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COMPUTER PROGRAMS AND DATA BASES USEFUL FOR PREDICTION OF GROUND MOTION RESULTING FROM EARTHQUAKES IN CALIFORNIA AND THE CONTERMINOUS UNITED STATES

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INTRODUCTION

The capability to predict seismic intensity and several parameters of ground motion resulting from earthquakes in California and the conterminous United States (USA-48) is provided by the programs and data bases included on these disks (GD-MOTION1 and GD-MOTION2). In addition, numerous analyses have already been conducted using these programs, many of such results being included on these disks.

I have stated repeatedly and will continue to stress that the intensity values predicted by these programs are only for shaking aspects of intensities. Susceptibility to liquefaction or other modes of ground failure is not a mapped geological/geophysical parameter, so I cannot construct maps predicting such phenomena. However, such ground failure regimes do correlate with surficial ground condition, water saturation and topographic slope. Given knowledge of these parameters, predicted intensities are an essential element in predicting failure as a result of specific earthquakes.

The investigations supporting the parameterizations used in these programs have been published previously (see References) or are presented in the discussion of the model included at the end of this manual. These programs, as regards predicting intensities, have been extensively tested. Thus, these programs are not submitted for validation, but for use in a variety of societal modes. The modes of predicting strong ground motion are described in the last section of this manual. The calibration scheme of maximum velocity versus intensity, based upon the San Fernando earthquake, has successfully predicted observed relationships of these parameters in several regions of the world. The model is considered to be useful for predicting maximum velocity and acceleration throughout a world calibrated for attenuation parameter.

Users of the programs are invited to suggest additional ground motion parameters whose prediction would be useful.

All files generated by these programs are stored in the appropriate sub-directories and are available for re-display when the same event parameters are entered at a later time.

HARDWARE REQUIREMENTS

The codes provided are for use on IBM machines or IBM clones. A critical hardware detail that must be met in order to properly display the input and output files of all programs on these disks is use of a VGA monitor with Screen 12 characteristics, i. e, 640 X 480, 16 color. The programs will set these characteristics if they are so settable. If they are not so settable, the programs will not run. You should have a hard disk of such size that you can devote 20 megabytes or so to the programs and output files of these programs. You can, of course, discard outfiles after use or store them in a backup mode, thus reducing greatly the required storage on your hard disk. When generating output files using 'QUAKPLOT', have at least a megabyte of available hard disk space for temporary use by the program. During some runs, you will generate temporary files which require 900 - 1000 KB. You'll know about them only if there's too little room.

There are many calculations for each analysis. The programs which carry out the extensive calculations REQUIRE a math-coprocessor. You may be unhappy with the time for calculations unless you have a 386 25 Mhz machine equipped with a math coprocessor. Of course, overnight batch runs will make a coprocessor-equipped AT satisfactory. Finally, your computer must be able to read 3½" DSHD 1.4 MB diskettes.

PACKAGES PROVIDED

There are three packages of codes and data included on these disks, each package addressing different problems:

PACKAGE A -- This package calculates and displays predictions of intensity and several ground motion (maximum acceleration, maximum velocity and maximum displacement) and damage parameters (wood-frame and unreinforced concrete buildings)for earthquakes throughout most of California. The area covered is displayed on the first screen of 'QUAKPLOT', the area extending from Mendocino County to the Mexican border and eastward from the coast to include the Central Valley of California and much of California east of the San Andreas Fault in southern California. The earthquake studied can lie outside this area, either offshore or eastward into Nevada. Calculations are made on a ½ ' x ½ ' grid over 2° of latitude and 1½° of longitude, 4° x 1½°, or 4° x 3°. Each grid element has an assigned ground condition based on the Olaf Jenkins Edition of the Geological Map of California (published by the California Division of Mines), *References 1 and 7*, and other sources. Details on running 'QUAKPLOT', the main driver, will be given below. All pertinent codes and data files (both input and many already calculated output files) are included in two self-decompressing files on Diskette 'GDMOTION-1'. These files will expand to 10.7 megabytes when decompressed.

PACKAGE B -- This program displays files previously calculated for the San Francisco Bay Area. Any Bay Area map generated by 'QUAKPLOT' can be displayed by 'BAYPRED', the main driver for Package B. The reason for including Package B is that numerous summary files, based on the four earthquakes assigned probabilities of occurrence in the next thirty years by the USGS (USGS Circular 1053), have been calculated by procedures not included in this package. These files present calculated probabilities of the investigated ground motion parameters reaching indicated levels at each ½' x ½' site during the next thirty years. In addition, a complete set of ground motion files for each of these four earthquakes, as well as for a repeat of the San Francisco earthquake of 1906, are included. Since no calculations are involved for display of these files, a VGA-equipped AT is satisfactory. 'DISKONEA.EXE' contains the codes for Package B. 'DISKTWO.EXE', on Diskette 'GDMOTION-2', contains the output data files. 'DISKTWO.EXE' is a self-decompressing file that expands to 5.6 megabytes. Details on operation of 'BAYPRED' will be given below.

PACKAGE C -- This package of programs and files calculates and displays the same types of output files as does Package A, the area of investigation, however, being the USA-48. There are some significant differences both in input and output. All output maps are for a single assigned ground condition. The grid size for calculations is 25 km x 25 km. The problem of detailed ground condition is handled by allowing selection of seven different ground conditions. In this package, nine types of ground motion files are calculated and stored for each selected set of fault and ground condition parameters. 'USAPLOT' is the main driver, while 'USACOMPO' allows you to composite previously calculated files of several events. 'PLOTUSA.EXE', on 'GDMOTION-2', is the self-decompressing file (expands to 5.6 MB) that contains all codes and data files for these programs, as well as numerous calculated output files.

INSTRUCTIONS FOR USING PACKAGE A ('QUAKPLOT.EXE', ETC.)

INSTALLING PACKAGE A ON A HARD DISK -- All files have been provided in two self-decompressing files (DISKONEA.EXE and DISKONEB.EXE) which have complete directory and sub-directory structures. 'DISKONEA.EXE' contains all executable codes, all data files required to run the codes, as well as output files for Fault '01'. 'DISKONEB.EXE' contains more output files I have already generated, many of which may be of interest to you. You need only decompress the files in 'DISKONEA.EXE' in order to execute all plotting programs and to generate new output files.

Place diskette 'GDMOTION-1' in A: (if appropriate, use 'B:' wherever I indicate 'A:'). Go to C:\> or D:\> (multi-megabyte hard disk). At the DOS prompt, type 'A:\DISKONEA and hit 'Enter'. A complete sub-directory structure under 'GDMOTION' will be devloped on your hard disk with all files properly placed. The 'DISKONEA.EXE' file will remain safely on the disk in A:. The decompressed files of 'DISKONEA.EXE' will require 4.1 megabytes on your hard disk. If you wish to inspect the files in 'DISKONEB.EXE', follow the identical procedures as for decompressing 'DISKONEA.EXE'. The 'DISKONEB.EXE' files when decompressed require 5.6 megabytes of disk space.

The following files should be in the root directory D:\GDMOTION: --

File Name	Description
QUAKPLOT.EXE	Start up program for Package A
FAULTPLT.EXE	Called by 'QUAKPLOT'
QUAK2PLT.EXE	Called by 'QUAKPLOT'
BAYPRED.EXE	Start up program for Package B.
PRBGRDMO.EXE	Called by 'BAYPRED'.
USGSB.GRH	Data file for a screen
USGSL.GRH	Data file for a screen
USGSR.GRH	Data file for a screen
USGST.GRH	Data file for a screen
FIGBOT.GRH	Data file for a screen
FIGTOP.GRH	Data file for a screen
NEWBOT.GRH	Data file for a screen
NEWTOP.GRH	Data file for a screen

If you decompress both 'DISKONEA.EXE' and 'DISKONEB.EXE', there will be many files in numerous sub-directories. The required data files are in .\FAULTS, .\GRO, .\GRD and .\RND. The many files in other sub-directories are output files for several faults and models. If you decide you do not need all of the output files provided in 'DISKONEB.EXE', deletions can be made in subdirectories whose names begin with 'EVENT' (\EVENTACC, \EVENTVEL, etc.). DELETE NOTHING FROM THE MAIN DIRECTORY OR OTHER SUB-DIRECTORIES. DO NOT DELETE ANY SUB-DIRECTORIES. I suggest a controlled deletion. The second and third symbols in file names constitute the fault designator used in the file 'FAULTS.LST' in subdirectory \FAULTS. You can compare file names and fault designators and retain files for earthquakes of interest, deleting all others. With a bit of use, you will become familiar with the mode of naming output files.

Names of output files are in the form 'XXXXXXXX.XXX', where:

- The first letter and the fourth and fifth letters designate the area covered by the file. If the area covered by the file is 1½° x 2°, the first letter describes the area and the fourth and fifth letters are 'XX'. The pertinent first letters are 'B' for Bay Area, 'G' for Mendocino area, and 'L' for central Los Angeles area;

  If the area covered by the file is 4° x 1½° (either the western or eastern half of a 4° x 3° area), the first letter specifies the 4° x 3° area ('B', 'R', or 'Y' for blue, red and yellow areas of the second screen of 'QUAKPLOT') while the fourth and fifth letters will be either 'WW' or 'EE". Whenever you select one of the four quadrants of the blue, red or yellow areas, the resultant calculated output files will contain data for the complete western or eastern half of the area;

- The second and third letters of the file name are the two character fault designator displayed via command on the fourth screen of 'QUAKPLOT';

- The sixth and seventh letters generally describe the type of ground motion parameter calculated ('MM' for MMI, 'AC' for acceleration, etc.). Occasionally, the seventh letter will be 'A', 'J' or 'L' in response to a ground condition selection you can make within 'QUAKPLOT'

- The eight letter designates the stress drop used ('1' for normal stress drop, '3' for stress drop a la the Loma Prieta earthquake);

- The ninth letter designates fault type, probability (for included files to be displayed via programs and files in 'PACKAGE B', see below) or is set to 'G'. 'S' designates strike-slip, 'T' designates thrust. IMPORTANT!!!!!! This letter is set via the query within 'QUAKPLOT' about the nature of the fault (in addition, a critical parameter of the model is also set by your answer to that query). However, you should have decided when you made the pertinent fault file whether it is to be considered a thrust or a strike-slip fault. If you wish it to be a thrust fault, you should include that fact in the title you give the fault. The only indication on the screen of fault type is what you included in that title. I model a thrust fault by placing the line source within the model six or so km in the down-dip direction from the surface trace of the fault (done when making the fault file) and using a 'C' value of 20 (set by query within 'QUAKPLOT');

- The tenth letter sets average ('5') or near-maximum ('9') expected value of a ground motion parameter (acceleration, velocity or displacement). For other types of output, this letter has no meaning;

- The eleventh letter has meaning only when calculating expected loss (sixth and seventh letters are 'LO') or when the ninth letter is 'P' (probability maps displayed via PACKAGE B, see below). For loss files, the eleventh letter specifies structure type ('P' for pre-1940 wood-frame, 'D' for post-1940 wood-frame, 'R' for unreinforced concrete residential, 'C' for unreinforced concrete commercial). For the probability files used with 'PACKAGE B', the symbols used for the eleventh letter follow exactly the symbols used in the headers for the probability files.

As already noted, the visual presentation is designed solely for SCREEN 12 display (i. e., VGA 640 X 480 , 16 COLOR) with 80 character width and 30 lines of text. These parameters are set by the program if they are permissable.

INPUT DATA AND FILES -- The required input data and files are as follows:

- ▪▪ A fault defined by its end points (lat/long). Most of the faults of interest are probably in '\GDMOTION\FAULTS\FAULTS.LST'. How to display 'FAULTS.LST' and select a fault from those present in the file, as well as how to generate a file for a fault not as yet in 'FAULTS.LST', will be described below.
- ▪▪ Depth of focus for California earthquakes is treated as a constant and is not adjustable.
- ▪▪ Ground conditions used are as in the .GRO files. You cannot generate a uniform ground condition map. You can change the .GRO files. If you do, you must use the symbols included in the headers of the .GRD files or in USGS Bulletin No. 1838.
- ▪▪ Stress drop ('Normal' or '1.3 x Normal'). You select at run time.
- ▪▪ Non-exceedance value (.50 or .95) for ground motion values. You select at run time.

OUTPUT FILES -- These programs generate and display the following types of maps for earthquakes within California -

- Modified Mercalli Intensity
- Maximum Acceleration - .50 non-exceedance
- Maximum Acceleration - .95 non-exceedance
- Maximum Velocity - .50 non-exceedance
- Maximum Velocity - .95 non-exceedance
- Maximum Displacement - .50 non-exceedance
- Maximum Displacement - .95 non-exceedance
- % Loss Pre-1940 wood-frame
- % Loss Post-1940 wood-frame
- % Loss Unreinforced concrete commercial
- % Loss Unreinforced concrete residential

One map is made on each run of 'QUAKPLOT'. The file is properly stored for future calling and use.

IMPORTANT NOTE -- Experience tells me that I should stress an important limitation as regards use of the damage analyses. The curves used of % damage versus structural type are statistical curves, i. e. they do not pretend to address the maximum and minimum levels of expected damage to individual homes. Where average damage is predicted at 3%, many homes will suffer no damage whatever while there will be those within the 'same' geology that suffer severe damage. What I classify as a uniform ground condition will in fact be markedly variable. Most sites on 'saturated alluvium' will not be liquefiable but some will be with the potential for high damage even though mean damage for 'saturated alluvium' will be low. It is certainly true that, if shaking is all that is of concern, modern wood-frame homes in California will easily withstand .25 g with very little damage. However, the filled ground at San Francisco Marina failed drastically at less than .20 g. At comparable levels of acceleration or greater, the Bay Muds along the south-west shore of the Bay did not liquefy and there was little damage to modern homes.

I make no effort to address slope failure of various sorts. Numerous modern homes in the Santa Cruz Mountains, on 'strong rock' as regards my ½' x ½' digitization, were severely damaged or totally wrecked by the Loma Prieta earthquake because they were built on local patches of colluvium which slumped at the time of the earthquake. The impact of time of an earthquake relative to heavy seasonal rainfall is not addressed even though there is clear evidence that slope failure at time of some earthquakes is linked to rainfall in the weeks prior to some earthquake. A final factor that must always be kept in mind is that even seemingly minor errors in modern construction can result in major damage. Along Rebecca Drive in the Santa Cruz Mountains, numerous large modern homes were severely damaged at sites where very low levels of damage were predicted based on bed-rock characteristics. Post-earthquake investigations established that all of the severe damage resulted either from slope failure or failure to meet code requirements.

Therefore, a too simplistic interpretation of the damage maps may lead to gross errors as regards individual sites. For planning and estimation of overall impact of an earthquake on a community, the maps are of great use. However, individual building sites require individual analysis.

ENTERING DATA FROM THE KEYBOARD -- The programs have been written so that most information from the keyboard is entered by pressing the keys indicated on the screen WITHOUT USE OF THE 'ENTER' key. Every key pressed is recorded. If you hit the 'Enter' key after a correct entry, the 'Enter' key will be treated as the first key for the next required entry If you make an error in an entry (say, the one above, or you meant to type 'EQU' but accidentally hit 'R' as the first letter), hit as many more keys as required for the entry (in the case above, two more keys), and then start again with a correct typing of the entry. In most cases, all incorrect sequences of keys are recognized as unacceptable and the program returns to the presentation requesting the entry on which you just erred. The program places your computer in 'Caps Lock' mode. Do not change it.

If the 'Enter' key is required, the text on the screen tells you so. Go slowly the first few times you run the program and read everything presented. In nearly all cases where you must enter data from the keyboard, the text indicates either the acceptable options or the correct format for the input. Follow the instructions rigorously and you will have no problems. In a few cases, you are asked a question which clearly requires a 'Yes' or 'No' answer, such questions having neither format nor '(Y/N)' indicated. In these situations you respond with either 'Y' or 'N'.

Errors in entry of latitude and longitude can be confusing. If you are careful, there will be no problems. Latitudes are entered in degrees (XX) and minutes (XX.XX), as are longitudes (XXX and XX.XX).

- If you use any keys other than "0" to "9" and ".", a two second "KEYING ERROR" message will appear on the data entry line, followed by "ANOTHER ONE (Y/N)?". Answer "Y" if you wish to enter different coordinates.

- If the third entry in a minute entry is not ".", the "KEYING ERROR" message appears in the data entry line, followed by "ANOTHER ONE (Y/N)?". Proceed as above.

- If you enter a minute value of greater than 60.00, the "KEYING ERROR" message appears in the data entry line, followed by "ANOTHER ONE (Y/N)?". Proceed as above.

- If you enter coordinates which are outside the mapped area, a two-second "SITE OFF MAP" message appears in the data entry line, followed by "ANOTHER ONE (Y/N)?". Answer "Y" if you wish to enter different coordinates.

- If you enter coordinates of a site which is mapped as water, a two-second "SITE IN WATER" message appears in the data entry line, followed by "ANOTHER ONE (Y/N)?". Answer "Y" if you wish to enter different coordinates.

If you just can't clear things up, press 'F1' and then 'Enter'. The display will return to the beginning of the lat/long sequence. Start over with entry of latitude and longitude.

You should always proceed to normal termination of a display. There is provision at the end of a run to investigate another model. If this option is reached via use of 'F2' (see below) rather than by normal procedures, there may be an error that will abort the program. I believe that I have eliminated that problem. Use of 'F2' will only rarely if ever cause a problem. I mention the possibility just as guidance.

MAKING A NEW FAULT FILE -- You must create an entry in the file FAULTS.LST (in subdirectory \FAULTS) for each fault or rupture you wish to study. This entry must be made before calculations based on this fault can proceed. By properly following instructions in the program, an entry will be made in the file 'GDMOTION\FAULTS\FAULTS.LST' and the generated fault file will be included in subdirectory 'GDMOTION\FAULTS'. To make this entry and to proceed to calculations, do as follows (all of this can be done as part of a regular 'QUAKPLOT' run):

- Be sure you are in directory 'D:\GDMOTION>'
- At the prompt 'DOS:\GDMOTION>', type 'QUAKPLOT' and hit 'Enter'.
- After reading the screen, hit any key ONCE and wait for the screen to change.
- Enter 'BAY' or any other acceptable trio, then enter 'EQU'.
- Enter '??'. You will be shown the faults previously defined. There may be more than can be shown on the first screen. If you wanted to use one of these, you would simply enter its two digit designator. If there are more previously defined models, the bottom line will give the possibility of entering 'M' and then hitting 'Enter'. Keep entering 'M' and hitting 'Enter' until the bottom line invites you to enter 'F'. Do it.
- Now follow instructions carefully, observing the indicated formats.
- The file name - first request - must end in '.FAU'.
- When you enter the name of the fault (<= 30 character entry), include an indication that it is a THRUST fault if so it is. The fault files included in FAULTS.LST as shipped have no indication of fault type if the fault is assumed to be STRIKE-SLIP. The fault name is printed on the monitor screen and is the only indicator of fault type.
- Enter latitude and longitude for one end of the fault, followed by latitude and longitude of the other end, being certain to use the format indicated (lat deg's as xx, lat min's as xx.xx, long deg's as xxx, long min's as xx.xx). My practise is to move the line source for a thrust or oblique fault about 6 kilometers in the down-dip direction from the surface trace of the fault.
- The file is made and you are presented with screens that finish the model. A step-by-step walk-through of 'QUAKPLOT' is given below.

SPECIAL KEYS -- There are four keys (F1 to F4) that have been set for your use:

- F1 (followed by hitting of 'Enter'): Will return you to 'Value at Lat & Long?'. Use if confused when entering Latitude and Longitude data, or if you wish to return to that place from further along in the program.

- F2: Takes you to the last query (Another Investigation?). Just a quick way out.

- F3: This key sets up the screen (i. e., removes the question box) for TSR screen capture via a memory resident program that you have. Note carefully, however, that I do not use the standard VGA 16-color palette. Therefore, screen capture programs that work only with the standard palette will severely corrupt the colors I used. Make certain that you purchase a capture program that reformats the palette.

- F4: Returns you to 'Value at Lat & Long?' after using screen capture.

IMPORTANT -- Never abort runs while 'QUAK2PLT' is running (i. e., when the display is telling you to be patient as arrays are being calculated). If you make the mistake of aborting such a run, you may leave files in the main directory and sub-directories that will prevent the running of any model or the model you were running at the time you aborted the run by leaving an incomplete file in a sub-directory. Remove any unexpected files from the main 'GDMOTION' directory. Remove the partial file from the sub-directory of your new output file.

A DETAILED WALK-THROUGH OF 'QUAKPLOT' -- You are now lead in a step-by-step fashion through 'QUAKPLOT.EXE'.

STEP 1 - You have entered 'QUAKPLOT' as noted above. Read the screen, press any key ONCE and wait for the time-delayed screen to change. Do NOT hit more than one key once!!

