Regional Geochemical Map of West Java, Indonesia: Evaluation for Environmental and Mineral Resources

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Abstract. A The regional geochemical mapping project was conducted by the Centre for Geological Survey, Geological Agency, Ministry of Energy and Mineral Resources during 2011 to 2012 in Banten and West Java Provinces areas. Geological and topographic maps with scale of 1:100,000 as the base maps were used. Stream sediment samples were collected in this geochemical mapping project with the fraction size are 80# and the density of samples represent one sample for about 25 km². The project already successfully collected 1215 stream sediment samples covering twenty one base maps. The samples collecting was the result of collaboration between Geological Agency and universities. Moreover, the geochemical analysis was conducted with the XRF (X-Ray Fluorescence) method at the Geological Laboratory of Centre for Geological Survey. This method could analyze for 30 elements and show significant anomalies with presuming result from natural product or derived from human or urban activities. The volcanic products from quaternary volcanoes are clearly identified on distribution of As, Ba, Cl, Cu and Zr elements. Epithermal mineralization zone has an anomaly of distribution of Cu, Fe, Pb, and Zn. Meanwhile the human activities are showing from geochemical map of Cl, Cr, Cu, Hg, Pb and Zn that show scattered anomalies localized close to the cities, industries and mining area.

Keywords: Geochemical map; Stream Sediment; West Java

1. Introduction
Geochemical mapping project was done by Centre for Geological Survey, Geological Agency, Ministry of Energy and Mineral Resources in 2011 and 2012 for Banten and West Java Province respectively. The purpose of this project is to create an Indonesian geochemical database for mineral resources. The project successfully collected 1215 stream sediments, with the fraction of size were 80# and the density of sample represent 1 sample for 25 km². The samples were collected by collaboration field work between Geological Agency and universities (UNPAD, ITB, UGM, UPN Veteran and IST Akprind). The geological and topographic maps with scale of 1:100,000 were used for field work base maps. For the progress report purpose, the atlas of geochemical map of West Java region was published by [1].

The regional geochemical map of West Java is bounded by Longitude 105°00’E and 109°00’E; Latitude 5°50’ S and 8°00’S. Simplified geological features in this region consist of Quaternary and Tertiary- Sediments, Tertiary-, Mesozoic Plutonic, undifferentiated volcanic and plutonic rocks. Some
commodities of gold and base metal are widespread in this region following the low and high epithermal mineralization zone with specific deposit type of mineralization (Figure 1).

Figure 1. Metalogenic map of West Java (Modified from [2]).

2. Data and Method
The data used in this paper is the result of elemental geochemical analysis from the stream sediment sample of the West Java geochemical mapping project. The target of stream sediments sampling in this project was to collect 1 sample in the $5 \times 5$ km grid cell ($25\text{km}^2$). The advantage of using stream sediments is representing a composite of the drainage basin lithology, more efficient, effective and low cost [3].

The 80# stream sediment samples were dried and crushed by jaw crusher to obtaining particle size of $200\text{H}$. Polyvinyl alcohol and borate acid then were added to the powder and finally pressed by pellet machine. The X-Ray fluorescence instrument (XRF, ARL 9900 Thermo Scientific) belongs to Geological Laboratory of Centre for Geological Survey was used for geochemical analysis. About 30 elements could be determined, these elements are shown as follows: Ag, Al, As, Ba, Ca, Ce, Cl, Co, Cr, Cu, Fe, Hg, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, Sc, Si, Sr, Te, Ti, V, Zn and Zr. According to the large number of the samples (1215 samples), table of the geochemical result is not shown in this paper, only geochemical maps of some elements were displayed for further discussion.

The method for configure geochemical map used interpolated value by ArcGIS and Geosoft Oasis Montaj software. Krigging method on the ArcGis software was used for contouring elemental concentration. Class intervals with colour as cold (blue) to hot (red) trend displayed for increasing elemental concentration, while the frequency distribution diagram was analyzed using Geosoft Oasis Montaj software.

3. Result and Discussion
Regional geochemical maps are an important tool for exploration of mineral resources, and nowadays it is widely used for environmental issues [4]. The results of regional geochemical map of elements are shown in Figure 2 – Figure 13, arranged in alphabetical order. In this paper, only 12 elemental
geochemical maps are displayed. These elements were chosen for discussion according to any possible environmental problem and/or possibility for mineral resources in several places in West Java region. Areas with anomalous elements concentration and statistical analysis were described on the map.

The elements of Ba, Cu, Fe and La Cu (Figure 3, Figure 6, Figure 7 and Figure 9 respectively) show an anomaly pattern in the area of Bandung, Rangkasbitung, Bogor, and Cirebon. These elements show higher concentration in these areas and have a similar pattern to volcanic rocks complex (Figure 2). Clearly shown by the north west–southeast trend pattern of La element (Figure 9) which is may similar elongate to the volcanic belt of Java Island as described by [5].

The area of cities such as Jakarta, Bandung, Indramayu, and Rangkasbitung containing elevated concentrations of Ce, Cl and Pb (Figure 4, Figure 5 and Figure 12, respectively). These three elements and heavy metal are known as hazardous toxic elements which usually come from industrial and urban pollutions [6]. The anomalies pattern of these elements may reflect as an anthropogenic matter come from these cities. Heavy metal pollution has also reported in the bay of Jakarta which has an effect on the death of fish [7]. Another anthropogenic element such as As–arsenic (Figure 2), distributed scatteredly and shows a rather high concentrations in volcanoes area (Tangkuban Perahu Volcano–Bandung), field rice area and cities (Indramayu, Purwakarta Rangkasbitung and Jakarta).

These are examples of geochemical map of elements that can be interpreted with the most important being bedrock geology, the presence of mineral deposits (as a natural feature) or associated with anthropogenic pollution. Sukabumi-Bogor district is a gold mineralized area and surprisingly high anomaly of mercury (Hg) as shows in Figure 8. This element is a one of anthropogenic element used for leaching the gold from bed rocks by the local miner as reported by [8].

![Figure 2. Geochemical Map for As (arsenic)](image2)

![Figure 3. Geochemical Map for Ba (barium)](image3)

![Figure 4. Geochemical Map for Ce (cerium)](image4)

![Figure 5. Geochemical Map for Cl (Clorin)](image5)
Figure 6. Geochemical Map for Cu (copper)

Figure 7. Geochemical Map for Fe (iron)

Figure 8. Geochemical Map for Hg (mercury)

Figure 9. Geochemical Map for La (lantanum)

Figure 10. Geochemical Map for Mo (molibdenum)

Figure 11. Geochemical Map for Ni (nickel)
Other patterns have no obvious explanation; for example, the concentration of Mo-molybdenum and Zr-zirconium (Figure 13 and Figure 17 respectively). These elements have anomaly pattern at the south of Sukabumi. These patterns may be caused by the existence of Mesozoic plutonic rocks with the more acid composition. Contrast with the pattern of element associated with mafic volcanic such as Ni-nickel (Figure 14), which is located in the eastern part of West Java region. Striking differences of Zr and Ni patterns between the western part and eastern part of the map may correspond to the associated bed rocks and the fault system.

4. Conclusions
As a conclusion, the regional geochemical map of West Java shows an indication of significant elements anomalies. The natural products of volcanic are clearly identified by distribution of As, Ba and La. Oldest rocks from Mesozoic may reflect by Mo and Zr pattern. Meanwhile the influences of human activities were showed from Hg, Cl, Cu, and Pb pattern that scattered locally anomalies close to the city, farming, and industry areas. For further application, these maps may help the stakeholders for locating resources, identifying pollution, and giving opinion on contaminate sites.

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