

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 from June 8 – 10, 2003 in the contact area between Panasogan and Waturanda Formations in Karangsambung, Kebumen – East Java is done. GPR RAMAC system with 50 and 100 MHz antennae 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 contact area between Panasogan and Waturanda Formations. The processed data were analyzed with the help of instantaneous attributes and the so-called joint time frequency (JTFA) analysis. Study result shows 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 with 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.

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Keywords: GPR, Antenna frequency, Noise, Geology formation, Instantaneous attributes.

1. Introduction

Ground Penetrating Radar (GPR) as one of geophysics methods which using electromagnetic wave with non-destructive and high resolution benefits. Propagation of radar wave on medium showed by attenuation and velocity where both are influenced by dielectric and conductive of material. Application of GPR such as 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, included structural and stratigraphical mapping (Annan and Davis, 1989).

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

The scientific contribution of this paper is the new procedure in data processing to eliminated ring down and noise. A GPR data Processing to be useful in imaging contact area and subsurface should be designed using JTF analysis.

2. Methods

Area of study is in Karang Sambung located in Kebumen, Central of Java. Geographically, Kebumen position on 109° 30' – 110° 00' EL dan 7° 30' – 8° 00' SL. At north was bordered with Yogyakarta, south with Hindia ocean, west with Banyumas. (Figure 1)

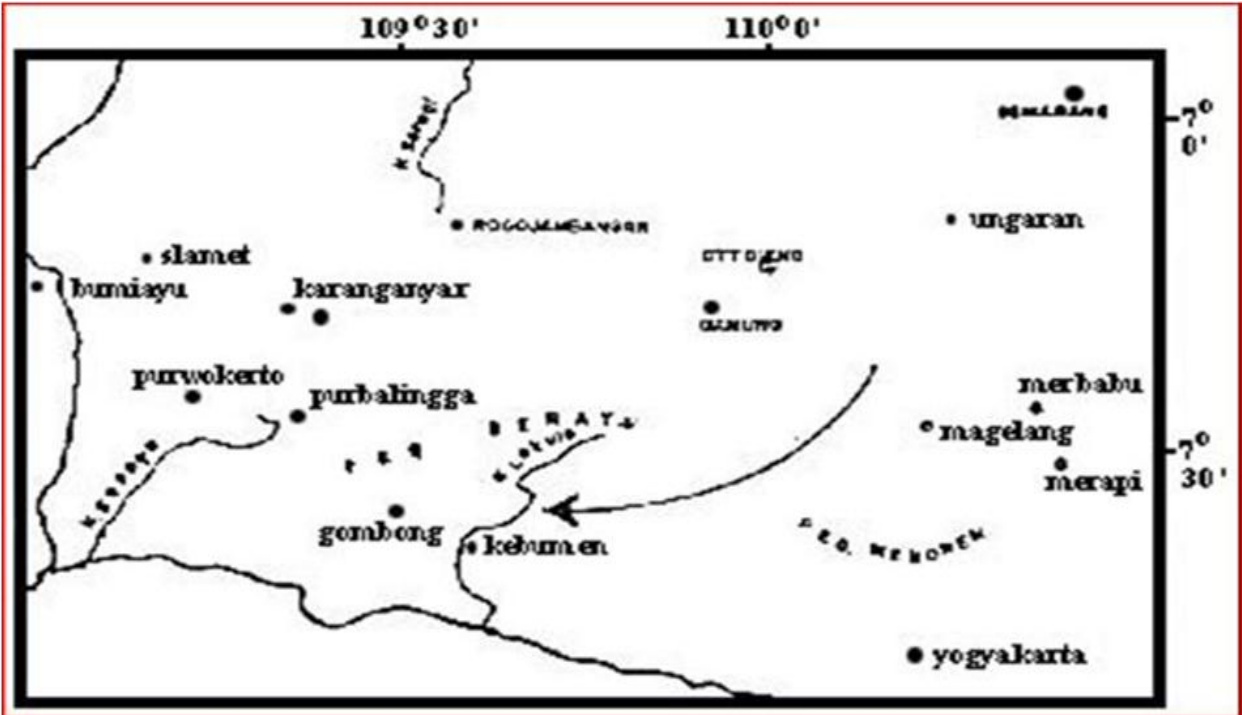


Figure-1. Study Area Location (Location is indicated by arrow)

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

Based on stratigraphy and geology 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.

