

SYNTHETIC MICROSEISMIC DATASETS

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CALGARY***



CREWES

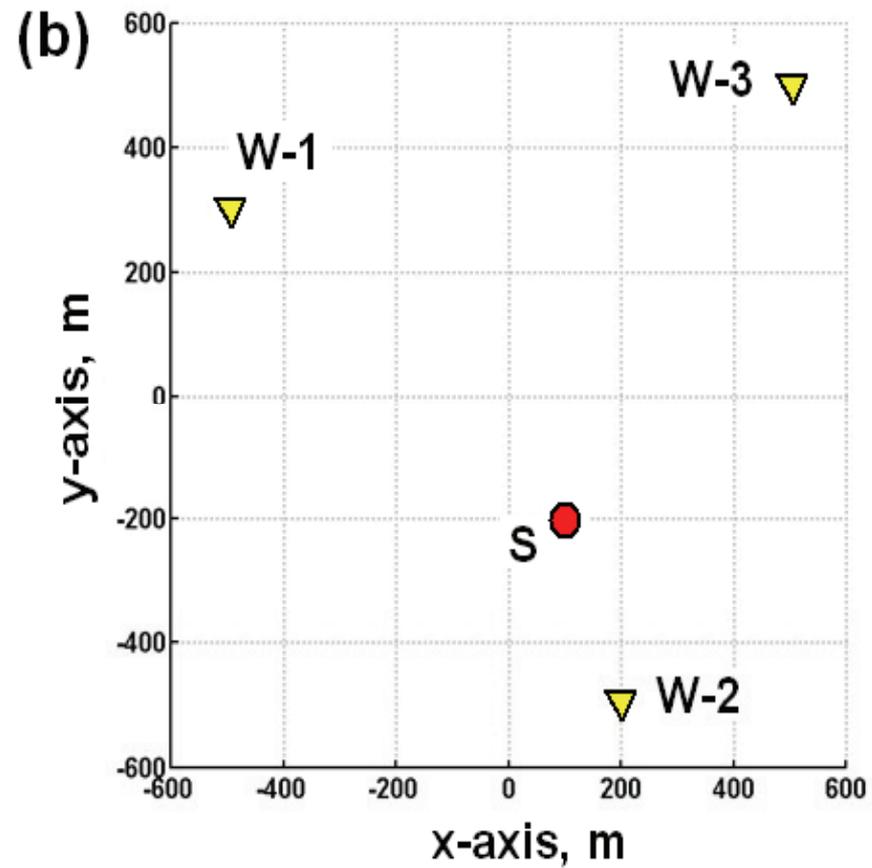
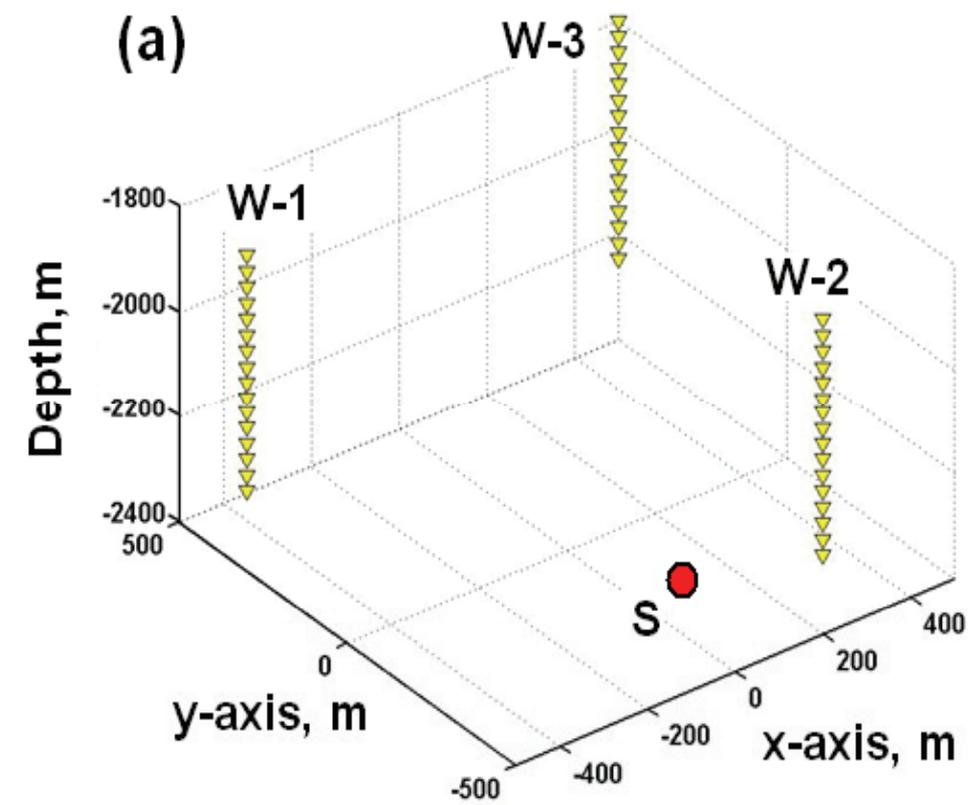
NOISY SYNTHETIC MICROSEISMIC DATASETS

***Intended to be used for evaluating various
microseismic hypocenter location techniques.***

METHODS FOR CREATING SYNTHETIC MICROSEISMOGRAMS

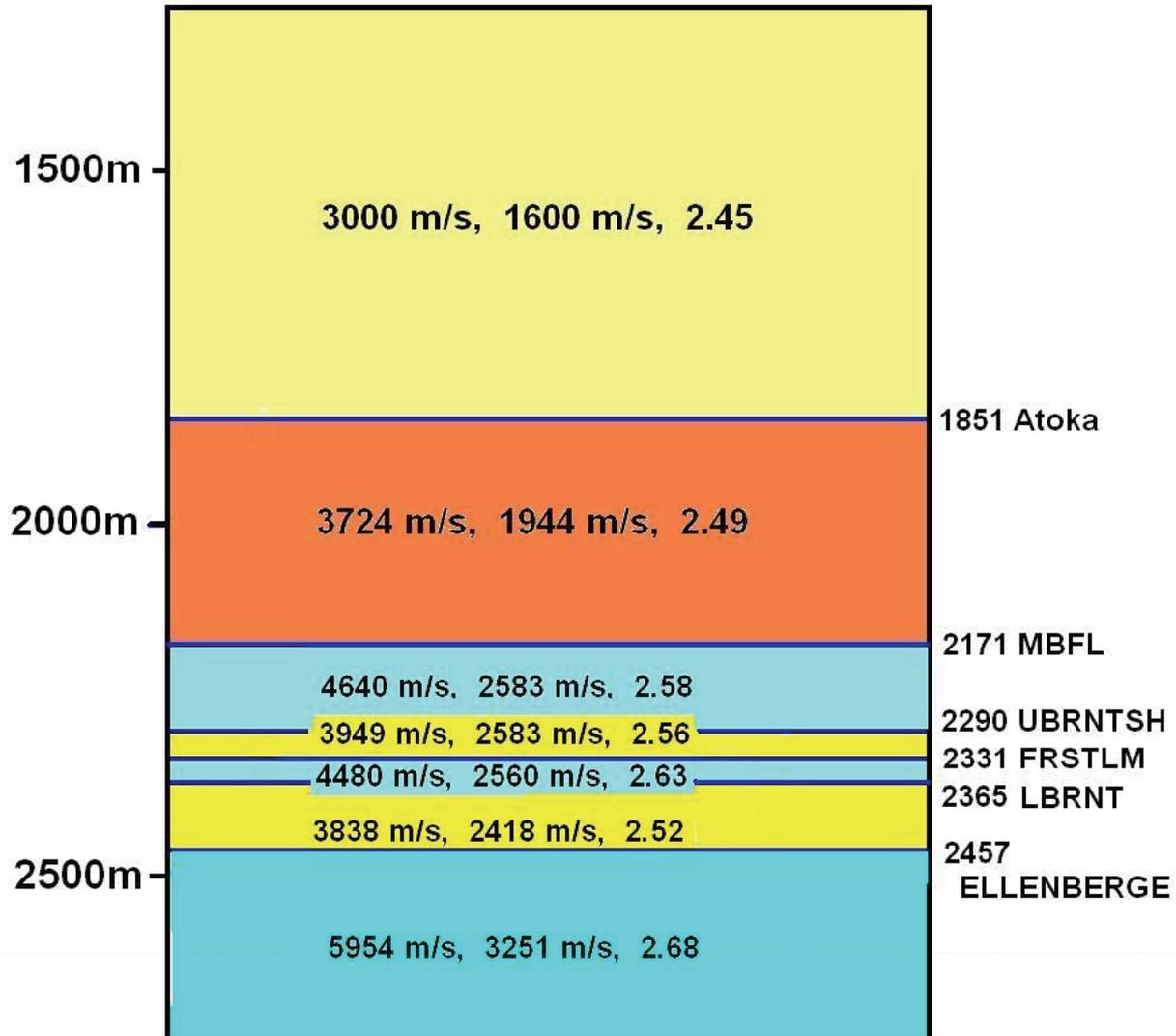
Horizontal Layered Earth Velocity Models.

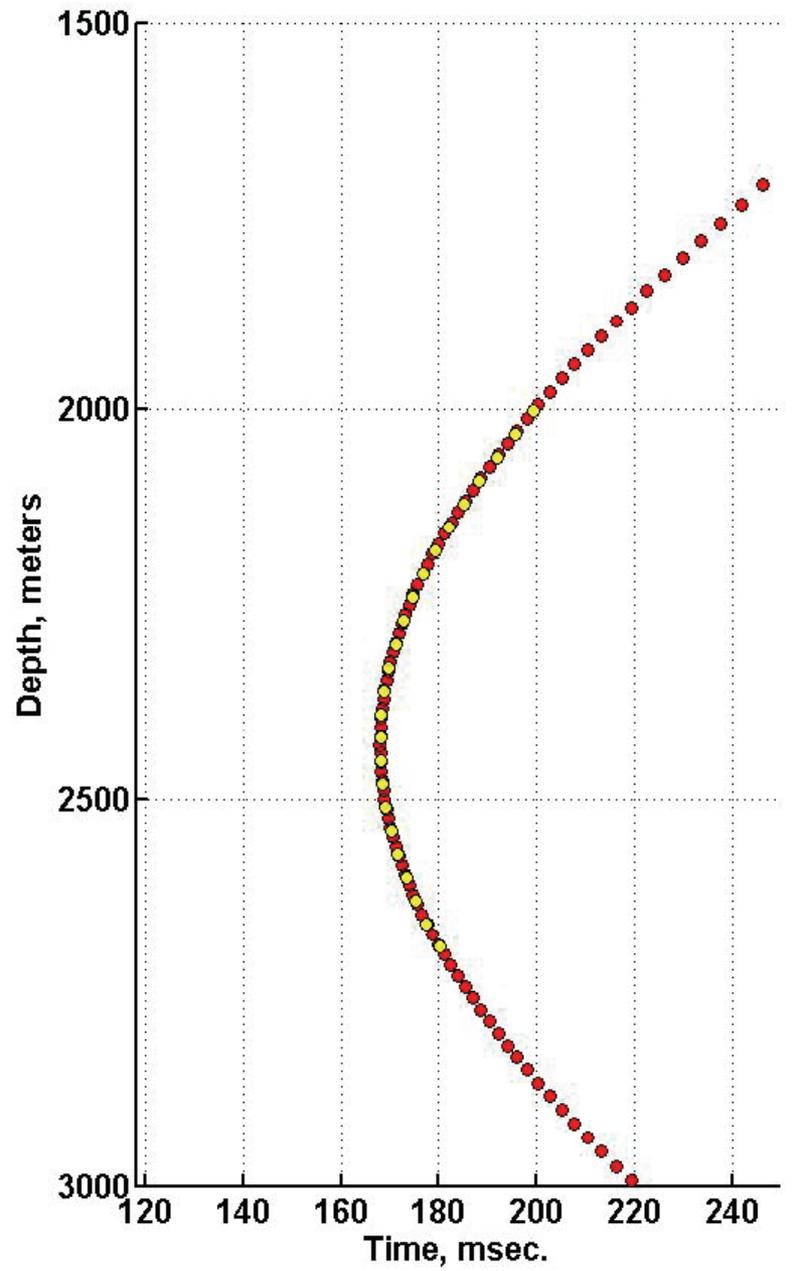
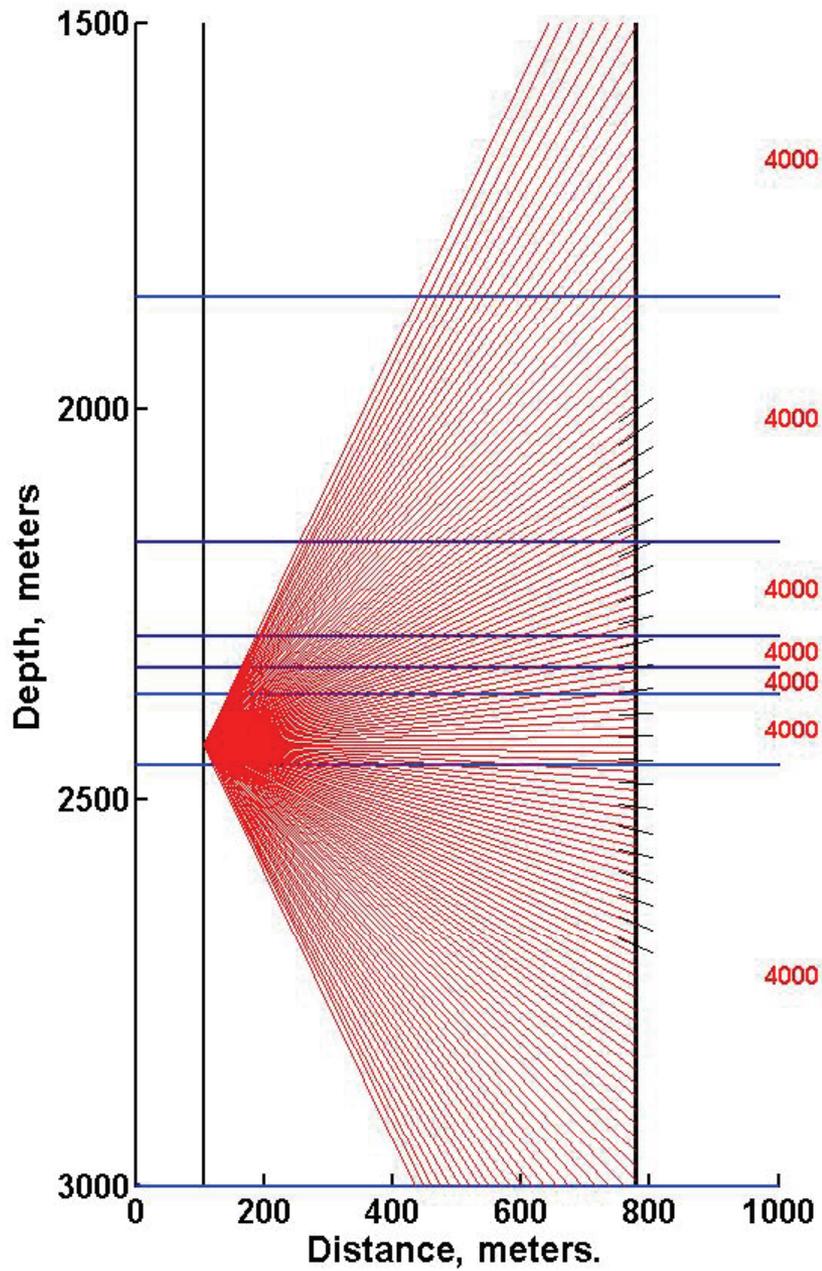
- 1. Ray tracing to get P and S arrivals times; then convolve with synthetic source wavelets.***
- 2. Time-stepping finite difference algorithm.***

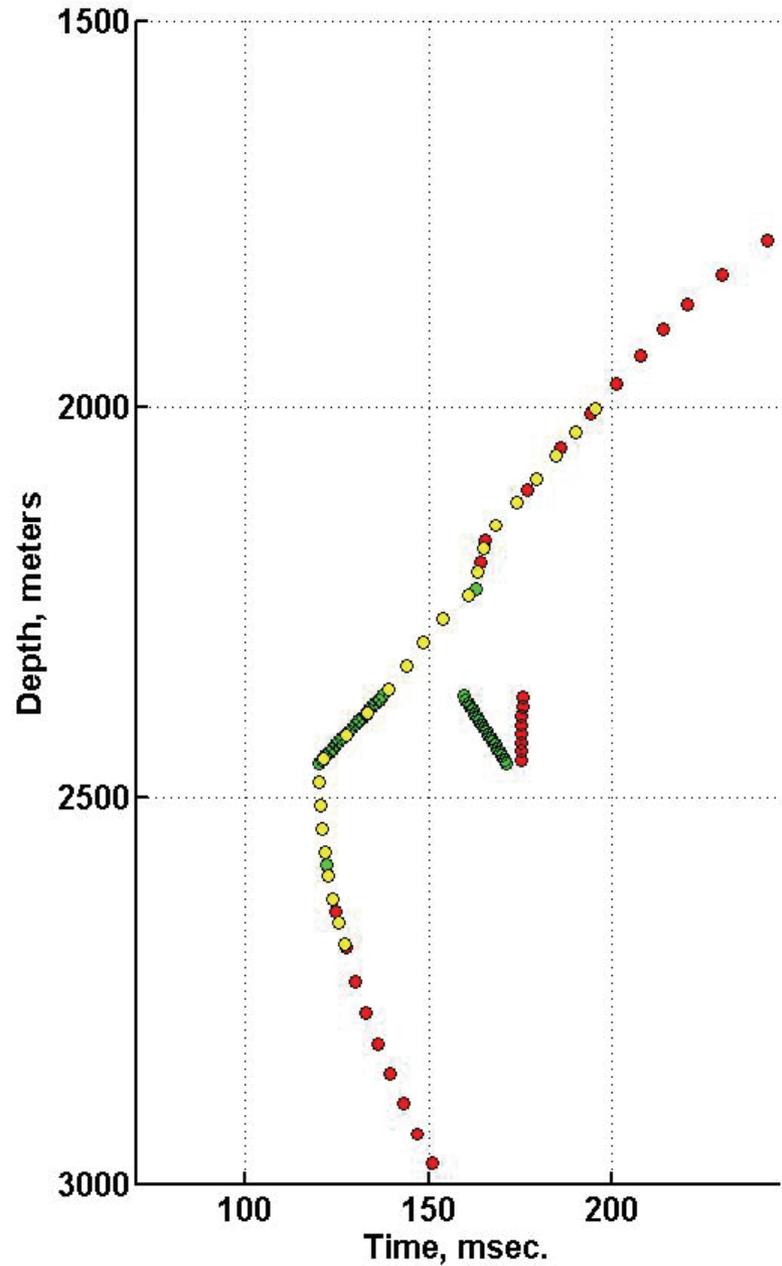
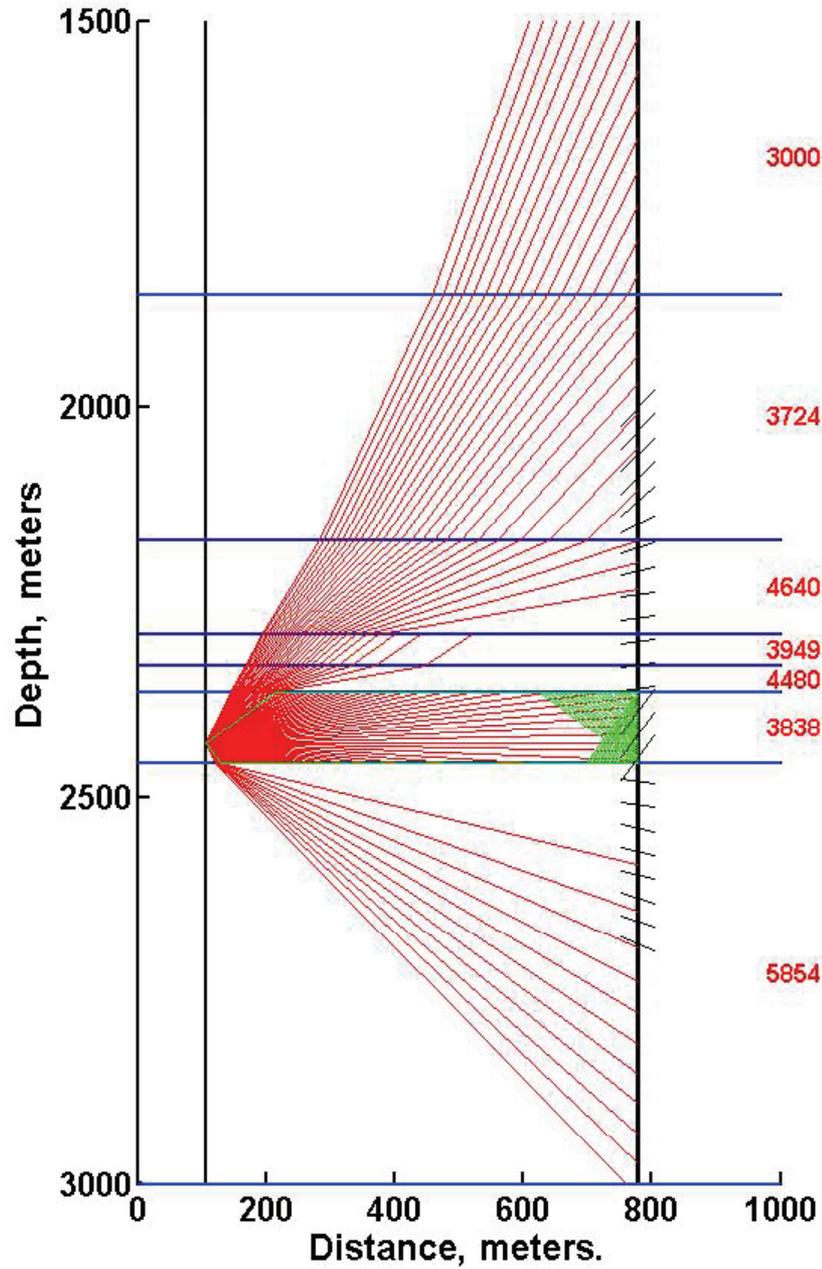


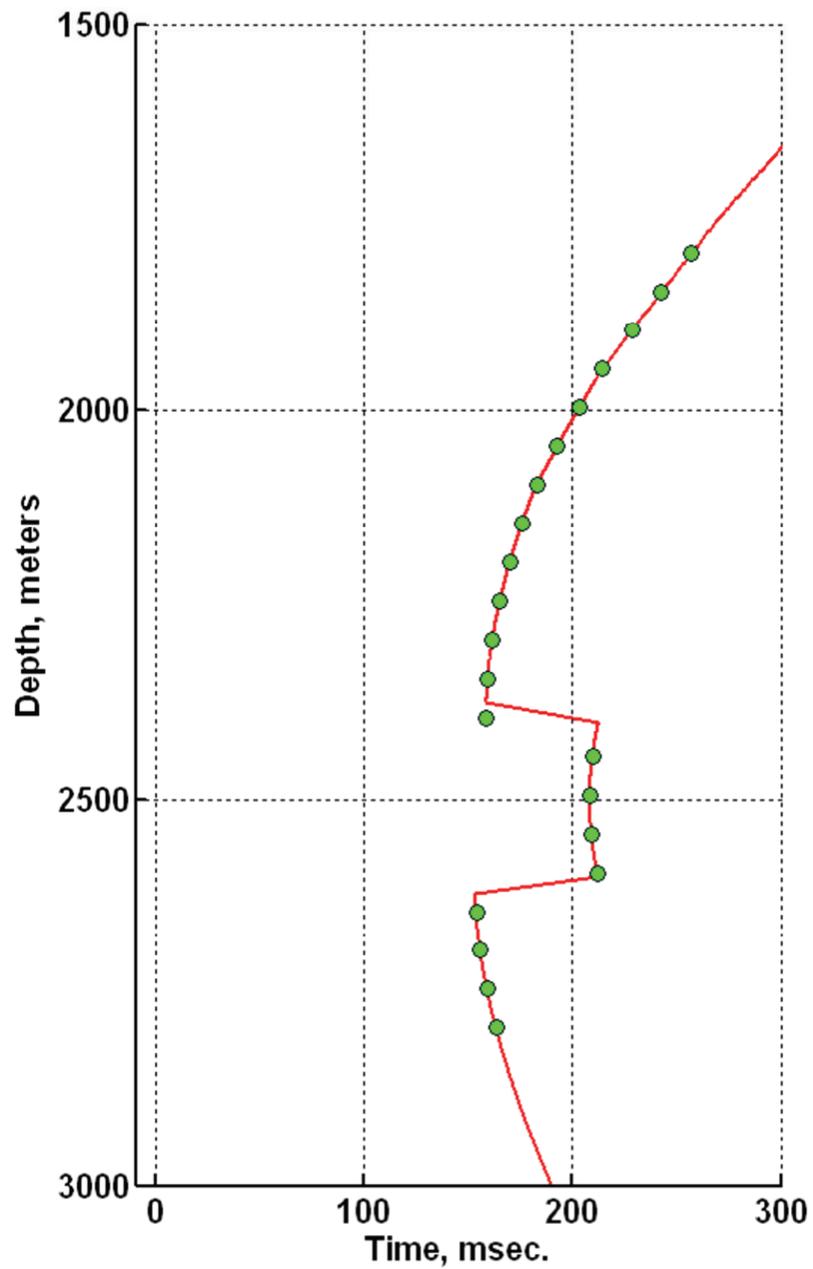
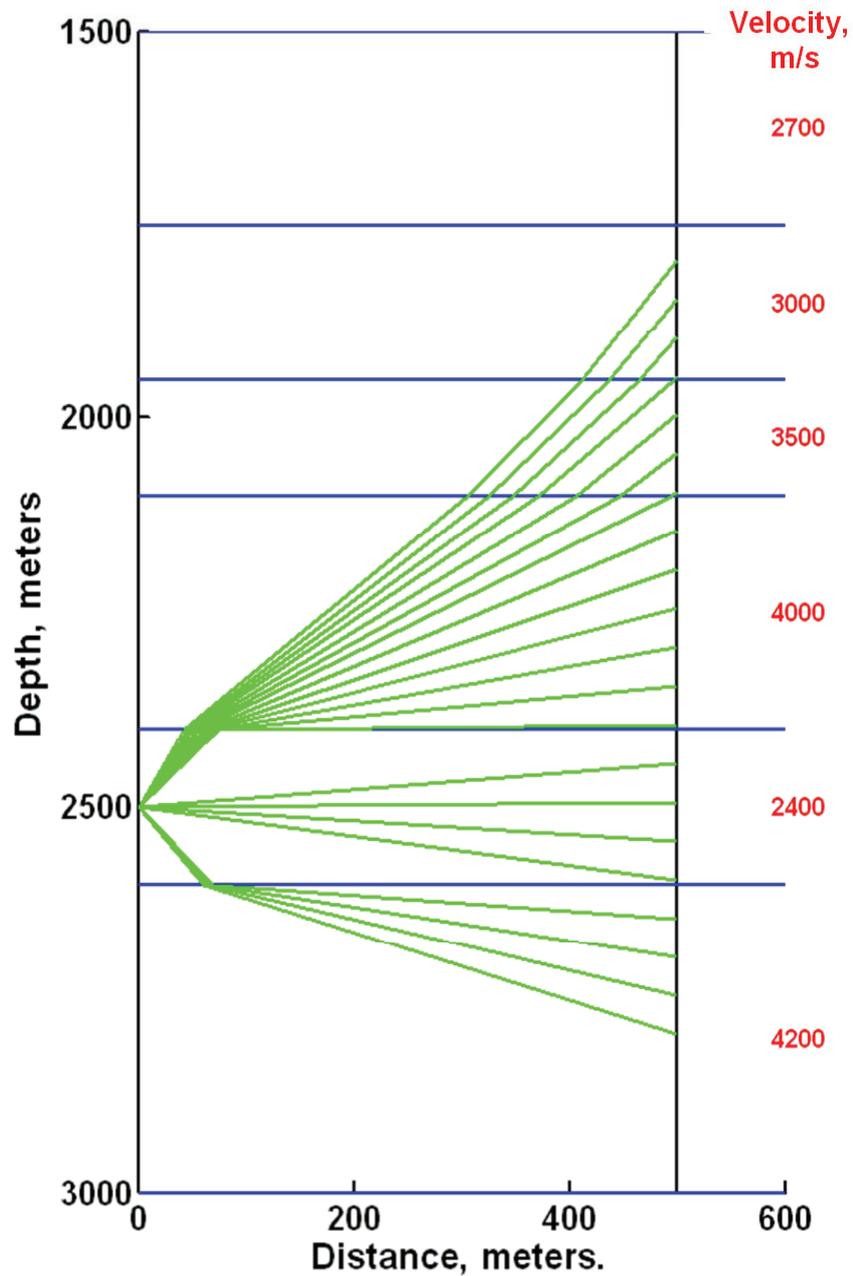
Velocity and Density Model for Calculating Synthetic Microseismograms

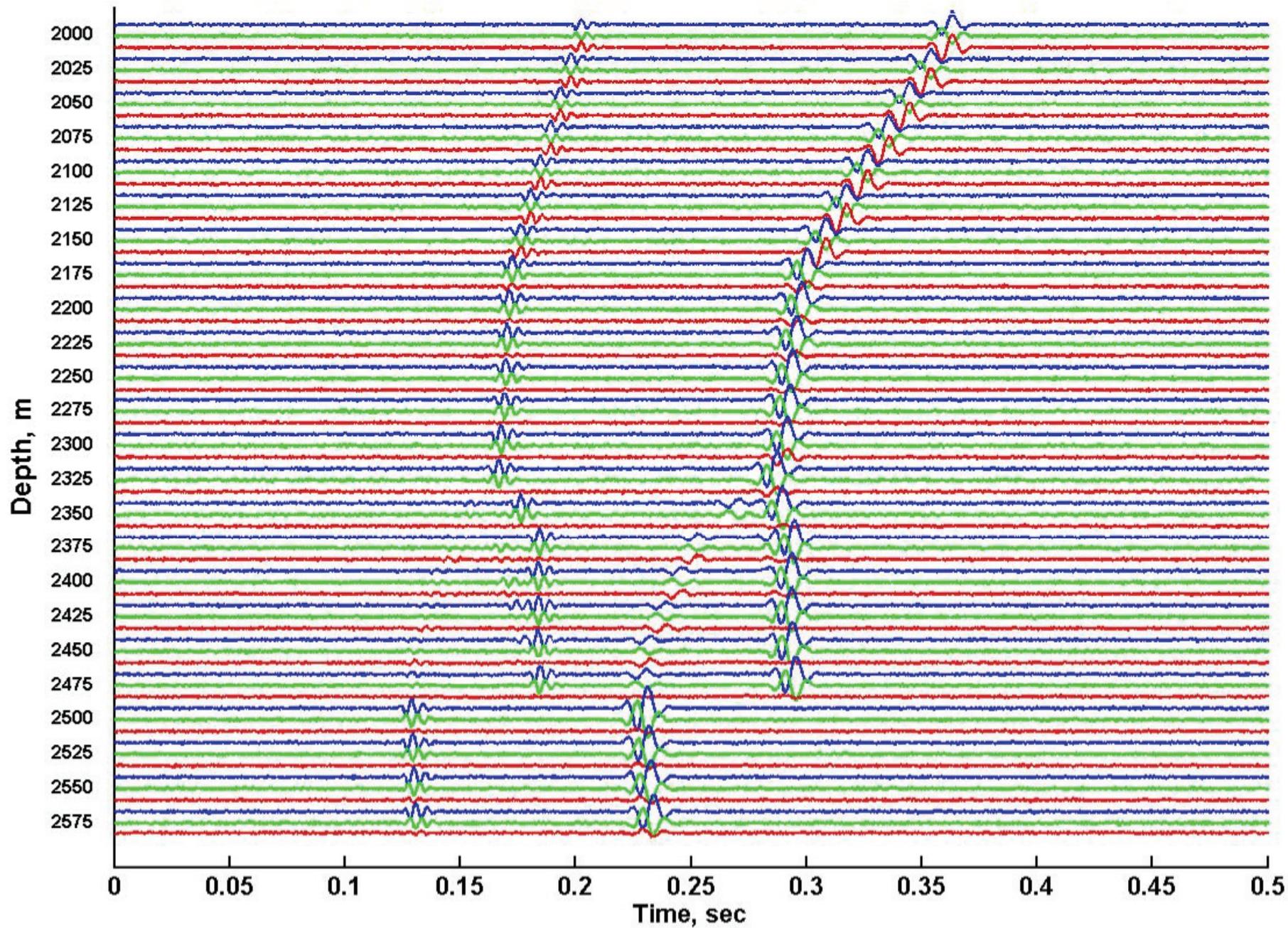
(courtesy Jamie Rich, Devon Energy Corp.)

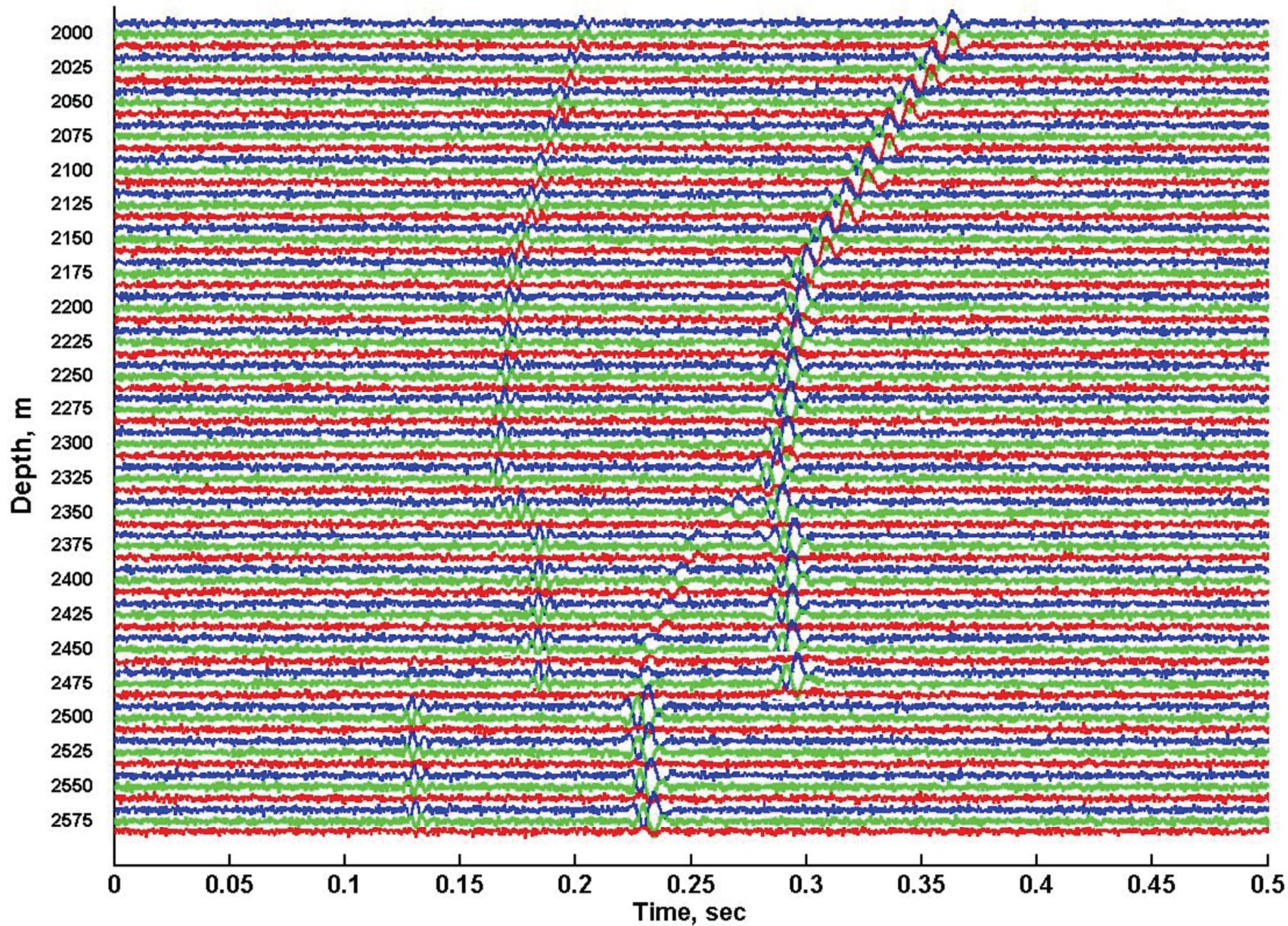




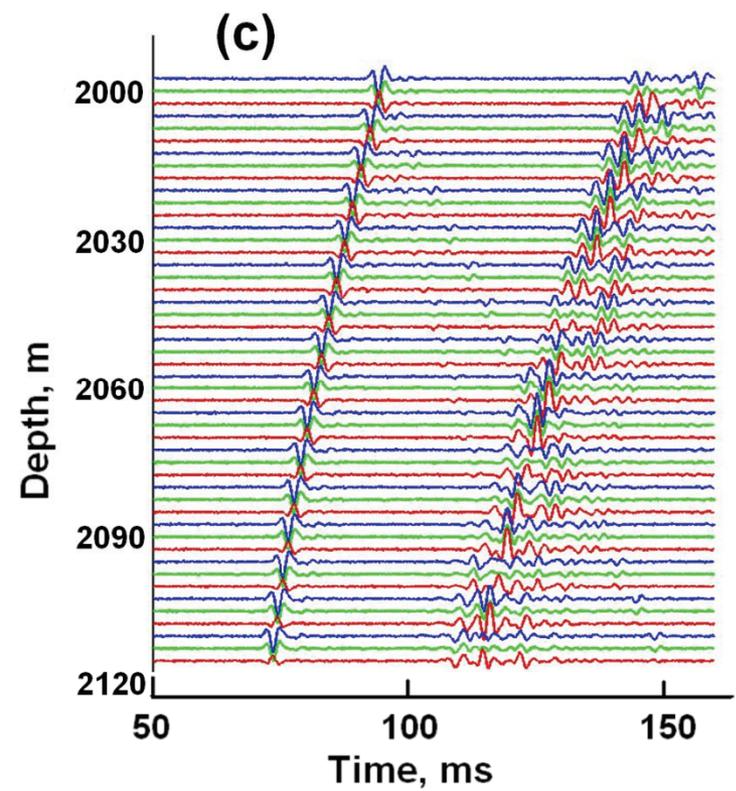
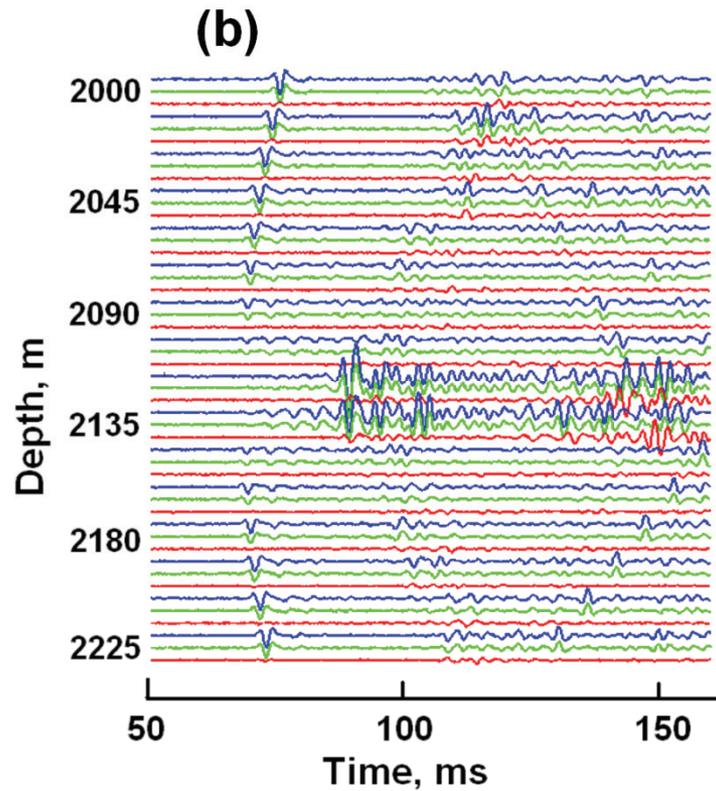
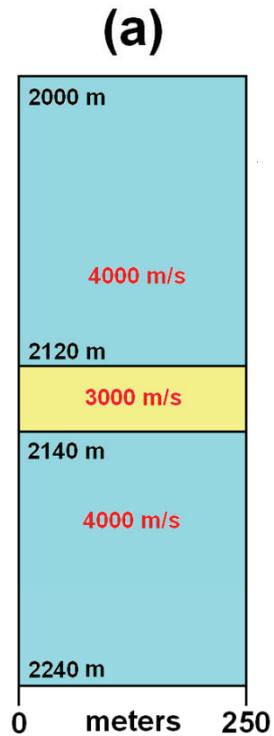




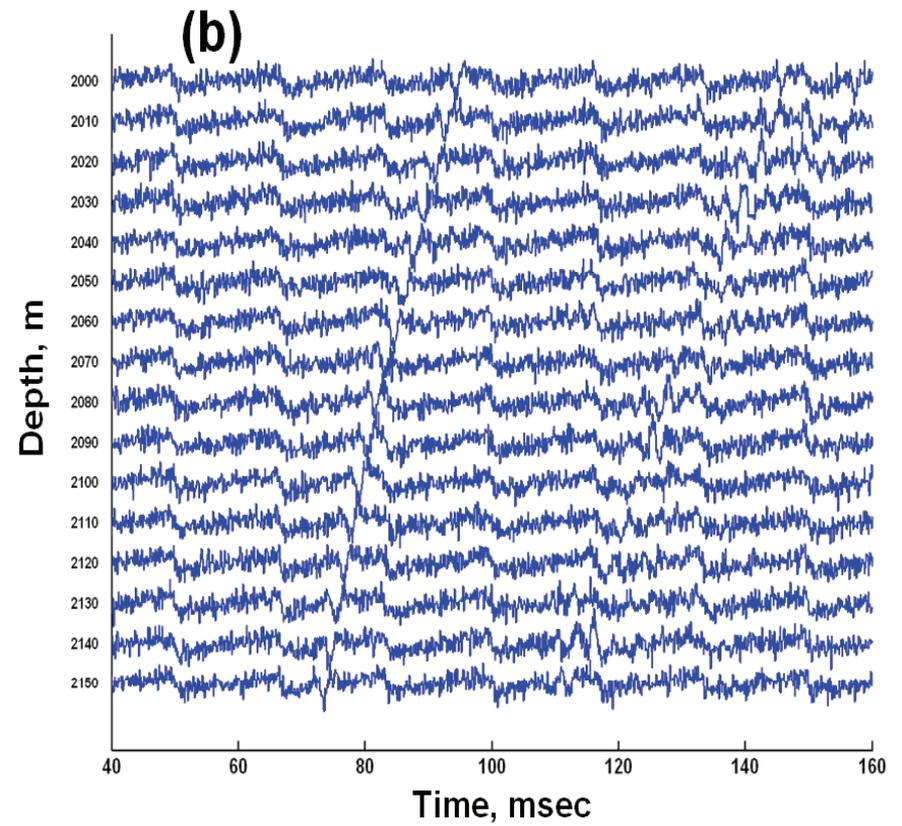
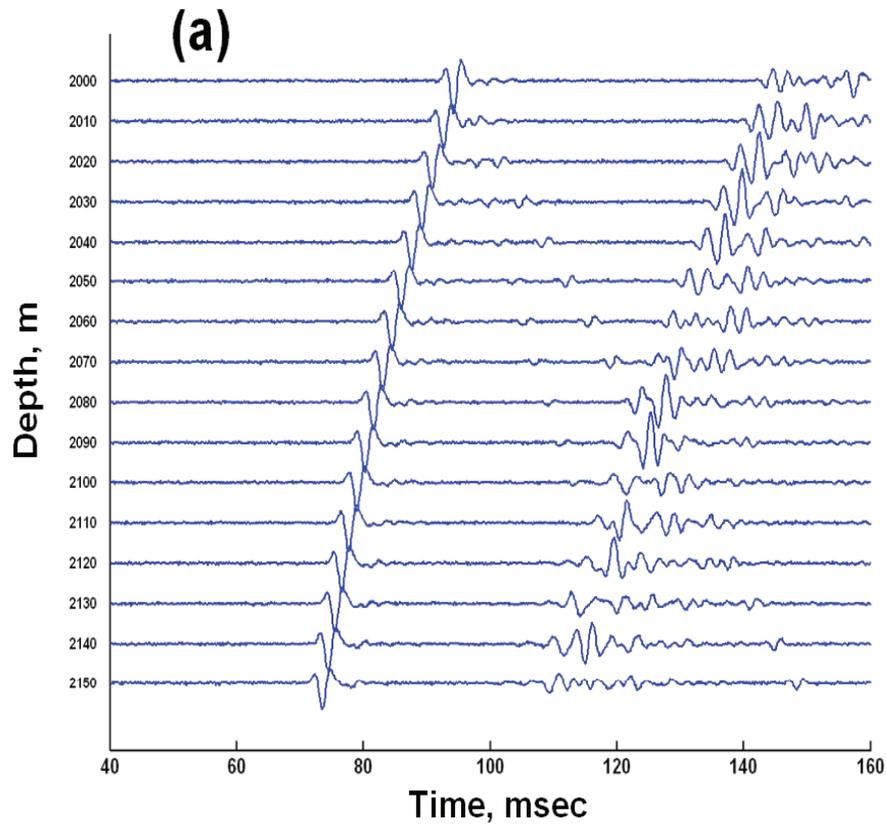




Synthetic microseismograms created by 2D finite difference elastic modeling.



Add random and harmonic noise.



