LEVEL III

A059036

IMPROVED PROCEDURES FOR DETERMINING SEISMIC SOURCE DEPTHS FROM DEPTH PHASE INFORMATION

QUARTERLY REPORT

1 Apr - 30 Jun 78

Edward Page
Richard Houck

Jul 78

9p.

April 1, 1978 to
June 30, 1978

F08606-77-C-0007 ARPA Order-1620

Sponsored by:
Advanced Research Project Agency
ARPA Order No. 1620

Notice of Disclaimer

The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, the Air Force Technical Applications Center, or the U.S. Government.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Improved Procedures for Determining Seismic Source Depths from Depth Phase Information		5. TYPE OF REPORT & PERIOD COVERED Quarterly Report 4/1/78-6/30/78
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Edward Page, Richard Houck		8. CONTRACT OR GRANT NUMBER(s) F08606-77-C-0007
9. PERFORMING ORGANIZATION NAME AND ADDRESS ENSCO, Inc., 5408A Port Royal Road, Springfield, VA 22151		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS VT/7710
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE July 1978
		13. NUMBER OF PAGES 9
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) VELA Seismological Center 312 Montgomery Street Alexandria, VA 22314		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Seismic depth, depth phase, echo detection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

To compensate for sparse coverage of the AI events by the SRO/ASRO and SDCS networks, the depth determination program has been modified to process seismic array data. This will substantially increase the proportion of AI events that can be processed. A total of 28 events were examined during this quarter; 14 of these could not be processed due to inadequate data. Of the remaining 14 events, depth estimates were obtained on 6 of them, 4 were found — next page

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

F-200.1473

ARMED SERVICES PROCUREMENT REGULATION

to be outside the 10-80 km depth range examined, and 4 are in secondary processing.

SUBJECT: Improved Procedures for Determining Seismic Source Depths from Depth Phase Information

AFTAC Project No.	VELA T/8710
ARPA Order No.	2251
ARPA Program Code No.	6F10
Name of Contractor	ENSCO, INC.
Contract No.	F08606-77-C-0007
Effective Date of Contract	1 October 1977
Reporting Period	1 April 1978 to 30 June 1978
Amount of Contract	$160,833
Amount of Last Contract Modification	$70,910
Project Scientist	Edward A. Page (703) 321-9000

INTRODUCTION AND SUMMARY

During this quarter, a total of 28 events from the Area of Interest (AI) data set were examined, and the source depth determination program was modified to process seismic array data. The use of array data has turned out to be necessary because most events in the AI data set have sparse coverage on the SRO and SDCS networks, making it impossible to base our analysis entirely on SRO and SDCS as originally planned. Array data was initially processed by treating each array element as an individual station. However, this is of questionable validity, since it results in many stations that have the same Δ and are also likely to have similar non-depth-phase cepstrum features, which will then tend to reinforce and give spurious depth plot peaks. A later program change allows data from up to 30 stations to be processed at once, thus permitting array and individual station data to be analyzed together. One station can then be chosen from each array and reprocessed with the individual station data to give an unbiased result.

Of the 28 AI events examined, 14 could not be processed due to inadequate coverage at teleseismic distances. Depth estimates were made on 6 of the remaining 14 events, no depths were obtained on 4 of them, and 4 events are in secondary processing.

MAJOR ACCOMPLISHMENTS

PROCESSING OF SEISMIC ARRAY DATA

Coverage of AI events by stations in the SRO/ASRO and SDCS networks has been poor, with very few events having as many as three stations with visible P waves. Since the performance of our depth determination technique depends on detecting depth phases for many different stations and primary phases, better coverage is necessary before depth estimates can be made on a significant proportion of the AI events. The obvious solution to this problem is to use data from other sources, namely, data from the different seismic arrays.

Originally, array data was processed by reading the seismograms from each array element and treating them as separate stations. This approach turned out to be unsatisfactory, since each array element will have the same Δ, and thus the same depth phase delay times at each trial depth. This allows any cepstrum features that occur consistently at the same delay time for several array elements to sum into the depth plots like true depth phase peaks. These constant-delay-time features are likely to be present in a set of array element seismograms and will result in spurious peaks on the final depth plots. (In a data set with a large range of Δ's, any constant delay time cepstrum features would be smeared out by the expected variation of depth phase delay time with Δ, and would not produce a strong depth plot peak.) Also, the significance level algorithm assumes that the stations have a wide range of Δ's, and is not useful when a large number of stations with the same Δ are used.

To get around this difficulty, the depth determination program has been modified to handle a maximum of 30 stations. This allows the analyst to process all the available data, including individual stations and array elements, in a single run. Then, one element can be chosen from each array and rerun with the single station data to get depth plots that are not biased in favor the arrays. The initial "all available seismograms" run takes advantage of the possible reductions in random noise resulting from using all the array elements, while the second "single element" run eliminates any spurious features arising from the duplicate Δ's of the array elements.

AI EVENT PROCESSING

A total of 28 events from the AI data set have been examined, but 14 of them could not be run through the depth determination program due to inadequate data. An event is considered to have inadequate data if it does not have a visible P wave arrival on at least two stations at teleseismic distances. Close-in data is not acceptable because our depth determination technique is presently based on teleseismic phases; the use of close-in data may be valid with some modifications, but a whole new research project would be necessary to determine this. A minimum of two stations is required because the technique needs repeated depth phases to get a well-defined depth estimate -- even with two stations, a significant depth plot peak can only rarely be obtained. Of the 14 rejected events, 8 had visible P waves on only one station, 3 had no visible P wave arrivals, and 3 were not teleseismic.

Results from 10 of the useable events are shown in Table 1; the remaining 4 events are in secondary processing and have not been listed. In determining the number of stations, each array counts only as one station, not as the number of array elements. For the 4 events with the depth listed as "none," no significant depth plot peaks were detected. Since these events had adequate data to arrive at a depth estimate, this means that the source depth is outside the search interval of 10-80 km.

The reliability of each depth estimate is given as a letter grade. For the events with the depth listed as "none," this grade is an estimate of the probability that the source depth is outside the 10-80 km range. To aid in the evaluation of the discrimination capability of this depth determination technique, these reliability grades will be converted to numerical probabilities in the final report, although they will still be basically qualitative.

TABLE 1. AI PROCESSING RESULTS

EVENT NO.	NO. OF STATIONS	DEPTH (km)	RELIABILITY
1	5	36	F
14	4	20	F
16	3	31	Q
17	2	32	P
19	7	34	G
20	6	NONE	F
21	2	NONE	VP
22	4	NONE	VP
41	3	NONE	Q
50	10	19	G

RELIABILITY GRADES:

G = Good
F = Fair
P = Poor
VP = Very Poor
Q = Questionable