Seismic and resistivity surveys to the Sakuradani Kofun tumuli after the Noto earthquake

能登地震による櫻谷古墳の被害状況把握のための比抵抗・弾性波探査を組み合わせた複合非破壊探査

2024年1月1日、能登半島を襲った大地震は、富山県屈指の規模を誇る櫻谷古墳に甚大な被害を与えた。1号墳では亀裂や陥没、2号墳では深さ6mにもおよぶ大陥没が生じ、復旧のための第一歩として、地震による盛土被害状況の把握のため、比抵抗と弾性波を組み合わせた複合的な非破壊探査を実施した。その結果、1号墳では陥没坑付近の斜面近くが高比抵抗、と後方部中央の1m深度が高比抵抗値・低弾性波速度であると観測され、緩み領域である可能性が示された。また、墳丘底部(深さ4m〜)は低比抵抗・低速度であり、雨水等が帯水している可能性が示唆された。2号墳では陥没孔付近が高比抵抗・高弾性波速度と観測され、緩み領域で低い弾性波速度として解釈される一般的な地盤内空洞の解釈とは異なる結果となった。また、北側斜面の浅い部分は高比抵抗、深い部分は低比抵抗・低弾性波速度と観測され、1号墳と同様帯水層となっている可能性が示唆された。

Introduction

The Noto Earthquake of January 2024 caused substantial damage to the Sakuradani Kofun Tumuli in Takaoka City, Toyama Prefecture, resulting in notable sinkholes and cracks across Tumulus No. 1 and Tumulus No. 2. To accurately assess this damage and consider future remedial measures, we conducted a comprehensive, non-destructive investigation using both seismic exploration and electrical resistivity tomography (ERT).

Seismic & ERT Survey

In the two-dimensional resistivity survey, a portable dynamic cone penetration test (DCPT) was performed to measure ground strength and to investigate a method currently under development that utilizes the DCPT device to complement the traditional resistivity survey.
In seismic explorations, 24 geophones spaced 0.5 meters apart were used. A chirp signal generated by a portable vibration-speaker source, with a high-frequency range of 20-300 Hz, and cross-correlation signal processing were employed to improve the signal-to-noise ratio and enhance the accuracy of investigating the shallow layer at a depth of approximately 10 meters.

Results

Fig. 3 shows the results of the ERT survey and Vs inversion using the Rayleigh wave survey. Both Tumulus No. 1 and No. 2 had an average Vs velocity of 190 m/s and a resistivity of 700 Ω·m. In Tumulus No. 1, a low-Vs and a high-resistivity area were observed at a depth of approximately 1–2 m in the central part (a-1) of the line A2-A3. Additionally, a low-Vs area and a low-resistivity area were observed throughout the area at depths of 4 m or deeper (a-2). The former was a relaxation area. Meanwhile, the latter is believed to be a water-saturated layer caused by rainwater infiltration, both of which are considered vulnerable areas. In Tumulus No. 2, a sinkhole with a depth of 6 m on the southern slope was observed as a high-Vs and a high-resistivity area (b-1). Additionally, a high-resistivity area was observed on the surface of the northern slope (b-2). A low-Vs and low-resistivity area (b-3) was observed at a 4m deep of the mound, considered vulnerable area.