POSSIBLE EXTENSIONS

- ***VTI and TTI layers.***
- ***Sloping or gently curving interfaces.***
- ***Faults.***

Byun/Kumar Approximation for VTI /TTI qP Group Velocity

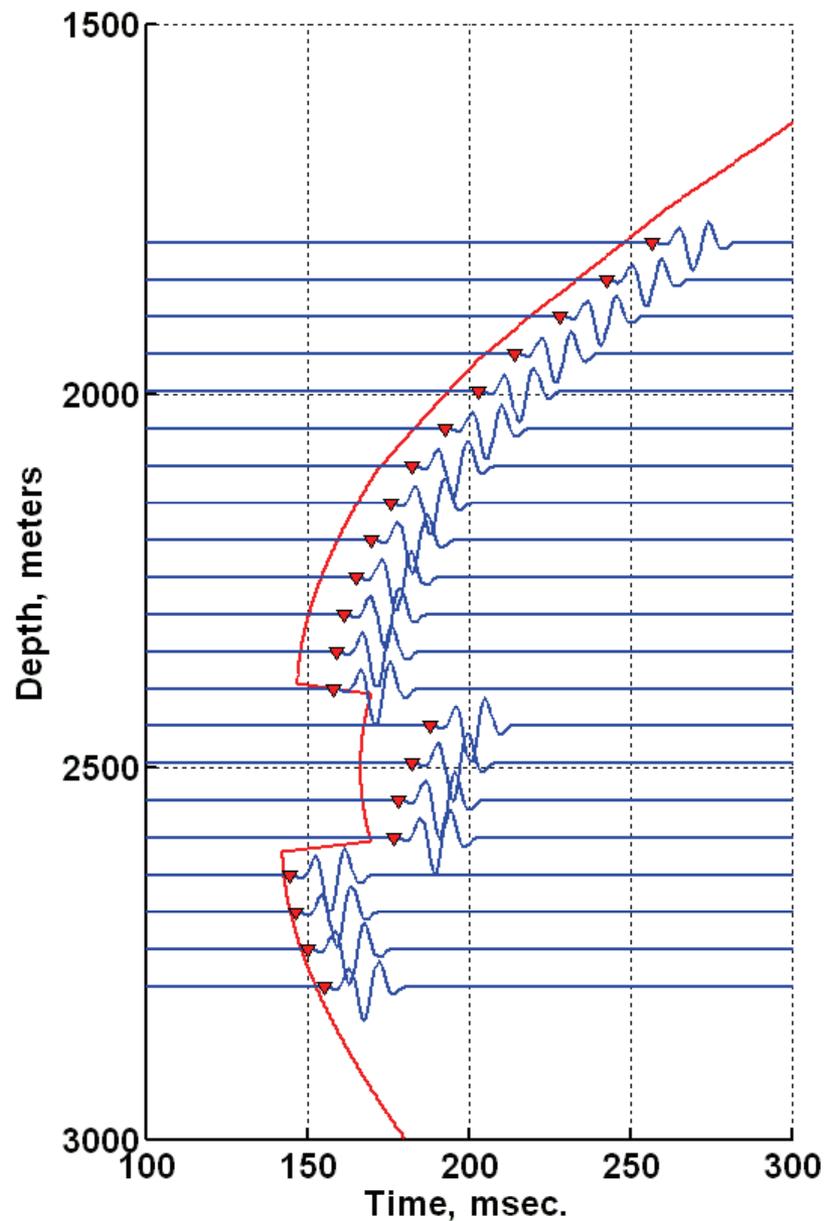
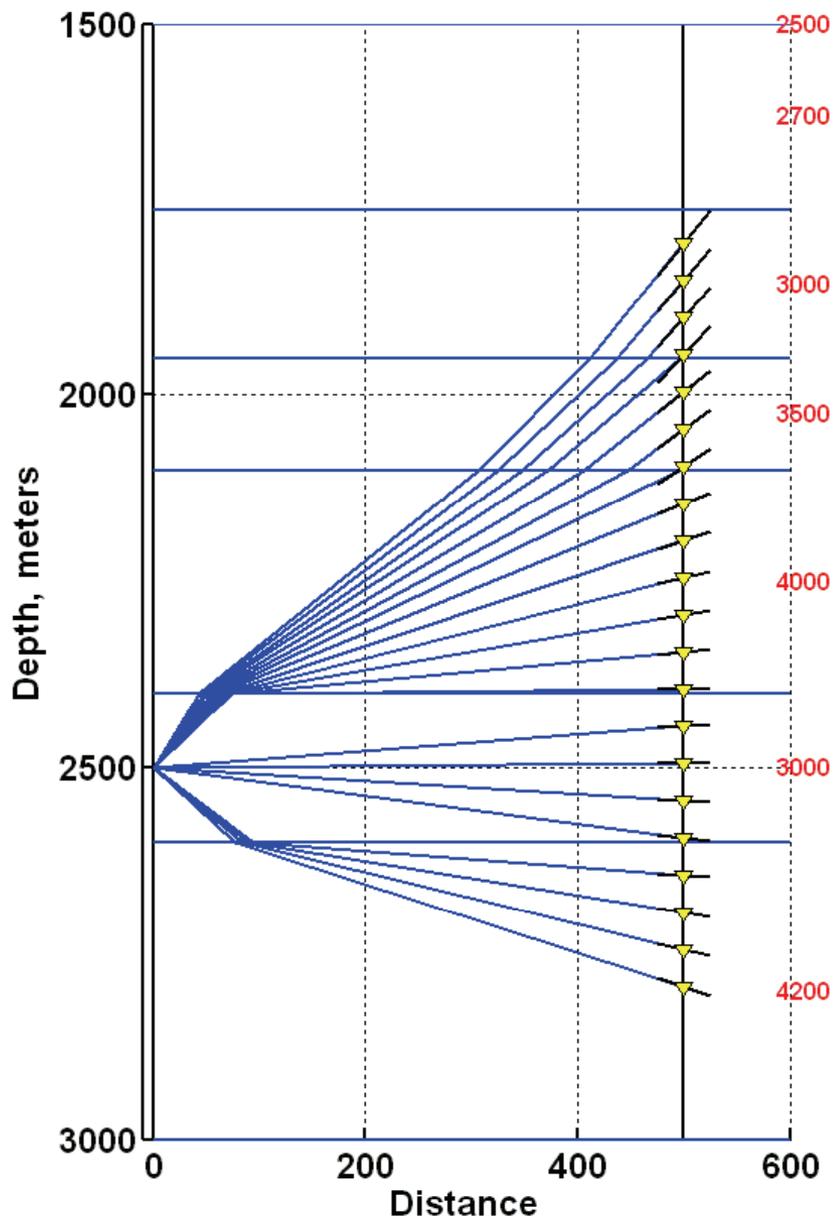
$$V_p^{-2}(\phi) = a_0 + a_1 \cos^2(\phi + \psi) - a_2 \cos^4(\phi + \psi)$$

$$a_0 = V_h^{-2},$$

$$a_1 = 4V_{45}^{-2} - 3V_h^{-2} - V_v^{-2},$$

$$a_2 = 4V_{45}^{-2} - 2V_h^{-2} - 2V_v^{-2}.$$

***Fermat's principle and ray tracing in anisotropic layered media
(Wong, 2010, CREWES Research Reports 22, 88.1-88.8)***

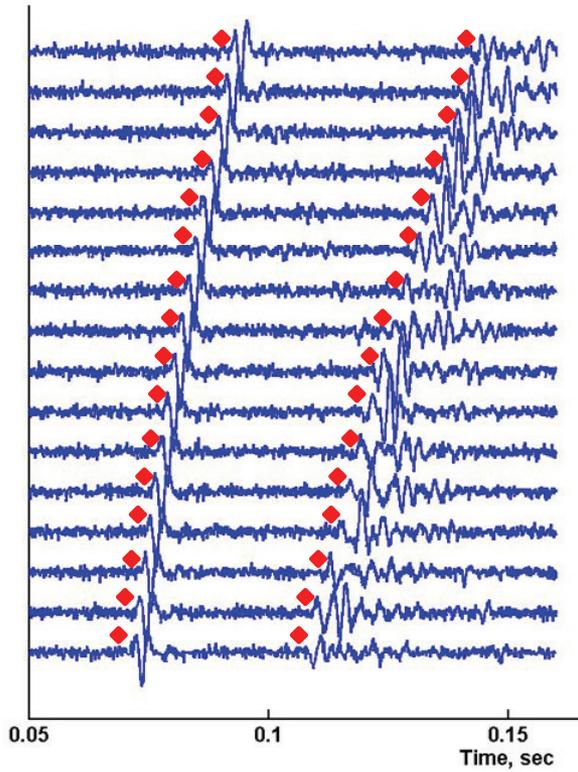


SYNTHETIC MICROSEISMIC DATA FILES

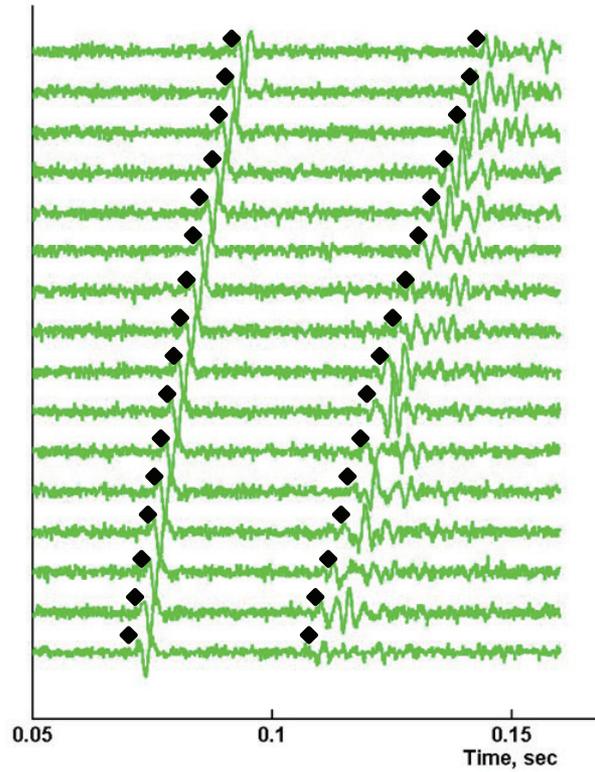
- ***Various SNRs.***
- ***Trace Length = 3 seconds.***
- ***Sample interval = .00025 seconds.***
- ***Random delays for t_0 values.***
- ***48 or 96 traces for 16 or 24 3C geophones.***
- ***Traces stored in SEG-2 or SEG-Y format.***

- 1. Read SEG-2 or SEG-Y file.*
- 2. Apply recognition procedure.*
- 3. Discard noise file.*
- 4. Identify good file.*
- 5. Pick arrival times and estimate n_x , n_y , and n_z .*
- 6. Run hypocenter location routine.*

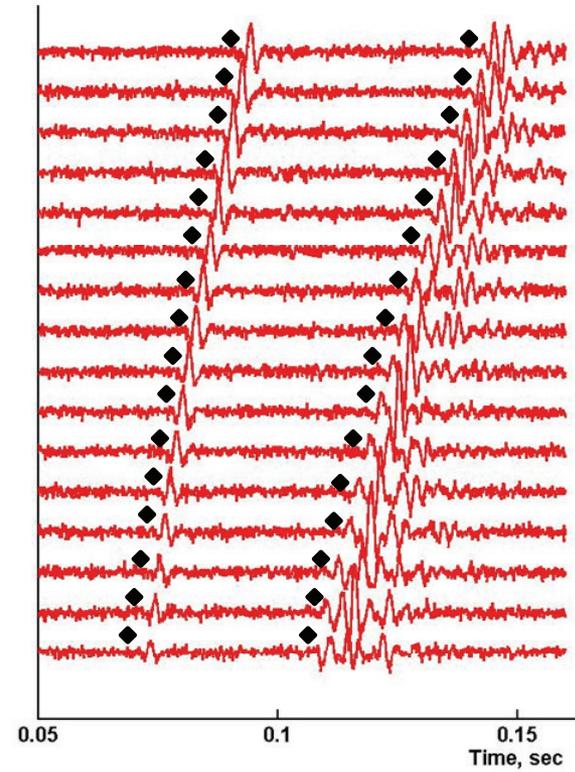
x-component



y-component



z-component



Through ray tracing, we can quickly forward calculate the following observable quantities:

$$\tau_{Pj} = F_P(\mathbf{x}_S, \mathbf{y}_S, \mathbf{z}_S, \mathbf{x}_{rj}, \mathbf{y}_{rj}, \mathbf{z}_{rj}, \underline{V}_P, \underline{h}) ;$$

$$\tau_{Sj} = F_S(\mathbf{x}_S, \mathbf{y}_S, \mathbf{z}_S, \mathbf{x}_{rj}, \mathbf{y}_{rj}, \mathbf{z}_{rj}, \underline{V}_S, \underline{h}) ;$$

$$(n_{xj}, n_{yj}, n_{zj})_P = F_\theta(\mathbf{x}_S, \mathbf{y}_S, \mathbf{z}_S, \mathbf{x}_{rj}, \mathbf{y}_{rj}, \mathbf{z}_{rj}, \underline{V}_P, \underline{h}) ;$$

$j = 1, 2, \dots, m = \text{number of 3C geophones.}$

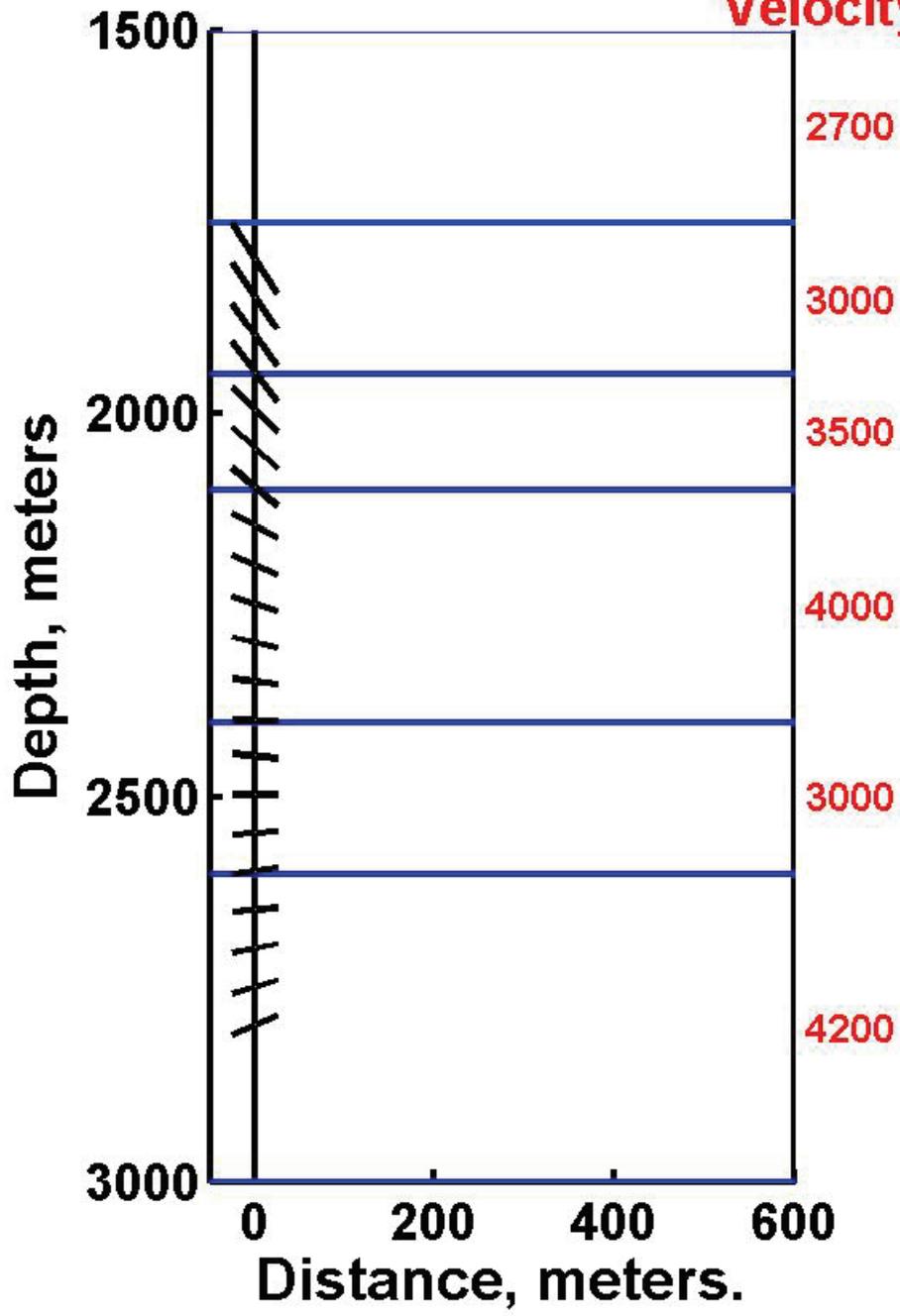
Assuming that the quantities in yellow are known and fixed, we can invert these equations, either singly or in combination, to find the source coordinates $(\mathbf{x}_S, \mathbf{y}_S, \mathbf{z}_S)$.

One method for hypocenter location in 3D space:

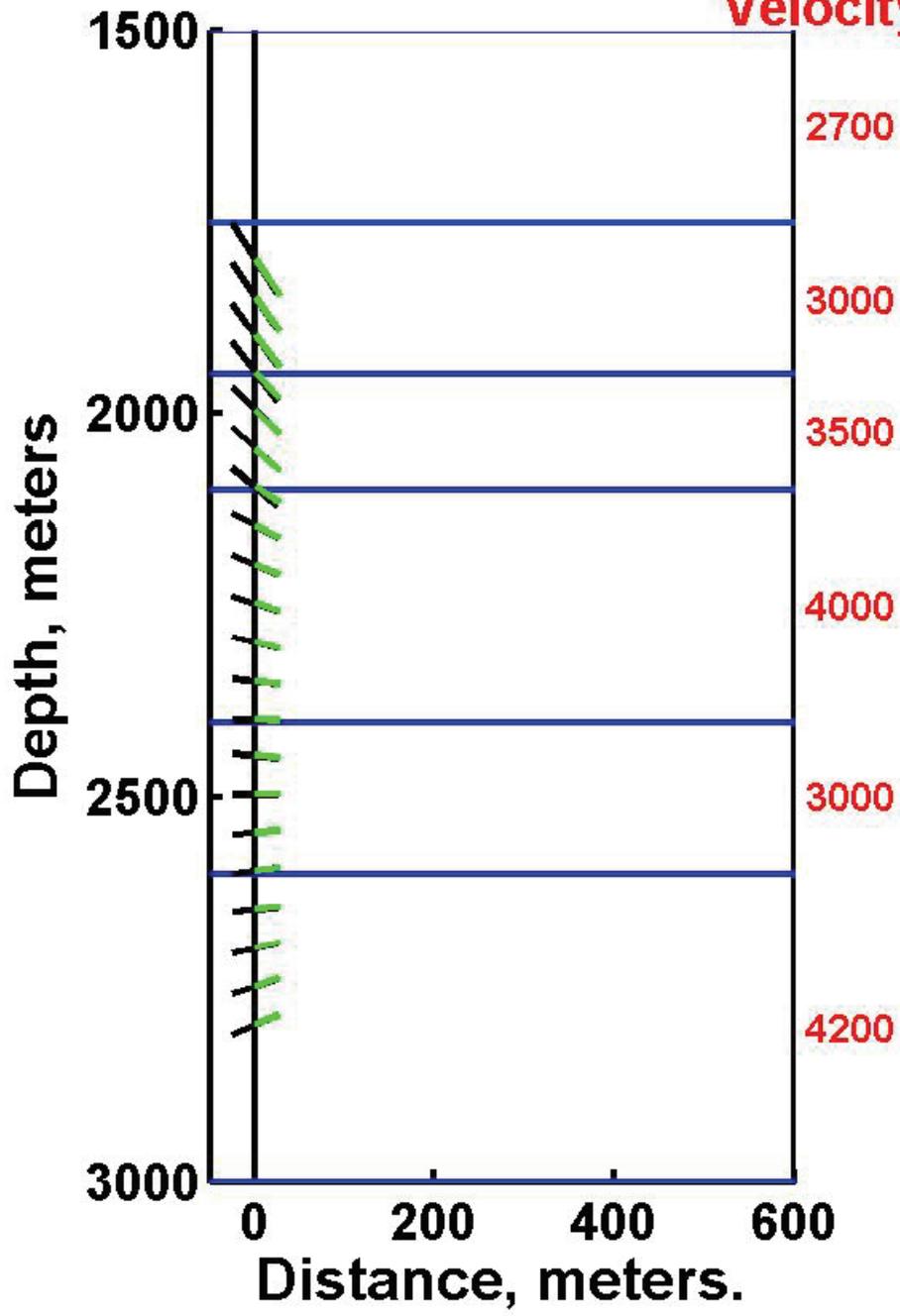
*Back-project from geophones along
propagation vectors.*

*(Han et al., 2010. Back-propagation analysis for hypocenter
location, CREWES Research Report 22, 31.1-31.9)*

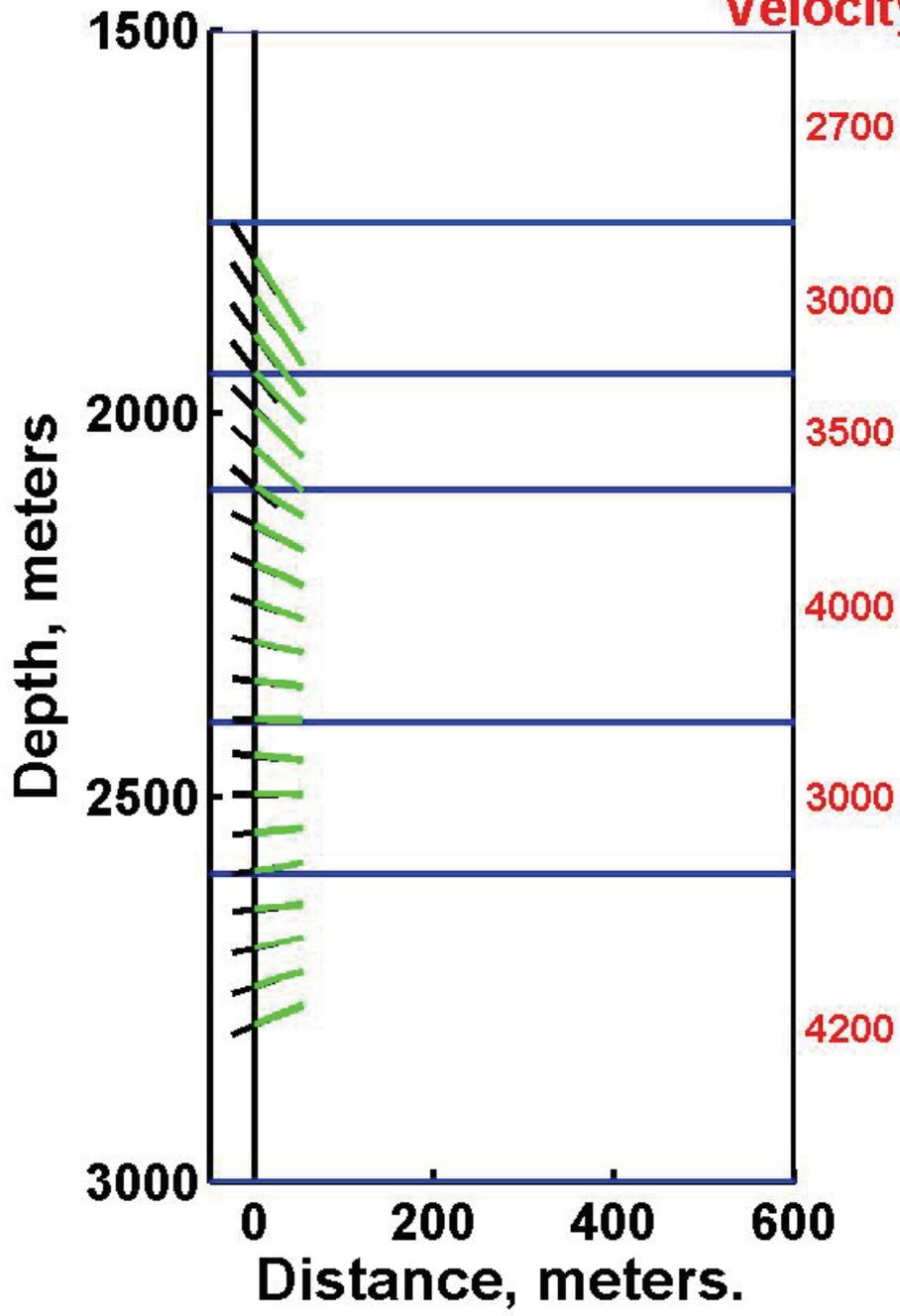
Velocity, m/s



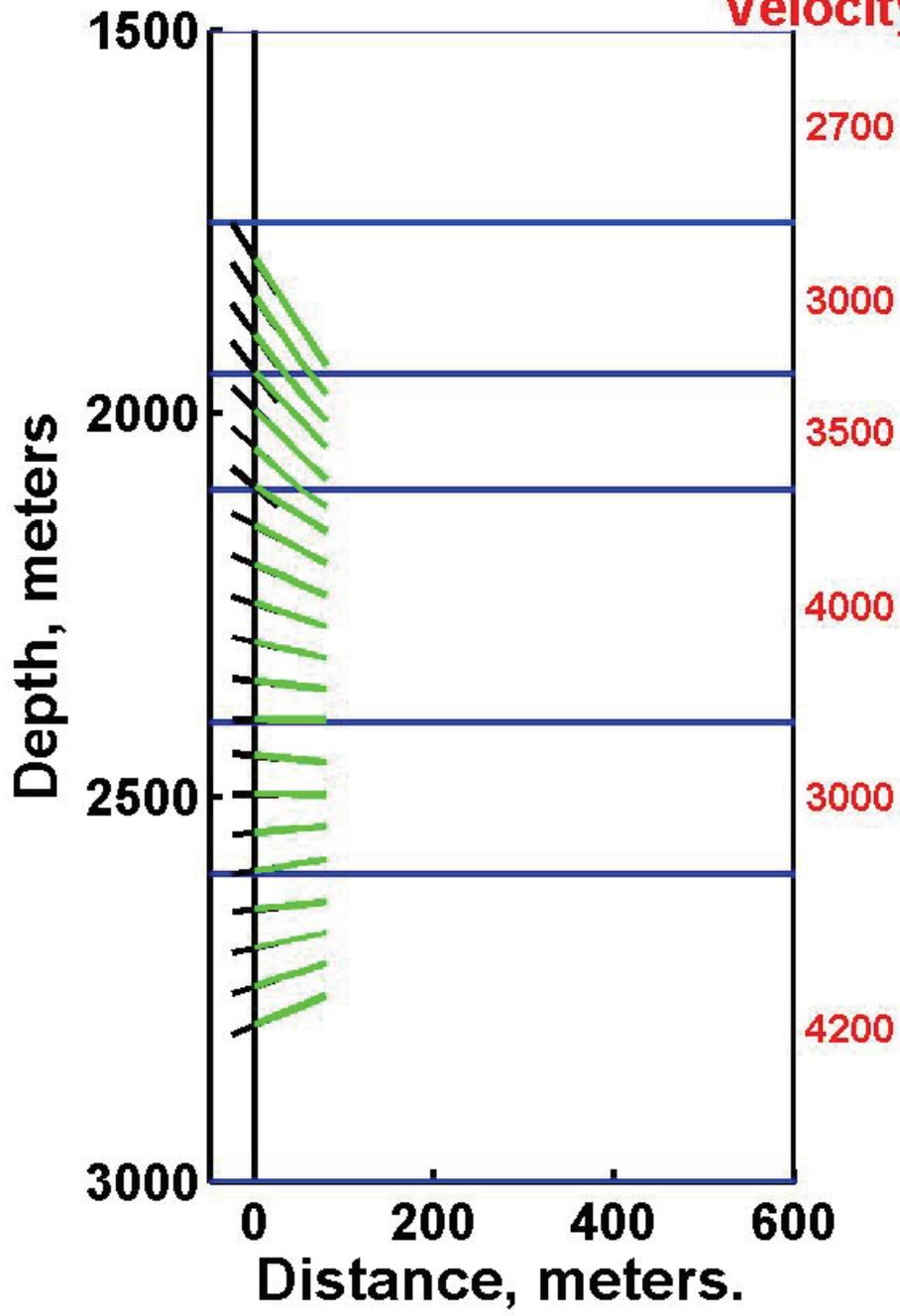
Velocity, m/s



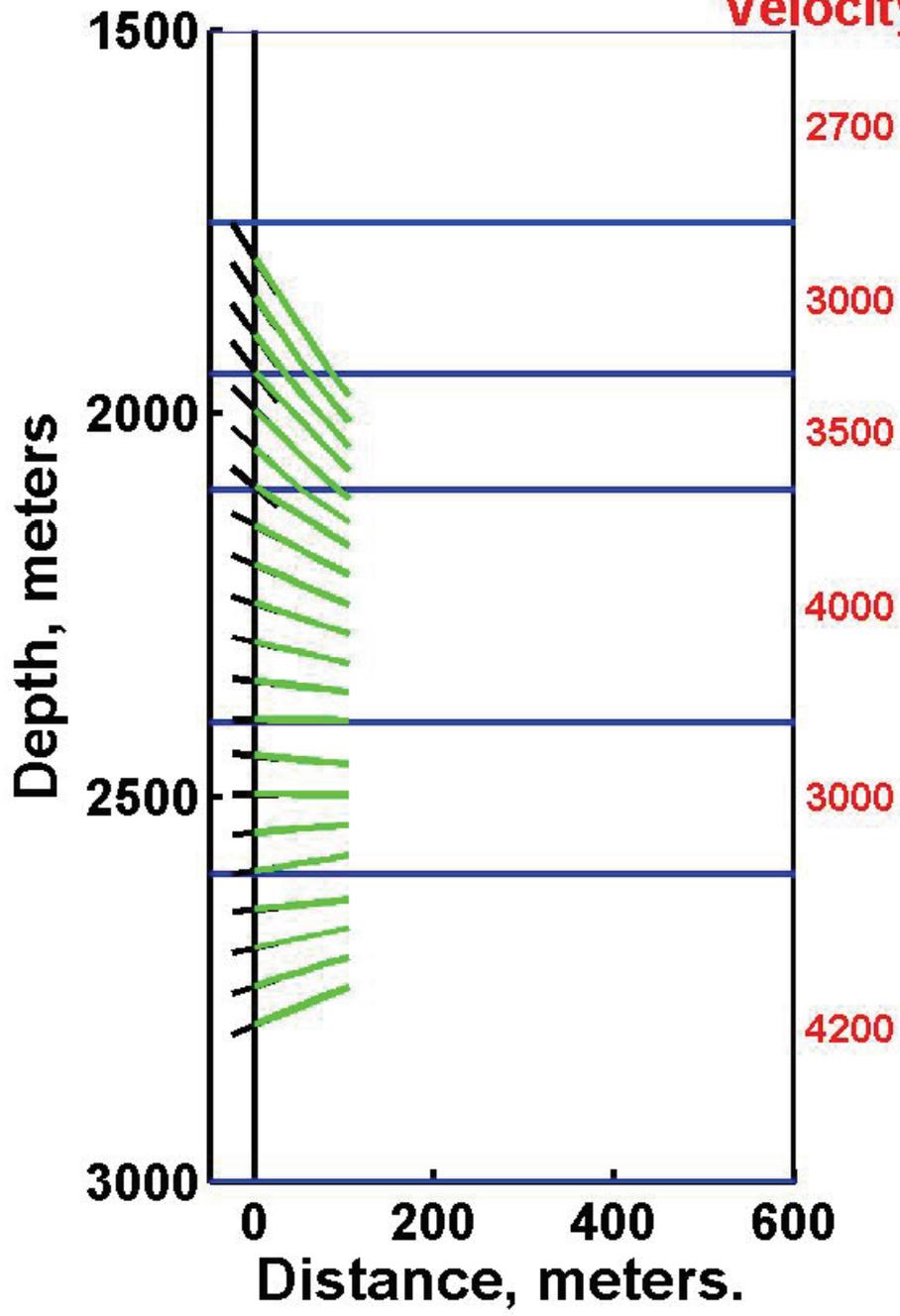
Velocity, m/s



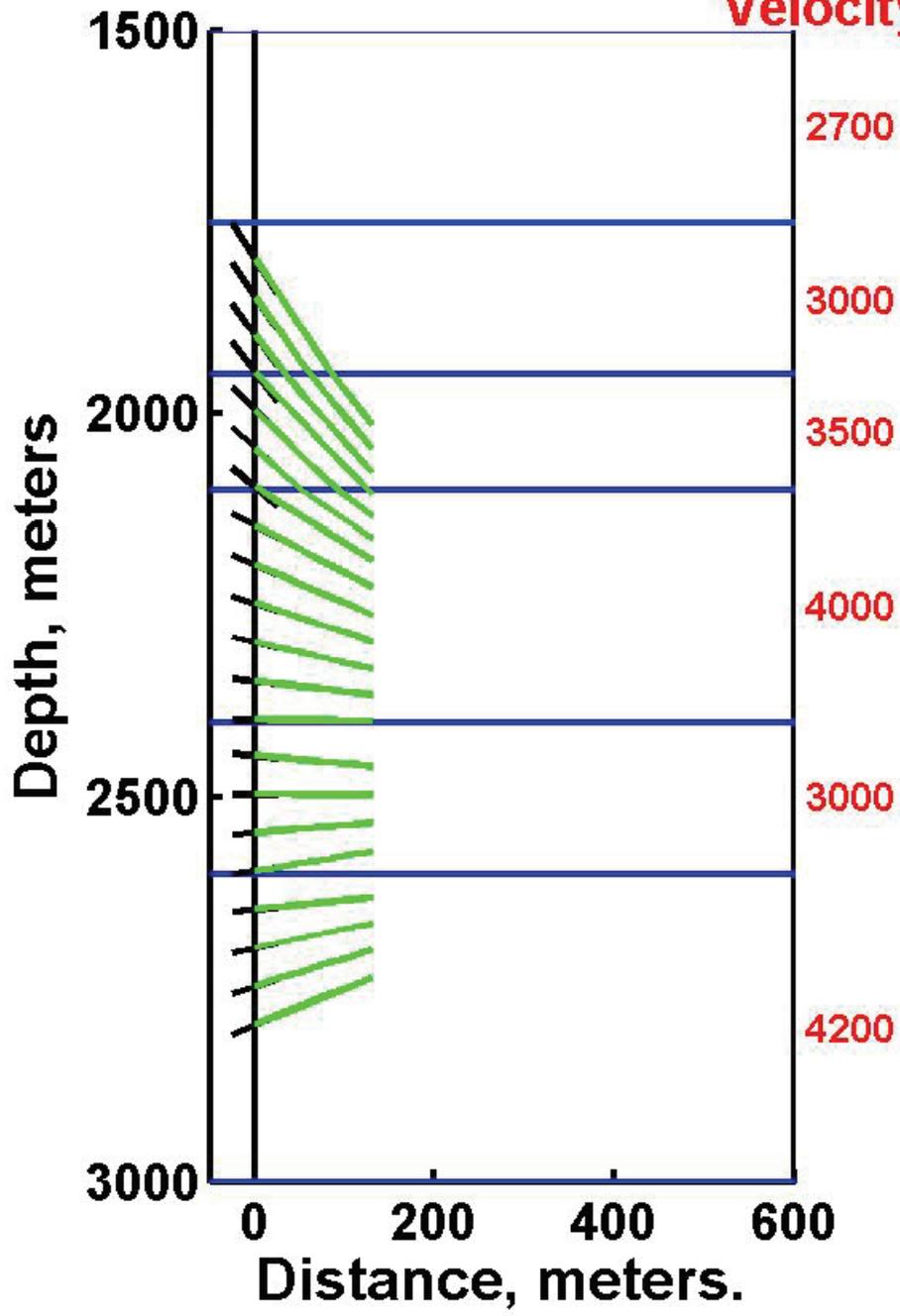
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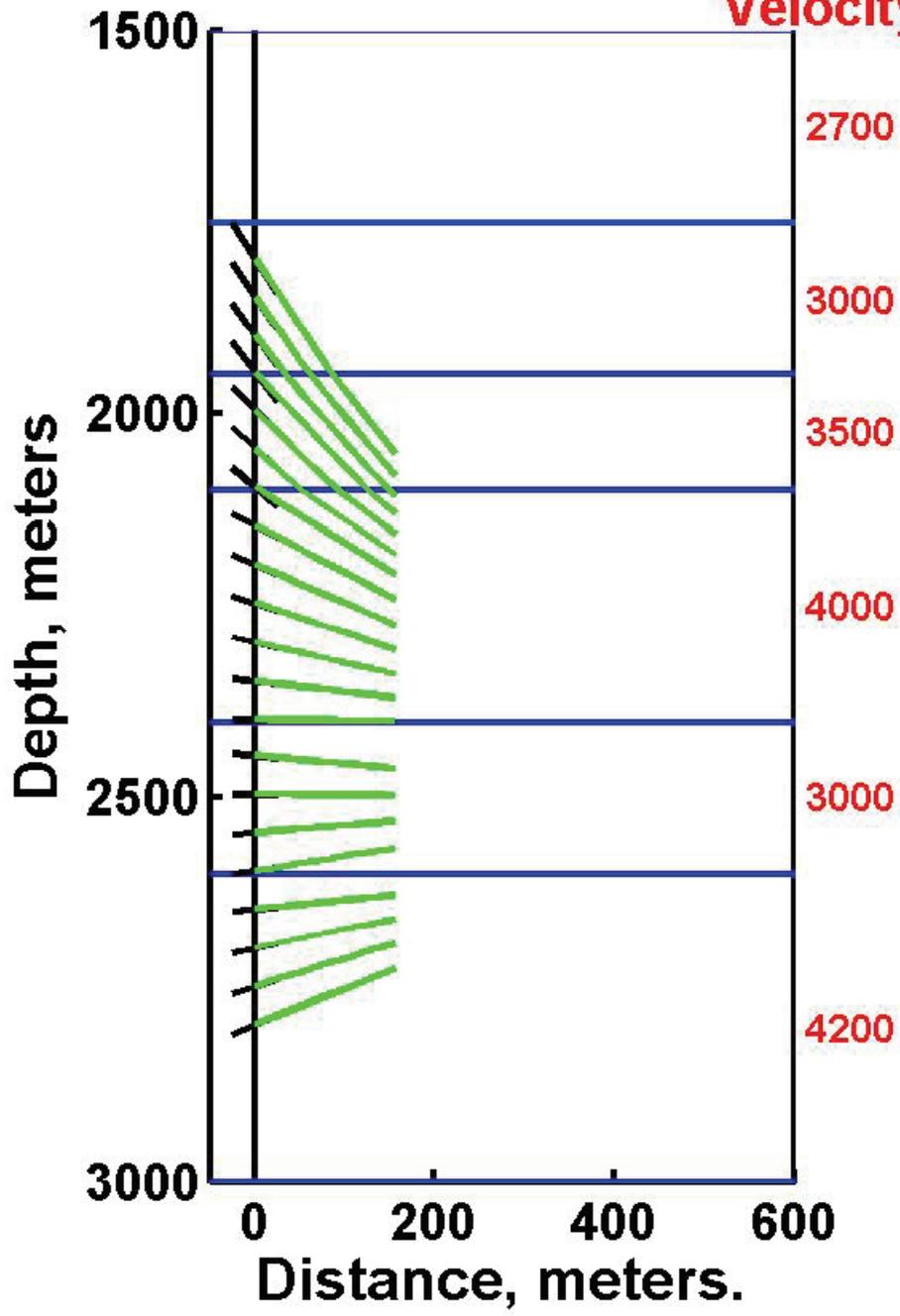
Velocity, m/s



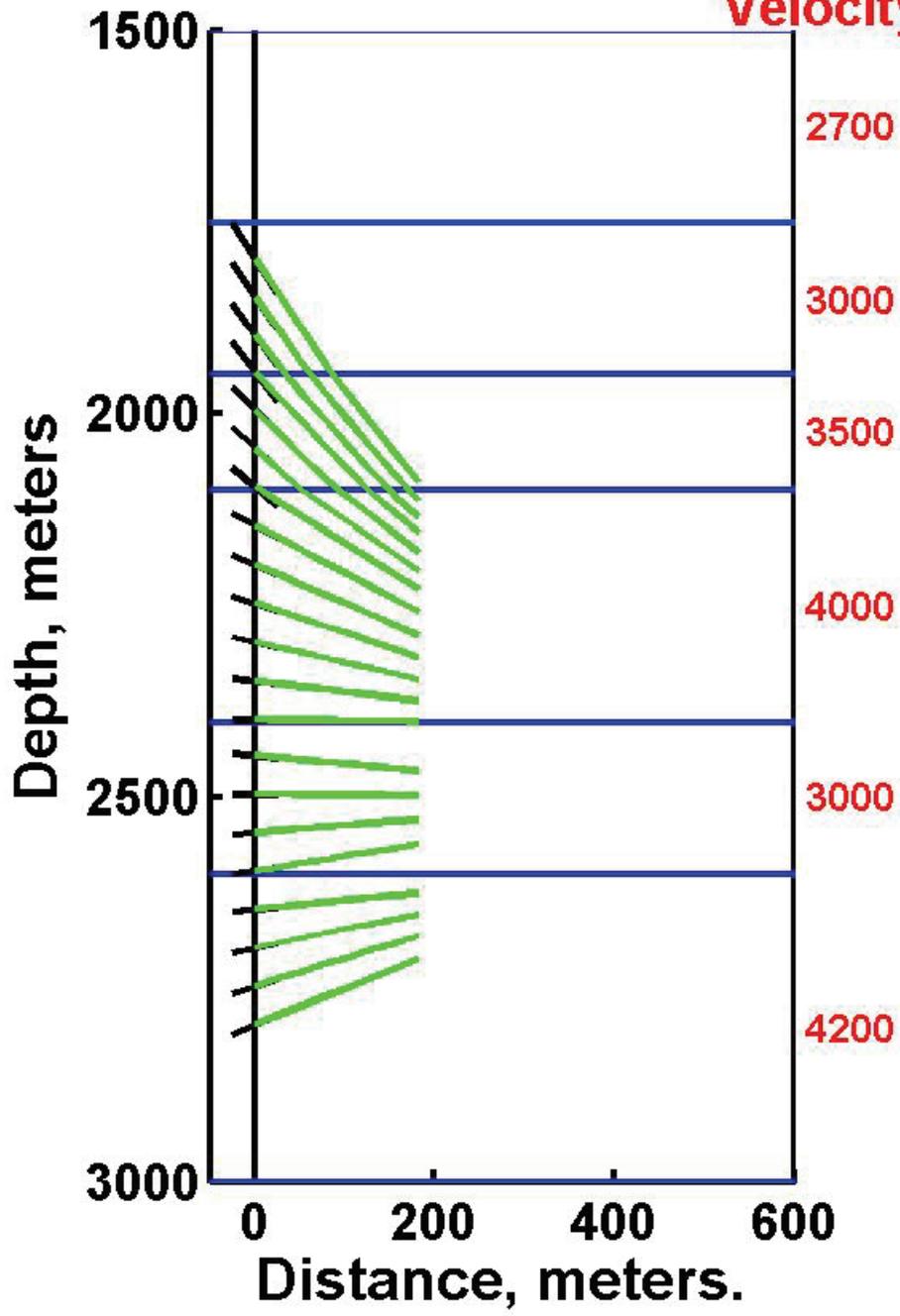
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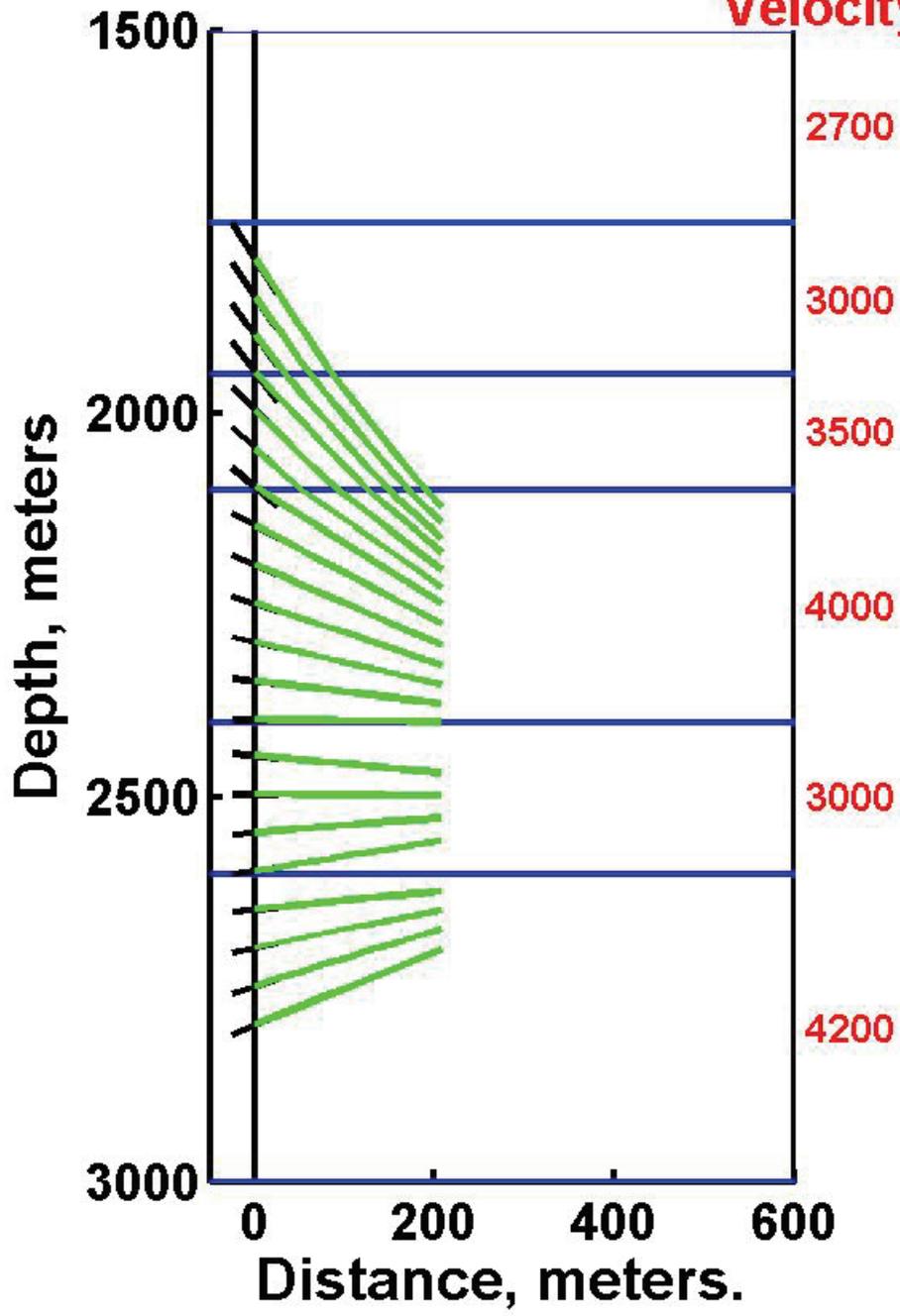
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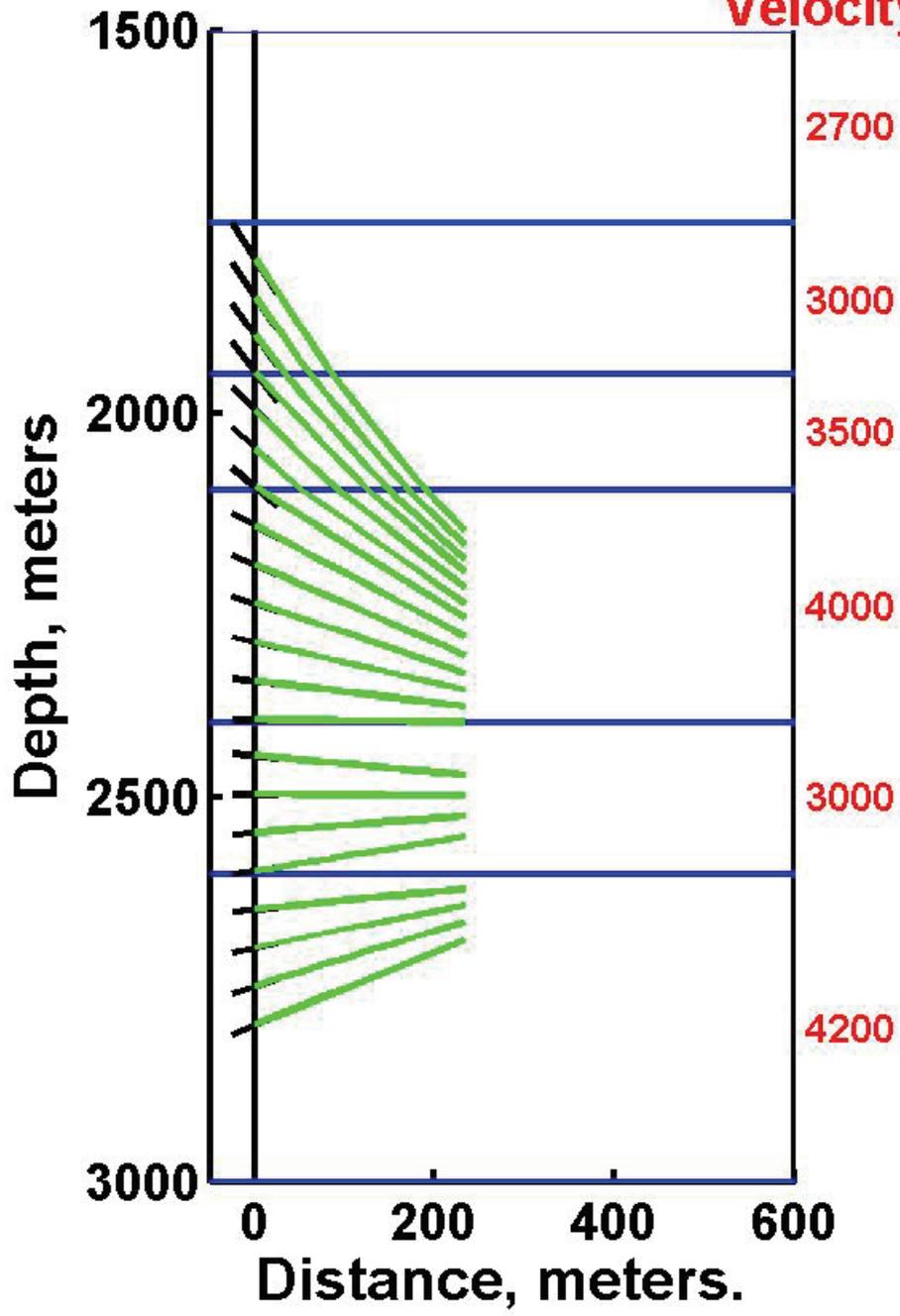
Velocity, m/s



