

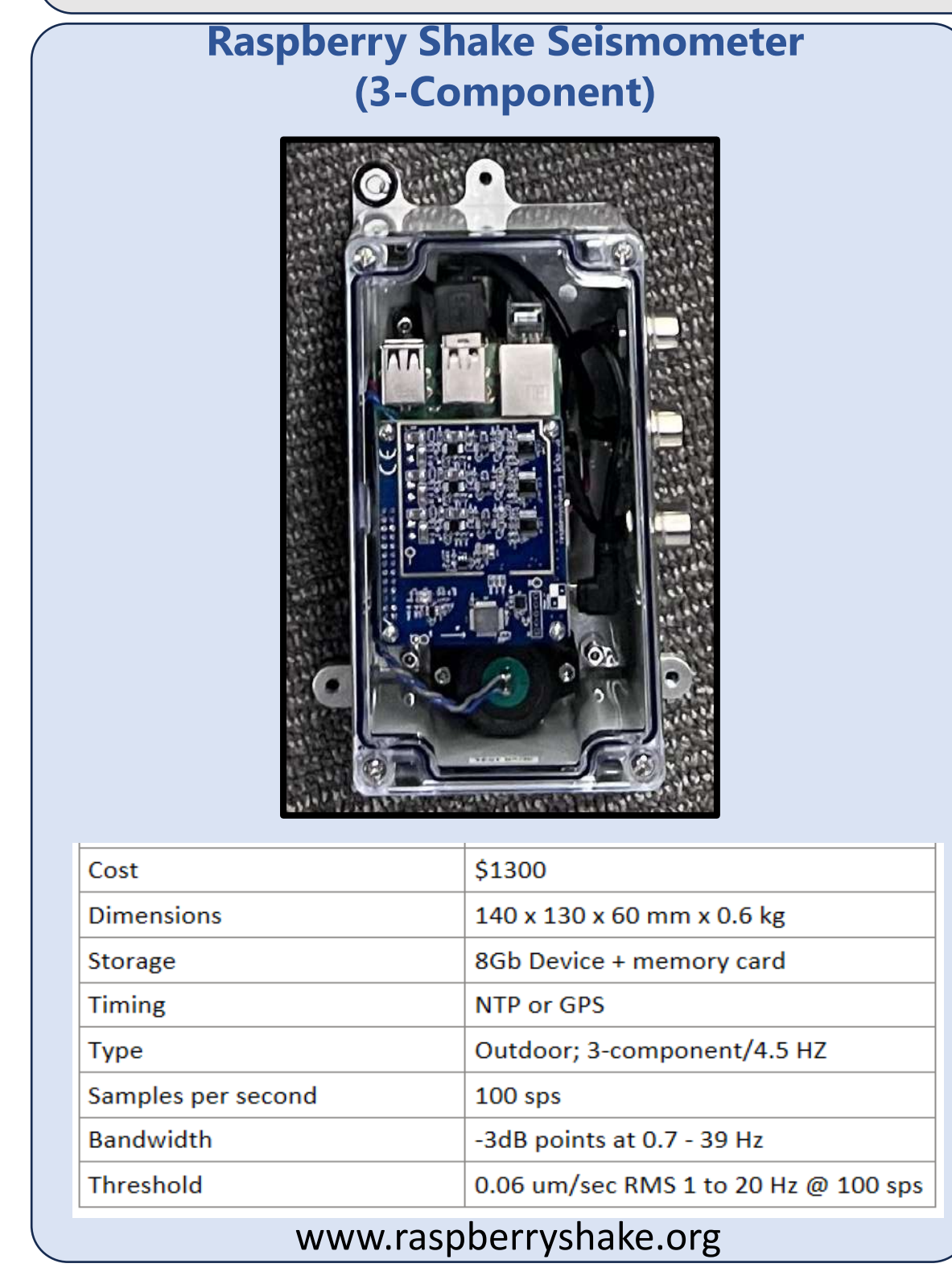
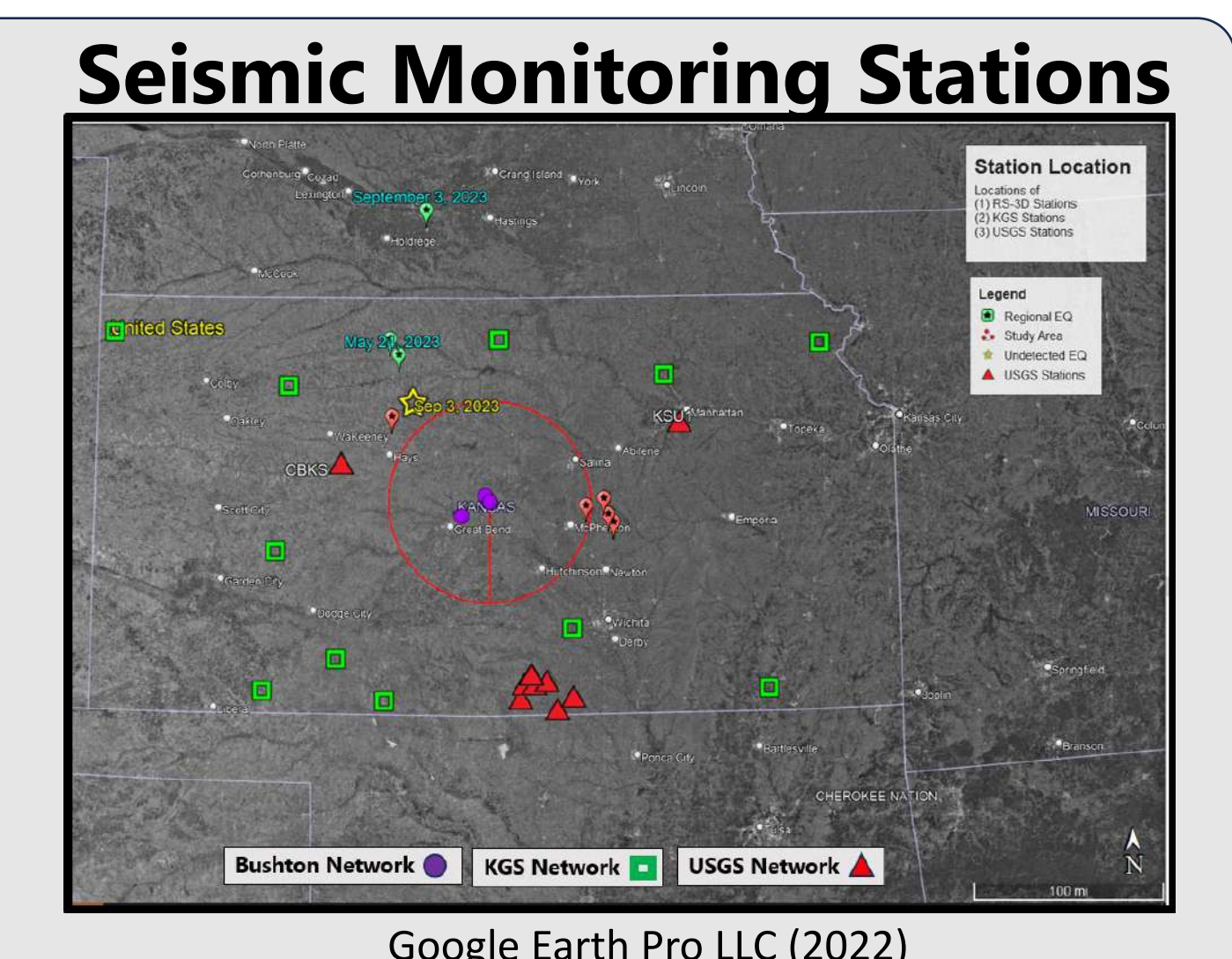