STEP 2 - Read the screen and select the area you want by entering the indicated three-letter code. RED, BLU and YEL give you 4° latitude x 3° longitude areas, while all others give you 2°x 1½° areas. RNW is the northwest quarter of RED, etc. Any entries other than those shown will result in no change of the screen. Try again. DO NOT HIT 'ENTER' AT ANY TIME WHEN ENTERING DATA IN THE MAIN PROGRAM (i. e., all the time except when entering a new fault model, see below).

STEP 3 - The only permissable entries are 'GEO' and "EQU'. 'GEO' will cause immediate presentation of the geologic map of the area selected, geology being expressed in relative seismic intensity units (USGS Prof. Paper 1360 and USGS Bull. 1332). Further manipulations of this map are as for calculated ground motion maps. See Step 11.

Entry of 'EQU' starts you on the path of presenting a calculated file for a specific fault model and ground motion parameter.

STEP 4 - You now select a fault model via its two symbol designator. If you know the appropriate one ('06' happens to be the one for San Francisco 1906), enter it now. If you don't know the designator, enter '??'.

4a: You now are given a screen of previously defined models. If you want one of these, enter its designator (two left-hand characters) and hit 'Enter'. AS NOTED AT THE TOP OF THE SCREEN, ALL ENTRIES ON THIS SET OF SCREENS REQUIRE AN 'ENTER'. In order to see other defined models, type 'M' and hit 'Enter'. Select a model or move along. Finally, you come to a screen that exhausts the list of defined models. Now is when you can make a new fault model. Type 'F' and hit 'Enter' in order to do this.

4aa: Enter a DOS-acceptable file name, ending it with '.FAU'.

4ab: Select an unused fault designator (numbers and letters are OK).

4ac: Enter the fault name you wish to use (<= 30 characters). I suggest you include length and magnitude in the file name. Where do you get these? From the fault-file you are in the process of making!! So, if you want to include these quantities in your title, do as follows (not neat but it works). Put something in the title here. Complete the fault-file as described below. Proceed as far as you want with investigating this model as described below. When you finally shut-down 'QUAKPLOT', look at the fault file you just made. You can find it in the \FAULTS\ sub-directory. Read the length and magnitude from the top line (the other number is the number of data points describing the fault. Go to the end of the file to find the number of points; the other number is the length in kilometers). Now, look at the file 'FAULTS.LST' (also in \FAULTS\) and change the title you first entered for the new model to one including the length and magnitude. As discussed earlier, include in the fault name an indication of fault type (I include no indication if the fault is strike-slip, a 'TH' if is a thrust or high angle oblique-slip.

4ad: Enter the eight comma-delimited values requested in the format shown and in sequence (lat1(deg), lat1(min), long1(deg), long1(min), followed by the other four values in order.

The fault-file will now be calculated, appropriately stored, and you will go to the point in the program you would have reached by entering a fault designator from the extant list (i. e., Step 5).

STEP 5 - Select an 'S' or a 'T'. (You are back in the main program so do not use 'Enter' when entering data.) IT IS NOT INTENDED THAT YOU INVESTIGATE THE 'S' AND 'T' BEHAVIOR OF THE SAME FAULT FILE. It is intended that you decided when you made the fault file what type of fault it was and that you included any designation of fault type in the fault name. The entry you make here influences calculations and helps in specification of a previously calculated file, but it does not influence the screen labeling.

STEP 6 - Select 'I'(MM Intensity), 'A' (maximum acceleration), 'V' (maximum velocity), 'D' (maximum displacement), or 'L' (% loss to structures). Any other letters are ignored.

STEP 7 - 'N' means a stress drop consistent with ground motion data (intensity is a ground motion parameter!) for nearly all California and USA-wide earthquakes (San Francisco 1906, San Fernando 1971, both Imperial Valley earthquakes (1949 and 1979), Long Beach (1933), etc., Seattle (1949), New Madrid (1811), Charleston (1886), and many Chinese earthquakes). 'H' is as required to explain data of the Loma Prieta (1989) earthquake (1.3 x 'N')).

STEP 8 - Your selection in Step 6 leads to some branching here. If you have selected 'I' in Step 6, you go directly to Step 9. If you selected 'A', 'V' or 'D', you will be asked to select

8a: Either 'A' or 'M', i. e., either the .50 non-exceedance value (A) or the .95 non-exceedance value (M).

If you selected 'L' in Step 6, you will be asked to select

8b: Either 'P', 'D', 'R' or 'C', i. e., pre-1940 wood-frame, post-1940 wood-frame, unreinforced concrete residential, or unreinforced concrete commercial.

STEP 9 - In the ground condition files, relative seismic response of each ½'x ½' cell is indicated by letters, each of which is assigned a numerical value (RFI relative to water-saturated alluvium). All of this is described in the USGS documents cited above. 'J' (0) stands for saturated alluvium, i. e., alluvium with water table at or near the surface, while 'K' (-0.5 RFI re 'J') is for alluvium with the water table at 10' to 30' and 'L' (-1.0 RFI re 'J') is for alluvium with the water table at 30' to 100'. In the SF Bay Area, other letters are used for many alluvium deposits as we follow the units described in a special USGS Bay Area study. Throughout much of southern California, alluvium classification is strictly by depth to water table, while in the remainder of the state, alluvium is arbitrarily described by 'L' in some areas and by 'J' in others. You may have reason to assume either 'J' or 'L' in your studies ('L' is certainly better than 'J' in nearly all of the Central Valley). So, you have three options: use J,K and L as shown on the geology/ground condition maps (A); treat all J,K and L cells as J (J); or treat all J,K and L cells as L (L).

STEP 10 - All selections you have made on this screen are shown at the bottom of the screen in green. If they are OK, press 'Y'. If they are not, press 'N' and start over.

STEP 11 - Assuming you entered 'Y', the file is either now calculated or recovered from disk if either you or I made it previously. Be patient if calculating. Here is where it is important that you have a 386 co-processor equipped machine, particularly if you are doing a 4° x 3° area. The result of your entry of 'Y' ultimately will produce a completed screen.

STEP 12 - Fifteen colors potentially can occur on the map. If the map is confusing, i. e., if it is difficult to detect the 'hotspots', you can simplify the screen. Enter 'H' to do this.

> *12a*: You simplify the screen by retaining 1 to 9 of the high value colors (1 retains only red, 4 retains red through yellow, etc.). All other colors will be changed to light grey.
>
> *12aa*: Having gone this route, you are now asked whether you wish to draw again with fewer colors (A), redraw the entire map (R), or continue through the program (C). I suggest that you redraw (R) before continuing (C) as there are procedures below that you may want to apply to a complete map. After redrawing, you will have to step your way via 'C' and 'N' entries to Step 13. If you do not want hotspot displays when you first reach Step 12, simply enter 'C'.

STEP 13 - Answer 'Y' or 'N' to the query "VALUE AT LAT AND LONG?'. If 'N', you move to Step 14. If you enter 'Y', there are a series of steps for entering the latitude and longitude values. The only comments required are that you carefully observe the format specifications given on the screen, and type carefully. Re-read the section above titled "ENTERING DATA FROM THE KEYBOARD. Errors in keying are reported to you on the data entry line. You can then reenter correct coordinates. Be assured that failures in performance are the result of your keying errors. A simple error is entry of coordinates of a point that is not on the map. Green lines in the top of the left-hand legend tell you the area covered by the map.

On the 4° x 3° displays, each ½' x ½' cell of the input data is assigned to a pixel. Thus, even on those plots, all information calculated is retained and readable on the final output. Therefore, no other display you could generate from the output files would display more information. Of course, the 2° x 1½° maps have four pixels assigned to each ½' x ½' cell of the input ground motion data.

The data shown for each selected latitude and longitude are the color (and thus ground motion value as read from the table on the left side of the screen) for the appropriate cell, as well as the relative ground condition used for that cell, expressed by letter (as in the documents cited above) and by numeric value (RFI relative to saturated alluvium or 'J'). If that ground condition is inappropriate for your site, correct the predicted value of ground motion via tables and figures in USGS Bull. 1332.

STEP 14 - By answering 'N' to ' ANOTHER ONE ? ', you leave the lat/long sequence. You then are asked if you want to calculate map statistics. If you don't, just type 'N'. If you answer 'Y', you select

> *14a*: Either 'C' for Count (number of square minutes of land area covered by each map color) or 'P' for Percent, the values shown being calculated using the Count data. It really makes little difference which you select as the other is immediately available by answering 'Y' to the next query. If you answer 'N' to that query, you go to Step 15.

STEP 15 - You are done with this map. If you want to study another, answer 'Y' to this query ('ANOTHER INVESTIGATION ?') and you will be returned to the beginning of the program. Answer 'N' and you are out of 'QUAKPLOT' and back to the 'D:\GDMOTION>' prompt.

REMEMBER the availability of the F3 and F4 keys which allow you to capture any screen in a permanent file (if you have a memory-resident screen capturing TSR) that can be converted to a color transparency either as it is or after modification via use of a painting program.

INSTRUCTIONS FOR USING PACKAGE B ('BAYPRED.EXE', ETC.)

IMPORTANT -- This program can only display previously generated and stored files for the San Francisco Bay Area. There is no capability within this program to generate new files. You need to use this program only if you are interested in the suite of files based upon simultaneous use of similar files of the four earthquakes predicted at assigned probabilities by the USGS (maximum predicted levels of ground motion or probability of reaching specified levels of ground motion). You will probably find 'QUAKPLOT' more useful and informative for all files dealing with a single event.

MONITOR REQUIRED -- As noted above, the presentation is designed solely for SCREEN 12 display (i. e., VGA 640 X 480, 16 COLOR) with 80 character width and 30 lines of text. These parameters are set by the program if they are permissable.

INSTALLING FILES ON A HARD DISK -- All pertinent executable codes are in DISKONEA.EXE. All output data files concerned solely with Package B are in the self-decompressing file 'DISKTWO.EXE' which has a complete directory and sub-directory structure consistent with that of 'DISKONEA.EXE'. Place the diskette 'GDMOTION-2' in A:. Go to C:\> or D:\> (the IDENTICAL place you put the contents of 'DISKONEA.EXE'and 'DISKONEB.EXE', as 'BAYPRED.EXE' can display many of the files generated by 'QUAKPLOT.EXE'. At the DOS prompt, type 'A:\DISKTWO -d' and then hit 'Enter'. BE SURE TO INCLUDE THE '-d'! Otherwise, you will get all files in a single directory and the program won't run. If you make this error, just delete all files added to D:> and re-use 'DISKTWO'. There are numerous files because I have provided you with output files for several faults and many probability files as described above. When expanded, all files require 4.5 MB. The 'DISKTWO.EXE' file will remain safely on disk in A:. If you do not want all of the output files provided, deletions can be made in subdirectories holding 'BFFXXXXX.XXX' FILES. HOWEVER, AFTER SUCH DELETION, YOU CANNOT DISPLAY PROBABILITY MAPS WITH 'BAYPRED' AS THE 'BFF....' FILES ARE THE PERTINENT FILES. DO NOT DELETE FILES FROM ANY OTHER SUB-DIRECTORIES. If you do not want to display any of the Bay Area probability maps, just forget about 'DISKTWO.EXE'. Don't decompress it and use 'QUAKPLOT' of Package A for displaying the other types of Bay Area maps.

TYPES OF FILES DISPLAYABLE BY 'BAYPRED' -- This program displays the following classes of maps for earthquakes in the San Francisco Bay Area -

▪▪ For individual earthquakes (files also displayable by 'QUAKPLOT'):
- MM Intensity
- Maximum acceleration - .50 non-exceedance
- Maximum acceleration - .95 non-exceedance
- Maximum velocity - .50 non-exceedance
- Maximum velocity - .95 non-exceedance
- Maximum displacement - .50 non-exceedance
- Maximum displacement - .95 non-exceedance
- % loss pre-1940 wood-frame
- % loss post-1940 wood-frame
- % loss unreinforced concrete commercial
- % loss unreinforced concrete residential

▪▪ Composite maps for the four Bay Area earthquakes predicted at specified probabilities to occur within the next thirty years (USGS Circular 1053):

- Maximum intensity; normal stress drop (NSD)
- Maximum velocity; NSD and 0.50 or 0.95 non-exceedance
- Maximum velocity; 1.3 x NSD and 0.50 or 0.95 non-exceedance
- Maximum acceleration; NSD and 0.50 or 0.95 non-exceedance
- Maximum acceleration; 1.3 x NSD and 0.50 or 0.95 non-exceedance
- Maximum displacement; NSD and 0.50 or 0.95 non-exceedance
- Maximum displacement; 1.3 x NSD and 0.50 or 0.95 non-exceedance
- Maximum % loss; NSD and pre-1940 wood-frame, post-1940 wood-frame, unreinforced concrete residential, or unreinforced concrete commercial.
- Maximum % loss; 1.3 x NSD and pre-1940 wood-frame, post-1940 wood-frame, unreinforced concrete residential, or unreinforced concrete commercial.
- Probability of MMI >= VII, VIII or IX at NSD.
- Probability of acceleration >= .032, .064, .128, .256, 512 or 1.024 g at NSD and non-exceedance values of 0.50 and 0.95.
- Probability of acceleration >= .032, .064, .128, .256, 512 or 1.024 g at 1.3 x NSD and non-exceedance values of 0.50 and 0.95.
- Probability of velocity >= 16, 32, 64 or 128 cm/sec at NSD and non-exceedance values of 0.50 and 0.95.
- Probability of velocity >= 16, 32, 64 or 128 cm/sec at 1.3 x NSD and non-exceedance values of 0.50 and 0.95.
- Probability of displacement >= 8, 16, 32 or 48 cm at NSD and non-exceedance values of 0.50 and 0.95.
- Probability of displacement >= 8, 16, 32 or 48 cm. at 1.3 x NSD and non-exceedance values of 0.50 and 0.95.

ENTERING DATA AT THE KEYBOARD -- The instructions given under Package A on this topic apply here also. Therefore, they are not repeated.

SPECIAL KEYS -- The instructions given under Package A on this topic apply here also. Therefore, they are not repeated.

A DETAILED WALK-THROUGH OF 'BAYPRED' --

IMPORTANT NOTE -- Some of the same keying sequences in 'BAYPRED' are as in 'QUAKPLOT'. Where this is the case in the following discussion, you are referred to the 'QUAKPLOT' discussion.

STEP 1 - At the 'GDMOTION>' prompt, enter 'BAYPRED' and hit 'Enter'.

STEP 2 - Read this screen, press any key ONCE and wait for the screen to change.

STEP 3 - You have several alternatives.

- *3GR*: Select 'GR' and get the geological map expressed in relative seismic intensity units (USGS Bulletin 1838). Go to Step 4.

- *3EQ*: Select one of the six earthquakes (you can actually select any earthquake for which you have already made a file and whose fault designator you remember).

- *3EQI*: Select 'I' and get a predicted MMI map which incorporates the ground condition data. Always remember that predicted intensities are solely shaking intensities. Additional ground condition data are required if the intensities of these maps are to be converted to ground failure intensities. See comments in the Introduction.

  3EQIa: Select normal ('N') or 1.3 x normal ('H') stress drop. Go to Step 4.

  3EQMO: Select 'A', 'V', or 'D' and get maps of predicted maximum acceleration, velocity or displacement, all maps including ground condition data.

  3EQMOa: Select 'N' or "H'.

  3EQMOb: Select predicted average value ('A') or nearly maximum predicted value ('M'). Go to Step 4.

  3EQLO: Select 'L', getting maps of predicted loss for several structural types, all maps incorporating the ground condition data.

  3EQLOa: Select structural type ('D', 'P', 'R', or 'C'). Loss estimates are solely concerned with losses due to shaking. They do not include losses due to ground failure, fire, etc.

  3EQLOb: Select 'N' or 'H'. Go to Step 4.

- *3EQFF*: Select 'FF' and get a probability or maximum ground motion expected map based upon the four Bay Area earthquakes predicted with assigned probabilities in USGS Circular 1053.

  - *3EQFF?*: Select 'I', 'A', 'V', or 'D' (probability of reaching or exceeding a specific intensity ('I') or level of ground motion ('A', 'V', or 'D').

  - *3EQFFI*: Select 'I'.

3EQFFIa: Select 'N' or 'H'.

3EQFFIb: Select maximum expected intensity ('M') or probability of reaching or exceeding an assigned intensity ('P'). If you selected 'M', go to Step 4.

If you selected 'P', then

3ERFFIc: Select MM intensity VI, VII, VIII, or IX. Go to Step 4.

•• *3EQFFMO*: Select 'A', 'V', or 'D'.

3EQFFMOa: Select 'N' or 'H'.

3EQFFMOb: Select 'A' or 'M'.

3EQFFMOc: Select maximum value predicted for any of the four earthquakes ('M'), or select probability of reaching or exceeding a level of strong motion to be assigned in the next step ('P'). If you select 'M', then go to Step 4.

If you select 'P', then

3EQFFMOd: Select one of the seven indicated ranges, your choice of type of ground motion under *3EQFFMO* determining the selections now available. Go to Step 4.

STEP 4 - If all entries are as you wish (read what you have entered in the lower box on the left of the screen), respond to the 'Everything OK?' at the lower right corner of that box by entering 'Y'. After entering 'Y', you will get the requested map and associated legends if the requested file exists, allowing you to proceed to Step 5. If the file does not exist, you will be so informed and then sent to Step 3.

If you decide you do not want that map or if you see that you have made an error, enter 'N' and return to Step 3.

STEP 5 - For orientation, you may wish to display sites of several Bay Area communities. If you do not wish to see city locations, answer 'N' and go to Step 6. If you wish to see city locations, answer 'Y' and go to

5a: Both possible answers clear the screen of the cities, 'Y' returning you to Step 5, while 'G' moves you to Step 6.

STEP 6 - You now decide whether to investigate predicted parameters at specific sites defined by latitude and longitude. This is the identical sequence previously extensively discussed under 'QUAKPLOT'and 'ENTERING DATA FROM THE KEYBOARD'. If you answer 'Y' at the query, see Step 13 of the 'QUAKPLOT' discussion for guidance. Either initially or ultimately, you will answer 'N' to the query about another lat/long, such an answer taking you to Step 7.

STEP 7 - You may wish to enlarge part of a figure for inspection or for capturing (Remember availability of F3 and F4 keys). If are not interested, answer 'N' and you will be taken to Step 8. If you answer 'Y', you go to

7a: You have the option to select one of three areas, all of which were defined on the screen display associated with Step 2. After you select one of the three, the screen is redrawn and you are returned to Step 7. Finally, you answer 'N' at Step 7 and go to Step 8.

STEP 8 - You are finished with this file. If you answer 'N' to the query about 'ANOTHER INVESTIGATION ?', you are returned to the DOS prompt. If you answer 'Y', you are returned to Step 3.

REMEMBER the availability of the F3 and F4 keys which allow you to capture any screen in a permanent file (if you have a memory-resident screen capturing TSR) that can be converted to a color transparency either as it is or after modification via use of a painting program.

SUGGESTIONS FOR OTHER TYPES OF FILES ONE CAN MAKE AND DISPLAY

USING MAPS OF TYPES ALREADY MADE BY 'QUAKPLOT' -- All output files are simple ASCII files, the intent being to make them easy to understand and manipulate. So what might you wish to do? One thing might be to make a plot of the maximum intensity, acceleration, loss, etc., expectable throughout a map area as the result of a specified set of potential earthquakes. First, use 'QUAKPLOT' to generate the set of single event maps. Second, write a program which reads each of the files in turn, replacing a cell value if its value for event N+1 is greater than for event N. Make a new file identical in format to that of the single event maps, remembering to maintain the header structure and changing lines specifying content. Give the resultant file a name consistent with its content (see description of file names given above), using a unique 'fault designator'. Third, add a line to 'FAULTS.LST' (in sub-directory .\FAULTS) with the selected fault designator and a 'fault name' describing the map content. Fault designators can include numerals and/or letters. Put the calculated file in the appropriate '\EVENTxxx' sub-directory, run 'QUAKPLOT' answering questions normally, and there it is.

Since I do not believe anybody can make meaningful estimates of probabilities of California earthquake occurrences within the next N years (maybe one or two but certainly not several or more), I have not included the capability to plot probabilities within 'QUAKPLOT'.

MAKING NEW TYPES OF MAPS WITH 'QUAKPLOT' -- In USGS Bulletin 1838, many types of files not presently made by 'QUAKPLOT' are described. The ability to make all of these can be easily added to 'QUAKPLOT'. Contact me about which of these or others you might like added to the next version. If there are several requests for specific additions to capability, I will do the work.

INSTRUCTIONS FOR USING 'USA', 'USAPLOT', AND 'USACOMPO' (ON DISK 'GDMOTION-2')

INSTALLING FILES ON A HARD DISK -- All files have been provided in a self-decompressing file which has a complete directory and sub-directory structure. Place the disk provided in A:. Go to C:\> or D:\> (multi-megabyte hard disk). At the DOS prompt, type 'A:\PLOTUSA You will create a root directory named 'USAPLOT' with numerous sub-directories. There are numerous files because I have provided you with output files for several faults and models. When expanded, all files require 3.2 MB. The 'PLOTUSA.EXE' file will remain safely on the disk in A:.