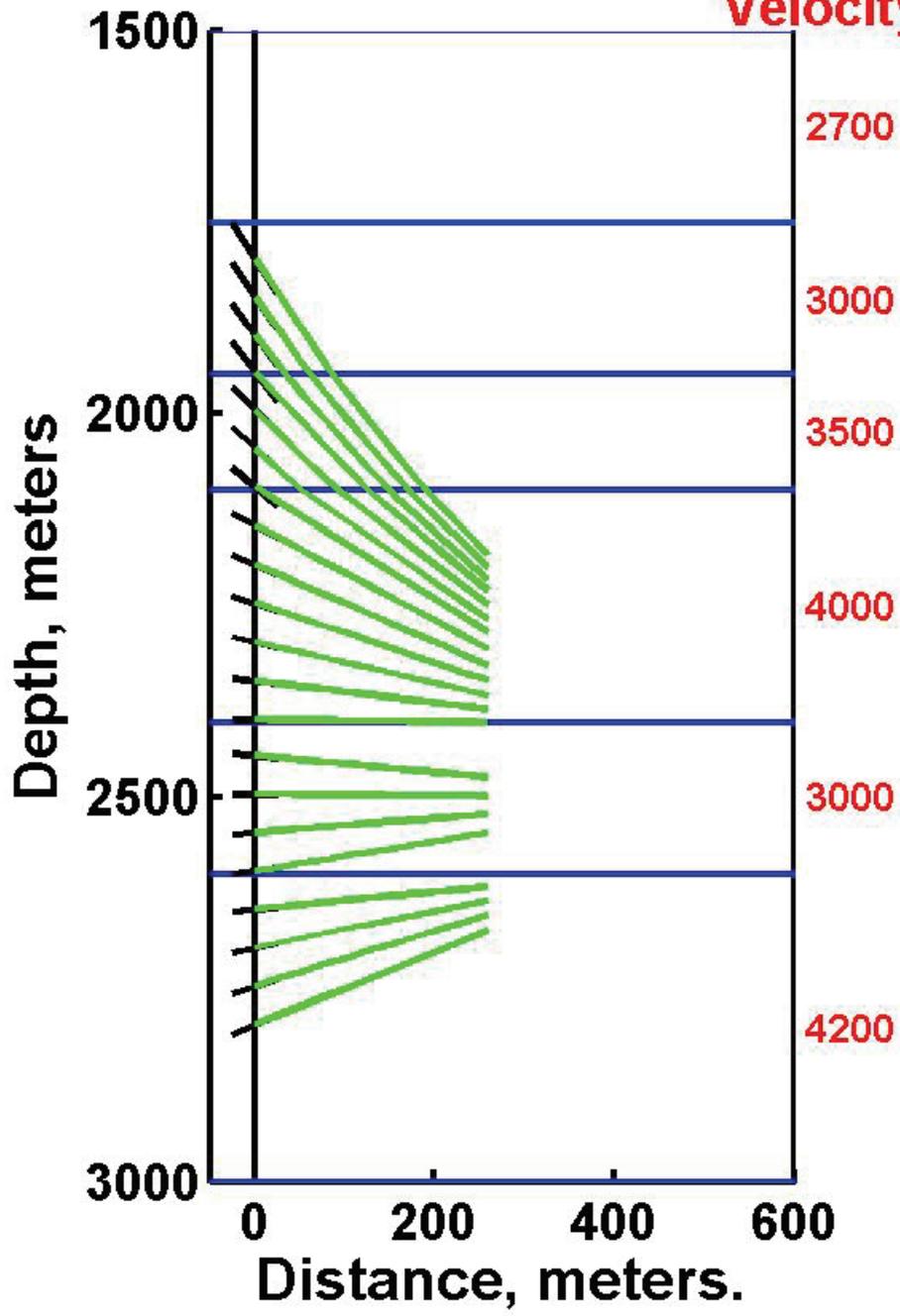
Velocity, m/s



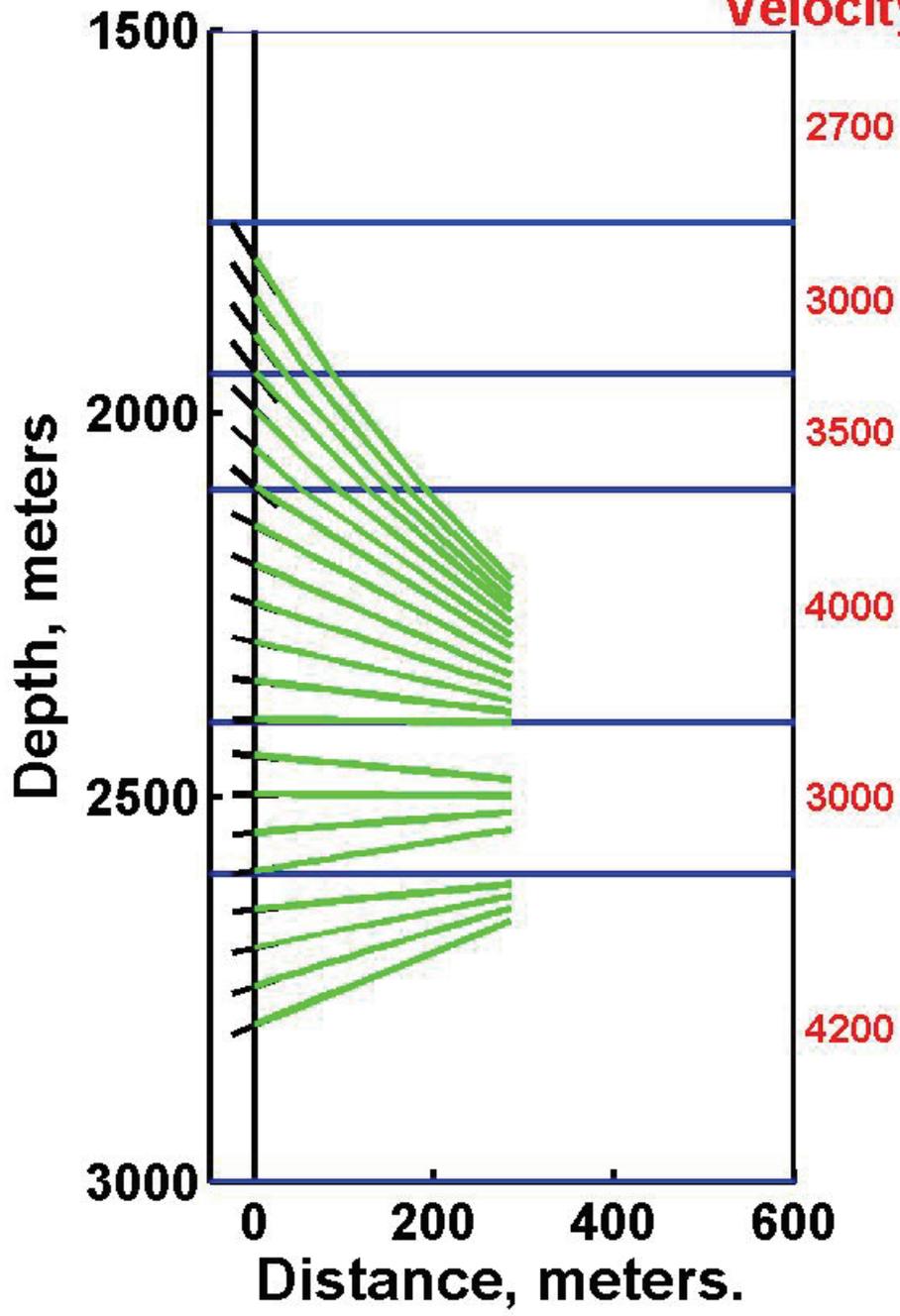
Velocity, m/s



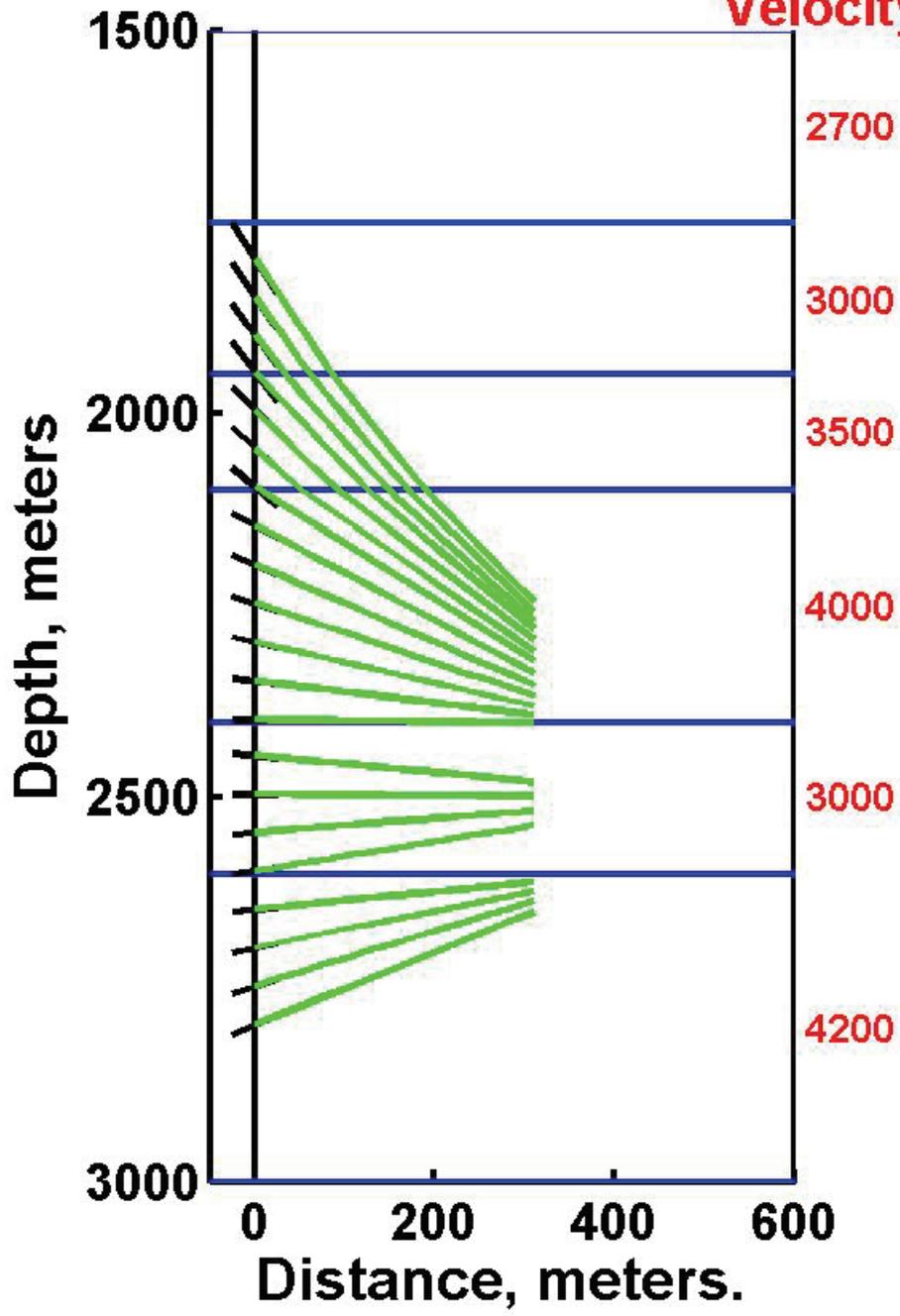
Velocity, m/s



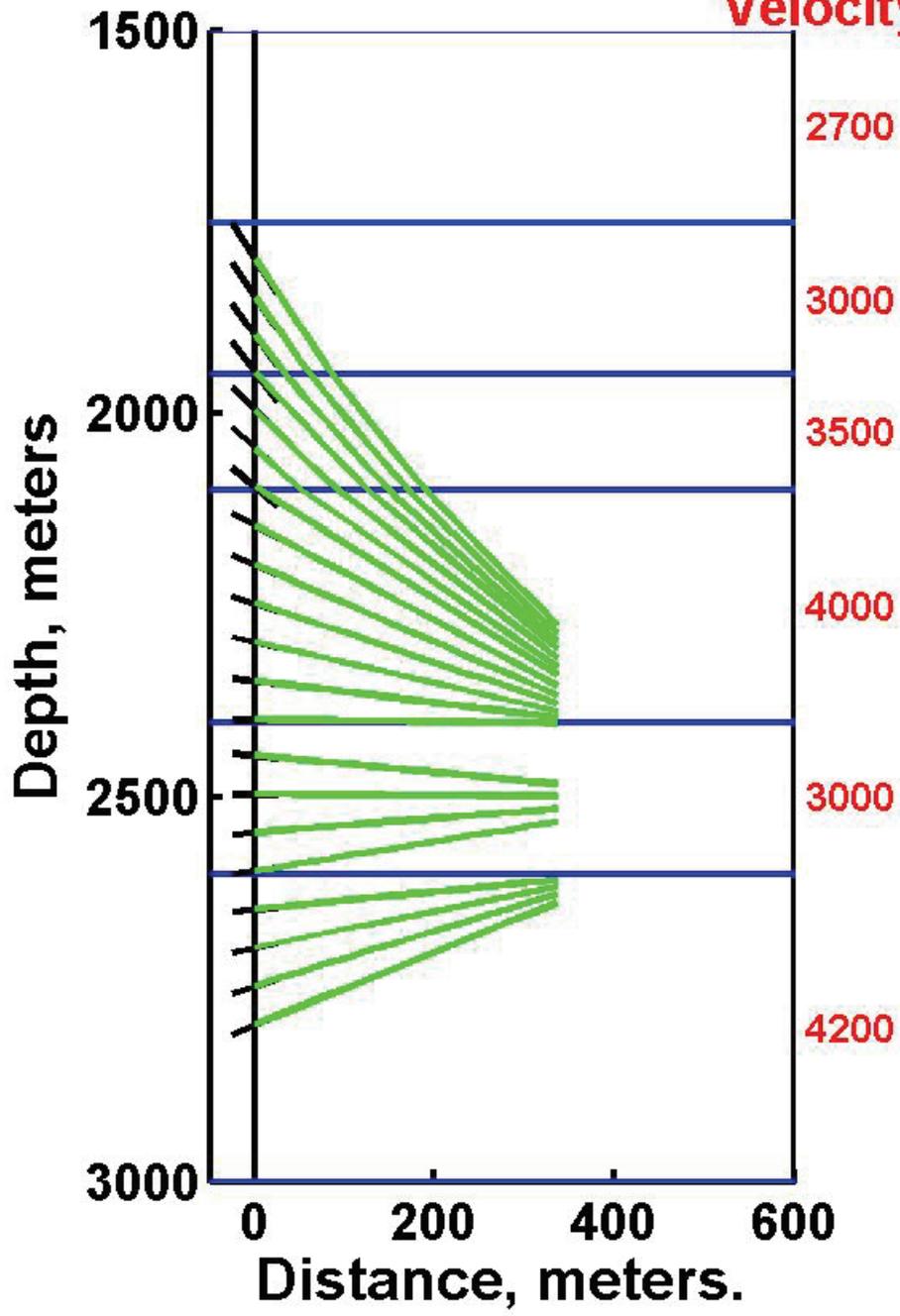
Velocity, m/s



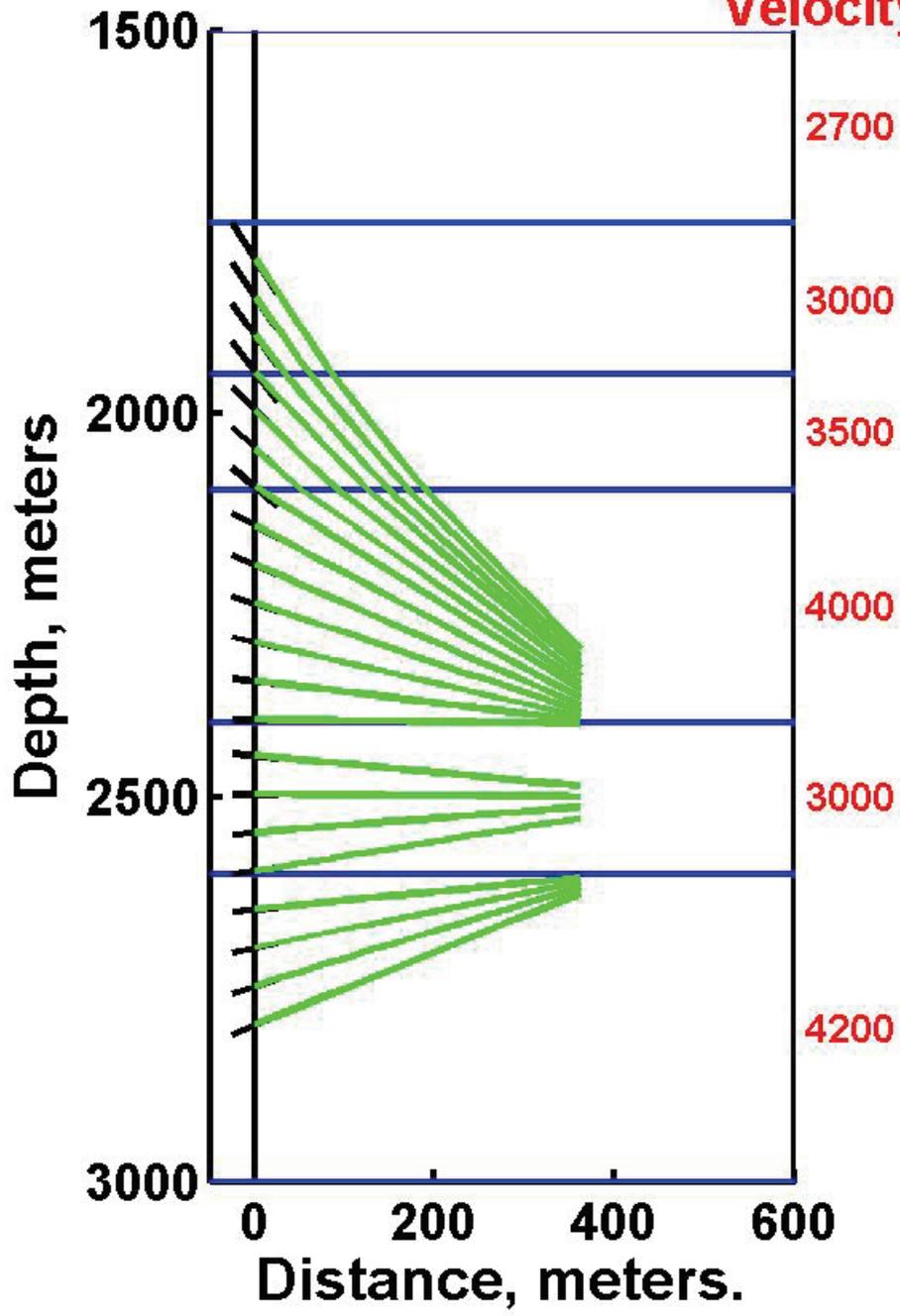
Velocity, m/s



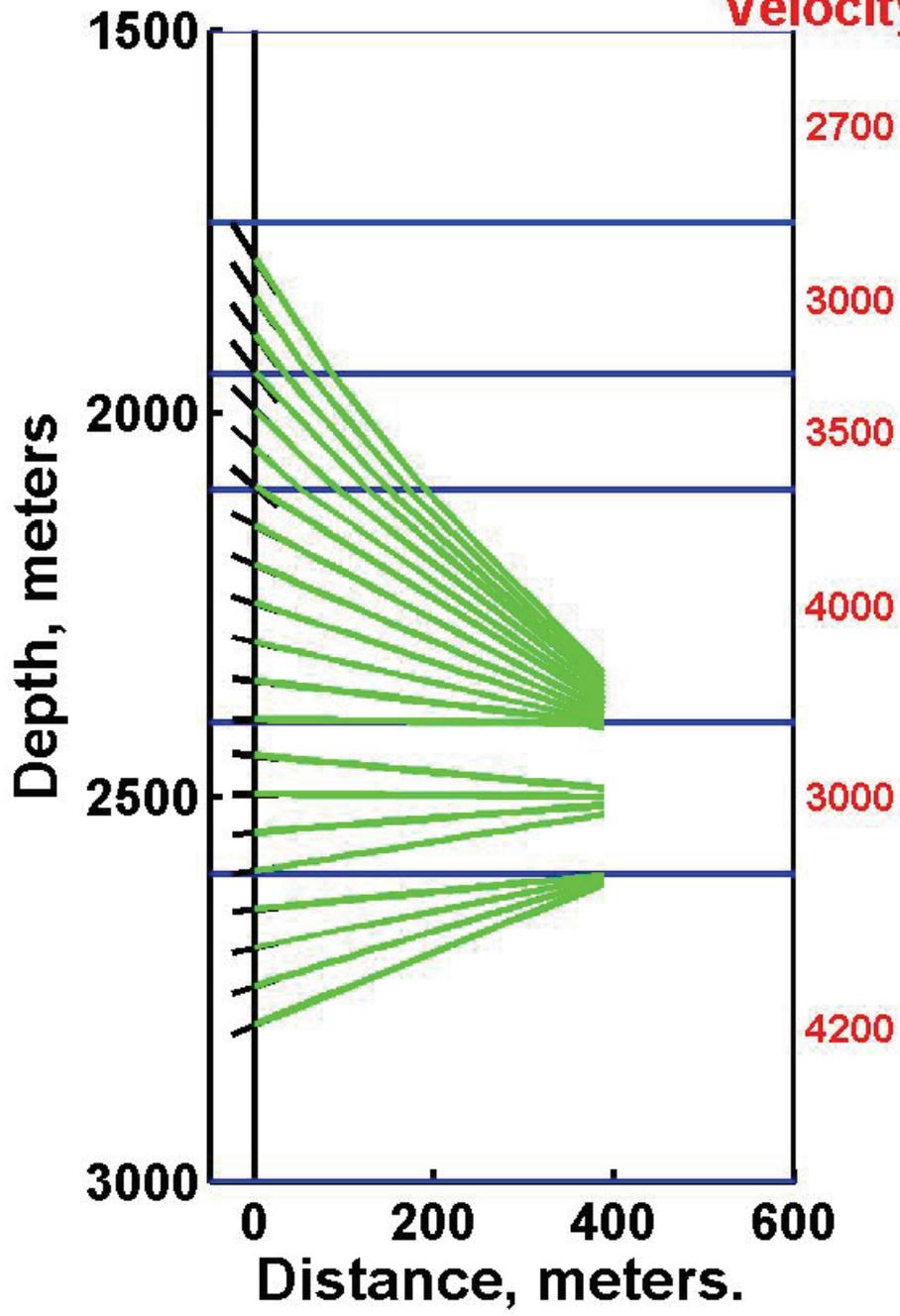
Velocity, m/s



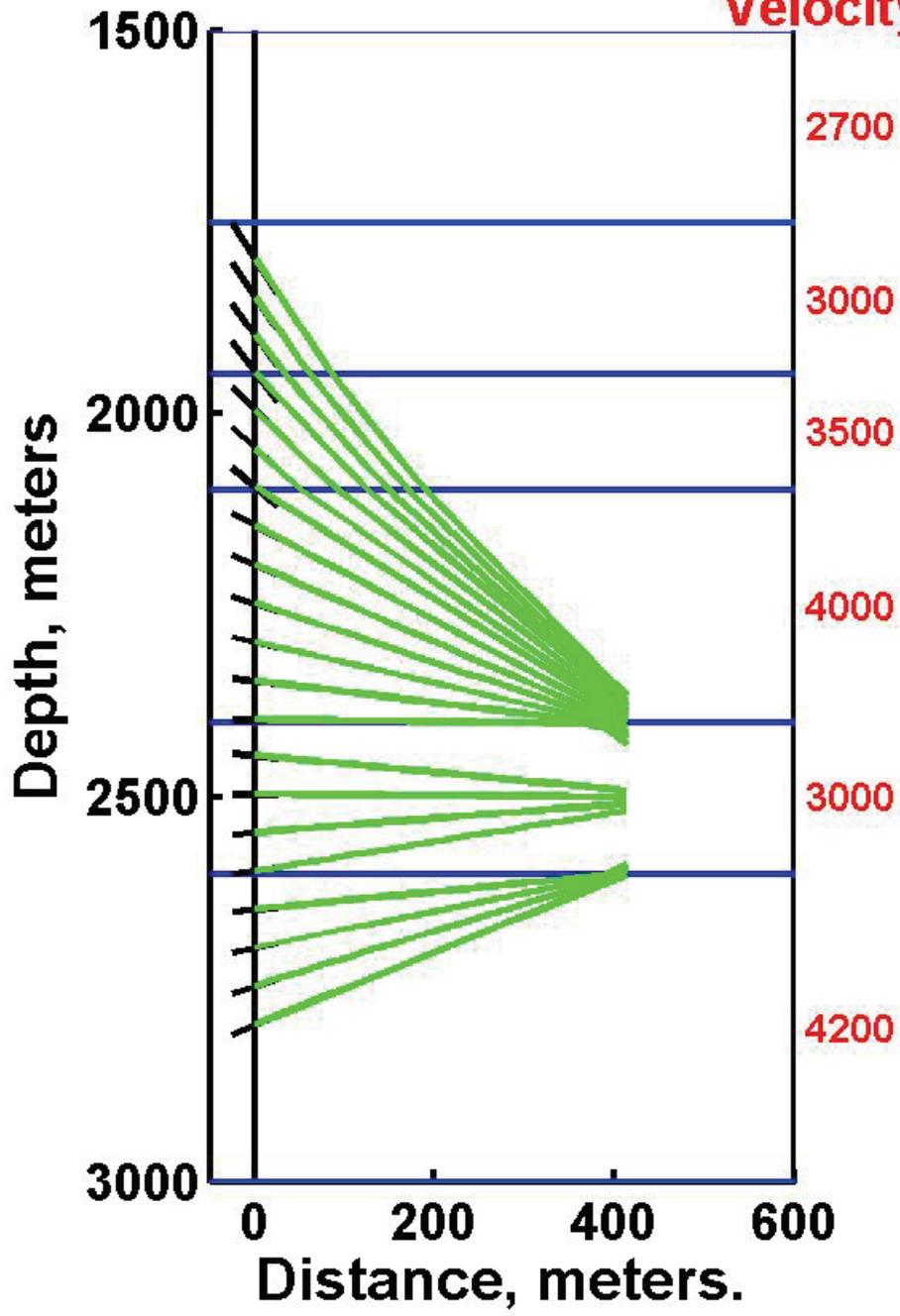
Velocity, m/s



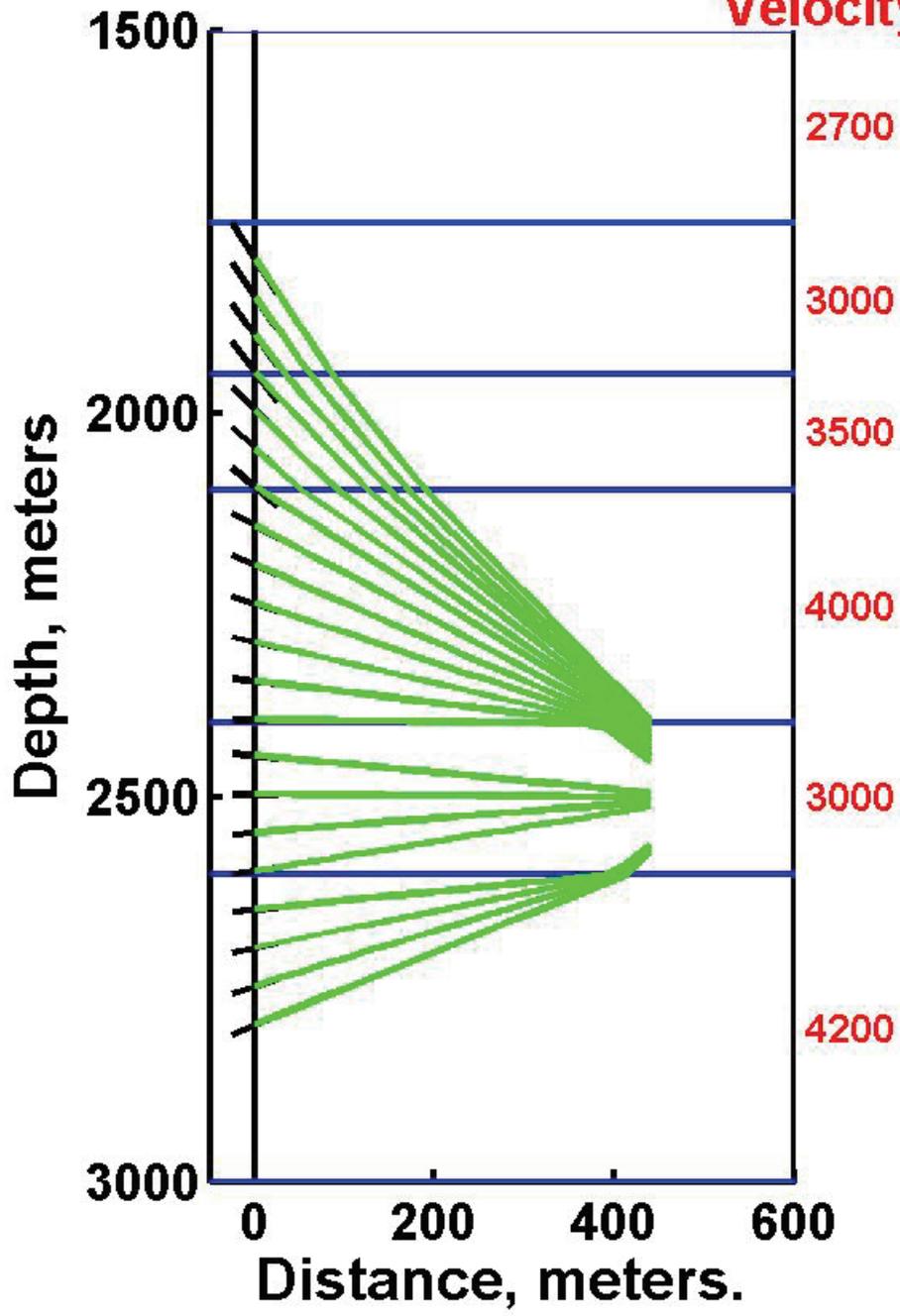
Velocity, m/s



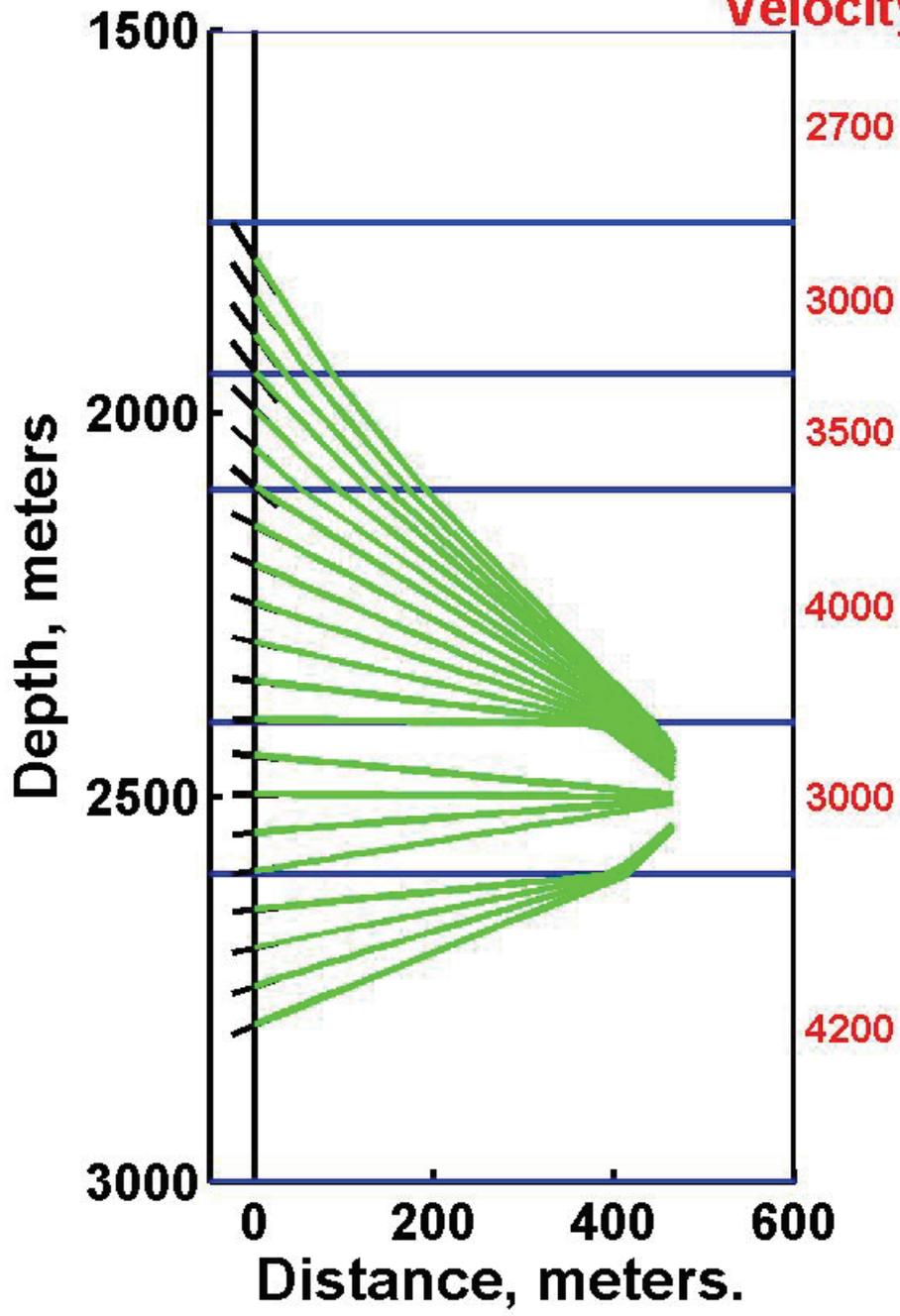
Velocity, m/s



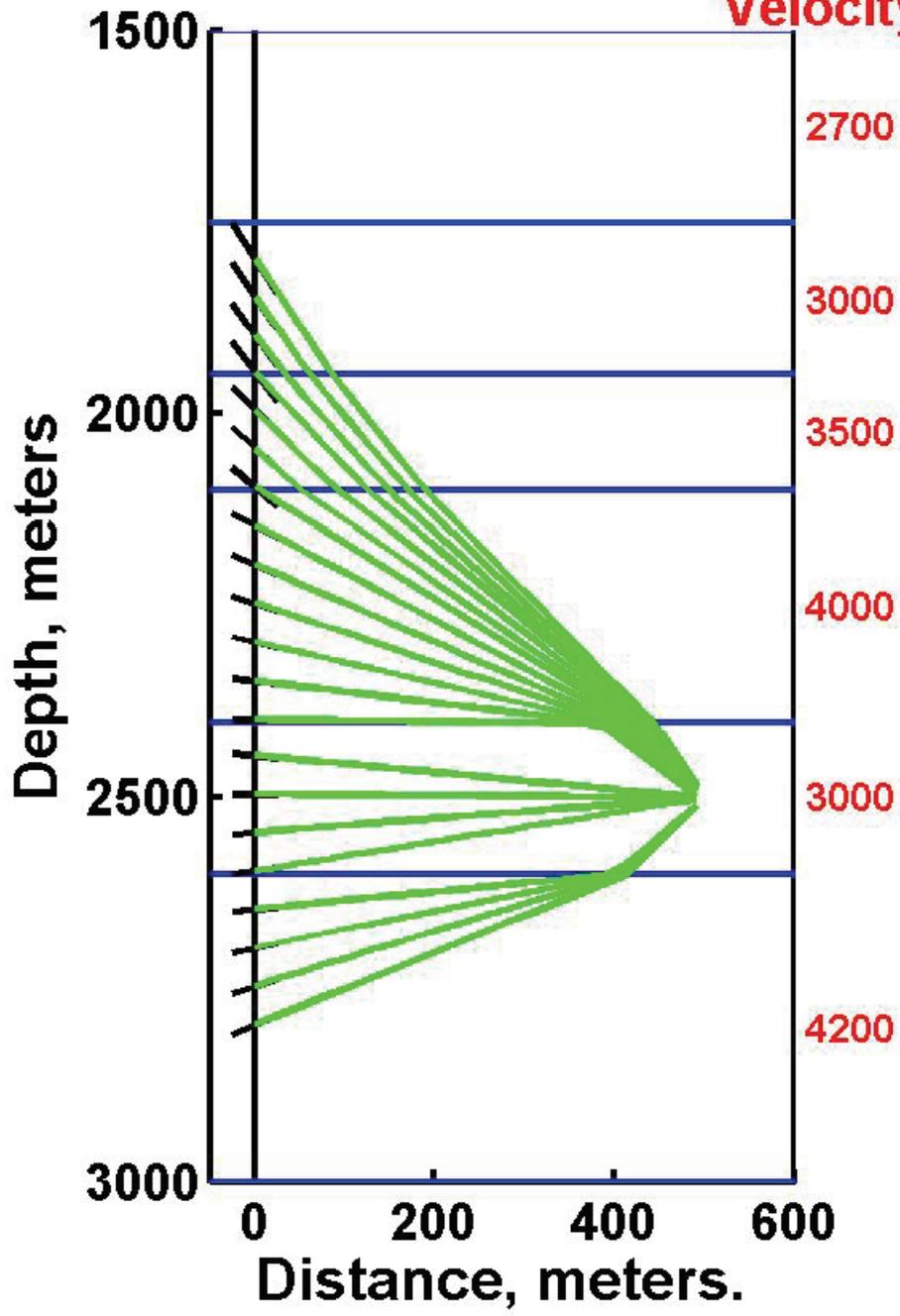
Velocity, m/s



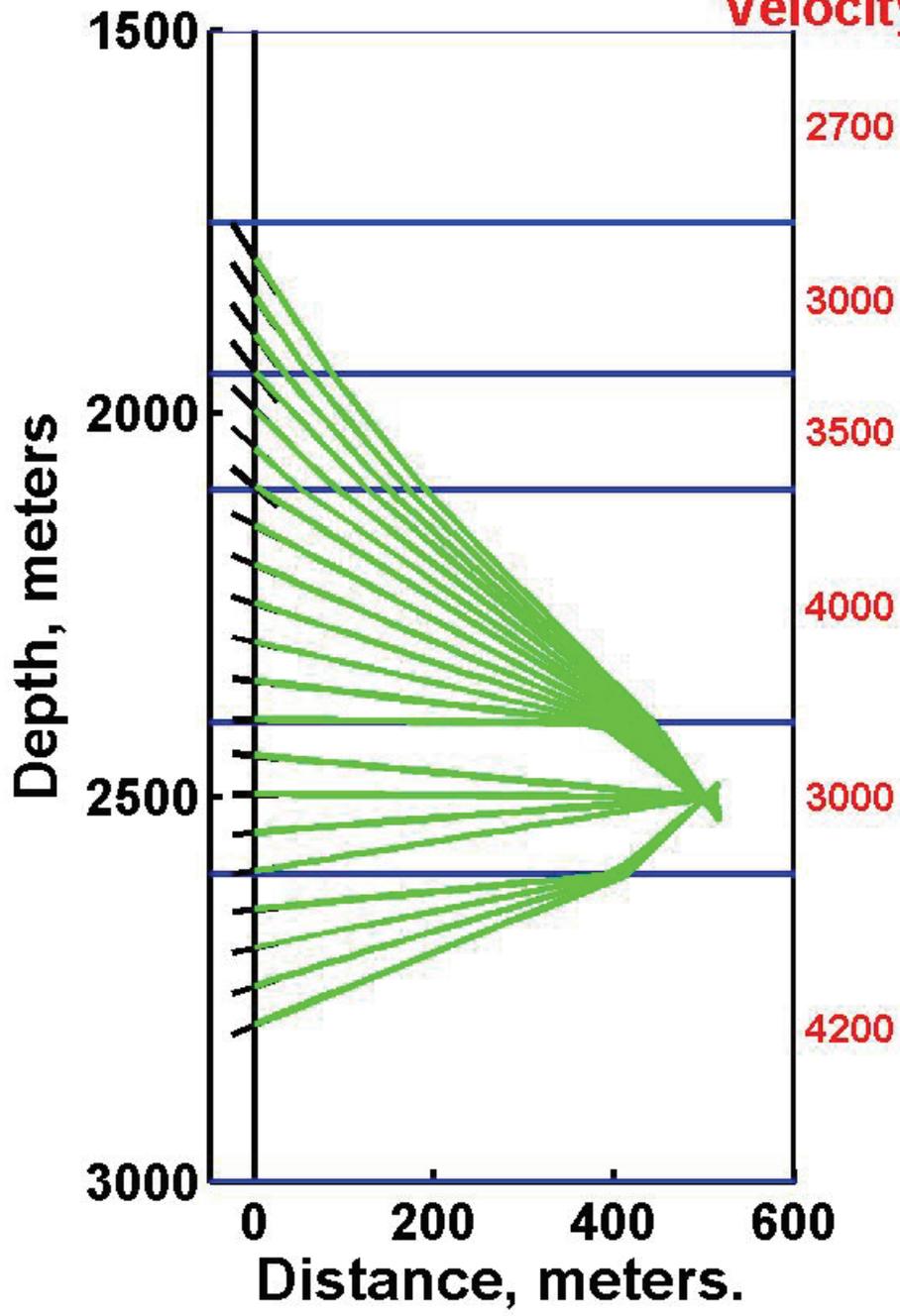
Velocity, m/s



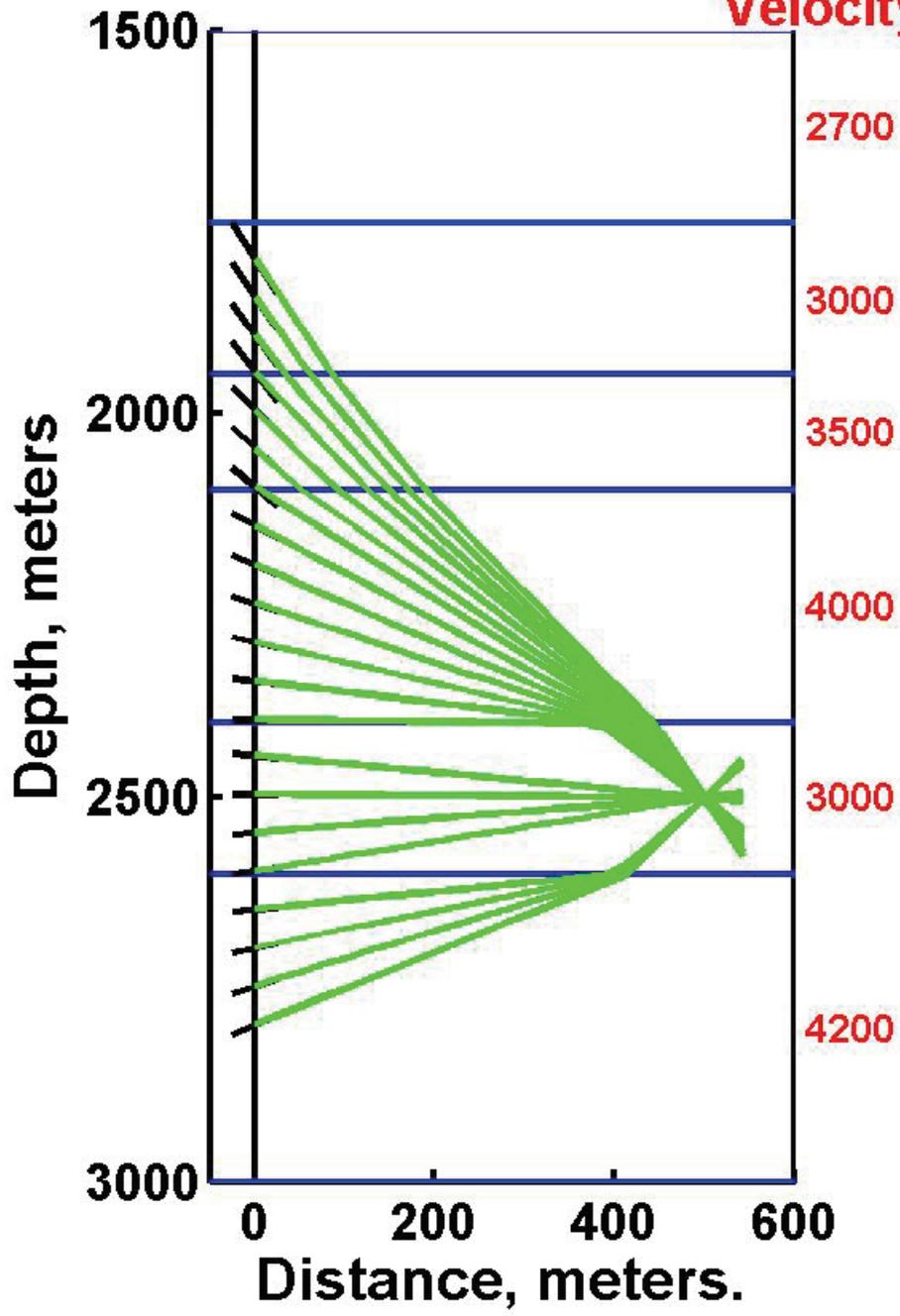
Velocity, m/s



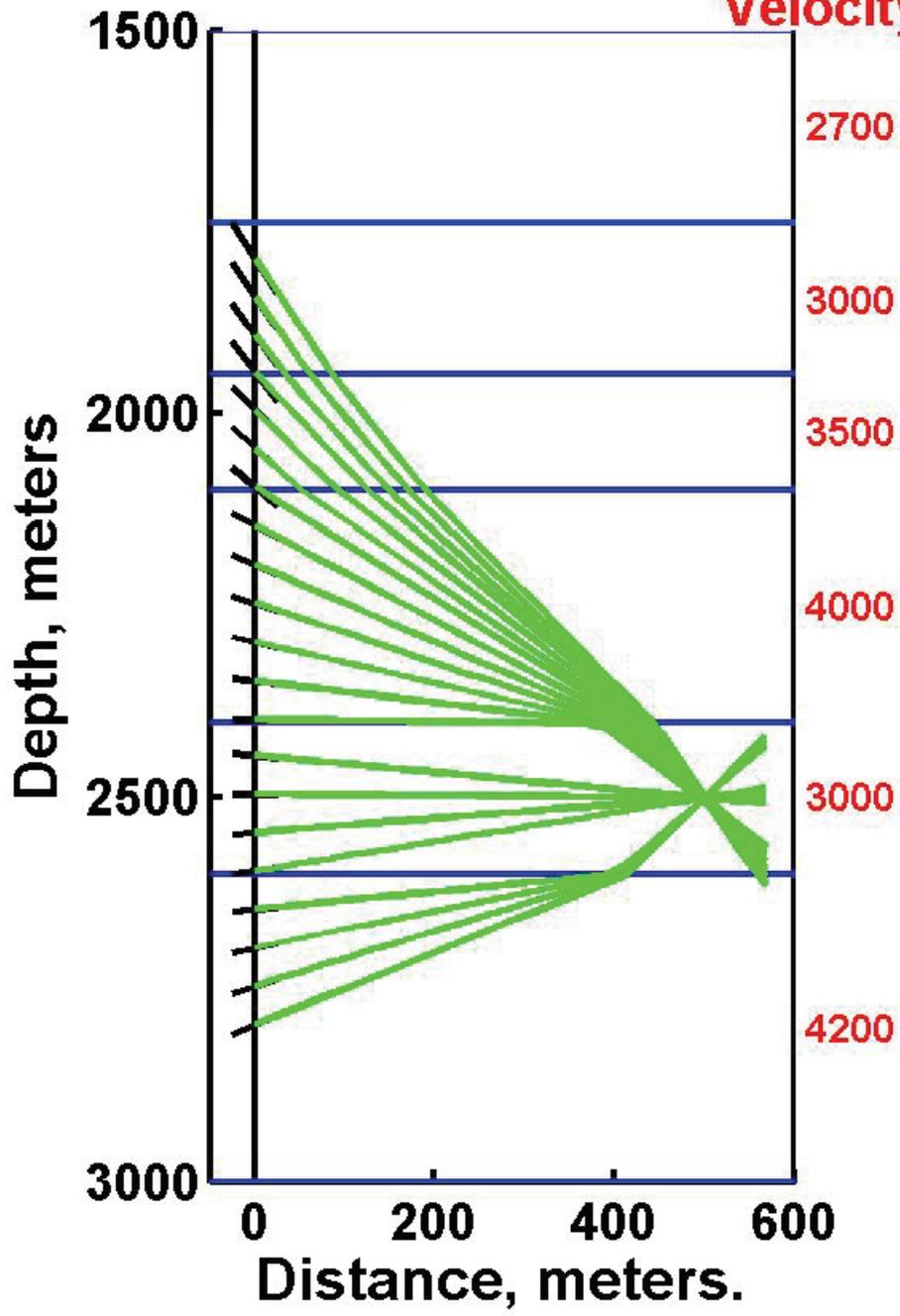
Velocity, m/s



