Factors in Determining the Survey Depth from Passive Surface Waves

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Outline

- Overview
- Simulation of Passive Surface Waves
- Factors Affecting Depth of Investigation
- Field Data Example
- Conclusion

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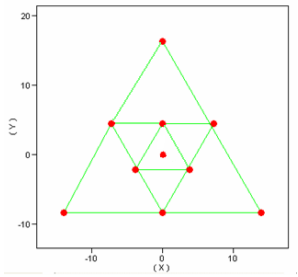
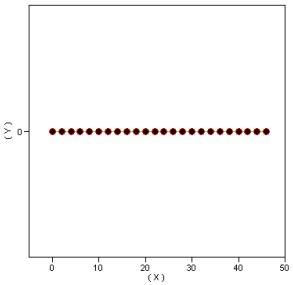
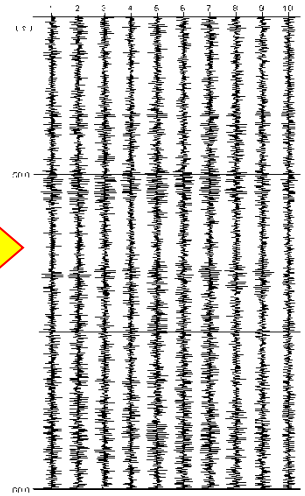
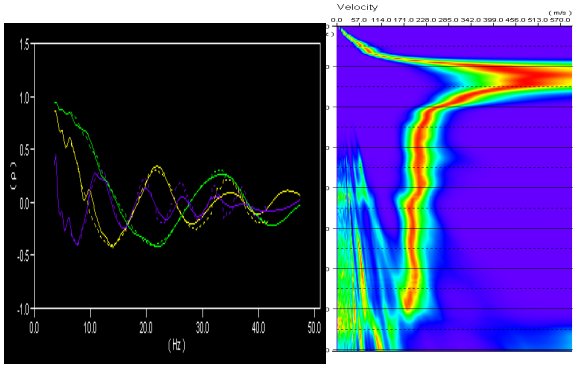
Overview: Procedure

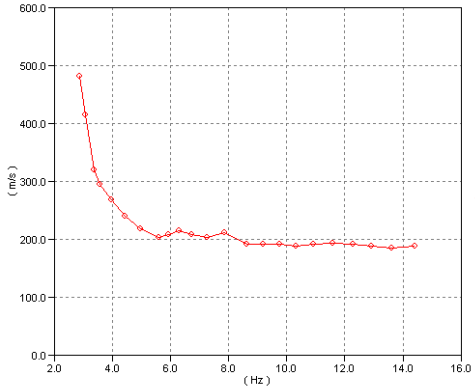


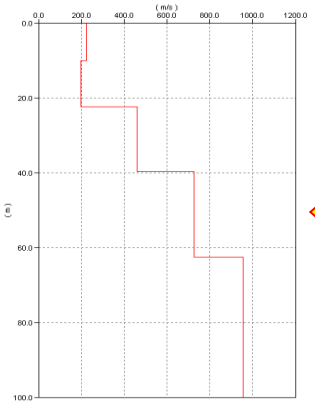
or











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Overview: Dispersion Analysis Methods

There are two methods to determine the phase velocity of passive surface waves:

1. SPAC / ESPAC

   Fitting the spatial autocorrelation coefficient

2. Beam-forming (FK)

   Azimuth scanning in FK, FV, or FP domain

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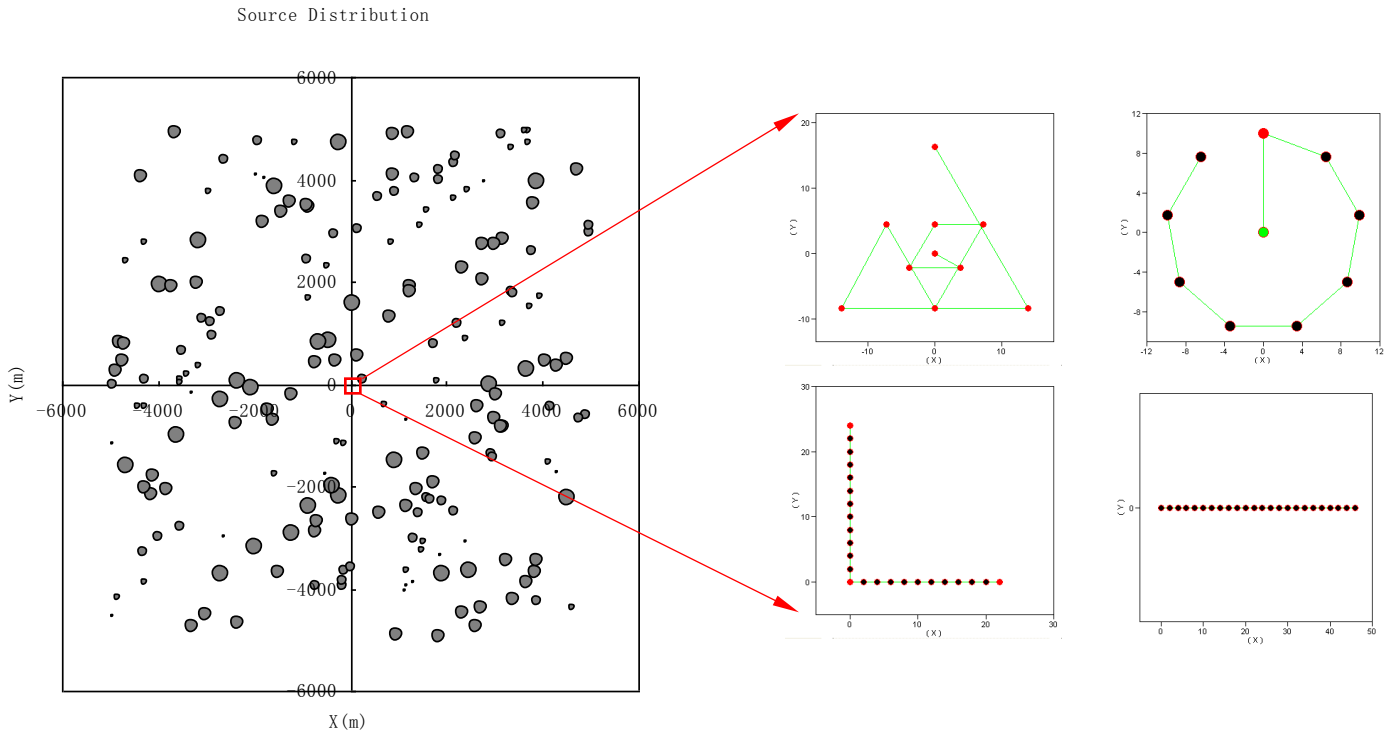
Passive Surface Wave Simulation



- 200 sources with different strengths are randomly distributed and triggered
- Four types of arrays are located at the center
- Sources are almost omnidirectional