If you decide you do not need all of the output files provided, deletions can be made in subdirectories \USAACC, \USAVEL, \USAINT and \USALOS. DELETE NOTHING FROM THE MAIN DIRECTORY OR OTHER SUB-DIRECTORIES. DO NOT DELETE ANY SUBDIRECTORIES. I suggest a controlled deletion. The second and third symbols in file names constitute the fault designator used in the file USAFLTS.LST in sub-directory \USAFLTS\. You can compare file names and fault designators and retain files for earthquakes of interest, deleting all others.

ROOT DIRECTORY FILES -- You always begin with 'USA.EXE'. It calls either 'USAPLOT.EXE' or 'USACOMPO.EXE' depending upon your wishes. 'USAPLOTH.EXE' is called from 'USA.EXE'. 'CLRDISK.EXE' and 'USAINTGM.EXE' are called from 'USAPLOT.EXE'. The file 'USA.INP' holds model data that are required for all calculations. 'USAINTGM.EXE' is written in FORTRAN, all others in QUICKBASIC.

TYPES OF MAPS DISPLAYED -- These programs generate and display several classes of maps for earthquakes within the coterminous USA -

- Single maps with defined event parameters. All are made by 'USAPLOT' and are permanently stored. The defined parameters for each set of maps are:
  - latitude and longitude of center of rupture
  - strike of fault (+ east of North, - west of North)
  - length of rupture in kilometers
  - attenuation value ('K') at epicenter (1.00, 1.25, 1.50, or 1.75)

I STRONGLY RECOMMEND THAT 'QUAKPLOT' BE USED FOR GENERATING MAPS FOR EARTHQUAKES OF WESTERN CALIFORNIA !!!!!!

  - depth of focus
  - ground condition to be used. All maps are for uniform ground condition. You select one of seven. See below.
  - a listing of the nine types of maps always generated for each model is one of the displays in 'USAPLOT', so it is not given here.
- The model of attenuation factor 'k' versus location used in the model is available as a special output. It is available when selecting a map for display. See discussion below of 'USAPLOT'.
- Composite maps of the single maps described above. These maps are made by ('USACOMPO'). They are not permanently stored. Either capture them as a picture file by use of F3 and F4 and your memory-resident screen capture program or re-make them each time.

ACCESS TO VARIOUS GROUND CONDITIONS -- The USA-48 map is digitized in 25 km x 25 km cells, i. e, far too coarse for useful categorization of cells by a single geological parameter. This problem of detailed ground condition is handled by making all maps for a uniform ground condition while allowing you to use seven different ground conditions (0.0 (saturated alluvium) to -3.0 in steps of -0.5. If you know the ground condition at a lat/long of interest, run the maps for that ground condition and enter the lat/long to find the predicted value.

USE OF KEYBOARD -- The admonitions given for use of the keyboard when running the two previous packages apply for Package 3 also. Exercising any one of the three packages will make you adept with all of them.

MAKING FAULT FILES -- You must generate an entry in the file 'USAFLTS.LST' (in .\USAFLTS) for each fault or rupture you wish to study. This entry must be made before making the nine maps. By properly following instructions in the program, this one-line file will be made automatically, will be permanently stored in 'D:\USAPLOT\USAFLTS\USAFLTS.LST' and will be available for future use. See the Package 3 walk-through below for details.

A DETAILED WALK-THROUGH OF 'USAPLOT' --

STEP 1 - At the 'USAPLOT>' prompt. enter 'USA' and hit 'Enter'.

STEP 2 - Select 'S' for Single map. Read the next screen and wait for it to change.

STEP 3DEF - Assume you wish to use a previously defined fault (see Step 3NEW if you wish to make a new fault file).

3DA: If you remember its two-digit designator, enter it now. You will go to Step 4.

3DBa: If you do not remember its designator, enter '??' You will be shown a screen of previously defined faults (there may be more than can be shown on the first screen). If you want to use one of those on the first screen, enter its two-digit designator. You will go to Step 4.

3DBb: If there are more than eight previously defined models, you can see the next set by entering 'MO'. Keep using 'MO' until you find the fault file you want. Then enter its designator and go to Step 4.

STEP 3NEW - Assume you wish to make a (NEW) fault file.

3NA: Keep using 'MO' until the bottom line on the screen invites you to type 'FF' if you want a new fault file. Enter 'FF'.

3NB: Read the screen, and follow instructions carefully, observing the indicated formats (i. e., length as xxx.x, strike of fault as sxx.x where 's' is '+' or '-', etc.). You will need the k value at the epicenter in order to know the permissable maximum length of rupture. Find it either in USGS Prof. Paper 1223 or by displaying the attenuation map (See Step 5). The title format is a suggestion. It contains model information that is not displayed anywhere else on the output screen. After you press 'Enter', the file is made and stored and you go to Step 4.

STEP 4 - You are presented with a screen on which you finish the model.

4A: Select 'S' for (S)trike-slip or 'T' for (T)hrust.

4B: Select the ground condition desired, the unit being intensity difference between the chosen ground condition and saturated alluvium (i. e., '0' means saturated alluvium, '2.5' means 2.5 intensity units below that expected on saturated alluvium.

4C: If you made an error or wish to change one of these two parameters, hit 'N' and enter these two values again. If everything is 'OK', hit 'Y'. You will go to Step 5. If you selected a previously uncalculated model, you will see a screen telling you to be patient while calculations proceed. When calculations are complete, the screen will change to Step 5.

STEP 5 - You now have the option of selecting one of the nine maps automatically generated for each model ('1' to '9') or the USA-48 attenuation map ('A'). Select one of them and go to Step 6.

STEP 6 - Read this figure carefully. All data essential to use and understand the map are included. A few comments may be useful. The digitization is by 25 km X 25 km cells. The dashed lines of latitude and longitude are every five degrees, extending in longitude from 65° W to 125° W and in latitude from 25° N to 50° N. The length scaling is shown by the 15-color bar under the upper labels, each color being of 100 km length. The epicentral area insert is five times the scale of the main map, and uses at all points the k value at the center of the rupture.

The 'r' values given opposite each color at the bottom of the map are the radii of the circles with the areas of the correlative values of the mapped parameter and all higher values (as shown on the main map) with area measured in 625 square kilometer (25 X 25) increments. In many cases, the epicentral area values on the main map will be poorly defined. Look at the epicentral area map and use the distance scale at the top of the map, remembering that each segment of that scale represents 20 kilometers on the epicentral area map.

The logic used for handling the change in attenuation from one k region to the other occasionally leads to anomalous results. Just ignore such clearly physically anomalous values and smooth your evaluation if such occasional features impact on sites of significance to you. I may play with that sometime in the future but not now.

Press 'Y' to proceed to Step 7

STEP 7 - The only analysis possible with 'USAPLOT' is determination of values at locations specified by latitude and longitude. If you answer 'N' here, you will go to Step 8. If you answer 'Y',

> *7A*: Enter latitude and longitude in the formats specified. All instructions given for Packages 1 and 2 apply here with the only addition being that longitude degrees must always be a three-digit entry, the first digit being '0' for longitudes of less than 100°. The instructions given above under "ENTRY OF DATA FROM THE KEYBOARD" apply here, with the slight change that "SITE IN WATER" is changed to "NO VALUE" since points in water, Canada and Mexico are included under this message. Dots will appear on the main and epicentral maps at the selected latitude and longitude (red on main map, dark blue on the epicentral map). For sites within the area of the epicentral map, the parameter value on that map will be shown under the latitude and longitude values on the right side of the screen. Note that the 'epicentral area' map uses a fixed value of k (that at the middle of the rupture) even if the k values change within the 'epicentral area' (see maps for the 'Southern Illinois' earthquake). This may be slightly inconvenient on occasion but you can think your way around the problem. When you finally answer 'N' to whether you wish to analyse further points, you will go to Step 8.

STEP 8 - If you answer 'N' to this query, you will go to Step 9. If you answer 'Y', you will be returned to Step 5.

STEP 9 - If you answer 'N' to this query, you will leave the program and go to the 'USAPLOT>' prompt. If you answer 'Y', you will be returned to Step 3.

A WALK-THROUGH OF 'USACOMPO' --

IMPORTANT -- You should select 2 to 6 previously stored models and files whose comparison is meaningful in some sense (such as maximum events in each k area, 3 km ruptures in each k area, etc.).

STEP 1 - Type 'USA' at the '.\USAPLOT>' prompt and hit 'Enter'.

STEP 2 - Select 'C'.

STEP 3 - Enter any number from 2 to 6.

STEP 4 - Select the map type of the nine available you wish to display The only comment required is that you must have already generated all of the maps you are going to specify in this and the next step.

STEP 5 - Complete models by selecting 'T' or 'S', and ground condition.

STEP 6 - You now enter the several fault designators in any sequence. The several maps are successively overlaid, keeping the highest value calculated for each cell. After the last overlay sequence, the map is completed and you go to Step 7.

STEP 7 - Press 'Y' to proceed.

STEP 8 - The only analysis possible with 'USACOMPO' is determination of values at locations specified by latitude and longitude. If you answer 'N' here, you will go to Step 9. If you answer 'Y',

> *8A*: Enter latitude and longitude in the formats specified. All instructions given for Packages 1 and 2 apply here with the only addition being that longitude degrees must always be a three-digit entry, the first digit being '0' for longitudes of less than 100°. Dots will appear on the main map at the selected latitude and longitude. When you finally answer 'N' to whether you wish to analyse further points, you will go to Step 9.

STEP 9 - If you answer 'N' to this query, you will go to Step 10. If you answer 'Y', you will be returned to Step 4.

STEP 10 - If you answer 'N' to this query, you will leave the program and go to the 'USAPLOT>' prompt. If you answer 'Y', you will be returned to Step 3.

REMEMBER the availability of the F3 and F4 keys which allow you to capture any screen in a permanent file (if you have a memory-resident screen capturing TSR) that can be converted to a color transparency either as it is or after modification via use of a painting program.

BRIEF SYNOPSIS OF MODEL

INTRODUCTION

The several elements of this model are:

1 -- Seismic response of the various possible site ground conditions expressed in units of relative intensity, i. e. microzonation for ground condition.

2 -- Regional attenuation of intensity-relevant wave types and frequencies, this factor being highly variable over the earth and of great importance, i. e., zonation for attenuation. One requires a specification of this parameter throughout the area over which relevant earthquake energy passes (this may be greater than the area for which predictions are made).

3 -- Radiation model for seismic source.

Given specification of the above three factors, predictions of seismic intensity are straightforward.

4 -- Correlation of seismic strong motion parameters with intensity, thus achieving microzonation for such parameters on the same scale as used in Item 1, i. e., relative amplification of maximum acceleration, maximum velocity, relative damage to structures, etc.

Given specification of all four factors above, predictions of all modeled ground motion parameters can be achieved on whatever scale of microzonation desired.

1 -- RELATIVE SEISMIC RESPONSE

As presently used, this is a single parameter quantity expressing relative amplitudes of ground motion on different geological formations for the same input signal from depth, such information being acquired via empirical investigations (*Reference 2*). The scaling for depth of water-table in alluvium was not available via Borcherdt's data but was generated by myself using observations in California and the data of Medvedev (*Reference 3*).

As used in the program, these relative amplitude data have been converted to expected relative intensities, by expressing the relative amplitudes as powers of two (2). Normalization is a power of zero (0) for saturated alluvium (i. e., saturated to the surface) so that all other powers are negative. The coefficients turn out to be relative RFI (Rossi-Forel Intensities). Note that this power of 2 scaling is only correct for RFI, not for MMI (Modified Mercalli Intensities). As discussed in *References 4 thru 7*, RFI are a physically real quantity in that they display simple scaling laws with other ground motion parameters while MMI do not. It is unfortunate that usage in the USA followed Wood (*Reference 10*), resulting in a switch from RFI to MMI. However, the deed was done and we must now live with it and its inconsistencies. Because of the simplicity of the RFI/motion parameter relationships, all calculations in these programs are done in terms of RFI, RFI being converted to MMI only if the output is a map of seismic intensity.

A factor that severely impacts on interpretation and prediction of seismic intensity maps (remembering that the pertinent aspect of intensity is its correlation with damage) is lack of the requisite discipline in using definitions of seismic intensity pertinent to the structural types actually existing in a shaken area. This works both ways. Thus, when I investigated the historical intensity maps of China, most were totally useless (and, no doubt remain totally useless) for interpretive purposes (*Reference 9*). The only useful (i. e., internally consistent and interpretable) maps were those carefully evaluated and reinterpreted in recent years, the effort having been made to establish damage factors for the varieties of Chinese structures commensurate with damage levels for structural types used in definition of MMI units. On the other hand, the major changes in construction practice in California and elsewhere in recent years have led to "observed intensity maps" that are simply uninterpretable in terms of older maps and any model based on older maps. Thus, it is nearly impossible to observe shaking intensities of IX in California these days for two reasons; (1) MMI nearly define intensity IX out of existence, and (2) modern construction practice for wood-frame structures prevents occurrence of the failure modes due to shaking that characterize accepted definitions of intensity IX/X. Of course, old structures still fail as expected and buildings still get built that, for one reason or another, do not meet code or are not adequately covered by code. MMI must be defined in terms of structural types at risk or only greater and greater confusion will result. See *Reference 7.*

When making predictions for areas other than California, I make the attempt to establish a correlation of geologic units in these other areas with California. I would advise any who wish to use these programs in other areas to conduct the requisite investigations on the various ground conditions of the region of interest. The only requirements are field deployable seismometers and local to regional small earthquakes.

An observation reported 16 years ago (*Reference 4*), and one still consistent with available strong motion data from large California earthquakes as interpreted within this model, is that all observed earthquake-related ground motions not involving ground failure are quantitatively interpretable as small amplitude elastic motion. Thus, relative seismic intensity values determined in the San Francisco Bay Area via measurements of very low amplitude waves from nuclear explosions near Las Vegas, Nevada, have been used to successfully predict relative intensities from IV to IX/X, as well as strong motion values over the same intensity range, for several earthquakes.

Though there are some statements above and below that may seem to have an "oracular' flavor. i. e., dicta from on high without supporting documentation, I assure you that all seemingly categorical statements here presented are supported by data presented in the cited documents.

2 -- REGIONAL ATTENUATION

The variations in attenuation of damage-relevant seismic phases and frequencies is so extreme across the USA (and mainland China) that many early concepts about relative physical sizes of earthquakes and expectable damage levels versus energy released by earthquakes in different regions of the USA have been abandoned or grossly revised. Thus, in *References 4 and 5*, it was demonstrated that the New Madrid Earthquakes of 1811-1812 had rupture lengths of 3 kilometers or so and had energy releases comparable to those of a 3 km rupture in California, the incredible differences in the felt areas of such earthquakes being explainable totally on the basis of differing attenuation factors in the two regions.

The pattern of attenuation factor throughout a region, large or small, is determinable via study of the isoseismal maps of historical earthquakes in the area. The maps must, of course, be carefully drawn against definitions of intensity that apply to the area of study. The critical item is the spacing of isoseismals on uniform ground condition in areas somewhat removed from the epicentral area (to escape the impact of depth of the earthquake on the spacing of the isoseismals). The greater the spacing, the lower the attenuation.

I have found one must consider a couple of factors in making the requisite interpretations. The first is that intensities of III and less are useless. The lowest boundary of use will be the III/IV boundary.

The second factor is a bit trickier. Note above that I said isoseismal spacing on uniform ground condition. How does one do this when most (all I have ever seen) intensity maps are drawn without any concern for ground condition? Some grotesque anomalies appear on such maps because of this practise. The interpretation I used for intensity maps was that the furthest mapped extent of an intensity boundary was expressive of its extent on saturated alluvium.

So, do it. First, you decide location of the rupture and its length via study of the near-field isoseismals. Then you make the spacing measurements in directions both perpendicular and parallel to the presumed rupture (if the isoseismals, even the small ones, appear circular "perpendicular" and "parallel" lose meaning and all radial measurements are treated as "perpendicular" (K values of 4). *Reference 7* contains a large set of figures (Figures 12) that allow you to use your measurements to establish the attenuation parameter (K in my nomenclature). Of course, you establish the parameters of your earthquake at the same time.

This discussion may seem somewhat irrelevant to a short text about the model. The reason for including it is as an introduction to the Figures 12 of *Reference 7* and the resultant implications about source energy release as a function of K value. It is demonstrated in *References 4 and 5* that all 3 kilometer ruptures in the USA release the same amount of energy in the intensity bandpass. Great earthquakes in eastern USA are not high stress drop events nor are they associated with long ruptures. They have the same few tens of bars pre-stress in the focal environment and surrounding volume as do California earthquakes. Earthquakes occur not where stress is high but where stress can be released. The large radii of various types of damage expected as the product of any 3 km rupture in eastern USA are the result of the very low attenuation with distance, not from high source energy.

An important conclusion of investigations of attenuation of intensity-relevant seismic phases (and one consistent with theoretical investigations) is that propagation of these phases (largely S_g) is a full crustal phenomenon with little or no relation to shallow surficial geology. Thus, the attenuation observed shows no relation to details of surficial geology. Geologic units are of relevance only in dictating the amplitude of surficial motion developed at a site in response to the delivery of energy from depth into the unit. Thus, a model that successfully predicts attenuation as well as relative response of different rock types need only incorporate a regional parameter for attenuation and individual corrections for each surficial geological unit.

The attenuation law used is, of course, regionally dependent. 'USAPLOT' takes account of changes in K in its prediction of ground motions.

3 -- SOURCE MODEL

Though I fully realize that the energy of an earthquake is derived from volume release of pre-stress, it is convenient and adequate to assume a line source at an assigned pseudo-depth. The energy law is that of Gutenberg (*Reference 11*) with energy release being linked to length of rupture, not to magnitude. This point is discussed in *Reference 6* in some detail. For routine interpretation (as in all programs on these diskettes), I assume uniform distribution of energy release along the fault, i. e., uniform rupture at approximately shear wave velocity in the surrounding rocks. Rupture approaching shear wave velocity along the full length of fault movement) produces the source spectrum typical of most crustal earthquakes. Slower rupture velocities can lead to marked reduction of intensity-relevant energy (*References 6,7,and 8* and discussion of the Parkfield CA earthquake). The model, as it is always assuming a high rupture rate, will determine the rupture length associated with a high rupture velocity. The proper way to think about our "conventional continental earthquakes" is that they are the high speed member of a failure process that extends from stable very low speed sliding through episodic slow creep events and slow earthquakes (those radiating detectable seismic waves only at long periods) through failure events of variable rupture velocity to events which fail at nearly shear wave velocity throughout their entire length. It is easy to show that nearly all movement in subduction zones is characterized by no radiation of seismic energy, i. e., by simple sliding at very low velocity. The basis of such faulting behavior is water pressure in the failure zone being at load pressure (i. e., the same phenomenon that leads to the nearly aseismic sliding along the central San Andreas Fault).

The model for California, i. e., the area of potentially long ruptures, explicitly takes account of signal persistence, calculating intensity based on energy arriving at a site 5 seconds either side of the arrival having the shortest distance to travel from the rupture. The insertion of this detail in the model achieved accurate prediction of intensity patterns for earthquakes from ML 5.5 to the largest in California (rupture lengths of 5 or so kilometers to 400+ kilometers).

A 'depth' term is required in the model. The value found appropriate for most earthquakes (even eastern USA earthquakes) is 25 (i. e., a depth of about 15 km) when considering strike slip earthquakes. For such earthquakes, the line source is placed along the surface trace of the fault (if there is one - there never is in eastern USA, so just place the short source at the 'epicenter') - and use a pseudo-depth value of 25 unless you have reason to use something else. See discussion of Seattle (1949) earthquake in *Reference 6* and sensitivity of near-field isoseismal pattern to depth of focus. Finally, in order to model the near-field intensities of the San Fernando (1972) thrust earthquake (they were unusually high), it was required to decrease the pseudo-depth value to 20. So, I suggest modeling the source for such quakes as a line source moved some kilometers in the downdip direction from the surface trace at a pseudo-depth value of 20. Such modeling of the Loma Prieta (1989) earthquakes helps predict the very high levels of ground motion observed above that earthquake.

The model as presently constituted predicts shaking aspects of ground response or intensity, not ground failure. Thus, the model could be extended to predict liquefaction if all areas of saturated alluvium have been characterized as to liquefaction potential as a function of intensity or other ground motion parameter. At present, I do not have such data for California or USA-48 alluvium. So, the program predicts shaking and leaves it to the user to know the liquefaction characteristics of sites of importance to him or her.

Mathematical details of the entire model can be found in *References 4, 5, 6, and 7.*

Amplification as the result of topographic focusing in not included in the model.

