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STUDY OF LAYERED STRUCTURE ON CONTACT BOUNDARY AREA OF FORMATION PANASOGAN-WATURANDA BY APPLYING GROUND PENETRATING RADAR METHOD

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ABSTRACT

Study on Ground-penetrating radar (GPR) data from a common-offset profiling measurement carried out in the contact area between Panosogan and Waturanda Formations in Karangsambung, Kebumen – Central of Java is done. GPR RAMAC system is utilized. The aim of the study is to recognize and eliminate surface-scattering noise and ring-down effects, to image subsurface layered structure and to identify a contact area between Panosogan and Waturanda Formations. The processed data were analyzed with the help of instantaneous attributes and the so-called joint time frequency (JTFA) analysis. Study results show that some diffraction patterns appeared in radargram are resulting from scattering of surface-objects. These can be eliminated with f-k filtering and migration. Ring-down effect resulted from impedance mismatch between subsurface electrical properties and those of antenna is difficult to eliminate. However, it can be well recognized and analyzed in the JTF representation. Instantaneous attributes and JTF analysis are proved to be useful tools in imaging the contact area and subsurface layered structures.

Keywords: GPR, Antenna frequency, Noise, Geology formation, Geology structure, Instantaneous attributes, JTF Analysis, Data processing.

Contribution/ Originality

The new procedure in data processing to eliminate ring down and noise. A GPR data Processing useful in imaging contact area and subsurface should be designed by using JTF analysis

1. INTRODUCTION

Ground Penetrating Radar (GPR) is one of geophysics methods using electromagnetic waves with non-destructive and high resolution benefits. Propagation of radar wave on medium is shown by attenuation and velocity where both are influenced by dielectric and conductive of

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material. Application of GPR is for mineral exploration, groundwater exploration, geological inspection, geotechnics and archeological issue. Special implementation is for base rock depth, joint on rock, subsurface situation mapping like pipe and tunnel, including structural stratigraphical mapping [1].

In this paper, GPR method is applied for showing lateral or vertical profile of layered structure at contact boundary area in the formation Panasogan-Waturanda nearby Bendung Kali Gending, whereabouts outcrop data on that areas, generally seemed there were lithology changes from clay-sandstone (Panasogan Formation) becoming Breccia-Sandstone(Waturanda Formation). The primary data acquisition process found antenna ('ring down') and noise caused as electromagnectic wave scattering from object on surface.('surface scattering') This issue is part of this paper to be eliminated.

2. METHODS

The area of study is KarangSambung located in Kebumen, Central of Java. Geographically, Kebumen is on 109^0 30' – 110^0 00' EL dan 7^0 30' – 8^0 00' SL. At north was bordered with Yogyakarta, south with Hindia ocean, west with Banyumas. (Figure 1)