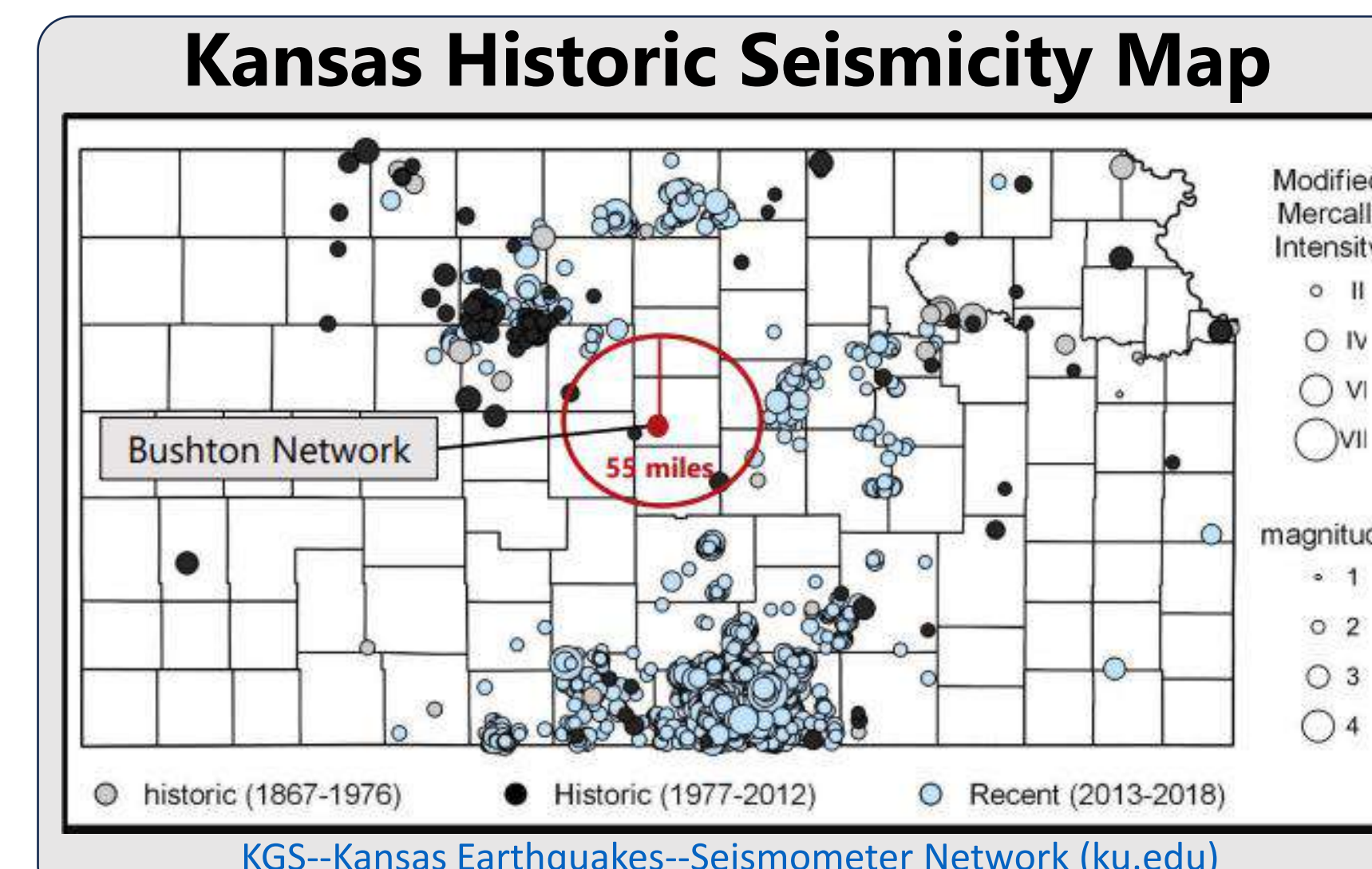