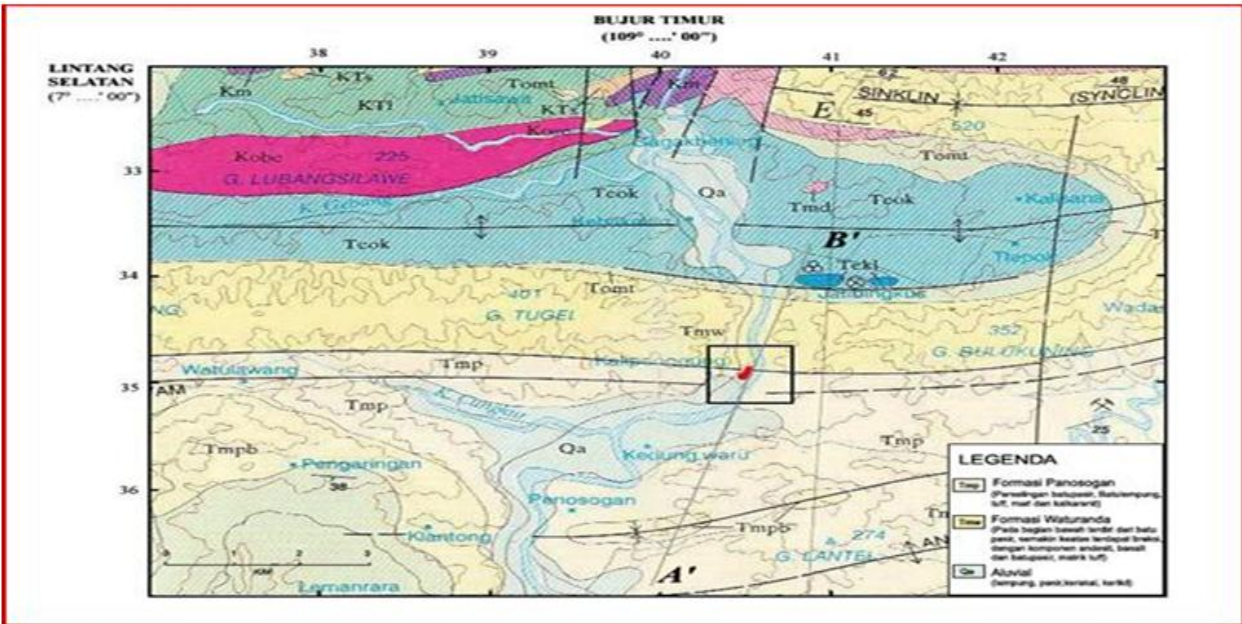


Figure-2. Geology Map of Study Area (Red line showing the location).

In the other hand to show contact boundary Panasogan-Waturanda formation can illustrated in figure 3.