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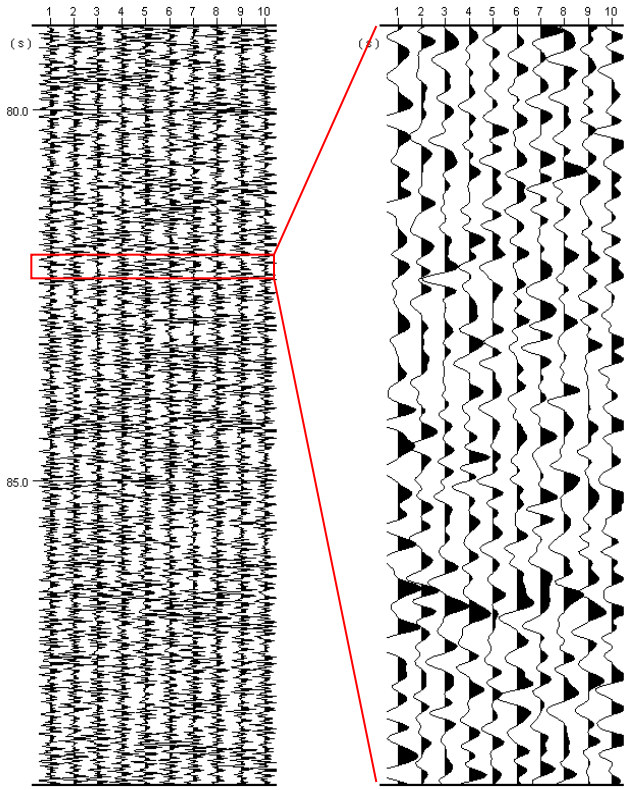
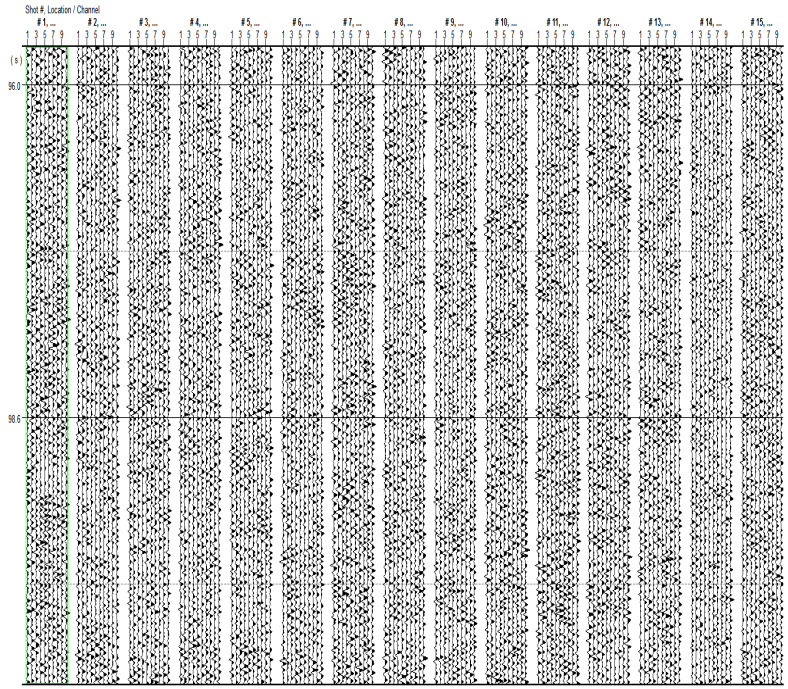
Passive Surface Wave Simulation (Cont'd)





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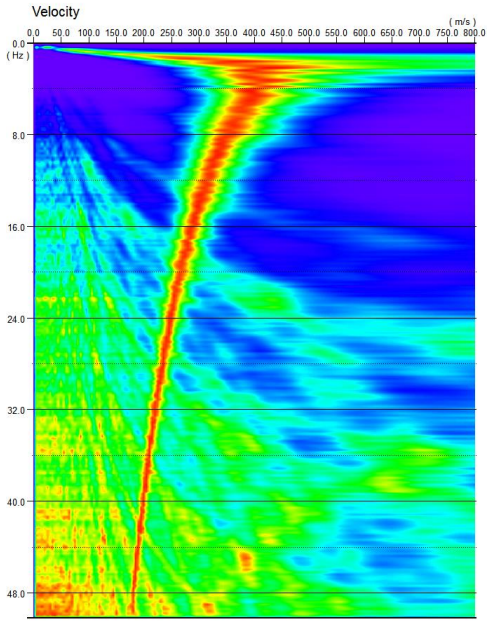
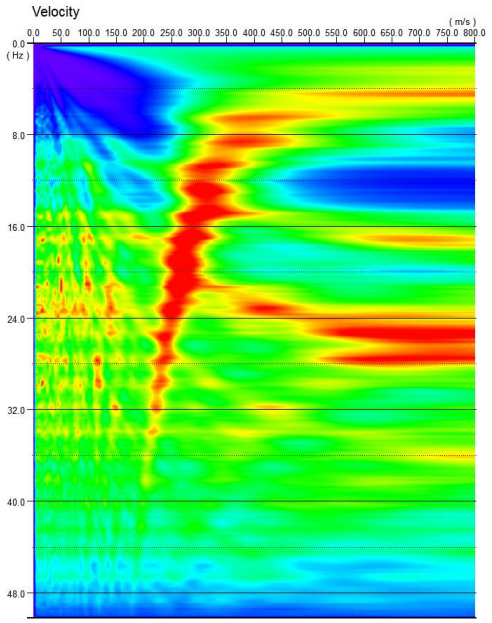
Factors Affecting Depth of Investigation

1. Analysis Method
2. Array Type
3. Array Size
4. Number of Geophones
5. Frequency Response of Geophones
6. Number of Records

Factors: Analysis Methods



SPAC

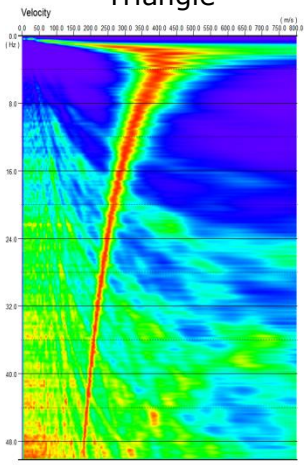


FK (Beam-forming)

