A Robust P-wave-based Source Measure of the North Korea-declared Nuclear Test

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Summary

This study explores the utility of additional seismic phases in the initial P-wave packet for a moretransportable source estimator as well as to gain diagnostic insights into the 2013 North Korea-declared nuclear test (NK3). The amplitudes and periods of the "Pa" phase, the "Pi" phase and the "M" phase in the P-wave (which are the largest in the Sweb) were measured in the TTHS, and compared with the isotropic source. The differences are then compared against the patterns of historic nuclear test sites reported in Jih et al. (1998, 1999). The results suggest that the amplitudes and periods of the "Pa" phase in the North Korea test were lower than those of similar tests in Semipalatinsk and Azirg. The "M" phase, on the other hand, was similar to those in Semipalatinsk and Azirg.

4. Possible Test Site-Specific Characteristics

It appears that, on the average, Novaya Zemlya explosions have a bit smaller m(Pmax) than those in Semipalatinsk, possibly due to depth effects - and not the geology. The NK3 has m(Pa), m(Pb), and m(Pmax) measured as 1.62, 4.79, and 5.02, respectively (See Appendix. The resulting m(Pmin) = 4.79, m(Pmax) = 5.02, and m(Pa) = 4.44 (Rogozin et al., 2016) are, respectively, clearly more similar to those patterns at Lop Nur and Orenburg, and distinct from Semipalatinsk or Azirg. Given that Semipalatinsk, Novaya Zemlya, Lop Nur, and Punggye are said to have hard rock geology, perhaps the testing practice (e.g., the adopted scaled depth for tunnel testing) is closer between Punggye and Lop Nur? Further investigation is required, of course. Nevertheless, it is safer to assume all test sites are different until empirically proved otherwise.

5. Conclusion

- Little-known advantages of using m(Pa) as a source measure are presented:
  - m(Pa) gives very good estimates for several historic events that are difficult to nuclear arms control treaties.
  - m(Pmax) as a source size measure outperforms the traditional m(Pmax), so long as Pa has good S/N ratio.
  - m(P max) is proved to be a robust source measure in that m(Pa)-W formula can be readily transported from Semipalatinsk to Lop Nur, as demonstrated in Appendix.
  - m(Pa) works well in mountainous test sites because it is intrinsically immune to free surface interaction and no effect on m(Pa). Hence it is always more transportable than m(Pmax).
  - To the extent that Punggye has a stable, hard upper mantle (as Jih et al. (2015) suggests), m(Pa)-W formula established for Semipalatinsk and Azirg would be applicable to Punggye as well.
  - If the source size of the NK3-Punggye turn out to have a stronger attenuation (as Kedrov and Kedrova (2011) assert), then Semipalatinsk’s m(Pa)-W still gives a good lower bound of yield for Punggye tests.

Preliminary examination of the patterns of m(Pa)-m(Pmax) and m(Pa)-m(Pmax) across various test sites suggests the testing practice (e.g., depth of burial) at Punggye is, despite being different from those observed in Semipalatinsk minus other test sites, but more rigorous and thorough statistical investigations are needed along this line.

Appendix, NK3 As Seen At The IMZ Stations

We made phase picks of 178 arrivals at 78 IMZ seismic station/arrays (27 arrays and 51 three-component). Since the Pmax phase is always recorded at Lop Nur and Novaya Zemlya, the NK3 analysis was concentrated at one station rather than counting the individual elements of certain arrays.) The 2012 IDC version of Geotool which came as part of the PTFS, released NDC-in-a-Box software was used. Table below shows the number of arrivals of each phase type. This table does not include phase picks. The NK3 has m(Pa), m(Pb), and m(Pmax) measured as 1.62, 4.79, and 5.02, respectively.

<table>
<thead>
<tr>
<th>Test site</th>
<th>m(Pa)</th>
<th>m(Pb)</th>
<th>m(Pmax)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semipalatinsk</td>
<td>1.62</td>
<td>4.79</td>
<td>5.02</td>
</tr>
<tr>
<td>Lop Nur</td>
<td>2.05</td>
<td>4.90</td>
<td>5.11</td>
</tr>
<tr>
<td>Punggye</td>
<td>2.71</td>
<td>5.02</td>
<td>5.02</td>
</tr>
</tbody>
</table>

From Jih et al. (2015), Table 10, Page 45.

Reference


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