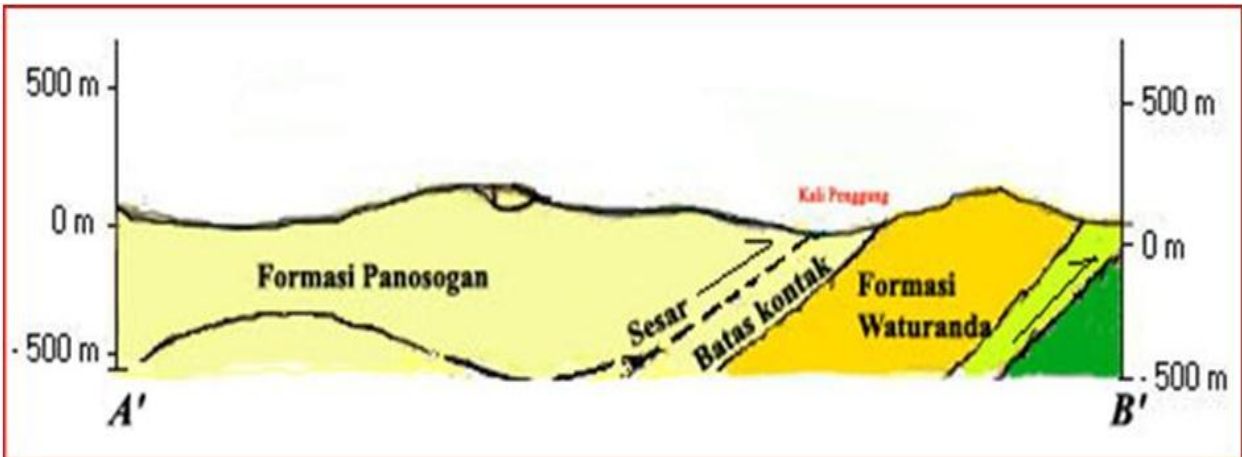


Figure-3. Geology Profile which showing Contact Boundary between Panasogan- Waturanda formation. (Source: Kebumen Geology Map, Java, 1992)

The data acquisition is done horizontally on area around contact boundary 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 as 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° E/40 SW, meanwhile outcrop in volcanic-breccia components determined as small chunks because layer around it has been eroded. Another breccia's outcrop was showed off on rock underneath Bendung Kali Gending Board at the end of A-B profile.

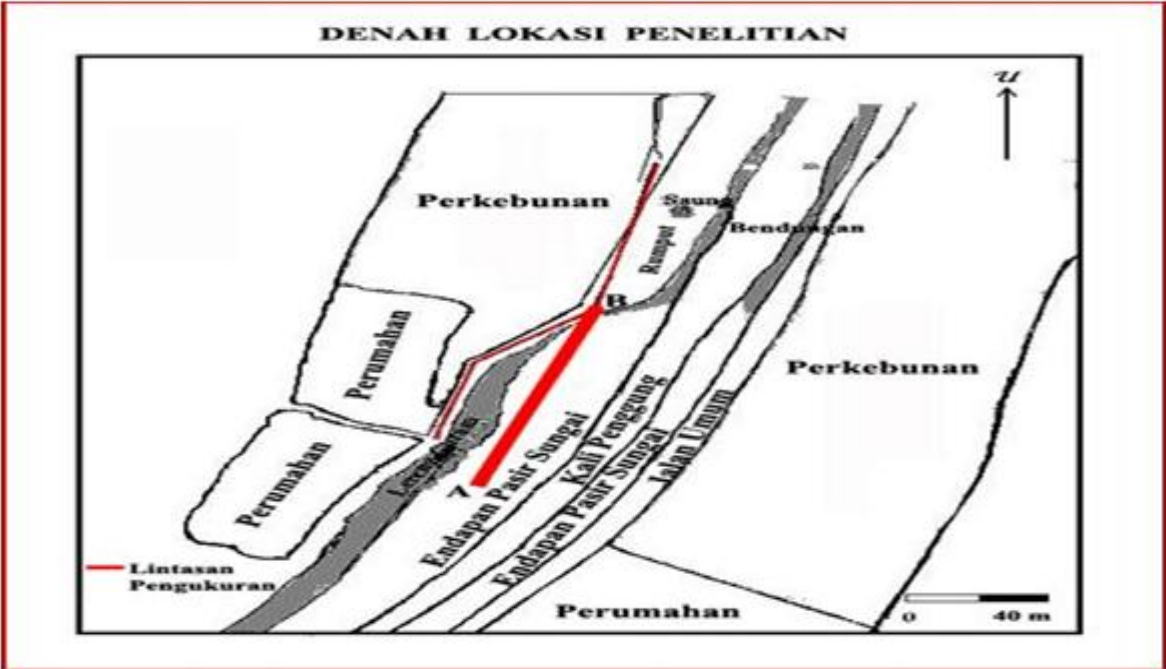


Figure-4. Measurement traverse line (Red) GPR.

2.2. GPR Measurement

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

GPR measurements on this study area using Reflection profiling configuration where mid frequency used is 100 MHz and 50 MHz. Application of different Mid antenna frequency in this measurement is hope can produce best resolution in different depth (Budiyo, 2001).

Parameters are considered in the acquisition process were shown in table below:

Table-I2.1. 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

2.3. Data Processing

Data processing of GPR used PC ReflexW 3.0 software, aimed to reconstruct image by eliminating noise and gain signal to noise ratio, so the interpretation of subsurface condition can be visualized well (Sandmeier, 1998).