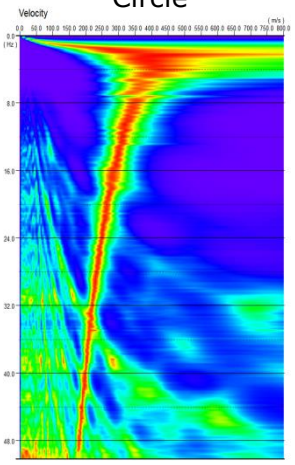
- SPAC method prefers the omnidirectional waves
- FK method prefers the dominant energy from a narrow angle

Factors: Array Type

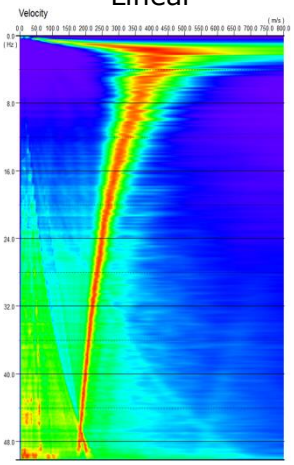
Triangle



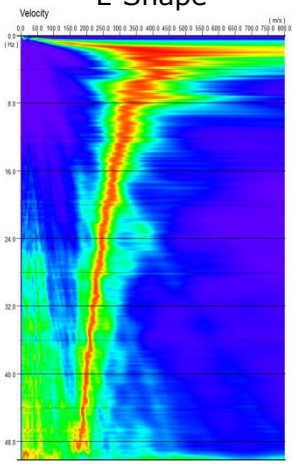
Circle



Linear

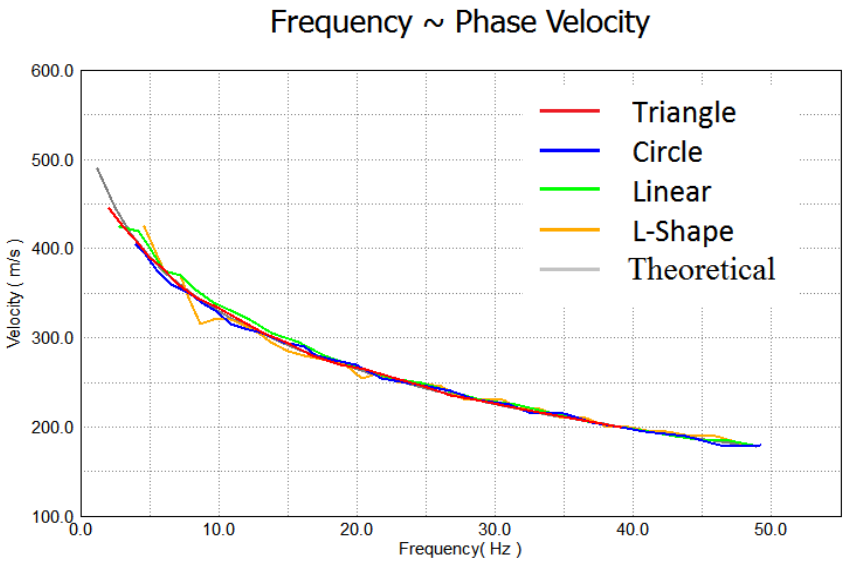


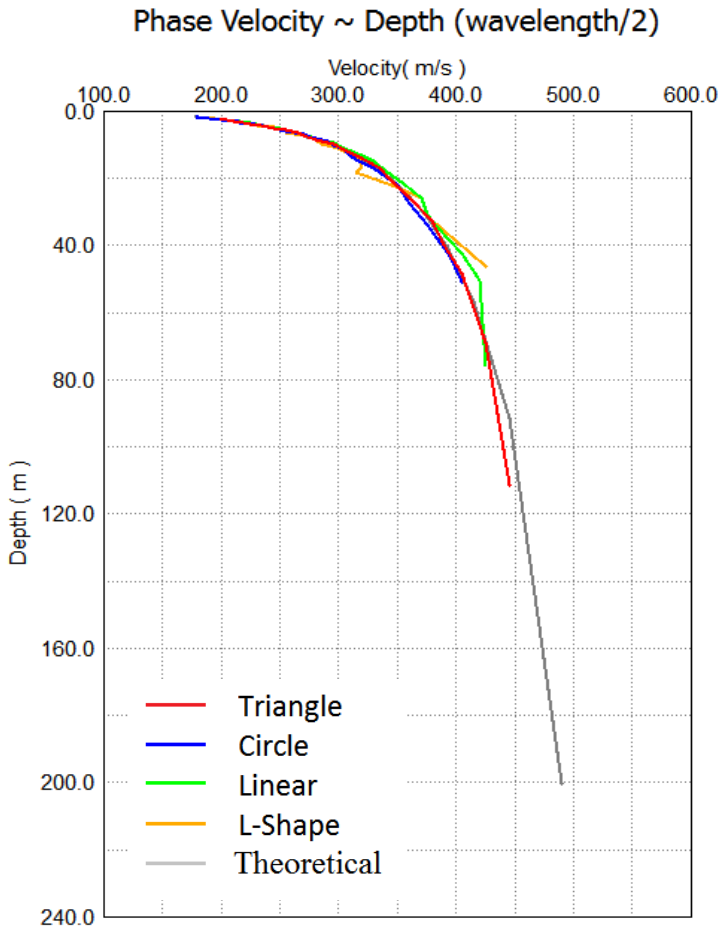
L-Shape



- 2D arrays (triangle, circle, cross, L-shape) allow waves coming from any direction. Triangle array usually works best.
- 1D array (linear) only works when waves travel along the profiles (roadside) or come from all directions (like the simulated waves here).

Factors: Array Type (Cont'd)