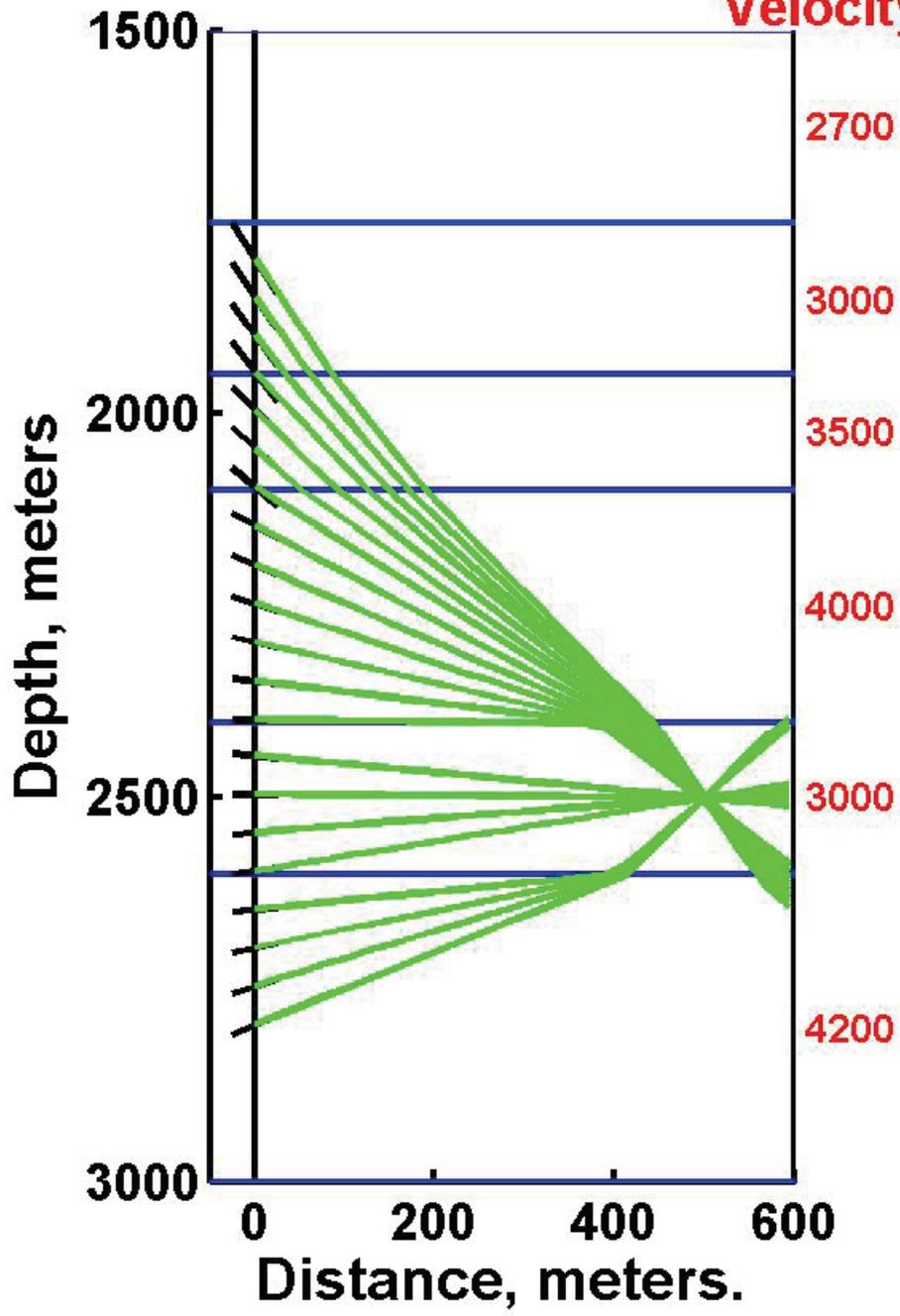
Velocity, m/s



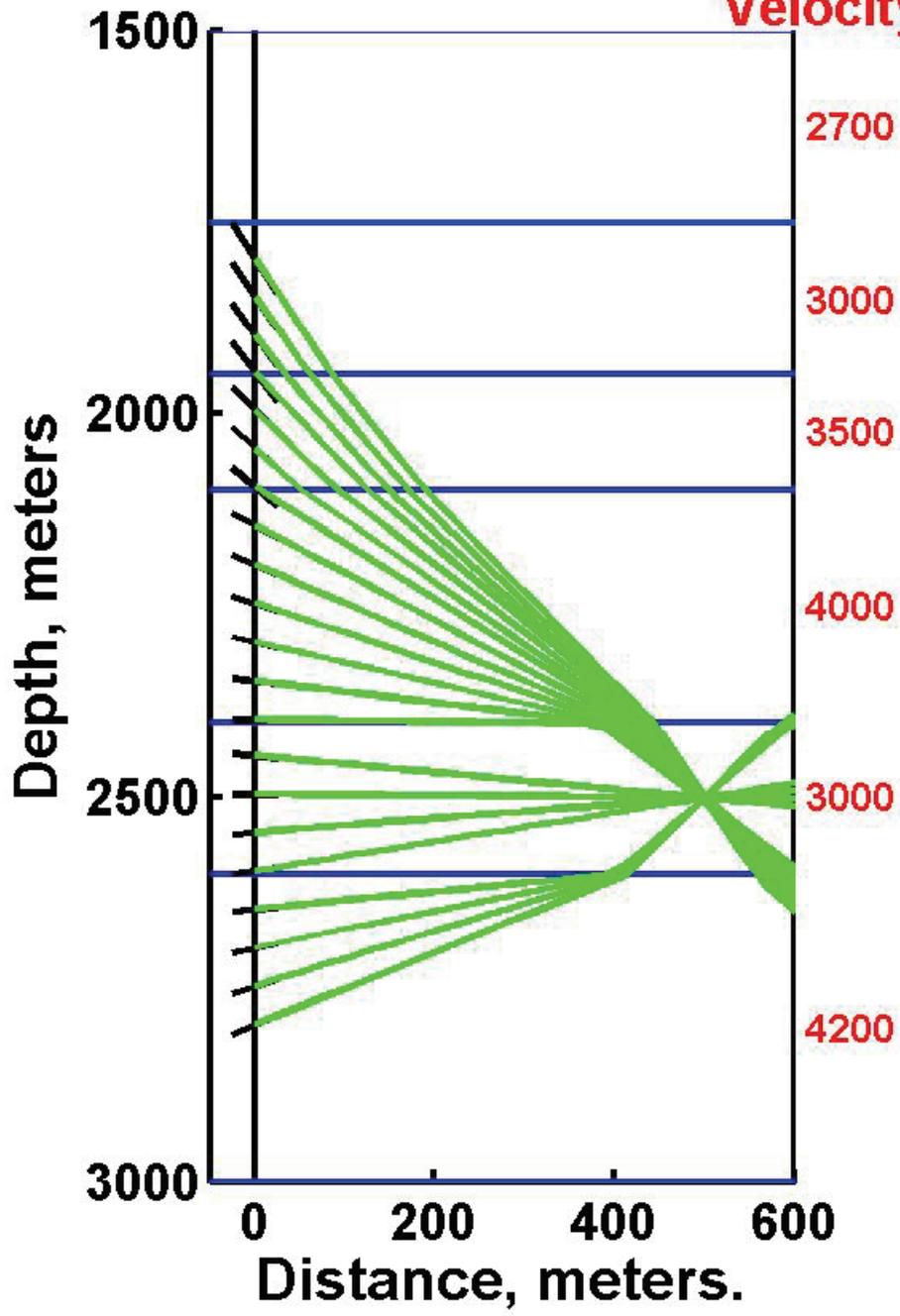
Velocity, m/s

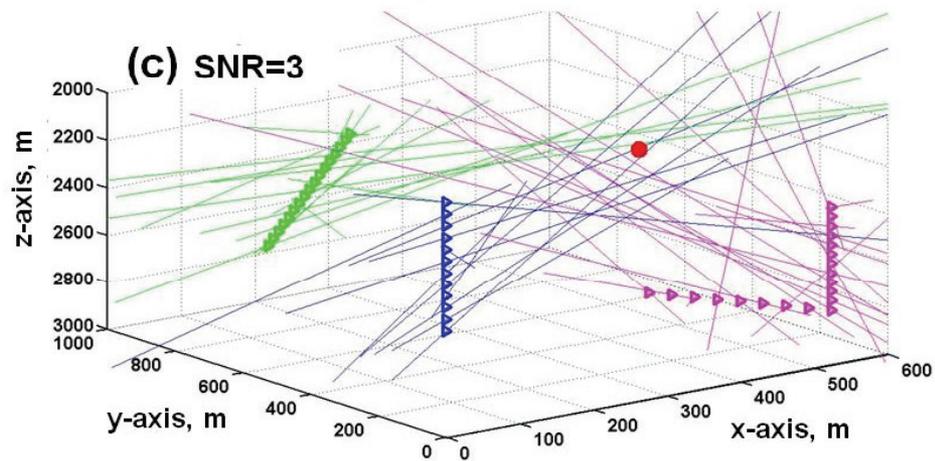
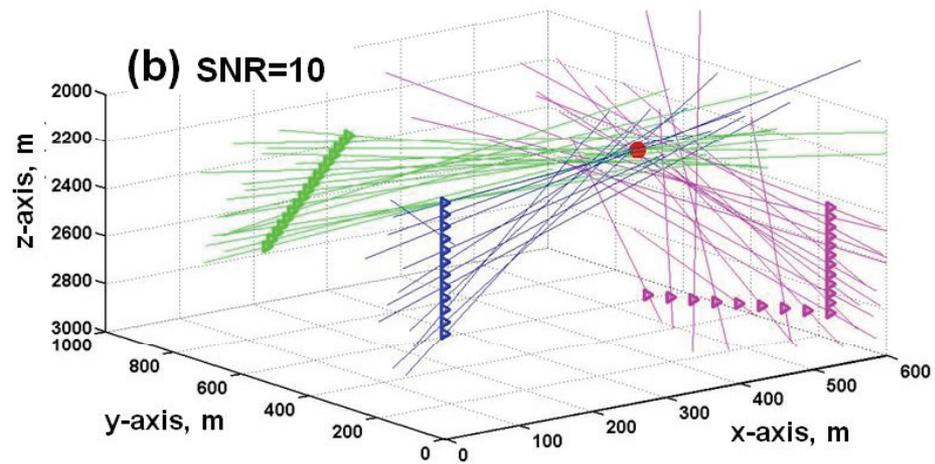
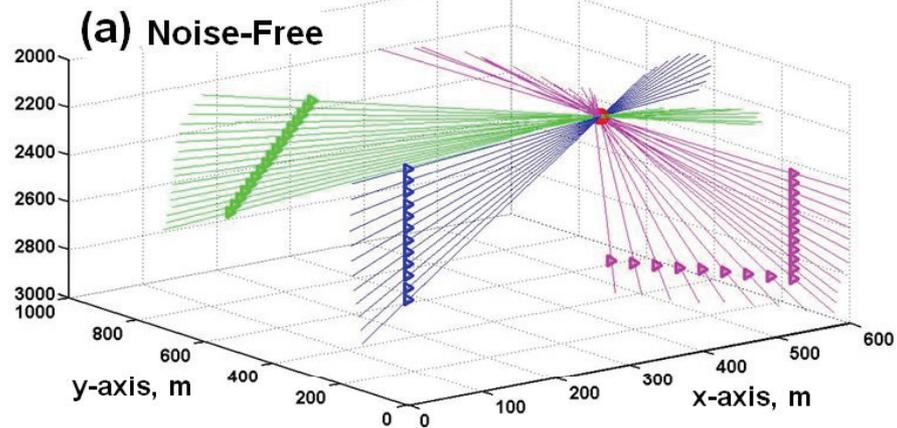


Velocity, m/s

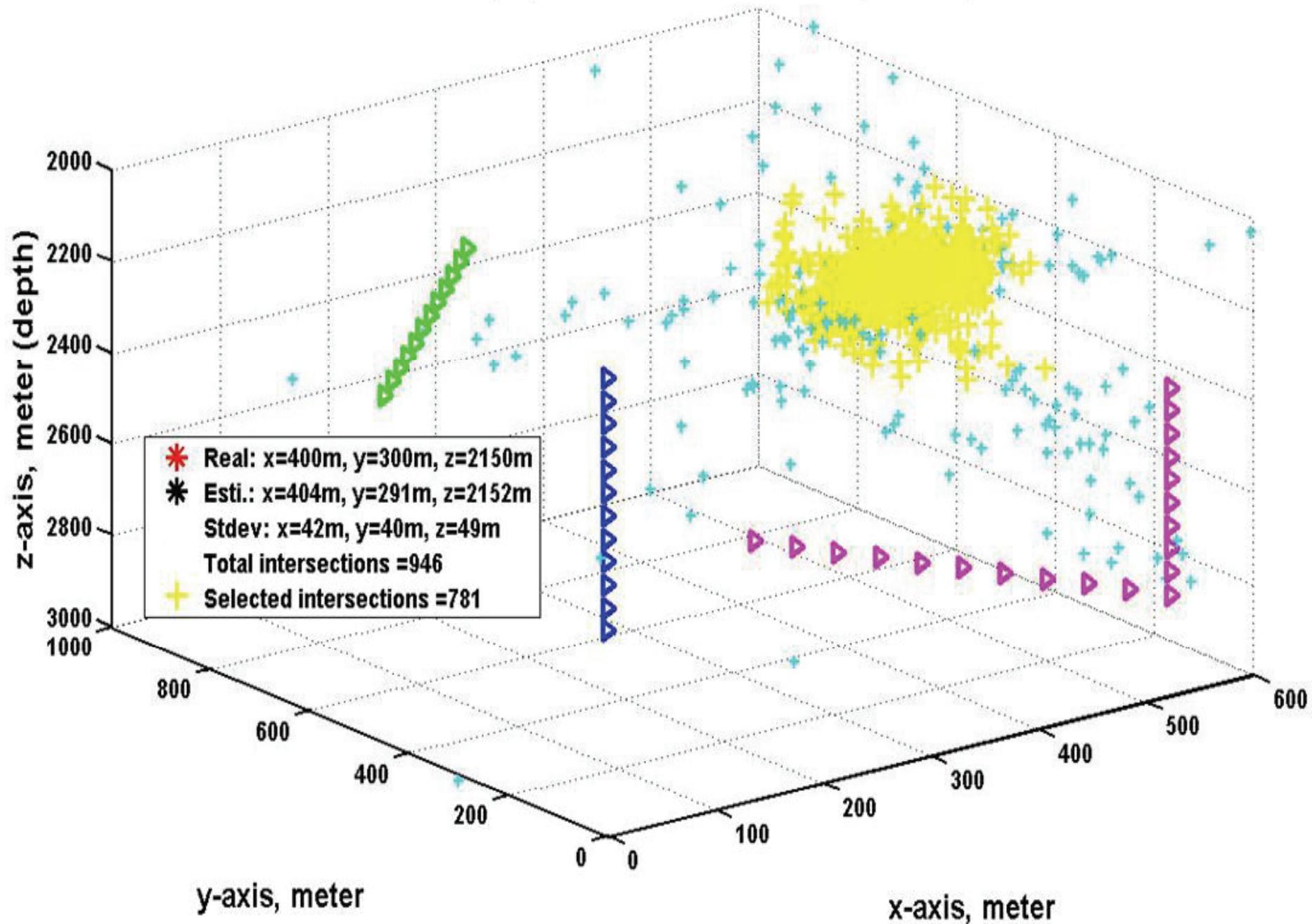


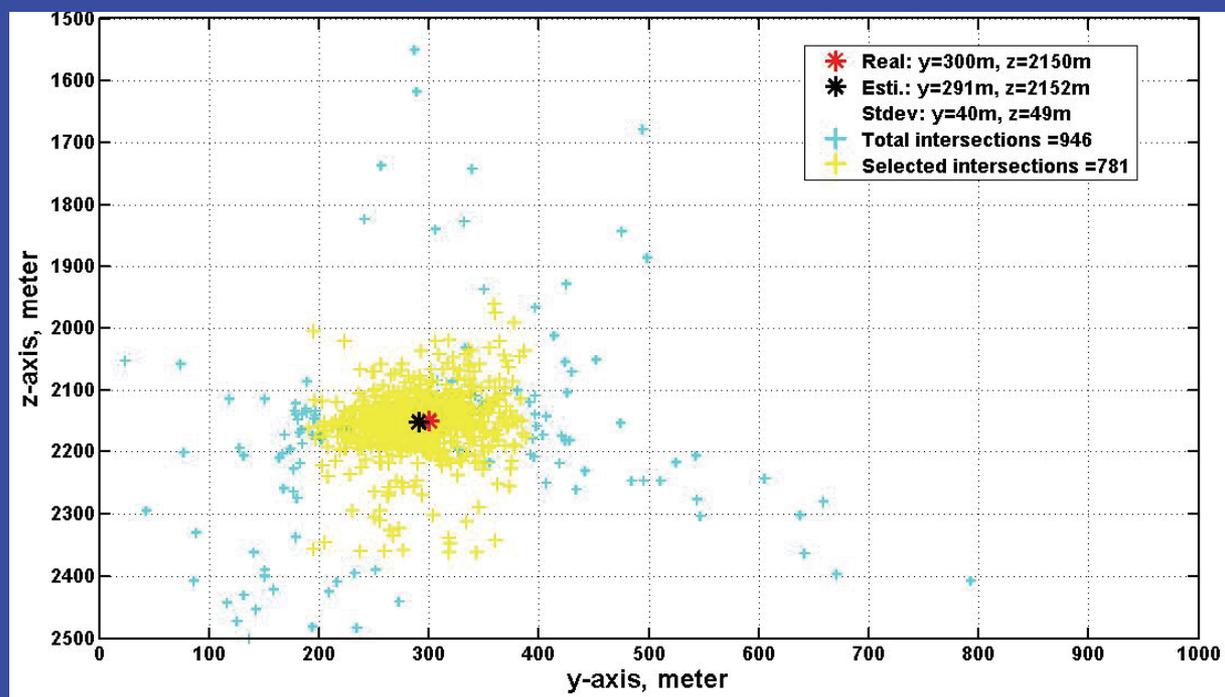
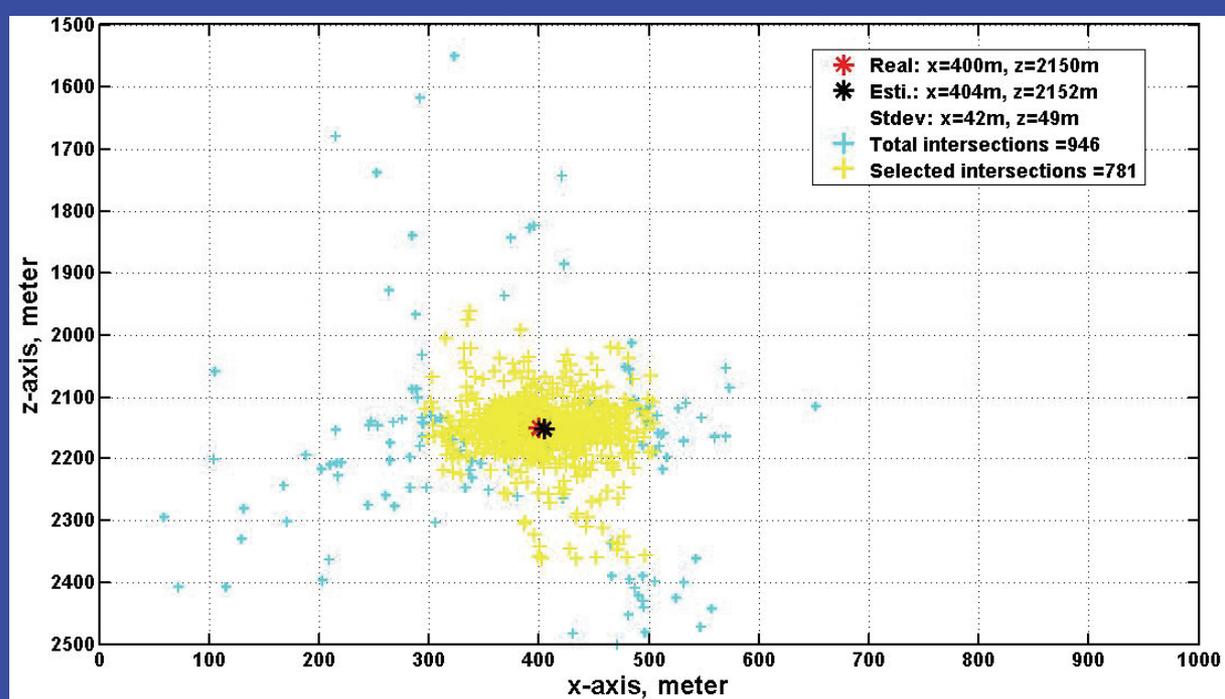
Velocity, m/s



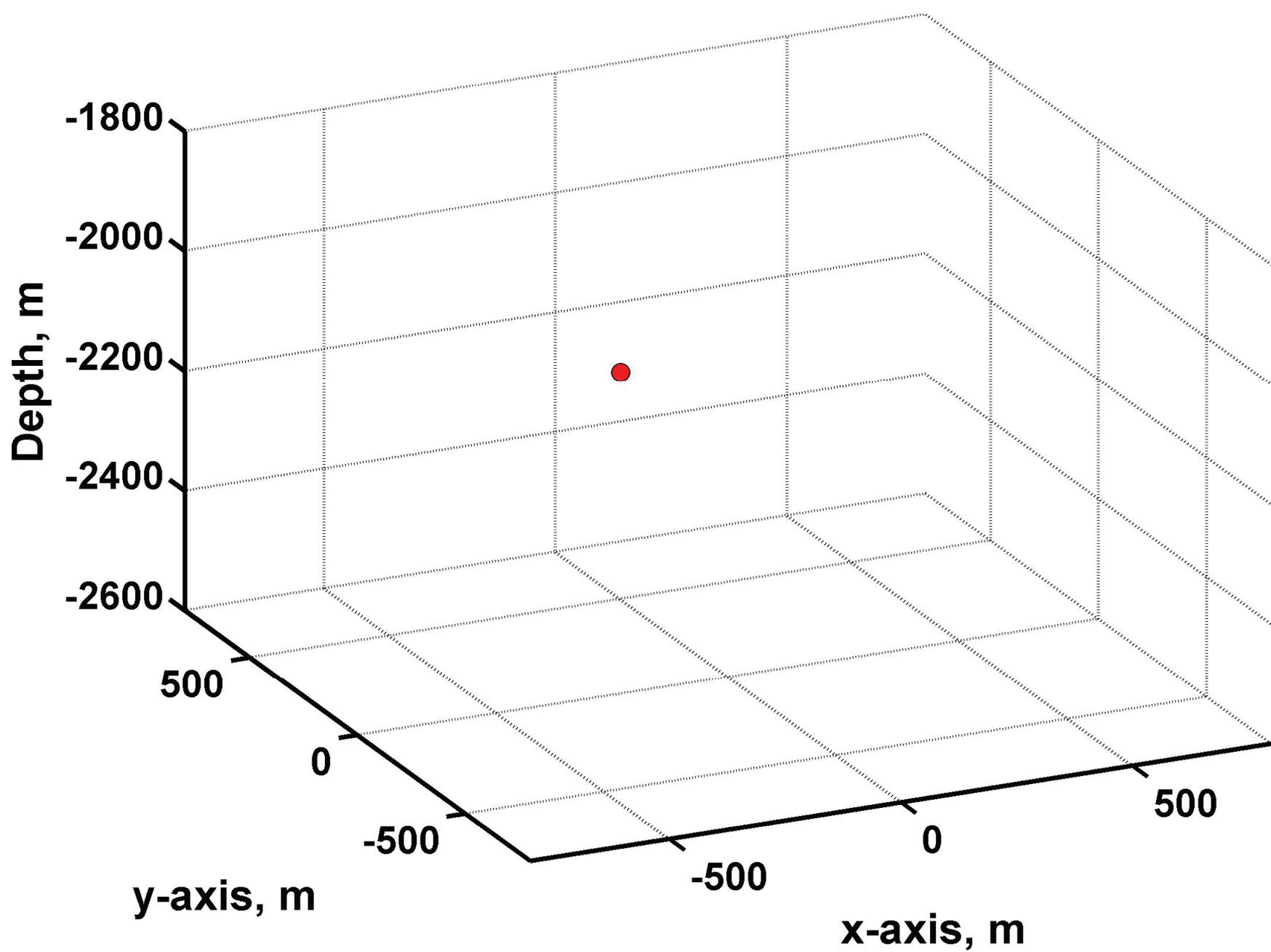


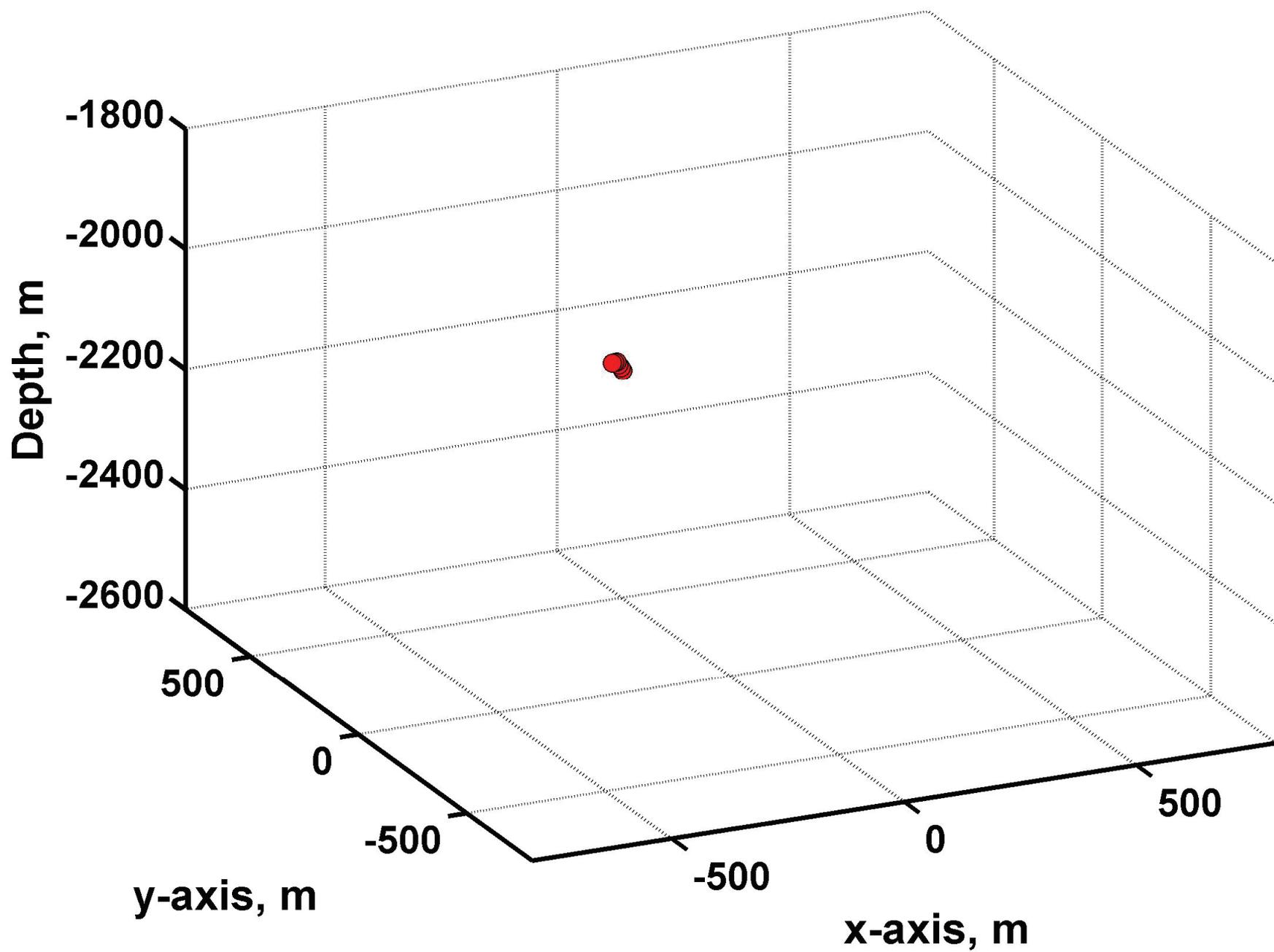
3D back-projection with noise reduction (SNR = 3)

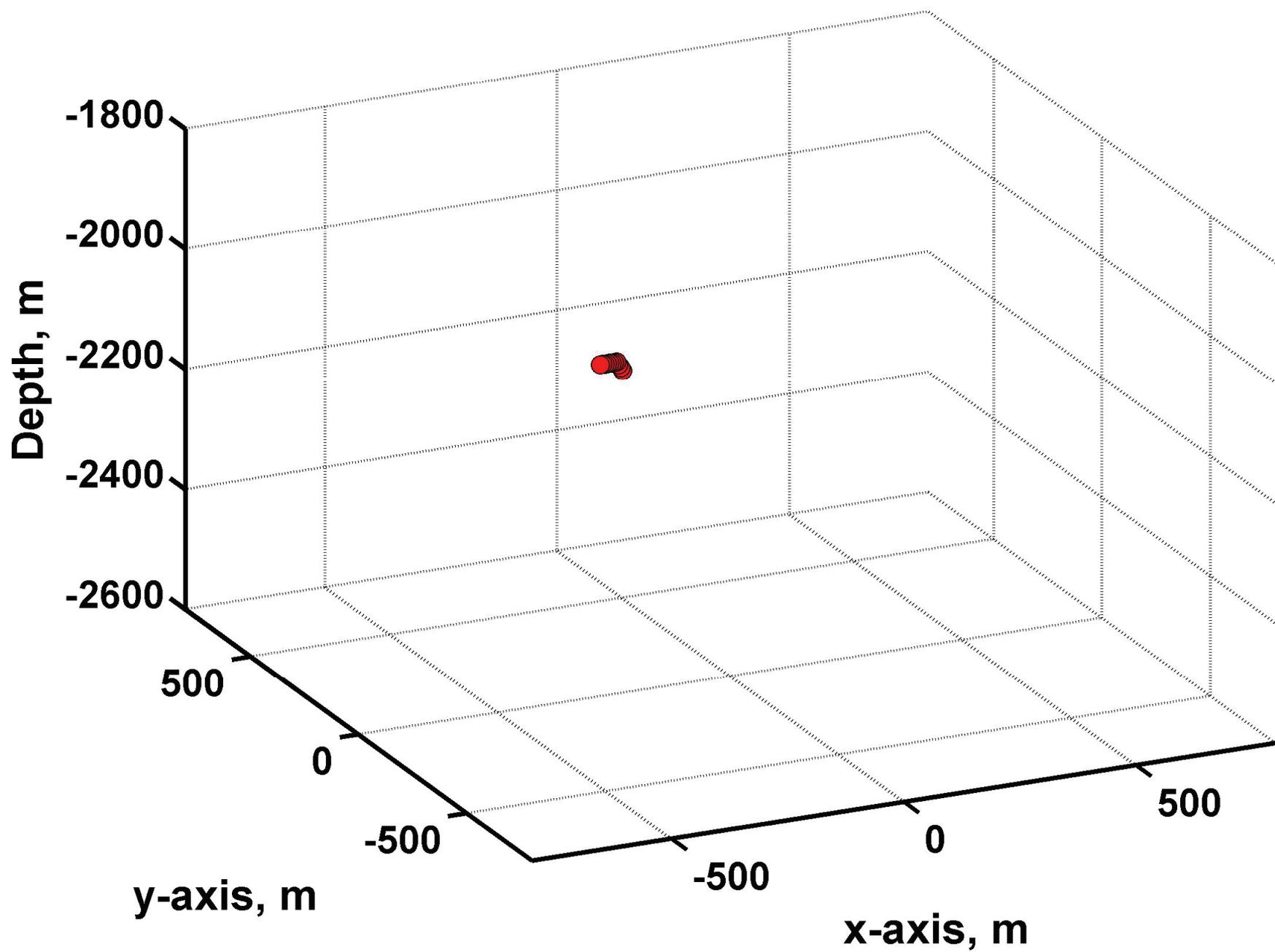


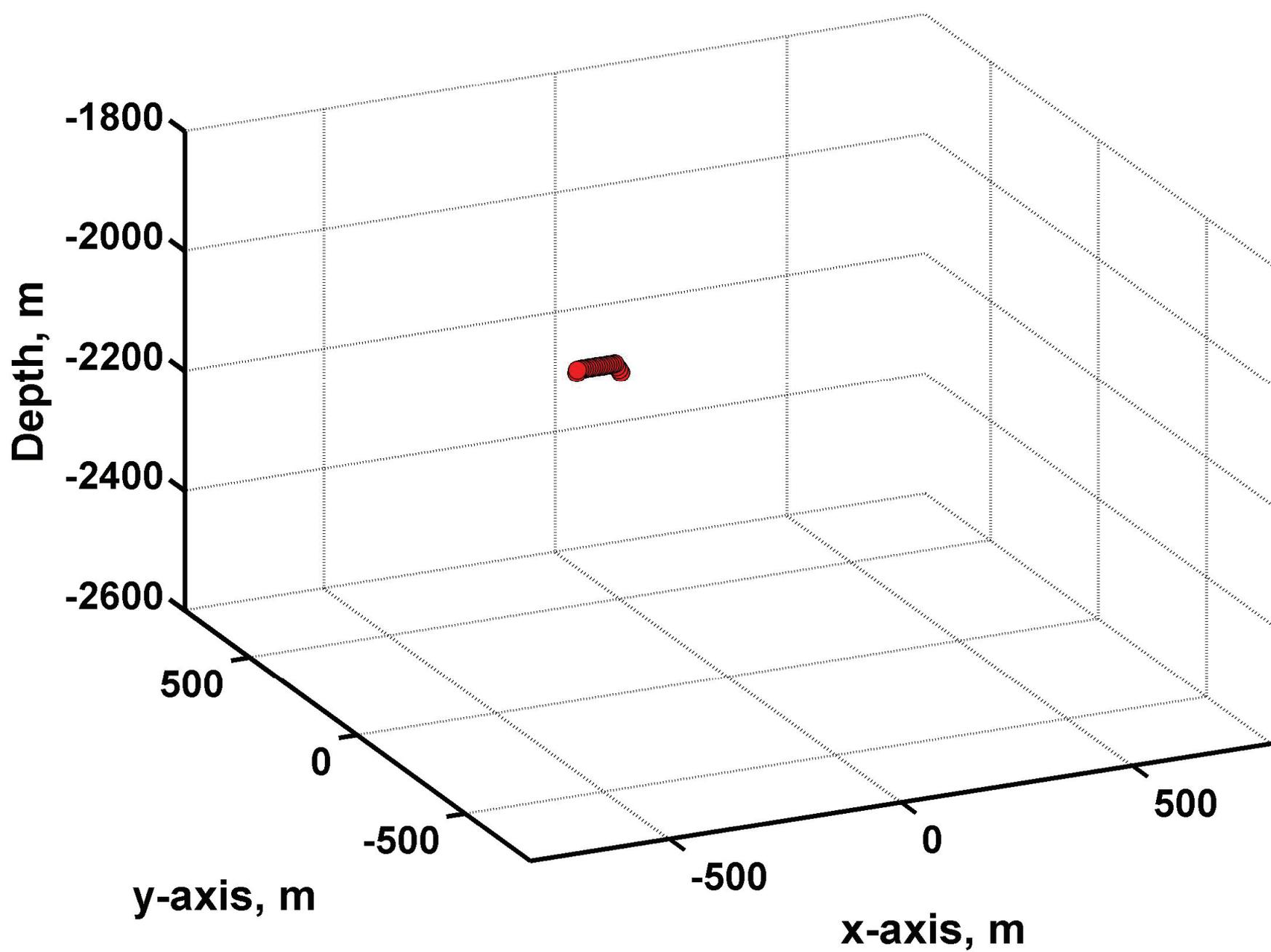


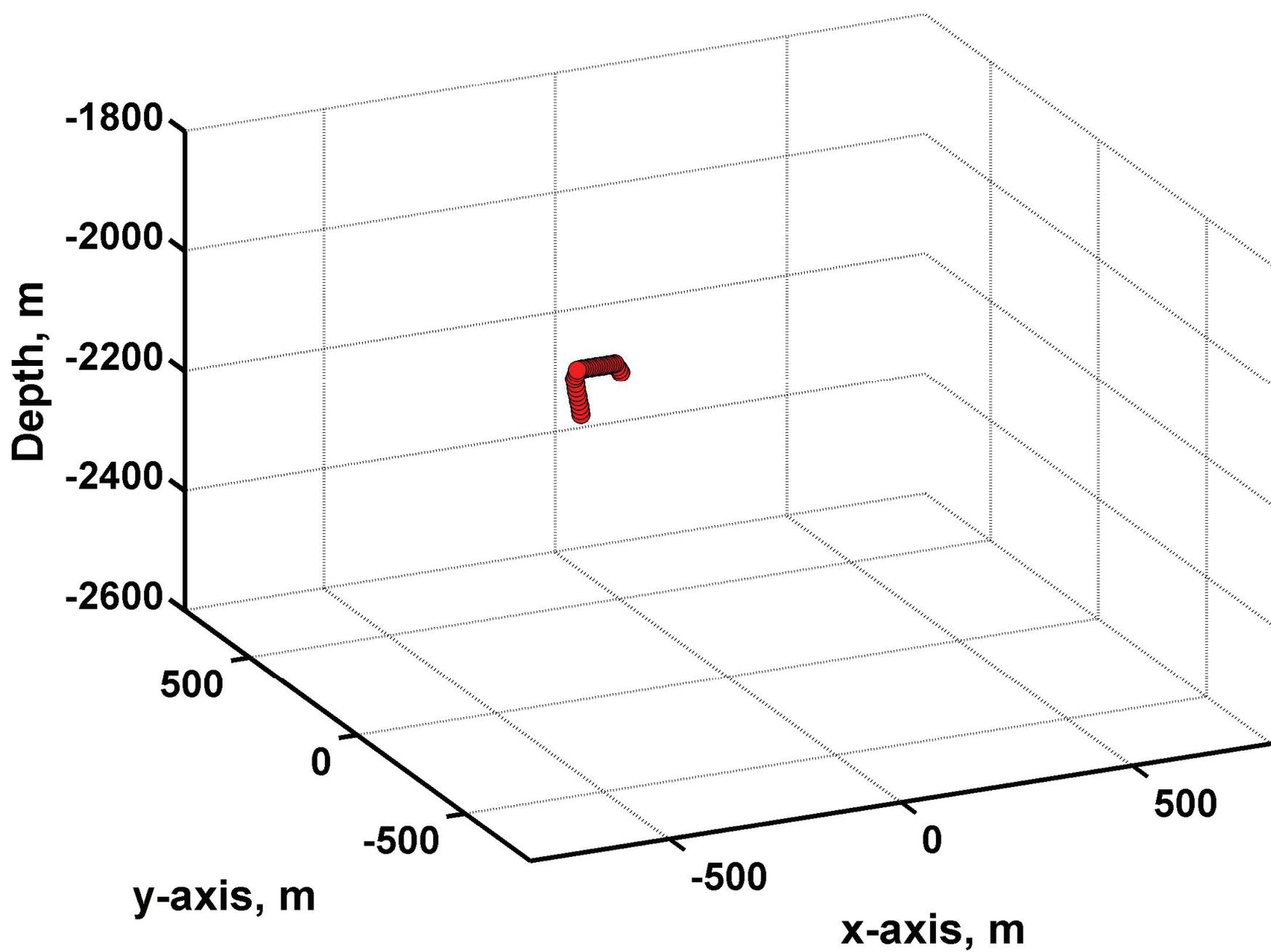
*We can place swarms of microseism hypocenters
anywhere we want in 3D space ...*