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 found that velocity from diffraction is 0.3 m/ns. Therefore, can be interpreted that cause of the diffraction is object on surface. We suspected the source is object/metal inside the wall nearby survey location.

Instead hyperbolic diffraction, seemed there was a phenomenon 'ring down', this phenomenon was captured on radargram, Ring down was a phenomenon caused as incorrect impedance effect between antenna (transmitter and receiver) and 'ground'. This feature disturbed while we're interpreting, the appearance is similar with reflector. Ring down can be recognized by its characteristics which relatively straight and uninterrupted by reflection or diffraction (Mary *et al.*, 1999).

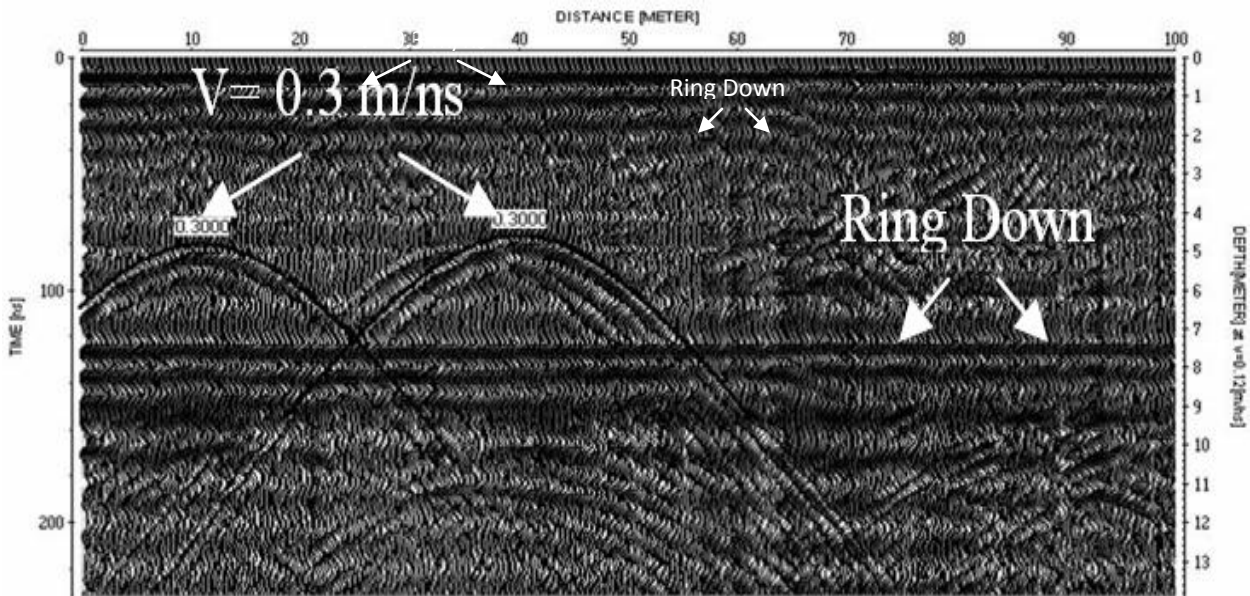


Figure-5. Radargram after filtered dewow and dc-shift

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

Meeting point of crossed reflector was suspected as limit of river and road surface. Estimation of river deposit was supported by outcrop which mixture of sand river deposit with clay, cobble, pebble, and another composites which was sediment by river, where this deposit was a deposit beneath measuring antenna. Bottom limit from this deposit estimated on 42 ns, was a unconformity between sloped reflectors on left side and straight reflectors on right side. Sloped reflectors that placed at 40 metres from A, were reflectors on Panasogan Formation. Suspected those sloped reflectors are alternation of sandstone-clay with slope 40° . After those distance, Slope reflectors and straight reflectors was 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, approximately we can estimate contact boundary area. Those data showed between 40-70 metres from A, exact position from boundary can be determined with sure. It was no correlation between core drilling data with GPR, so the determination was by interpolation from outcrop position between those formations (Fisher *et al.*, 1994).