4 -- PREDICTION OF STRONG GROUND MOTION

'QUAKPLOT' has, at present, only the capability to present maps of maximum acceleration, maximum velocity, maximum displacement and the four structural damage maps noted above under A. Other capabilities (RMS band-limited acceleration, for example) can be easily added if some users would desire it. A version of my prediction program is available which allows prediction of all of the ground motion parameters figured in *Reference 7* via use of the MPD relationships of *Reference 7*, producing an output ASCII file that can be used as desired.)

A few comments on the inclusion of such calculations within the model are pertinent. In *References 6 and 7*, I reported on the correlations of RFI/MMI with numerous ground motion parameters derived from the strong motion data of the San Fernando (1972) earthquake. Three statistical fits to the data were shown. The least squares correlation was absurd to publish (severely asymmetric). The most reasonable fit was that which minimized the sum of the perpendicular distances (MPD) of all data from the best fit relationship. An example of the MPD fit to the data can be seen in *Figure 1A*, the maximum velocity versus maximum acceleration data of that earthquake as well as the MPD statistical fit and flanking parallel lines at separations of log(2) and log(3) in acceleration. The data are keyed for ground condition at the recording sites. There is no evidence that maximum velocity/maximum acceleration ratios have any dependence on ground condition. For those who might suggest that the hard rock values suggest a different relationship, I include *Figure 1B*, random plots of maximum velocity in accordance with the statistics of the data of *Figure 1A* at the observed maximum acceleration values. All nine of those plots are equivalent small sample expressions of the same statistical model. Note that the plot at the upper left nearly reproduces the observed pattern.

Extensive strong motion data are available for the Imperial Valley (1979) and the Loma Prieta (1989) earthquakes - earthquakes within the same geotectonic region as the San Fernando earthquake -. as well as for the Chile (1968) earthquake, all of these data being plotted on *Figure 2*. The data of the California earthquakes display the same maximum velocity versus maximum acceleration relationship as do the data of the San Fernando earthquake. If the data were keyed for site ground condition, they would show no dependence on rock type. These data can also be plotted as RFI versus maximum acceleration and RFI versus maximum velocity. Again, there is no dependence of plotted values on site ground condition for any of the three earthquakes, while the data of the Imperial Valley and San Fernando earthquakes equally agree with the MPD relationships of of *Reference 7*. Equivalent data of the Loma Prieta earthquake are slightly different and will be discussed below. However, the differences are such as to suggest special causes associated with the Loma Prieta source. Therefore, it seems to be warranted to include the ground motion calculations for maximum acceleration versus RFI and maximum velocity versus RFI as an aspect of 'QUAKPLOT'.

Without presenting the pertinent data, I simply note that the maximum displacement versus maximum velocity or versus RFI are distinctly different for all of these three earthquakes, the data of the Loma Prieta earthquake yielding amplitudes of displacement half those of the San Fernando earthquake for the same RFI or maximum velocity with maximum displacement being at a shorter period also. Even slightly different depth and crustal velocity structure will markedly influence amplitudes of the relevant long period seismic phases. I have included in 'QUAKPLOT' the RFI versus maximum displacement relationship of the San Fernando earthquake, but it must be used with detailed knowledge of source characteristics or with caution.

The data of the Loma Prieta earthquake indicate other reasons for careful interpretation. *Figure 3A* includes all Loma Prieta RFI versus maximum acceleration data except for stations on the east side of San Francisco Bay. Other than for numerous sites on Franciscan rocks (J_f), the data agree nicely with the San Fernando MPD relationship under the assumption that the stress drop for this earthquake was 1.3 times greater than for normal earthquakes in California. All except one of the J_f values at low RFI are in San Francisco, nearly all on topographic highs. The J_f value not in San Francisco (the one at RFI VII) is also atop a hill. Increased ground motion on topographic highs is a phenomenon often observed throughout the world. The generally accepted interpretation for the high values of acceleration on J_f in San Francisco for this earthquake is based on resort to a cusp in S_g. I simply note that observed values of ground motion for that earthquake can be quantitatively explained by more conventional factors such as abnormal stress drop (required to explain data at all ranges, not just at the range of the cusp), the location of San Francisco along the extension of the rupture (see *Figure 7* for clarificationof this point) and topographic amplification, a widely observed and oft-reported phenomenon. The model and observations are consistent with the interpretation that ground failure at the Marina in San Francisco was the result of building on un-engineered filled ground incredibly sensitive to liquefaction (much more so than natural deposits, as evidenced by the markedly different behavior of filled ground and natural alluvium at the Marina). Bay Muds at the south end of the San Francisco Bay experienced accelerations and velocities certainly greater than anything at the Marina with no evidence of liquefaction. I should add that carefully engineered ground at Foster City experienced maximum ground motion about a third of that on surrounding natural deposits with no liquefaction. Failure at the Marina was the result of ignorance about liquefaction of fine silts and clays, the filling having taken place just after World War I.

Now note *Figure 3B*, the RFI versus maximum acceleration data for East Bay stations. The high acceleration values on Bay Muds have been used to support the S_g cusp argument since some are at the same distance from the Loma Prieta earthquake as the Marina. However, note that as a set, independent of range (and the ranges are very different) or rock type, the observed values are twice those observed elsewhere (compare with *Figure 3A*). No resort to an S_g cusp can explain these data. These abnormal amplitudes are in agreement with the inordinately high local magnitude reported by UC Berkeley for this earthquake (M_L measured at 1.8 seconds in S_g). Apparently, there was some azimuthal focusing for this earthquake and RFI values were higher than the model is predicting, even after increasing stress drop by a factor of 1.3.

Whatever the detailed explanation of the Loma Prieta data, they do indicate that an earthquake which in source mechanism is abnormal relative to nearly all earthquakes in its area may generate abnormal ground motion at the level of a factor of 2 to 3. Having said this, I must reiterate what I said above, i. e., that the normal model has successfully predicted the RFI and MMI values for nearly all California and USA-wide earthquakes - San Francisco 1906, San Fernando 1971, both Imperial Valley earthquakes (1949 and 1979), Long Beach (1933), etc., New Madrid (1811), Charleston (18--) - and Italian and many Chinese earthquakes.

What about the applicability of these San Fernando relationships to the prediction of strong motion parameters in eastern USA and elsewhere? By a freak of fate and geology, we have data which allow clarification of this matter.

Before proceeding to a discussion of those data, I include a brief discussion of a type of figure that I extensively used and described in *Reference 9*, but I fear is little understood. Consider *Figure 4A* and ignore the data on it for the moment. Just consider its structure. For the assigned conditions (K value, i. e., attenuation parameter and C value - 1.375 and 15 in this case), the plot presents intensity boundaries as a function of length of rupture (thus of maximum observed intensity I(MAX), long period magnitude M_S and seismic moment Mo) and range. I have generated a large suite of such figures. Given the observed data of an earthquake (I(MAX) if available from very near-field, M_S, Mo and intensity boundaries), you plot these on several figures seeking the figure on which all observed values lie on a vertical line. *Reference 9* gives several series in which the sensitivity of model parameters to attainment of a vertical distribution of observations is illustrated. As an example, look at the *Figure 4* set, which indicate the sensitivity of the 'best-fit solution' to model parameters. *Figures 4A* and *4C* are the solutions presented in *Reference 9* for two earthquakes, a small USA earthquake and the Tungshan, China earthquake of July 1976, while *Figures 4B* and *4D* are models with only slightly perturbed parameters. It is clear that even these small perturbations in the models lead to unintepretable configurations.

However, do not think that you can always find a model to fit, even with poor data. That is not the case. Some published intensity maps are so poorly drawn or so poor that no interpretation is possible. Faith in such interpretations grows as you do several quakes from the same region and always find the same K values.

The important data for estimation of RFI versus maximum velocity and maximum acceleration are those of the Chile (1968) earthquake. *Figure 2* included the observed maximum velocity versus maximum acceleration data for this earthquake. The data have the same mean slope as the comparable San Fernando data, but the accelerations for a given velocity are twice those for the California earthquakes. *Figure 5A* is a plot of the same data of the Chile earthquake as used in *Figure 2* with the stations now keyed for ground condition, there again being no indication of a correlation of velocity/acceleration with ground condition. I give only two models of attenuation and source parameters, all other models investigated being denied by the observed parameters of the earthquake. The first, *Figure 5B*, is for a K value of 1.125 and a C value of 60, while *Figure 5C* is for a K value of 1.000 and a C value of 60. The C values of 60 imply a depth of focus of 40-50 kilometers. The intensity data (maximum limit of an intensity on saturated alluvium) line up better on *Figure 5C* (one must just ignore a discrepant point) and with I(MAX) but not with the observed M_S. It is important to realize that the intensity boundaries for this earthquake closely approximate circles as the K values of 1.000 and 1.125 require. Note that the model fit by the data conforms in pattern to that observed for eastern USA earthquakes (*Reference 7*), i. e., circular intensity boundaries even at short epicentral distances. In addition, the length of rupture implied by *Figure 5C* is 1 km! The failure to agree with the observed M_S value is now apparent. The long period data make it clear that there was a much longer rupture associated with this earthquake than was associated with radiation of the intensity-relevant frequencies. The obvious interpretation is that the rupture velocity along all except a very short segment of the failed fault surface was so slow as to eliminate significant radiation of intensity-relevant frequencies (a la Parkfield (1966)).

If one then uses the source/radiation model of *Figure 5C*, one finds an RFI versus maximum velocity relationship identical to that for California earthquakes (*Figure 5D*), leading to the conclusion that maximum acceleration as a function of RFI was double that in California. As the best estimate I have, I use such relationships for predicting maximum velocity and maximum acceleration in EUS, an area of K = 1.

Figure 6A presents the maximum acceleration versus maximum velocity data for the 1980 Irpinia earthquake of Italy, illustrating agreement with the relationships derived from the San Fernando earthquake. *Figure 6B* presents the best fit model for the intensity data of the Irpinia (1980), Italy, earthquake, i. e., K=1.5. *Figure 6C* establishes that the RFI versus maximum velocity relationship of California and Chile applies also to Italy, i. e., earthquakes in three of the four K zones I use display the identical RFI versus maximum velocity relationships. This is not too surprising as maximum velocity measurements are always within the band-pass of seismic intensities. Therefore, there appears to be a universally applicable RFI (or MMI) versus maximum velocity relationship and a K-dependent RFI versus maximum acceleration relationship.

Figures 7 and *8* show the resultant relationships between length of rupture, magnitude, and fall-off of maximum velocity as a function of distance and direction in California and eastern USA for strike-slip earthquakes. *Figures 9* and *10* are for maximum acceleration. *Figure 11* is for the conditions of *Figure 9* with the slight change to a thrust earthquake a la the San Fernando earthquake.

I conclude that it is legitimate to include in 'USAPLOT' the capability to predict maximum velocity and maximum acceleration according to the relationships discussed above. I also included the capability to predict damage to the four structural types that show strong correlation with intensity in California. I decided to not include the capability to predict maximum displacement.

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FIGURES

Figure 1A -- Maximum velocity versus maximum acceleration data of the San Fernando (1972) earthquake compared with the MPD relationship calculated from the data. Data are keyed for ground condition, indicating no separation of data as a function of ground condition.

Figure 1B -- Random Maximum Velocity at Granite Maximum Acceleration, based on data of *Figure 1A*.

Figure 2 -- Maximum velocity versus maximum acceleration data of the Loma Prieta (1989), the Imperial Valley (1979) and the Chile (1968) earthquakes compared with MPD relationships of *Figure 1*. Note the agreement of the data of the California earthquakes with the MPD relationship of the San Fernando earthquake. Also, note that the data of the Chile earthquake show maximum acceleration to have been twice as great for a given maximum velocity value.

Figure 3A - Maximum velocity versus predicted RFI for the Loma Prieta (1989) earthquake compared with the MPD fit of the same types of data for the San Fernando (1972) earthquake - ALL STATIONS EXCEPT THOSE IN THE EAST BAY.

Figure 3B - Maximum velocity versus predicted RFI for the Loma Prieta (1989) earthquake compared with the MPD fit of the same types of data for the San Fernando (1972) earthquake - EAST BAY STATIONS.

Figure 4A - Analysis of MMI, M_S, and I(MAX) data of the USA earthquake of 14 December 1950. Solution presented in *Reference 8*.

Figure 4B - Analysis of MMI, M_S, and I(MAX) data of the USA earthquake of 14 December 1950. Model parameters are only slightly perturbed from those of *Figure 4A* but data become uninterpretable as to fault parameters.

Figure 4C - Analysis of MMI, M_S, and I(MAX) data of the Tungshan, China, earthquake of 28 July 1976. Solution presented in *Reference 8*.

Figure 4D - Analysis of MMI, M_S, and I(MAX) data of the Tungshan, China, earthquake of 28 July 1976. Model parameters are only slightly perturbed from those of *Figure 4C* but data become uninterpretable as to fault parameters.

Figure 5A - Maximum acceleration versus maximum velocity for the 1985 Chile earthquake, the data being keyed for ground condition.

Figure 5B - Analysis of MMI, M_S, and I(MAX) data of the Chile (1968) earthquake - Model I. Data do not agree with this model.

Figure 5C - Analysis of MMI, M_S, and I(MAX) data of the Chile (1968) earthquake - Model II. Data appear to agree with this model, implying a very short source volume for the intensity-relevant frequencies (circular intensity boundaries) and a long source for the long period M_S-relevant periods.

Figure 5D - Maximum velocity versus RFI for the Chile (1968) earthquake compared with the MPD relationship calculated from the data of the San Fernando earthquake. The agreement of the San Fernando relationship and the velocity data of the Chile earthquake implies that the acceleration data of the Chile earthquake are high relative to the San Fernando earthquake relationship.

Figure 6A - Maximum acceleration versus maximum velocity data for the 1980 Irpinia earthquake of Italy.

Figure 6B - Analysis of MMI, M_S, and I(MAX) data of the Irpinia (1980) earthquake. Data appear to agree with this model, i. e., 4k = 6 (K = 1.50).

Figure 6C - Maximum velocity versus RFI for the Irpinia (1980) earthquake compared with the MPD relationship calculated from the data of the San Fernando earthquake. Thus, the three regions characterized by 4K = 4,6 and 7 (K = 1.00, 1.50 and 1.75) appear to have the identical maximum velocity versus Intensity relationship.

Figure 7 -- Maximum velocity versus fault length & distance of observation for California (4K = 7, K = 1.75) - STRIKE-SLIP EARTHQUAKE. The relation between intensity and maximum velocity is the same as that on *Figure 8*.

Figure 8 -- Maximum velocity versus fault length & distance of observation for eastern USA (4K = 4, K = 1.00) - STRIKE-SLIP EARTHQUAKE. The relation between intensity and maximum velocity is the same as that on *Figure 7*.

Figure 9 -- Maximum acceleration versus fault length & distance of observation for California (4K = 7, K = 1.75) - STRIKE SLIP EARTHQUAKE. The relation between intensity and maximum acceleration differs from that on *Figure 10* in that maximum acceleration for a given intensity is half that on *Figure 10*.

Figure 10 - Maximum acceleration versus source length and distance of observation for eastern USA (4K = 4, K = 1.00) - STRIKE SLIP EARTHQUAKE. The relation between intensity and maximum acceleration differs from that on *Figure 9* in that maximum acceleration for a given intensity is twice that on *Figure 9*.

Figure 11 - Maximum acceleration versus source length and distance of observation for California (4K = 7, K = 1.75) - THRUST SLIP EARTHQUAKE. The relation between intensity and maximum acceleration is the same as that on *Figure 7* being the different pattern of MMI (and RFI) in the near-field.

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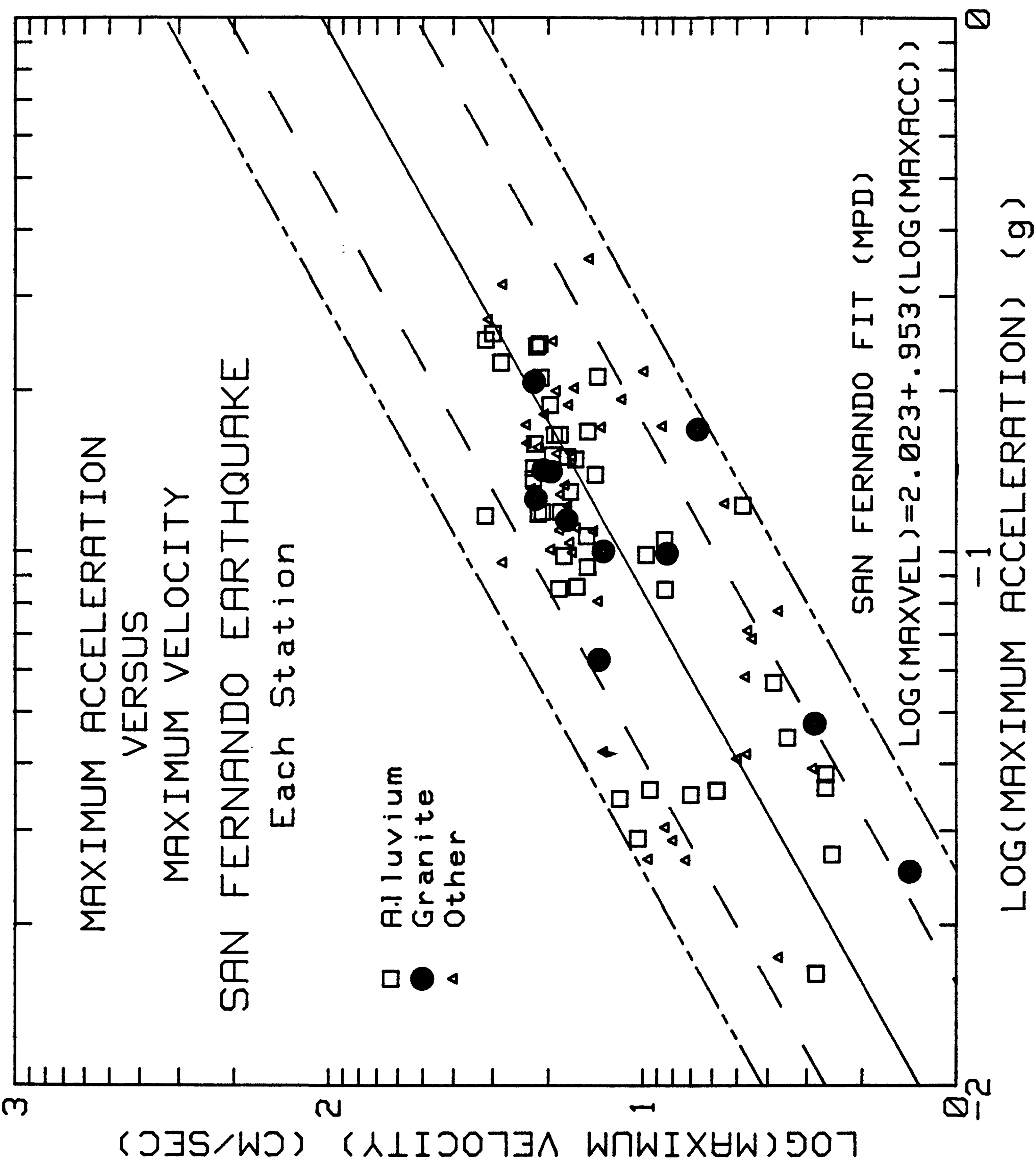

MAXIMUM ACCELERATION
VERSUS
MAXIMUM VELOCITY
SAN FERNANDO EARTHQUAKE
Each Station
Alluvium
Granite
Other
SAN FERNANDO FIT (MPD)
LOG(MAXVEL)=2.Ø23+.953(LOG(MAXACC))
LOG(MAXIMUM ACCELERATION) (g)
LOG(MAXIMUM VELOCITY) (CM/SEC)
-2
-1
Ø
Ø
1
2
3