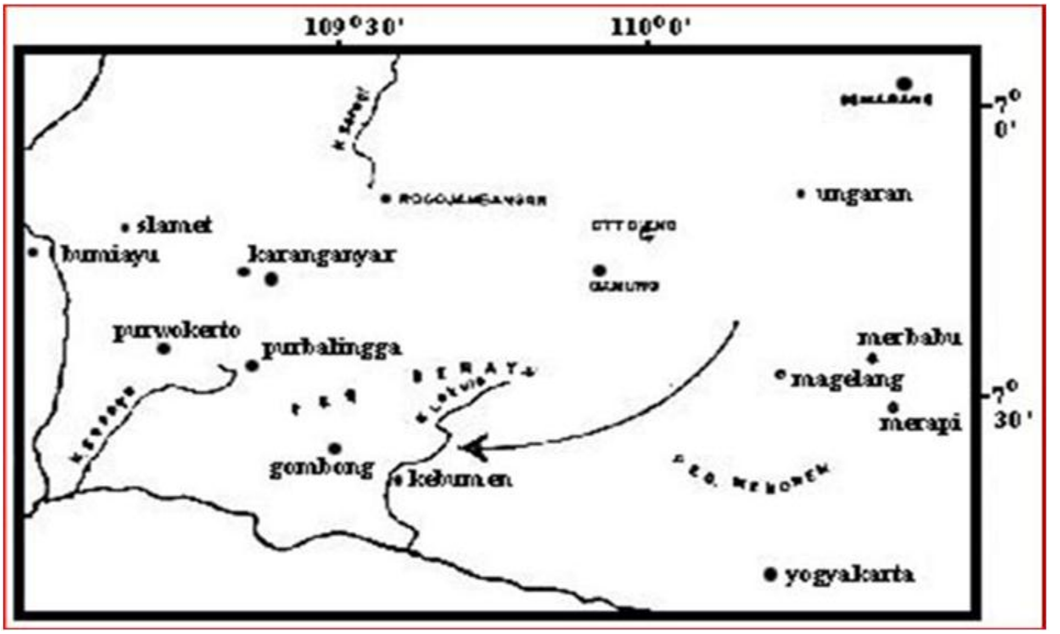


Figure-1. Study Area Location (Location is indicated by arrow)
(**Source:** Geologic Map of Kebumen Quadrangle Java, 1992) [2]

Geomorphologically, this area has four morphology units, namely Unit of wavy hills, disordered hills, conical volcano valley, and plateau.

Based on stratigraphical and geological structure this area is well-known as complex geology order, where stratigraphy periods are hard to be determined, they didn't follow continuity and superposition rules. Generally, Different Rock units were separated by faults and joints which the size can't be predicted.

The geology of Study area was shown in Figure 2. There were Waturanda formation, Panasogan Formation, and alluvium deposit.

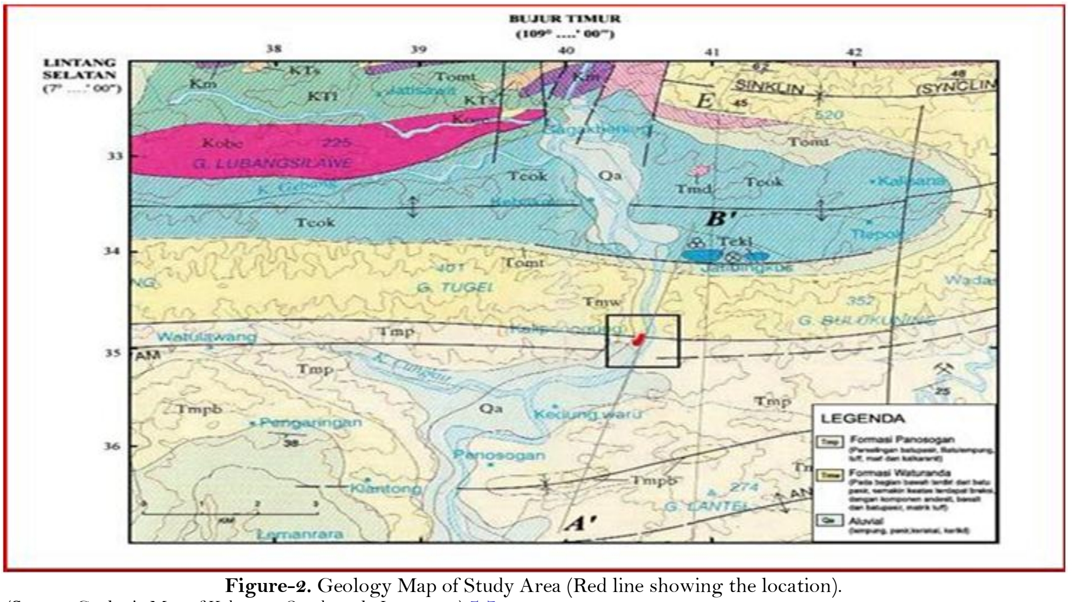


Figure-2. Geology Map of Study Area (Red line showing the location).
(**Source:** Geologic Map of Kebumen Quadrangle Java, 1992) [2]

Contact boundary of Panasogan-Waturanda formation is illustrated in figure 3.

