Poso Sand-mining Site |
|----------|---------------|-----------|------------|-----------------------|
| Al$_2$O$_3$ | %             | <0.01     | <0.01      | <0.01                 |
| BaO      | %             | <0.01     | <0.01      | <0.01                 |
| CaO      | %             | <0.01     | <0.01      | 0.01                  |
| Cr$_2$O$_3$ | %            | <0.01     | <0.01      | <0.01                 |
| Fe$_2$O$_3$ | %          | 0.58      | 0.55       | 0.56                  |
| K$_2$O   | %             | 0.01      | 0.01       | 0.01                  |
| MgO      | %             | 0.02      | <0.01      | 0.02                  |
| MnO      | %             | 0.01      | 0.02       | 0.01                  |
| Na$_2$O  | %             | <0.01     | <0.01      | <0.01                 |
| Ni       | %             | <0.01     | <0.01      | <0.01                 |
| P$_2$O$_5$ | %           | 0.01      | 0.01       | 0.01                  |
| SiO$_2$  | %             | 99.40     | 99.38      | 99.30                 |
| SO$_3$   | %             | <0.01     | 0.04       | <0.01                 |
| SrO      | %             | <0.01     | <0.01      | <0.01                 |
| TiO$_2$  | %             | <0.01     | 0.02       | 0.01                  |
| LOI      | %             | 0.00      | 0.00       | 0.03                  |
| Sum      | %             | 100.00    | 100.00     | 100.00                |

These results indicate that the SiO$_2$ mineral content obtained from the Poso Lake, Poso River and Poso Sand-mining Site are 99.4%, 99.34% and 99.30%, respectively. Silica content in quartz rock in the three locations in this study are similar as the results of the characterization of quartz sand before purification for samples obtained at the same location [5] and has a higher composition compared to the results of research on silica composition found in several other places in Indonesia [6]. The XRD characterization results for each sample are shown in figures 1 to figure 3.

Determination of the crystal structure of quartz rock is done through the process of matching data between the XRD results with the data bank using the Search Match software. The results obtained in the form of XRD peaks results to get the crystal structure, lattice constants, Miller index, 2θ (diffraction angle) and d-value (diffraction plane) shown in table 2.

The Search Match data matching results inform about the Miller index and the group space in the sample with SiO$_2$ content. The miller index value obtained in all three samples is [101] with a trigonal crystal structure (hexagonal axes) which make it possible to purify the rock to achieve pure Silicon for the solar panel.
**Figure 1.** The XRD characterization results for the sample from Poso Lake

**Figure 2.** The XRD characterization results for the sample from Poso River

**Figure 3.** The XRD characterization results for the sample from Poso Sand-mining Site
### Table 2. XRD peaks to get the crystal structure, lattice constants, Miller index, 2θ (diffraction angle) and d-value (diffraction plane)

| No. | Sample Name       | Crystal System (hexagonal axes) | 2θ [°] | d [Å] |
|-----|-------------------|---------------------------------|--------|-------|
| 1   | Poso Lake         | trigonal                        | 31.03  | 3.3467|
| 2   | Poso River        | trigonal                        | 31.01  | 3.3481|
| 3   | Poso Sand-Mining Site | trigonal                    | 31.03  | 3.3461|

### 4. Conclusion
Characterization of SiO₂ content was carried out using the XRF and XRD methods. XRF characterization produces information about the types of elements contained and the amount of elemental concentration in each sample which showing that the SiO₂ mineral content obtained from the Poso Lake, Poso River and Poso Sand Mining Site are 99.4%, 99.34% and 99.30%, respectively. While the XRD characterization in the form of peaks is the relationship between the angle and intensity of the X-ray. The XRD spectra resulting that the miller index value obtained in all three samples is [101] with a trigonal crystal structure (hexagonal axes) which make it possible to purify the rock to achieve pure silicon for the solar panel.

### Acknowledgement
We would like to thank the Directorate General of Higher Education who has provided research funding through DPRM Dikti with “Penelitian Strategi Nasional” scheme.

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