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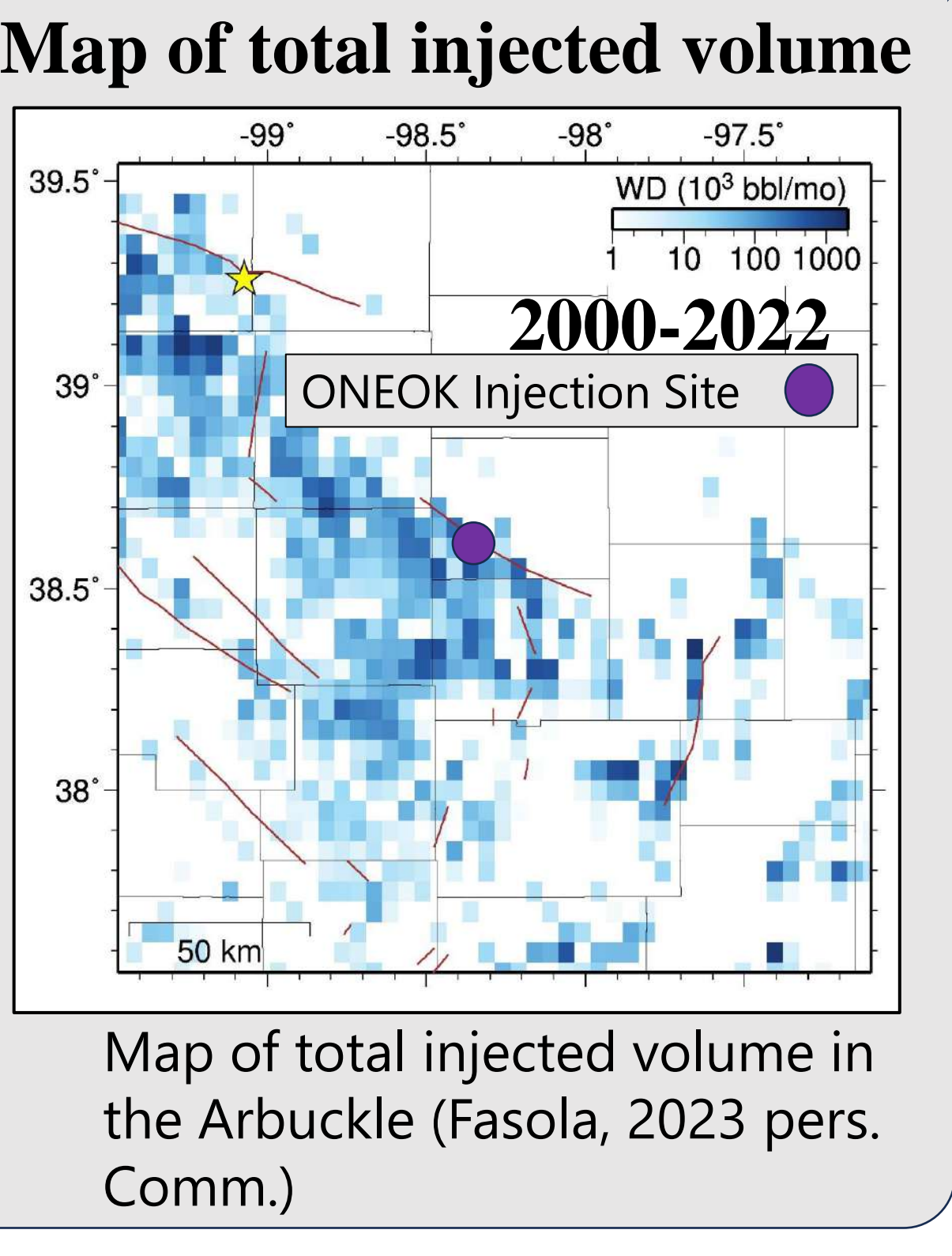
Introduction