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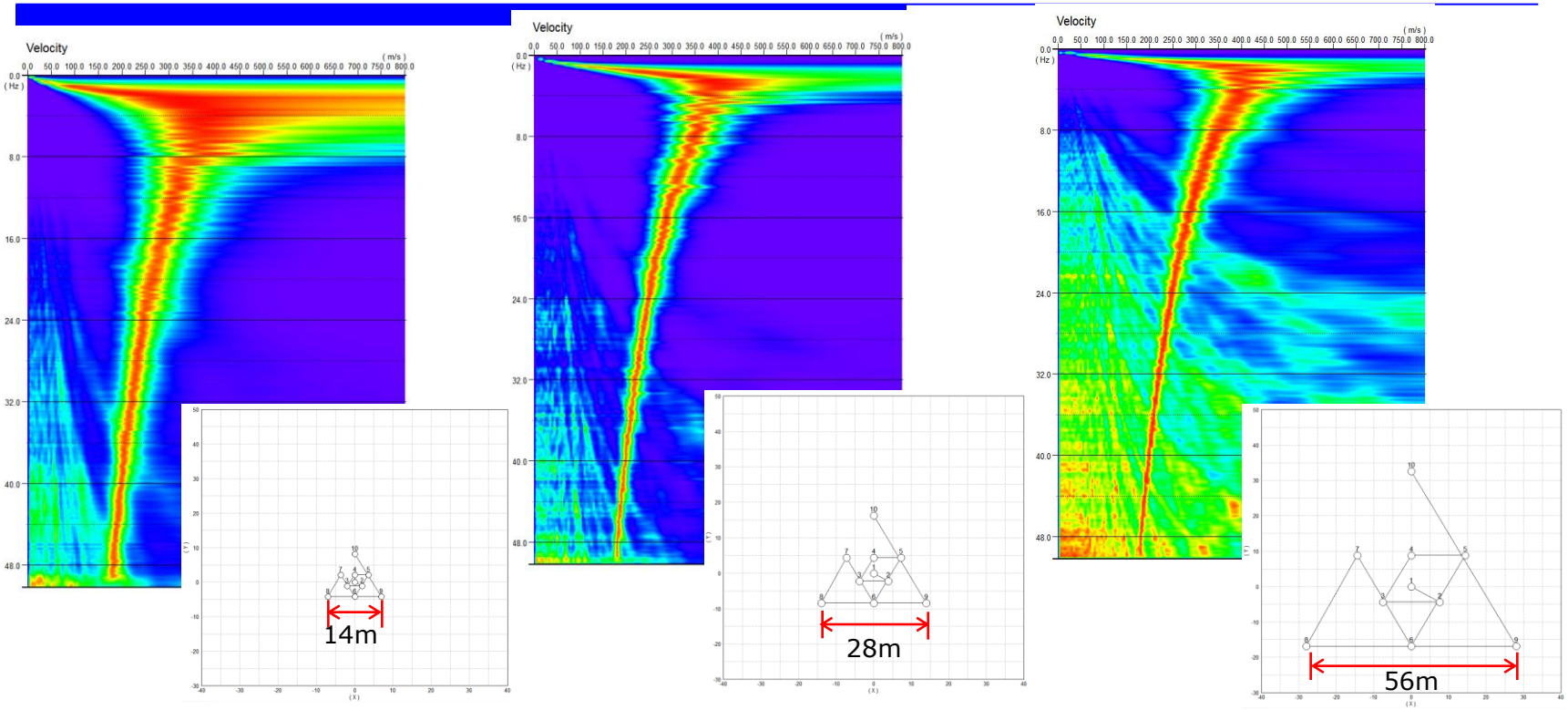