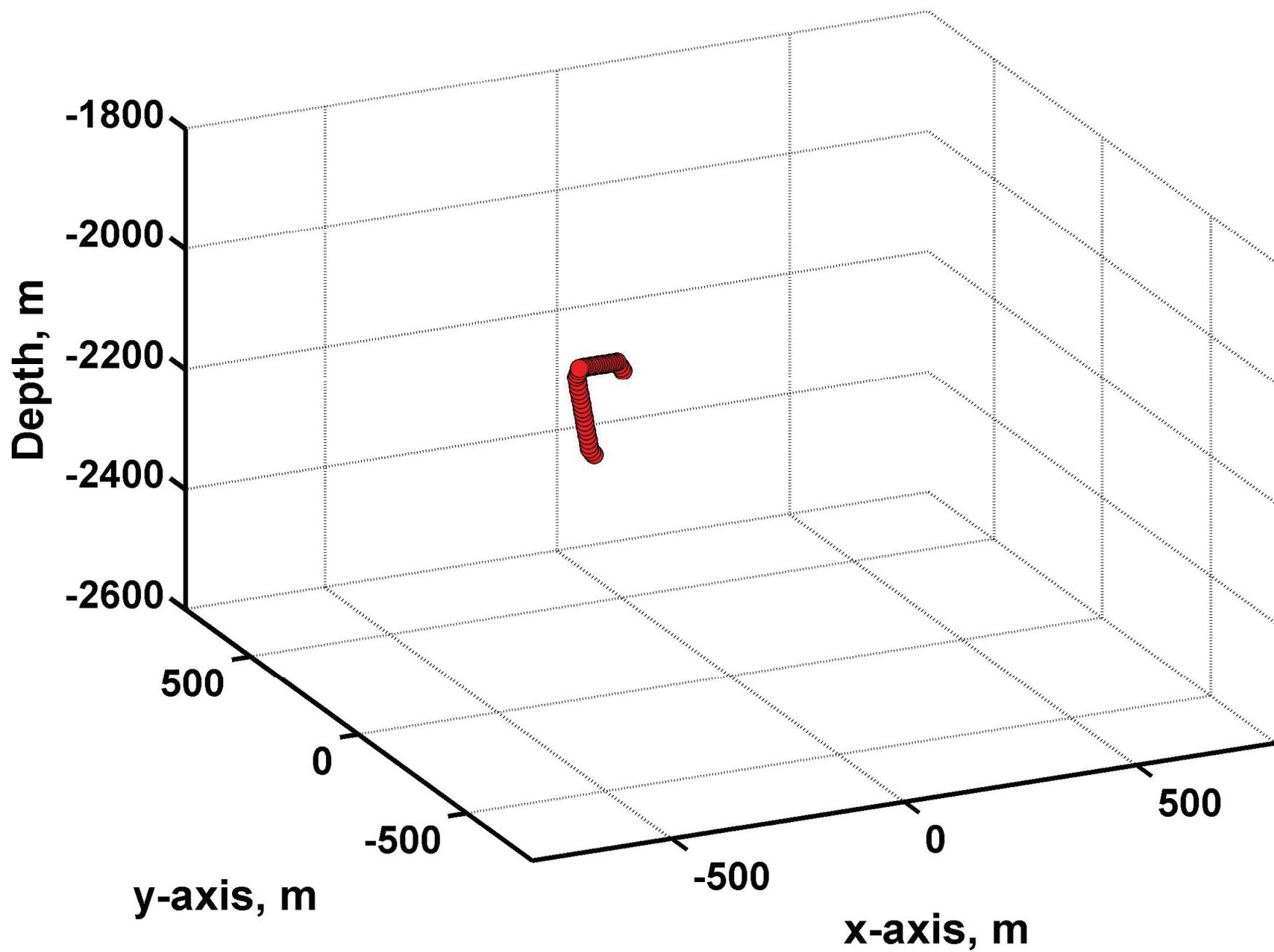


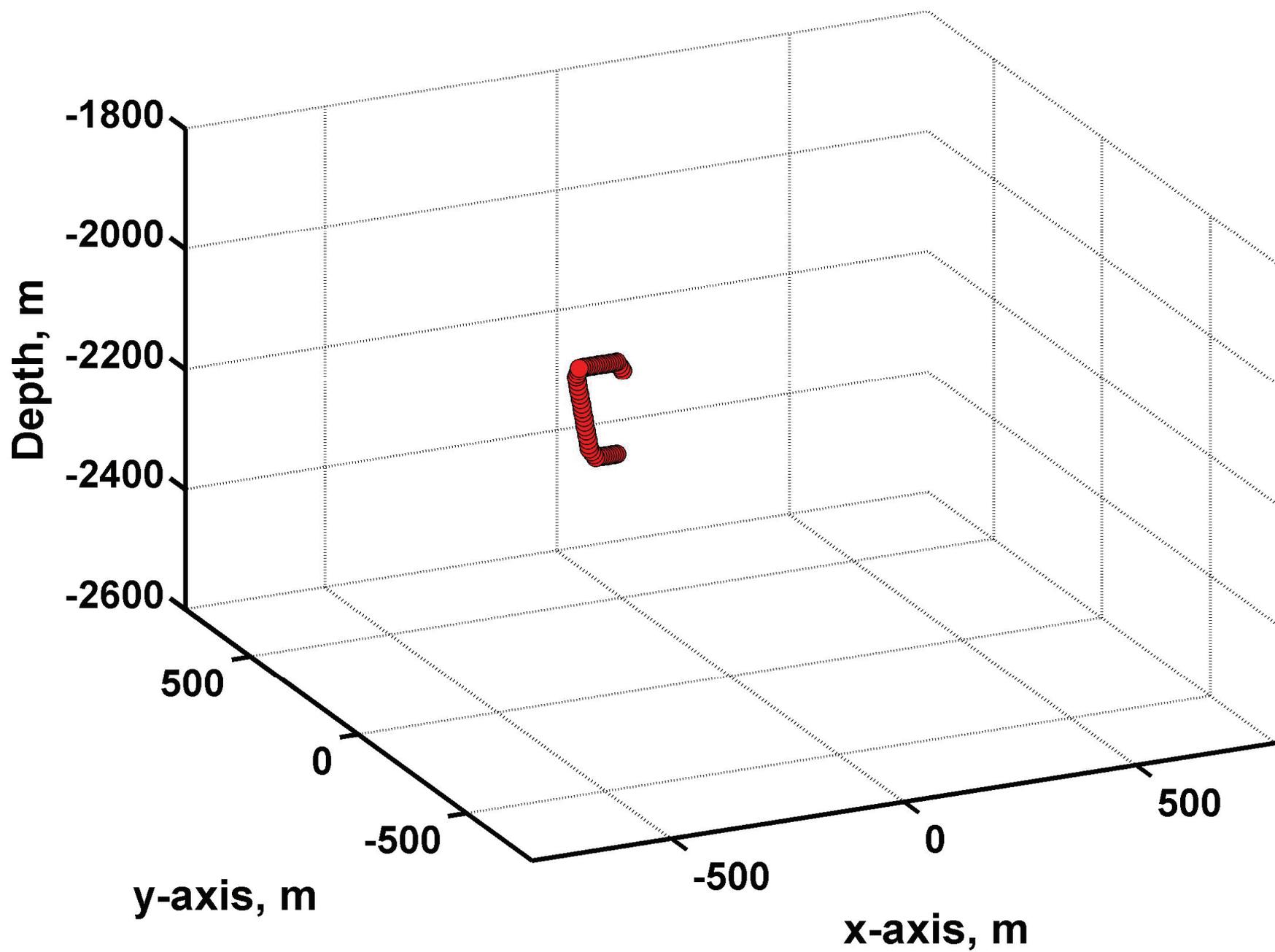


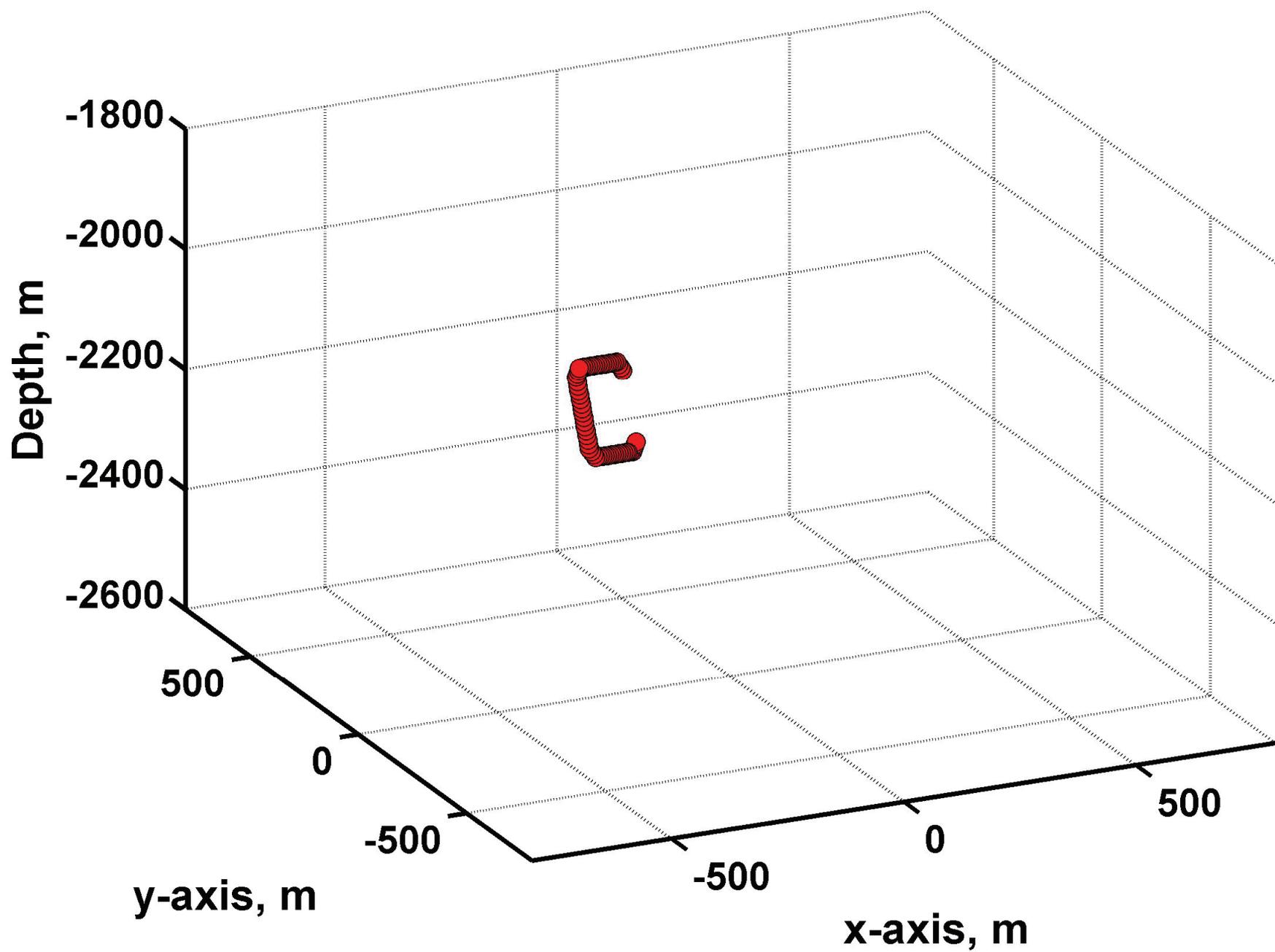


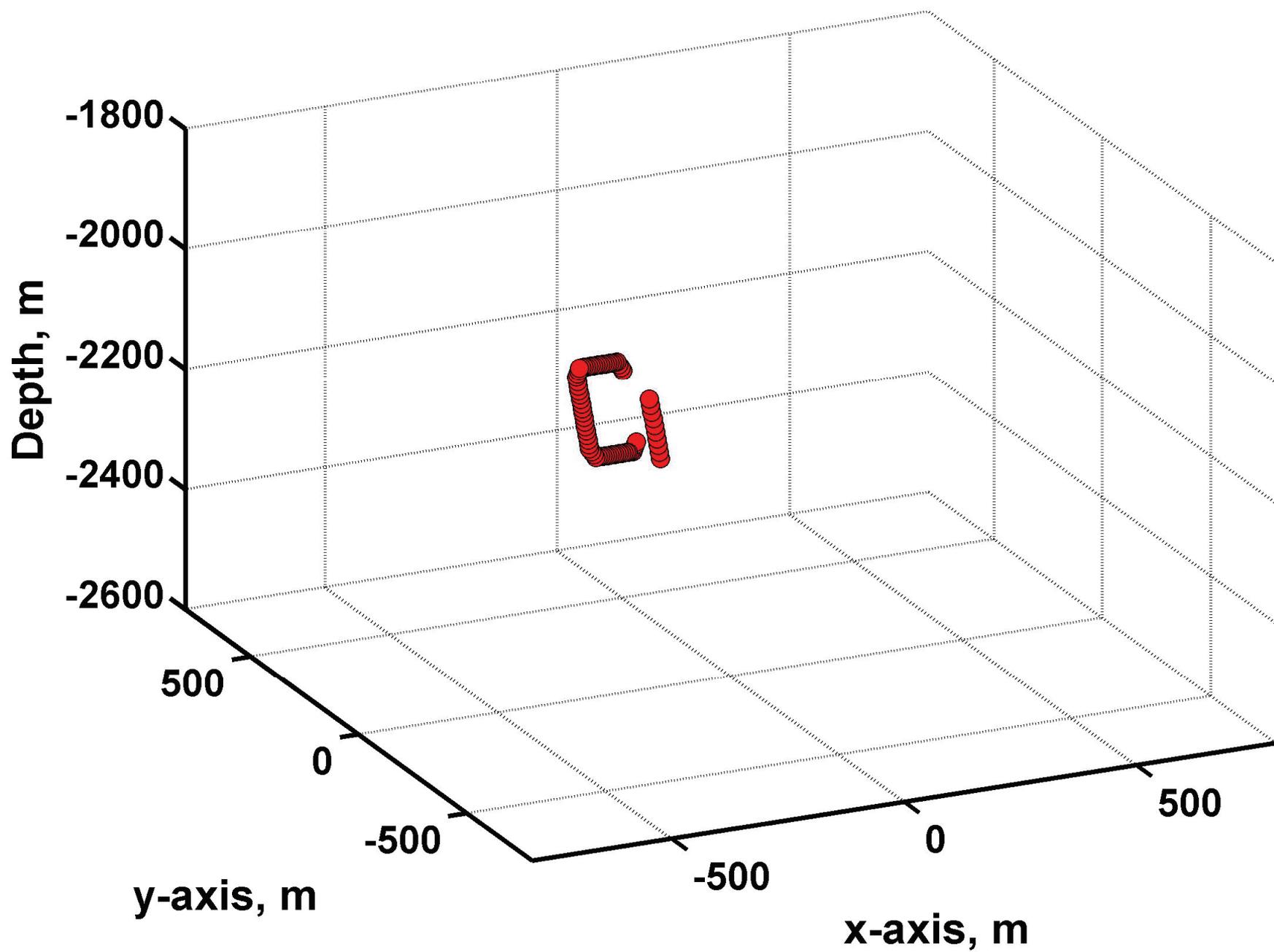


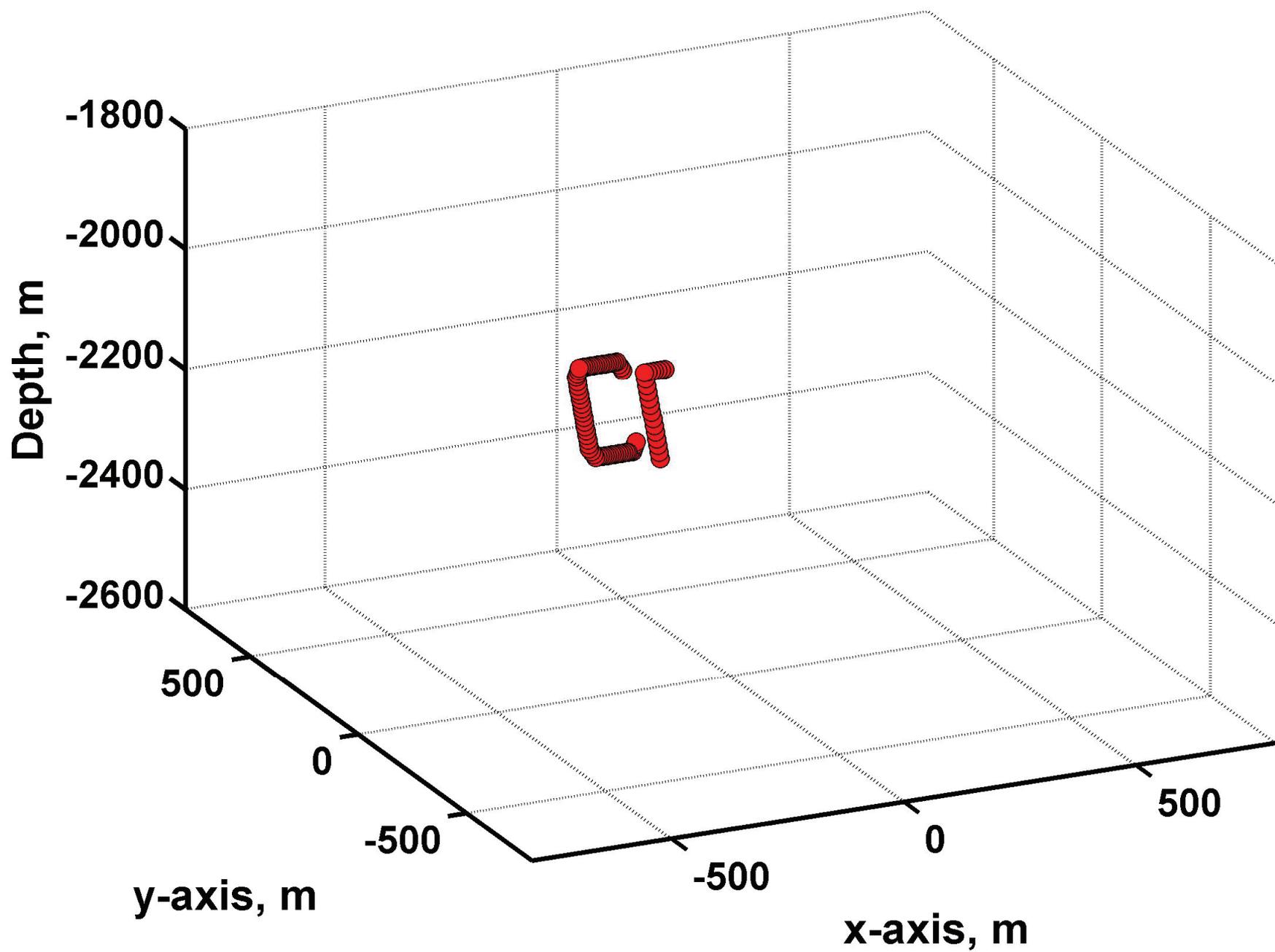


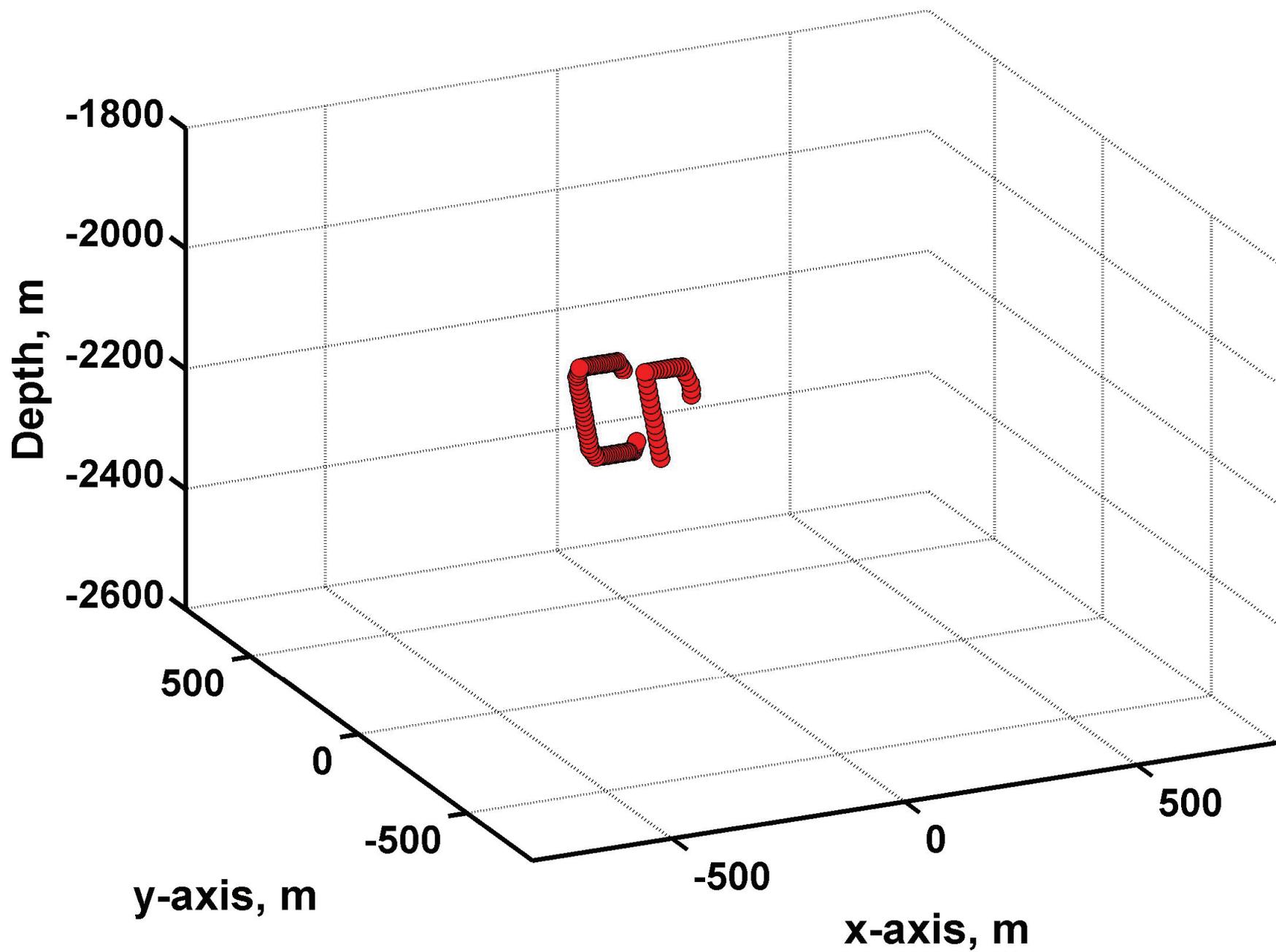


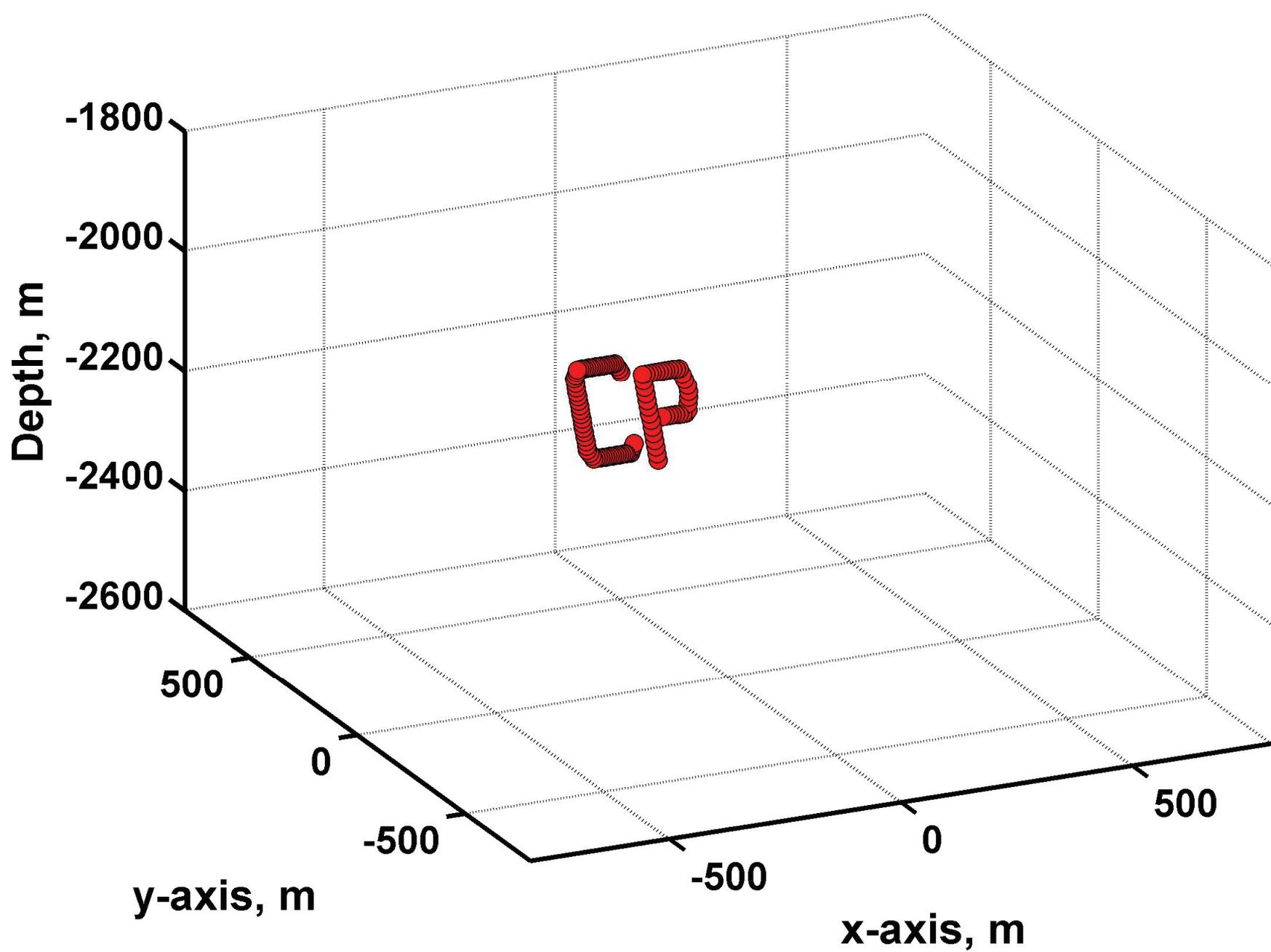


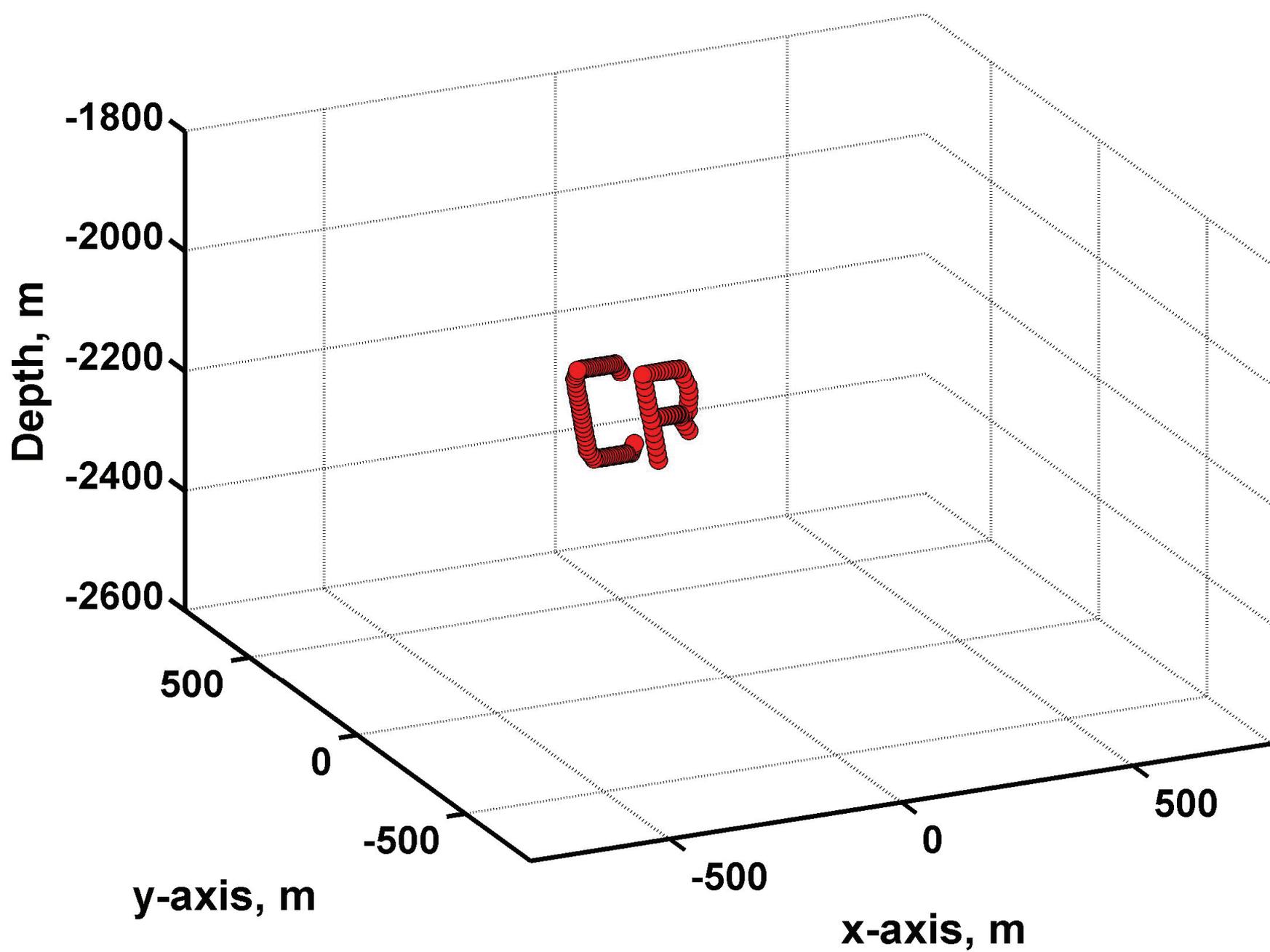


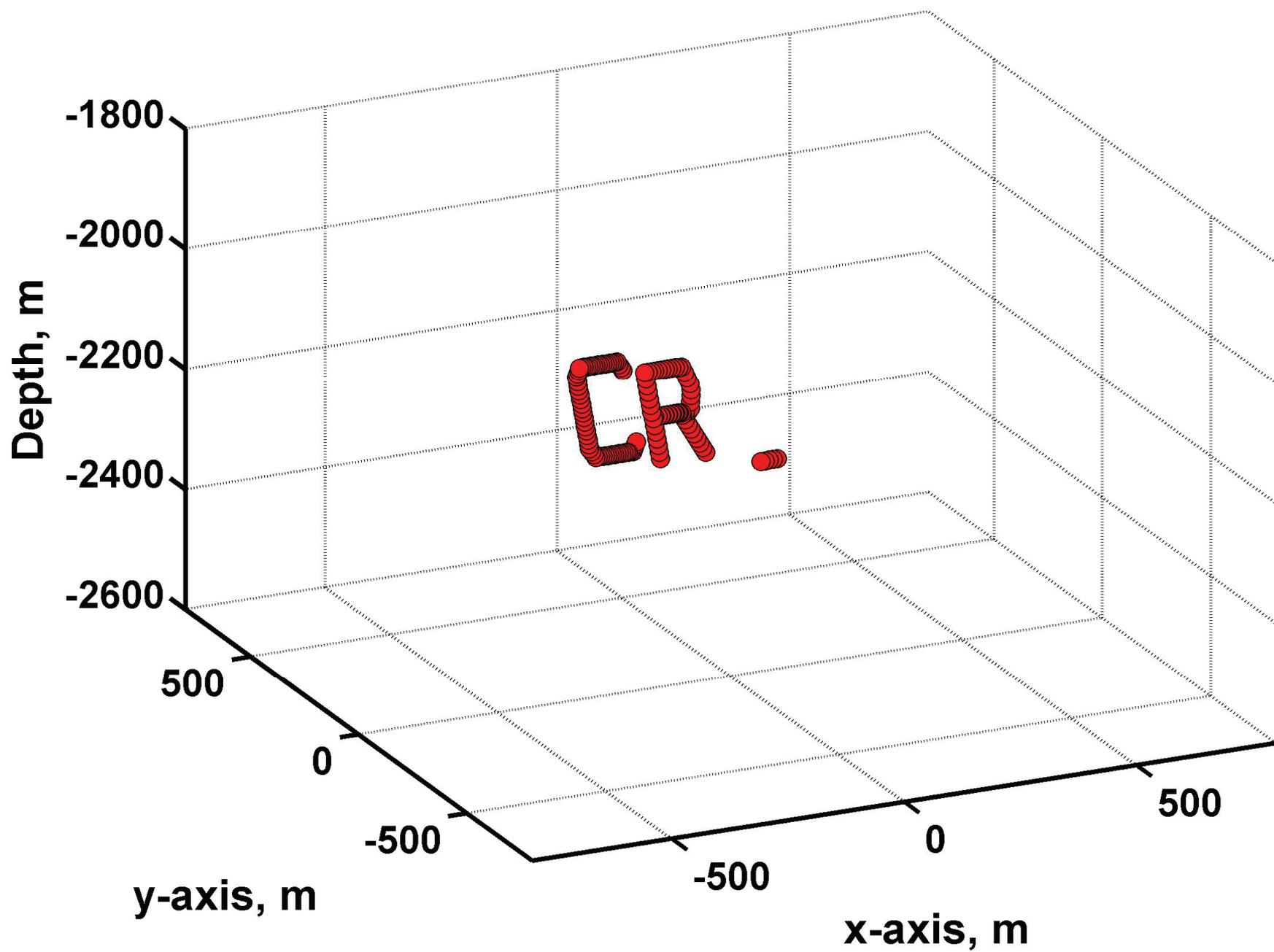


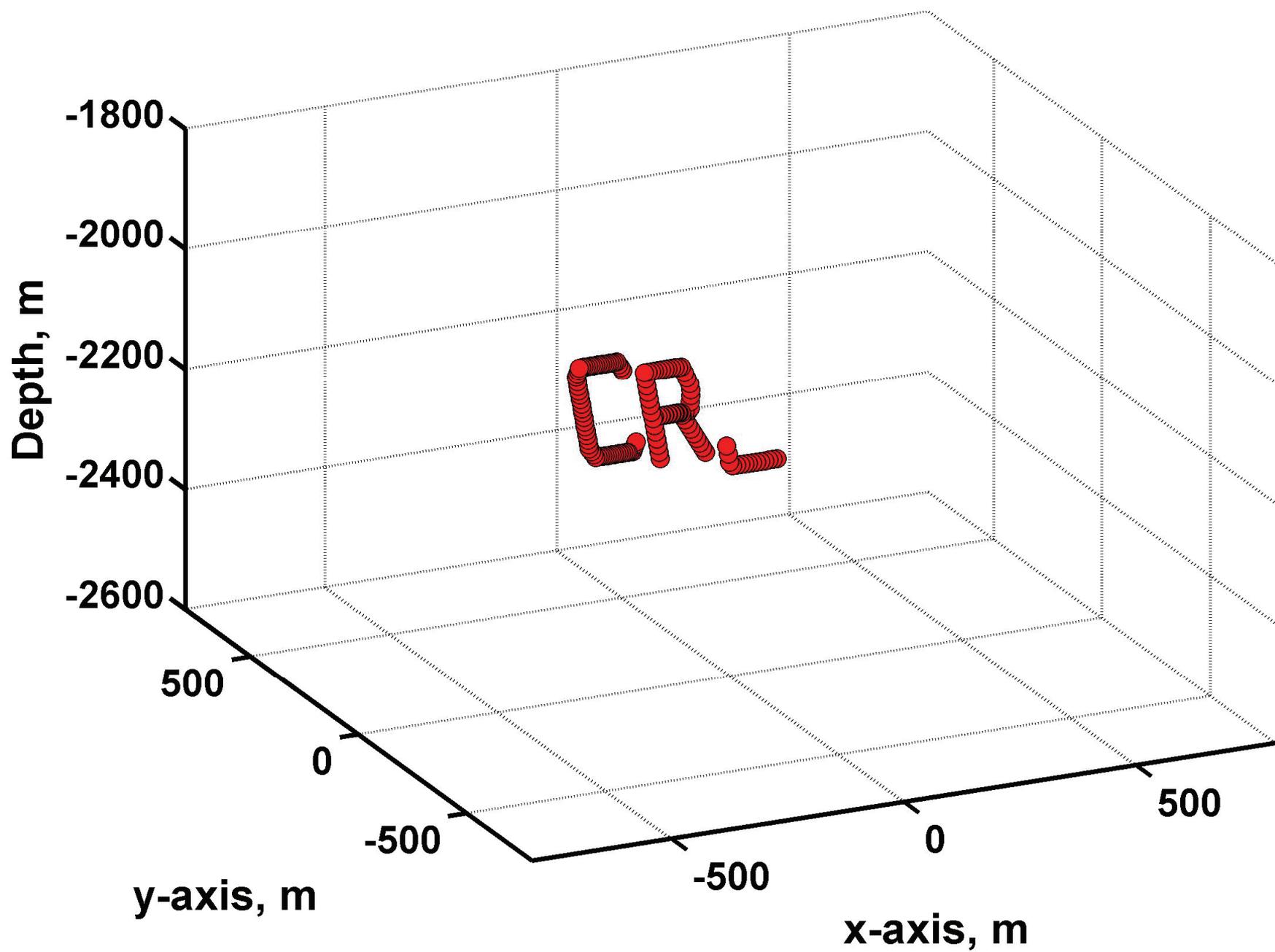


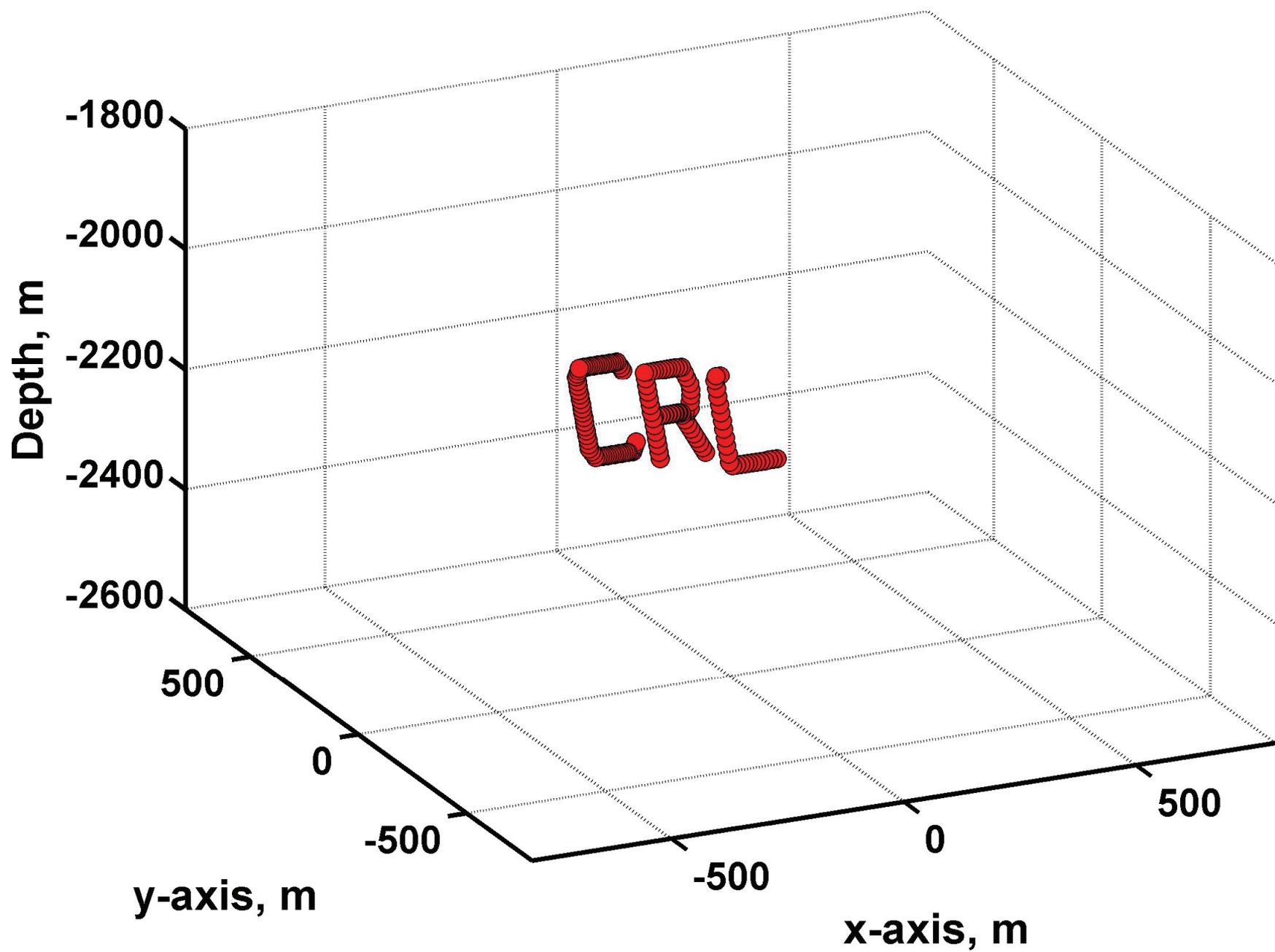


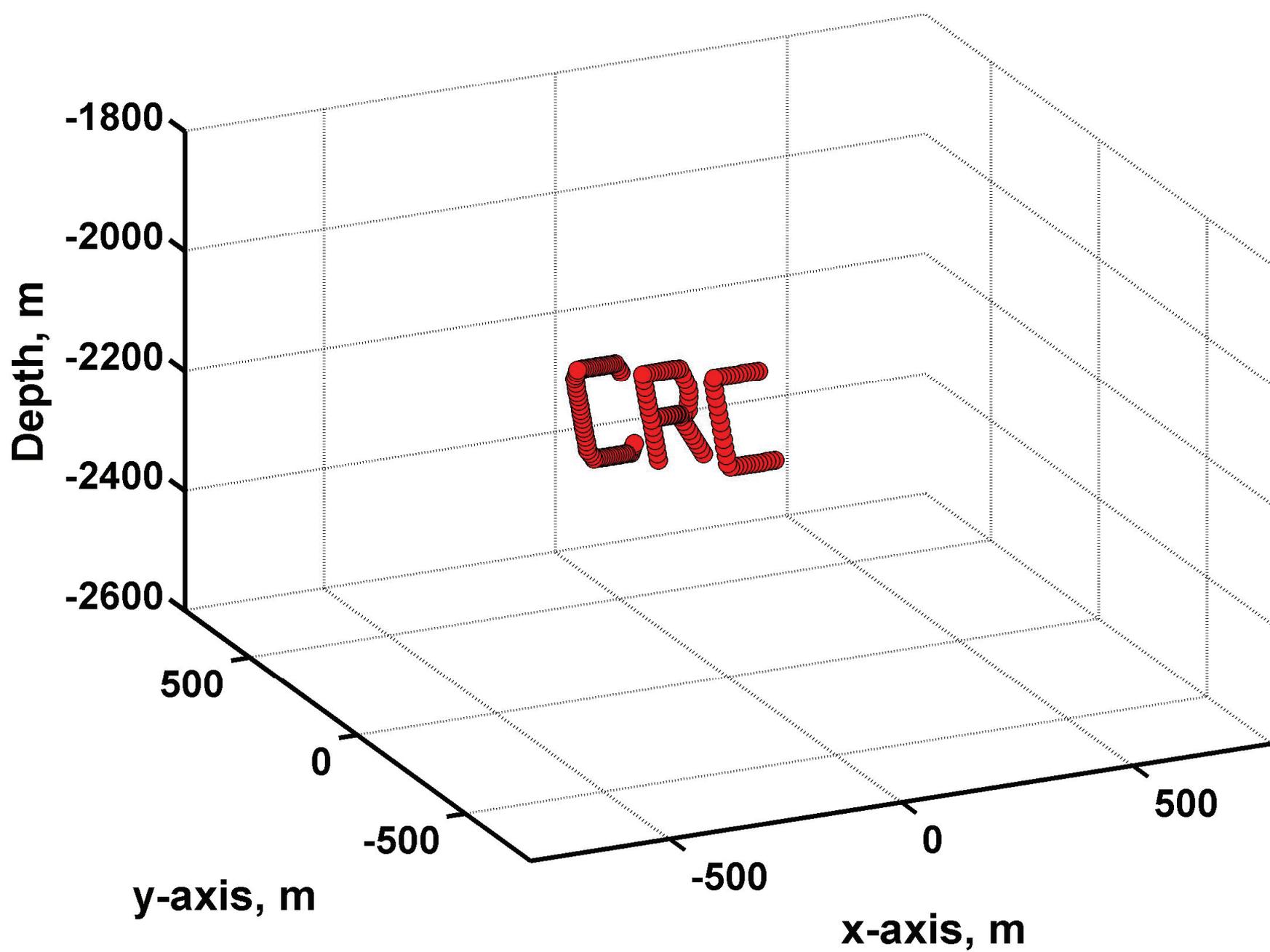


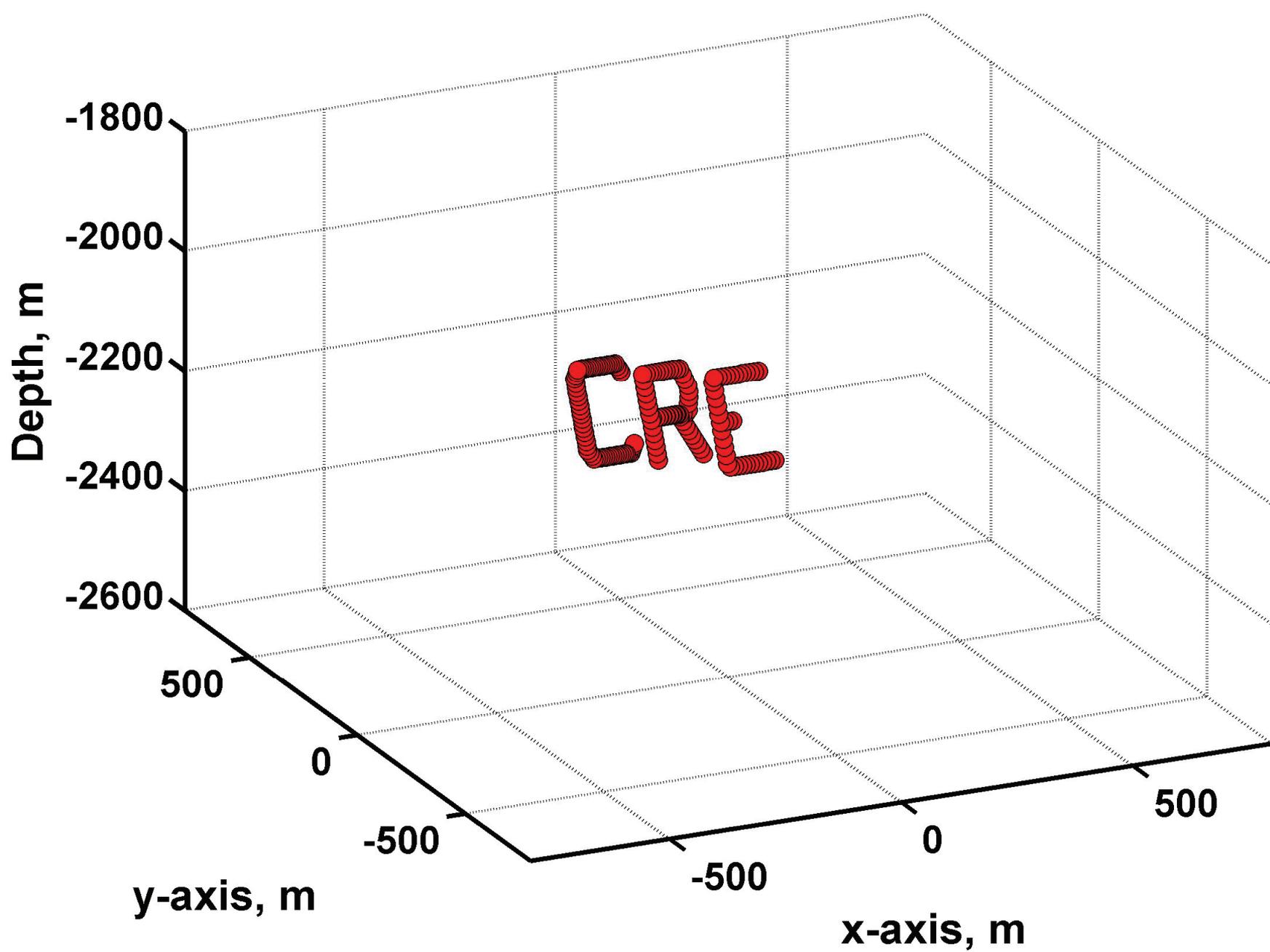