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

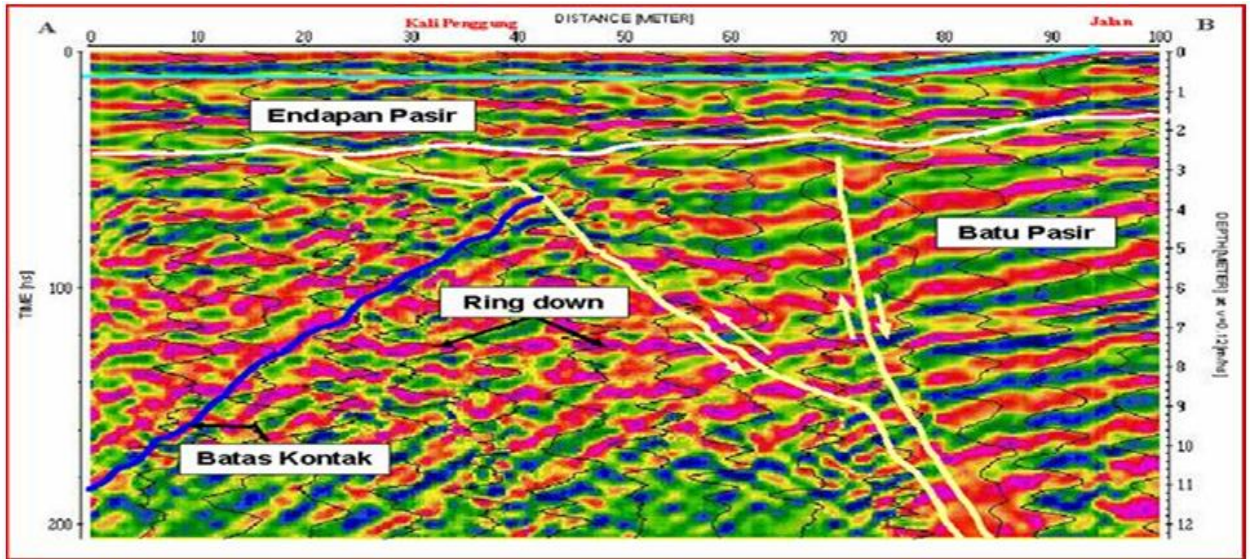


Figure-6. Radargram after migration Stage

At 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 seemed that high relative energy domination was displayed red color. Generally for these straight reflectors had high and massive continuity. It signed that generally lithology on that reflector relative same with sediment environment. Meanwhile on sloped reflectors, 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 relatively straight and continuable on that time with small contrast around it. In simple way, horizontal lining with structure boundary almost similar with trace riil.