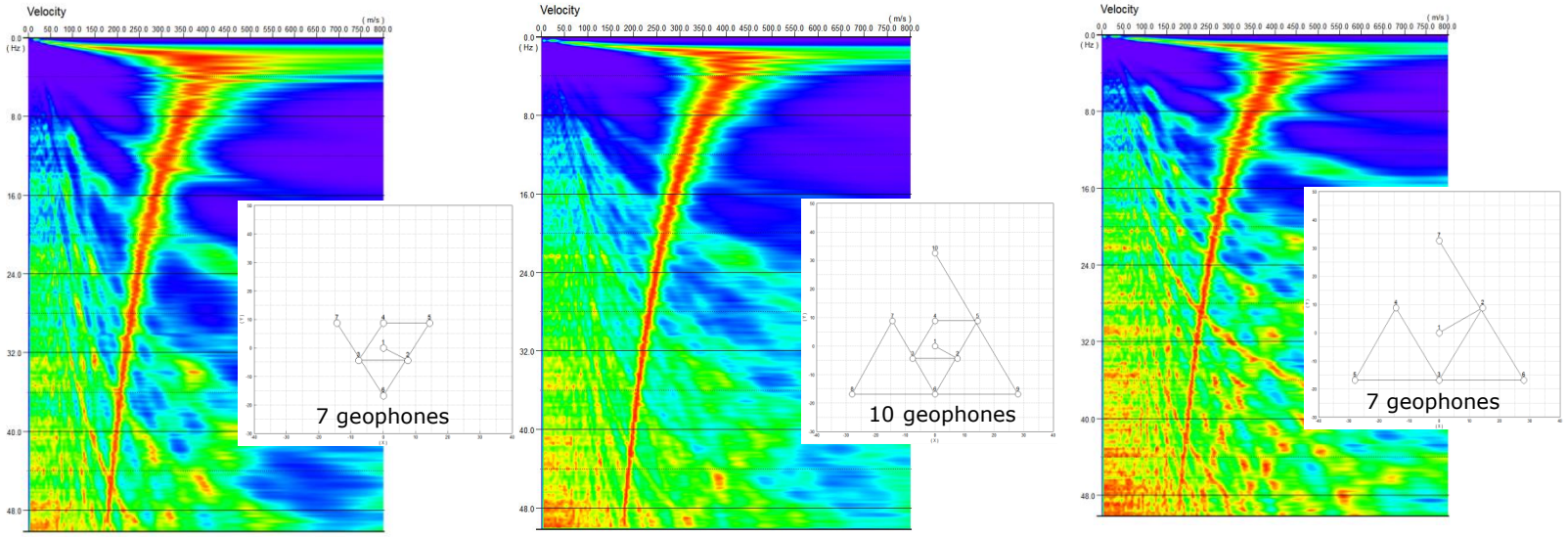
Factors: Array Size