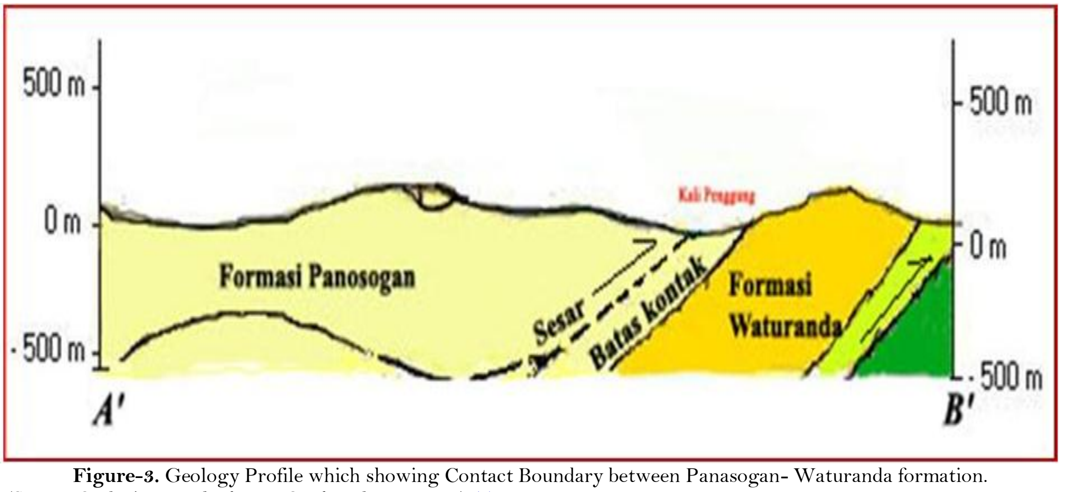


Figure-3. Geology Profile which showing Contact Boundary between Panasogan- Waturanda formation.
(**Source:** Geologic Map of Kebumen Quadrangle Java, 1992) [2]

The data acquisition is done horizontally on the area around contact boundary of Panasogan-waturanda formation, Bendung Kali Gending, Karang sambung, Sadang Subdistrict, Kebumen, Central Java with 100 m line. How the inspection was conducted will be explained is below:

2.1. Geology Observation

Geology Data acquisition was observed on layer which showed off at Penggung Bank on A-B profile (Figure 4). Outcrops that were seen are : Clay-Sandstone bedding and volcanic breccias components, clay-sandstone bedding has strike/ apparent dip N100^0 E/40 SW, meanwhile outcrop in volcanic-breccia components was determined as small chunks because the layer around it has been eroded. Another breccia's outcrop was showed off on the rock underneath Bendung Kali Gending Board at the end of A-B profile.

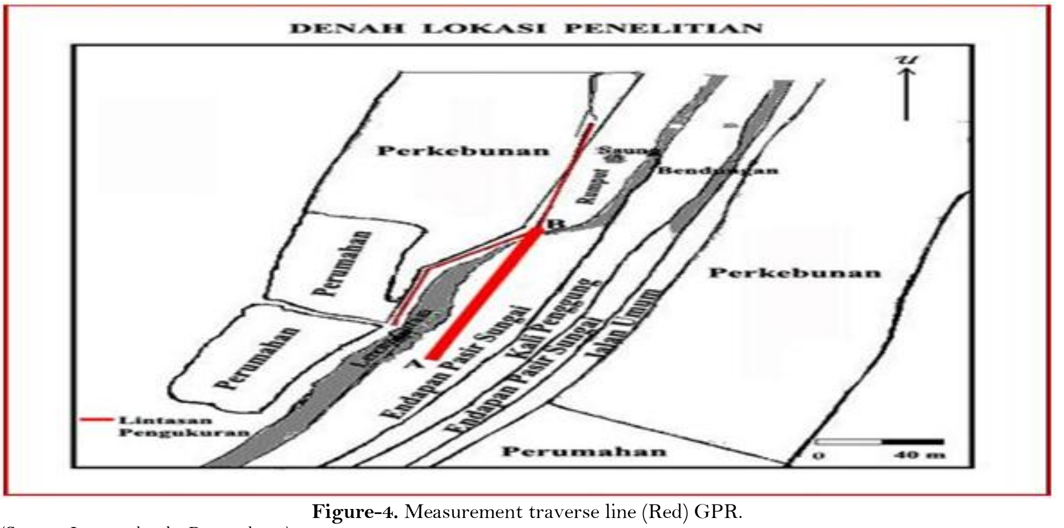


Figure-4. Measurement traverse line (Red) GPR.