- The growing interest in geologic carbon dioxide (CO₂) sequestration raises the concern that high-rate fluid injections may induce seismicity.
- To mitigate seismic hazard risk, it is recommended that seismic monitoring networks are installed at injection sites, which will require efficient and affordable earthquake monitoring technology.
- This study evaluates the low-cost Raspberry Shake 3D seismometer and readily available components, such as wireless modems, solar panels, and weather-resistant housing (~\$3,500) as a suitable alternative to the traditional and more costly broadband stations (~\$35,000).
- A final assessment will determine whether the RS-3D seismometer is effective for monitoring induced local seismicity.

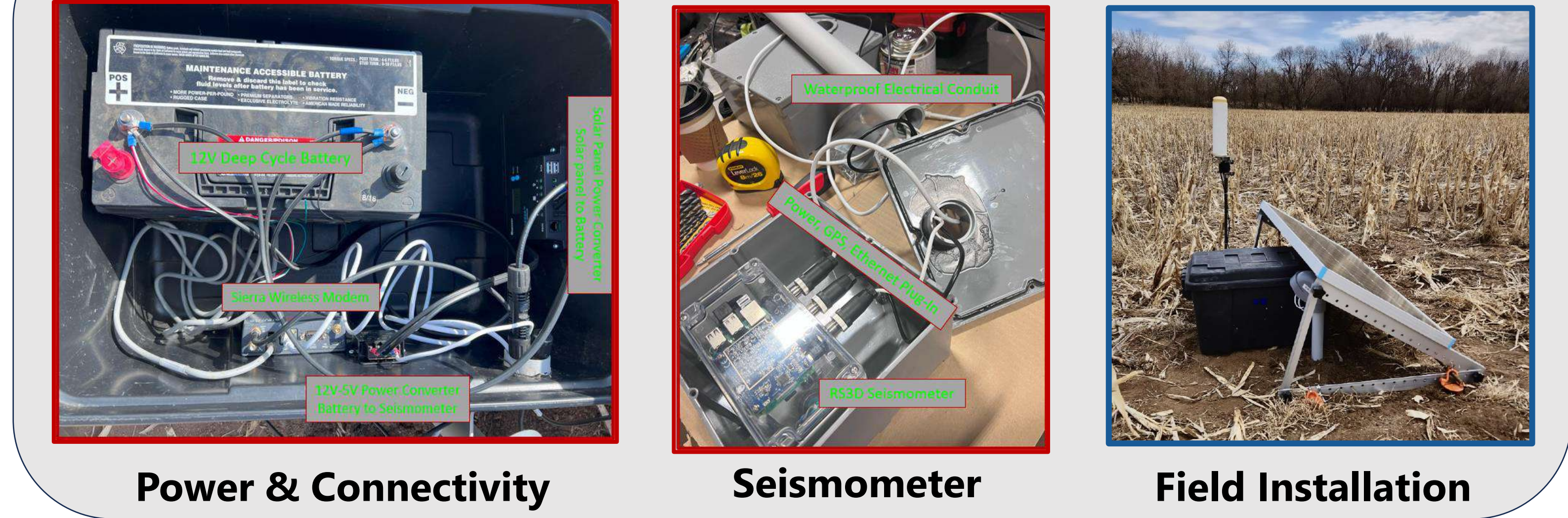
Background



(Top left) Modified map from the KGS depicting minimal seismic activity within the Bushton study area. (Top right) Modified map showing a lack of monitoring stations from state networks. The RS3D network is installed in Bushton, KS to fill in coverage for local seismicity from April 2023 until March 2024