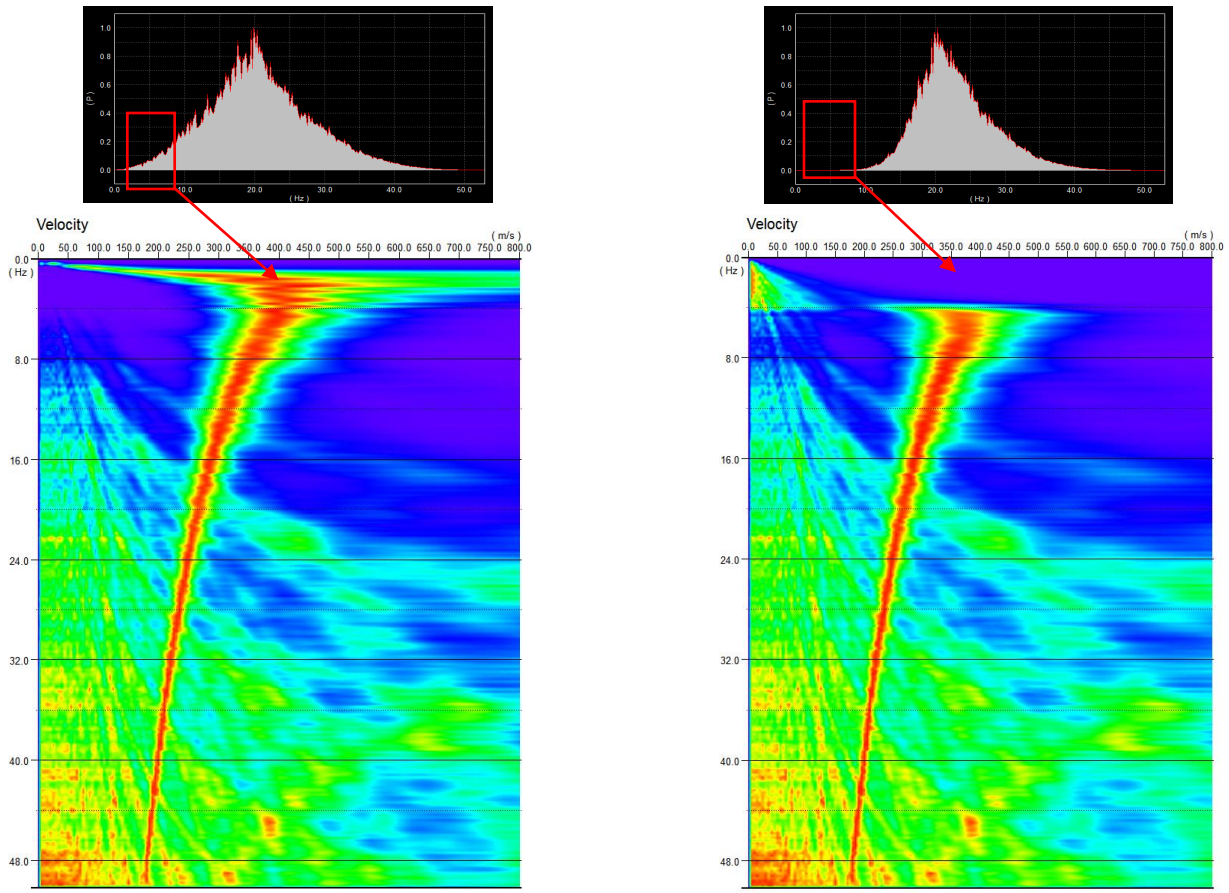
- The larger the array, the higher the resolution and the less the uncertainties, especially at low frequencies.
- The large array could cause more spatial aliasing, especially at high frequencies, but usually does not affect interpretation.

Factors: Number of Geophones



The greater the number of geophones, the higher the resolution, and the less the uncertainties at low frequencies

Factors: Frequency Response of Geophones



- Prefer geophones with lower resonant frequency
- Geophones should have good phase response (minimal phase distortion)