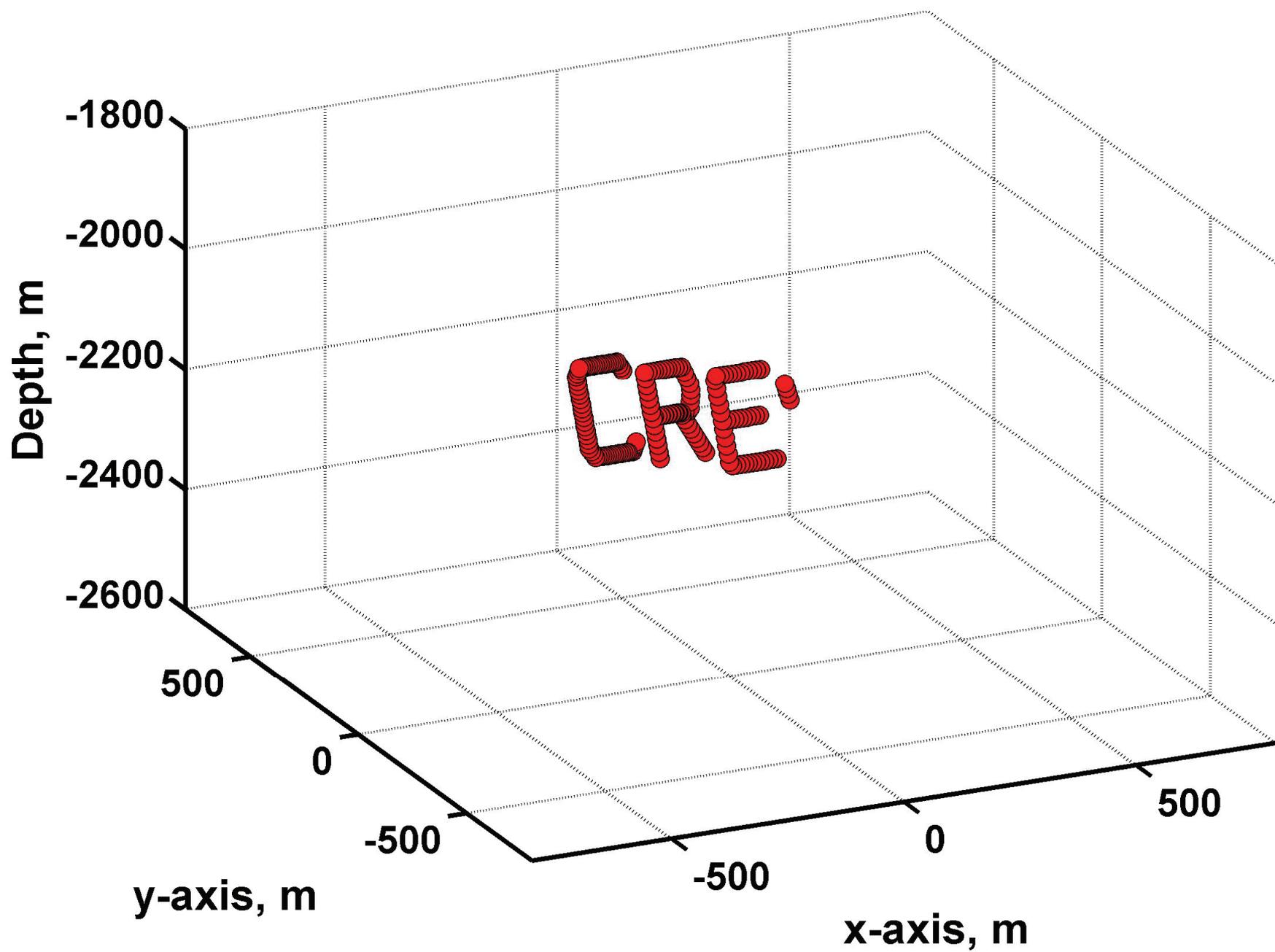


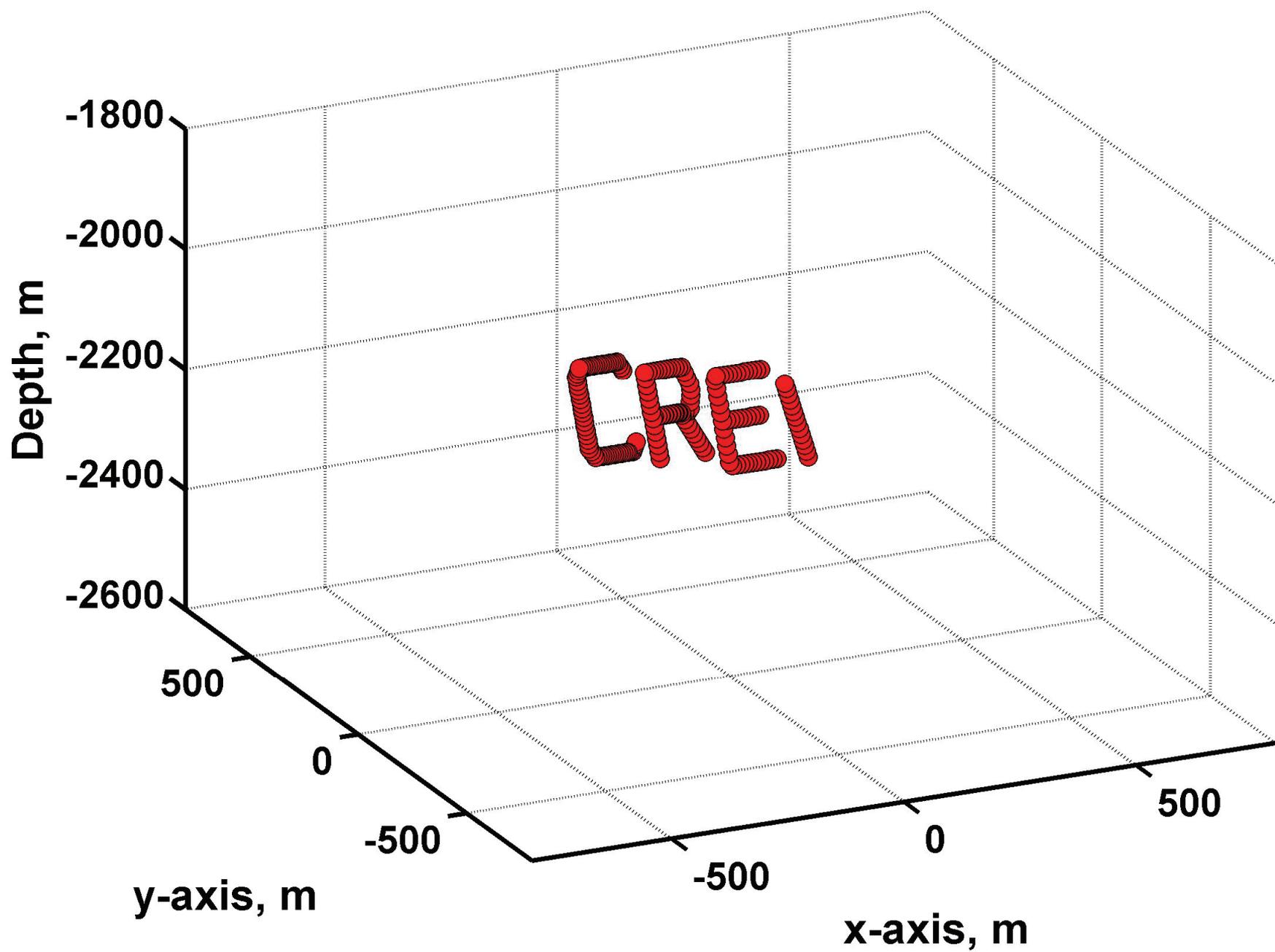


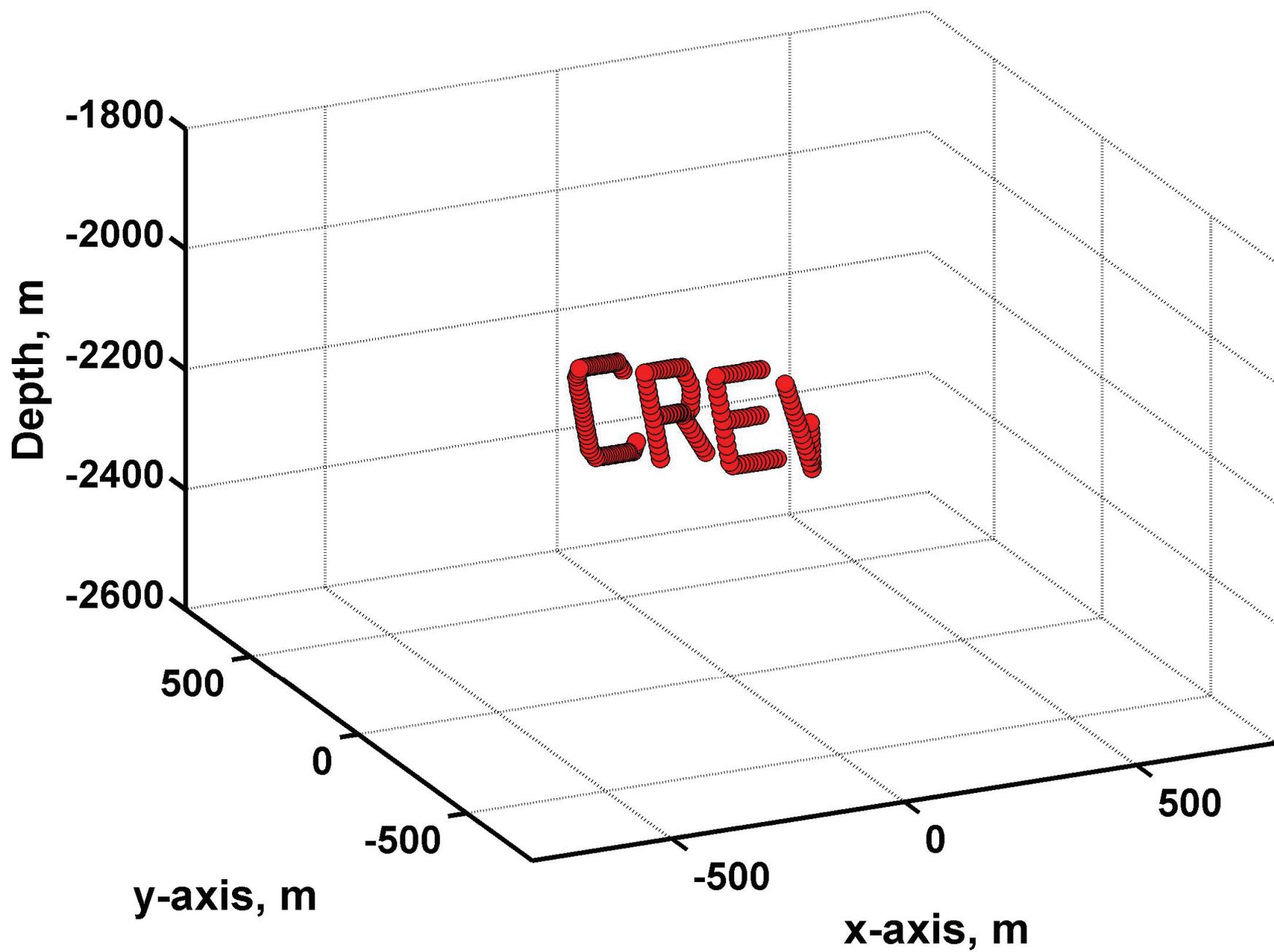


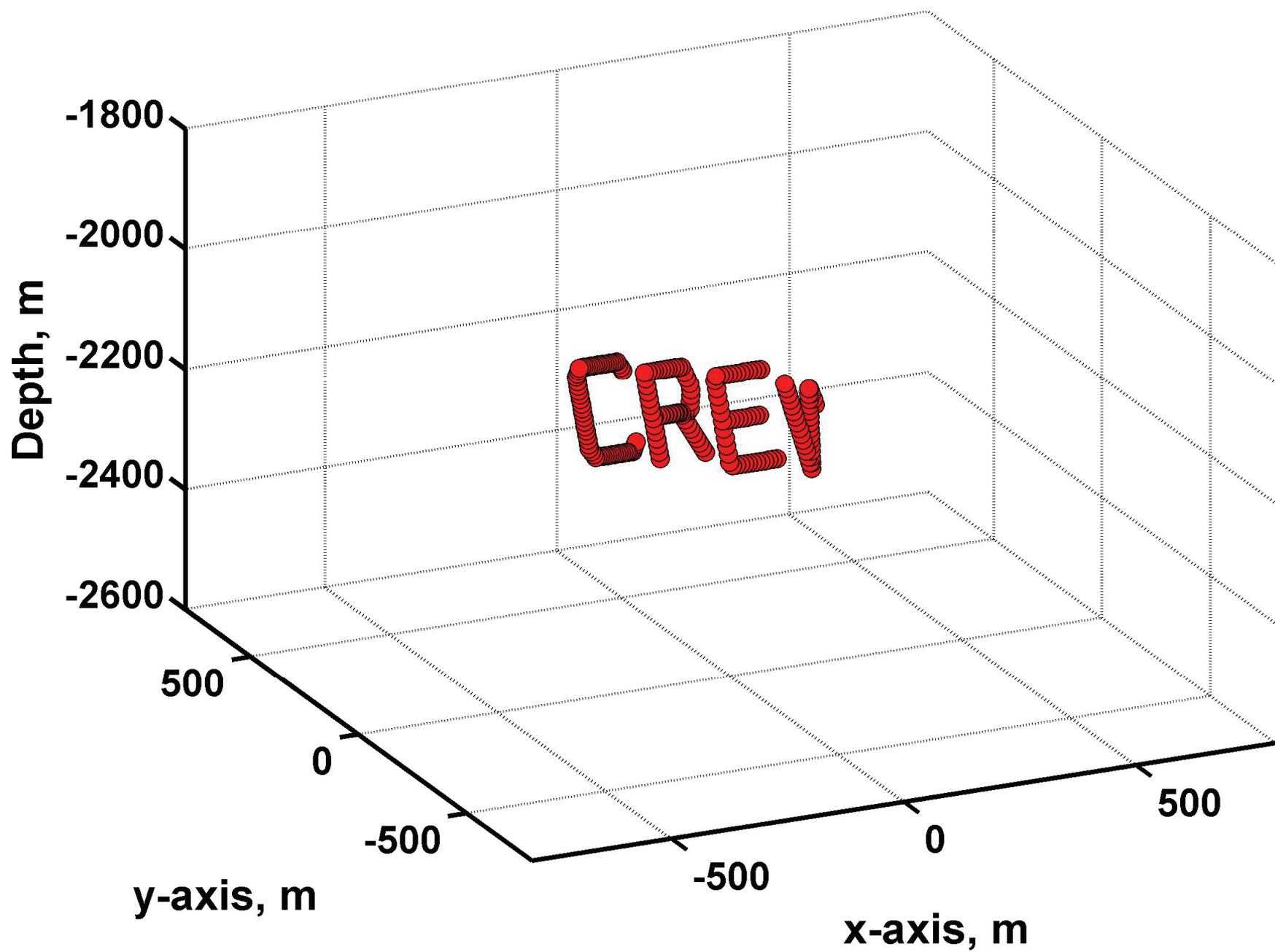


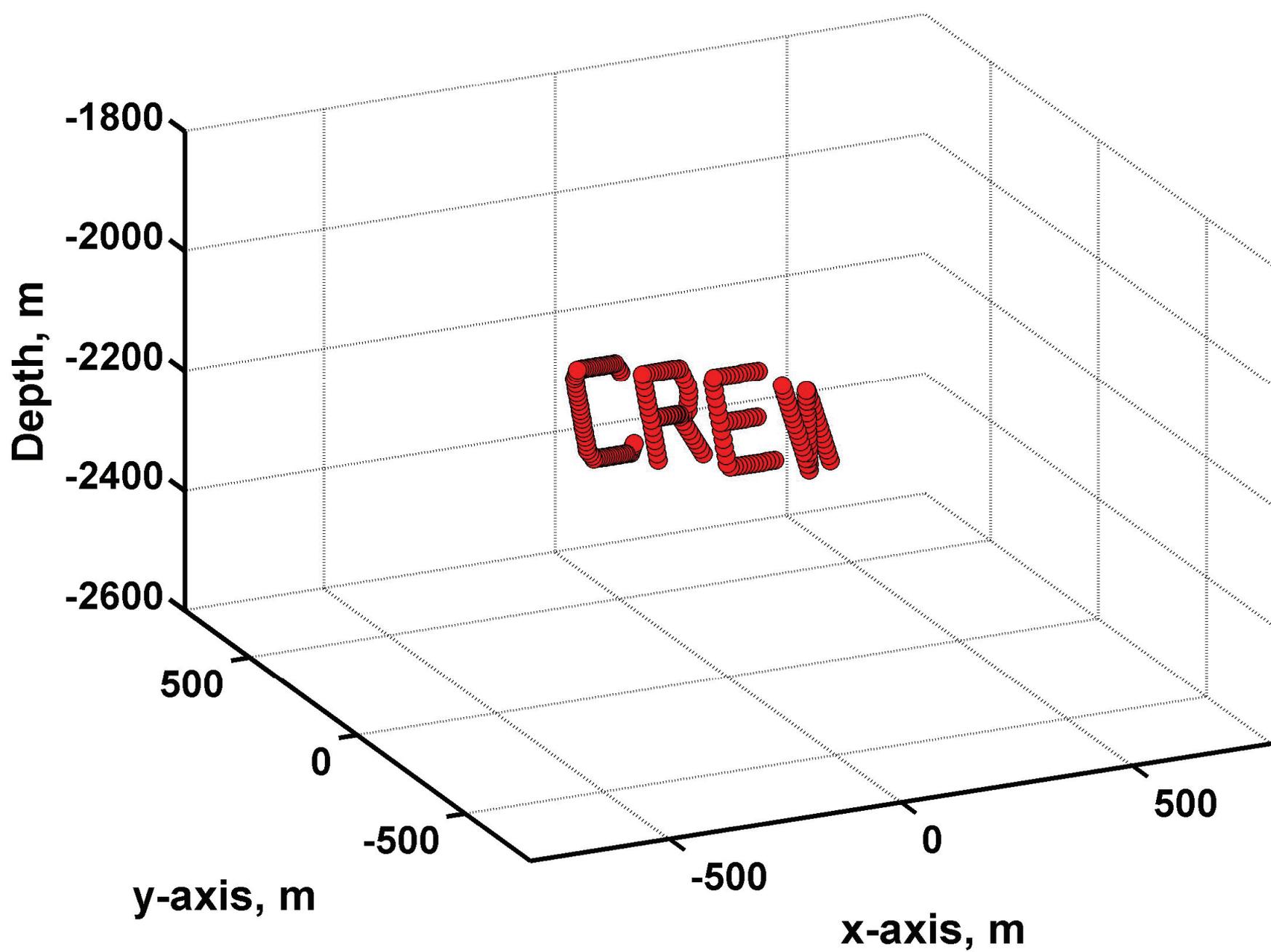


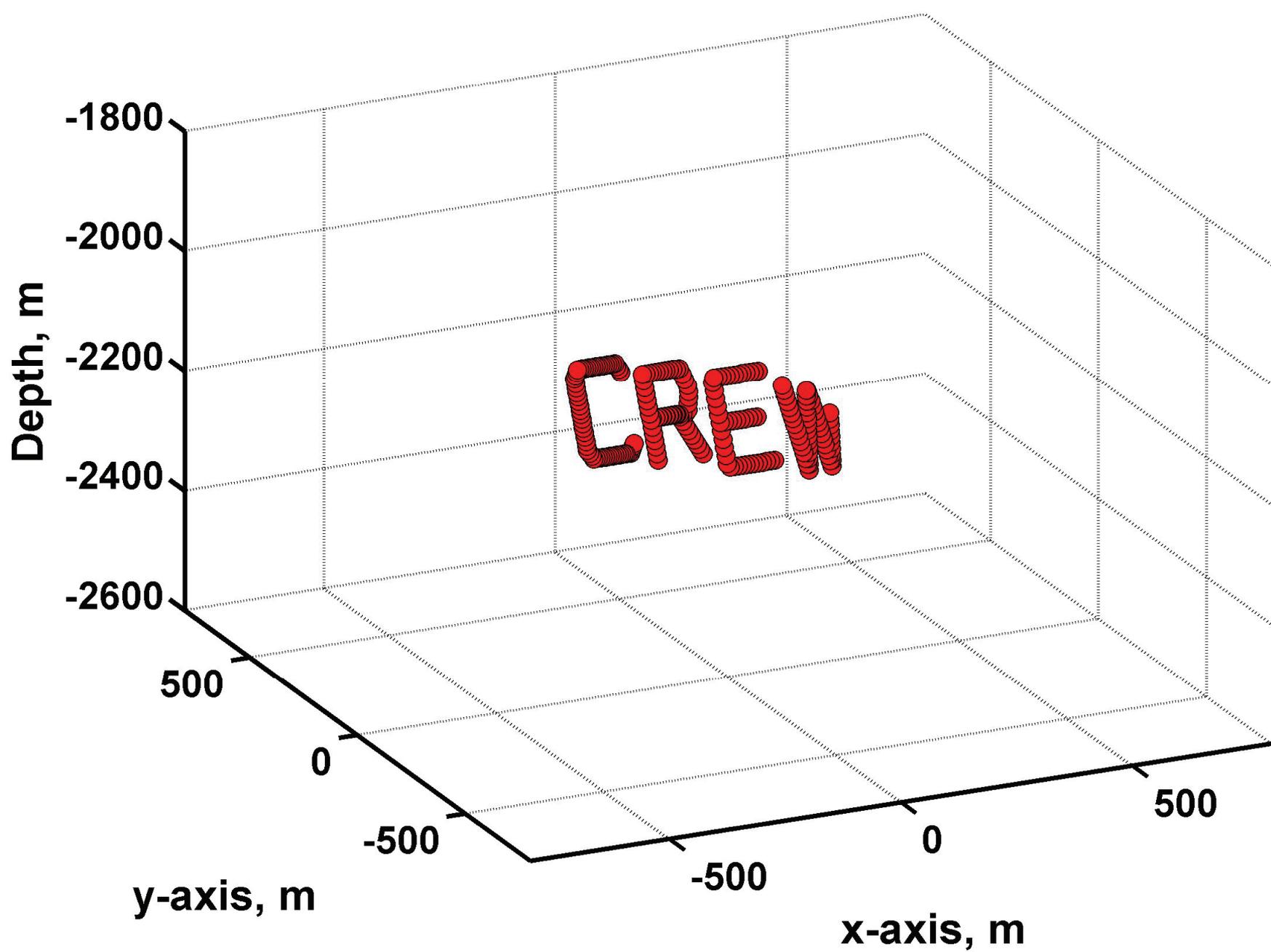


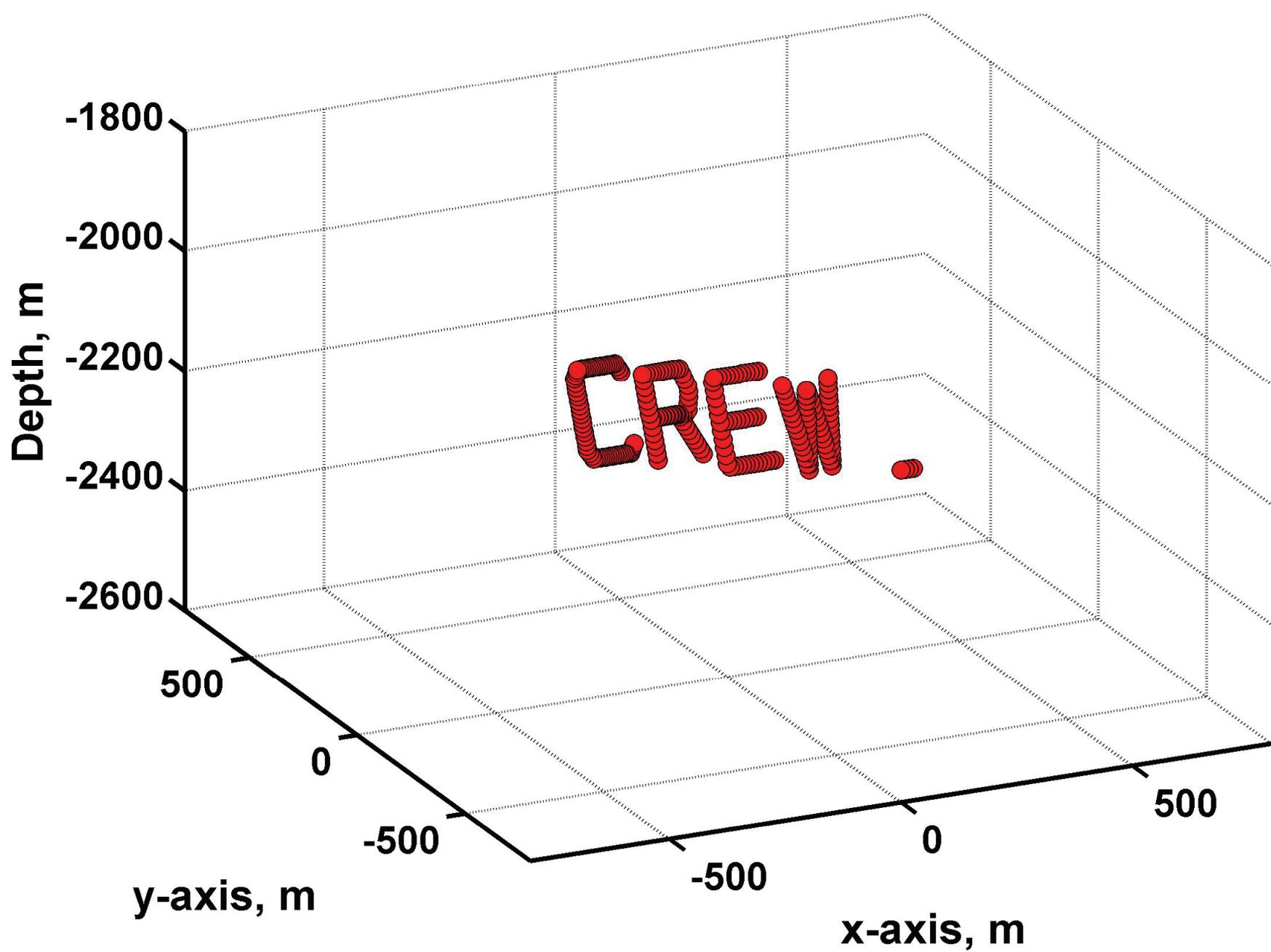


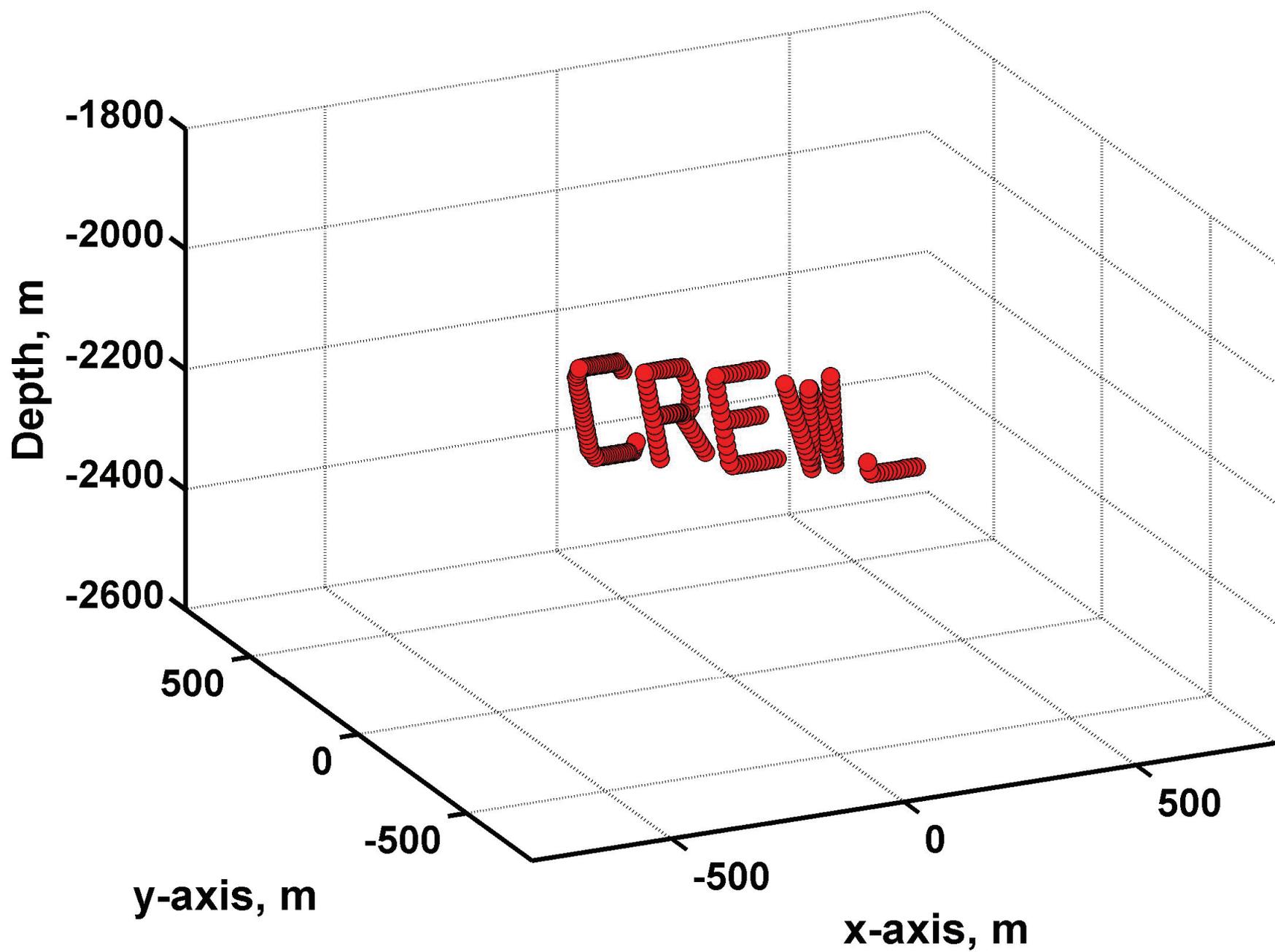


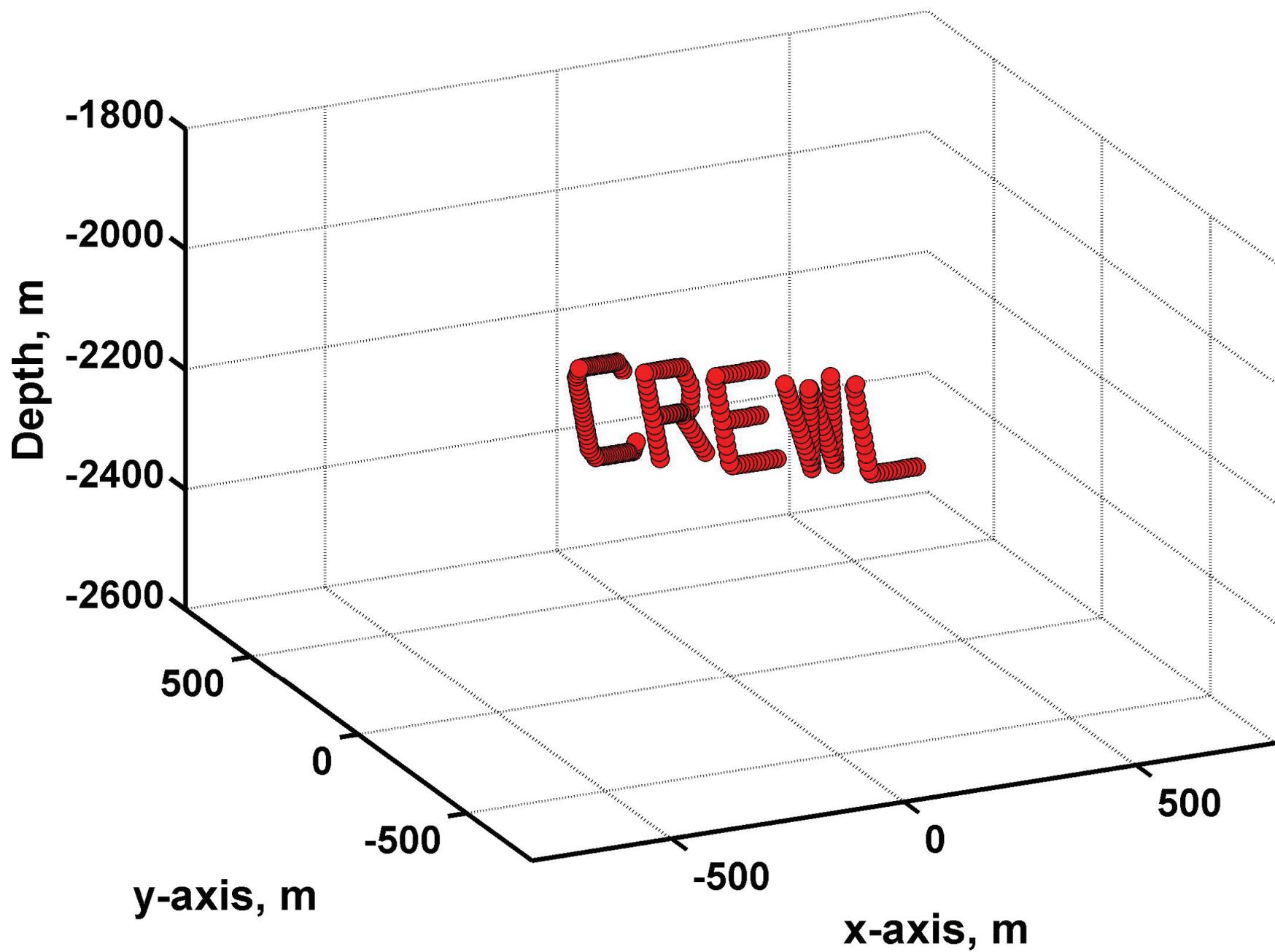


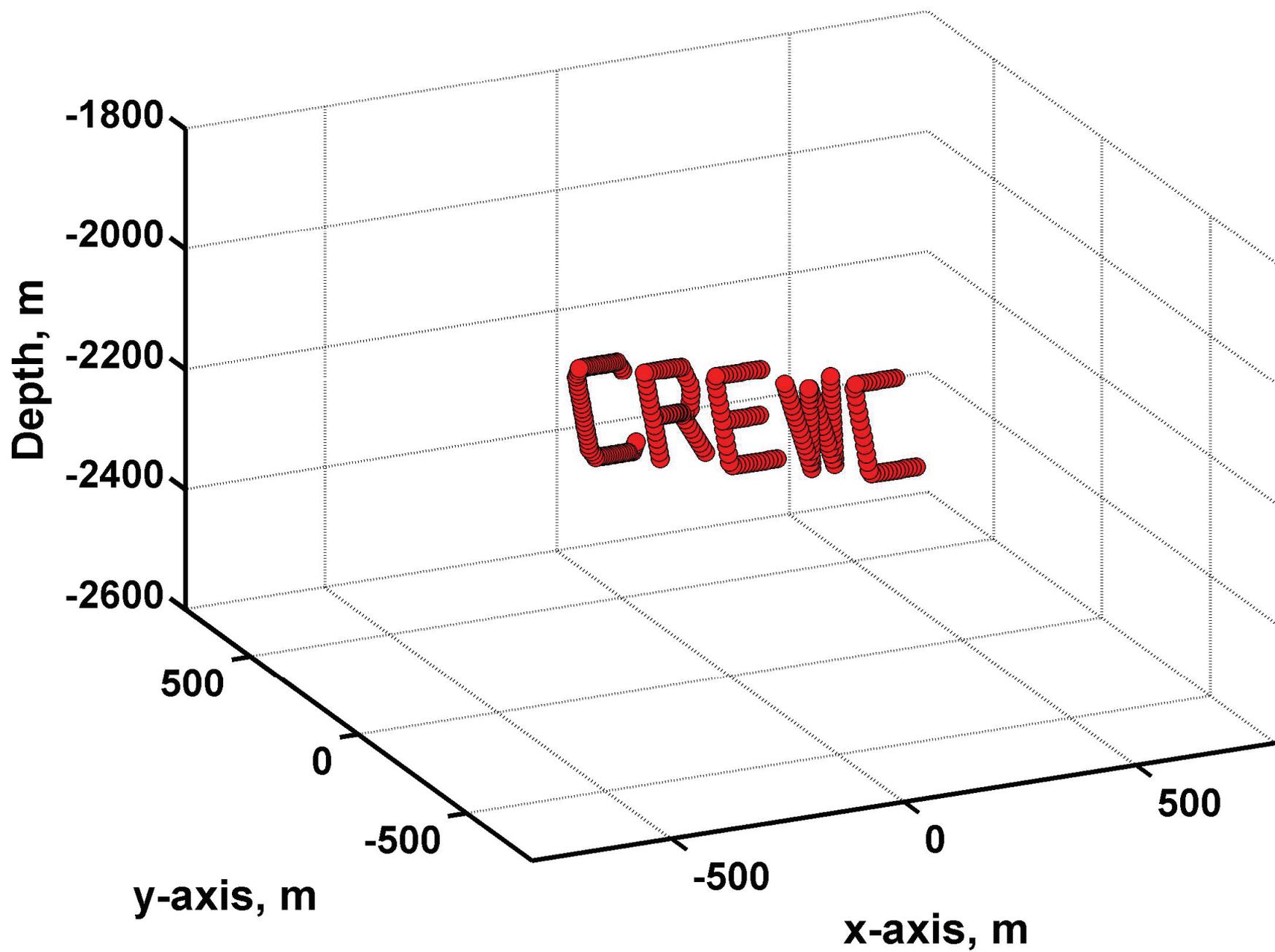


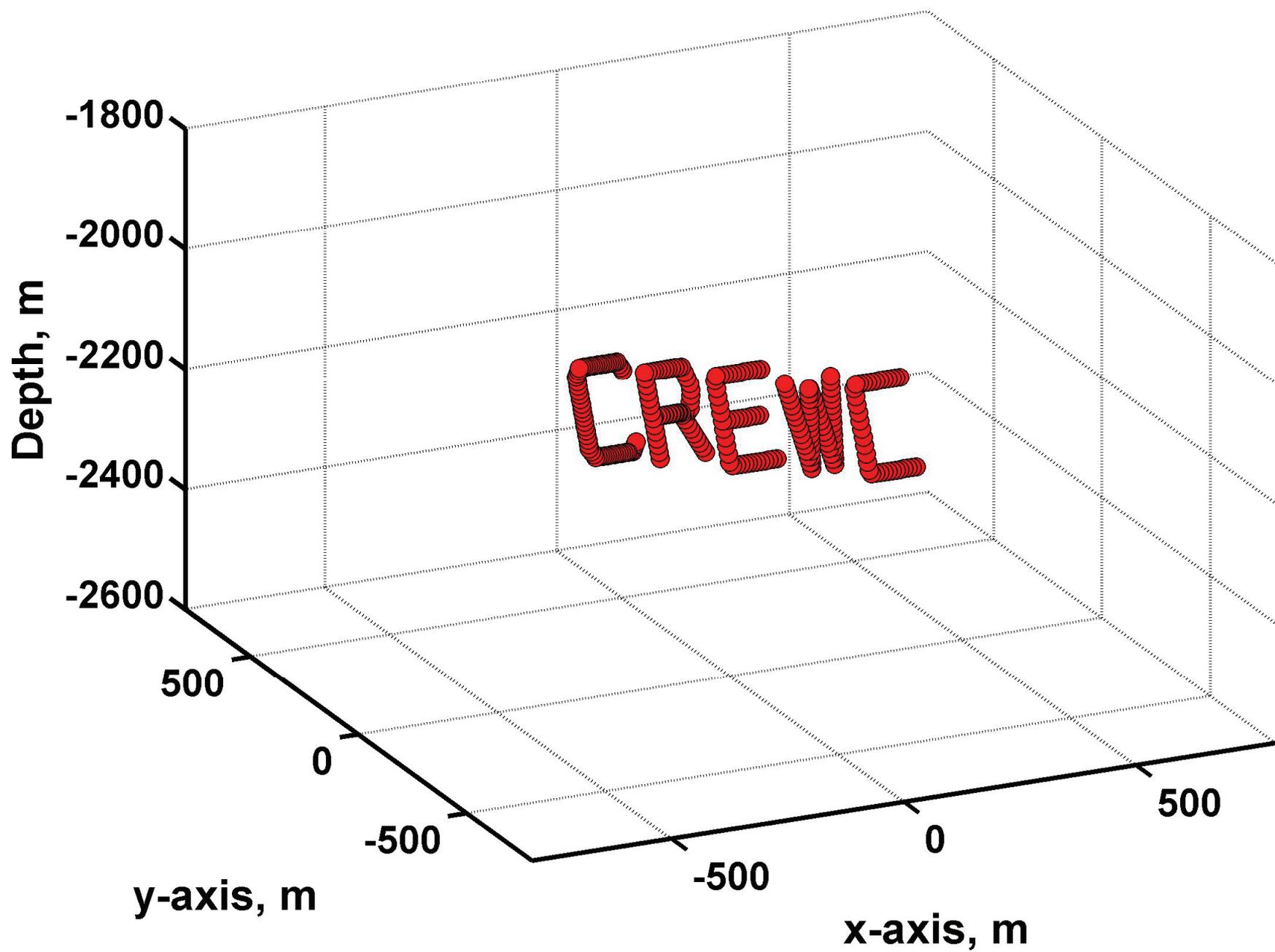


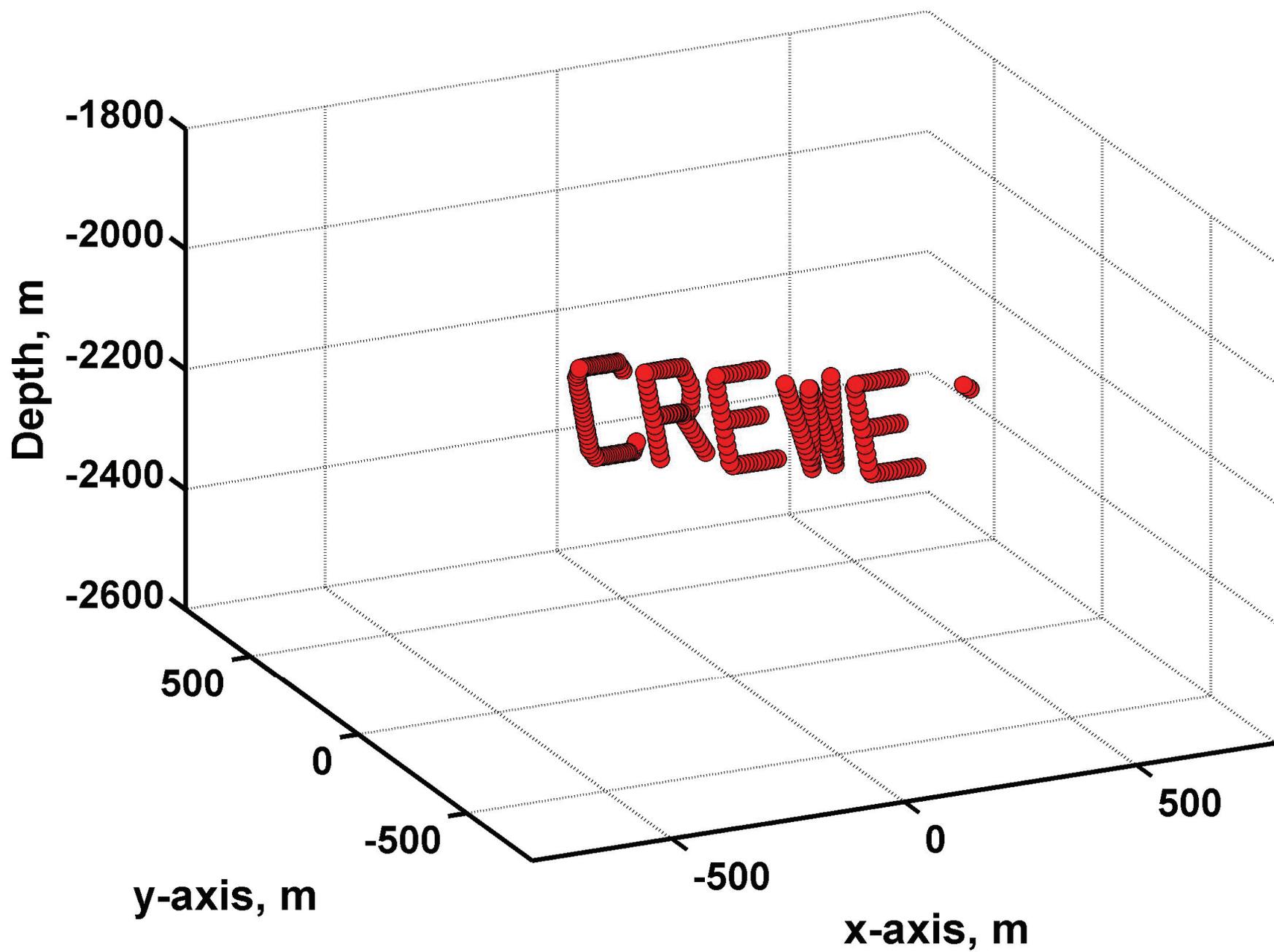