Figure 1A

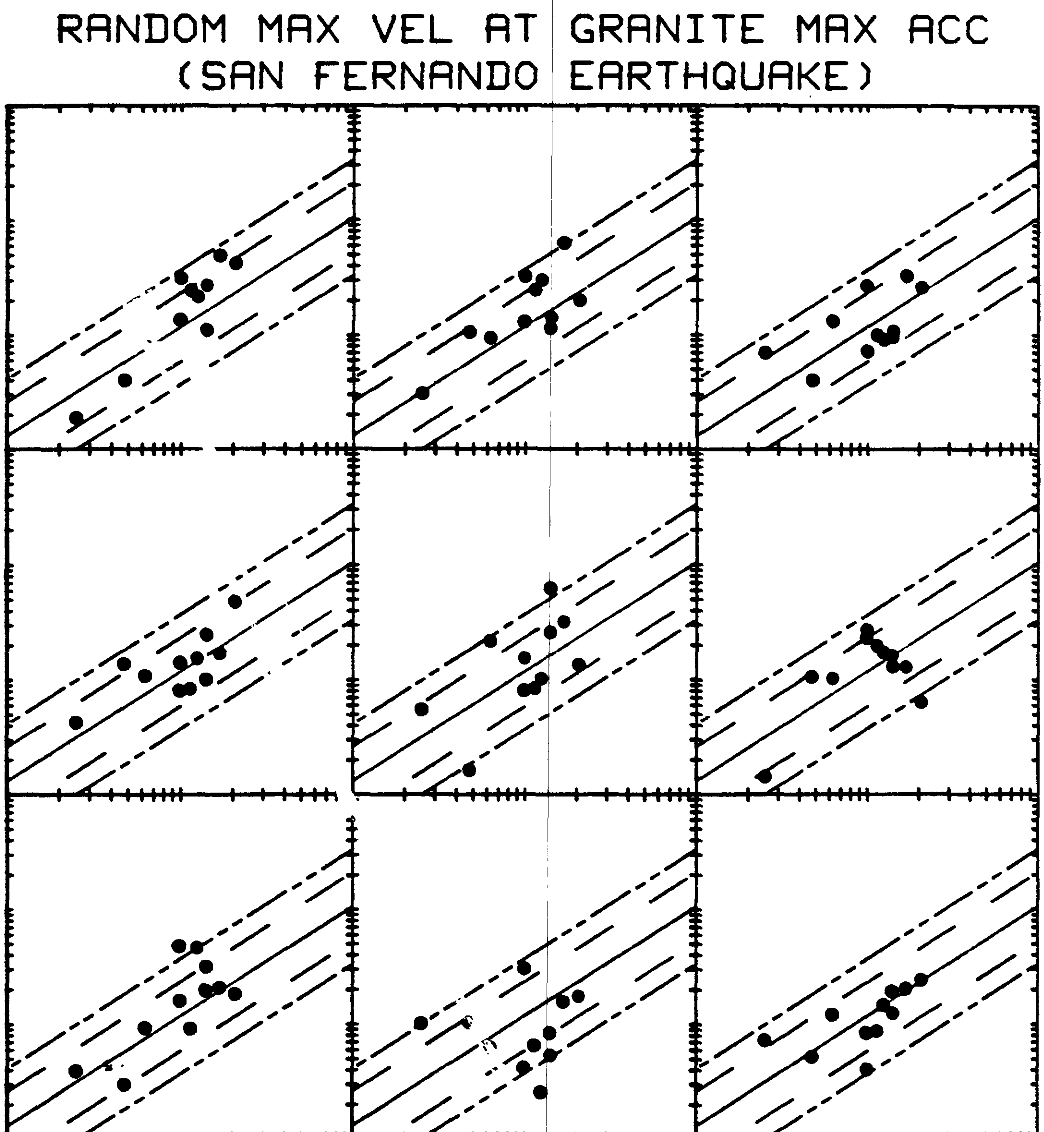


Figure 1B

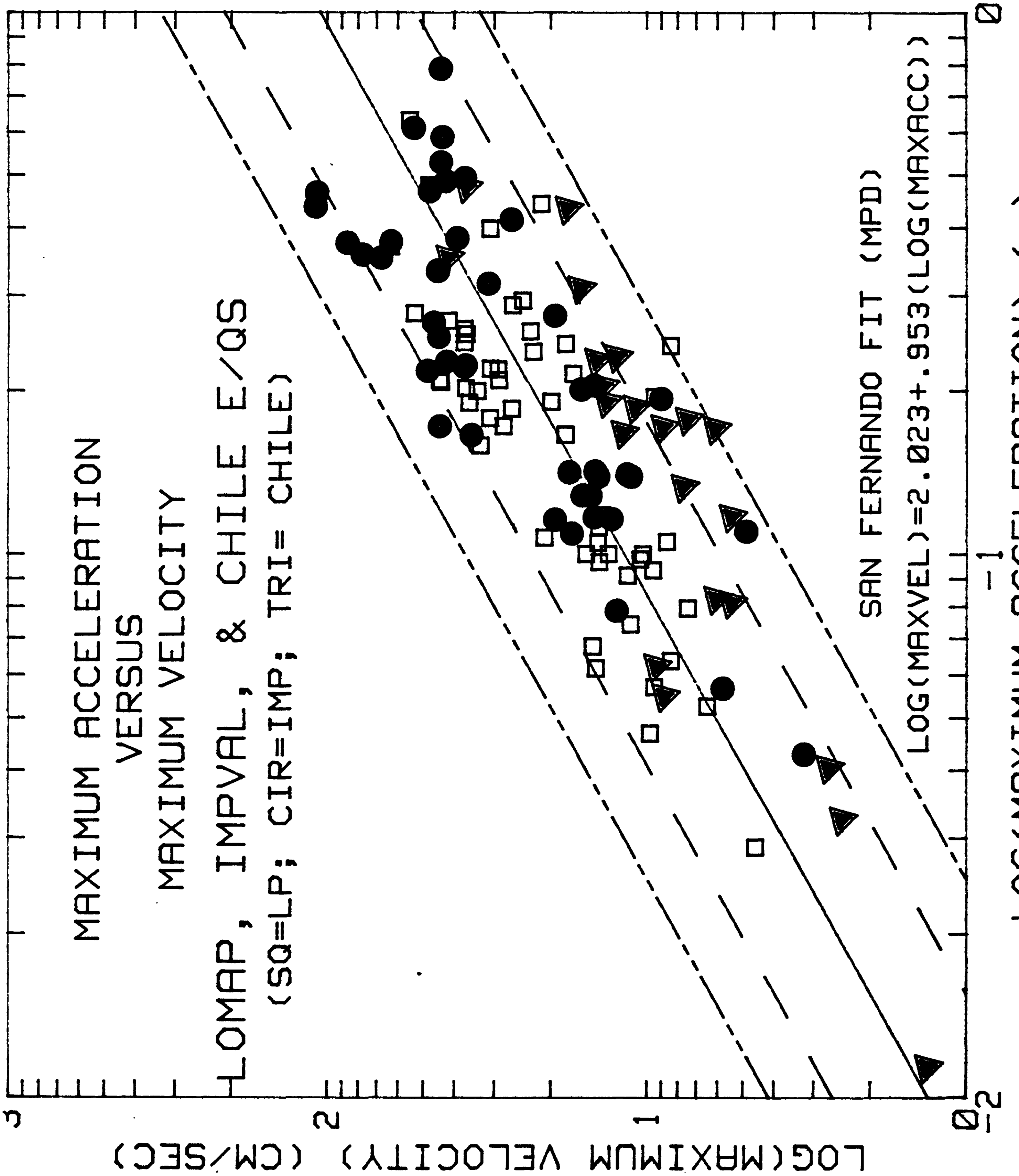

MAXIMUM ACCELERATION
VERSUS
MAXIMUM VELOCITY
LOMAP, IMPVAL, & CHILE E/QS
(SQ=LP; CIR=IMP; TRI= CHILE)
SAN FERNANDO FIT (MPD)
LOG(MAXVEL)=2.023+.953(LOG(MAXACC))
LOG(MAXIMUM ACCELERATION) (g)
LOG(MAXIMUM VELOCITY) (CM/SEC)
-2
-1
0
1
2
3

Figure 2

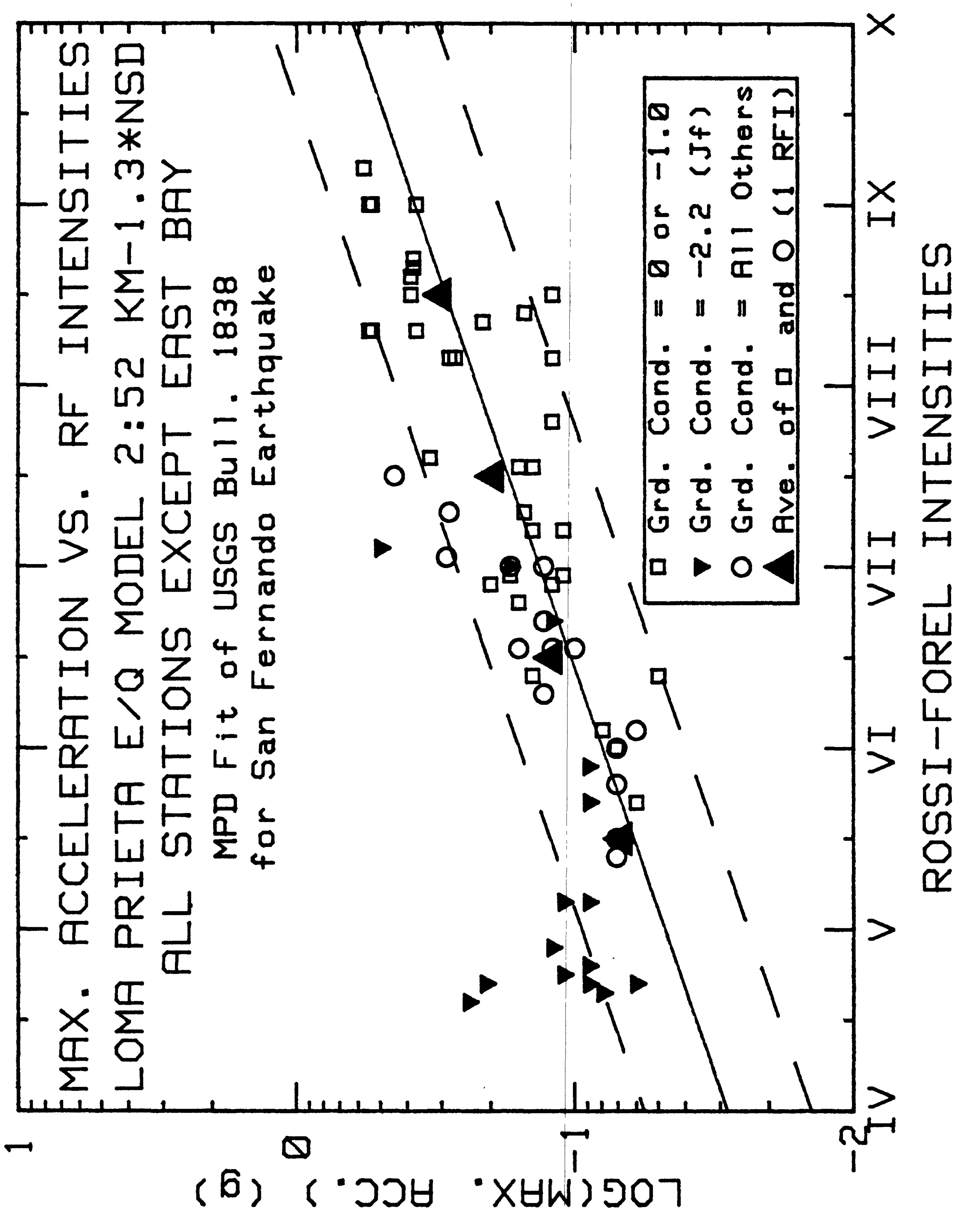

MAX. ACCELERATION VS. RF INTENSITIES
LOMA PRIETA E/Q MODEL 2:52 KM-1.3*NSD
ALL STATIONS EXCEPT EAST BAY
MPD Fit of USGS Bull. 1838
for San Fernando Earthquake
Grd. Cond. = 0 or -1.0
Grd. Cond. = -2.2 (Jf)
Grd. Cond. = All Others
Ave. of □ and ○ (1 RFI)
LOG(MAX. ACC.) (g)
1
0
-1
-2
IV
V
VI
VII
VIII
IX
X
ROSSI-FOREL INTENSITIES

Figure 3A

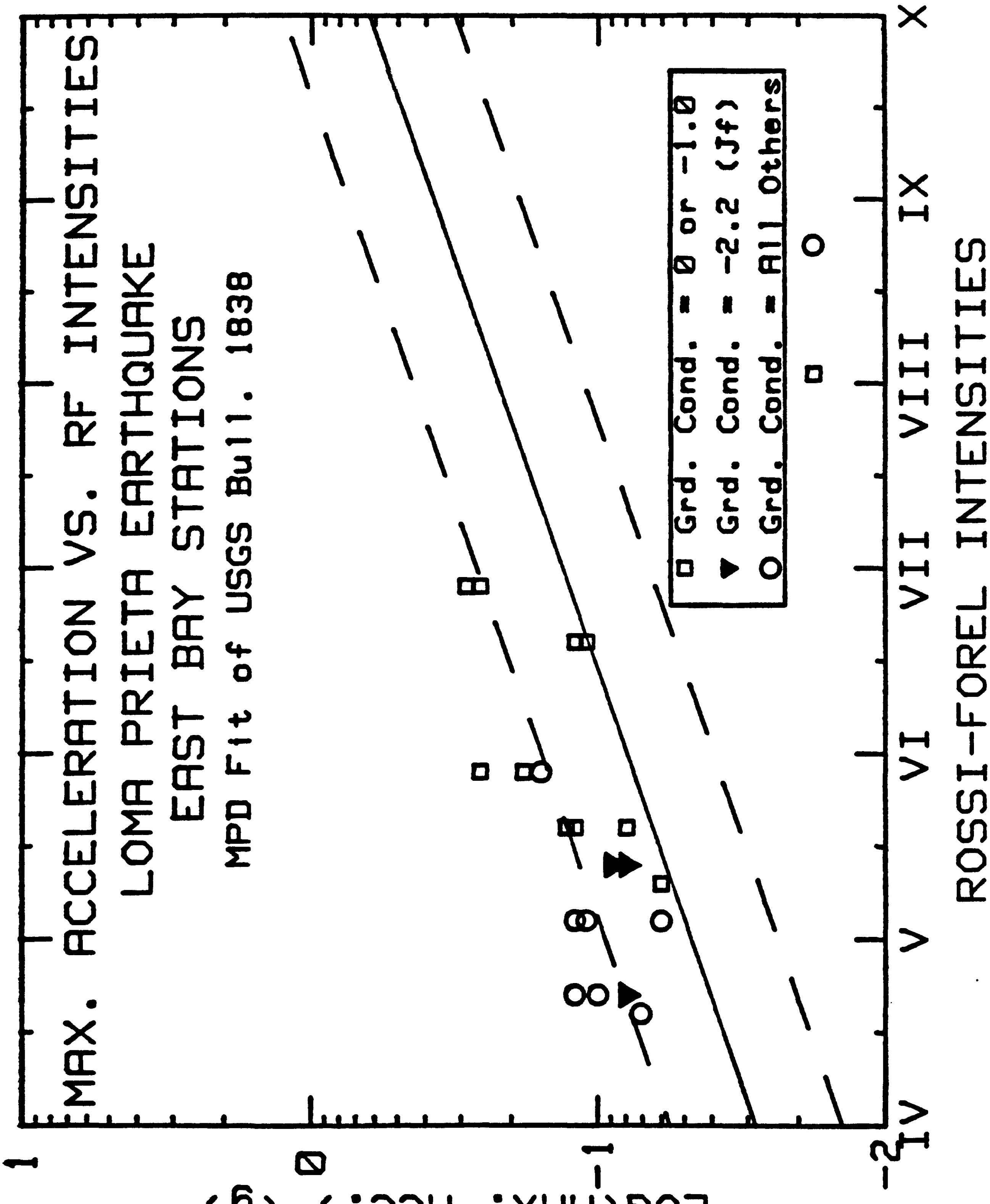

MAX. ACCELERATION VS. RF INTENSITIES
LOMA PRIETA EARTHQUAKE
EAST BAY STATIONS
MPD Fit of USGS Bull. 1838
□ Grd. Cond. = 0 or -1.0
▼ Grd. Cond. = -2.2 (Jf)
○ Grd. Cond. = All Others
LOG(MAX. ACC.) (g)
1
0
-1
-2
ROSSI-FOREL INTENSITIES
IV
V
VI
VII
VIII
IX
X

Figure 3B

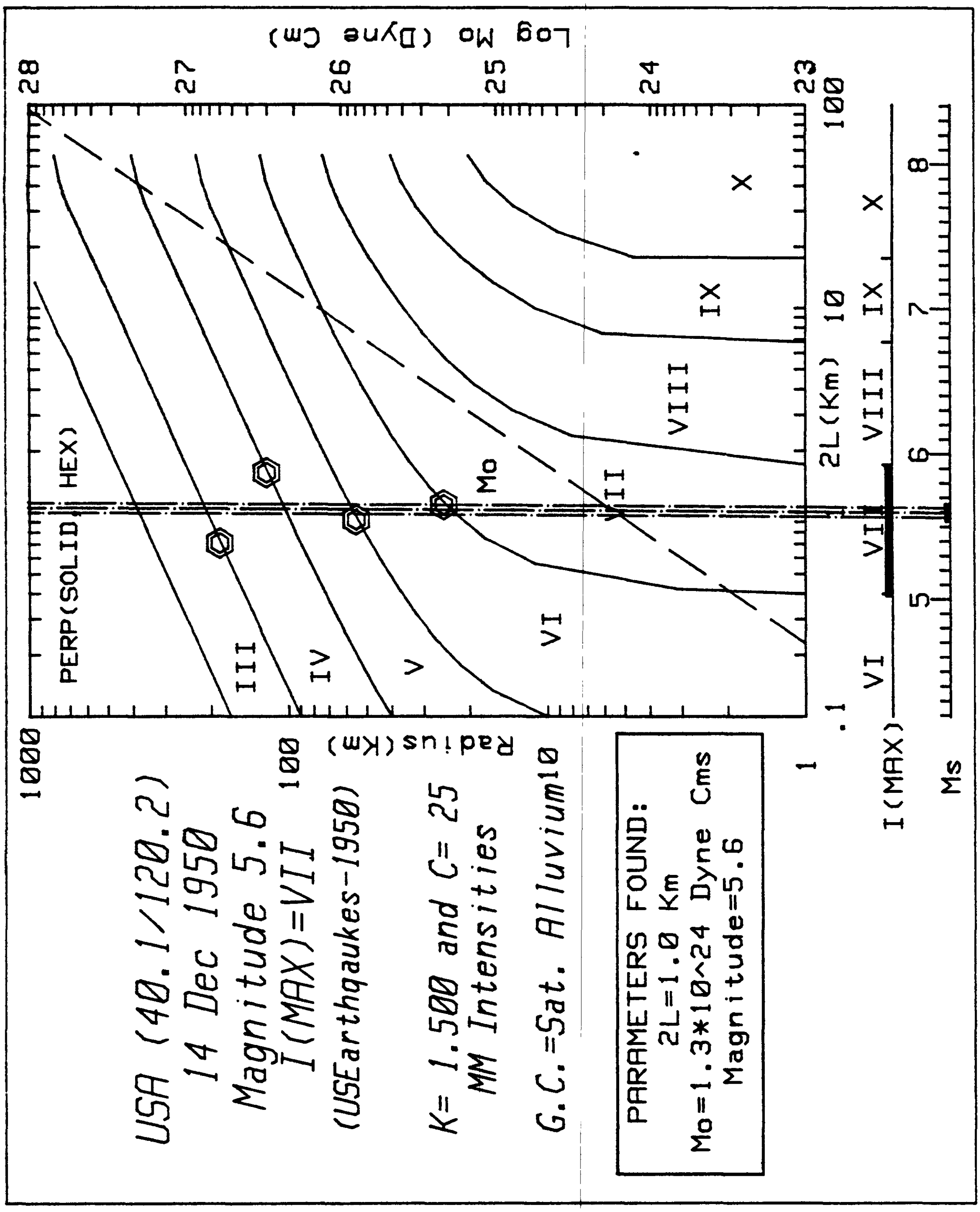
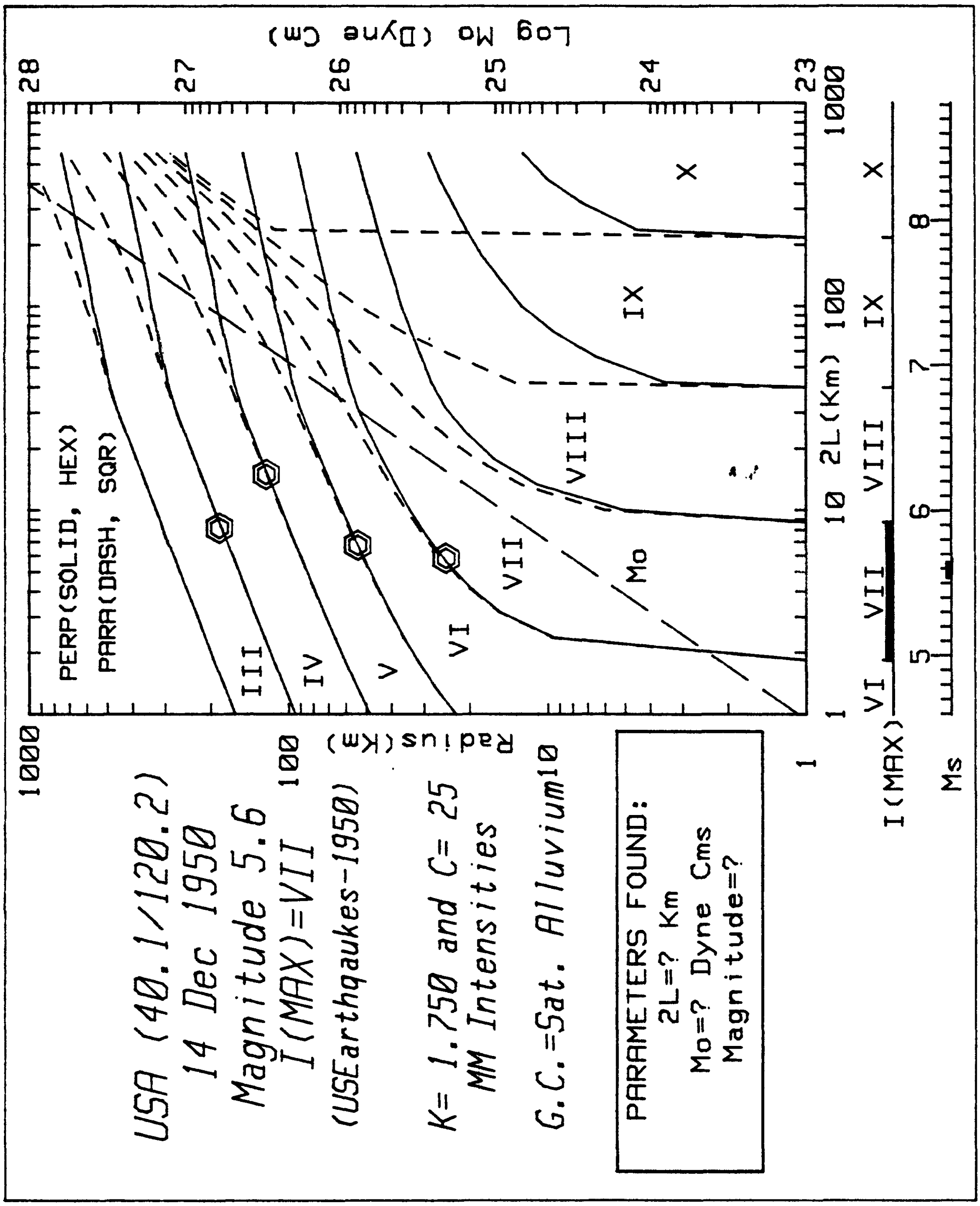