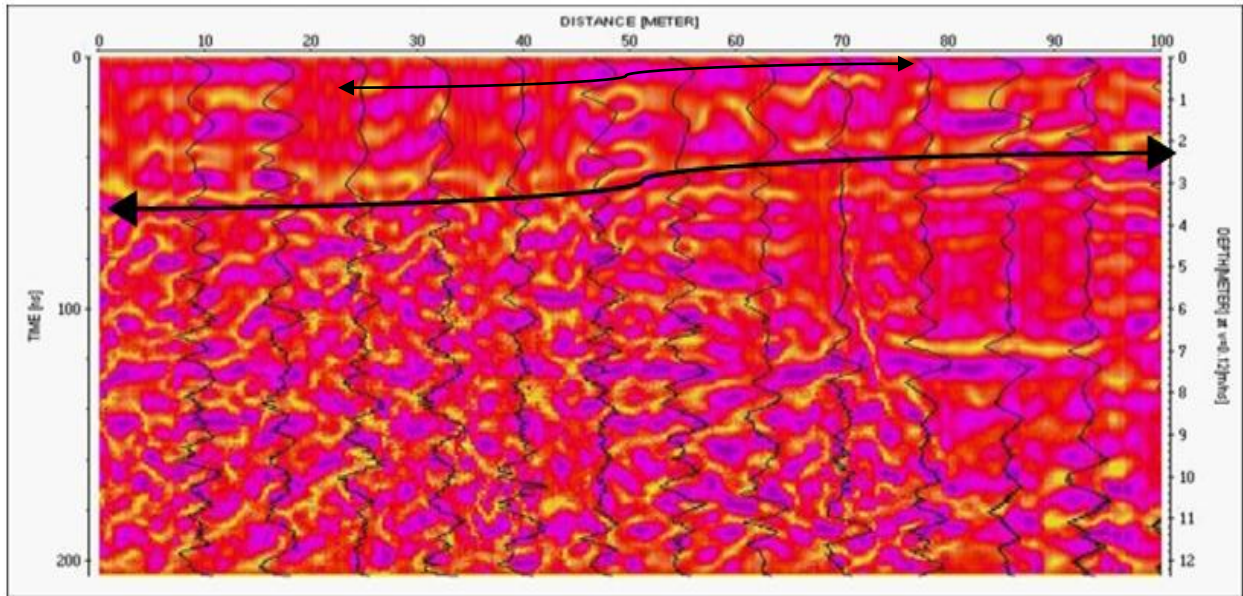


Figure-7. Reflection strength section of radargram profile 100 MHz

At the moment phase section (figure 8), describing the size of the layer continuity, because phase is the angle between the real trace and imaginary trace, then the value range from -1800 to 1800. The display of instantaneous phase tend to strengthen the weak coherent and 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, clearly visible that the differences is very contrast with the reflectors surround it. From these 2 attributes used, instantaneous phase shows the reflector's continuity better than the reflection strength.

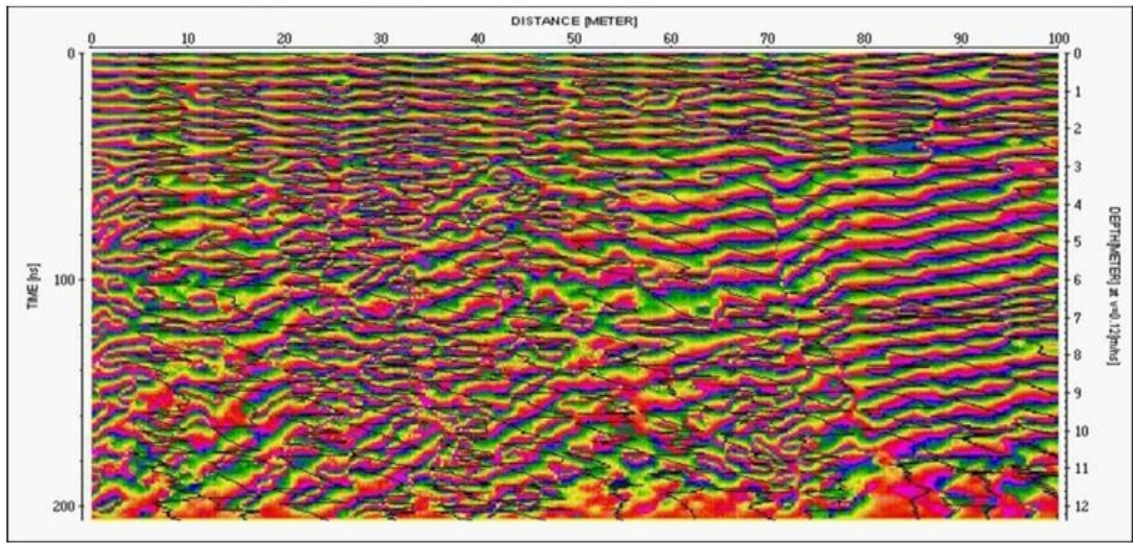


Figure-8. Instantaneous phase section of radargram profile 100 MHz

3.2. Time-Frequency Analysis

For the time-frequency analysis, we use Smoothed Pseudo Wigner Ville (SPWV) distribution, which the fills is the amplitude own by a trace, so the method is similar to cut vertically from a trace to see how the frequency content over time. The trace taken is the trace from conventional radargram, not from attribute section (Sun and Young, 1995).

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 spread into the subsurface where the frequency content is relatively still in 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 also observed at 125-140 ns and has frequency content 60-120 MHz while the signal emitted by the transmitter has range in the same bandwidth, I 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 visible from 0 to 50 ns, while above the time 50 ns is not visible. It is caused by the amplitude of the signal is very small, so it will not be displayed by the software. Detail can be seen in Figure 9.