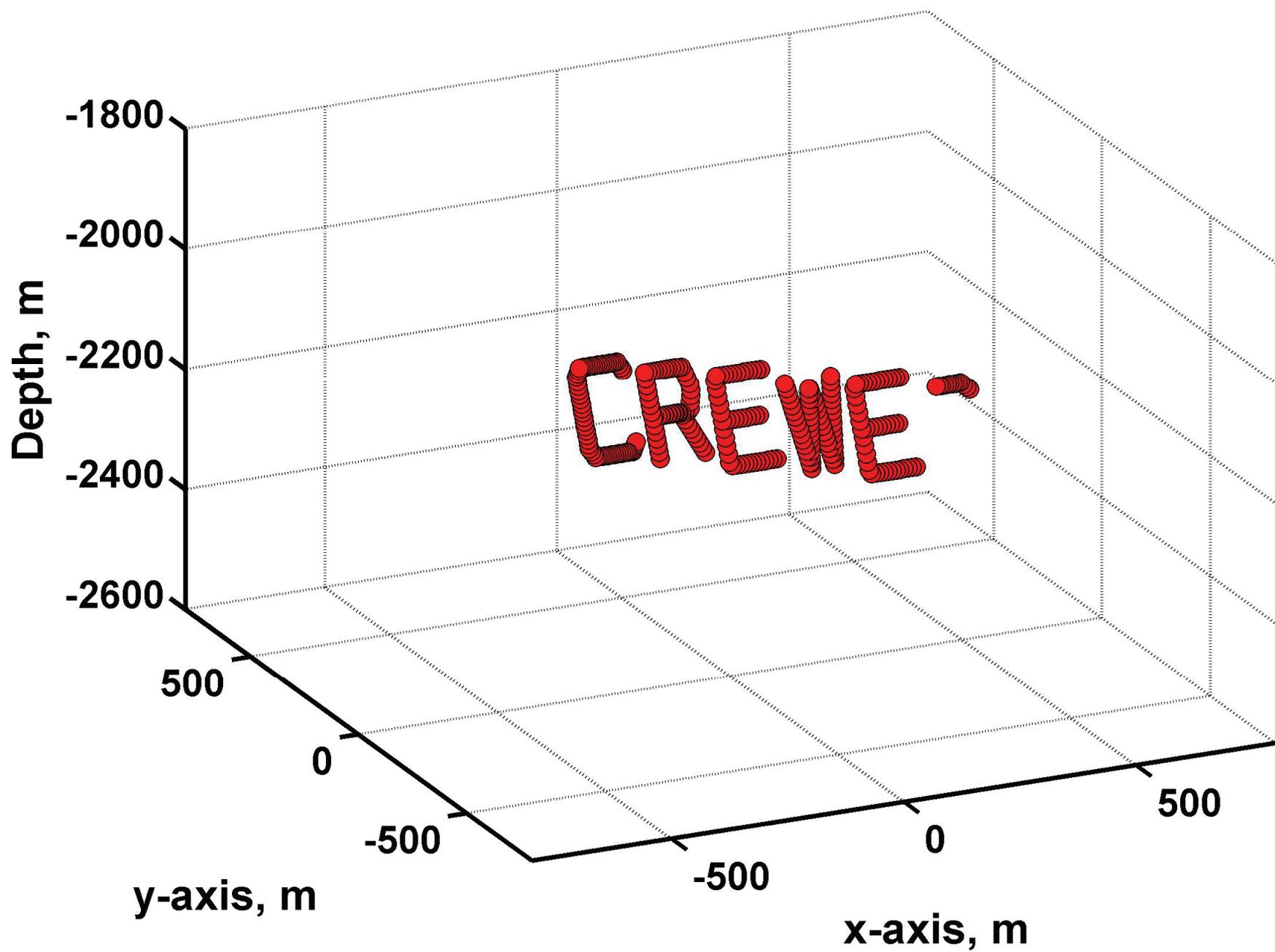


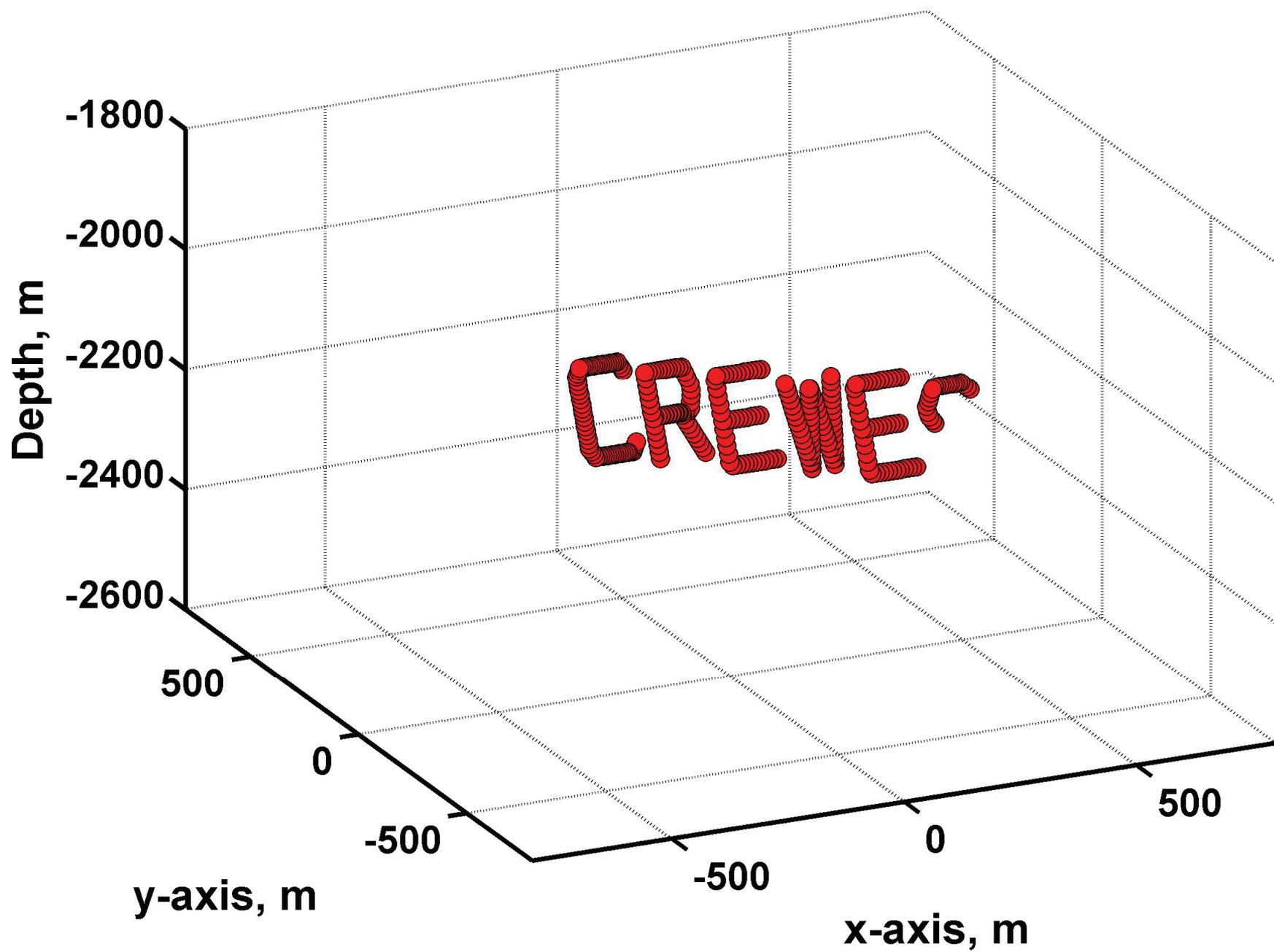


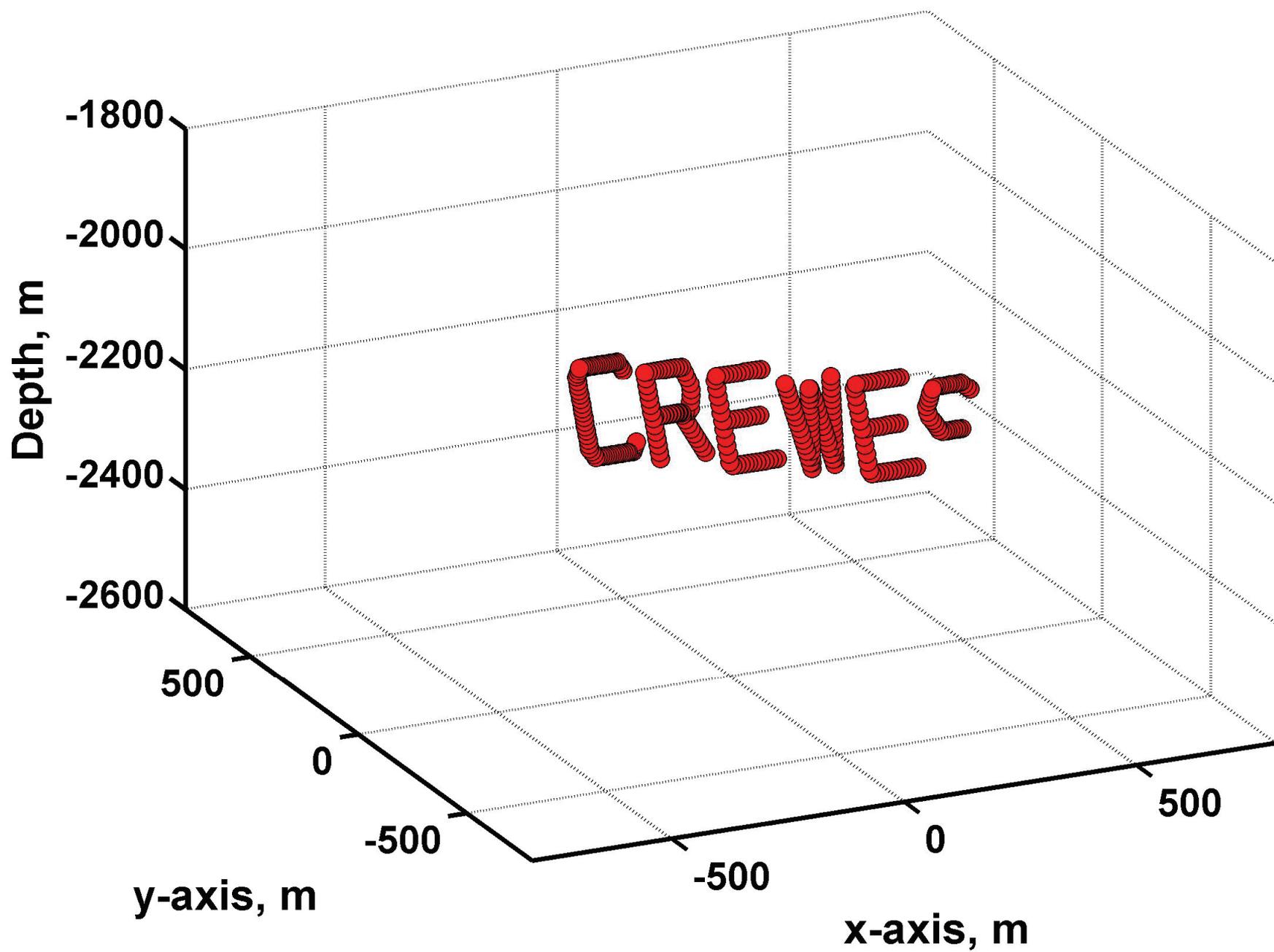


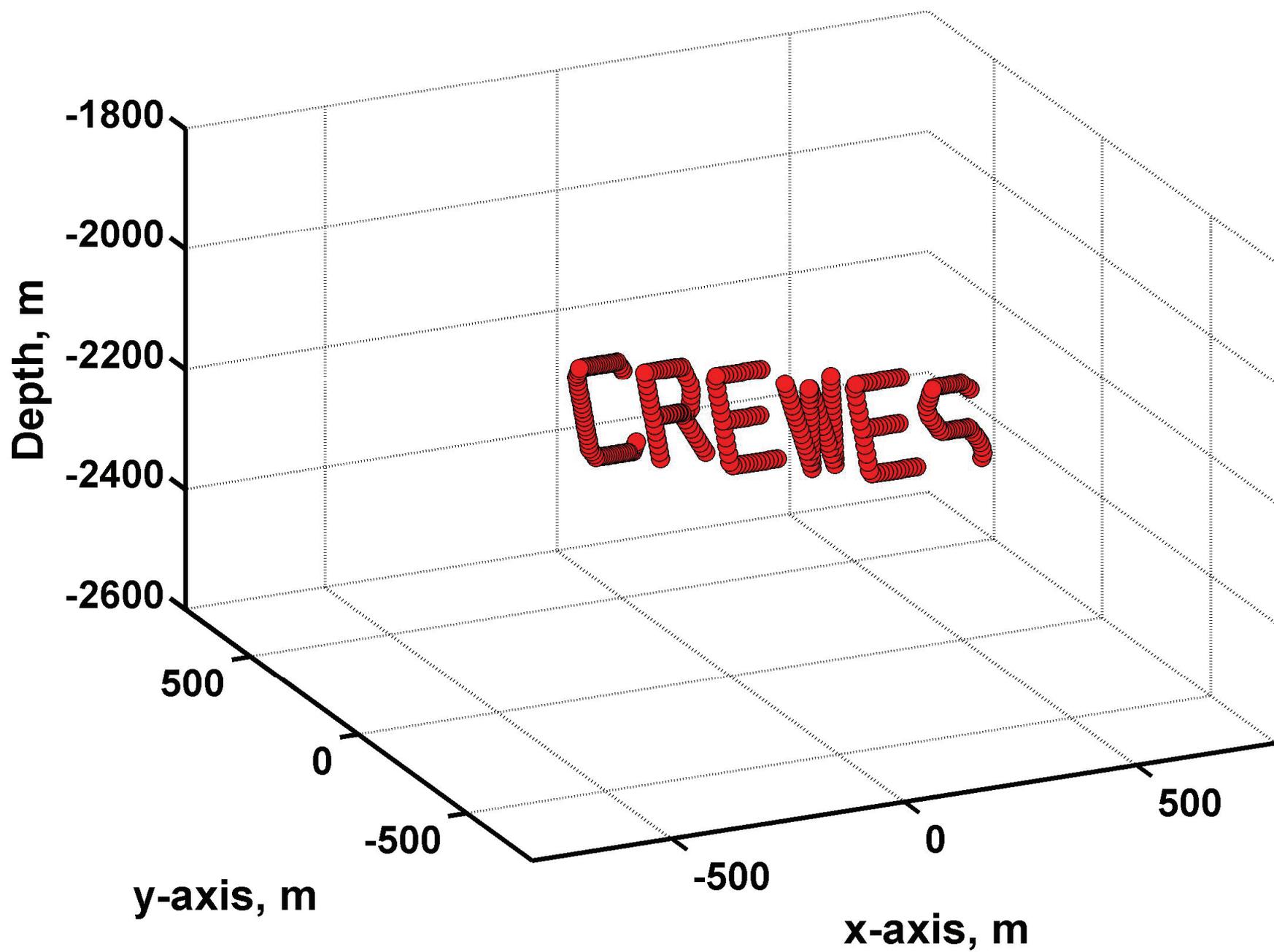


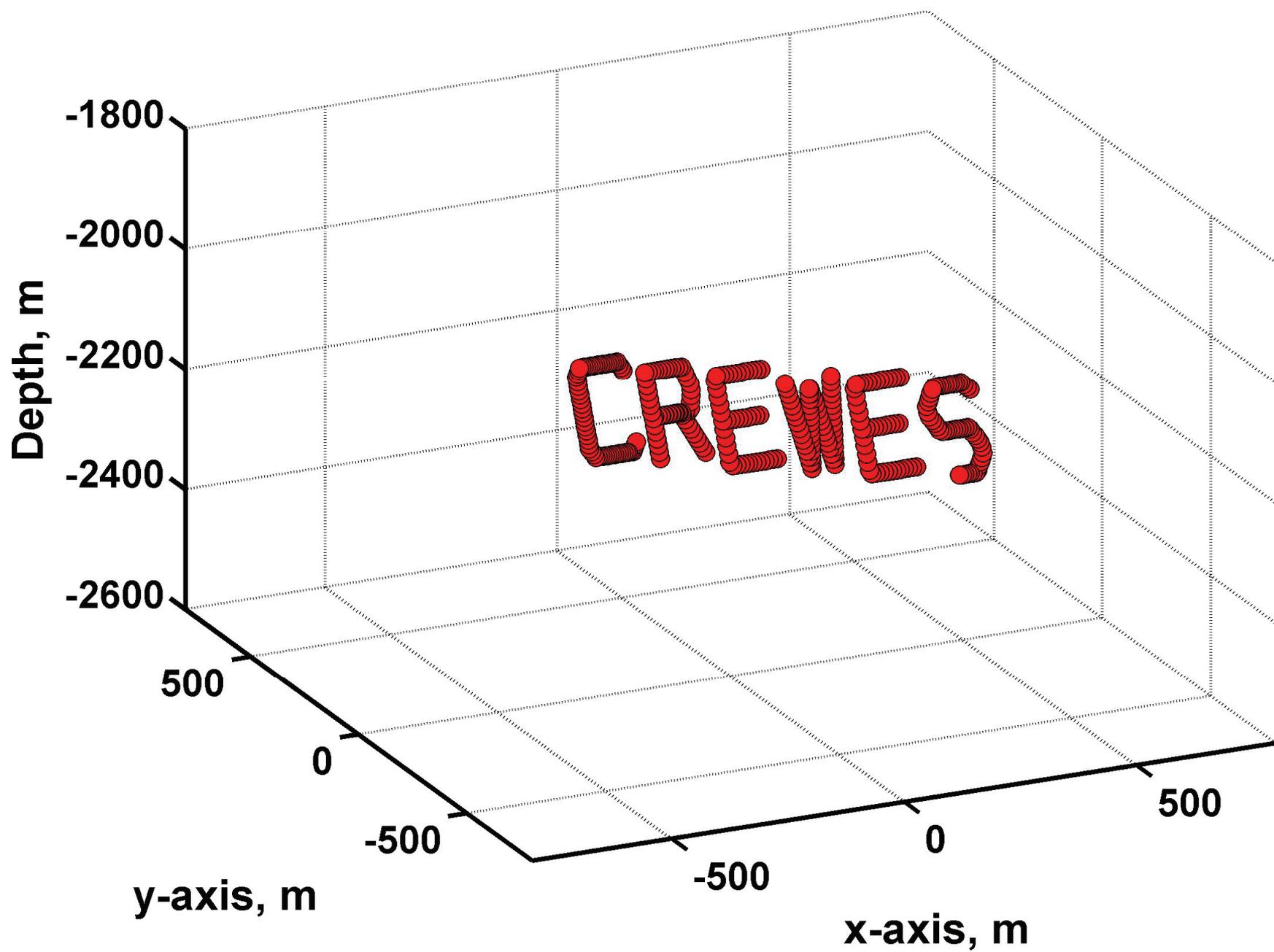


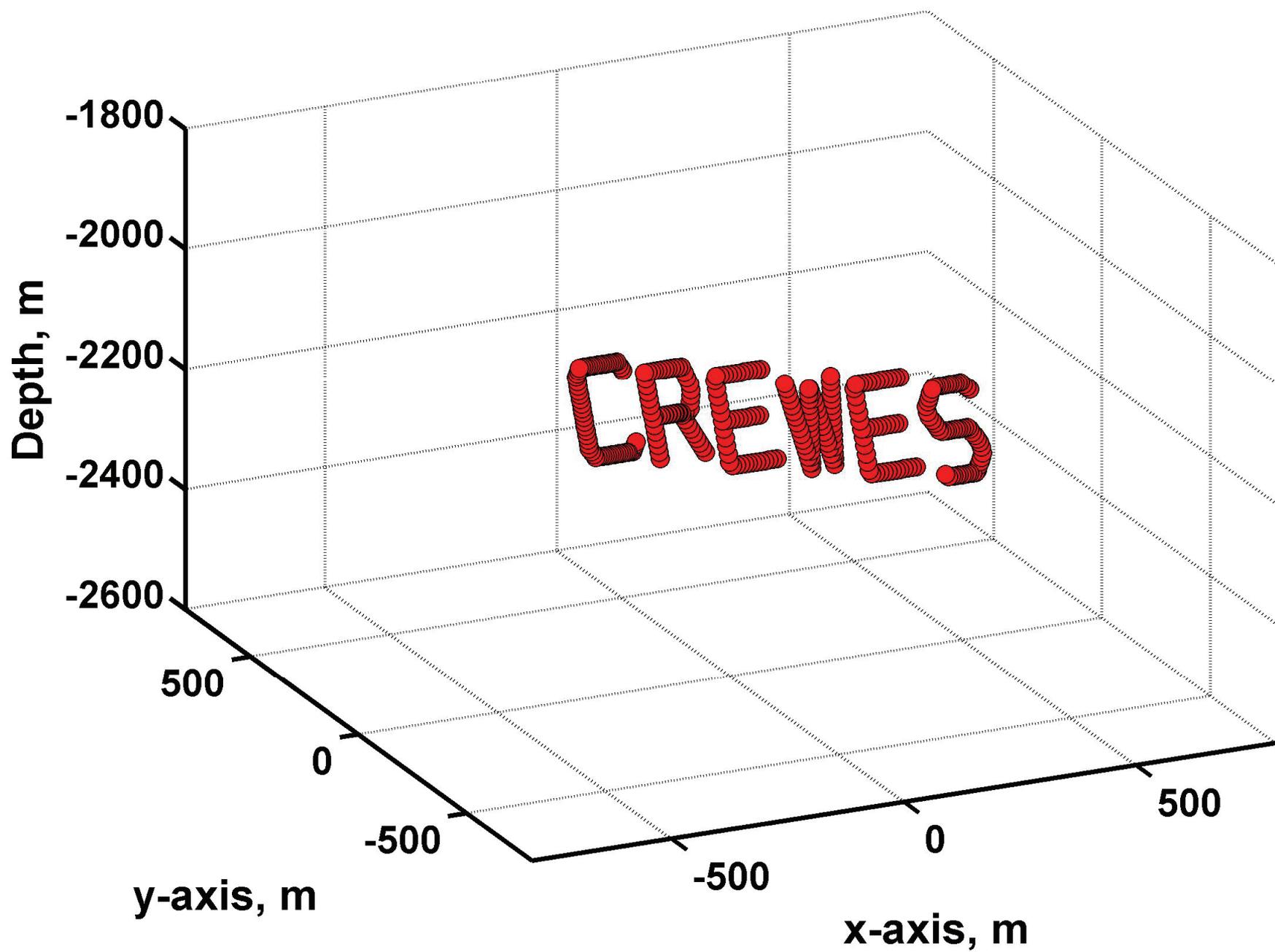




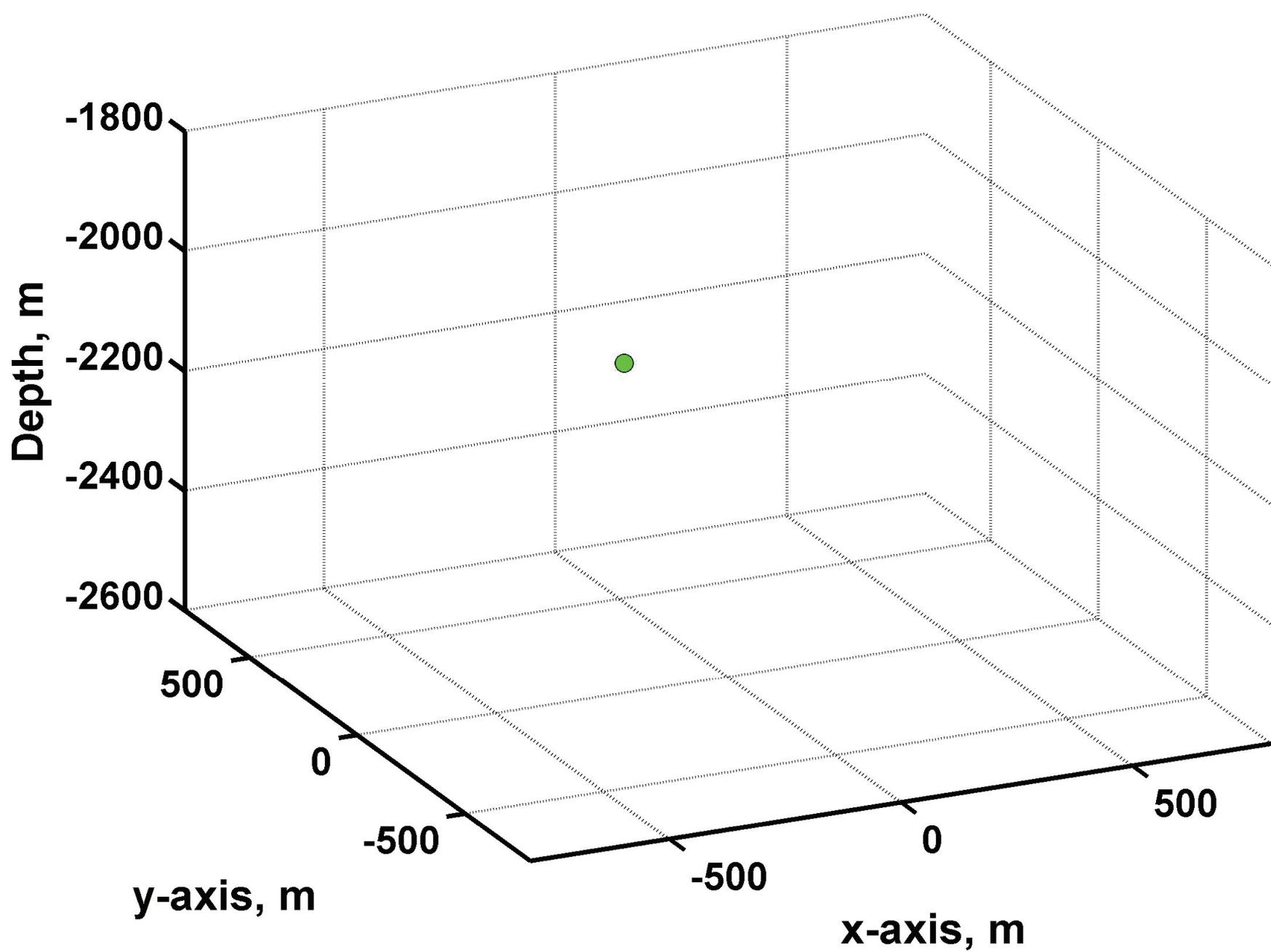


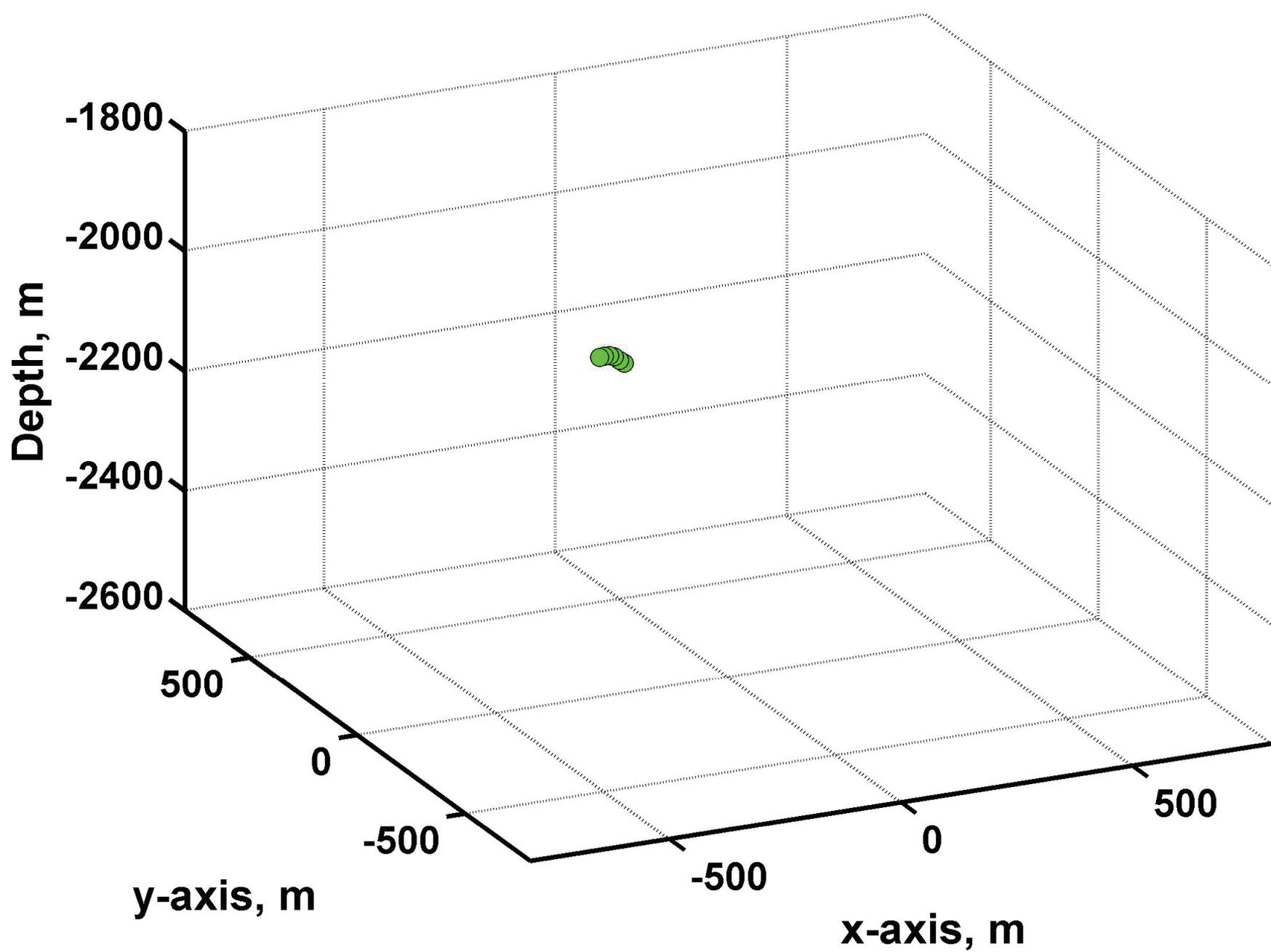


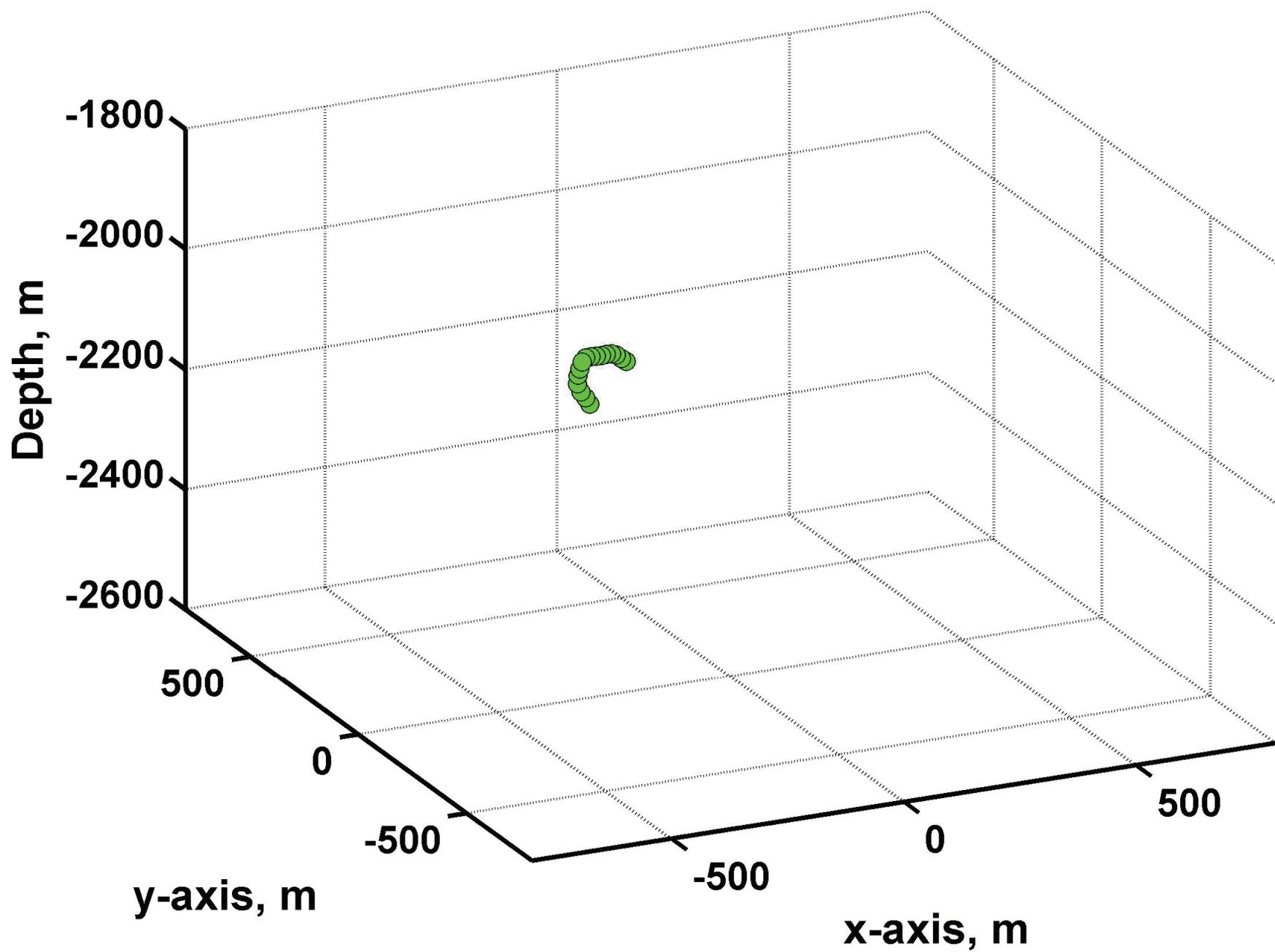


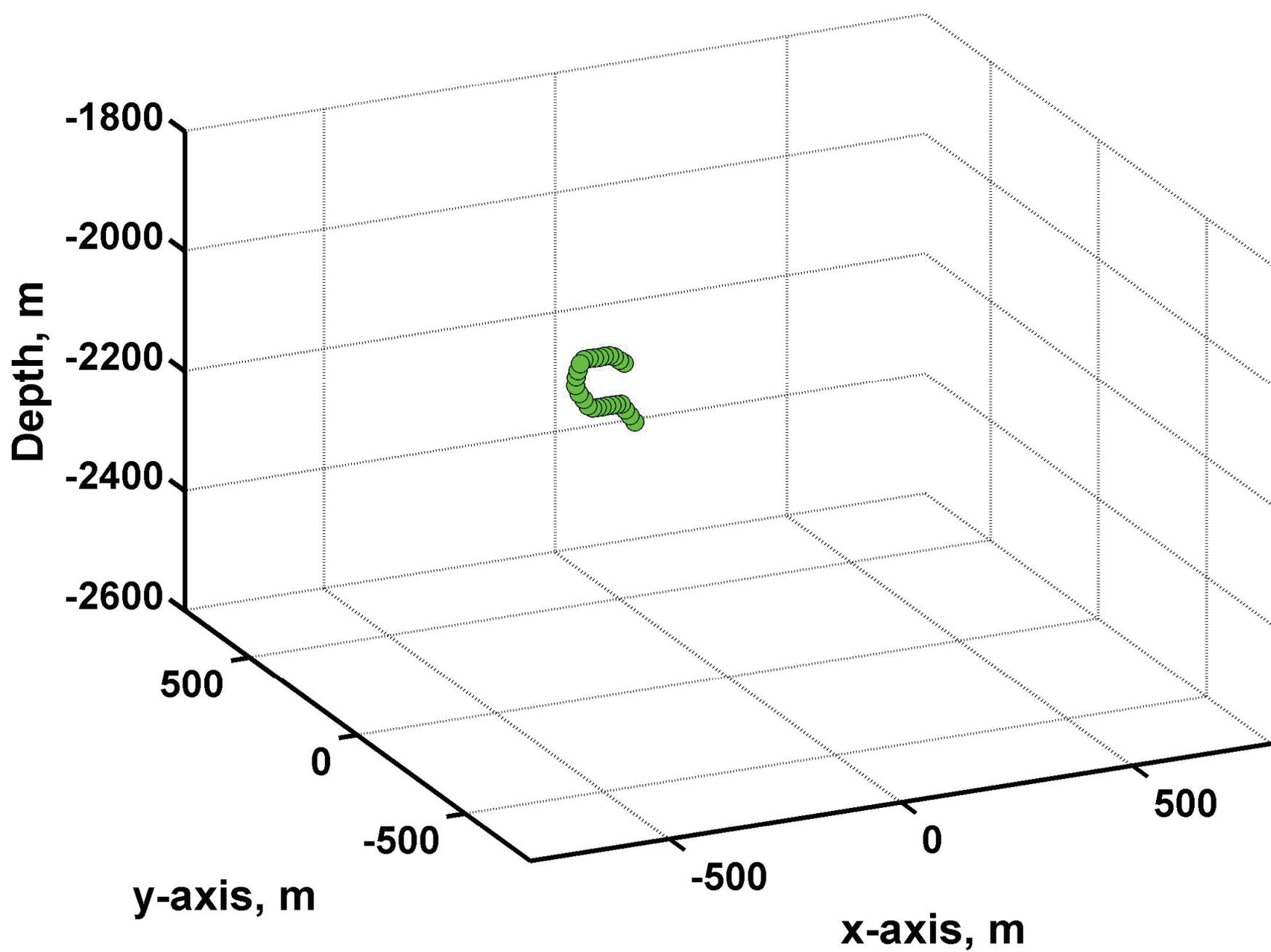


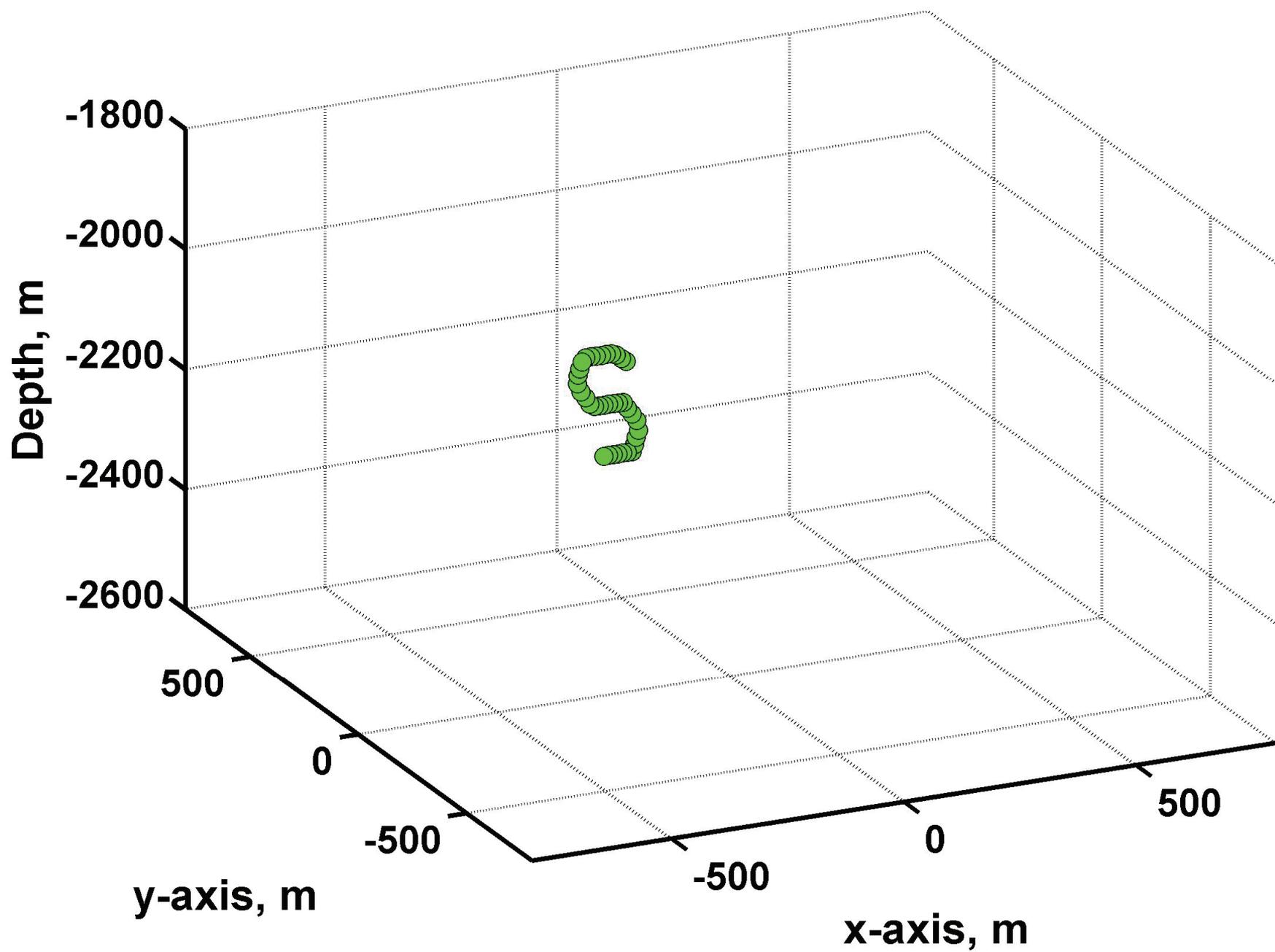
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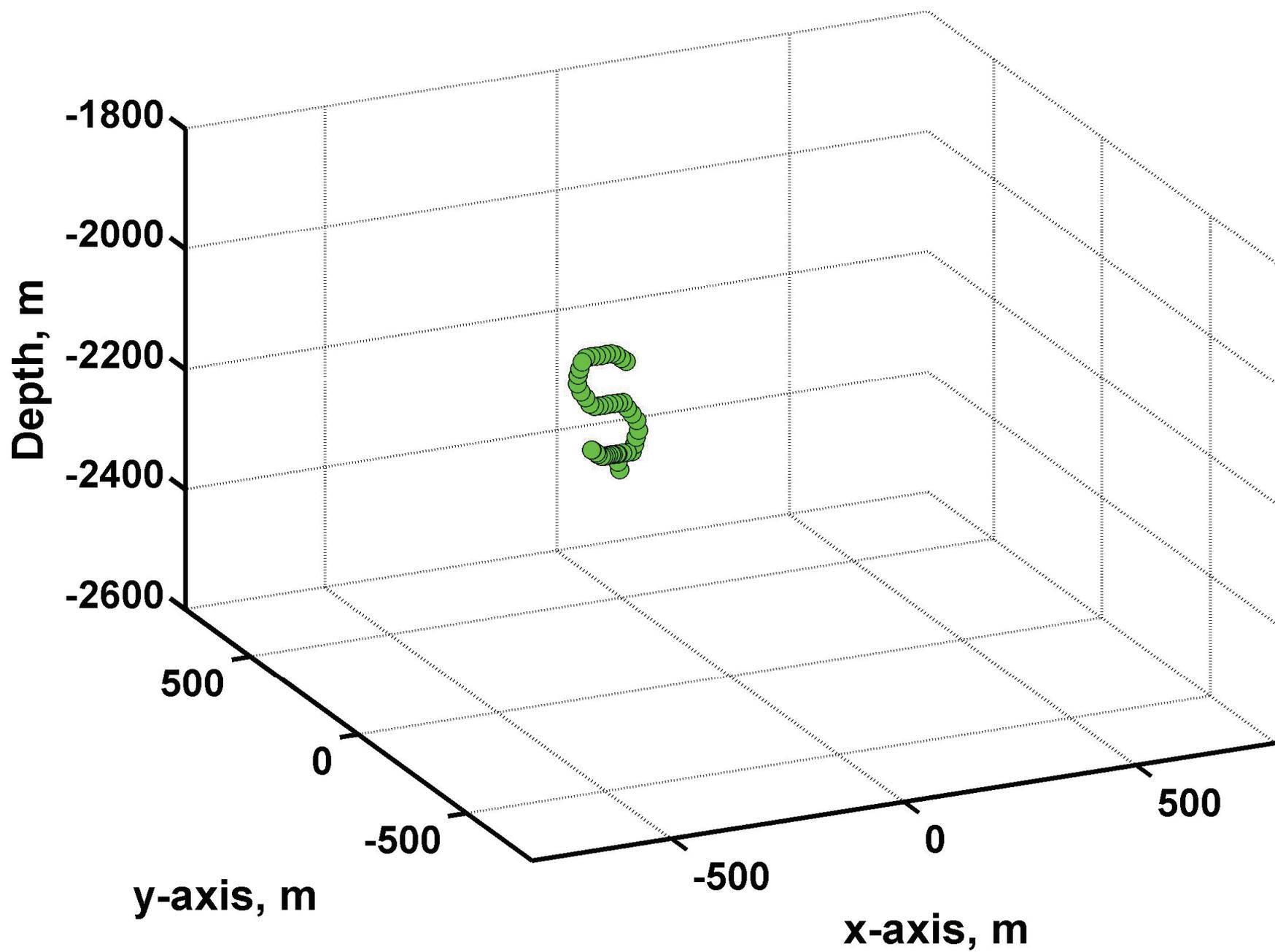