(**Source:** Layouts by the Researchers)

2.2. GPR Measurement

Tools used in measurements are GPR/RAMAC, GPS, Geology compass, roll meter. Measurement profile was a line from A to B with general direction N10^0 E with 100 m distance. Measurement traverse line is shown in Figure 4.

GPR measurements on this study area use Reflection profiling configuration where mid frequency used is 100 MHz and 50 MHz. Application of different Mid antenna frequency in this measurement can hopefully produce best resolution in different depth [3].

Parameters considered in the acquitition process were shown in the able below:

Table-l2.1. Parameters of Data Acquisition

Parameters	Frequency 100 MHz	Frequency 50 MHz
Time windows (ns)	230	230
Station spacing (m)	0.2	0.2
Antenna separation (m)	1	2
Sampling interval (ns)	0.48	0.96
Sampling number	483	240
Antenna orientation	PR-BD	PR-BD

(**Source:** Parameters by the Researchers)

2.3. Data Processing

Data processing of GPR using PC ReflexW 3.0 software aimed of reconstructing image by eliminating noise and gain signal to noise ratio, so the interpretation of subsurface condition can be visualized well [4].

The stages of data processing are:

Raw data ----- Editing+Gain ---Dewow----DC-Shift---Move start time ---- Static Correction---Spike deconvolution------Bandpass Butterworth --- Background Removal ----f-k Filter-----Migration---- Atributte ------Time-Frequency Analysis.

3. RESULTS

3.1. Profile Interpretation

Profile which had been filtered dewow and dc-shift (fig 5) observed there was hyperbolical diffraction pattern (at 80 ns), where those diffraction patterns are overlayed on velocity curve and the velocity from diffraction is 0.3 m/ns. Therefore, it can be interpreted that the cause of the diffraction is the object on surface. We suspected the source is object/metal inside the wall nearby the survey location.

Instead hyperbolical diffraction, it seemed that there was a phenomenon of ring down. This phenomenon was captured on radargram. Ring down was a phenomenon caused by incorrect impedance effect between antenna (transmitter and receiver) and ground. This feature disturbed while we're interpretating, the appearance is similar with reflector. Ring down can be recognized by its characteristics relatively straight and uninterrupted by reflection or diffraction [5].