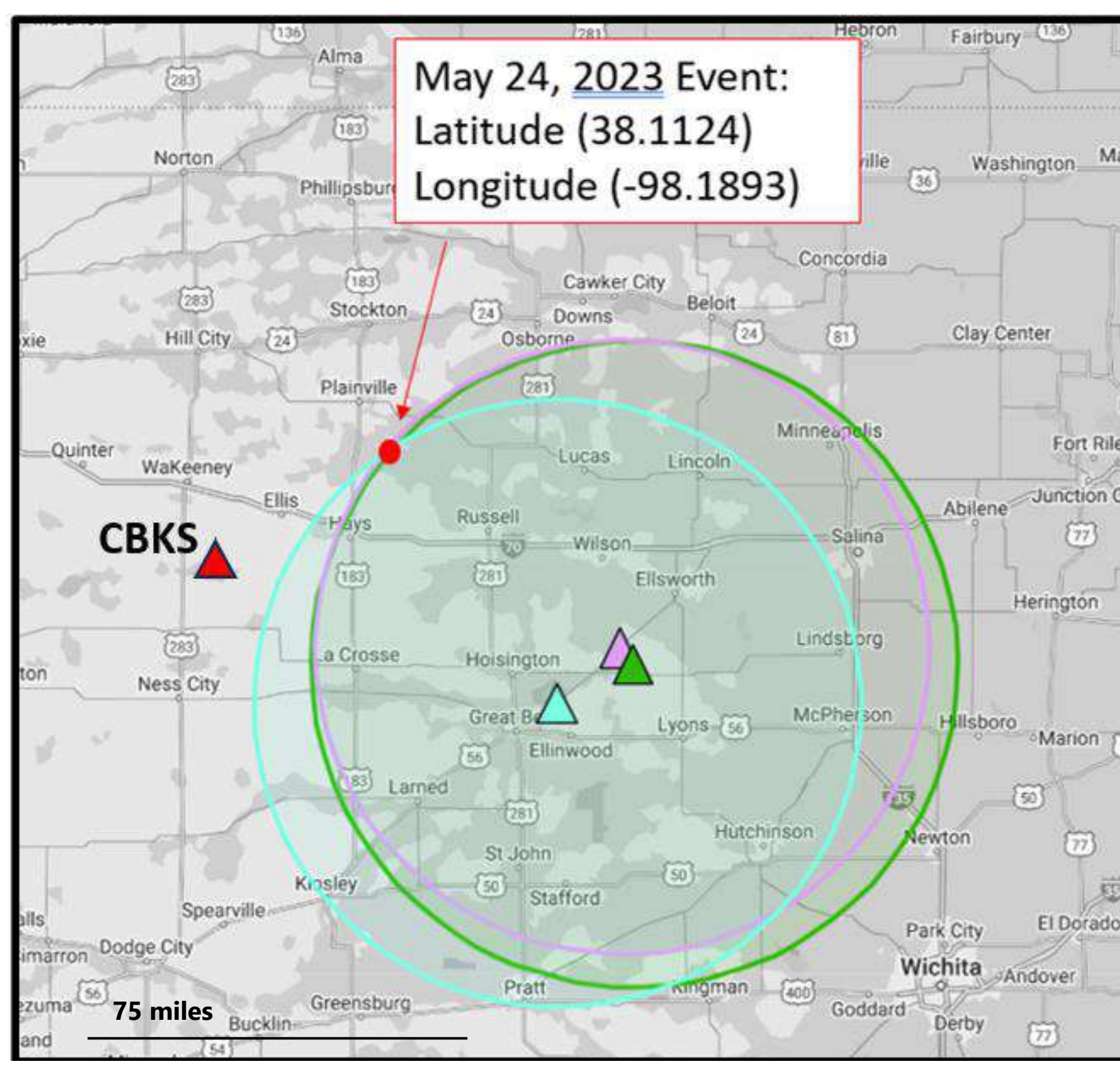


RS3D Seismic Station



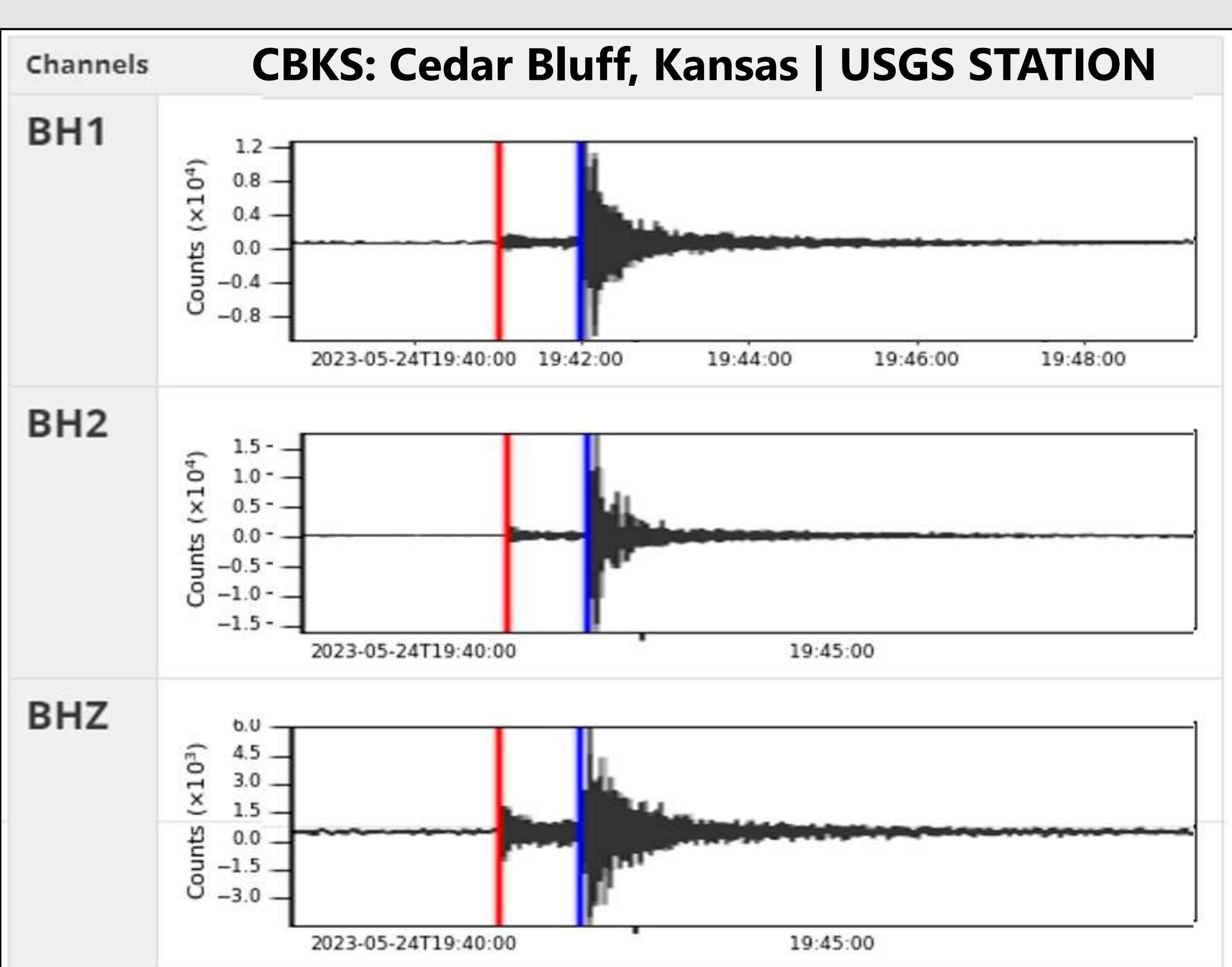
Detected Regional Earthquake Event

Modified Map of Regional Earthquake Recorded on May 24th



Modified map of a regional earthquake recorded by the USGS and the Bushton Network. The event occurred a few weeks after the network installation. The USGS station in Cedar Bluff, Kansas is a typical USGS broadband station, and the Bushton Network is composed of RS-3D stations.