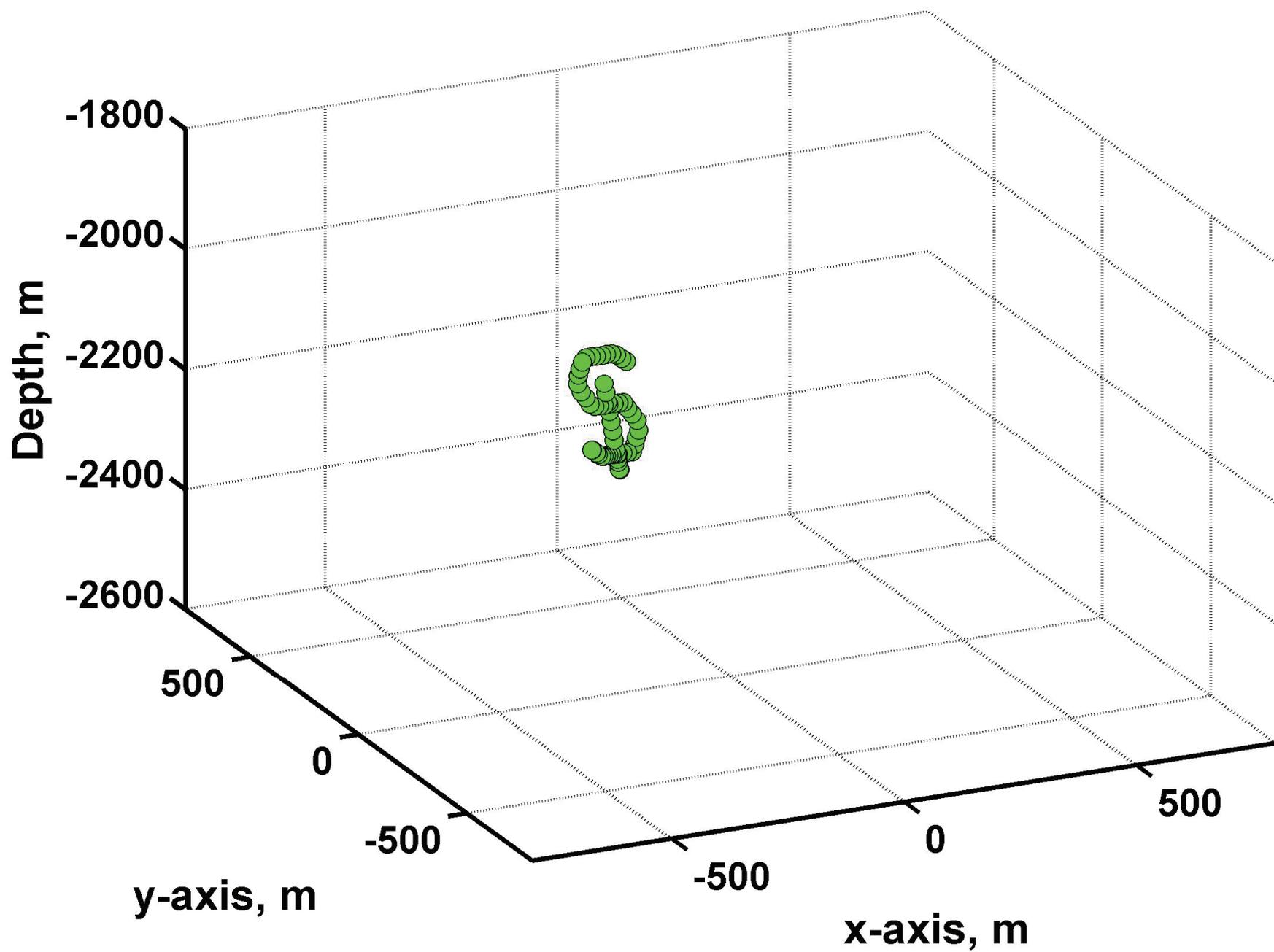


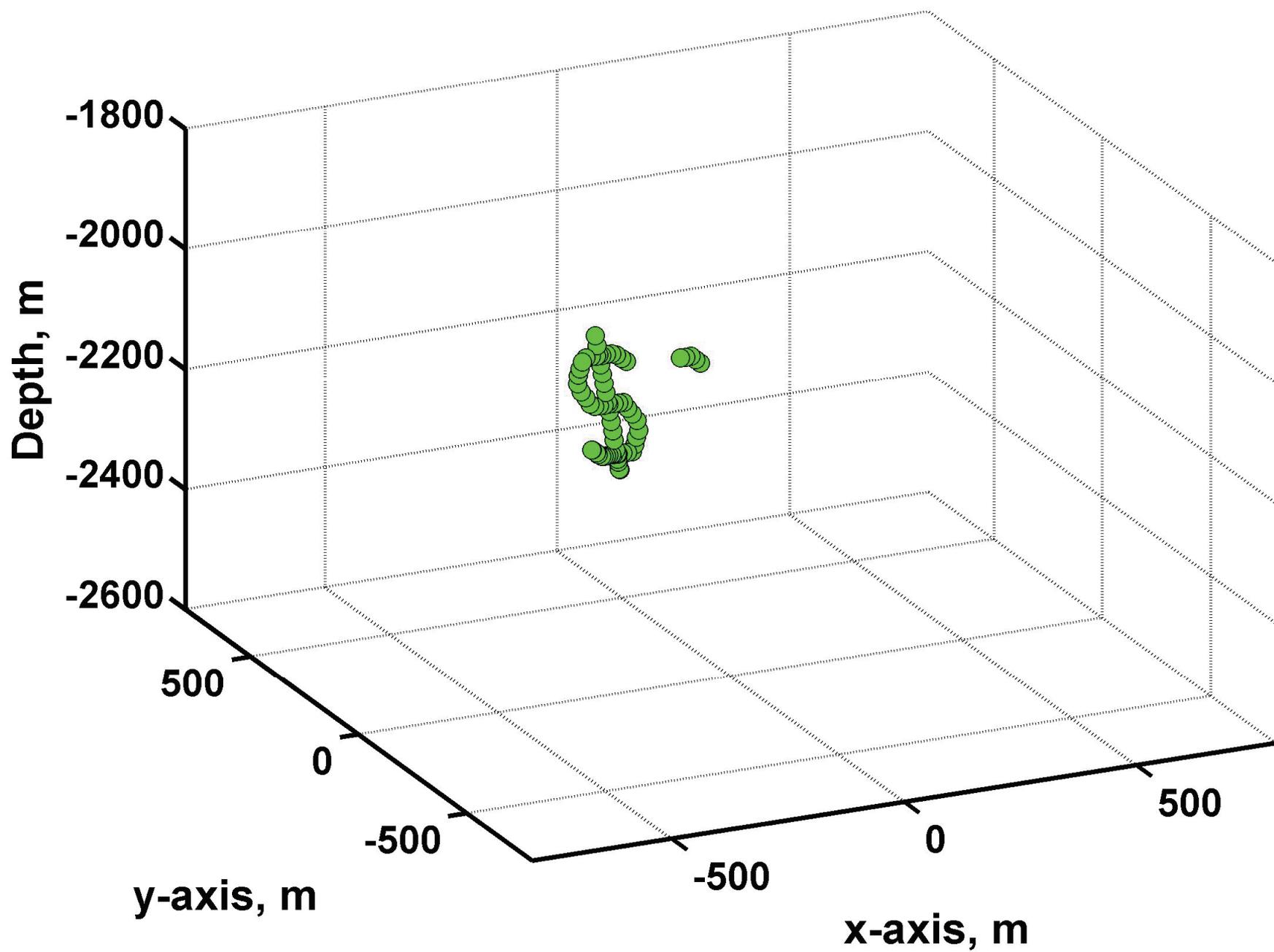


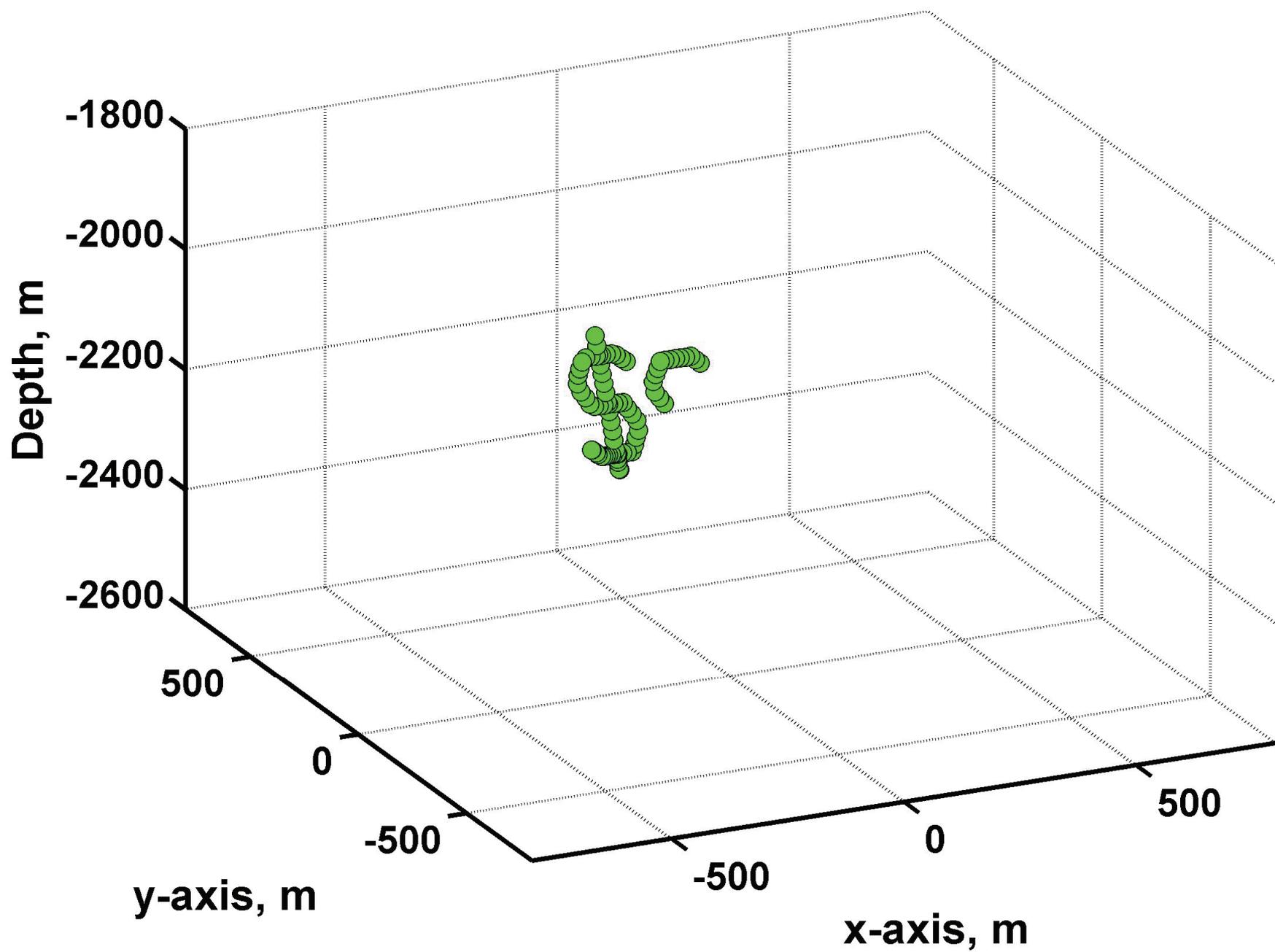


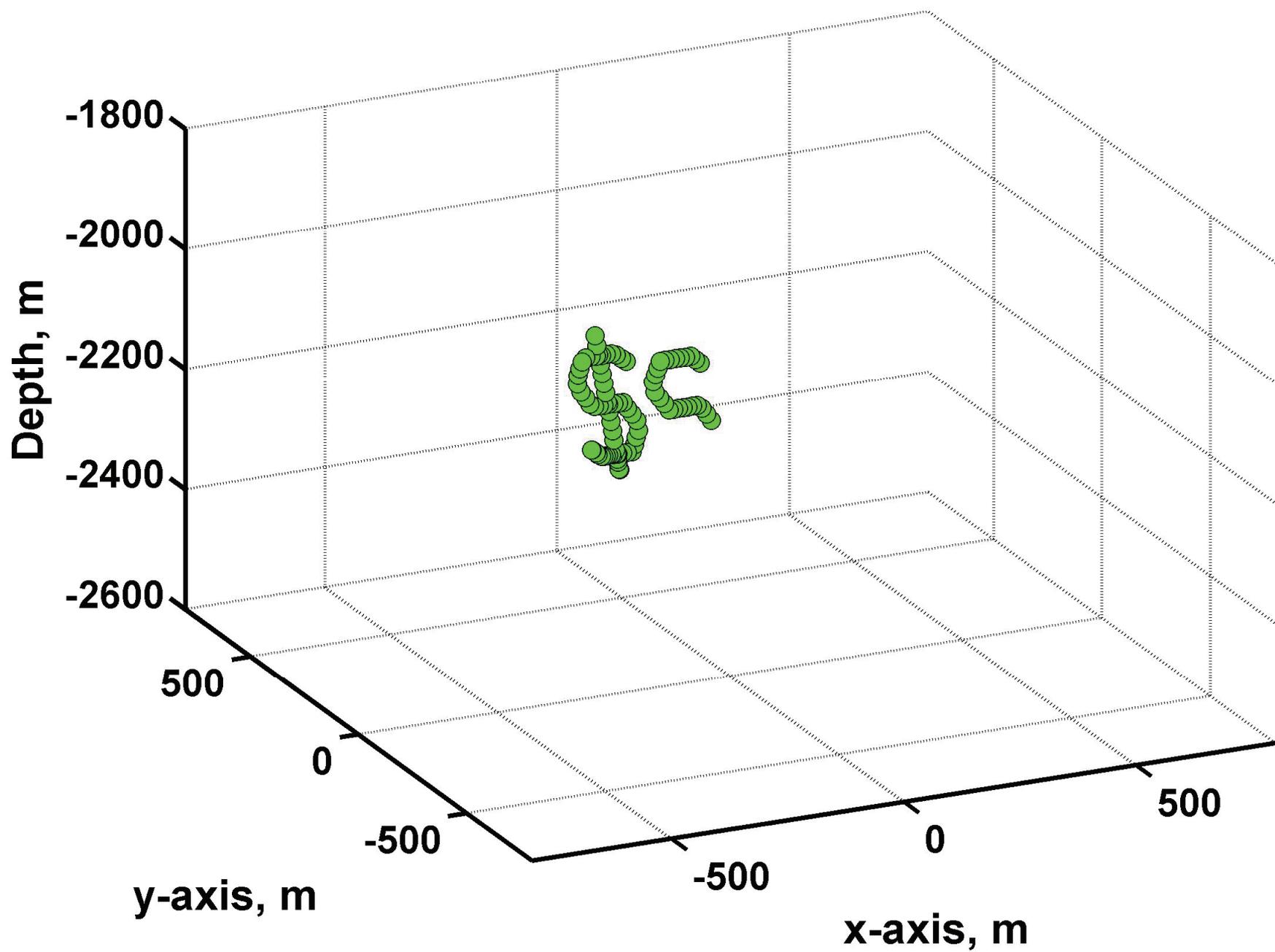


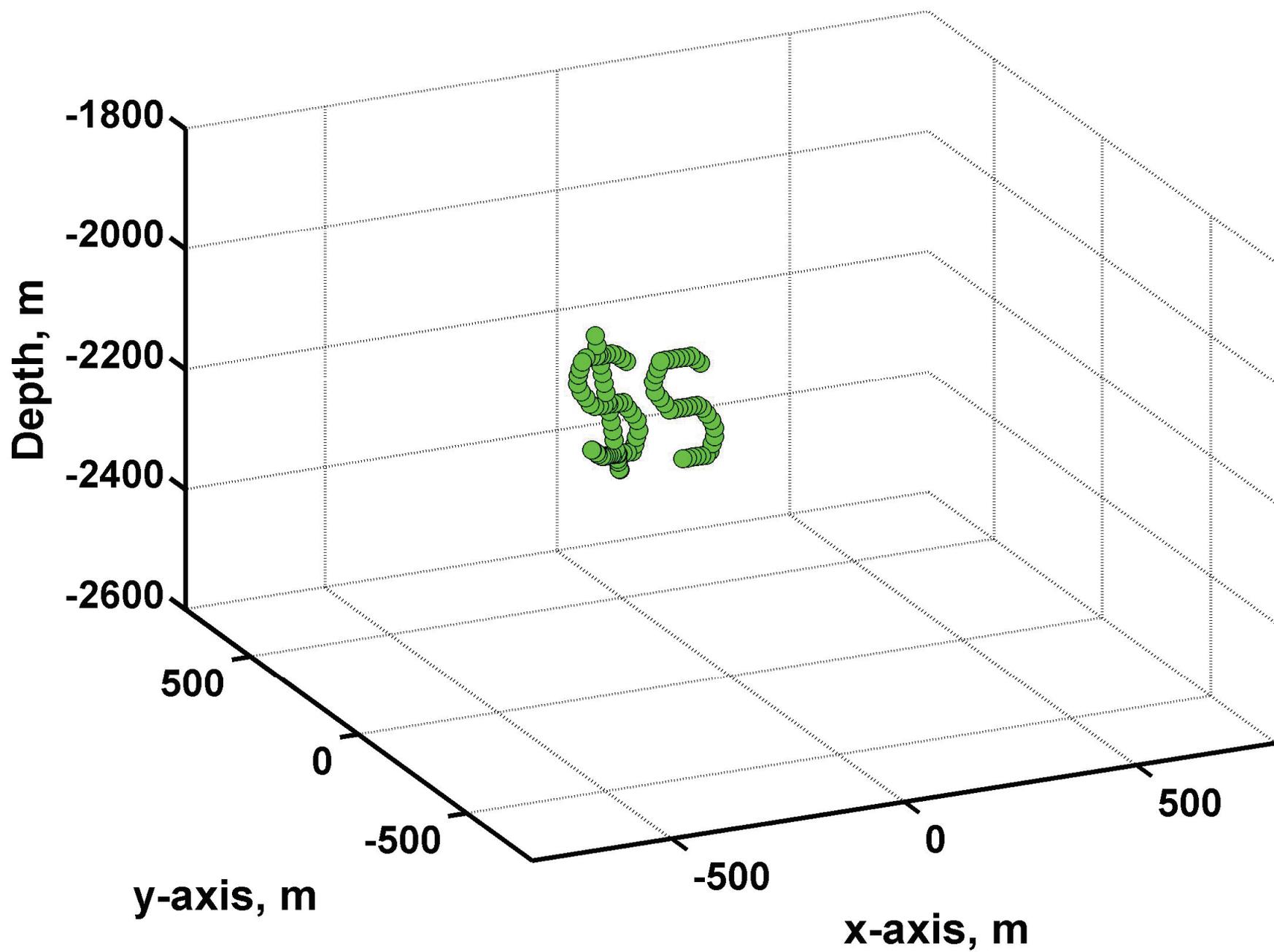


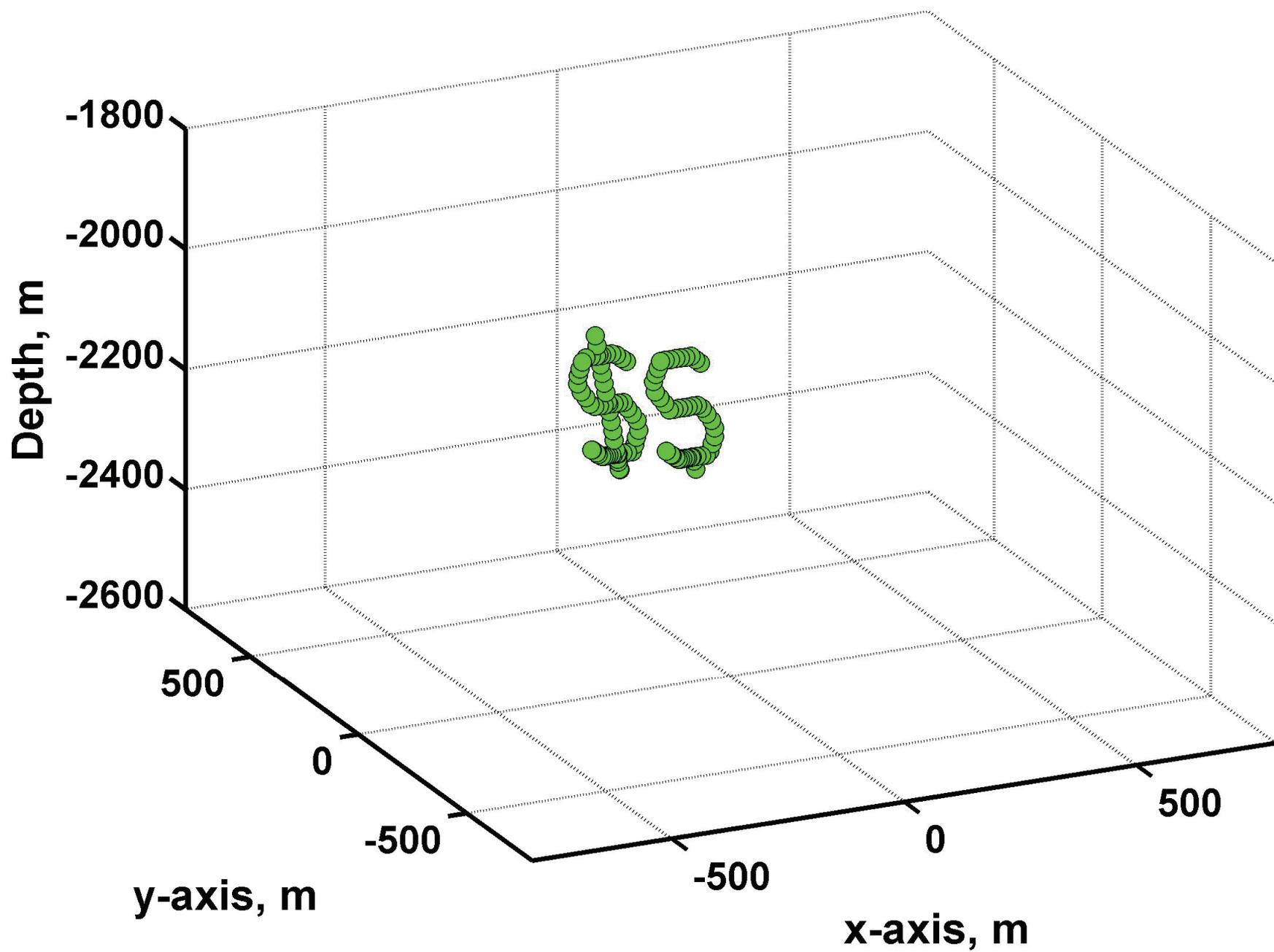


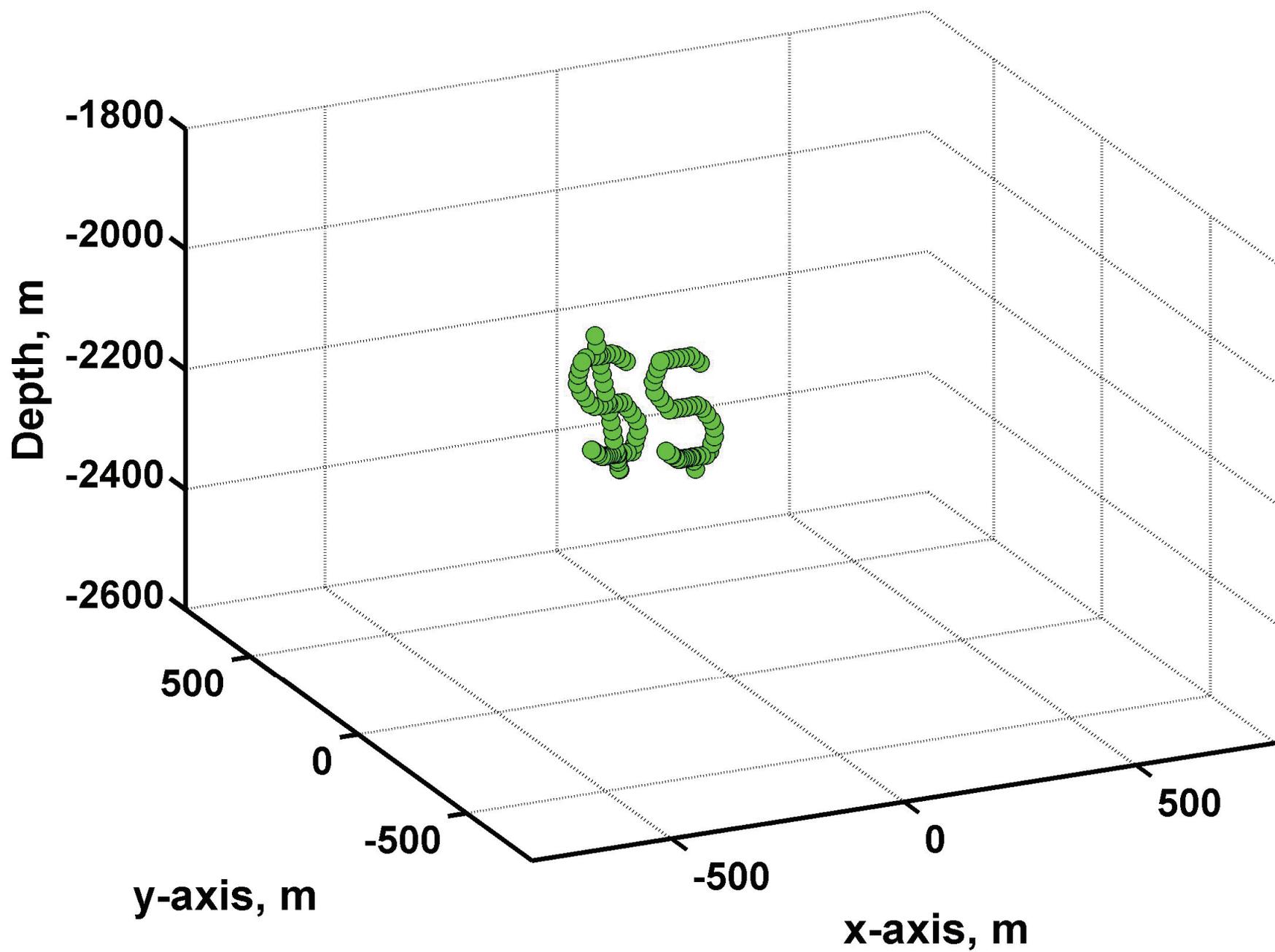


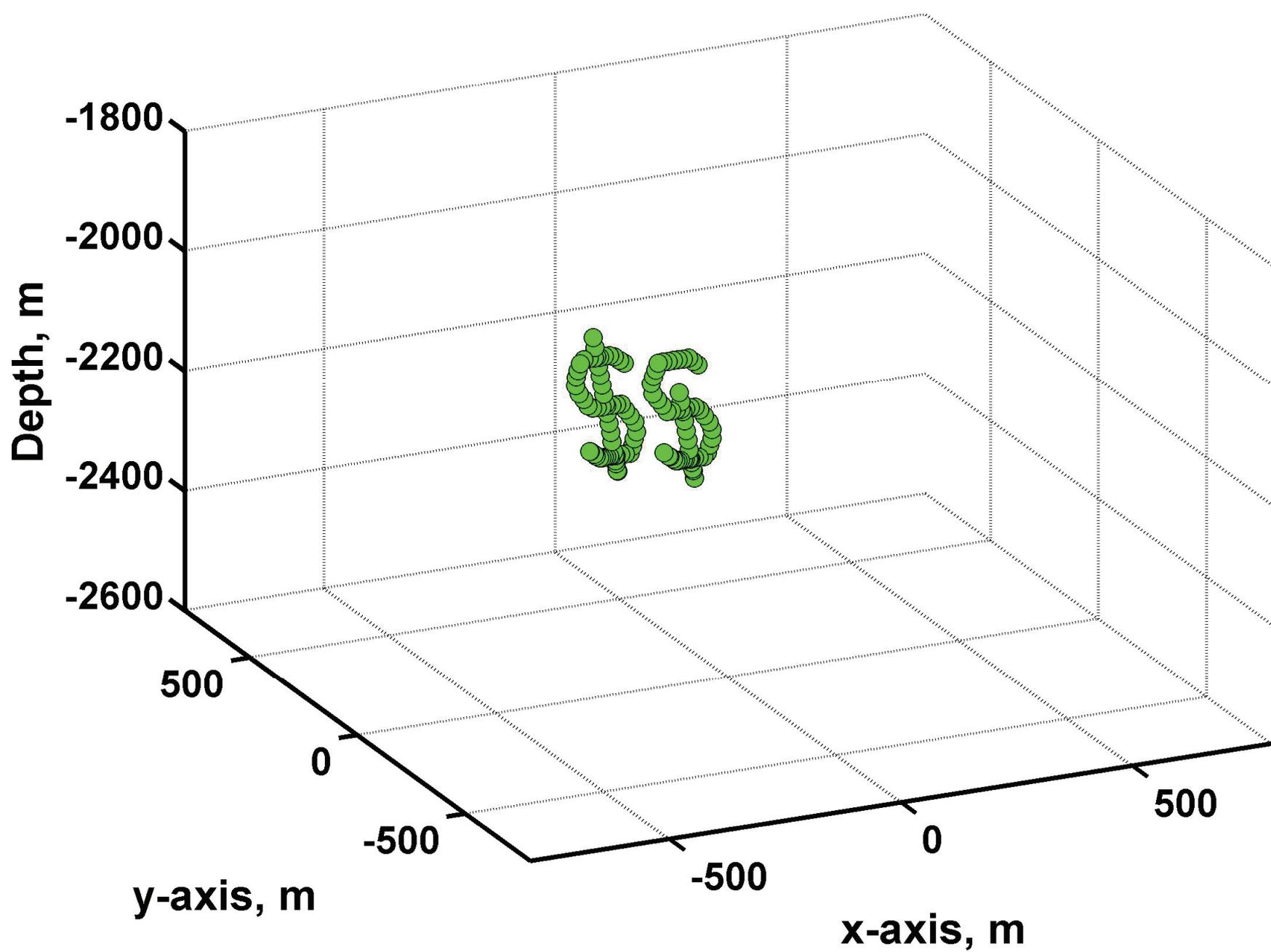


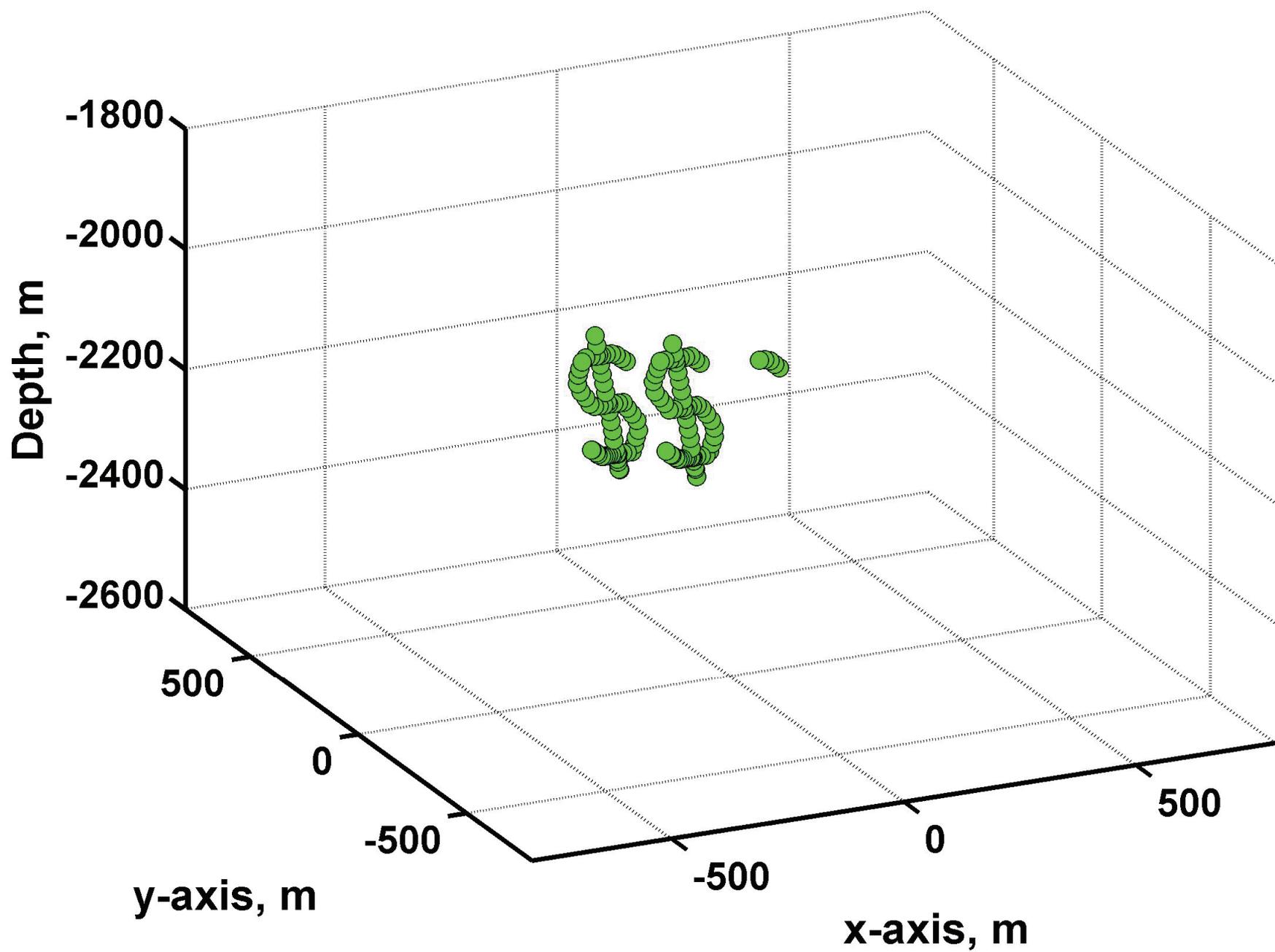


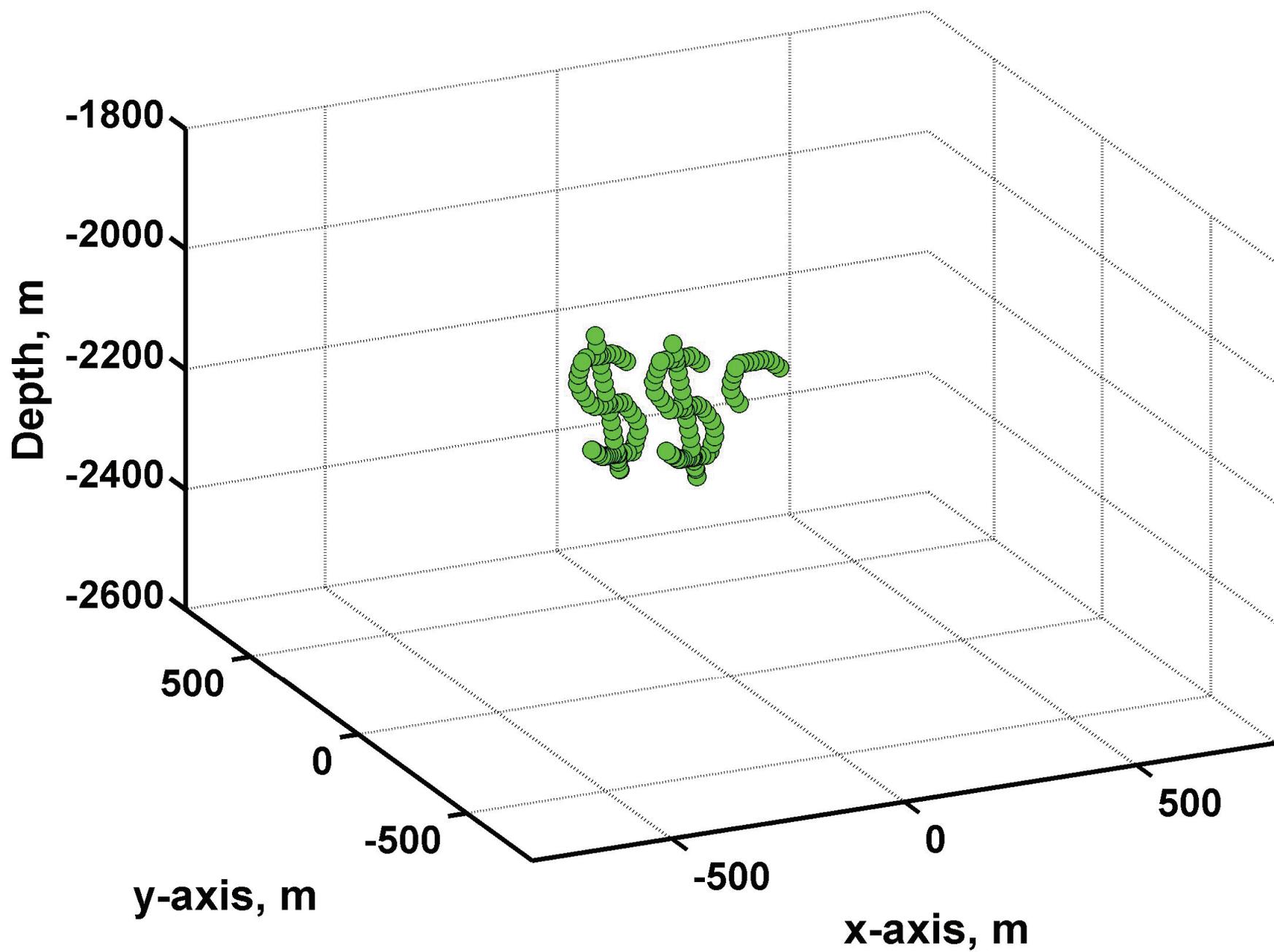


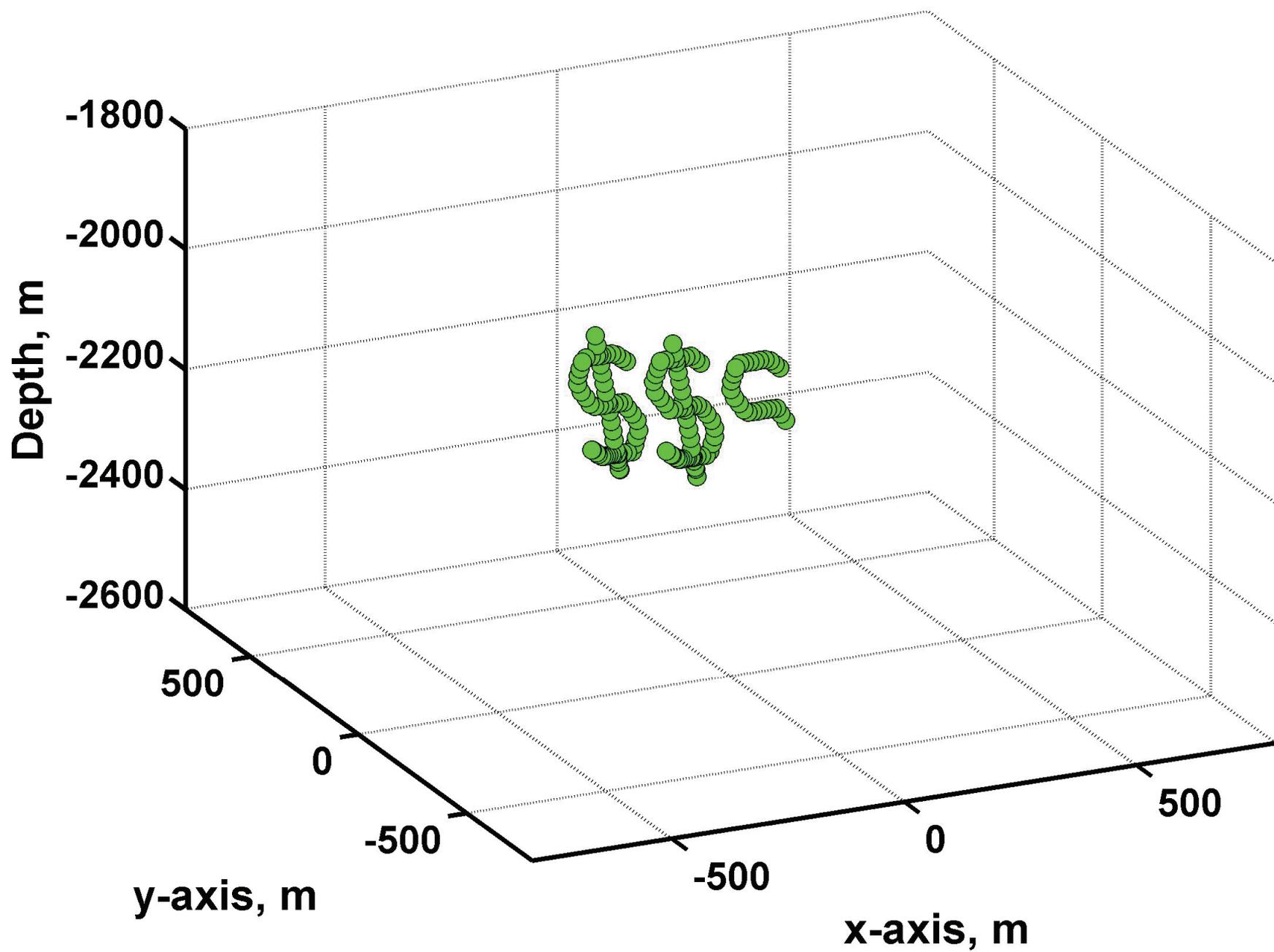


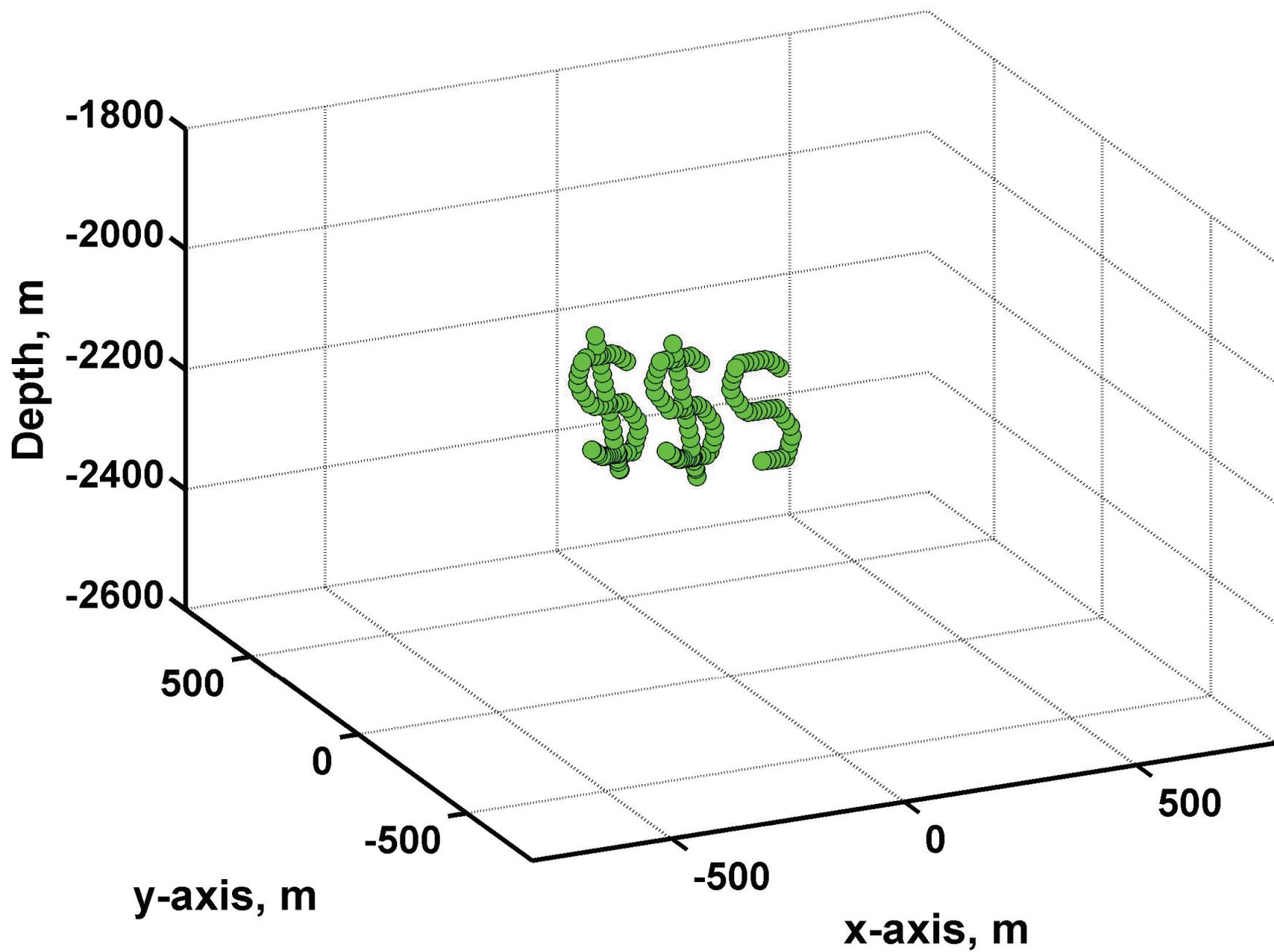


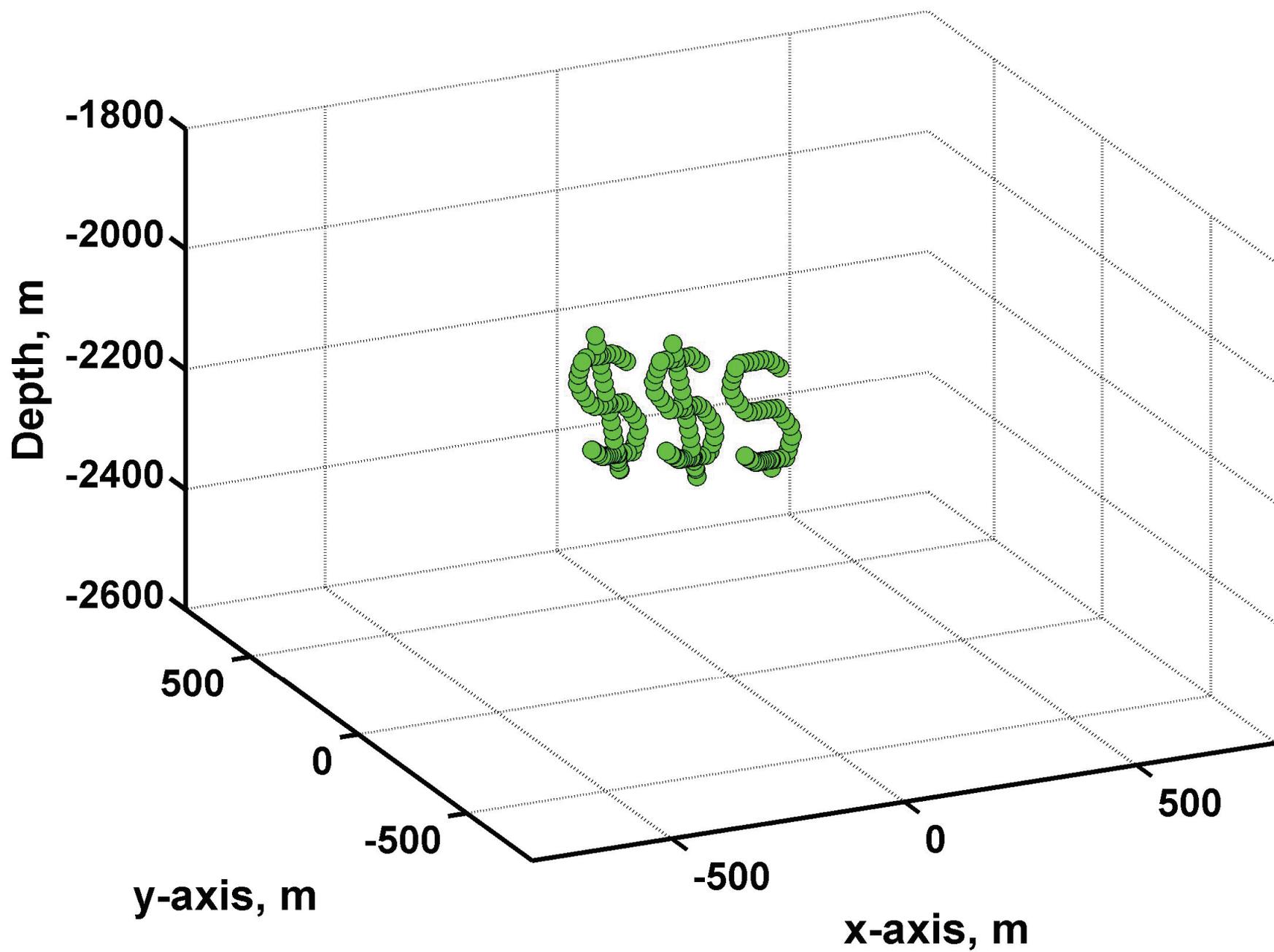


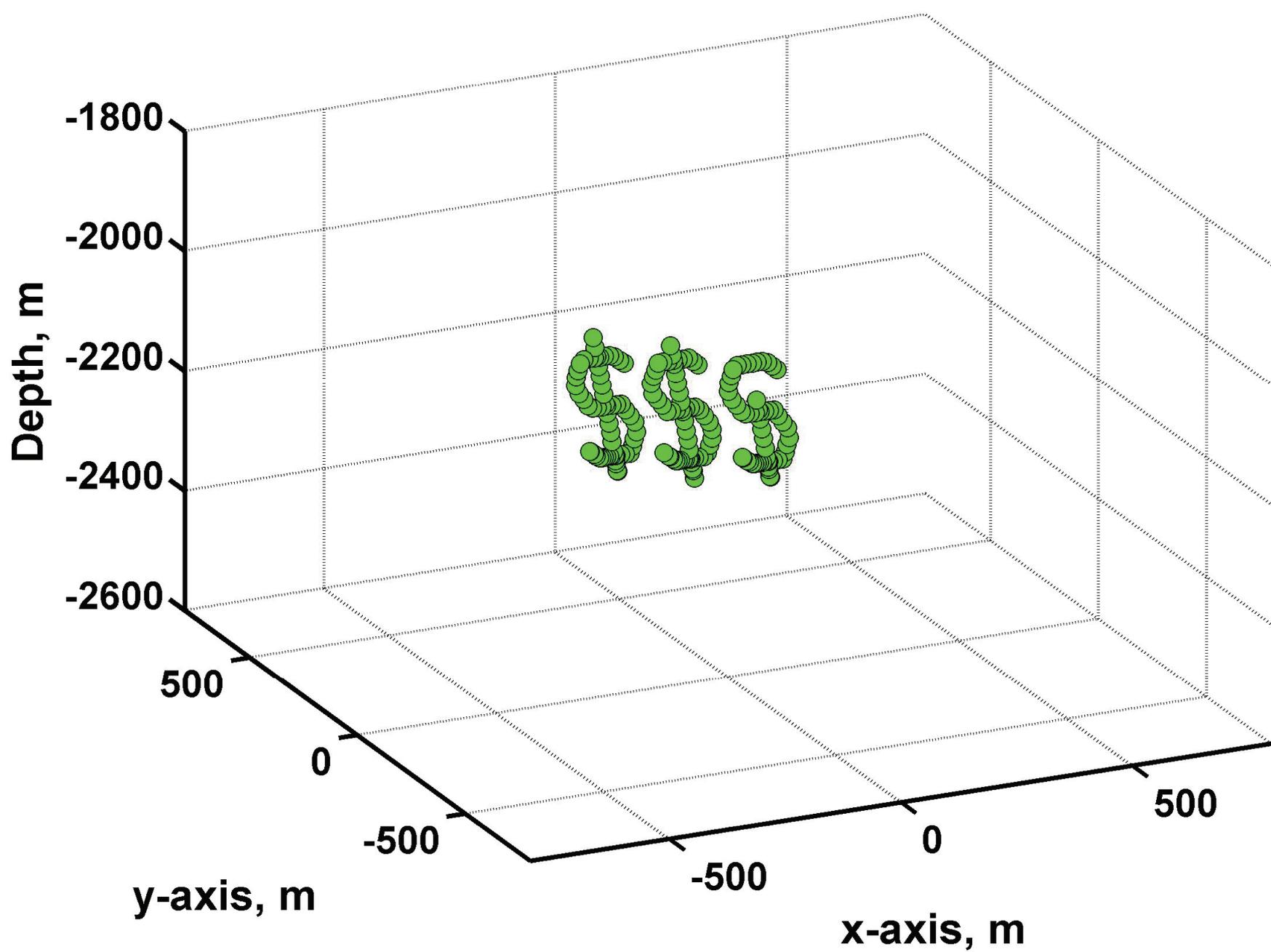


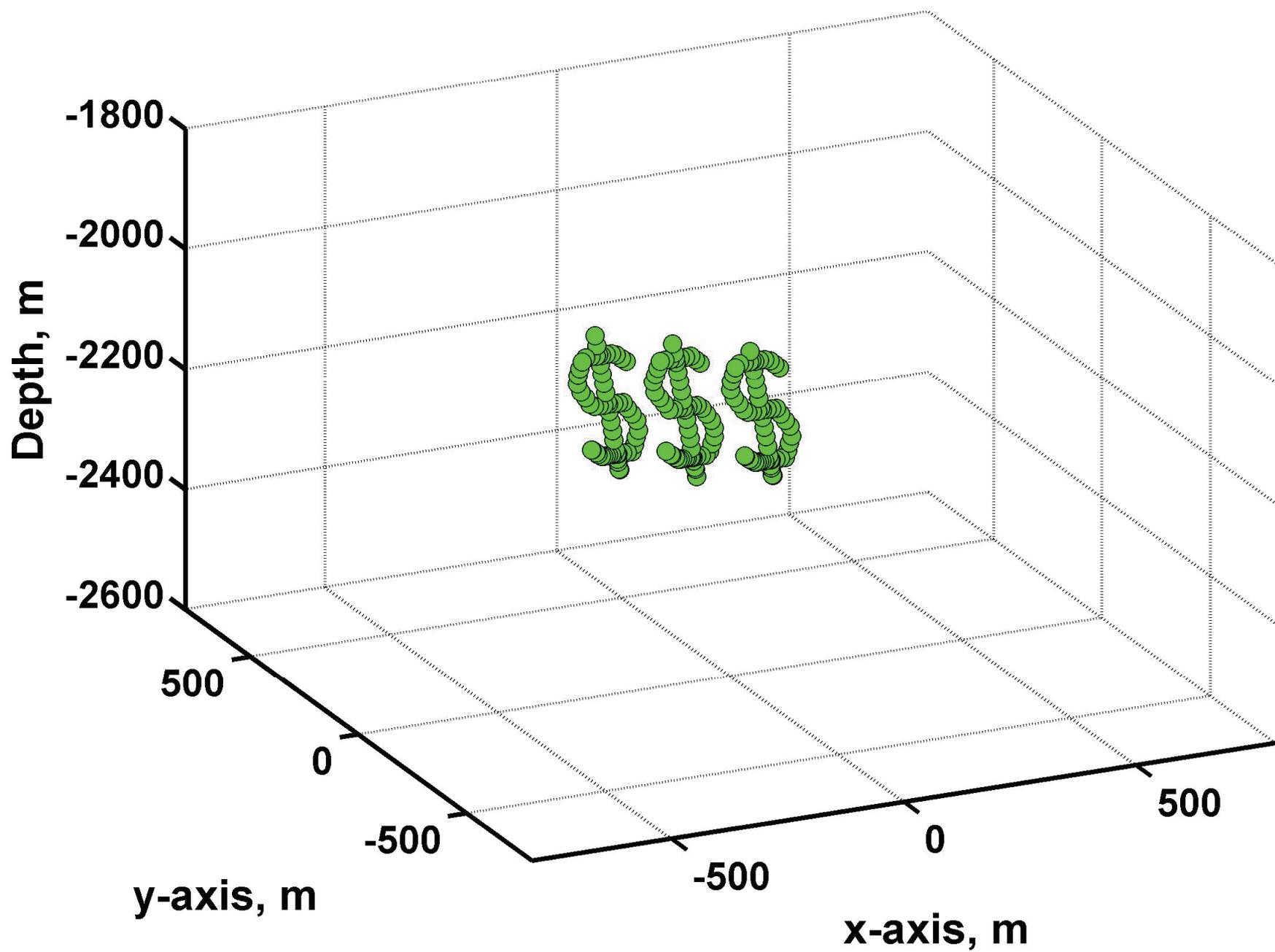


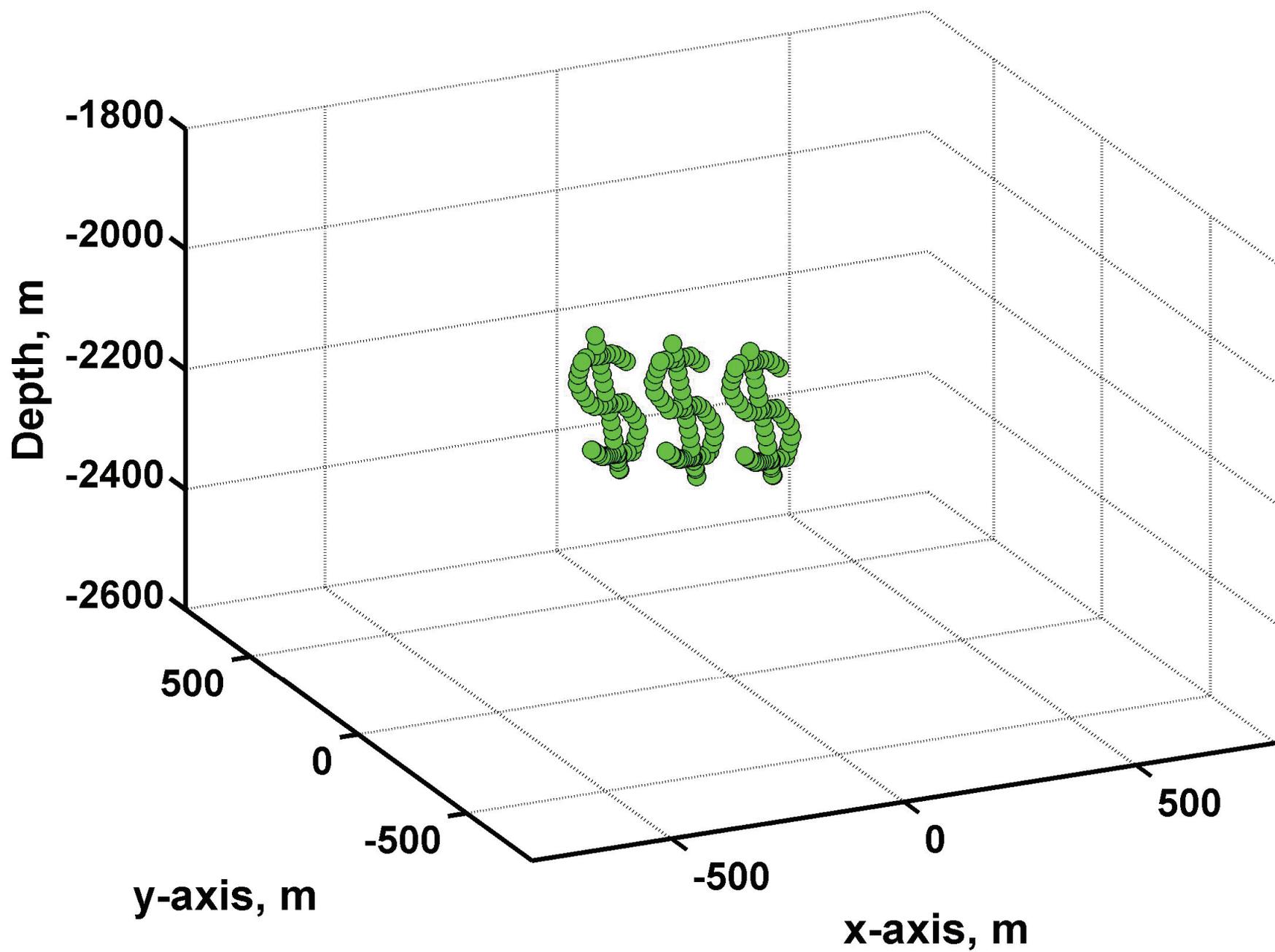












CONCLUSION

For specific 3C geophone arrays and specific velocity models, we will create many data files, each containing seismograms from a different microseismic source location.

These files will be distributed to any sponsor who wants to use them for testing location algorithms.

ACKNOWLEDGEMENTS

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