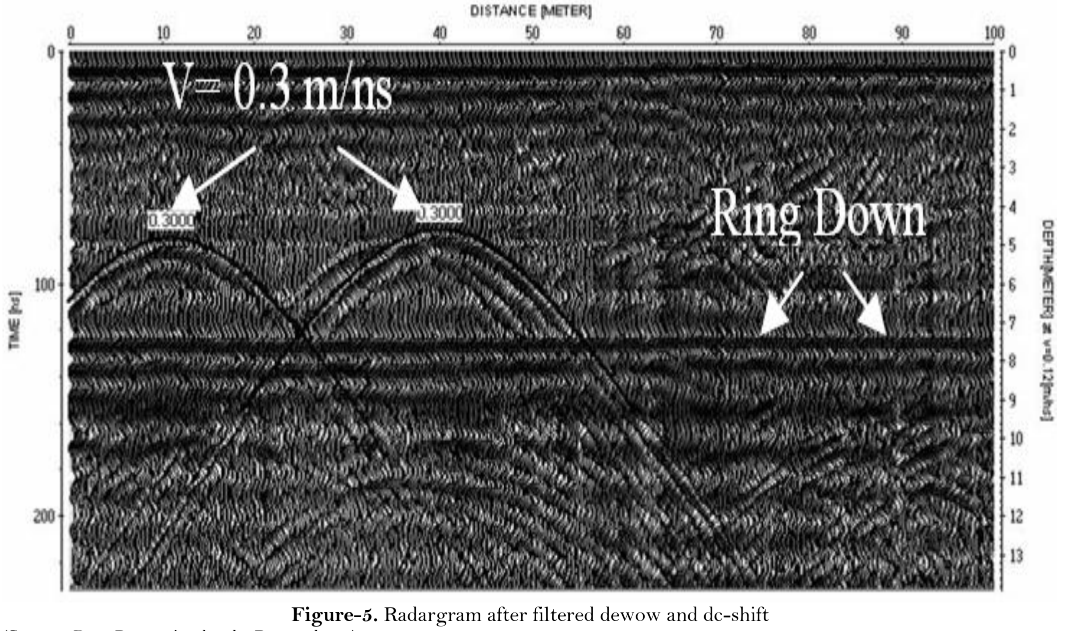


Figure-5. Radargram after filtered dewow and dc-shift

(**Source:** Data Processing by the Researchers)

After 100 MHz profile was processed till migration stage (Figure 6), during 0 till 10 ns it seemed there were patterns almost similar with diffraction pattern but can be eliminated, moreover those patterns didn't have any meaning to be interpretated. Upper limit of sand river deposit was estimated on 10 ns, thus recognized by continuity of reflector which relatively high and there was a another reflector crossover.

Meeting point of crossed reflector was suspected as limit of river and road surface. Estimation of river deposit was supported by outcrop which is the mixture of sand river deposit with clay, cobble, pebble, and another composites which were the sediment by river, where this deposit was a deposit beneath measuring antenna. Bottom limit from this deposit estimated on 42 ns, was a uncomformity between sloped reflectors on the left side and straight reflectors on the right side. Sloped reflectors placed at 40 metres from A were reflectors on Panasogan Formation. Those sloped reflectors are alternation of sandstone-clay with slope 40^0. After those distance, Slope reflectors and straight reflectors were estimated as reflectors owned by Waturanda Formation. This was caused on 70 metres distance from A, there was a breccias outcrop, as part of Waturanda. From data above, we can approximate estimate contact boundary area. Those data showed between 40-70 metres from A, exact position from boundary can be determined for sure. There was no correlation between core drilling data with GPR, so the determination was by interpolation from outcrop position between those formations [6].

On those reflectors which were suspected as part of Waturanda formation contained facies shifting whereabouts limited between straight and slope reflectors. It indicated as sandstone and breccias, this was signed by high relative continuity and based on literatures in that the area had domination of sandstone lithology and normal fault.

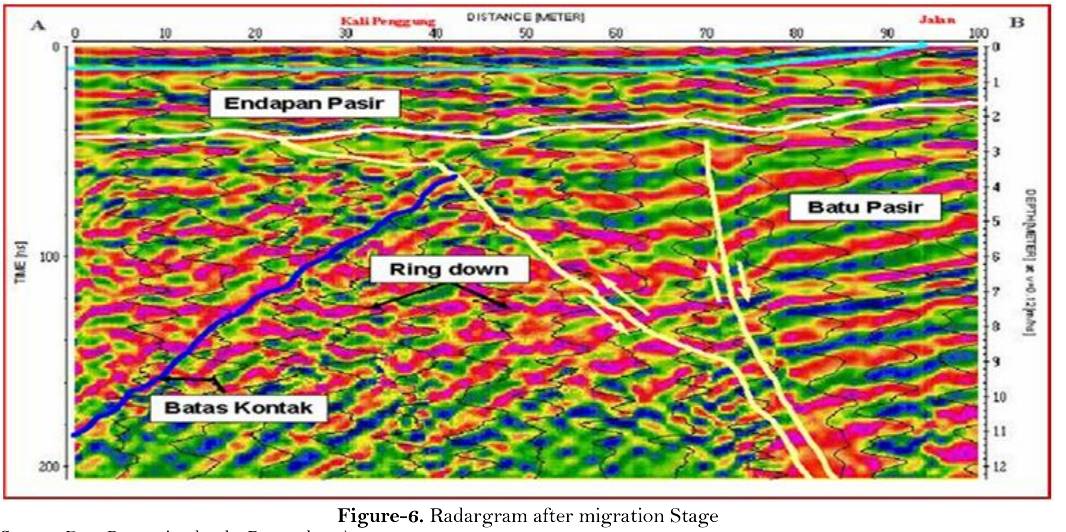


Figure-6. Radargram after migration Stage
(**Source:** Data Processing by the Researchers)