USA (40.1/120.2)
14 Dec 1950
Magnitude 5.6
I(MAX)=VII
(USEarthqaukes-1950)
K= 1.500 and C= 25
MM Intensities
G.C.=Sat. Alluvium10
PARAMETERS FOUND:
2L=1.0 Km
Mo=1.3*10^24 Dyne Cms
Magnitude=5.6
PERP(SOLID) HEX)
Radius(Km)
Log Mo (Dyne Cm)
2L(Km)
I(MAX)
Ms
Mo

Figure 4A



USA (40.1/120.2)
14 Dec 1950
Magnitude 5.6
I(MAX)=VII
(USEarthqaukes-1950)
K= 1.750 and C= 25
MM Intensities
G.C.=Sat. Alluvium10
PARAMETERS FOUND:
2L=? Km
Mo=? Dyne Cms
Magnitude=?
PERP(SOLID, HEX)
PARA(DASH, SQR)
Radius(Km)
Log Mo (Dyne Cm)
2L(Km)
I(MAX)
Ms
III
IV
V
VI
VII
VIII
IX
X
Mo

Figure 4B

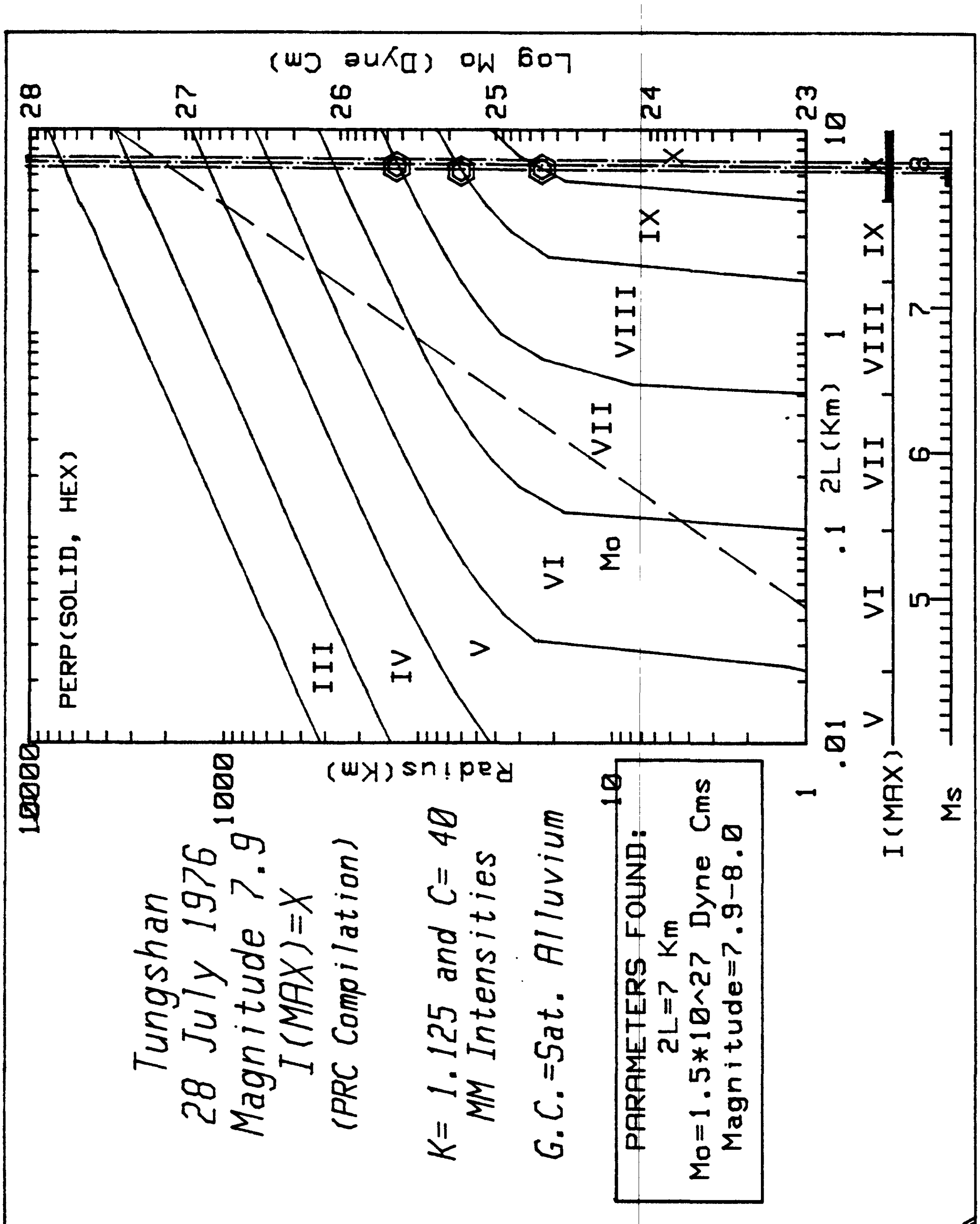
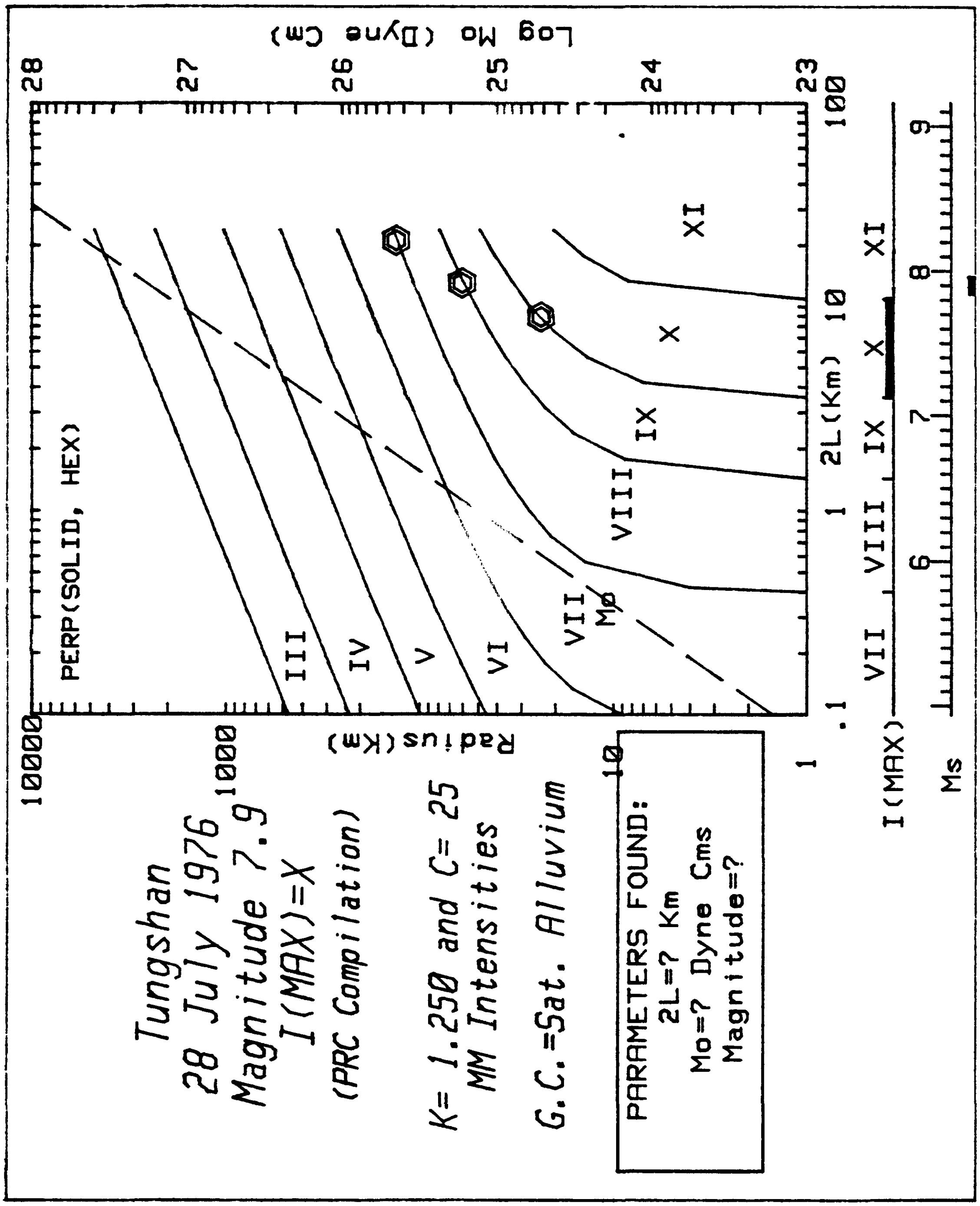

Tungshan
28 July 1976
Magnitude 7.9
I(MAX)=X
(PRC Compilation)
K= 1.125 and C= 40
MM Intensities
G.C.=Sat. Alluvium
PARAMETERS FOUND:
2L=7 Km
Mo=1.5*10^27 Dyne Cms
Magnitude=7.9-8.0
PERP(SOLID, HEX)
Radius(Km)
Log Mo (Dyne Cm)
2L(Km)
I(MAX)
Ms
III
IV
V
VI
VII
VIII
IX
Mo

Figure 4C



Tungshan
28 July 1976
Magnitude 7.9
I(MAX)=X
(PRC Compilation)
K= 1.250 and C= 25
MM Intensities
G.C.=Sat. Alluvium
PARAMETERS FOUND:
2L=? Km
Mo=? Dyne Cms
Magnitude=?
PERP(SOLID, HEX)
Radius(Km)
10000
1000
10
1
Log Mo (Dyne Cm)
28
27
26
25
24
23
2L(Km)
.1
1
10
100
I(MAX)
VII
VIII
IX
X
XI
Ms
6
7
8
9
III
IV
V
VI
Mo

Figure 4D

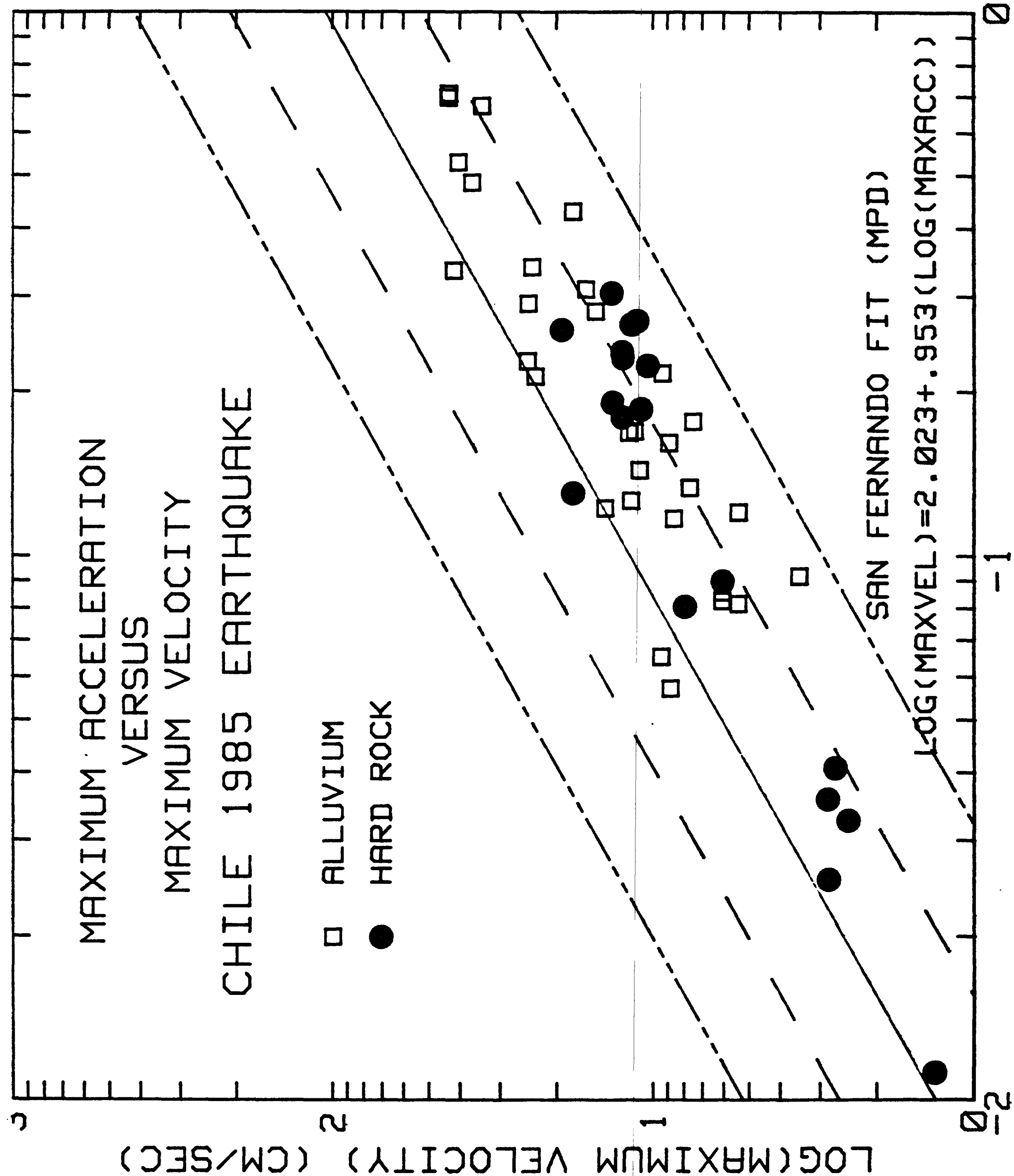

MAXIMUM ACCELERATION
VERSUS
MAXIMUM VELOCITY
CHILE 1985 EARTHQUAKE
ALLUVIUM
HARD ROCK
SAN FERNANDO FIT (MPD)
LOG(MAXVEL)=2.023+.953(LOG(MAXACC))
LOG(MAXIMUM ACCELERATION) (g)
LOG(MAXIMUM VELOCITY) (CM/SEC)
-2
-1
Ø
1
2
3

Figure 5A

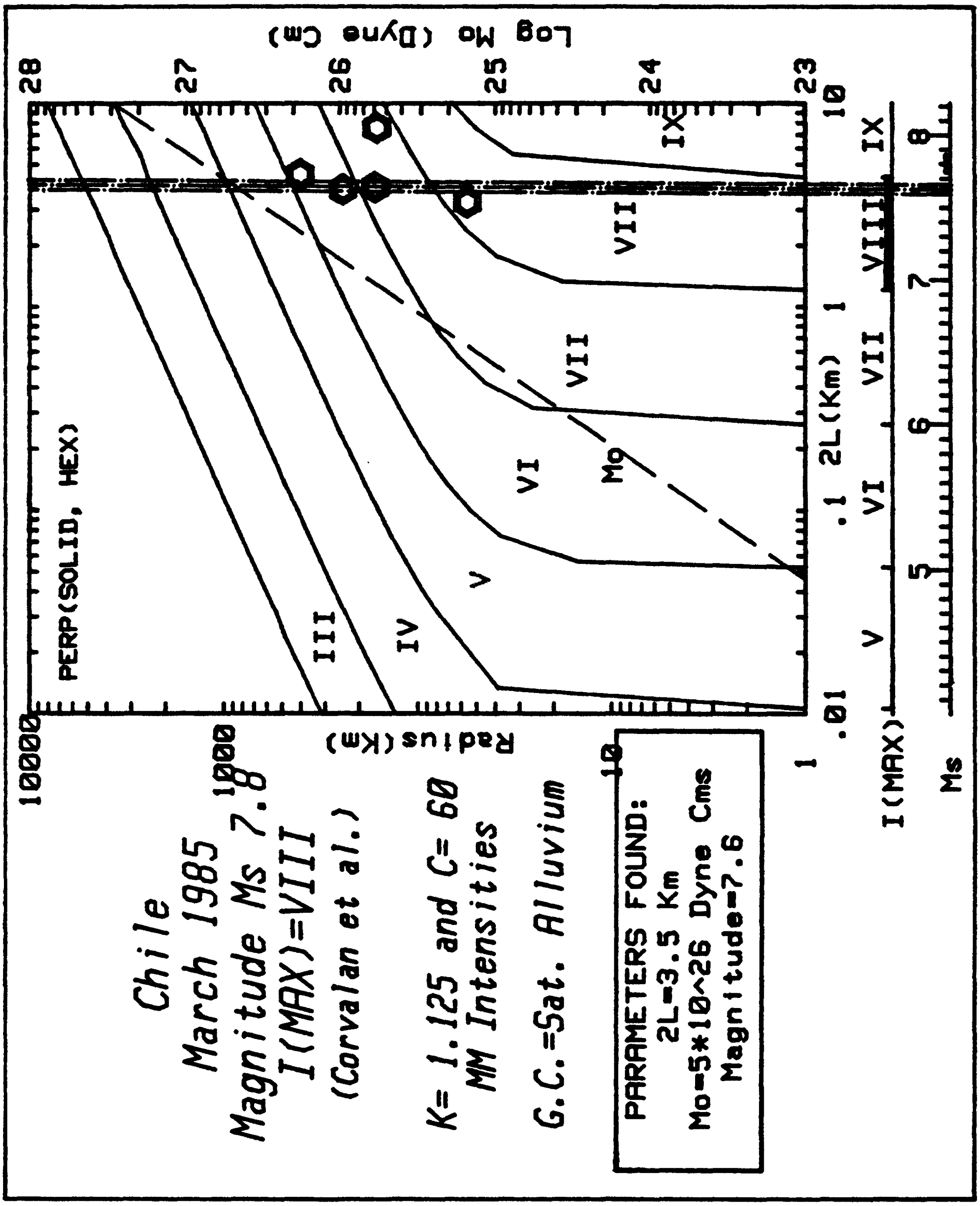

Chile
March 1985
Magnitude Ms 7.8
I(MAX)=VIII
(Corvalan et al.)
K= 1.125 and C= 60
MM Intensities
G.C.=Sat. Alluvium
PARAMETERS FOUND:
2L=3.5 Km
Mo=5*10^26 Dyne Cms
Magnitude=7.6
PERP(SOLID, HEX)
Radius(Km)
Log Mo (Dyne Cm)
2L(Km)
I(MAX)
Ms