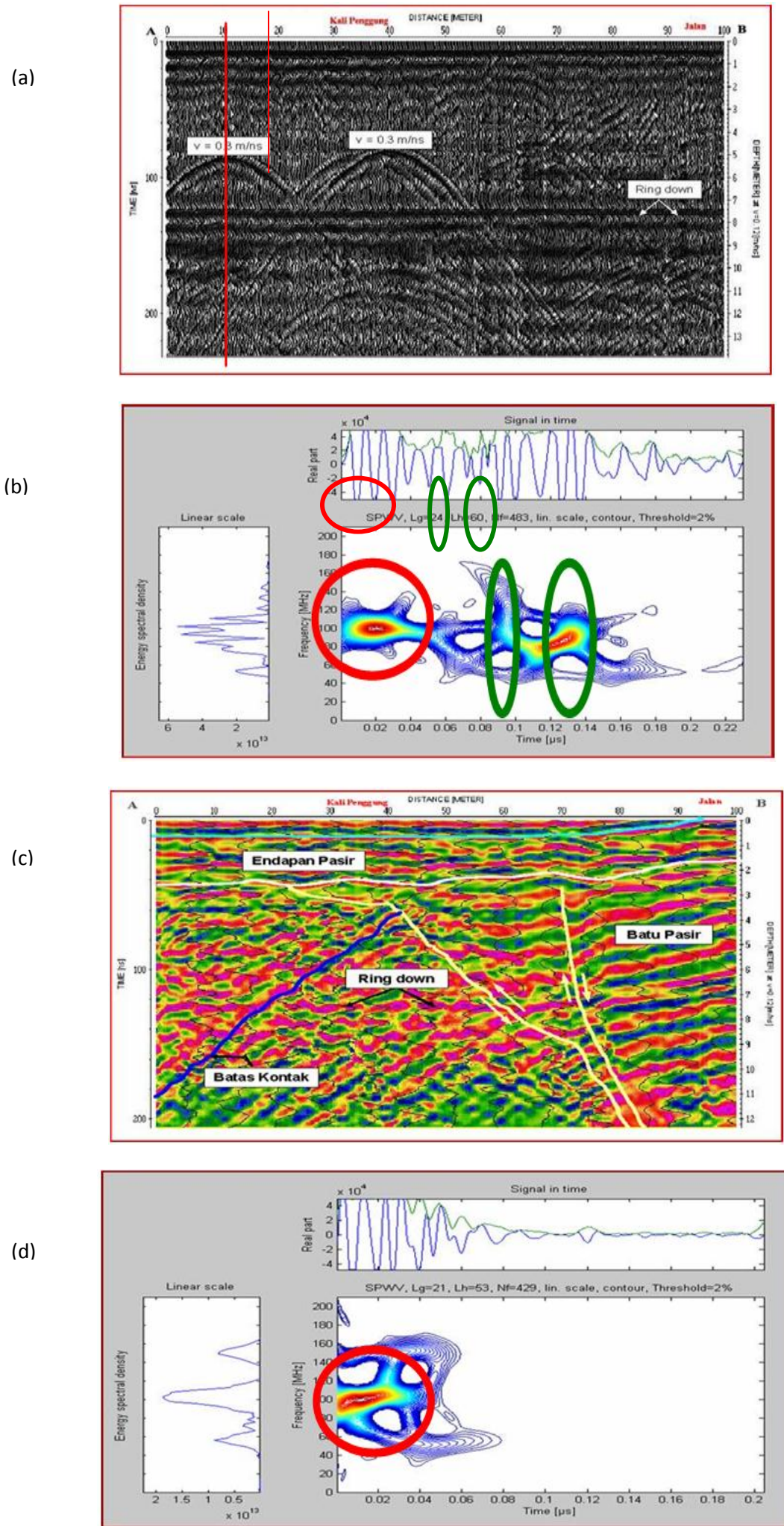


Figure-9. Time-Frequency representation using SPWV distributed on trace 35 profile 100 MHz
(a) The trace position that analyzed on radargram after being filtered by dewow and dc-shift
(b) Representation SPWV from trace 35 on radargram a
(c) The trace position that analyzed on radargram after migration state
(d) Representation SPWV from trace 35 on radargram c

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 ring down pattern due to 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 at depths up to 12 meters where deposit of sand, sandstone, fault and the contact border of Panosogan formation – Waturanda.

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