Strong reflection profile (Fig 7) describes magnitudes from square root total energy at a moment. The value is always positive on strong reflection display. On this profile high relative energy domination was displaying red color. Generally these straight reflectors had high and massive continuity. It showed that generally lithology on that reflector was relatively the same as sediment environment. Meanwhile on sloped reflectors, it seemed not massive instead alternated its reflection. It showed there was lithology made periodically like alternated bedding. At the 125 ns was observed ring down which was relatively straight and continuable on that time with small contrast around it. In the simple way, horizontal lining with structure boundary was almost similar with trace riil.

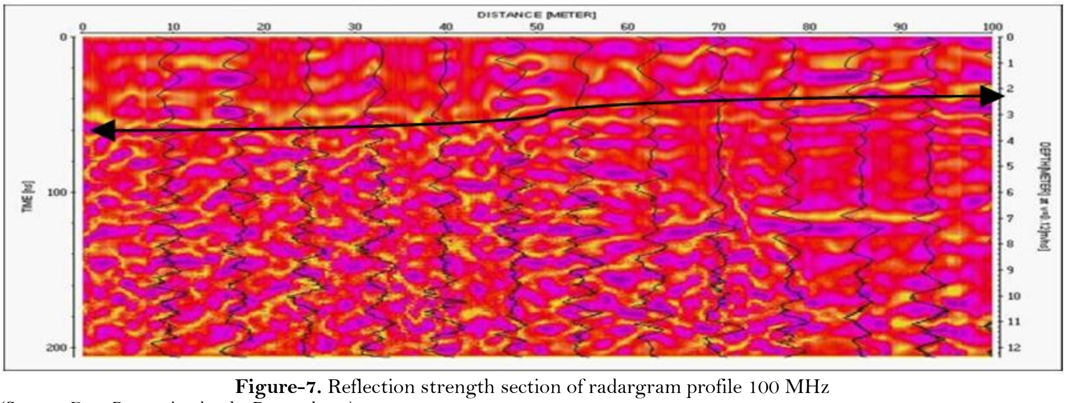


Figure-7. Reflection strength section of radargram profile 100 MHz
(**Source:** Data Processing by the Researchers)

At the moment phase section (Figure 8), describes the size of the layer continuity, because the phase is the angle between the real trace and imaginary trace, then the values range from -1800 to 1800. The display of instantaneous phase tends to strengthen the weak coherent and does not rely on the reflection strength, so that the instantaneous phase display can see the weak reflectors which cannot be seen on radargram. In addition, the appearance of the ring down at time 125 ns is clearly visible that the differences are very contrast with the reflectors surrounding. From these 2 attributes used, instantaneous phase shows the reflector's continuity is better than the reflection strength.