Fig.1 bird-eye view of Sakuradani Kofun Tumuli

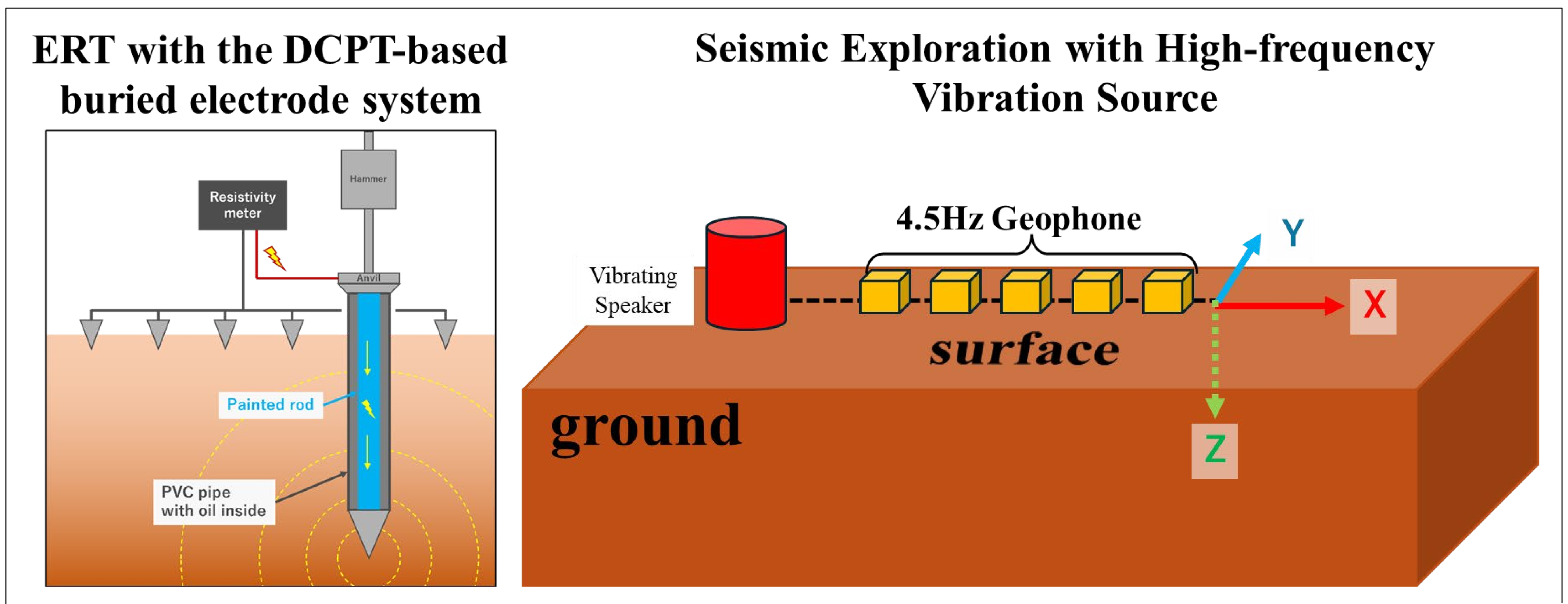

Fig.2 Overview of Electric resistivity Tomography(ERT) and Seismic survey

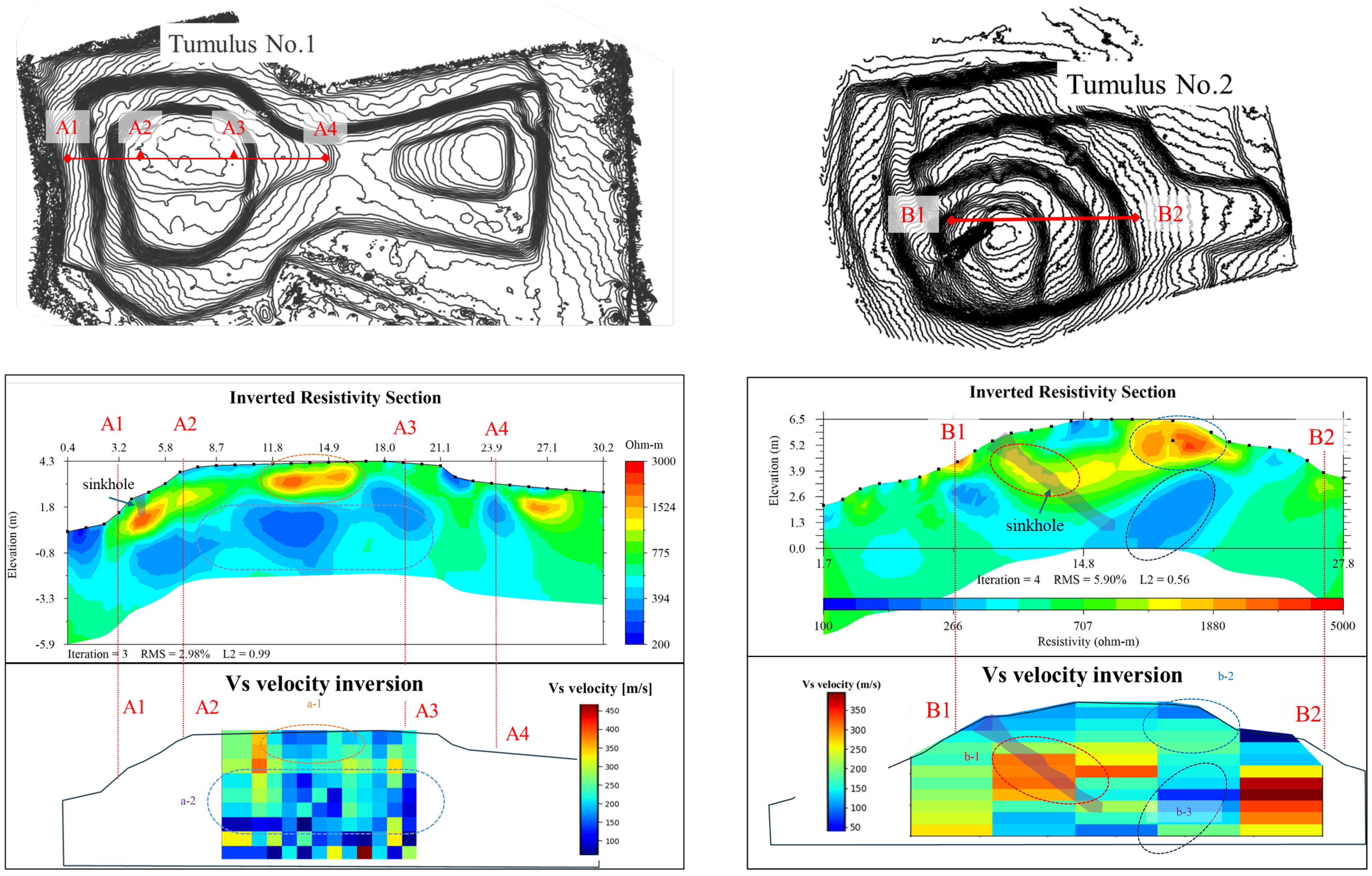

Fig.3 The result of ERT resistivity inversion and Vs inversion of Tumulus No.1 (left) and No.2 (right).

For further information, contact below.
Yutaro Hara (2025)
Bw-304, Institute of Industrial Science, the University of Tokyo
TEL: +81-3-5452-6843
E-mail: kuwano@iis.u-tokyo.ac.jp

原佑太郎、土方渉太郎 (2025)
桑野研究室
東京大学 生産技術研究所 Bw-304
電話: 03-5452-6843
E-mail: kuwano@iis.u-tokyo.ac.jp