Figure 5B

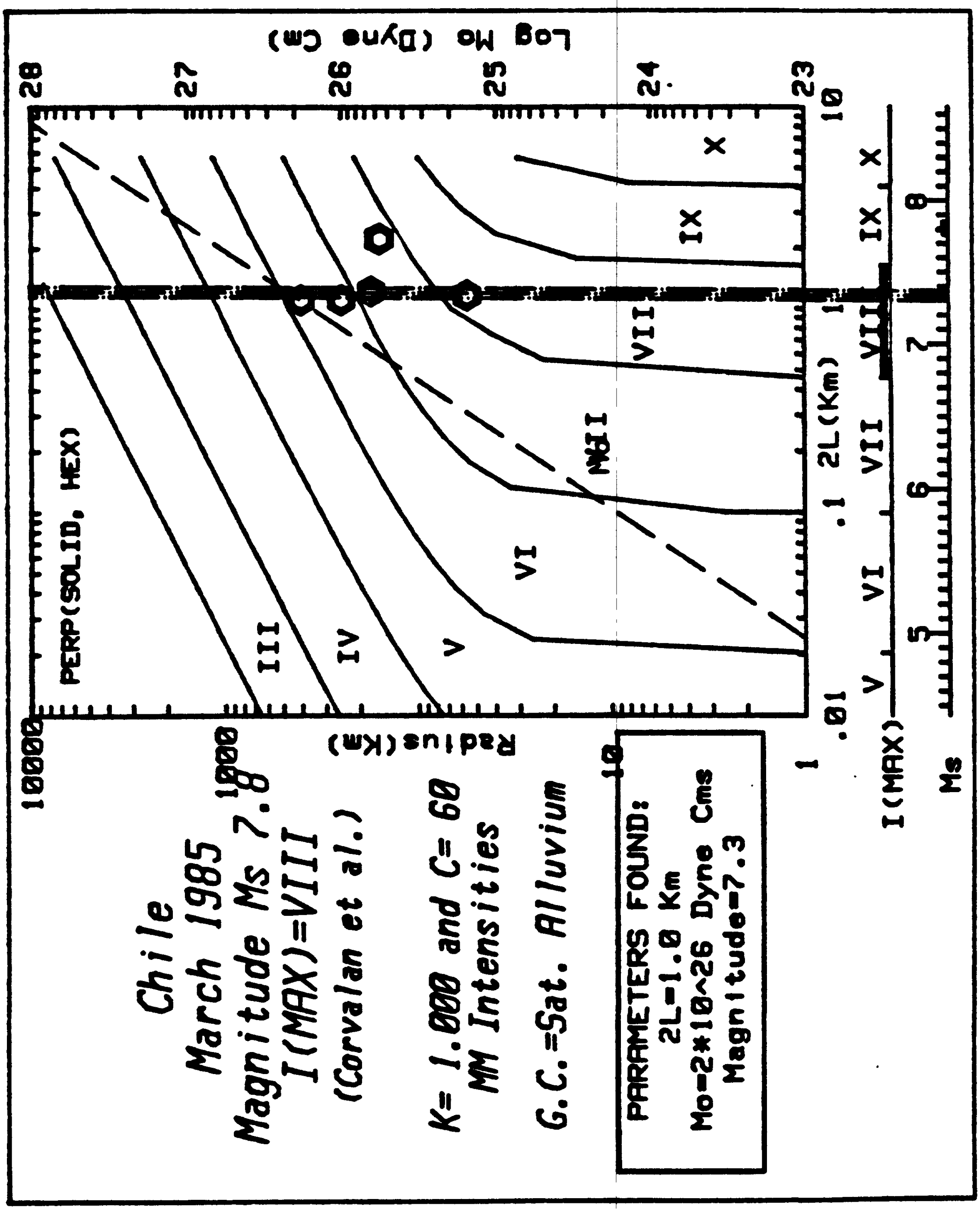

Chile
March 1985
Magnitude Ms 7.8
I(MAX)=VIII
(Corvalan et al.)
K= 1.000 and C= 60
MM Intensities
G.C.=Sat. Alluvium
PARAMETERS FOUND:
2L=1.0 Km
Mo=2*10^26 Dyne Cms
Magnitude=7.3
PERP(SOLID, HEX)
Log Mo (Dyne Cm)
Radius(Km)
2L(Km)
I(MAX)
Ms

Figure 5C

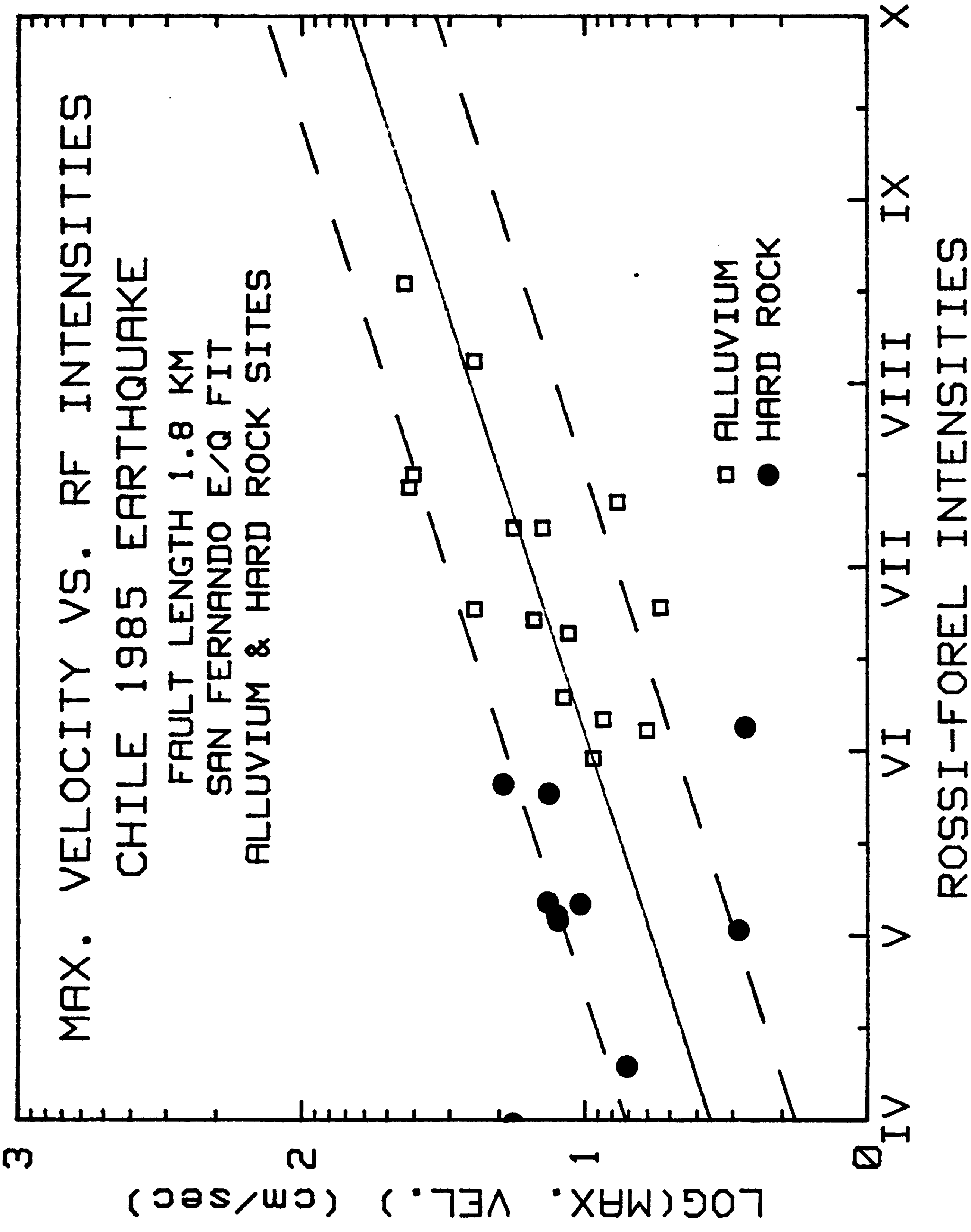

MAX. VELOCITY VS. RF INTENSITIES
CHILE 1985 EARTHQUAKE
FAULT LENGTH 1.8 KM
SAN FERNANDO E/Q FIT
ALLUVIUM & HARD ROCK SITES
ALLUVIUM
HARD ROCK
ROSSI-FOREL INTENSITIES
IV
V
VI
VII
VIII
IX
X
LOG(MAX. VEL.) (cm/sec)
0
1
2
3

Figure 5D

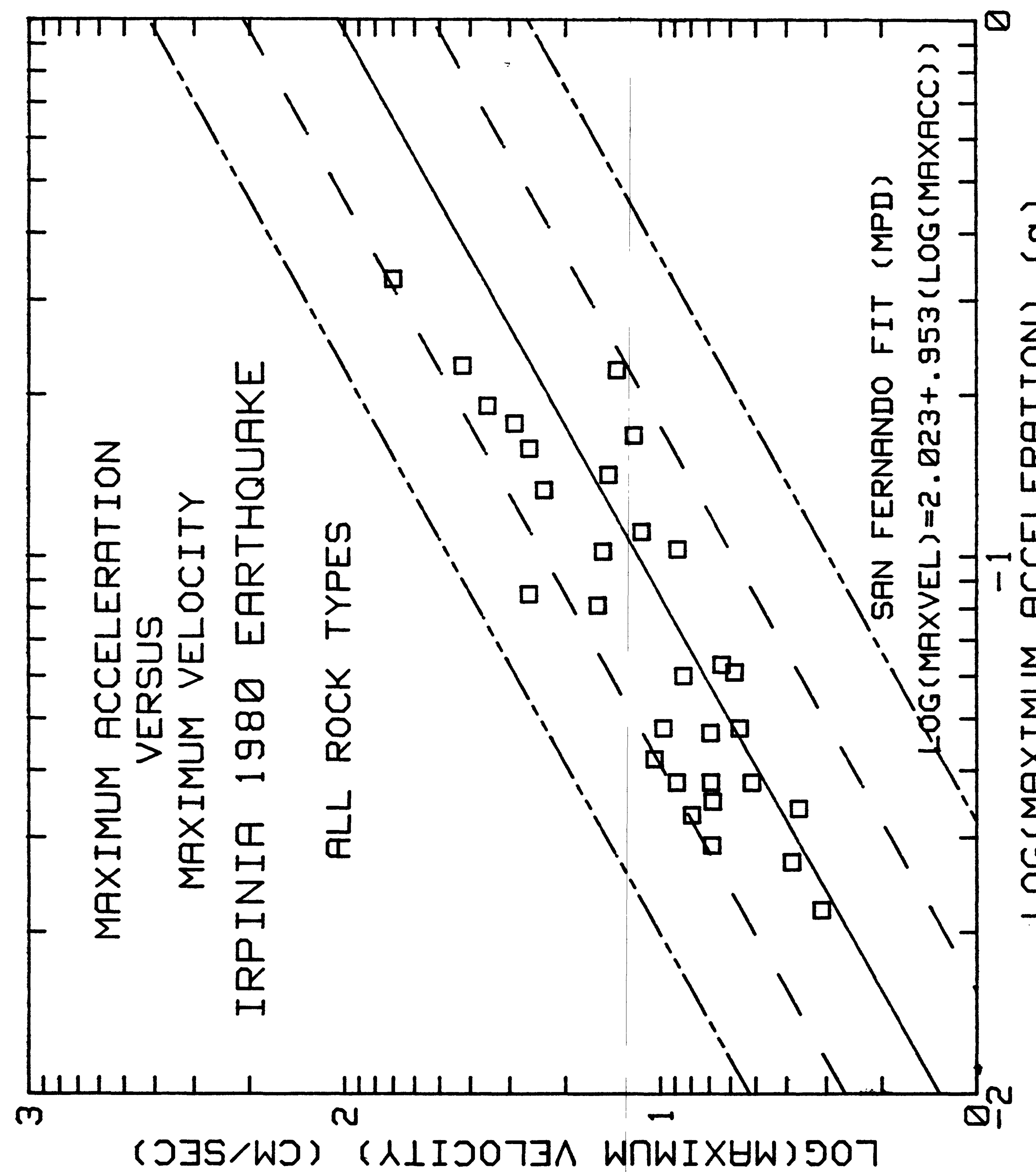
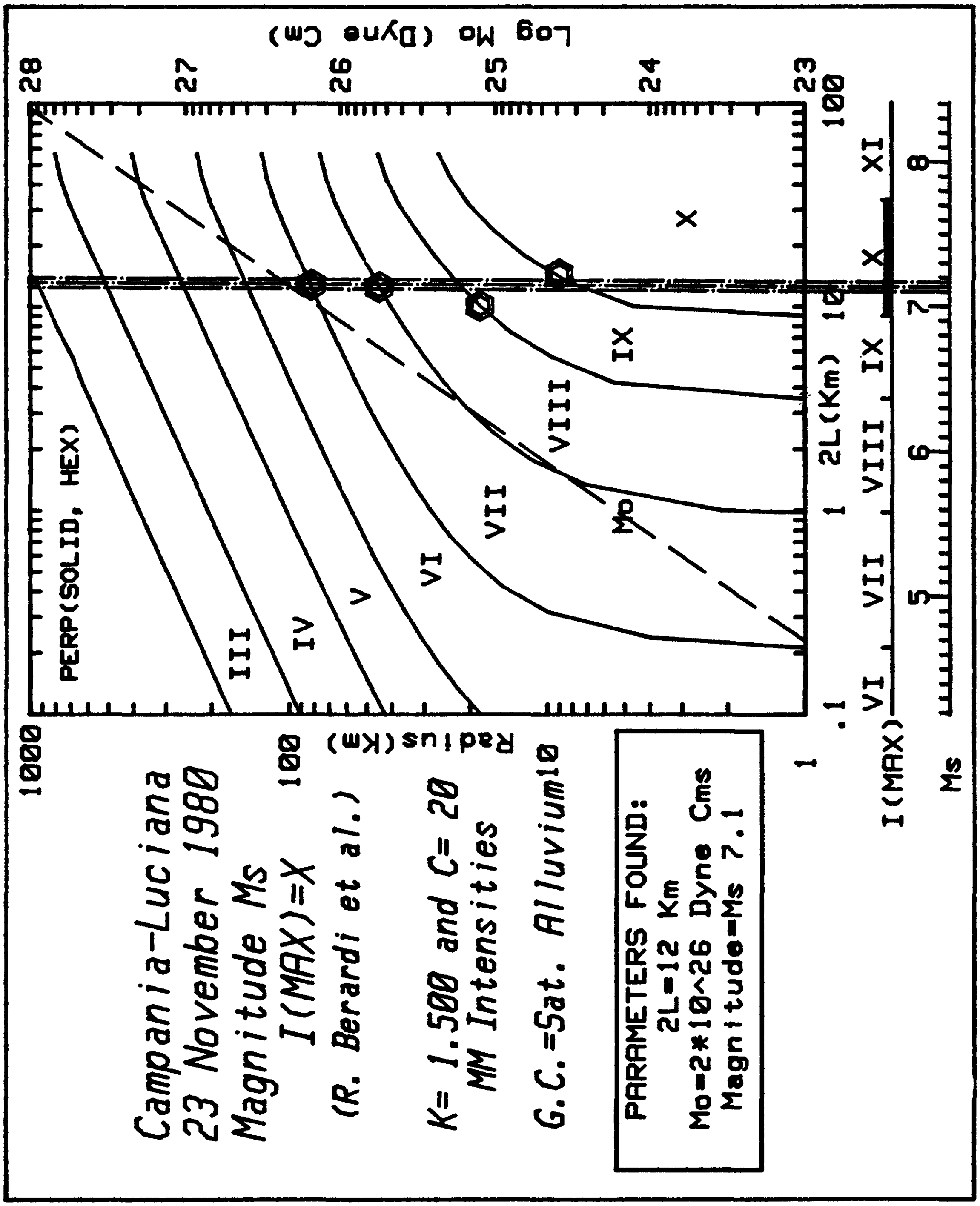

MAXIMUM ACCELERATION
VERSUS
MAXIMUM VELOCITY
IRPINIA 1980 EARTHQUAKE
ALL ROCK TYPES
SAN FERNANDO FIT (MPD)
LOG(MAXVEL)=2.023+.953(LOG(MAXACC))
LOG(MAXIMUM ACCELERATION) (g)
LOG(MAXIMUM VELOCITY) (CM/SEC)
-2
-1
0
3
2
1
0

Figure 6A



Campania-Luciana
23 November 1980
Magnitude Ms
I(MAX)=X
(R. Berardi et al.)
K= 1.500 and C= 20
MM Intensities
G.C.=Sat. Alluvium10
PARAMETERS FOUND:
2L=12 Km
Mo=2*10^26 Dyne Cms
Magnitude=Ms 7.1
PERP(SOLID, HEX)
Log Mo (Dyne Cm)
Radius(Km)
2L(Km)
I(MAX)
Ms

Figure 6B

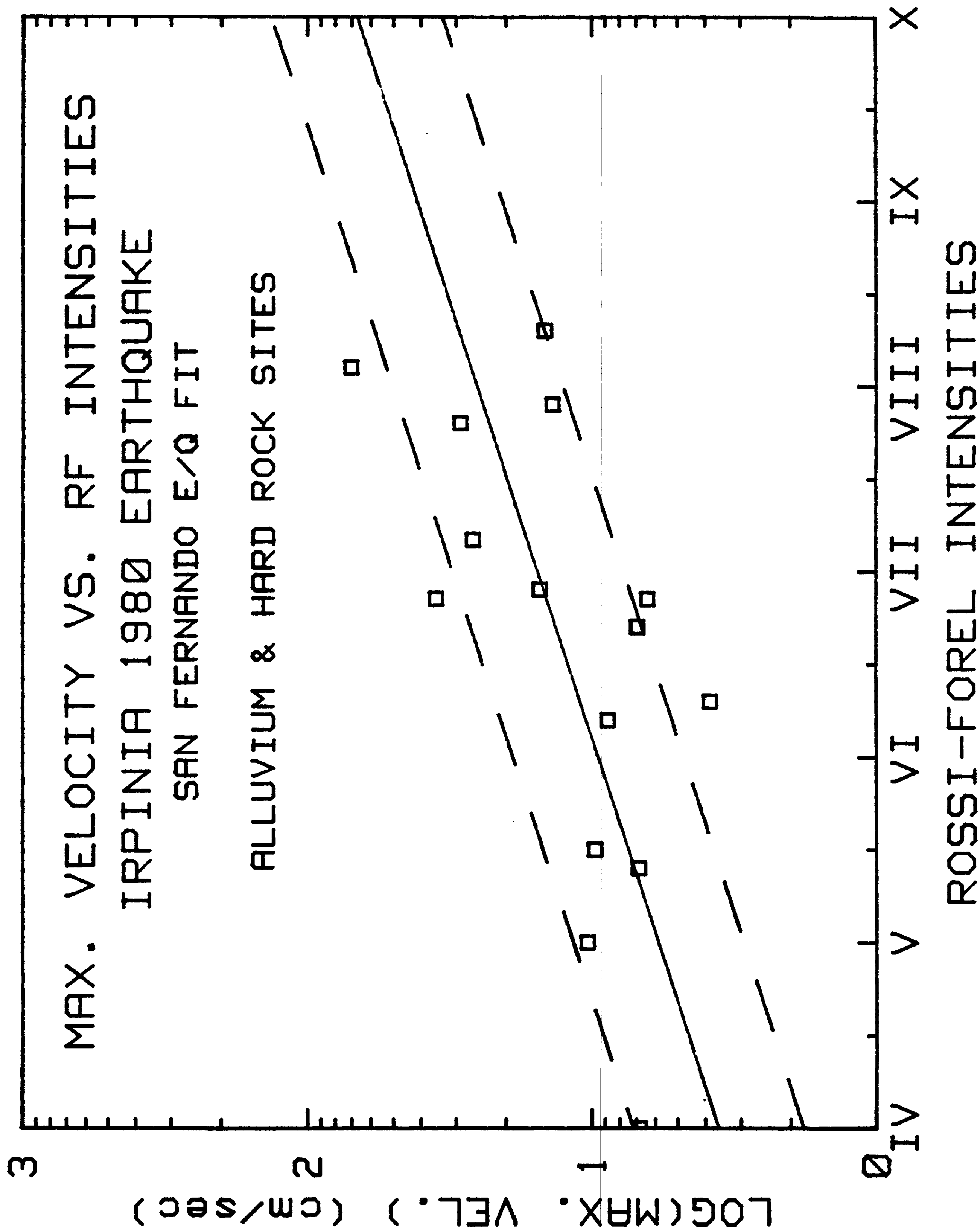
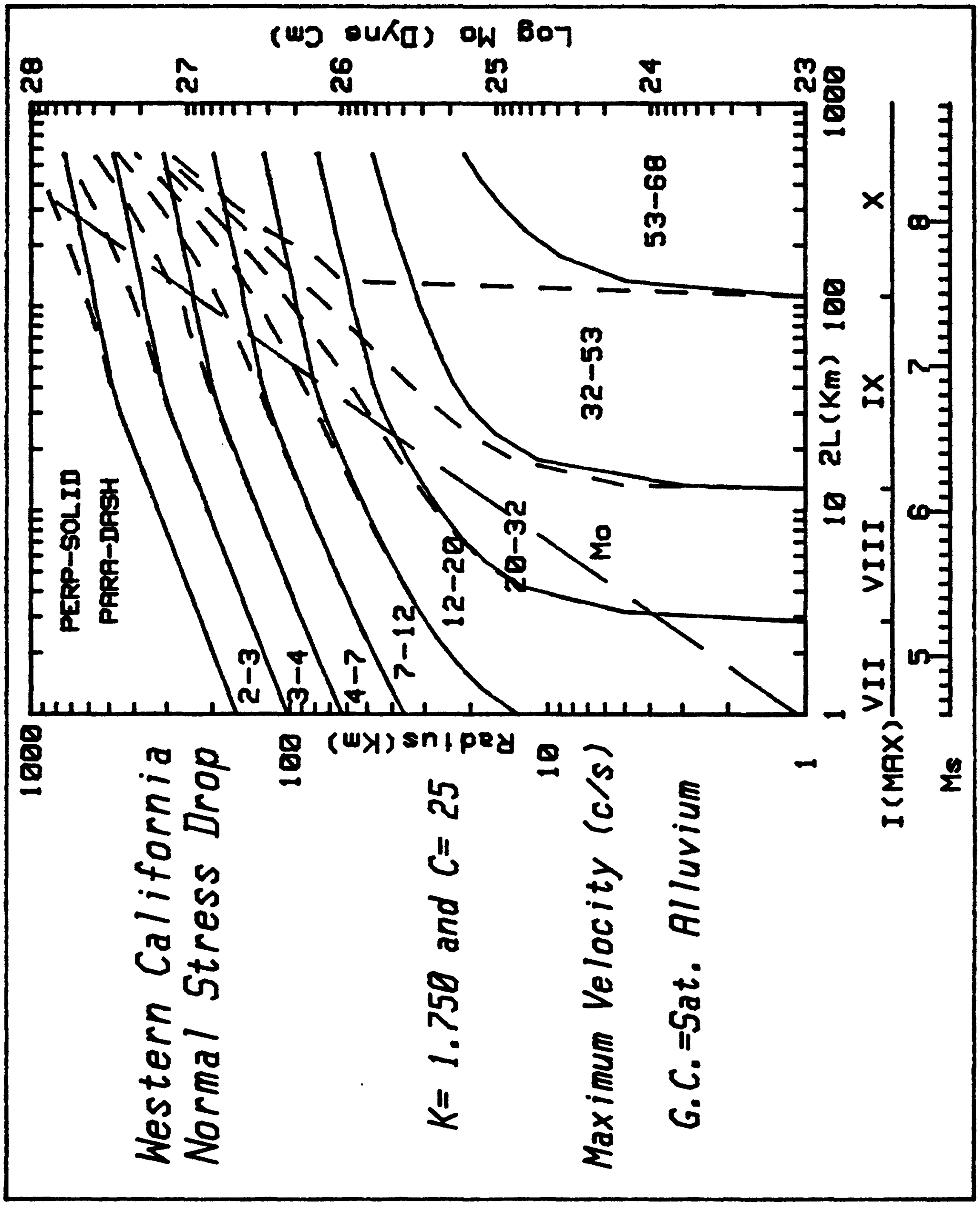