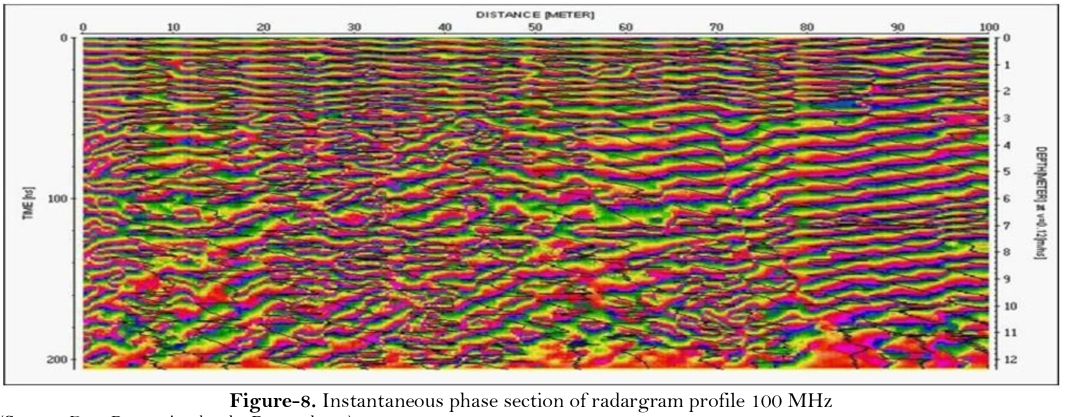
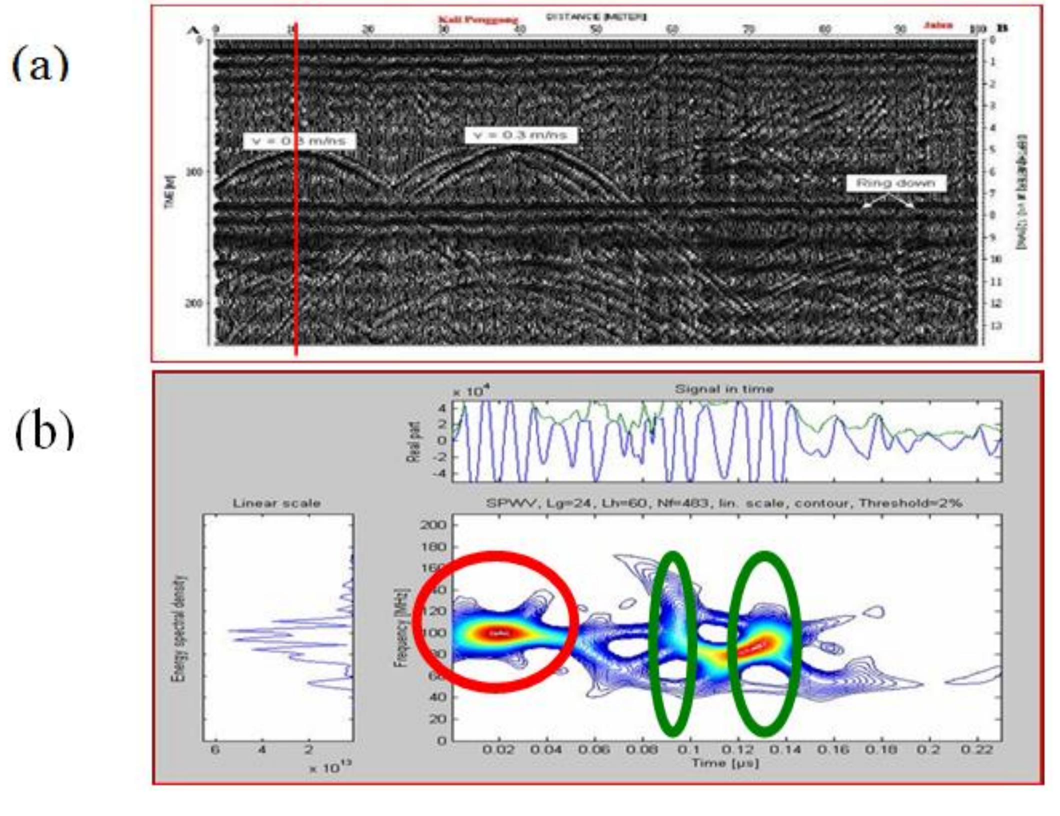


Figure-8. Instantaneous phase section of radargram profile 100 MHz
(**Source:** Data Processing by the Researchers)

