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Seismic diagnostics and analysis of the consequences of a chemical explosion in an urban environment

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INTRODUCTION AND MAIN RESULTS

Seismic analysis of the 27.09.2023 Tashkent chemical explosion estimated energy, magnitude, and TNT yield, along with P- and S-wave velocities. Spectral and amplitude studies revealed high P/S ratios and dominant high-frequency content, confirming a shallow explosive source and emphasizing the need for enhanced seismic monitoring and mitigation..

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Introduction

This report presents the results of seismic data analysis related to a chemical explosion that occurred at a warehouse in Tashkent city on September 27, 2023, at 21:52 UTC. The explosion caused significant destruction and was accompanied by the release of shock and seismic waves, which were recorded by regional seismological stations.

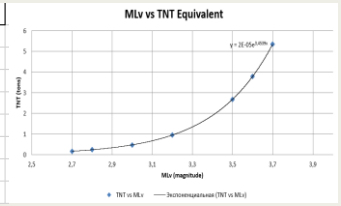
Methods/Data

- **Calculated seismic energy and TNT equivalent**

Seismic wave arrival times were taken from regional stations. The energy (E) was calculated using the formula: $\log_{10}(E) = 1.5 * MLv + 4.8$

The TNT equivalent was calculated from energy in joules as: TNT (tons) = E / 4.184×10⁹

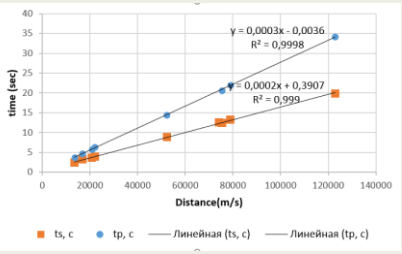
MLv	log10_E	E_J	TNT_kg	TNT_ton
3,5	10,05	11220184543	2 681,69	2,68
3,6	10,2	15848931925	3 787,99	3,79
2,7	8,85	707945784,4	169,20	0,17
3	9,3	1995262315	476,88	0,48
3,7	10,35	22387211386	5 350,67	5,35
3,2	9,6	3981071706	951,50	0,95
2,8	9	1000000000	239,01	0,24
3,7	10,35	22387211386	5 350,67	5,35



- **Velocity Model and Interpretation**

The velocity structure derived from the arrival times of P and S waves across the network allows further characterization of the source. The following table shows calculated velocities and S–P time differences for several stations. These values were computed from observed arrival times and epicentral distances.

Distance_m	tp_sec	ts_sec	Vp_mps	Vs_mps
13528,16	2,38	3,71	5684,1	3646,4
20751,01	3,61	5,72	5748,2	3627,8
16854,8	3,18	4,73	5300,25	3563,38
22069,55	3,94	6,31	5601,41	3497,55
52308,6	8,82	14,5	5930,68	3607,49
75382,94	12,41	20,58	6074,37	3662,92
74017,32	12,64	20,6	5855,8	3640
78891,43	13,27	21,98	5945,1	3589,24
122858,2	19,87	34,27	6183,1	3585,01



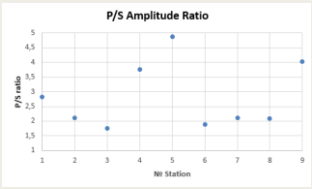
- **Comparison with SEL3 Event**

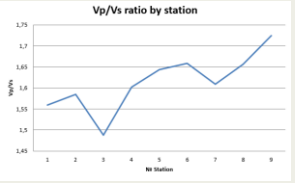
A potential correlation with the SEL3 event (mb 4.5) was investigated. However, a time offset of ~7 minutes and spatial distance of ~45 km strongly suggest this was not the same event, but rather a separate or mischaracterized detection.

Parameter	Explosion	SEL3 Event ID 24778230
Date and Time (UTC)	2023-09-27 21:52:00	2023-09-27 21:58:57
Magnitude	~3.5 (estimated)	mb 4.5
Depth	0 km	0 km

Results

The explosion released a seismic energy equivalent to approximately 9.94 × 10⁹ J(E), averaging a TNT equivalent of around 2.4 tons. The estimated average local magnitude (MLv) is approximately 3.46. Calculated P- and S-wave velocities, along with the Vp/Vs ratios, showed consistent values across stations, with Vp/Vs averaging around 1.6. This ratio, commonly used to characterize the elastic properties of the medium, further supports the shallow, high-energy explosive source nature of the event.





Waveform analysis revealed elevated P/S amplitude ratios (>2), which are characteristic of explosive sources. In contrast, natural tectonic earthquakes typically exhibit ratios close to ~1.

Conclusions

The results highlight the hazard of industrial facilities in urban areas and the need for better monitoring. They are also relevant for organizations like CTBTO in improving discrimination of man-made explosions.