Event Comparison: USGS VS Raspberry Shake



Waveform comparison of the M3.2, May 24, 2023, earthquake event recorded by both the USGS broadband seismometers and the low-cost, Raspberry Shake 3-Component seismometers. The events appear to be of similar quality on a regional scale.

Detected Local Earthquake



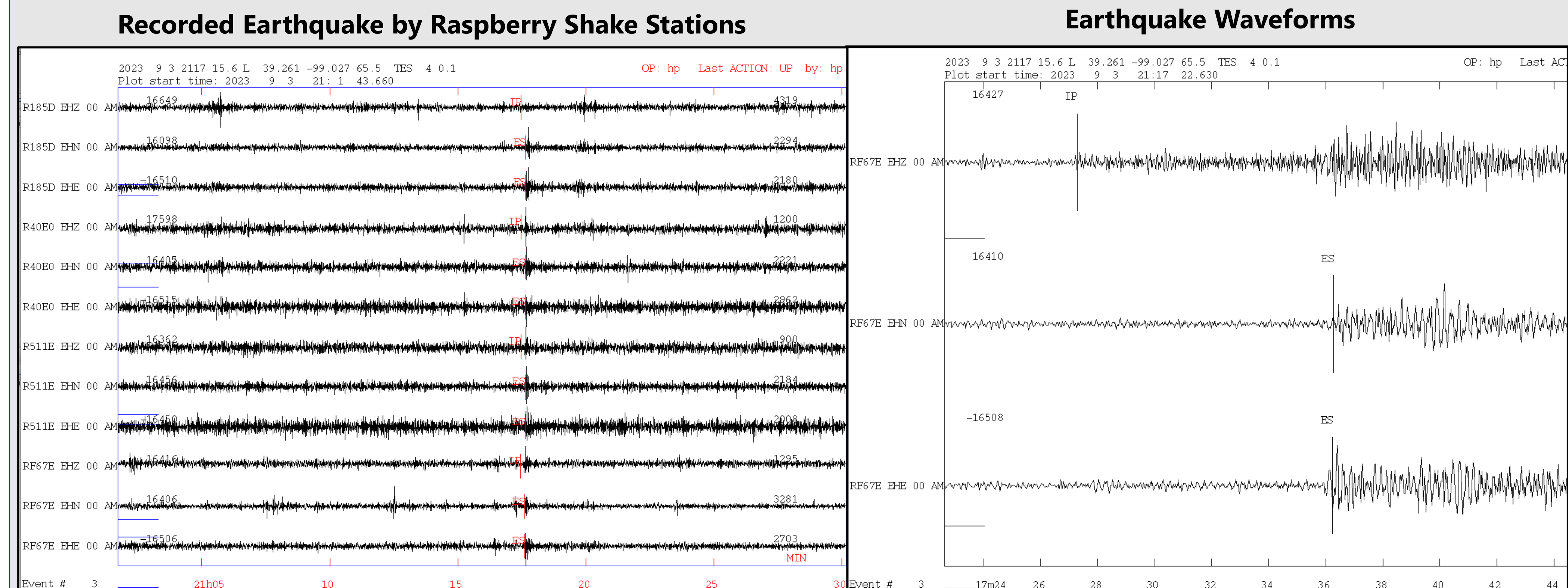
Modified Map of Detected Events on September 3, 2023

Modified map created on Google Earth Pro 2022 showing the location of two earthquakes that occurred on September 3rd, 2023. These events were undetected by other monitoring networks. The Raspberry Shake sensors detected and recorded the two events well.

Map of Reported Events the month of September 2023

Modified map of all events (M2>) reported by the USGS during the month of September 2023. The only earthquake recorded by state monitors occurred on September 1st, 2023. Two earthquakes occurring on September 3rd, 2023, located approximately 49 miles away from the Bushton Network were not reported.