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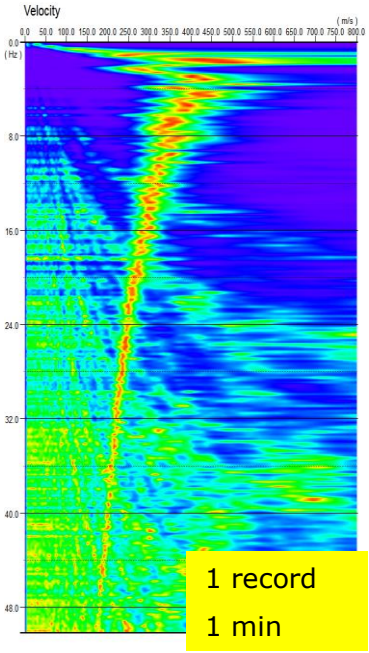
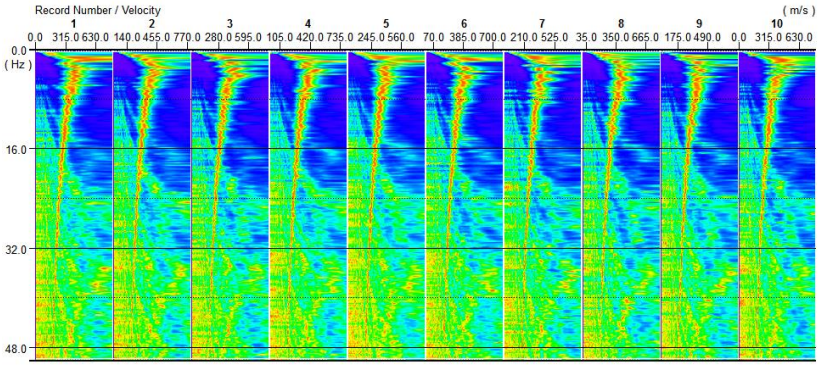
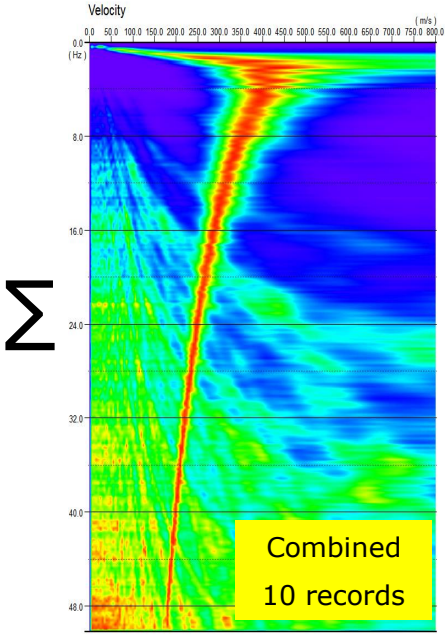
Factors: Number of Records







- SPAC (the azimuthally averaged coherency method) assumes waves are omnidirectional, which may be achieved by recording over a long time.
- Typically 15~20 1-min records are required for analysis.

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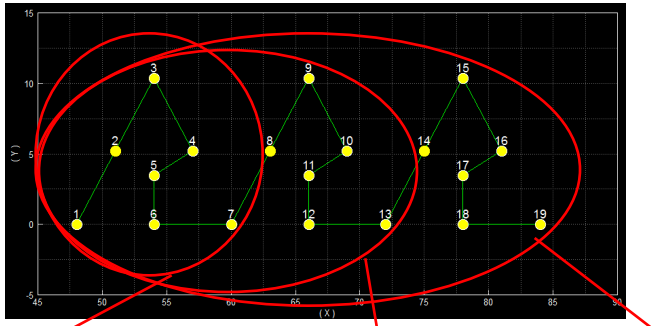
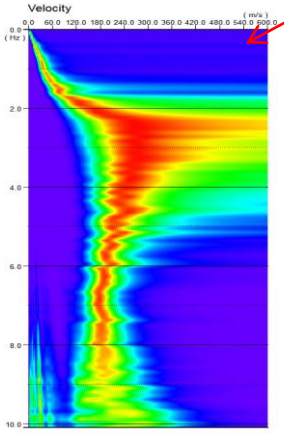
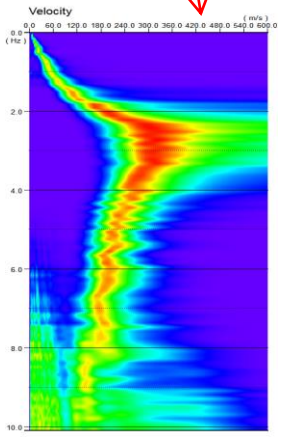
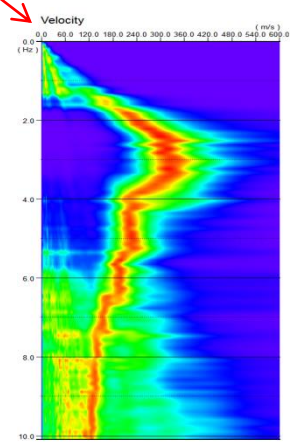




1 triangle



2 triangles



3 triangles

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Conclusion

- Passive surface waves can image greater depth due to stronger energy at low frequencies.
- Many factors affecting the depth of investigation should be considered.
- Normally the nested equilateral triangle array along with SPAC method can produce better results.