MAX. VELOCITY VS. RF INTENSITIES
IRPINIA 1980 EARTHQUAKE
SAN FERNANDO E/Q FIT
ALLUVIUM & HARD ROCK SITES
ROSSI-FOREL INTENSITIES
IV
V
VI
VII
VIII
IX
X
LOG(MAX. VEL.) (cm/sec)
0
1
2
3

Figure 6C



Western California
Normal Stress Drop
K= 1.750 and C= 25
Maximum Velocity (c/s)
G.C.=Sat. Alluvium
PERP-SOLID
PARA-DASH
Radius(Km)
2L(Km)
Log Mo (Dyne Cm)
I(MAX)
Ms
Mo
2-3
3-4
4-7
7-12
12-20
20-32
32-53
53-68
VII
VIII
IX
X

Figure 7

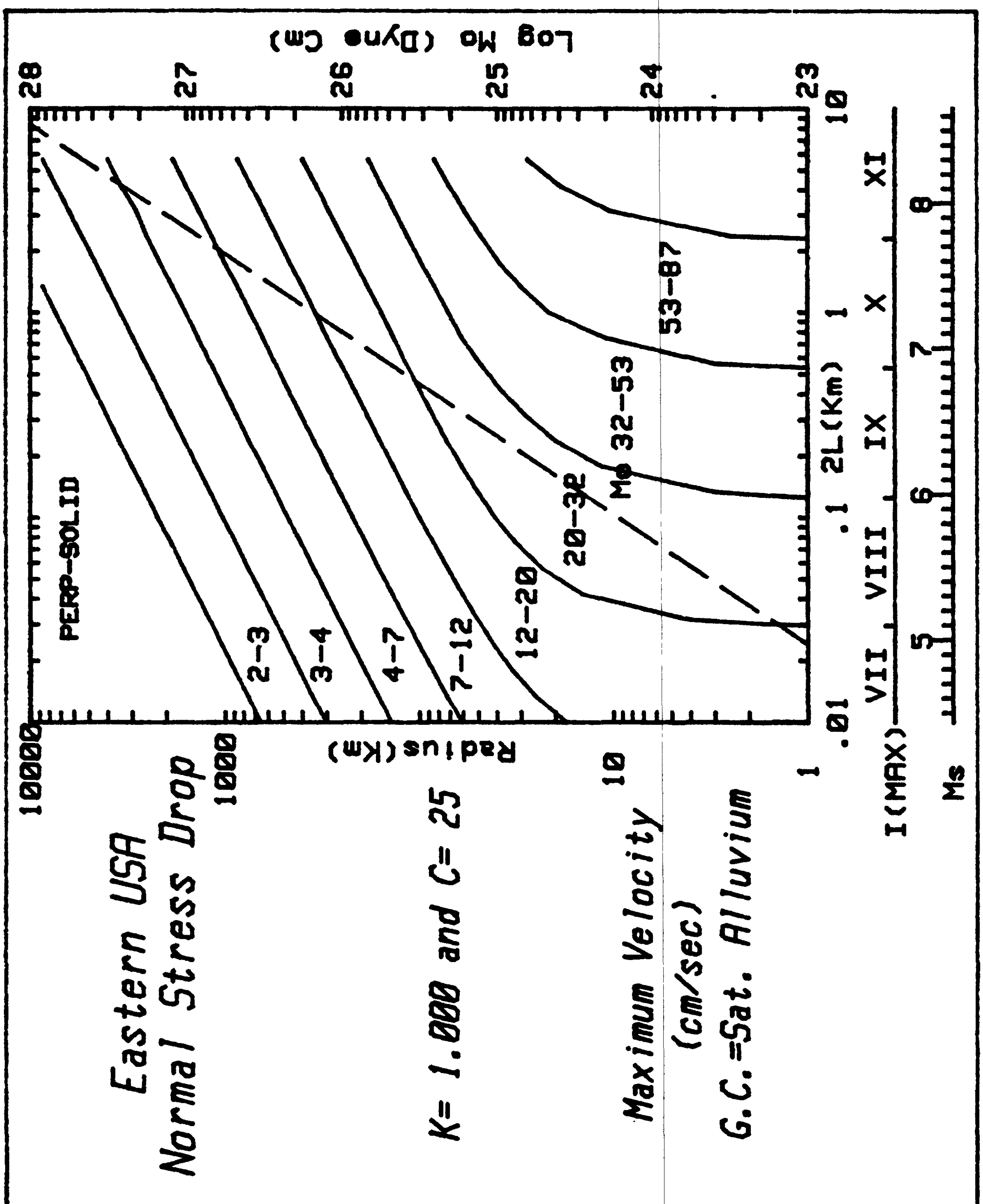

Eastern USA
Normal Stress Drop
K= 1.000 and C= 25
Maximum Velocity
(cm/sec)
G.C.=Sat. Alluvium
PERP-SOLID
2-3
3-4
4-7
7-12
12-20
20-32
Mo 32-53
53-87
Radius(Km)
10000
1000
10
1
Log Mo (Dyne Cm)
28
27
26
25
24
23
2L(Km)
.01
.1
1
10
I(MAX)
VII
VIII
IX
X
XI
Ms
5
6
7
8

Figure 8

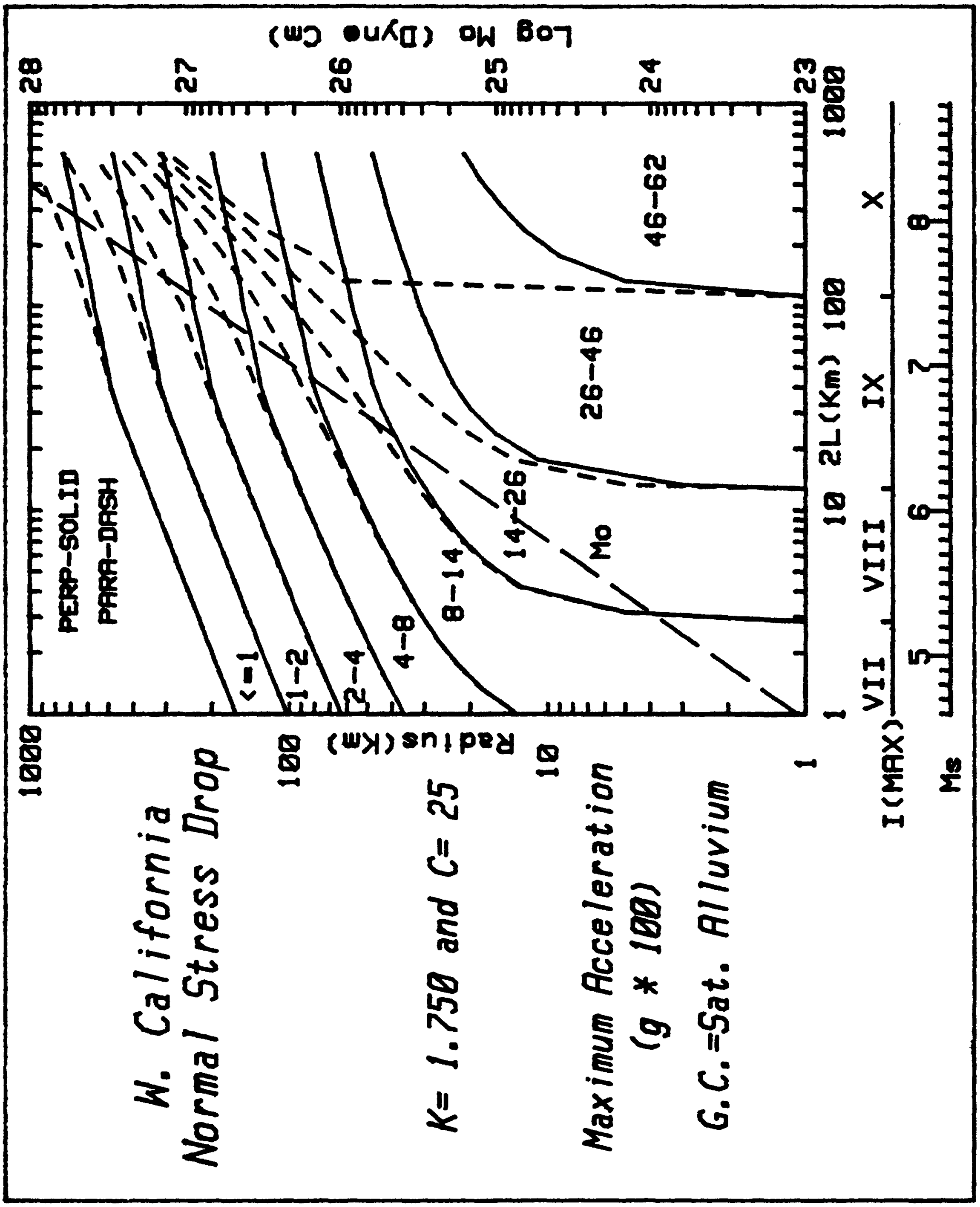

W. California
Normal Stress Drop
K= 1.750 and C= 25
Maximum Acceleration
(g * 100)
G.C.=Sat. Alluvium
PERP-SOLID
PARA-DASH
Log Mo (Dyne Cm)
Radius(Km)
2L(Km)
I(MAX)
Ms
<=1
1-2
2-4
4-8
8-14
14-26
26-46
46-62
Mo

Figure 9

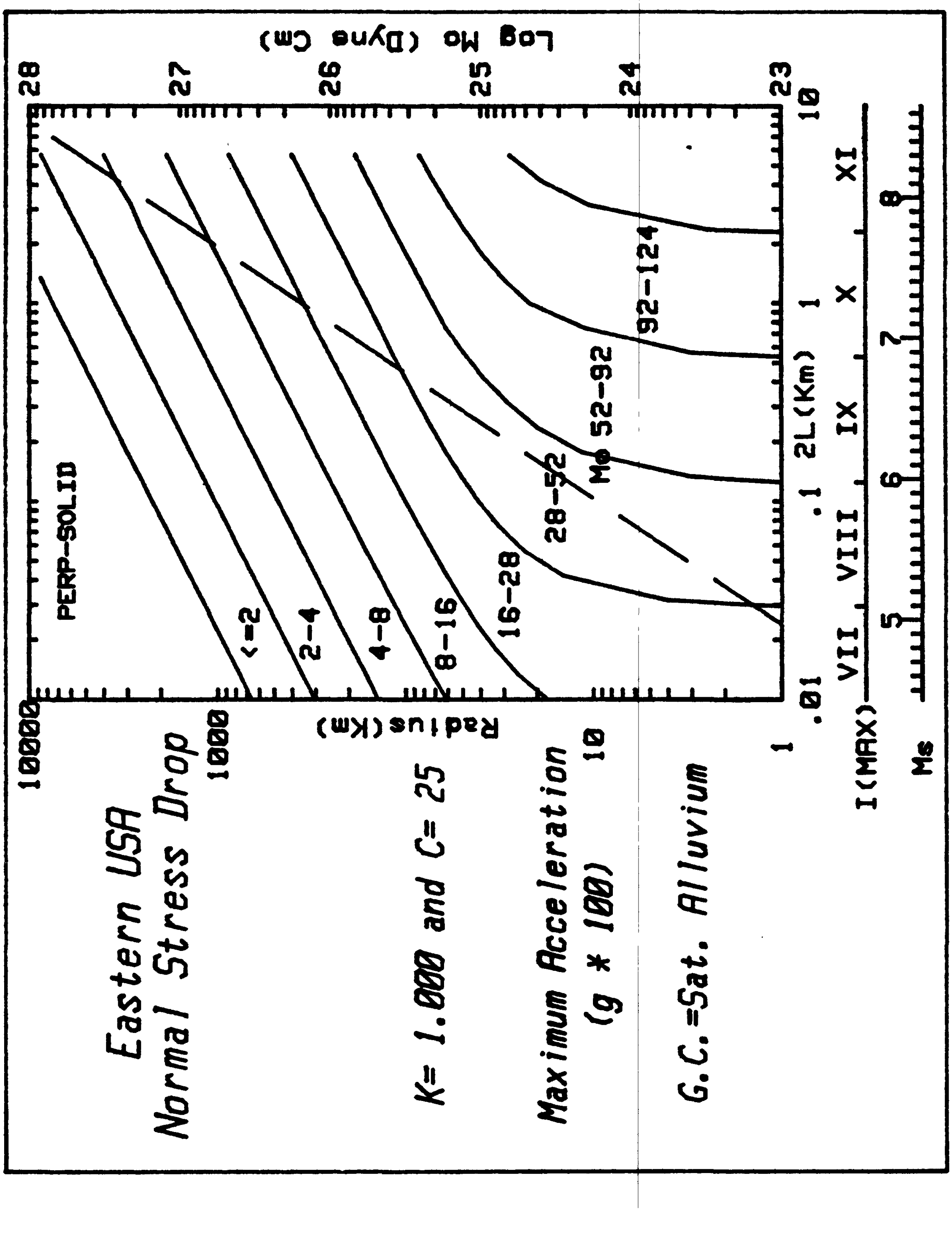

Eastern USA
Normal Stress Drop
K= 1.000 and C= 25
Maximum Acceleration
(g * 100)
G.C.=Sat. Alluvium
PERP-SOLID
<=2
2-4
4-8
8-16
16-28
28-52
Mo 52-92
92-124
Log Mo (Dyne Cm)
28
27
26
25
24
23
Radius(Km)
10000
1000
10
1
2L(Km)
.01
.1
1
10
I(MAX)
VII
VIII
IX
X
XI
Ms
5
6
7
8

Figure 10

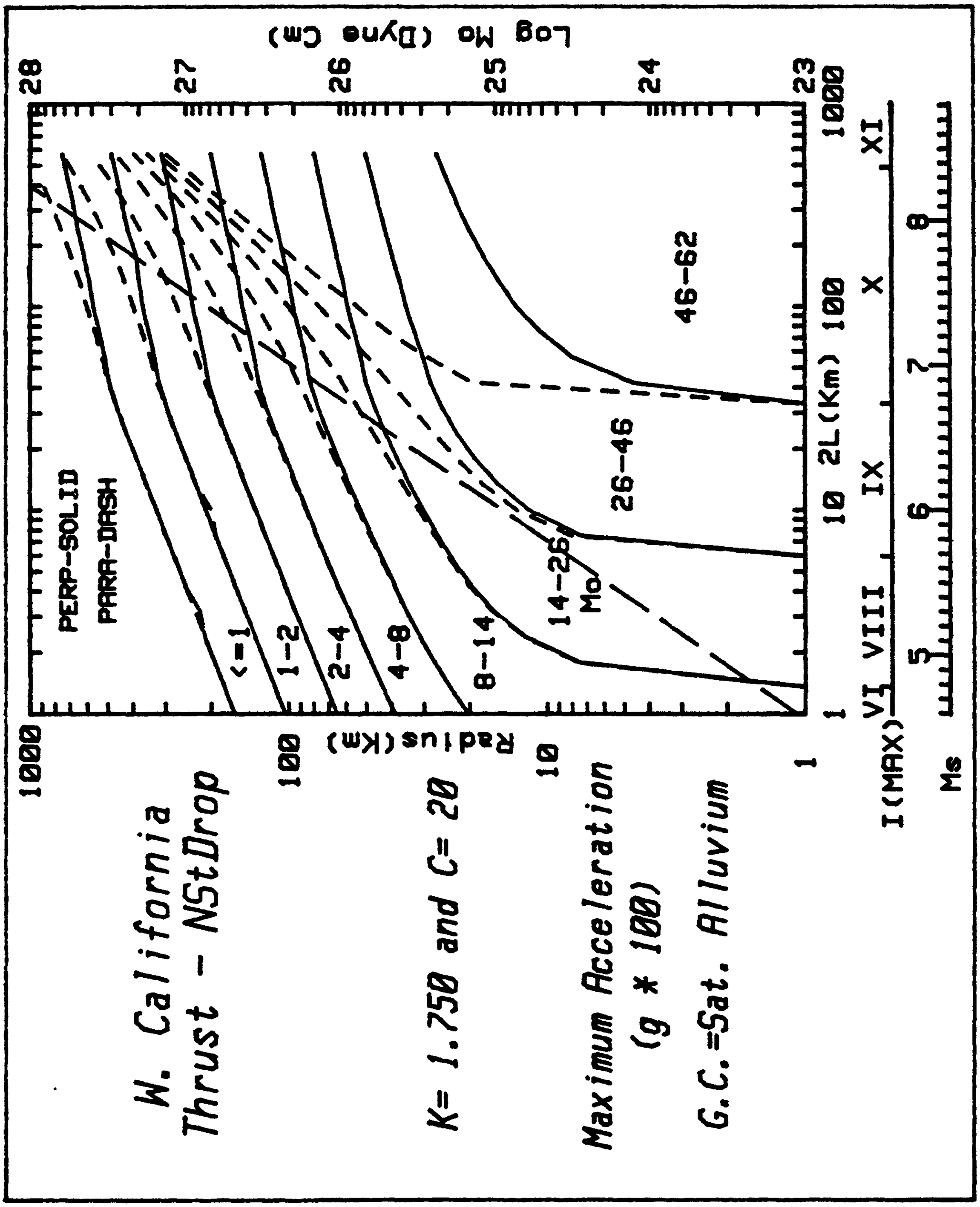

W. California
Thrust - NStDrop
K= 1.750 and C= 20
Maximum Acceleration
(g * 100)
G.C.=Sat. Alluvium
PERP-SOLID
PARA-DASH
<=1
1-2
2-4
4-8
8-14
14-26
26-46
46-62
Mo
Radius(Km)
2L(Km)
Log Mo (Dyne Cm)
I(MAX)
Ms
VI
VIII
IX
X
XI
1000
100
10
1
28
27
26
25
24
23
5
6
7
8

Figure 11