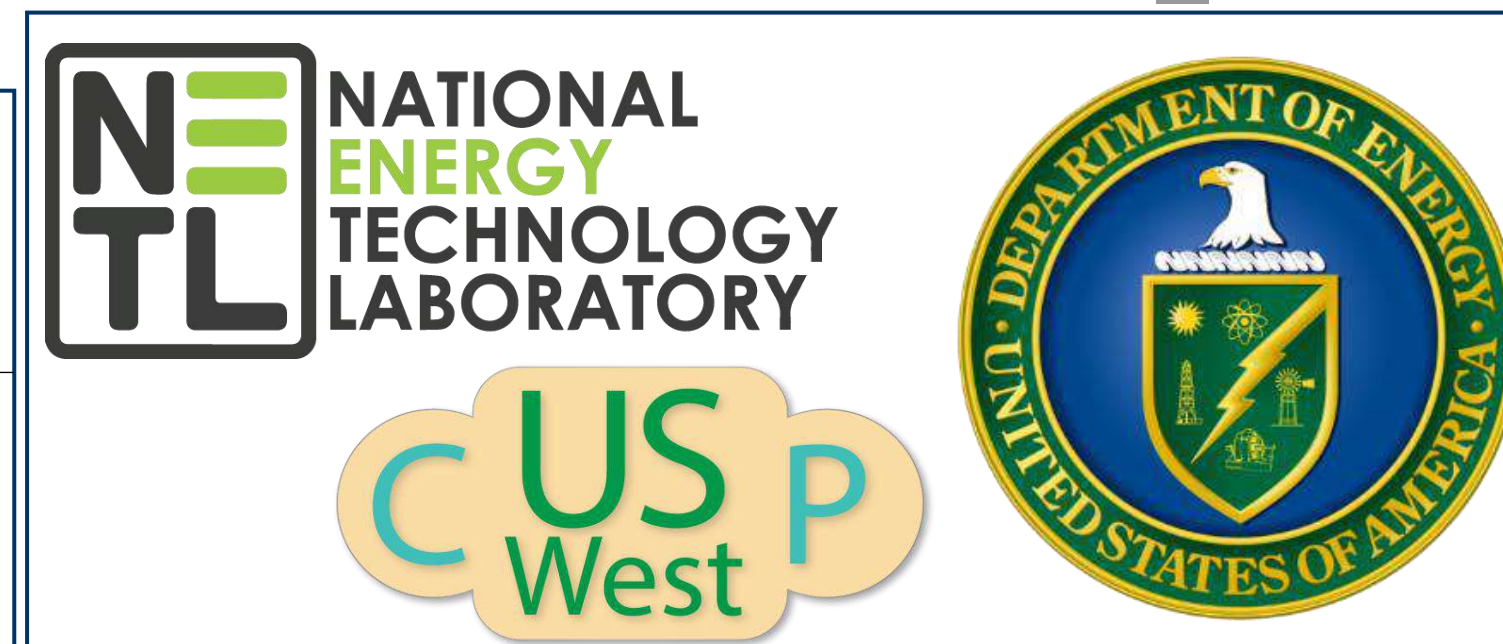
Local Earthquakes Detected by the Bushton Network on September 3, 2023



The processed seismic event from September 3, 2023, shows a clear earthquake recorded by the Bushton monitoring network. This event was not reported by KGS, nor USGS. Local - earthquake occurred at the time (UTC 21:17:06) and 4-miles north of Natoma, Kansas.

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References: Templeton, D.; Schoenball, M.; Layland-Bachmann, C.; Foxall, W.; Guglielmi, Y.; Kroll, K.; Burghardt, J.; Dilmore, R.; White, J. Recommended Practices for Managing Induced Seismicity Risk Associated with Geologic Carbon Storage; NRAP-TRS-I-001-2021; DOE-NETL-2021.2839; NRAP Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Pittsburgh, PA, 2021; p 80. DOI: 10.2172/1834402



Conclusions and Next Steps:

- The installation of low-cost seismic stations utilizing RS3D seismometers demonstrates the capability to monitor both local and regional seismic activity effectively.
- In the following months, an STA/LTA trigger will be used to detect events, magnitudes of each event will be calculated, and template matching the data will help detect smaller events missed by the STA/LTA trigger.
- As per the recommendations of the NRAP, a 12-month earthquake catalog will be completed by April 2024.