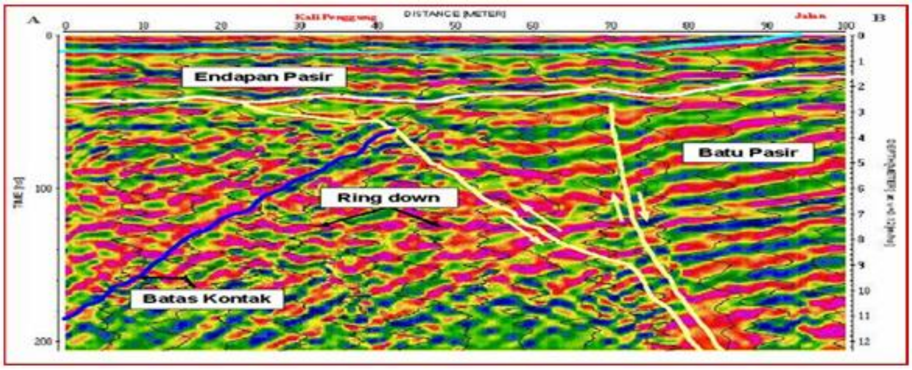
3.2. Time-Frequency Analysis

For the time-frequency analysis, we use Smoothed Pseudo Wigner Ville (SPWV) distribution, where the fills are the amplitude owned by a trace, so the method is similar to cut vertically from a trace to see how the frequency content is over time. The trace taken is the trace from conventional radargram, not from attribute section [7].

In SPWV representation of the trace analyzed, we can observe the frequency content of the signal emitted by the transmitter. At the time of 0-40 ns, the effect of pulse emitted by transmitter is still strong when the electromagnetic wave spreads into the subsurface where the frequency content is relatively still in the range of 60 – 120 MHz. Moreover we can observe the frequency content of the phenomenon of diffraction and ring down, from some selected trace in radargram after dewow and dc-shift, in which the frequency content of diffraction can be seen in the time of 80 ns and has a frequency content of 60-160 MHz. Ring down phenomenon is also observed at 125-140 ns and has frequency content 60-120 MHz while the signal emitted by the transmitter has the range in the same bandwidth in other words frequency content of diffraction and ring down is similar with the signal. For the trace that has been processed to migration phase, representation of frequency content is visible from 0 to 50 ns, while above the time 50 ns is not visible. It is caused by the amplitude of the signal which is very small, so it will not be displayed by the software. Details can be seen in Figure 9.



(c)



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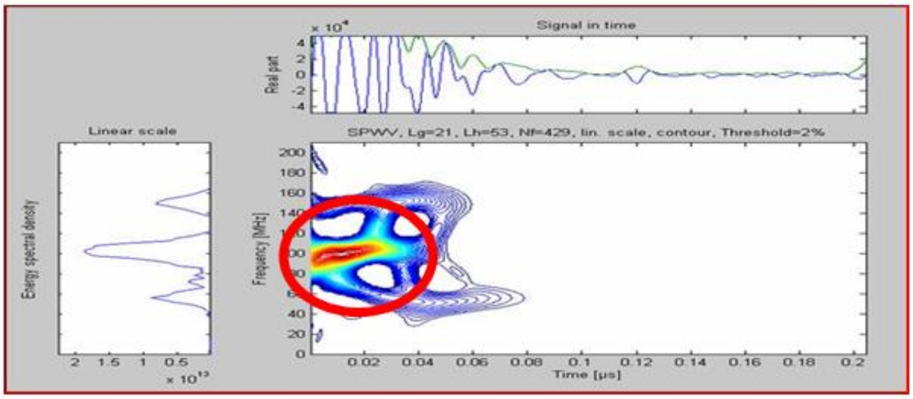

Figure-9. Time-Frequency representation using SPWV distributed on trace 35 profile 100 MHz

(a) The trace position analyzed on radargram after being filtered by dewow and dc-shift
(b) Representation SPWV from trace 35 on radargram a
(c) The trace position analyzed on radargram after migration state
(d) Representation SPWV from trace 35 on radargram c

(**Source:** Data Processing by the Researchers)

4. CONCLUSION

From this study we can conclude that the hyperbole diffraction pattern due to scattering of electromagnetic waves emitted from the cliff on the edge of Penggung river can be identified by matching the velocity curve with v = 0.3 m/ns, and can be eliminated by doing f-k filter and migration process. As for the pattern Ring - down due to the impedance mismatch between the GPR antenna and ground, it is difficult to be eliminated during data processing. So a method called Joint Time – frequency Energy Analysis can be used to see the frequency content from diffraction and ring down. Radargram interpretation is at depths up to 12 meters where deposit of sand, sandstone, fault and the contact border of Panosogan formation – Waturanda.

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